CHEMISTRY

BOOKS - CENGAGE CHEMISTRY (ENGLISH)

THERMODYNAMICS

Solved Examples

1. A process in which pressure remians constant is called

A. Isochroic process

B. Isothermal process

C. Adiabatic process

D. Isobaric process

2. Which one of the following is a state property/function?

A. Heat

B. Work

C. Internal energy

D. Potential enegry

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3. Which of the following is an extensive property?

A. Ethanlpy

B. Concentration

C. Density

D. Visocity

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4. If temperature of the system remains constant during the course of change, the change is

A. Isothermal

B. Adiabatic

C. Isobaric

D. Isochroic

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5. A process in which volume remians constant is called

A. Isochoric process

B. Isothermal process

C. Adiabatic process

D. Isobaric process

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6. Identify intensive property from the following

A. Volume

B. Mass

C. Enthalpy

D. Temperature

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7. Which of the following is an extensive property of the system?

A. Refractive index

B. Viscosity

C. Tempertature

D. Volume

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8. An isolated system is that system in which

A. There is not exchange of enegry with the surroundings.

B. There is exchange of mass nad enegry with the surroundings.

C. There is no exchange of enegry and mass with the surroundings.

D. There is exchange of mass with the surroundings.

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9. Thermodynamic is concerned with

A. Total enegry of a system

B. Enegry chnages in a system

C. Rate of a chemicle change

D. Mass changes in nuclear reactions

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10. Internal energy of a system of molecules is determined by taking into consideration its

A. Kinetic enegry

B. Vibrational enegry

C. Rotantional energy

D. All kinds of energies present in the molecules

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11. A thermodynamic quantity is that

A. Which is used in thermochemistry.

B. Which obeys all laws of thermodynamic.

C. Quantity whose value depends only upon the state of the system.

D. Quantity which is used in measuring thermal changes.

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12. Thermodynamic equilibrium involves

A. Chemical equilibrium

B. Thermal equilibrium

C. Mechanical equilibrium

D. All the the three

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13. For an adiabatic process, which of the following relations is correct?

A. $\Delta U = 0$

B. $P\Delta V = 0$

C. $q = 0$

D. $q = \ + w$

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14. Two liters of N_2 at $0^{\circ}C$ and 5 atm pressure is expanded isothermally against a constant external pressure of 1 atm untill the pressure of gas reaches 1 atm. Assuming gas to be ideal, claculate the work of expansion.

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15. Calculate the work done when done when 1.0 mol of water at $373K$ vaporises against an atmosheric pressure of $1.0atm$. Assume ideal gas behaviour.

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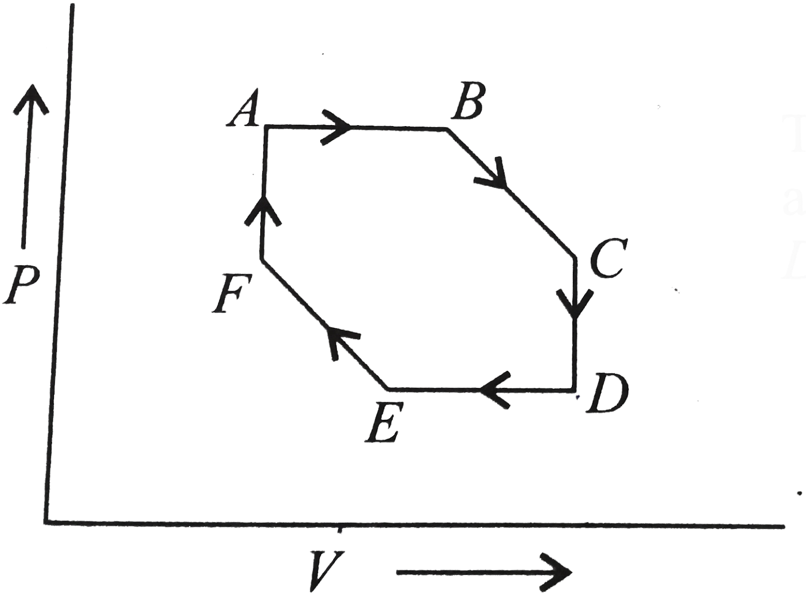
16. Identify different steps in the following cyclic process:



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17. A gas expands by $0.5L$ against a constant pressure of $1atm$. Calculate the work done in joule and calorie.

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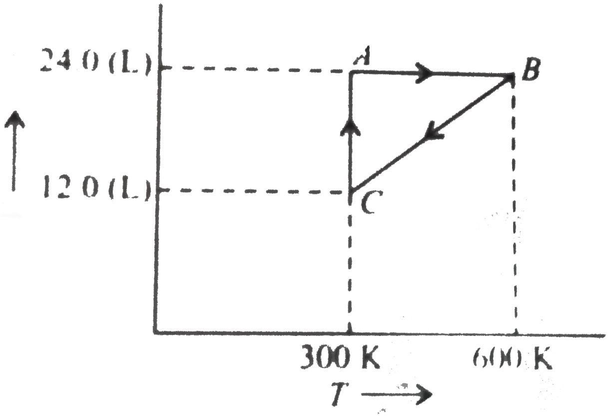
18. One made of an ideal gas is put through a series of changes as shown in the graph in which $A, B,$ and C, mark the three stages of the system. At each stage the variables are shown in the graph.

a. Calculate the pressure at three stages of system.

b. Name the process during the following chnages:

i. A to B ii. B to C

iii. $C$to$A$ iv. Overall change



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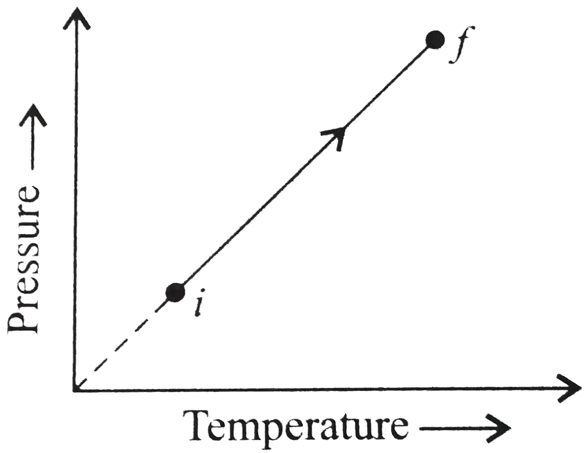
19. A thermodynamic system consists of a cylinder-piston attangement with ideal gas in it. It goes from the state i to the state f as shwon in the figure. The work done by gas during the process is



A. Zero

B. Negative

C. Positibe

D. Nothing can be predicted

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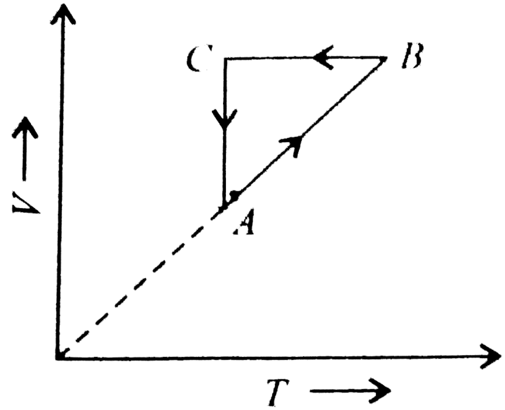
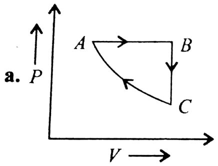
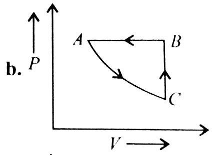
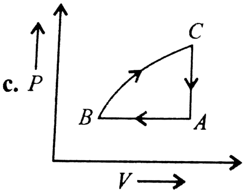
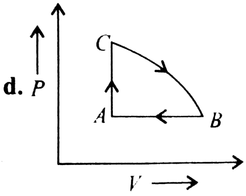
20. A cyclie process $ABCA$ is shwon in a V - T diagram. The corresponding P - V diagram is



A.


B.


C.


D. 

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21. Which one of the following statements about state function is correct?

A. Internal energy enthalpy, heat and work are all thermodynamic state functions.

B. A state function depends both on the past history of a system and on it present condition.

C. The state function describing a system of equilibrium changes with time.

D. The difference in a state function for any process depends only on the initial and final states.

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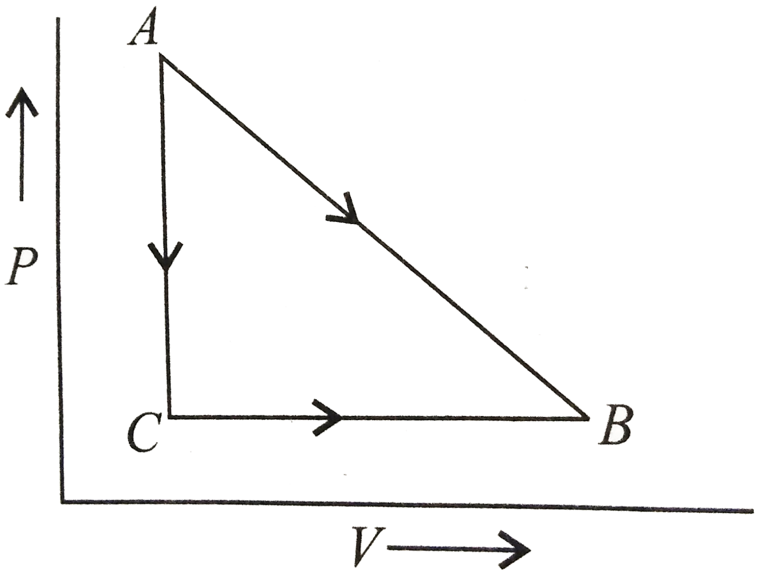
22. Consider the modes of transformations of a gas form state A to state B as shown in the given P - V diagram. Which one of the following is true?



A. $\Delta H = q$ along $A \rightarrow C$.

B. ΔS is same along both $A \rightarrow B$ and $A \rightarrow C \rightarrow B$

C. w is same along both $A \rightarrow B$ and $A \rightarrow C \rightarrow B$

D. $w > 0$ along both $A \rightarrow B$ and $A \rightarrow C$

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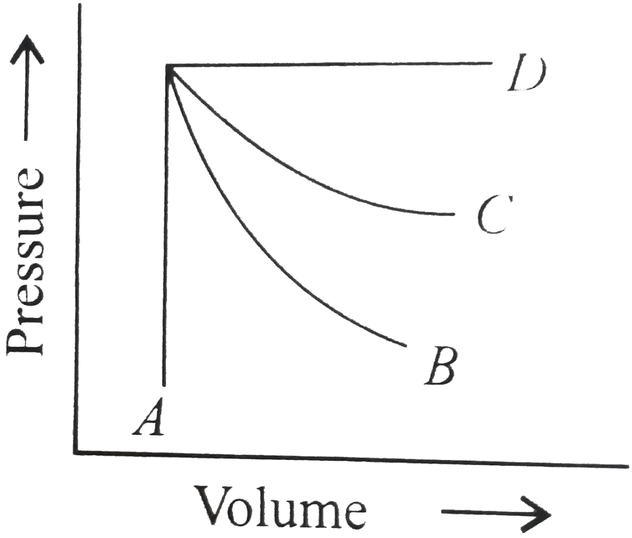
23. Which of the following statements is/are correct?



A. A represents isochroic process

B. B represents adiabatic process

C. C represents isothermal process

D. D represents isobaric process

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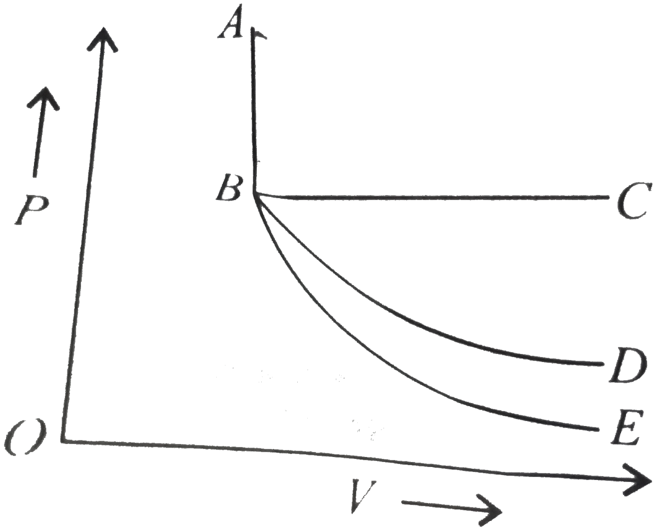
24. In P - V diagram shown below,



A. AB represents adiabatic process.

B. AB represents isothermal process.

C. AB represents isobaric process.

D. AB represents isochoric process.

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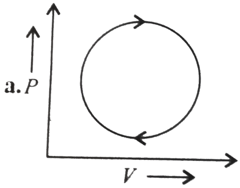
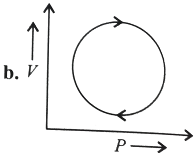
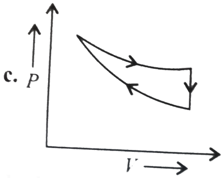
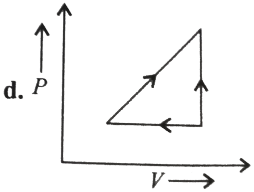
25. The following are the P - V diagram for cyclic process for a gas. In which of these processes, heat is not absorbed by the gas?

A. 

B. 

C. 

D. 

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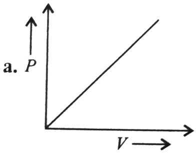
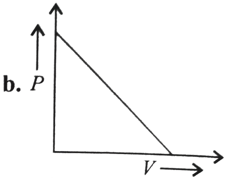
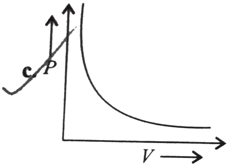
26. The graph betwene P and V at constant temperature should look like

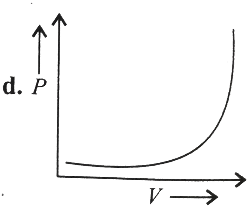
A. 

B. 

C.



D.



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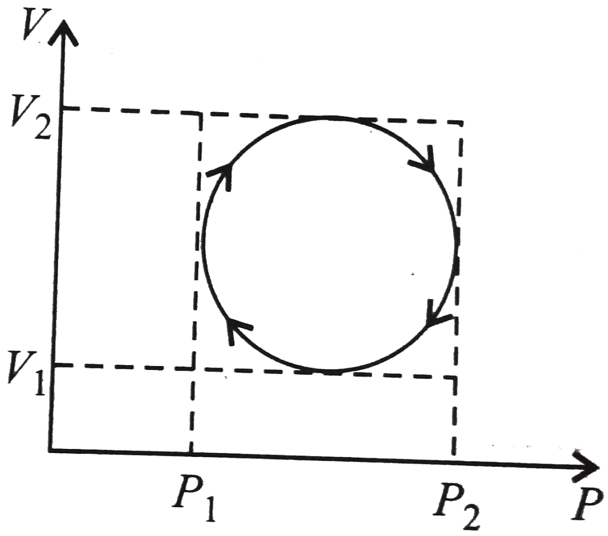
27. In the cyclic process shown on V - P diagram, the magnitude of the work done is



A. $\pi\left(\frac{P_2 - P_1}{2}\right)^2$

B. $\pi\left(\frac{V_2 - V_1}{2}\right)^2$

C. $\frac{\pi}{4}\left(P_2 - P_1\right)\left(V_2 - V_1\right)$

D. $\pi\left(P_2V_2 - P_1V_1\right)$

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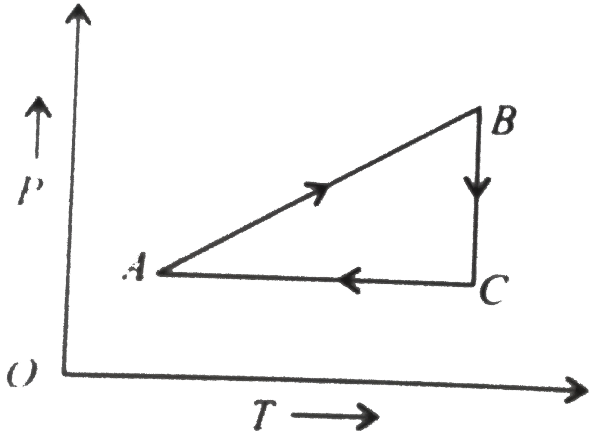
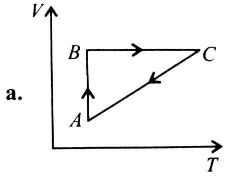
28. A cyclic process is shown in the P - T diagram.

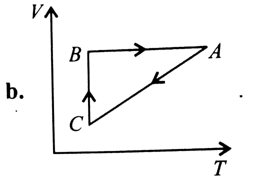


Which of the curve shows the same process on a V - T diagram?

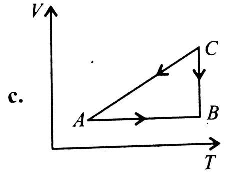
A.

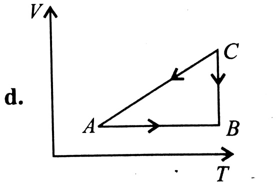


B.



C.



D. 

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29. Calculate the work done in open vessel at $300K$, when $92gNa$ reacts with water. Assume ideal gas neture.

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30. Calculate the work done when a system raises a colume of water of radius $5.0mm$ through $10cm$.

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31. Calculate the work done when $56g$ of iron reacts with hydrochloric acid in (a) a closed vessel of fixed volume and (b)an open beaker at $25^{\circ} C$.

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32. A system is provided $50J$ of heat and work done on the system is $20J$. What is the change in the internal enegry?

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33. The work done by a system is $10J$, when $40J$ heat is supplied to it. Calculate the increase in the internal enegry of system.

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34. A gas occupies $2L$ at STP. It is provided $300J$ heat so that it volume becomes $2.5L$ at $1atm$. Caluclate the change in its internal enegry.

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35. A certain electric motor produced $16kJ$ of energy each second as mechanical work and lost $3kJ$ as heat to the surroundings. What is the change in the internal energy of the motor and its power supply each second?

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36. An insulated container is divided into two equal portions. One portion contains as ideal gas at pressure P and tenperature T. The othe portion is a perfect vaccume. If a hole is opened between the two portions, claculate

a. the change in internal energy.

b. the change in temperature.

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37. $2.8g$ of N_2 gas at $300K$ and $20atm$ was allowed to expand isothermally against a constant external pressure of $1atm$. Calculate $\Delta U, q,$ and W for the gas.

38. At $27\,^\circ C$, one mole of an ideal gas is compressed isothermally and reversibly from a pressure of $20atm$ to $100atm$. Calculate ΔE and $q.\left(R = 2calK^{-1}mol^{-1}\right)$

39. One mole of an ideal gas is heated at constant pressure from $0\,^\circ C$ to $100\,^\circ C$.

a. Calculate the work done.

b. If the gas were expanded isothermally and reversibly at $0\,^\circ C$ from $1atm$ to some othe pressure P, what must be the final pressure if the maixmum work is equal to the work in (a)?

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40. Calculate the maximum work done in expanding $16g$ of oxygen at $300K$ occupying volume of $5dm^3$ and isothermally untill the volume become $25dm^3$?

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41. Calculate q, w, and ΔU for the isothermal reversible expansion of one mole of an ideal gas from an initial pressure of 2.0 bar to a final pressure of 0.2 bar at a constant temperature of $273K$.

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42. Calculate the maximum work down when pressure on $10g$ of hydrogen is reduced from 20 to $1atm$ at a constant temperature of $273K$. The gas behaves ideally. Will there be any change in internal energy. Also calculate q. $\left(R = 2calK^{-1}mol^{-1}\right)$

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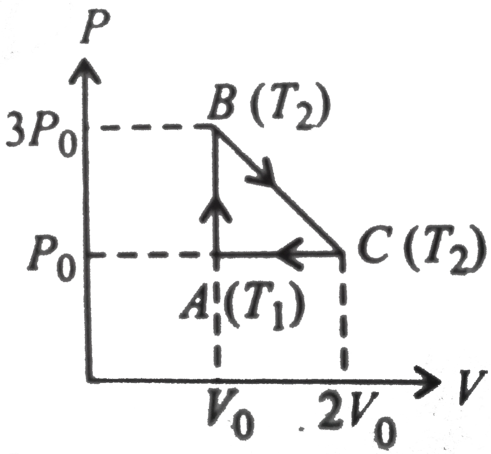
43. One mole of an ideal mono-atomic gas is taken round cyclic process ABC as shown in figure below. Calculate work done



A. The work done by the gas.

B. The heat rejected by the gas in the path $CA$and the heat absorbed by the gas in the path AB.

C. The net heat absorbed by the gas in the path BC.

D. The maixmum temperature attained by the gas during the cycle.

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44. An ideal gas absorbs $600 cal$ of heat during expansion from $10L$ to $20L$ against the constant pressure of $2 atm$. Calculate the change in internal enegry.

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45. Calculate the workdone taking place when an ideal gas undergoes isothermal expansion.

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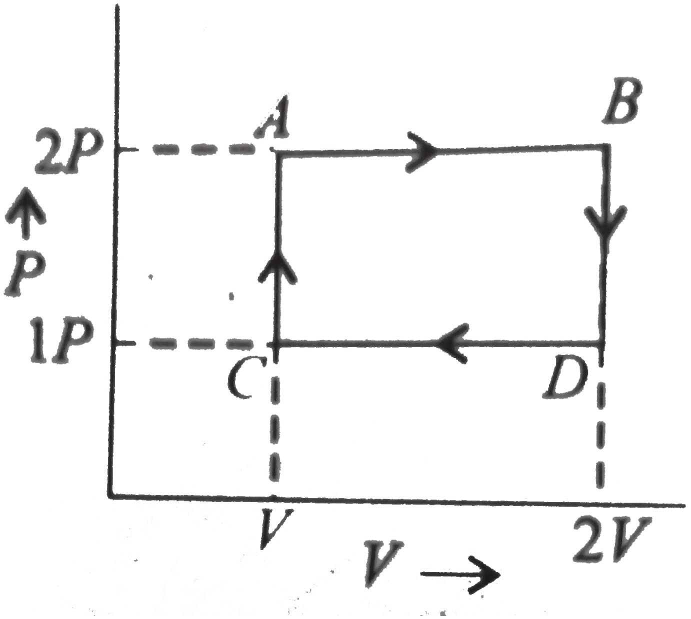
46. An ideal mono-atomic gas follows the path $ABCD$. The work donw during the complete cycle is



A. $-PV$

B. $-2PV$

C. $-\frac{1}{2}PV$

D. Zero

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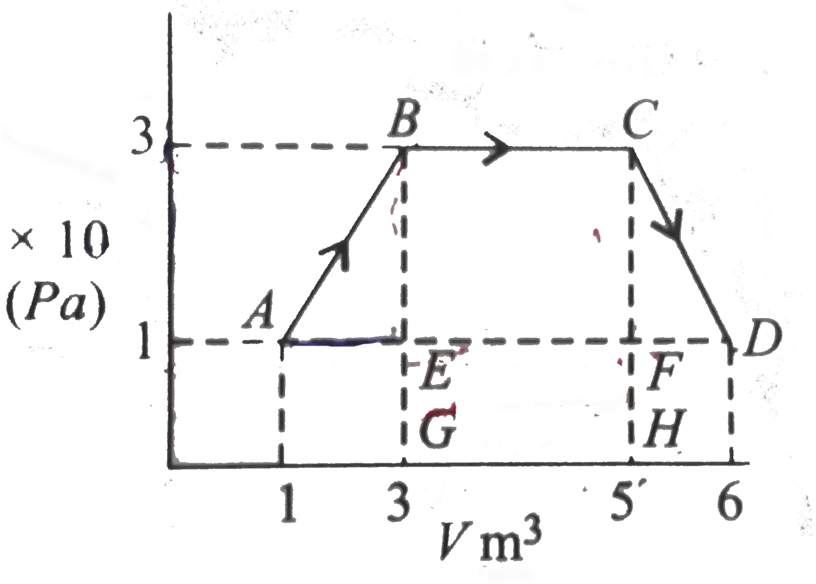
47. The net work done through a series of changes reported in figure for an ideal gas is



A. $-6 \times 10^5 J$

B. $-7 \times 10^5 J$

C. $-12 \times 10^5 J$

D. $+12 \times 10^5 J$

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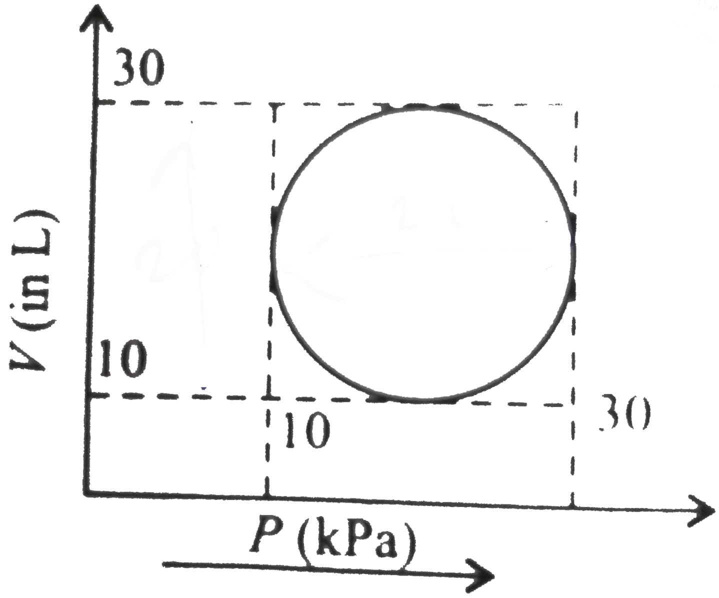
48. Heat energy absorbed by a system in going through a cyclic process shown in figure is



A. $10^7 \pi J$

B. $10^4 \pi J$

C. $10^2 \pi J$

D. $10^{-3} \pi J$

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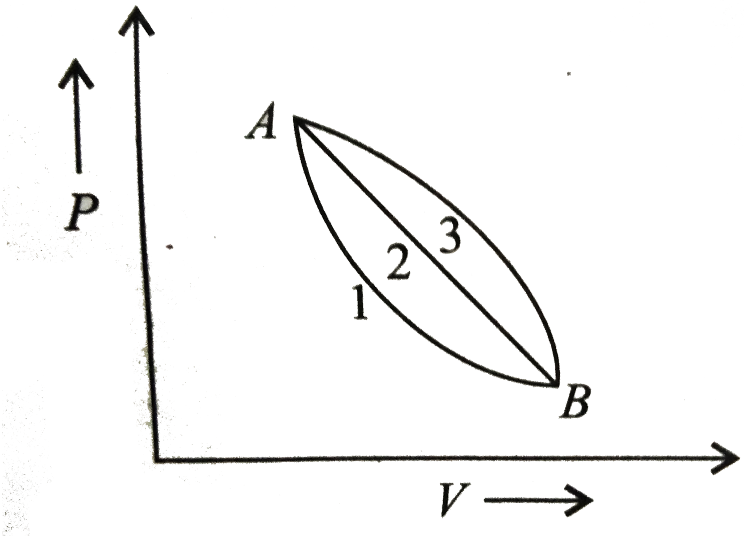
49. A given mass of gas expands from state A to state b by three paths $1, 2,$ and 3 as shown in the figure below. If w_1, w_2 and w_3, respectively, be the work done by the gas along three paths, then



A. $w_1 > w_2 > w_3$

B. $w_1 < w_2 < w_3$

C. $w_1 = w_2 = w_3$

D. $w_1 < w_2, w_1 < w_3$

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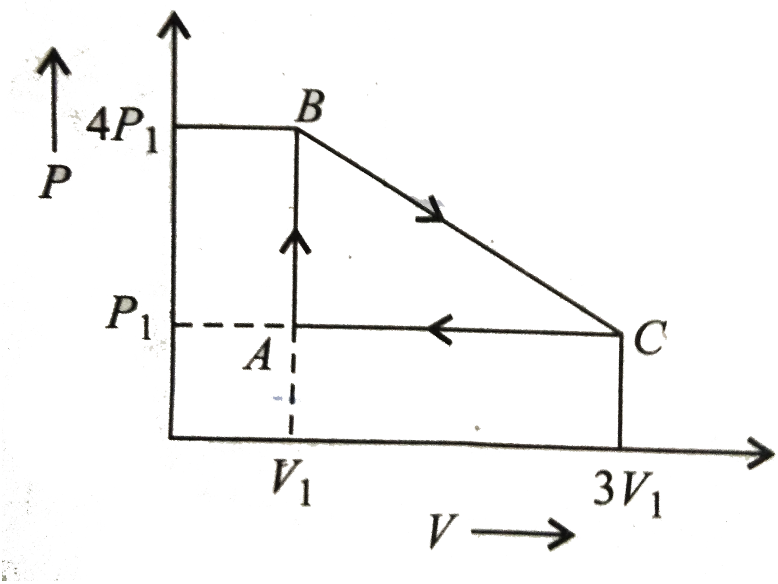
50. An ideal gas is taken around the cycle $ABCD$ shown in the P_V diagram below. The net work done by the gas during the cycle is equal to



A. $12P_1V_1$

B. $6P_1V_1$

C. $3P_1V_1$

D. P_1V_1

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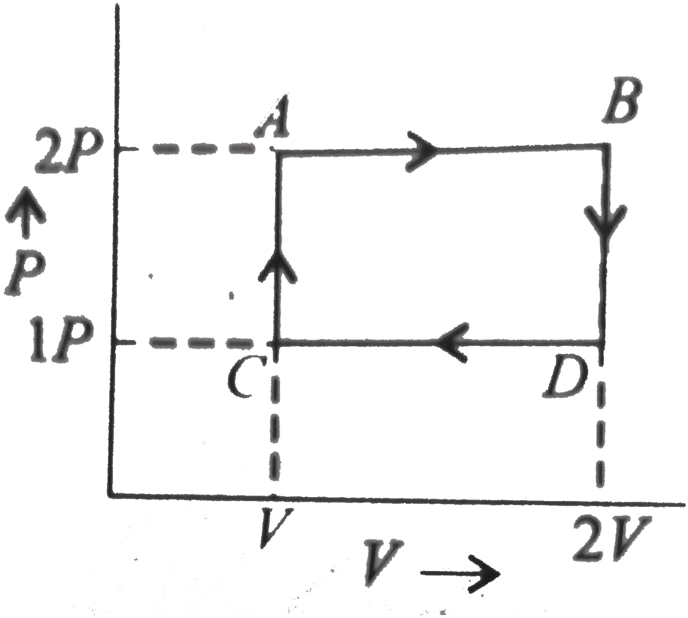
51. An ideal mono-atomic gas follows the path $ABDC$. The work done during the complete cycle is



A. PV

B. $2PV$

C. $\frac{1}{2}PV$

D. Zero

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52. Can we measure the absolute value of internal enegry?

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53. One mole of SO_2 at $298K$ and $1atm$ pressure is heated in a closed vessel so that its temperature is $475K$ and pressure is $4atm$. It is then cooled so that temperature becomes $298K$ and pressure is $1atm$. What is that change in the internal energy of the gas?

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54. Neither q nor w is a state function but $q + w$ is a state function. Explain why?

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55. Which one of the following is a state property/function?

A. q

B. Heat capacity

C. Specific heat capcity

D. ΔH^{Θ}

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56. Under what conditions is the heat of reaction equal to enthalpy change?

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57. A gas expands from $3dm^3$ to $5dm^3$ against a constant pressure of $3atm$. The work done during the expansion if used to heat $10mol$ of water at temperature $290K$. Find the final temperature of water, if the specific heat of water $= 4.18g^{-1}K^{-1}$.

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58. Classify the following as open, closed, or isolated system.

a. A beaker containing as open, boiling water.

b. A chemical reaction taking place in an enclosed flask.

c. A cup of tea placed on a table.

d. Hot water placed in perfectly insulated closed container.

e. A thermos flask containing hot coffee.

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59. If ΔH is the enthalpy change and ΔU the change in internal energy accompanying a gaseous reaction, then

A. ΔH is always less than ΔU.

B. ΔH is always than ΔU.

C. ΔH is less than ΔU if the number of moles of gaseous products is greater than the number of moles of gaseous reactants.

D. ΔH is less than ΔU if the number of moles of gaseous products is less than the number of moles of gaseous reatants.

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60. Water is boiled under a pressure of $1.0 atm$. When an electric current of $0.50A$ from a $12V$ supply is passed for 300s through a resistance in thermal contact with it, it is found that $0.789g$ of water is vaporied. Calculate the molar internal enegry and enthalpy chnages at boiling point $(373.15K)$.

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61. $10g$ of argon gas is compressed isothermally and reversibly at a temperature of $27^{\circ}C$ from $10L$ to $5L$. Calculate $q, w, D \leq taU$, and ΔH for this process. $R = 2.0 calK^{-1} \mathrm{mol}^{-1}, \log_{10}2 = 0.30$. Atomic weight of $Ar = 40$.

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62. The internal enegry change in the conversion of $1.0 mol$ of the calcite form of $CaCO_3$ to the aragonite from is $+0.2 kJ$. Calculate the enthalpy change when the pressure is 1 bar, given that the densities of the solids are 2.71 and $2.93 gcm^{-3}$, respectively.

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63. One mole of a liquid (1 bar, $100 mL$) is taken in an adiabatic container and the pressure increase steeply to 100 . Then at a constant pressure of 100 bar, volume decreases by $1 mL$. Find ΔU and ΔH.

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64. $(\Delta H - \Delta U)$ for the formation of carbon monoxide (CO) from its elements at $298K$ is

$\left(R = 8.314 K^{-1} mol^{-1}\right)$

A. $-1238.78 Jmol^{-1}$

B. $1238.78 Jmol^{-1}$

C. $-2477.57 Jmol^{-1}$

D. $2477.57 Jmol^{-1}$

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65. The difference between the heats of reaction at constant pressure and a constant volume for the reaction $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ at $25^\circ C$ in kJ is

A. -7.43

B. $+3.72$

C. -3.72

D. $+7.43$

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66. The latent heat of vapourisation of a liquid at $500K$ and atm pressure is $10kcalmol^{-1}$. What will be change in internal energy of $3mol$ of liquid at same temperature?

A. $13.0kcal$

B. $-13.0kcal$

C. $27.0kcal$

D. $-27.0kcal$

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67. What is value of ΔU for reversible isothernal evaporation of $90g$ water at $100^{\circ}C$? Assuming water vapour behaves as an ideal gas, $\Delta_{vap\,.\,Water}H = 540calg^{-1}$

A. $9 \times 10^3 cal$

B. $6 \times 10^3 cal$

C. $4.49 cal$

D. None of the above

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68. One moles of strem is compressed reversibly of water at boiling point $100^\circ C$. The heat of vapourisation of water at $100^\circ C$ and $1 atm$ is $540 calg^{-1}$. Calculate ΔU and ΔH.

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69. The enthalpy combustion of a substance

A. Is always positive

B. Is always negative

C. Can be either zero or greater than zero

D. Is unpredictable till the calculations are done

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70. One litre-atmosphere is approximately equal to

A. $19.2J$

B. $101.3J$

C. $8.31J$

D. $831J$

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71. Calorific value of fat

A. Greater than that of carbohydrate or protein

B. less than either of carbohydrate of protein

C. Less than that of carbohydrate

D. Greater than that of carbohydrate

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72. Xg of ethanal was subjected to combustion in a bomb calorimeter and the heat produced is YJ. Then

A. ΔU (combustion) $= -XJ$

B. ΔU(combustion) $= YJ$

C. ΔU (combustion) $= -\frac{44Y}{X}Jmol^{-1}$

D. ΔH (combustion) $= \frac{44Y}{X}Jmol^{-1}$

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73. The reaction

$SO_2(g) + 1/2O_2(g) \rightarrow SO_3(g)$ should be

A. Endothermic

B. Exothermic

C. $\Delta H = 0$

D. Unpredictable

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74. A hypothetical reaction, $A \rightarrow 2B$, proceeds via following sequence of steps

$A \rightarrow C \qquad \Delta H = q_1$

$C \rightarrow D \qquad \Delta H = q_2$

$\frac{1}{2}D \rightarrow B \qquad \Delta H = q_3$

The heat of reaction is

A. $q_1 - q_2 + 2q_3$

B. $q_1 + q_2 - 2q_2$

C. $q_1 + q_2 + 2q_3$

D. $q_1 + 2q_2 - 2q_3$

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75. A gas expands from $3dm^3$ to $5dm^3$ against a constant pressure of $3atm$. The work done during the expansion if used to heat $10mol$ of water at temperature $290K$. Find the final temperature of water, if the specific heat of water $= 4.18g^{-1}K^{-1}$.

A. $290.2K$

B. $290.9K$

C. $298.0K$

D. $293.7K$

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76. The magnitude of ethalphy changes for reversible adiabatic expansion of a gas from volume V_1 to V_2(in L)is ΔH_1 and for irreversible adiabatic expansion for the same expansion is ΔH_2. Then

when ΔU_1 and ΔU_2 are the changes in magnitudes for the internal energy of gas in the two expansions.

A. $\Delta H_1 > \Delta H_2$

B. $\Delta H_1 < \Delta H_2$

C. $\Delta H_1 = \Delta H_2$

D. $\Delta H_1 = \Delta U_1$ and $\Delta H_2 = \Delta U_2$

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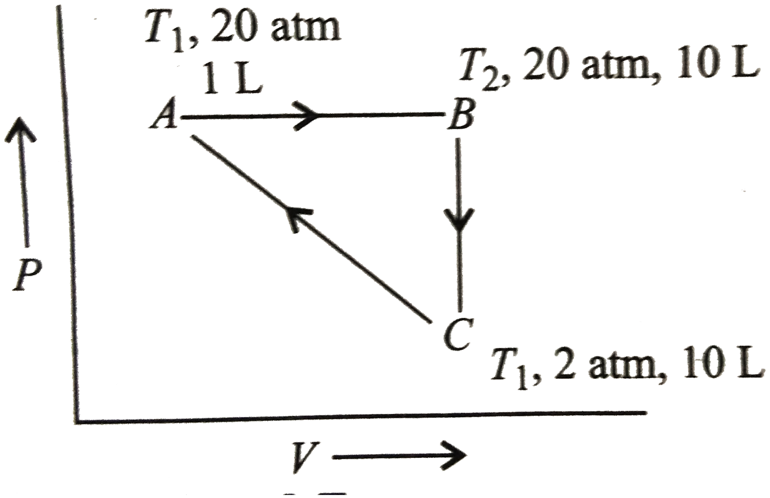
77. $1mol$ of a mono-atomic gas is subjected to following cyclic process:



a. Calculate T_1 and T_2.

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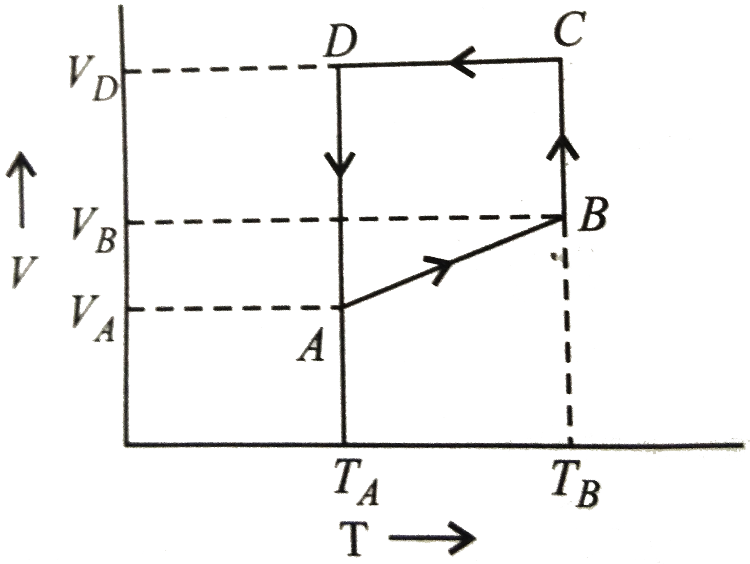
78. A mono-atomic ideal gas of two moles is taken through a cyclic process starting from A as shwon in the figure below.

The volume ratios are $V_B / V_A = 2$ and $V_D / V_A = 4$. If the temperature T_A at A is $27\,^{\circ}C$. Calculate



a. The temperature of gas at B.

b. Heat absorbed or evolved in each process.

c. Total wrok done in cyclic process.

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79. $4.0 mol$ of an ideal gas initially at $1.5 atm$ and $300 K$ is heated to $600 K$ where the pressure is $4.5 atm$. Also, $C_{vm} = a + bT, a = 25 JK^{-1} mol^{-1}, b = 0.03 JK^{-2} mol^{-1}$. Determine $\Delta U, \Delta H$.

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80. The molar heat capacity for a gas at constant T and P is

A. $\frac{3}{2}R$

B. $\frac{5}{2}R$

C. Dependent on the atomicity of the gas

D. Infinity

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81. A system has internal energy equal to U_1, $450J$ of heat is taken out of it and $600J$ of work is done on it. The final energy of the system will be

A. (a) $\left(U_1 + 150\right)$

B. (b) $(U + 1050)$

C. (c) $\left(U_1 - 150\right)$

D. (d) None of these

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82. A lead bullet weighing $18.0g$ and travelling at $500m/s$ is embedded in a wooden block of $1.00kg$. If both the nullet and the block were initially at $25.0^{\circ}C$, what is the final temperature of the block containing bullet? Assume no temperature loss to the surrounding. (Heat capacity of wood $= 0.5kcalkg^{-1}K^{-1}$, heat capacity of lead $= 0.030kcalkg^{-1}K^{-1}\Big)$

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83. A mixture contains $8gHe$ and $14gN_2$ in a vessel at $300K$. How much heat is required to increase the rms speed of these molecules to double their value. Also calculate the final temperatures.

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84. At very low temperatures, heat capacity of a solid is proportional to T^3 and can be written as: $C_P = \alpha T^3$ where $\alpha = 3 \times 10^8 Jmol^{-1}K^{-1}$. What is the change in enthalpy when a solid is heated from $0K$ to $300K$?

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85. 50 students sitting in the room of $5 \times 10 \times 3m^3$ dimensions. The air inside the room is at $27^\circ C$ and $1atm$ pressure. If each student loses 100 watt heat per second assuming the walls, ceiling floor, and all the material present inside the room is perfectly insulated as well as neglecting loss of air to the outside as the temperature is raised, how much rise in temperature will be noticed in 10 min ? Given $C_P = \frac{7}{2}R$ for air.

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86. 50 students sitting in the room of $5 \times 10 \times 3m^3$ dimensions. The air inside the room is at $27^\circ C$ and $1atm$ pressure. If each student loses 100

watt heat per second assuming the walls, ceiling floor, and all the material present inside the room is perfectly insulated as well as neglecting loss of air to the outside as the temperature is raised, how much rise in temperature will be noticed in 10 min ? Given $C_P = \frac{7}{2}R$ for air.

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87. A sample of ideal gas $(\gamma = 1.4)$ is heated at constant pressure. If $140J$ of heat is supplied to gas, find ΔU and W.

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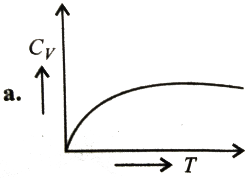
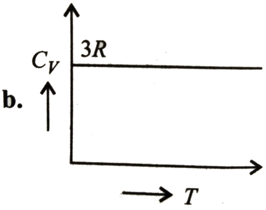
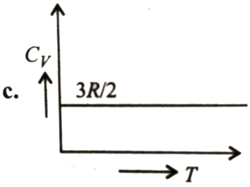
88. Graph for specific heat at constant volume for a monoatomic gas

A. 

B. 

C. 

D.

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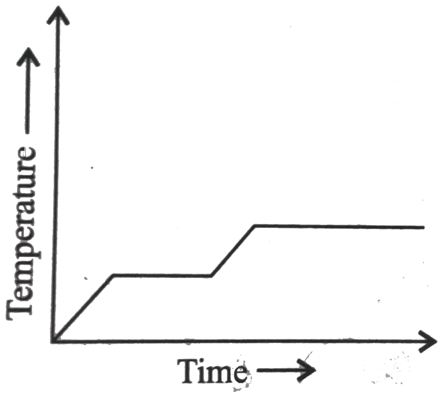
89. Heat is supplied to a certain homogeneous sample of amtter, at a uniform rate. Its temperature is plotted against time, as shown in the figure below. Which of the following conclusions can be drawn?



A. Its specific heat capacity is greater in the solid state than in the liquid state.

B. Its specific heat capacity is smaller in the solid state than in the liquid state.

C. Its latent heat of vaporisation is greater than its latent heat of fusion.

D. Its latent heat of vaporisation is smaller than its latent heat of fusion.

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90. Specific heat of constant pressure of a diatomic gas having molar mass M is approximately equal to

A. $\frac{\gamma R}{M(\gamma - 1)}$

B. $\frac{\gamma}{RM}$

C. $\frac{M}{R(\gamma - 1)}$

D. $\frac{\gamma RM}{\gamma + 1}$

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91. The following is not an endothermic reactions:

A. Combustion of methane

B. Decompositions of water

C. Dehydrogenation of ethane to ethylene

D. Conversion of graphite to diamond

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92. For the reaction

$N_2(g) + 3H_2(g) \rightarrow 2NH_2(g)$

Which of the following is correct?

A. $\Delta H = \Delta U$

B. $\Delta H > \Delta U$

C. $\Delta H < \Delta U$

D. $\Delta H = 2\Delta U$

Answer: c

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93. $100mL$ of a liquid is contained in an insulated container at a pressure of 1bar. The pressure is steeply increased to 100bar. The volume of the liquid is decreased by $1mL$ at this constant pressure. Find ΔH and ΔU.

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94. $14g$ oxygen at $0^{\circ}C$ and $10atm$ is subjected to reversible adiabatic expansion to a pressure of $1atm$. Calculate the work done in

a. Litre atmosphere.

b. Calorie (given, $C_P/C_V = 1.4\big)$.

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95. When a polyatomic gas undergoes an adiabatic process, its tempertaure and volume are related by the equation $TV^n =$ constant, the value of $n$will be

A. 1.33

B. 0.33

C. 2.33

D. 1

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96. A mono-atomic gas X and an diatomic gas y both initially at the same temperature and pressure are compressed adiabatically from a volume V to $V/2$. Which gas will be at higher temperature?

A. X

B. Y

C. both are same

D. Cannot be determined

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97. A flask of $1L$ having $NH_3(g)$ at $2.0atm$ and $200K$ is connected with the another flask of volume $800mL$ having $HCI(g)$ at $8atm$ and $200K$ through a narrow tube of negligible volume. The two gases react to form $NH_4(CI(s)$ with evolution of $43kJmol^{-1}$ heat. if heat capacity of $HCI(g)$ at constant volume is $20JK^{-1}mol^{-1}$ and neglecting heat capacity of flask, NH_4CI, and volume of solid NH_4CI formed, calculated in the flasks, produced, final temperature, and final pressure in the flasks. (Assume $R = 0.08LatmK^{-1}mol^{-1}\Big)$

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98. A gas originally at $1.10atm$ and $298K$ underwent a reversible adiabatic expansion to $1.00atm$ and $287K$. What is the molar heat capacity of the gas?

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99. One mol of an ideal diatomic gas underwent an adiabatic expansion form $298K, 15.00atm$, and $5.25L$ to $2.5atm$ against a constant external pressure of $1.00 atm$. What is the final temperature of the system?

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100. A sample of organ gas at $1 atm$ pressure and $27^{\circ} C$ expands reversibly and adiabatically from $1.25 dm^3$ to $2.50 dm^3$. Calculate the enthalpy change in this process. C_{vm} for orgon is $12.48 JK^{-1} mol^{-1}$.

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101. The relationship between enthalpy and internal energy change is

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102. In a thermodynamic process hellium gas obeys the law $T/p^{2/5} =$ constant. The heat given n moles of He in order to rise the temperature form T to $2T$ is

A. $8RT$

B. $4RT$

C. $16RT$

D. Zero

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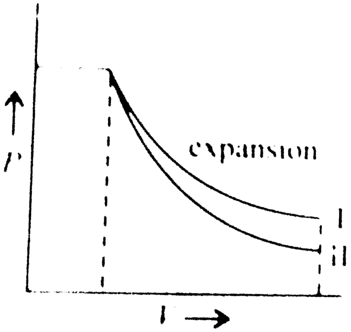
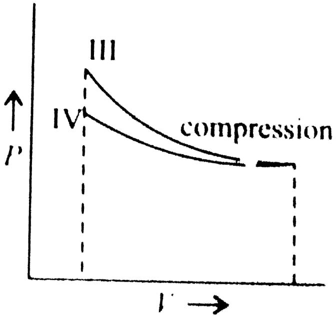
103. Which of the following graphs given below show (s) adiabatic process?





A. II, III

B. I, III

C. II, IV

D. I, IV

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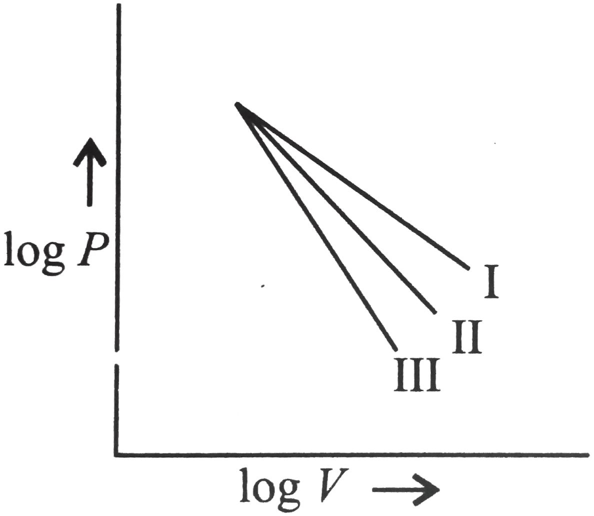
104. The following curve represent adiabatic expansions of gases He, O_2,and O_3 not necessarily in order. Which curve represnets for O_3?



A. I

B. II

C. III

D. Any one of these

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105. During an adiabatic expansion, a gas obeys $VT^3 =$ constant. The gas must be

A. Monoatomic

B. Diatomic

C. Polyatomic

D. Any of above

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106. Show that in an isothermal expansion of an ideal gas, a $\Delta U = 0$ and b. $\Delta H = 0$.

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107. A certain gas in expanded from $(1L, 10atm)$ to $(4L, 5atm)$ against a constant external pressure of $1atm$. If the initial temperature of gas is $300K$ and heat capacity for the process is $50J^{\circ}C^{-1}$, the enthalpy change during the process is: (use: $1L - atm = 100J$)

A. (a) $15kJ$

B. (b) $15.7kJ$

C. (c) $14.3kJ$

D. (d) $14.7kJ$

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108. $1mol$ of an ideal gas at $400K$ and $10atm$ is allowed to expand, adiabatically, against $2.0atm$ external pressure. Find the final temperature of the gas. [Use: $C_v = \frac{5}{2}R$]

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109. $5mol$ of an ideal gas at $293K$ is expanded isothermally from an initial pressure $0.4kPa$ to a final pressure of $0.1kPa$ against a constant external pressure of $0.1kPa$.

a. Calcualte q, w, Δ, U, and ΔH.

b. Calculate the corresponding value of $q, w, \Delta U$, and ΔH if the above pressure is carried out reversibly.

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110. For adiabatic expansiion of a perfect gas, $\frac{dP}{P}$ is

A. $\frac{dV}{V}$

B. $\gamma.\frac{dV}{V}$

C. $-\gamma\frac{dV}{V}$

D. $-\gamma^2 \frac{dV}{V}$

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111. $He, N_2,$ and O_3 are expanded adiabatically and their expansion curves between P and V are plotted under silimar conditions. About the ratio of the slope, which one is not correct?

A. The ratio of slopes of P - V curves for He and $O_3 is 1.25$.

B. The ratio of slopes of P - V curves for He and $N_2 is 1.20$.

C. The ratio of slopes of P - V curves for N_2 and $O_3 is 1.05$.

D. The slope of He is least steeper and for O_3 is most steeper.

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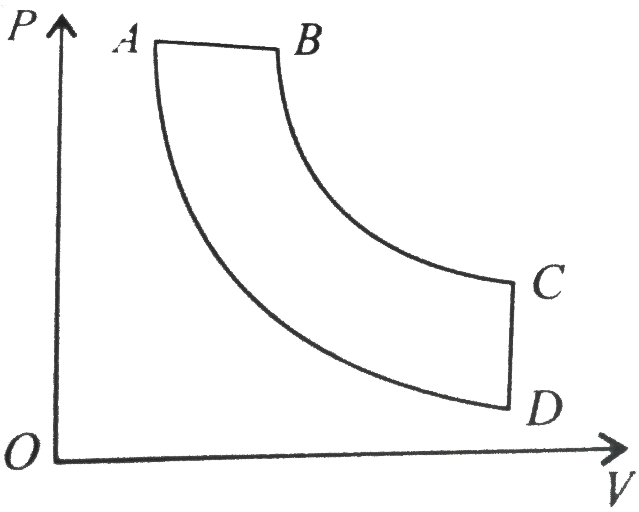
112. In the pressure-volume diagram given below, the isochoric, isothermal, isobaric, and isoentropic parts, respectively, are:



A. BA, AD, DC, DB

B. DC, CB, BA, AD

C. AB, BC, CD, DA

D. CD, DA, AB, BC

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113. What will be the final volume of a mole of an idela gas at $20\,^{\circ}C$ when it expands adiabatically from a volume of $5L$ at $30\,^{\circ}C?C_V$ of the gas $= 5cal/degree$.

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114. $2mol$ of an idela gas expand reversibly and isothermally at $25\,^{\circ}C$ from $2L$ to $10L$. Calculate the work done by the gas in calories.

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115. A gas is expanded from volume V_1 to V_2 through three different process:

a. Reversible adiabatic

b. Reversible isothermal

c. Irreversible adiabatic (against a constant external pressure $P_{ex}\big)$

The correct option is

A.

$$\left[\left(T_f\right)_{Gas}\right]_{\text{Reversible isothermal}} > \left[\left(T_f\right)_{GaS}\right]_{\text{Reversible adiabatic}} > \left[\left(T_f\right)_{Gas}\right]_{\text{Irreve}}$$

B.

$$\left[\left(T_f\right)_{Gas}\right]_{\text{Reversible isothermal}} > \left[\left(T_f\right)_{GaS}\right]_{\text{Irreversible adiabatic}} > \left[\left(T_f\right)_{Gas}\right]_{\text{Reve}}$$

C. $w_{\text{Reversible isothermal}} > w_{\text{Irreversible adiabatic}} > w_{\text{Reversible adiabatic}}$

D. $\left(P_f\right)_{\text{Reversible isothermal}} > \left(P_f\right)_{\text{Reversible adiabatic}} > \left(P_f\right)_{\text{Irreversible adiabatic}}$

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116. Work done in expansion of an idela gas from $4L$ to $6L$ against a constant external pressure of $2.5atm$ was used to heat up $1mol$ of water at $293K$. If specific heat of water is $4.184Jg^{-1}K^{-1}$, what is the final temperature of water.

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117. Calculate the standard heat of formation of carbon disulphide (l). Given that the standard heats of combustion of carbon (s), sulphur (s) and acrbon disulphide (l) are $-390, \ -290.0$, and $-1100.0 kJmol^{-1}$. Respectively.

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118. Calculate the heat of formation of acetic acid form the following data:

a. $CH_3COOH(l) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)\Delta H^{\ominus} = -200.0 kcal$

b. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H^{\ominus} = -94.0 kcal$

c. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^{\ominus} = -68.0 kcal$

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119. Given the following standard heats of reactions:

(a) heat of formation of water $= -68.3 kcal$, (b) heat of combustion of $C_2H_2 = -310.6 kcal$, (c) heat of combustion of ethylene $= -337.2 kcal$. Calculate the heat of reaction for the hydrogenation of acetylene at constant volume and at $25^\circ C$.

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120. Calculate ΔH of the reaction, $H - \overset{\overset{H}{|}}{C} | {\scriptstyle CI} - CI(g) \rightarrow C(s) + 2H(g) + 2CI(g)$

Bond energy for $C - H$ bond and $C - CI$ bond are $400kJ$ and $320kJ$, respectively.

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121. Calculate the enthalpy of the following reaction:

$H_2C = CH_2(g) + H_2(g) \rightarrow CH_3 - CH_3(g)$

The bond energies of $C - H, C - C, C = C,$ and $H - H$ are $99, 83, 147$,and $104kcal$ respectively.

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122. The bond dissociation energies of gaseous $H_2, C1_2,$ and $HC1$ are $100, 50,$ and $100kcalmol^{-1}$, respectively. Calculate the enthalpy of formation of $HC1(g)$.

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123. Calculate the enthalpy of formation of ammonia from the following bond energy data:

$(N-H)bond = 389kJmol^{-1}$, $(H-H)bond = 435kJmol^{-1}$, and $(N \equiv N)bond = 945.36kJmol^{-1}$.

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124. Methanol can be prepared synthetically by heating carbon monoxide and hydrogen gases under pressure in the presence of a catalyst. The reaction is

$CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$

Determine the enthalpy of this reaction by an appropriate combinantion of the following data:

a. $C_{(\text{graphite})} + \frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H^{\Theta} = -110.5kJmol^{-1}$

b. $C_{(\text{graphite})} + O_2(g) \rightarrow CO_2(g), \Delta H^{\Theta} = -393.5kJmol^{-1}$

c. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^{\Theta} = -285.9kJmol^{-1}$

d. $CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta H^{\Theta} = -726.6kJmol^{-1}$

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125. How much heat will be required to make $2kg$ of calcium carbide $\left(CaC_2\right)$ according to the following reaction?

$CaO(s) + 3C(s) \rightarrow CaC_2(s) + CO(g)$

The heats of formations of $CaO(s), CaC_2(s)$, and $CO(g)$ are -151.0, -14.0 ,and $-26.0kcal$, respectively.

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126. When 2mole of C_2H_6 are completely burnt $3129kJ$ of heat is liberated. Calculate the heat of formation of C_2H_6. $\Delta_f H^{\Theta}$ for CO_2 and H_2O are -395 and $-286kJ$, respectively.

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127. The standard enthalpies of formation at $298K$ for $CCl(g), H_2O(g), CO_2(g)$ and $HCl(g)$ are $-106.7, -241.8, -393.7,$ and $-92.5kJmol^{-1}$, respectively. Calculate $\Delta H^{\Theta}{}_{298K}$ for the reaction

$CCl_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4HCI(g)$

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128. Calculate the standard internal energy change for the following reactions at $25^{\circ}C$:

$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

$\Delta_f H^{\Theta} at 25^{\circ}C$ for $H_2O_2(l) = -188kJmol^{-1} H_2O(l) = -286kJmol^{-1}$

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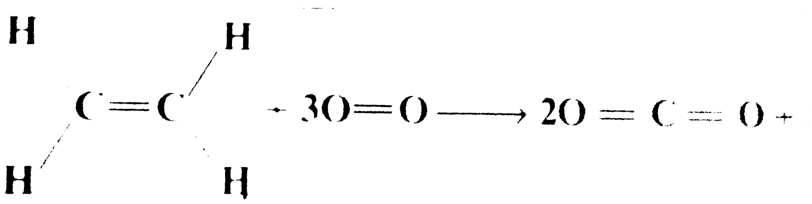
129. Calculate heat of combustion of ethene:



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130. The molar heat of formation of $NH_4NO_3(s)$ is -$367.54kJ$ and those of $N_2O(g)$and $H_2O(l)$ are $+81.46kJ$ and -$285.80kJ$, respectively, at $25^\circ C$ and $1atm$. Calculate ΔH and ΔU for the reaction.

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(l)$$

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131. Standard heat of formation at $298K$ is arbitrarily taken to be zero for

A. Liquid bromine

B. Gaseous bromine atoms

C. Gaseous bromine molecules

D. Solid bromine

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132. The standard heat of formation listed for gaseous NH_3 is $-11.0 kcal mol^{-1}$ at $298K$. Given that at $298k$, the constant pressure heat capacities of gaseous $N_2, H_2,$ and NH_3 are, respectively, $7.0, 6.0$ and $8.0 cal mol^{-1}$. Determine $\Delta H^{\Theta}{}_{298K}$ and ΔH_{773K} for the reactions:

$$\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$$

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133. At $25^{\circ} C$, the following heat of formations are given:

Compound	$SO_2(g)$	$H_2O(l)$
$\Delta_f H^{\Theta} kJ mol^{-1}$	-296.0	-285.0

For the reactions at $25^{\circ} C$,

$2H_2S(g) + Fe(s) \rightarrow FeS_2(s) + 2H_2(g), \Delta H^{\ominus} = -137kJm\infty l^{-1}$

$H_2S(g) + \frac{3}{2}O_2(g) \rightarrow H_2O(l) + So_2(g), \Delta H^{\ominus} = -562kJmol^{-1}$

Calculate the heat of formation of $H_2S(g)$ and $FeS_2(g)$ at $25^{\circ}C$.

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134. From the data at $25^{\circ}C$:

$Fe_2O_3(s) + 3C_{(\text{graphite})} \rightarrow 2Fe(s) + 3CO(g), \Delta H^{\ominus} = 492.0kJmol^{-1}$

$FeO(s) + C_{(\text{graphite})} \rightarrow Fe(s)CO(g), \Delta H^{\ominus} = 155.0kJmol^{-1}$

$C_{(\text{graphite})} + O_2(g) \rightarrow CO_2(g), \Delta H^{\ominus} = -393.0kJmol^{-1}$

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g), \Delta H^{\ominus} = -282.0kJmol^{-1}$

Calculate the standard heat of formation of $FeO(s)$ and $Fe_2O_3(s)$.

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135. Calculate the enthalpy of formation of $\Delta_f H$ for C_2H_5OH from tabulated data and its heat of combustion as represented by the following equaitons:

i. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g), \Delta H^{\ominus} = -241.8kJmol^{-1}$

ii. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H^{\Theta} = -393.5 kJmol^{-1}$

iii. $C_2H_5OH(l) + 3O_2(g) \rightarrow 3H_2O(g) + 2CO_2(g), \Delta H^{\Theta} = -1234.7 kJmol^{-1}$

A. a. $-2747.1 kJmol^{-1}$

B. b. $-277.7 kJmol^{-1}$

C. c. $277.7 kJmol^{-1}$

D. d. $2747.1 kJmol^{-1}$

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136. When enthyne is passed through a red hot tube, then formation of benzene takes place:

$\Delta_f H^{\Theta}\left(C_2H_2\right)(g) = 230 kJmol^{-1}$

$\Delta_f H^{\Theta}\left(C_6H_6\right)(g) = 85 kJmol^{-1}$

Calculate the standard heat of trimerisation of ethyne to benzene:

$3C_2H_2(g) \rightarrow C_6H_6(g)$

A. $205 kJmol^{-1}$

B. $605kJmol^{-1}$

C. $-605kJmol^{-1}$

D. $-205kJmol^{-1}$

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137. $\Delta H^{\Theta}{}' f298K$ of methanol is given by the chemical equation

A. $CH_4(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(g)$

B. $C(\text{graphite}) + \frac{1}{2}O_2(g) + 2H_2(g) \rightarrow CH_3OH(l)$

C. $C(\text{diamond}) + \frac{1}{2}O_2(g) + 2H_2(g) \rightarrow CH_3OH(l)$

D. $CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$

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138. Which of the following methods for the calculation of heat of a reaction is not correct?

A. $\Delta H^{\Theta}_{\text{reaction}} = \sum \Delta_f H^{\Theta}_{\text{products}} - \sum \Delta_f H^{\Theta}_{\text{reactants}}$

B. $\Delta H^{\Theta}_{\text{reaction}} = \sum (BE)_{\text{reactants}} - \sum (BE)_{\text{products}}$

C. $\Delta H^{\Theta}_{\text{reaction}} - \sum \Delta_{\text{comb}} H^{\Theta}_{(\text{reactants})} - \sum \Delta_{\text{comb}} H^{\Theta}_{(\text{products})}$

D. $\Delta H^{\Theta}_{\text{reaction}} = \sum \Delta_{\text{solution}} H^{\Theta}_{(\text{reactants})} - \sum \Delta_{\text{solution}} H^{\Theta}_{(\text{products})}$

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139. Given:

i. $2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s), \Delta H^{\Theta} = -193.4kJ$

ii. $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s), \Delta H^{\Theta} = -140.2kJ$

What is ΔH^{Θ} of the reaction?

$3Mg + Fe_2O_3 \rightarrow 3MgO + 2Fe$

A. $-227.2kJ$

B. $-272.3kJ$

C. $227.2kJ$

D. $272.3kJ$

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140. $F_2(g) + 2HCI(g) \rightarrow 2HF(g) + CI_2(g), \Delta H^{\Theta} = -352.18kJ$

Given heat of formation of $HF, \Delta_f H^{\Theta}{}_{(HF)} = -268.3kJ$ The heat of formation of HCl will be

A. $-22kJmol^{-1}$

B. $88kJmol^{-1}$

C. $-92.21kJmol^{-1}$

D. $-183.8kJmol^{-1}$

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141. Calculate ΔH at $85\,^{\circ}C$ for the reaction:

$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(l)$

The data: $\Delta H^{\Theta}_{298} = -33.0 kJ mol^{-1}$ and

Substance	$Fe_2O_3(s)$	$Fe(s)$	$H_2O(l)$	$H_2(g)$
$C_P^{\circ}\left(JK^{-1}mol\right)$	103.0	25.0	75.0	28.0

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142. Ethanol was oxidised to acetic acid in a catalyst chamber at $18\,^{\circ}C$. Calculate the rate of removel of heat to maintain the reaction chamber at $18\,^{\circ}C$ with the feed rate of $30 kg h^{-1}$ ethanol along with excess oxygen to the system at $18\,^{\circ}C$, given that a $42 mol\,\%$ yield based on ethanol is obtained. Given that

$\Delta_f H^{\Theta}{}' H_2O(l) = -68.0 kcal mol^{-1}$

$\Delta_f H^{\Theta}{}' C_2H_5OH(l) = -66 kcal mol^{-1}$

$\Delta_f H^{\Theta}{}' CH_3COOH(l) = -118 kcal mol^{-1}$

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143. Calculate the heat of formation of acetic acid form the following data:

a. $CH_3COOH(l) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)\Delta H^{\ominus} = -200.0kcal$

b. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H^{\ominus} = -94.0kcal$

c. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^{\ominus} = -68.0kcal$

A. $454.5kJmol^{-1}$

B. $-454.5kJmol^{-1}$

C. $-772kJmol^{-1}$

D. $-498kJmol^{-1}$

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144. Thermochemical equation for the combustion of ethylene gas, C_2H_4, is

$C_2H_4(g) \rightarrow 2CO_2(g) + 2H_2O(l), \Delta H^{\ominus} = -337kcal$

Assuming 70% efficiency, calculate the weight of water at $20^{\circ}C$ that can be converted into system at $100^{\circ}C$ by buring $1m^3$ of C_2H_4 gas measured at

STP. The heat of vaporisation of water at $20^{\circ}C$ and $100^{\circ}C$ are $1.00 kcal kg^{-1}$ and $540 kcal kg^{-1}$ respectively.

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145. The heat of combustion of glycogen is about $476 kJ mol^{-1}$ of carbon. Assume that average heat loss by an adult male is $150W$. If we were to assume that all the heat comes from oxidation of glycogen, how many units of glycogen ($1 mol$ carbon per unit) must be oxidised per day to provide for this heat loss?

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146. The temperature of a bomb calorimeter was found to rise by $1.617K$ when a current of $3.20A$ was passed for $27s$ from a $12V$ source. Calculate the calorimeter constant.

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147. Assume that for a domestic hot water supply $150kg$ water per day must be heated from $10\,^{\circ}C$ to $65\,^{\circ}C$ and gaseous fuel propane C_3H_8 is used for this purpose. What moles and volume of propane (in L at STP) would have to be used for heating domestic water, ΔH for combustion of propane is $-2050kJmol^{-1}$ and specific heat of water is $4.184 \times 10^{-3}kJg^{-1}$.

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148. The standard enthalpy of combustion at $25\,^{\circ}C$ of hydrogen, cyclohexene $\left(C_6H_{10}\right)$, and cyclohexane $\left(C_6H_{12}\right)$ are -241, -3800, and $-3920kJmol^{-1}$ repectively. Calculate the heat of hydrogenation of cyclohexene.

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149. A sample of $0.16gCH_4$ was subjected to combustion at $27\,^{\circ}C$ in a bomb calorimeter. The temperature of the calorimeter system (including water) was found to rise by $0.5\,^{\circ}C$. Calculate the heat of combustion of methane at

(a) constant volume and (b) constant pressure. The thermal capacity of calorimeter system is $17.7kJK^{-1}$ and $R = 8.314JK^{-1}mol^{-1}$.

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150. The heat of combustion of ethane gas is $-368kcalmol^{-1}$. Assuming that 60% of heat is useful, how many m^3 of ethane measured at NTP must be burned to supply heat to convert $50kg$ of water at $10^{\circ}C$ to steam at $100^{\circ}C$?

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151. The heat of combustion of ethylene at $18^{\circ}C$ and at constant volume is $-335.8kcal$ when water is obtained in liquid state. Calculate the heat of combustion at constant pressure and at $18^{\circ}C$?

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152. A gas mixture of $3.67L$ of ethylene and methane on complete combustion at $25^\circ C$ produces $6.11L$ of CO_2. Find out the heat evolved on buring $1L$ of the gas mixture. The heats of combustion of ethylene and methane are -1423 and $-891 kJmol^{-1}$, respectively, at $25^\circ C$.

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153. The heats of combustion of CH_4 and C_4H_{10} are -890.3 and $-2878.7 kJmol^{-1}$, respectively. Which of the two has greater efficiency as fuel per gram?

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154. The heat of combustion of $CH_4(g), C_2H_6(g)$ and $H_2(g)$ are -890.3, $-1559, 7$ and $-285.9 kJmol^{-1}$, respectively. Which of these fuels is most efficient?

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155. The standard molar heats of formation of ethane, carbon dioxide, and liquid water are -21.1, -94.1, and $-68.3kcal$, respectively. Calculate the standard molar heat of combustion of ethane.

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156. The standard heats of formation of $CH_4(g), CO_2(g)$ and $H_2O(g)$ are -76.0, -390.0, and $-240.0kJmol^{-1}$, respectively. Calculate the amount of heat evolved by burning $1m^3$ of methane measured under normal conditions.

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157. In a gobar gas plant, gobar gas is formed by bacterial fermentation of animal refuse. It mainly contains methane and its heat of combustion is $-809kJmol^{-1}$ according to following equation:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O, \Delta H = -809kJ$$

How much gobar gas would have to be produced per day for a small village of 50 families, it it is assumed that each family requires $20000kJ$ of energy per day? The methane content in gobar gas is 80% by mass.

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158. An intimate mixture of ferric oxide and aluminium is used as solid fuel in rockets. Calculate the fuel value per cm^3 of the mixture.

Heats of formation and densities are as follows:

$H^{\Theta}_{f\left(Al_2O_3\right)} = -399kcalmol^{-1}, H^{\Theta}_{f\left(Fe_2O_3\right)} = -199kcalmol^{-1}$

Density of $Fe_2O_3 = 4.0gcm^{-3}$, Density of $Al = 2.0gcm^{-3}$

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159. Diborane isa potential rocket fuel that undergoes combustion according to the reaction,

$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(g) + 3H_2O(g)$

From the following data, calculate the enthalpy change for the combustion of diborane:

A. $2B(s)+\left(\frac{3}{2}\right)O_2(g) \rightarrow B_2O_3(s), \Delta H^{\ominus} = -1273kJmol^{-1}$

B. $H_2(g)+\left(\frac{1}{2}\right)O_2(g) \rightarrow H_2O(l), \Delta H^{\ominus} = -286kJmol^{-1}$

C. $H_2O(l) \rightarrow H_2O(g), \Delta H = 44kJmol^{-1}$

D. $2B(s)+3H_2(g) \rightarrow B_2H_6(g), \Delta H^{\ominus} = 36kJmol^{-1}$

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160. The enthalpy of formation of methane at constant pressure and $300K$ is $-75.83kJ$. What will be the heat of formation at constant volume? $\left[R = 8.3JK^{-1}mol^{-1}\right]$

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161. Select the correct statement from the following:

A. In exothermic reaction, the value of equilibrium constant increases with rise of temperature.

B. In endothermic reaction, the value of equilibrium constant decreases with rise in temperature.

C. In exothermic reaction, the value of equilibrium constant decreases with rise of temperature.

D. In endothermic reaction, the value of equilibrium constant remains constant with rise of temperature.

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162. The burning of magnesium may be represented by:

$2Mg(s) + O_2(g) \rightarrow 2MgO(s), \Delta H^{\Theta} = -1204 kJ(mol)^{-1}$

Which one of the following correctly describe what would happen if the reaction were allowed to proceed at constant external pressure in such a way that no energy transfer could taken place between the reaction mixture and its surroundings?

A. No reaction could occur.

B. The tempertaure of the reaction mixture would increase.

C. The temperature of the reaction mixture would decrease.

D. The pressure of the system would increase.

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163. A gas mixture of $3.67L$ of ethylene and methane on complete combustion at $25^{\circ} C$ produces $6.11L$ of CO_2. Find out the heat evolved on buring $1L$ of the gas mixture. The heats of combustion of ethylene and methane are -1423 and $-891 kJmol^{-1}$, respectively, at $25^{\circ} C$.

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164. The enthalpy changes for two reactions are given by the equations:

$$2Cr(s) + \frac{3}{2}O_2(g) \rightarrow Cr_2O_3(s), \Delta H^{\ominus} = -1130kJ$$

$$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H^{\ominus} = -110kJ$$

What is the enthalpy change in kJ for the following reactions?

$$3C(s) + Cr_2O_3(s) \rightarrow 2Cr(s) + 3CO(g)$$

A. $-1460kJ$

B. $-800kJ$

C. $+800kJ$

D. $+1020kJ$

Answer: c

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165. Given that:

i. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = -94.05kcal$

ii. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -68.32kcal$

iii. $C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l), \Delta H = -310.62kcal$

The heat of formation fo acetylene is

A. $-1802kJ$

B. $+1802kJ$

C. $-800kJ$

D. $+228kJ$

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166. The standard molar heats of formation of ethane, carbon dioxide, and liquid water are -21.1, -94.1, and $-68.3kcal$, respectively. Calculate the standard molar heat of combustion of ethane.

A. $-372kcal$

B. $-240kcal$

C. $162kcal$

D. $183.5kcal$

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167. The reaction:

$$NH_2CN(s) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$$

Was carried out in a bomb caloriemeter. The heat released was $743kJmol^{-1}$.

The value of ΔH_{300K} for this reaction would be

A. $-740.5kJmol^{-1}$

B. $-741.75kJmol^{-1}$

C. $-743.0kJmol^{-1}$

D. $-744.25kJmol^{-1}$

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168. The value of ΔH_{O-H} is $109 kcal mol^{-1}$. Then formation of one mole of water in gaseous state from $H(g)$ and $O(g)$ is accompanied by

A. Release of $218 kcal$ of enegry

B. Release of $109 kcal$ of enegry

C. Absorption of $218 kcal$ of enegry

D. Unpredictable

Answer: A

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169. In the reversible reaction of the type $A + B \Leftrightarrow AB$, in general.

A. Neither of the reactions will be endothermic.

B. Both forward and backward reactions are exothermic.

C. Forward reaction will be exothermic.

D. Backward reaction will be exothermic.

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170. Which of the following expression is ture?

A. $\Delta_f H^{\Theta}(CO, g) = \frac{1}{2}\Delta_f H^{\Theta}\left(CO_2, g\right)$

B. $\Delta_f H^{\Theta}(CO, g) = \Delta_f H^{\Theta}(C, \text{graphite}) = \frac{1}{2}\Delta_f H^{\Theta}\left(O_2, g\right)$

C. $\Delta_f H^{\Theta}(CO, g) = \Delta_f H^{\Theta}(CO, g) - \frac{1}{2}\Delta_f H^{\Theta}\left(O_2, g\right)$

D. $\Delta_f H^{\Theta}(CO, g) = \Delta_{\text{comb}} H^{\Theta}(C, \text{graphite}) - \Delta_{\text{comb}} H^{\Theta}(CO, g)$

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171. The heat of combustion of solid benzoic acid at constant volume is $-321.30kJ$ at $27\ ^{\circ} C$. The heat of combustion at constant pressure is

A. $-321.30 - 300R$

B. $-321.30 + 300R$

C. $-321.30 - 150R$

D. $-321.30 - 900R$

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172. The enthalpy of formation of $H_2O(l)$ is -280.70 kJ/mol and enthalpy of neutralisation of a strong acid and strong base is -56.70 kJ/mol. What is the enthalpy of formation of OH^- ions?

A. $14kcal$

B. $35cal$

C. $10cal$

D. $7.5cal$

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173. Equal volumes of $1MHCI$ and $1MH_2SO_4$ are neutralised by $1MNaOH$ solution and x and $ykJ/$ equivalent of heat are liberated, respectively. Which of the following relations is correct?

A. $x = 2y$

B. $x = 3y$

C. $x = 4y$

D. $x = \frac{1}{2}y$

Answer: D

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174. Which of the following acid will release maximum amount of heat when completely neutralised by strong base $NaOH$?

A. $1MHCI$

B. $1MHNO_3$

C. $1MHCIO_4$

D. $1MH_2SO_4$

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175. The enthalpy of neutralisation of a strong acid by a strong base is $-57.32kJmol^{-1}$. The enthalpy of formation of water is $-285.84kJmol^{-1}$. The enthalpy of formation of hydroxyl ion is

A. $+228.52kJmol^{-1}$

B. $-114.26kJmol^{-1}$

C. $-228.52kJmol^{-1}$

D. $+114.2kJmol^{-1}$

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176. A constant pressure calorimeter consists of an insulated beaker of mass $92g$ made up of glass with heat capacity $0.75JK^{-1}g^{-1}$. The beaker contains $100mL$ of $1MHCI$ at $22.6^\circ C$ to which $100mL$ of $1MNaOH$ at $23.4^\circ C$ is added. The final temperature after the reactions is complete is $29.3^\circ C$, What is ΔH per mole for this neutralization reaction? Assume that the heat capacities of all solutions are equal that of same volumes of water.

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177. $150mL$ of $0.5N$ nitric acid solution at $25.35^\circ C$ was mixed with $150mL$ of $0.5N$ sodium hydroxide solution at the same temperature. The final temperature was recorded to be $28.77^\circ C$. Calculate the heat of neutralisation of nitric acid with sodium hydroxide.

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178. The enthalpy change ΔH for the neutralisation fo $1MHCI$ by caustic potash in dilute solution at $298K$ is

A. $68kJ$

B. $65kJ$

C. $57.3kJ$

D. $50kJ$

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179. Enthalpy of neutralisation of the reaction between $CH_3COOH(aq)$ and $NaOH(aq)$ si $-13.2kcalEq^{-1}$ and that of the reaction between $H_2SO_4(aq)$ and $KOH(aq)$ is $-13.7kcalEq^{-1}$. The enthalpy of dissociation of $CH_3COOH(aq)$ is

A. $-0.5kcalEq^{-1}$

B. $+0.5kcalEq^{-1}$

C. $-26.9kcalEq^{-1}$

D. $+13.45kcalEq^{-1}$

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180. Whenever an acid is neutralised by a base, the net reaction is

$$H^{\oplus}(aq)+\overset{\Theta}{O}H(aq)\rightarrow H_2O(l), \Delta H = -57.1kJ$$

Calculated the heat evolved for the following experiments?

$0.50mol$ of HCI solution is neutralised by $0.50mol$ of $NaoH$ solution.

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181. $150mL$ of $0.5N$ nitric acid solution at $25.35^{\circ}C$ was mixed with $150mL$ of $0.5N$ sodium hydroxide solution at the same temperature. The final temperature was recorded to be $28.77^{\circ}C$. Calculate the heat of neutralisation of nitric acid with sodium hydroxide.

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182. When a student mixed $50mL$ of $1MHCI$ and $50mL$ of $1MNaOH$ in a coffee cup calorimeter, the temperature of the resultant solution increases from $21\,^{\circ}C$ to $27.5\,^{\circ}C$. Assuming that the calorimeter absorbs only a negligible quantity of heat, that the total volume of solution is $100mL$, its density $1gmL^{-1}$ and that its specific heat is $4.18Jg^{-1}$. calculate:

a. The heat change during mixing.

b. The enthalpy change for the reaction

$HCI(aq) + NaOH(aq) \rightarrow NaCI(aq) + H_2O(aq)$

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183. The enthalpies of neutralization of a strong acid HA and a weaker acid HB by $NaOH$ are -13.7 and $-12.7kcalEq^{-1}$, respectively. When one equivalent of $NaOH$ is added to a mixture containing one equivalent of HA and HB, the enthalpy change was $-13.5kcal$. In what ratio is the base distributed between HA and HB?

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184. Calculate the heat of neutralisation from the following data:

$200mL$ of $1MHCI$ is mixed with $400mL$ of $0.5MNaOH$. The temperature rise in calorimeter was found to be $4.4^\circ C$. Water equivalent of calorimeter is $12g$ and specific heat is $1calmL^{-1}degree^{-1}$ for solution.

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185. At a particlular temperature

$H^{\oplus}(aq)+OH^{\ominus}(aq)\rightarrow H_2O(l), \Delta H=-57.1kJ$

The approximate heat evolved when $400mL$ of $0.2MH_2SO_4$ is mixed with $600mL$ of $0.1MKOH$ solution will be

A. $3.426kJ$

B. $13.7kJ$

C. $5.2kJ$

D. $55kJ$

Answer: A

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186. The reaction given below

$BaCl_2(s) + 2H_2O(l) \rightarrow BaCl_2.2H_2O, \Delta H^{\ominus} = -xkJ$ The value of $\Delta H^{\ominus}$ represents

A. Enthalpy of hydration

B. Enthalpy of solution

C. Enthalpy of atomization

D. None of the above

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187. The heats evolved in combustion of rhombic and monoclinic sulphur are, respectively, -70960 and $-71030cal$. What will be the heat of conversion of rhomic sulphur to monoclinic?

A. $70960cal$

B. $71030cal$

C. $-70 cal$

D. $+70 cal$

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188. If the enthalpy of combustion of C(graphite) is $-393.3 kJ mol^{-1}$, then for producing $39.3 kJ$ of heat the amount of carbon required is

A. $1.5 mol$

B. $0.5 mol$

C. $1.2 g$

D. $12 mg$

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189. Given $\Delta_i H^{\Theta}(HCN) = 45.2kJmol^{-1}$ and $\Delta_i H^{\Theta}\left(CH_3COOH\right) = 2.1kJmol^{-1}$. Which one of the following facts is true?

A. $pK_a(HCN) = pK_a\left(CH_3COOH\right)$

B. $pK_a(HCN) > pK_a\left(CH_3COOH\right)$

C. $pK_a(HCN) < pK_a\left(CH_3COOH\right)$

D. $pK_a(HCN) = (45.17/2.07)pK_a\left(CH_3COOH\right)$

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190. The heat of neutralisation of aqueous hydrochloric acid by $NaOH$ si $xkcalmol^{-1}ofHCI$. Calculate the heat of neutralisation per mol of aqueous acetic acid.

A. $0.5xkcal$

B. $xkcal$

C. $2xkcal$

D. Cannot be calculated from the given data

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191. Under the same conditions, how many mL of $MKOH$ and $0.5MH_2SO_4$ solutions, respectively, when mixed to form a total volume of $100mL$, produces the highest rise in temperature?

A. $67, 33$

B. $33, 67$

C. $40, 60$

D. $50, 50$

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192. Given: The heat of sublimation of $K(s)$ is $89kJmol^{-1}$.

$K(g) \rightarrow K^{\oplus}(g) + e^{-}, \Delta H^{\ominus} = 419kJ$

$F_2(g) \rightarrow 2F(g), \Delta H^{\ominus} = 155kJ$

The lattice enegry of $KF(s)$ is $-813kJmol^{-1}$, the heat of formation of $KF(s)$ is $-563kJmol^{-1}$. the E_A of $F(g)$ is

A. -413

B. -336

C. -1149

D. $+413$

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193. Ethalpies of solution of $BaCI_2(s)$ and $BaCI_2.2H_2O(s)$ are $-20.0kJmol^{-1}$ and $8.0kJmol^{-1}$, respectively. Calculate $\Delta_{hyd}H^{\ominus}$ of $BaCI_2$ to $BaCI_2.2H_2O$.

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194. If the heat fo dissolution of anhydrous $CuSO_4$ and $CuSO_4.5H_2O$ is $-15.89kcal$ and $2.80kcal$, respectively, then the heat of hydration fo $CuSO_4$ to form $CuSO_4.5H_2O$ is

A. $-13.09kcal$

B. $-18.69kcal$

C. $+13.09kcal$

D. $+18.69kcal$

Answer: B

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195. Given that

$CH_4(g) + 360kJ \rightarrow C(g) + 4H(g)$

$C_2H_6(g) + 620kJ \rightarrow 2C(g) + 6H(g)$

The value of $C - C$ bond enegry is

A. $260kJmol^{-1}$

B. $180kJmol^{-1}$

C. $130kJmol^{-1}$

D. $80kJmol^{-1}$

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196. One moles of anhydrous AB dissolves in water and liberates $21.0Jmol^{-1}$ of heat. The valueof ΔH^{Θ} (hydration) of AB is $-29.4Jmol^{-1}$. The heat of dissolution of hydrated salt $AB.2H_2O(s)$ is

A. $50.4Jmol^{-1}$

B. $8.4Jmol^{-1}$

C. $-50.4Jmol^{-1}$

D. $-8.4Jmol^{-1}$

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197. At $25^\circ C$, the following heat of formations are given:

Compound	$SO_2(g)$	$H_2O(l)$
$\Delta_f H^\Theta kJmol^{-1}$	-296.0	-285.0

For the reactions at $25^\circ C$,

$$2H_2S(g) + Fe(s) \rightarrow FeS_2(s) + 2H_2(g), \Delta H^\Theta = -137kJm\infty l^{-1}$$

$$H_2S(g) + \frac{3}{2}O_2(g) \rightarrow H_2O(l) + So_2(g), \Delta H^\Theta = -562kJmol^{-1}$$

Calculate the heat of formation of $H_2S(g)$ and $FeS_2(g)$ at $25^\circ C$.

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198. The 'heat of total cracking' of hydrocarbons ΔH_{TC} is defined as ΔH at $298.15K$ and $101.325kPa$ for the process below

$$C_nH_m + \left(2n - \frac{m}{2}\right)H_2(g) \rightarrow nCH_4(g)$$

Given that ΔH_{TC} is $-65.2kJ$ for C_2H_6 and $-87.4kJ$ for C_3H_8, calculate ΔH for

$$CH_4(g) + C_3H_8(g) \rightarrow 2C_2H_6(g)$$

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199. Bond dissociation enthalpies of $H_2(g)$ and $N_2(g)$ are $436.0 kJmol^{-1}$ and $941.8 kJmol^{-1}$, respectively, and ethalpy of formation of $NH_3(g)$ is $-46 kJmol^{-1}$. What is the enthalpy fi atomisation of $NH_3(g)$?. What is the avergae bond ethalpy of $N-H$ bond?

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200. If values of $\Delta_f H^{\Theta}$ of $ICI(g), CI(g)$, and $I(g)$ are, respectively, $17.57, 121, 34$, and $106.96 Jmol^{-1}$. The value of $I-CI$ (bond energy) in $Jmol^{-1}$ is

A. 17.57

B. 210.73

C. 35.15

D. 106.96

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201. For the reaction $K(g) + F(g) + K^{\oplus} + F^{\ominus}$ (separated ions $\Delta H = 19 kcal mol^{-1}$), if the ionisation potential of K and the electron affinity of $F^{\ominus}$ have a geometric means of $3.88 eV$ and $IP > EA$, calculate the values fo ionisation potential and electron affinity.

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202. For the percipitation reaction of $Ag^{\oplus}$ ions with $NaCI$, which of the following statements is true?

A. ΔH is zero for the reaction.

B. ΔG is zero for the reaction.

C. ΔG is negative for the reaction.

D. ΔG should be equal to ΔH.

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203. How much heat is required to change 10 g ice at $0^{\circ} C$ to steam at $100^{\circ} C$? Latent heat of fusion and vapour for H_2O are 80 cal/g and 540 cal/g respectively. Specific heat of water is 1 cal/g.

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204. A pistion exerting a pressure of $1.0 atm$ rests on the surface of water at $100^{\circ} C$. The pressure is reduced to smaller extent and as a result $10 g$ of H_2O eveportes and abosrb $20 kJ$ fo heat. Determine

A. a) ΔH

B. b) $Latent\ heat\ of\ vapourisation$

C. c) W

D. d) ΔU

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205. Find the heat of reaction

$2Na(s) + 1/2O_2(g) \rightarrow Na_2O(s)$

Given:

$Na_2O(s) + H_2O \rightarrow 2NaOH, \Delta H = -56kcal$

$2Na + 2H_2O \rightarrow 2NaOh + H_2, \Delta H = -88kcal$

$H_2 + 1/2O_2 \rightarrow H_2O, \Delta H = -68kcal$

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206. The ethalpies for the following reactions at $25^\circ C$ are given as:

$\frac{1}{2}H_2(g) + \frac{1}{2}O_2(g) \rightarrow OH(g), \Delta H = 10.06kcal$

$H_2(g) \rightarrow 2H(g), \Delta H = 104.18kcal$

$O_2(g) \rightarrow 2O(g), \Delta H = 118.32kcal$

Calculate the $O - H$ bond energy in the OH group.

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207. Determine the heat of transformaiton of $C_{(\text{dimamond})} \rightarrow C_{(\text{graphite})}$ form the following data:

i. $C_{(\text{diamond})} + O_2(g) \rightarrow CO_2(g), \Delta H^{\Theta} = -94.5kcal$

ii. $C_{(\text{graphite})} + O_2(g) \rightarrow CO_2(g), \Delta H^{\Theta} = -94.0kcal$

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208. Which of the following has highest heat of hydrogenation:

A. But-I-ene

B. $c$is-Bur-2-ene

C. trans-Bur-2-ene

D. Isobutane

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209. Given

a. $NH_3(g) + 3CI(g) \rightarrow NCI_3(g), 3HCI(g), \Delta H_1$

b. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta H_2$

c. $H_2(g) + CI_2(g) \rightarrow 2HCI(g), \Delta H_3$

Express the enthalpy of formation of $NCI_3(g)\left(\Delta_f H^{\Theta}\right)$ in terms of $\Delta H_1, \Delta H_2$,and ΔH_3.

A. $\Delta_f H^{\Theta} = \Delta H_1 - \dfrac{\Delta H_2}{2} + \dfrac{3}{2}\Delta H_3$

B. $\Delta_f H^{\Theta} = \Delta H_1 + \dfrac{1}{2}\Delta H_2 - \dfrac{3}{2}\Delta H_3$

C. $\Delta_f H^{\Theta} = \Delta H_2 - \dfrac{1}{2}\Delta H_2 - \dfrac{3}{2}\Delta H_3$

D. $\Delta_f H^{\Theta} = \Delta H_1 + \dfrac{1}{2}\Delta H_2 + \dfrac{3}{2}\Delta H_3$

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210. The heat enegry required to ionise the following molecules is given as follows:

$N_2(g) \xrightarrow{\Delta H_1} N^{2\oplus}(g), O_2(g) \xrightarrow{\Delta H_2} O_2^{\oplus}(g)$

$Li_2(g) \xrightarrow{\Delta H_3} Li^{2\oplus}(g), C_2(g) \xrightarrow{\Delta H_4} C_2^{\oplus}(g)$

Arrange the heat terms in decreasing order of enegry:

A. $\Delta H_1 > \Delta H_3 > \Delta H_2 > \Delta H_4$

B. $\Delta H_2 > \Delta H_3 > \Delta H_1 > \Delta H_4$

C. $\Delta H_3 > \Delta H_4 > \Delta H_1 > \Delta H_2$

D. $\Delta H_3 > \Delta H_1 > \Delta H_4 > \Delta H_2$

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211. The enthalpy of reaction does not depend upon:

A. the intermediate reaction steps

B. the temperature of initial and final state of the reaction

C. the physical states of reactants and products

D. use of different reactants for the formation of the same product

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212. Calculate the lattice energy of the reaction

$Li^{\oplus}(g) + CI^{\Theta}(g) \rightarrow LiCI(s)$

from the following data:

$\Delta_{\text{sub}}H^{\Theta}(Li) = 160.67kJmol^{-1}, \frac{1}{2}D\left(CI_2\right) = 122.17kJmol^{-1}IP(Li) = 520.07kJmol^{-1}$

and $\Delta_f H^{\Theta}(LiCI) = -401.66kJmol^{-1}$

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213. When a mole of crystalline sodium chloride is prepared, $410kJ$ of heat is produced. The heat of sublimation of sodium metal is $180.8kJ$. The heat of dissociation fo chlorine gas into chlorine atoms is $242.7kJ$. The ionization energy of Na and electron affinity of Cl are $493.\ kJ$ and $-368.2kJ$, respectively. calculate the lattice enegry of $NaCl$.

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214. The table given below lists the bound dissociation energy $\left(E_{diss}\right)$ for single covalent bonds formed between C and atom A, B, D, E.

What of the atoms has smallest size?

A. D

B. E

C. A

D. B

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215. The heat change at constant volume for the decomposition of silver (I) oxide is found to be $30.66kJ$. The heat change at constant pressure will be

A. $30.66kJ$

B. $> 30.66kJ$

C. $< 30.66kJ$

D. Unpredicatable

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216. i. $H_2(g) + CI_2(g) \rightarrow 2HCI(g), \Delta H = -xkJ$

ii. $NaCI + H_2SO_4 \rightarrow NaHSO_4 + HCI, \Delta H = -ykJ$

iii. $2H_2O + 2CI_2 \rightarrow 4HCI + O_2, \Delta H = -zkJ$

From the above equations, the value of ΔH of HCI is

A. $-xkJ$

B. $-ykJ$

C. $-zkJ$

D. $\frac{-x}{2}kJ$

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217. $N_{2(g)} + 2O_{2(g)} \rightarrow 2NO_2 + XkJ$

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)} + YkJ$

The enthalpy of formation of NO is

A. $(2X - 2Y)$

B. $X - Y$

C. $1/2(Y - X)$

D. $1/2(X - Y)$

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218. For which one of the follwing reactions does not molar enthalpy change of a reaction corresponds to the lattice enegry of KBr.

A. $K(s) + 1/2Br_2(l) \rightarrow KBr(s)$

B. $K(g) + 1/2Br_2 \rightarrow KBr(s)$

C. $K(g) + Br(g) \rightarrow KBr(g)$

D. $K^{\Theta}(g) + Br^{\Theta}(g) \rightarrow KBr(s)$

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219. The lattice energy of solid NaCl is 180 kcal/mol. The dissolution of the solid in water in the form of ions is endothermic to the extent of 1 kcal/mol. If the hydration energies of Na^{+} and Cl^{-} are in the ratio 6 : 5, what is the enthalpy of hydration of Na^{+} ion?

A. $-85 kcal mol^{-1}$

B. $-98 kcal mol^{-1}$

C. $+82 kcal mol^{-1}$

D. $+100 kcal mol^{-1}$

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220. The standard molar enthalpies of formation of cyclohexane (l) and benzene (l) at $25^{\circ} C$ are -156 and $+49 kJ mol^{-1}$, respectively. The standard enthaly of hydrogenation of cyclohenxene (l) at $25^{\circ} C$ is $-119 kJ mol^{-1}$ Use this data to estimate the magnitude of the resonance enegry of benzene.

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221. Consider the following two reactions:

i. Propene $+ H_2 \rightarrow$ Propane, ΔH_1

ii. Cyclopropane $+ H_2 \rightarrow$ Propane, ΔH_2 Then, $\Delta H_2 - \Delta H_1$ will be:

A. 0

B. $2BE_{C-C} - BE_{C=C}$

C. $BE_{C=C}$

D. $2BE_{C=C} - BE_{C-C}$

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222. Calculate the enthalpy of formation of ammonia from the following bond energy data:

$(N - H)bond = 389kJmol^{-1}, (H - H)bond = 435kJmol^{-1},$ and $(N \equiv N)bond = 945.36kJmol^{-1}$.

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223. Calculate the resonance energy of isoprene $\left(C_5H_8\right)$ from the data given. Standard Heats of combustion of isoprene, carbon and hydrogen are $-3186, -393.5,$ and $-285.83kJmol^{-1}$, respectively. Bond energies of $C = C, C - C, C - H$ and $H - H$ bonds are $615, 348, 413$ and $435.8kJmol^{-1}$ respectively. Standard heat of sublimation of graphite is $718.3kJmol^{-1}$.

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224. Calculate the resonance energy of toluene (use Kekule structure from the following data

$C_7H_8(l) + 9O_2(g) \rightarrow 7CO_2(g) + 4H_2O(l) + \Delta H, \Delta H^{\ominus} = -3910 kJmol^{-1}$

$C_7H_8(l) \rightarrow C_7H_8(g), \Delta H^{\ominus} = 38.1 kJmol^{-1}$

$\Delta_f H^{\ominus}(water) = -285.8 kJmol^{-1}$

$\Delta_f H^{\ominus}\left[CO_2(g)\right] = -393.5 kJmol^{-1}$

Heat of atomisation of $H_2(g) = 436.0 kJmol^{-1}$

Heat of sublimation of $C(g) = 715.0 kJmol^{-1}$

Bond energies of $C-H$, $C-C$, and $C=C$ are $413.0, 345.6$, and $610.0 kJmol^{-1}$.

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225. The standard heat of formation values of $SF_6(g), S(g)$, and $F(g)$ are $-1100, 275$, and $80 kJmol^{-1}$, respectively. Then the average $S-F$ bond enegry in SF_6

A. $310 kJmol^{-1}$

B. $220 kJmol^{-1}$

C. $309kJmol^{-1}$

D. $280kJmol^{-1}$

Answer: C

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226. Calculate the resonance enegry of N_2O form the following data

$\Delta_f H^{\Theta} of N_2O = 82kJmol^{-1}$

Bond enegry of $N \equiv N, N = N, O = O,$ and $N = O$ bond is $946, 418, 498,$ and $607kJmol^{-1}$, respectively.

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227. Calculate the resonance enegry of N_2O form the following data

$\Delta_f H^{\Theta} of N_2O = 82kJmol^{-1}$

Bond enegry of $N \equiv N, N = N, O = O,$ and $N = O$ bond is $946, 418, 498,$ and $607kJmol^{-1}$, respectively.

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228. Using the bond enthalpy data given below, calculate the enthalpy of formation of acetone (g).

Bond energy $C - H = 413.4 kJmol^{-1}$,

Bond energy $C - C = 347.0 kJmol^{-1}$,

Bond energy $C = O = 728.0 kJmol^{-1}$,

Bond energy $O = O = 495.0 kJmol^{-1}$,

Bond energy $H - H = 435.8 kJmol^{-1}$,

$\Delta_{\text{sub}} H^{\Theta} C(s) = 718.4 kJmol^{-1}$

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229. Enthalpy of hydrogenation of benzene is ΔH_1 and for cyclohexene is ΔH_2. The resonance energy of benzene is

A. $3\Delta H_1 - \Delta H_2$

B. $3\Delta H_2 - \Delta H_1$

C. $3\Delta H_1 + \Delta H_2$

D. $\Delta H_1 - 3\Delta H_2$

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230. For the reaction:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g), \Delta H = -571kJ$

bond energy of $(H - H) = 435kJ$ and of $(O = O) = 498kJ$. Then, calculate the average bond energy of $(O - H)$ bond using the above data.

A. $484kJ$

B. $-484kJ$

C. $271kJ$

D. $-371kJ$

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231. Use the bond energies in the table to estimate ΔH for this reaction: $CH_2 = CH_2 + Cl_2 \rightarrow ClCH_2 - CH_2Cl$

A. $\Delta H = 684kJ$

B. $\Delta H = -154kJ$

C. $\Delta H = 189kJ$

D. $\Delta H = 177kJ$

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232. Heat of formation of $2mol$ of $NH_3(g)$ is $= 90kJ$, bond energies of $H - H$ and $N - H$ bonds are $435kJ$ and $390kJmol^{-1}$, respectively. The value of the bond enegry of $N \equiv N$ will be

A. $-872.5kJ$

B. $-945kJ$

C. $872.5kJ$

D. $945kJmol^{-1}$

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233. The bond energies of $C = C$ and $C - C$ at $298K$ are 590 and $331kJmol^{-1}$, respectively. The enthalpy of polymerisation per mole of ethaylene is

A. $-70kJ$

B. $-72kJ$

C. $72kJ$

D. $-68kJ$

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234. A carnot engine operates between temperature $600K$ and $300K$. It absorbs $100J$ from the source. Calculate the heat transferred to the sink.

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235. A Carnot engine works between $120^\circ C$ and $30^\circ C$. Calculate the efficiency. If the power produced by the engine is $400W$, calculate the heat abosorbed from the source.

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236. Calculate the maximum efficiency of an engine operating between $110^\circ C$ and $25^\circ C$.

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237. Heat supplied to a Carnot egine is $453.6kcal$. How much useful work can be done by the engine that works between $10^{\circ} C$and $100^{\circ} C$?

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238. Calculate the maximum efficiency of an engine operating between $110^{\circ} C$ and $25^{\circ} C$.

A. 11.1%

B. 22.2%

C. 33.3%

D. 44.4%

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239. Heat supplied to a Carnot engine is $37.3kJ$. How much useful work in kJ can be done by the engine that operates between $0^{\circ}C$ and $100^{\circ}C$?

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240. Efficiency of a Carnot heat engine may be given as

A. $\frac{w}{Q_2}$

B. $1 - \frac{Q_2}{Q_1}$

C. $1 - \frac{T_1}{T_2}$

D. None of these

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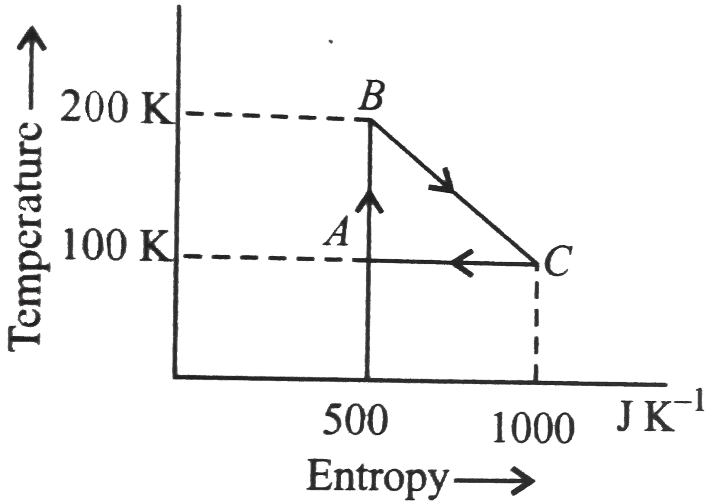
241. The efficiency of the reversible cycle shown in the given figure is



A. 33.33 %

B. 56 %

C. 66 %

D. 16.7 %

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242. A certain engine which operates in a Carnot cycle absorbe $3.0kJ$ at $400\,^{\circ}C$ in a cycle. If it rejects heat at $100\,^{\circ}C$, how much work is done on the engine per cycle and how much heat is evolved at $100\,^{\circ}C$ in each cycle?

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243. What percentage T_1 is of T_2 for a $10\,\%$ efficiency of a heat engine?

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244. The enthalpy change for a given reaction at $298K$ is $-xcalmol^{-1}$. If the reaction occurs spontaneously at $298K$, the entropy change at that temperature

A. Can be $-ve$ but numerically latger than $-x/298calK^{-1}$

B. Can be $-ve$, but numerically smaller than $x/298calK^{-1}$

C. Cannot be negative

D. Cannot be positive

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245. For the process

$NH_3(g) + HCI(g) \rightarrow NH_4Cl(s)$

A. Both ΔH and ΔS are positive

B. ΔH is -ve and ΔS is $+ve$

C. ΔH is $+ve$and ΔS is -ve

D. Both ΔH and ΔS are -ve

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246. Consider the following reaction:

$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$

The enthalpy change for this reaction at $1atm$ is equal to:

A. $-2\Delta_f H^{\Theta}\left[NaN_3(s)\right]$

B. $+2\Delta_f H^{\Theta}\left[NaN_3(s)\right]$

C. $3\Delta_f H^{\Theta}\left[N_2(s) + 2\Delta_f H^{\Theta}(Na(s)\right]$

D. $-\Delta_f H^{\Theta}\left[NaN_3(s)\right]$

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247. The enthalpy change for the combustion of $N_2H_4(l)$ (Hydrazine) is $-622.2kJmol^{-1}$. The products are $N_2(g)$ and $H_2O(l)$. If $\Delta_f H^{\Theta}$ for $H_2O(l) is - 285.8kJmol^{-1}$. The $\Delta_f H^{\Theta}$ for hydrazine is

A. $-336.4kJmol^{-1}$

B. $+50.6kJmol^{-1}$

C. $-622.2kJmol^{-1}$

D. $+336.4kJmol^{-1}$

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248. The enthalpies of formation fo organic substances are conveniently determined from

A. Ethalpy for combustion

B. Boiling point

C. Melting point

D. Ethalpy of neutralisation

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249. Ammonium chloride when dissolved in water leads to a cooling sensation. The dissolution of ammonium chloride at constant temperature is accompanied by

A. Increase in entropy

B. Decrease in entropy

C. No change in entropy

D. No change in enthalpy

Answer: A

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250. Which of the following statements relationship is not correct?

A. In an exothermic reaction, the enthalpy of products is less than that of the reactants

B. $\Delta_{\text{fusion}}H = \Delta_{\text{sub}}H - \Delta_{\text{vap}}H$

C. A reaction for which $\Delta H^{\Theta} < 0$ and $\Delta S^{\Theta} > 0$

D. ΔH is less that ΔU for the reaction $C(s) + 1/2O_2(g) \rightarrow CO(g)$

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251. Helium weighing $16g$ is expanded from $1atm$ to one-tenth of its original pressure at $30^\circ C$. Calculate the change in entropy assuming it to be an ideal gas.

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252. Calculate the entropy change when $2mol$ of an idela gas expand isothermally and reversibly from an initial volume of $2dm^3$ to $20dm^3$ at $300K$.

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253. Three moles of an ideal gas $\left(C_{v,m} = 12.5JK^{-1}mol^{-1}\right)$ are at $300K$ and $5dm^3$. If the gas is heated to $320K$ and the volume changed to $10dm^3$, calculate the entropy change.

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254. Determine the entropy change for the reaction given below:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

at $300K$. If standard entropies of $H_2(g)$, $O_2(g)$, and $H_2O(l)$ are $126.6, 201.20$, and $68.0JK^{-1}mol^{-1}$, respectively.

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255. One mole of an ideal gas at $25^{\circ}C$ is subjected to expand reversible ten times of its initial volume. The change in entropy of expansion is

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256. A sample of $10gH_2O$ is slowly heated from $27^{\circ}C \rightarrow 87^{\circ}C$. Calculate the change in entropy during heating. (specific heat of water $= 4200Jkg^{-1}K^{-1}$).

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257. Find the entropy change when 90 g of H_2O at $10\,^{\circ}$C was converted into steam at $100\,^{\circ}$C. [Given $C_P\left(H_2O\right) = 75.29JK^{-1}mol^{-1}$ and $\Delta H_{\text{vap}} = 43.932JK^{-1}mol^{-1}$]

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258. Calculate the total entropy change for the following reversible processes:

a. Isothermal b. Adiabatic

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259. Calculate entropy change when $10mol$ of an ideal gas expands reversible and isothermally from an initial volume of $10L$ to $100L$ at $300K$.

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260. Oxygen gas weighing $128g$ is expanded form $1atm$ to $0.25atm$ at $30^{\circ}C$. Calculate entropy change, assuming the gas to be ideal.

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261. Calculate the entropy change when $2mol$ of an idela gas expand isothermally and reversibly from an initial volume of $2dm^3$ to $20dm^3$ at $300K$.

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262. The molar internal energy of a gas over a temperature range is expressed as: $U_m(T) = a + bT + cT^2$, where $b = 16Jmol^{-1}K^{-1}$and $c = 6 \times 10^{-3}Jmol^{-1}K^{-2}$. Find:

a. $C_{V,m}at300K$

b. The entropy change when $1mol$ of a gas is heated from $300K$ to $600K$ at constant volume.

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263. A sample of an ideal gas is expanded to twice its original volume of $1m^3$ in a reversible process for which $P = \alpha V^2$, where $\alpha = 5atm m^{-6}$. If $C_{V,m} = 20 J mol^{-1} K^{-1}$, determine moalr change in entropy (ΔS_m) for the process.

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264. Which expansion will produce more change in entropy during reversible and isothermal process?

A. $1 mol H_2$ at $300K$ from $2L$ to $20L$

B. $1 mol N_2$ at $400K$ from $1L$ to $10L$

C. $1 mol O_3$ at $500K$ form $3L$ to $30L$

D. All have same ΔS

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265. $1 mol$ of an ideal gas is allowed to expand isothermally at $27^{\circ} C$ untill its volume is tripled. Calculated $Delya_{sys}S$ and $\Delta_{univ}S$ under the following conditions:

a. The expansion is carried out reversibly.

b. The expansion is a free expansion.

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266. One kilogram water at $0^{\circ} C$ is brought into contact with a heat reservoir at $100^{\circ} C$. Find

A. The change in entropy when temperature reaches to $100^{\circ} C$.

B. What is the change in entropy of reservoir?

C. Change in the entropy of universe.

D. The nature of process.

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267. The direct conversion of A to B is difficult, hence it is carried out as

$A \rightarrow C \rightarrow D \rightarrow B$

Given, $\Delta S_{\left(A \rightarrow C\right)} = 50eU, \Delta S_{\left(C \rightarrow D\right)} = 30eU, \Delta S_{(B \rightarrow D)} = 20eU$, where eU is entropy unit. Thus the change in entropy in $(A \rightarrow B)$ is:

A. $100eU$

B. $60eU$

C. $-100eU$

D. $-60eU$

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268. One moles of an ideal gas which $C_V = 3/2R$ is heated at a constant pressure of $1atm$ from $25^\circ C$ to $100^\circ C$. Calculate $\Delta U, \Delta H$ and the entropy change during the process.

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269. Two vessels of equal capacity are divided by a partition contain one mole of N_2 and two moles of O_2 gas. If the partition is removed and gases mixed isothermally, find the change in entropy due to mixing assuming initial and final pressure are same.

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270. $5mol$ of an ideal gas expands reversibly from a volume of $8dm^3$ to $80dm^3$ at a temperature of $27^\circ C$. Calculate the chngae in entropy.

A. $70.26JK^{-1}$

B. $80.55JK^{-1}$

C. $95.73JK^{-1}$

D. $107.11JK^{-1}$

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271. Which of the following processes is an isoentropic process?

A. (a) Isothermal process

B. (b) Adiabatic process

C. (c) Isobaric process

D. (d) Isochoric process

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272. Calculate the entropy change when 1mole of an ideal gas expands reversibly form an initial volume of $2L$ to a final voluume of $20L$ at $25^{\circ} C$.

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273. Calculate the change in entropy for the following reaction

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

Given:

$S^{\Theta}_{CO}(g) = 197.6JK^{-1}mol^{-1}$

$S^{\Theta}_{O_2}(g) = 205.03JK^{-1}mol^{-1}$

$S^{\Theta}_{CO_2}(g) = 213.6JK^{-1}mol^{-1}$

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274. Calculate the entropy change (ΔS) when $1mol$ of ice at $0^{\circ}C$ is converted into water at $0^{\circ}C$. Heat of fusion of ice at $0^{\circ}C$ is $1436cal$ per mol.

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275. Calculate ΔS for the formation of quantity of air containing 1 mole of a gas by mixing nitrogen and oxygen. (In air $N_2 = 80\%$ and $O_2 = 20\%$ $\Big)$

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276. $2dm^3$ of methane under $600kPa$ and $300K$ and $4dm^3$ of oxygen under $900kPa$ and $300K$ are forced into $3dm^3$ evacuated vessel, the temperature being maintained at $300K$. Calculate the change in entropy of gases assuming that they are ideal.

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277. Predict the sign of ΔS for each of the following process:

a. $O_2(g) \rightarrow 2O(g)$

b. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

c. $C(s) + H_2O(l) \rightarrow CO(g) + H_2(g)$

d. $Br_2(l) \rightarrow Br_2(g)$

e. $N_2(g, 10atm) \rightarrow N_2(g, 1atm)$

f. Desalination of water.

g. Devitrification of glass

h. Hard boiling of an egg

i. $C(s, \text{graphite}) \rightarrow C(s, \text{diamond})$

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278. At absolute zero, the entropy of a pure crystal is zero. This is

A. First law

B. Second law

C. Third law

D. None

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279. The units of entropy are

A. $JK^{-1}mol^{-1}$

B. $KJ^{-1}mol^{-1}$

C. $kJmol^{-1}$

D. $JK^{-1}mol^{-2}$

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280. For which reaction from the following, ΔS will be maximum?

A. $Ca(s) + \frac{1}{2}O_2(g) \rightarrow CaO(s)$

B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

C. $C(s) + O_2(g) \rightarrow CO_2(g)$

D. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

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281. For which of these processes is the value of ΔS negative?

i. Sugar is dissolved in water.

ii. Steam condenses on a surface.

iii. $CaCO_3$ is decomposed into CaO and CO_2.

A. i only

B. ii only

C. ii and iii only

D. ii and iii only

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282. In which of the following change entropy decreases?

A. Crystallisation of sucross form solution

B. Dissolving sucrose in water

C. Melting of ice

D. Vaporisation of camphor

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283. Which halogen in its standard state has the greatest absolute entropy per mole?

A. $F_2(g)$

B. $CI_2(g)$

C. $Br_2(l)$

D. $I_2(s)$

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284. Consider the reaction for the dissolution of ammonium nitrate:

$NH_4NO_3(s) \rightarrow NH_4^{\oplus}(aq) + NO_3^{\Theta}(aq)$

$\Delta H = +29.8KJmol^{-1}, \Delta S = 108.0JK^{-1}mol^{-1}$.

Calculate the change in entropy of the surroundings and predict whether the reaction is spontaneous or not at $25^{\circ}C$?

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285. The resting of iron occurs as:

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

The entalpy of formation of $Fe_2O_3(s) is - 824.0 kJmol^{-1}$ and entropy change for the reaction is $+550JK^{-1}mol^{-1}$. Calculate $\Delta_{surr}S$ and predict whether resuting of iron is spontaneous or not at $298K$.

Given $\Delta_{sys}H = - 553.0JK^{-1}mol^{-1}$

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286. Calculate the change in entropy for the fusion of $1mol$ of ice. The melting point of ice is $300K$ and molar enthalpy of fustion for ice $= 6.0kJmol^{-1}$.

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287. Molar heat capacity of CD_2O (deuterated form of formaldehyde) at constant pressure in $9calmol^{-1}K^{-1}at1000K$. Calculate the entropy change associated with cooling of $3.2g$ of CD_2O vapour from $1000 \rightarrow 900K$.

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288. Find the entropy change when 90 g of H_2O at $10\,^{\circ}$ C was converted into steam at $100\,^{\circ}$ C. [Given $C_P\left(H_2O\right) = 75.29JK^{-1}mol^{-1}$ and $\Delta H_{\text{vap}} = 43.932JK^{-1}mol^{-1}$]

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289. Calculate the enthalpy of vaporisation per mole for ethanol. Given $\Delta S = 109.8JK^{-1}mol^{-1}$ and boiling point of ethanol is $78.5\,^{\circ}$.

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290. Calculate the entrpoy change for the following reversible process:

$\alpha - T \in \ \Leftrightarrow \beta - T \in$ at

$1molat1atm300K$

$\left(\Delta_{trans}H = 2090Jmol^{-1}\right)$

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291. For liquid enthalpy of fusion is $1.435 kcal mol^{-1}$ and molar entropy change is $5.26 cal mol^{-1} K^{-1}$. The melting point of the liquid is

A. $0^{\circ} C$

B. $-273^{\circ} C$

C. $173 K$

D. $100^{\circ} C$

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292. Which of the following statement is false?

A. Entropy of substance in the liqid phase is lower than the entropy of the same substance in the gas phase

B. Spontaneous reactions always occur very rapidly.

C. ΔS for vaporisation of a solid is always positive.

D. A spontaneous reaction in one direction is always non-spontaneous in the revered direction.

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293. Considering entropy (S) as a theromodynamic parameter, the criterion for the spontaneity of any process is

A. $\Delta_{sys}S + \Delta_{surr}S > 0$

B. $\Delta_{sys}S - \Delta_{surr}S > 0$

C. $\Delta_{sys}S > 0$ only

D. $\Delta_{surr}S > 0$ only

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294. In a spontaneous process the system undergoes

A. A process which is exothermic and evolves a lot of heat.

B. A process which is slow and reversible.

C. A procee which takes plave only in presence of a catalyst.

D. A process that occurs without any input from the surroundings.

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295. For the reversible process, the value of ΔS is given by the expression:

A. $\frac{q_{rev}}{T}$

B. $T - q_{rev}$

C. $q_{rev} \times T$

D. $q_{rev} - T$

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296. In thermodynamics, a process is called reversible when

A. The surroundings and system change into each other.

B. There is no boundary between system and surrounding.

C. The surroundings are in equilibrium with the system.

D. The system changes into surroundings spontanously.

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297. For spontenous process

A. $\Delta_{\text{total}} S = 0$

B. $\Delta_{\text{total}} S > 0$

C. $\Delta_{\text{total}} S < 0$

D. None of these

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298. For liquid enthalpy of fusion is $1.435 kcal mol^{-1}$ and molar entropy change is $5.26 cal mol^{-1} K^{-1}$. The melting point of the liquid is

A. $100K$

B. $200K$

C. $300K$

D. $400K$

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299. The entropy of a crystalline substance a absolute zero on the basis of the third law of thermodynamics should be taken as

A. 100

B. 50

C. Zero

D. Different for different substance

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300. The least random state of water system is

A. Ice

B. Liquid water

C. Steam

D. Randomnes is same in all

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301. The value of entropy in the universe is

A. Constant

B. Decreaing

C. Increasing

D. Zero

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302. A spontanous change is always accompanied by an increase in entropy'.

The entropy change referred to in this statement is

A. $\Delta_{sys}S$

B. $\Delta_{universe}S$

C. $\Delta_{surr}S$

D. None of these

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303. Equilibrium mixture of ice and water is held at constant pressure. On heating some ice melts. For the system

A. (a) Entropy increases

B. (b) Free energy increases

C. (c) Free energy decreases

D. (d) Entropy decreases

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304. Calculate the entropy change accompanying the following change of state

$5mol$ of $O_2\left(27\,^{\circ}C, 1atm\right) \rightarrow 5molofO_2\left(117\,^{\circ}C, 5atm\right)$

C_P for $O_2 = 5.95caldeg^{-1}mol^{-1}$

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305. Calculate the entropy change accompanying the following change of state

$H_2O\left(s, 10\,^{\circ}C, 1atm\right) \rightarrow H_2O\left(l, 10\,^{\circ}C, 1atm\right)$

C_P for ice $= 9cladeg^{-1}mol^{-1}$

C_P for $H_2O = 18caldeg^{-1}mol^{-1}$

Latent heat of fustion of ice $= 1440calmol^{-1}at0\,^{\circ}C.$

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306. How does entropy changes with

a. Increase in temperature

b. Decrease in pressure?

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307. Is the entropy of the universe constant?

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308. What is the value of change in entropy at equilibrium?

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309. Arrange water vapour, liquid water, and ice in the order of increaing entropy.

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310. Do you expect ΔS to be $+ve$, $-ve$, or zero for the reaction

$H_2(g) + I_2(g) \Leftrightarrow 2HI(g)$

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311. Predict the entropy change (positive/negative) in the following:

A. A liquid substance crystallises into a solid

B. Temperature of a crystal is increased

C. $CaCO_3(s) \rightarrow CaO(S) + O_2(g)$

D. $N_2(g)(1atm) \rightarrow N_2(g)(0.5atm)$

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312. Arrange the following in the order of increasing entropy:

A. $1 mol of H_2O(s) at 0^\circ C$ and $1 atm$ pressure

B. $1 mol of H_2O(s) at 0^\circ C$ and $0.8 atm$pressure

C. $1 mol of H_2O(l) at 25^\circ C$ and $1 atm$ pressure

D. $1 mol of H_2O(l) at 25^\circ C$ and 0.8atm pressure

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313. Predict the sign of entropy change for each of the following changes of state.

A. $Hg(l) \rightarrow Hg(g)$

B. $AgNO_3(s) \rightarrow AgNO_3(aq)$

C. $I_2(g) \rightarrow I_2(s)$

D. $C(\text{graphite}) \rightarrow C(\text{diamond})$

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314. Which of the following preocesses are accompained by increase of entropy.

a. Dissolution of iodine in a solvent

b. HCI is added to $AgNO_3$ and a precipitate of $AgCI$ is obtained.

c. A partition is removed to allow two gases to mix.

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315. Place the following systems in order of increasing randomnes:

a. $1mol$ of a gas X b. $1mol$ of a solid X

c. $1mol$ of a liquid X

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316. Calculate ΔG^{Θ} for the following reaction at 298K:

$$CO(g) + \left(\frac{1}{2}\right)O_2(g) \rightarrow CO_2(g), \Delta H^{\Theta} = -282.84kJ$$

Given,

$$S^{\Theta}_{CO_2} = 213.8JK^{-1}mol^{-1}, S^{\Theta}_{CO(g)} = 197.9JK^{-1}mol^{-1}, S^{\Theta}_{O_2} = 205.0JK^{-1}mol^{-1},$$

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317. For the reaction

$A(s) \rightarrow B(s) + C(s)$

Calculate the entropy change at $298K$ and $1atm$ if absolute entropies (in $JK^{-1}mol^{-1}$) are :

$A = 130, B = 203, C = 152$

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318. Show that the reaction

$CO(g) + (1/2)O_2(g) \rightarrow CO_2(g)$

at $300K$ is spontaneous and exothermic, when the standard entropy change is $-0.094kJmol^{-1}K^{-1}$. The standard Gibbs free energies of formation for CO_2 and CO are $-394.4$and $-137.2kJmol^{-1}$, respectively.

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319. ΔH and ΔS for the reaction:

$Ag_2O(s) \rightarrow 2Ag(s) + (1/2)O_2(g)$

are $30.56 kJ mol^{-1}$ and $66.0 J JK^{-1} mol^{-1}$ respectively. Calculate the temperature at which free energy change for the reaction will be zero. Predict whether the forward reaction will be favoured above or below this temperature.

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320. For the reaction,

$2NO_g + O_2(g) \rightarrow 2NO_2(g)$

Calculate ΔG at $700K$ when enthalpy and entropy changes are $-113.0 kJ mol^{-1}$ and $-145 JK^{-1} mol^{-1}$, respectively.

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321. In the reaction $A^{\oplus} + B \rightarrow A + B^{\oplus}$, there is no entropy changes. If enthalpy change is $20 kJ$ of $A^{\oplus}$, calculate ΔG for the reaction.

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322. ΔH and ΔS for

$Br_2(l) + CI_2(g) \rightarrow 2BrCI(g)$

are $29.00 kJmol^{-1}$ and $100.0 JK^{-1} mol^{-1}$ respectively. Above what temperature will this reaction become spontaneous?

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323. Entropy is a measure of randomess of system. When a liquid is converted to the vapour state entropy of the system increases. Entropy in the phase transformation is calculated using $\Delta S = \frac{\Delta H}{T}$ but in reversible adiabatic process ΔS will be zero. The rise in temperature in isobaric or isochoric process increases the randomness of system, which is given by

$$\Delta S = 2.303 \text{ n C} \log\left(\frac{T_2}{T_1}\right)$$

$$C = C_P \text{ or } C_V$$

The temperature at whicgh liquid H_2Owill be in equrilibrium with its vapour is (ΔH and ΔS for vapourisation are 50 kJ mol^{-1} and 0.15 kJ $mol^{-1}K^{-1}$)

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324. Zinc reacts with dilute hydrochloric acid to give hydrogen at $17\,^{\circ}C$. The enthalpy of the reaction is $-12.00kJmol^{-1}$ of zinc and entropy change equals $50JK^{-1}mol^{-1}$ for the reaction. Calculate the free enegry change and predict whether the reaction is spontaneous or not.

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325. ΔH and ΔS for the system $H_2O(l) \Leftrightarrow H_2O(g)$ at $1atm$ are $40.63kJmol^{-1}$ and $108.8JK^{-1}mol^{-1}$, respectively. Calculate the temperature at which the rates of forward and backward reactions will be the same. Predict the sign of free enegy for this transformation above this temperature.

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326. For the reaction,

$SOCI_2 + H_2O \rightarrow SO_2 + 2HCI$

the enthalpy of reaction is $40.0kJ$ and the entropy of reaction is $336JK^{-1}$. Calculate ΔG at $300K$ and predict the neture of the reaction.

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327. Compute the standard free enegry of the reaction at $27^\circ C$ for the combustion fo methane using the give data:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

$Species$	CH_4	O_2	CO_2	$2H_2O(l)$
$\Delta_f H^\Theta (kJmol^{-1})$	-74.8	-	-393.5	-285.8
$S^\Theta (JK^{-1}mol^{-1})$	186	205	214	70

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328. Which of the following statements is correct?

A. ΔG is equal to ΔG^Θ when the system is at the standard state.

B. ΔG^Θ is zero when the system is at equilibrium.

C. ΔG measure how far the reaction is from equilibrium and how fast it is.

D. When ΔG is positive, the reaction should proceed forward to from more product.

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329. A reaction will never the spontaneous at any temperature and pressure if

A. $\Delta S = + ve, \Delta H = + ve$

B. $\Delta S = + ve, \Delta H = - ve$

C. $\Delta S = - ve, \Delta H = + ve$

D. $\Delta S = - ve, \Delta H = - ve$

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330. Quick lime: $(CaO)$is produced bu heating limestone $\left(CaCO_3\right)$ to derive off CO_2 gas.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g), \Delta_rH^{\Theta} = 180kJmol^{-1}, \Delta_rS^{\Theta} = 150JK^{-1}$

Assuming that variation fo enthalpy change and entropy change with temperature to be negligible, which of the following is correct?

A. Decomposition of $CaCO_3(s)$ is always nonspontaneous.

B. Decomposition of $CaCO_3(s)$ become spontaneous when temperature is less than $27^{\circ}C$.

C. Decomposition of $CaCO_3(s)$ become spontaneous when temperature is greater than $1200^{\circ}C$.

D. Decomposition of $CaCO_3(s)$ become spontaneous when temperature is greater than $927^{\circ}C$.

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331. $\Delta G^{\ominus}$ tells us:

a. Whether a change is feasible or not.

b. How far a reaction will proceed.

c. About emegry of activation.

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332. Identify the correct statement for change of Gibbs energy for a system $\left(\Delta_{sys}G\right)$ at constant temperature and pressure:

A. if $\Delta_{sys}G=0$, the system is still moving in a particular direction.

B. if $\Delta_{sys}G<0$, the process is not spontaneous

C. if $\Delta G>0$, the process is spontaneous

D. if $\Delta G=0$, the system has attained equilibrium

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333. $F_2C = CF - CF = CF_2 \rightarrow F_2C \mid FC = - CF_2 \mid CF$

For this reaction (ring closure), $\Delta H = -49kJmol^{-1}, \Delta S = -40.2JK^{-1}mol^{-1}$. Up to what temperature is the forward reaction spontaneous?

A. $1492\,^{\circ}C$

B. $1219\,^{\circ}C$

C. $946\,^{\circ}C$

D. $1089\,^{\circ}C$

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334. Fixed mass of an ideal gas contained in $10.0L$ sealed rigid vessel at $1atm$ is heated from $-73\,^{\circ}C$ to $27\,^{\circ}C$. Calculate change in Gibbs enegry if entropy of gas is a function of temperature as $S = 2 + 10^{-2}T\left(JK^{-1}\right)$. $(1atmL = 0.1kJ)$

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335. $1.0mol$ of an ideal gas initially present in a $2.0L$ insulated cylinder at $300K$ is allowed to expand against vacuum to $8.0L$. Determine w, ΔU, $\Delta_{\text{total}}S$, and ΔG.

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336. Sulphur exists is more than one solid form. The stable form at room temperature is rhombic sulphur. But above room temperature the following reaction occurs.

$S(\text{rhomic}) \rightarrow S(\text{monoclinic})$

If $\Delta H^{\Theta} = -276.144 J at 298 K$ and $1 atm$ and $\Delta G^{\Theta} = 75.312 J$

a. Calculate ΔS^{Θ} at $298K$.

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337. Calculate the free energy change when one mole of sodium chloride is dissolved in water at 298 K. (Given : Lattice energy of NaCl $= -777.8 kJmol^{-1}$

, Hydration energy of NaCl $= 774.1kJmol^{-1}$ and ΔS at$298K = 0.043kJmol^{-1}$.

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338. Will the reaction,

$I_2(s) + H_2S(g) \rightarrow 2HI(g) + S(s)$

proceed spontaneously in the forward direction of $298K$

$\Delta_f G^{\Theta} HI(g) = 1.8kJmol^{-1}, \Delta_f G^{\Theta} H_2S(g) = 33.8kJmol^{-1}$?

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339. The standard Gibbs free energies for the reaction at $1773K$ are given below:

$C(s) + O_2(g) \rightarrow CO_2(g), \Delta G^{\Theta} = -380kJmol^{-1}$

$2C(s) + O_2(g) \Leftrightarrow 2CO(g), \Delta G^{\Theta} = -500kJmol^{-1}$

Discuss the possibility of reducing Al_2O_3 and PbO with carbon at this temperature,

$4Al + 3O_2(g) \rightarrow 2Al_2O_3(s), \Delta G^{\Theta} = -22500kJmol^{-1}$

$2Pb + O_2(g) \rightarrow 2PbO(s), \Delta G^{\Theta} = -120kJmol^{-1}$

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340. In a fuel cell, methanol if used as fuel and oxygen gas is used as an oxidiser. The reaction is

$$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

Calculated standard Gibbs free enegry change for the reaction that can be converted into electrical work. If standard enthalpy of combustion for methanol is $-702kJmol^{-1}$, calculate the efficiency of conversion of Gibbs energy into useful work.

$\Delta_f G^\Theta$ for CO_2, H_2O, CH_3OH, O_2 is $-394.00, -237.00, -166.00$and $0kJmol^{-1}$ respectively.

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341. Using $._f G^\Theta(Hi) = 1.3kJmol^{-1}$, calculate the standard free enegry change for the following reaction:

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

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342. The emf of the cell reaction

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aQ) + Cu(s)$

is $1.1V$. Calculate the free enegry change for the reaction. If the enthalpy of the reaction is $-216.7kJmol^{-1}$, calculate the entropy change for the reaction.

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343. Calculate the equilibrium constant of the reaction :

$Cu(s) + 2Ag(aq) \Leftrightarrow Cu^{2+}(aq) + 2Ag(s)$

$E^{c-}\cdot_{cell} = 0.46V$

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344. In the reaction equilibrium

$N_2O_4 \Leftrightarrow 2NO_2(g)$

When 5 mol of each is taken and the temperature is kept at $298K$, the total pressure was found to be 20 bar.

Given : $\Delta_f G^{\ominus}_{n_2O_4} = 100kJ, \Delta_f G^{\ominus}_{NO_2} = 50KJ$

a. Find ΔG of the reaction at $298K$.

b. Find the direction of the reaction.

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345. When 1pentyne (A) is treated with $4N$ alcoholic KOH at $175^{\circ} C$, it is slowly converted into an equilibrium mixture of 1.3% of 1pentyne (A), 95.2% 2-pentyne (B) and 3.5% of $1, 2$-pentandiene (C). The equilibrium was maintained at $175^{\circ} C$. Calculate ΔG^{Θ} for the following equilibria:

$B \Leftrightarrow A, \Delta G^{\Theta} = 1?$

$B \Leftrightarrow C, \Delta G^{\Theta} = 2?$

From the calculated value of $\Delta G^{\Theta}1$and $\Delta G^{\Theta}2$, indicate the order of stability of A, B and C. Write a reasonable reaction mechanism showing all intermediates leading to A, B and C.

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346. What is the equilibrium constant K_c for the following reaction at $400K$?

$2NOCI(g) \Leftrightarrow 2NO(g) + CI_2(g)$

$\Delta H^{\Theta} = 77.2kJmol^{-1}$ and $\Delta S^{\Theta} = 122JK^{-1}mol^{-1}at400K$.

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347. For the equilibrium,

$PCI_5(g) \Leftrightarrow PCI_3(g) + CI_2(g)at25^{\circ}CK_c = 1.8 \times 10^{-7}$

Calculate ΔG^{Θ} for the reaction $\left(R = 8.314JK^{-1}mol^{-1}\right)$.

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348. The equilibrium constant at $25^{\circ}C$ for the process:

$CO^{3+}(aq) + 6NH_3(aq) \Leftrightarrow \left[Co\left(NH_3\right)_6\right]^{3+}(aq)$ is 2×10^7.

Calculate the value of ΔG^{Θ} at $25^{\circ}Cat25^{\circ}C\left[R = 8.314JK^{-1}mol^{-1}\right]$.

In which direction the reaction is spontaneous when the recatants and proudcts are in standard state?

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349. The equilibrium constant for the reaction

$CO_2(g) + H_2(g) \Leftrightarrow CO(g) + H_2O(g) at 298K$ is 73. Calculate the value of the standard free enegry change $\left(R = 8.314 JK^{-1} mol^{-1}\right)$

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350. For the water gas reaction,

$C(s) + H_2O(g) \Leftrightarrow CO(g) + H_2(g)$

the standard Gobbs free energy of reaction (at $1000K$) is $-8.1 kJmol^{-1}$. Calculate its equilibrium constant.

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351. Calculate ΔG^{Θ} for the conversion of oxygen to ozone, $\left(\frac{3}{2}\right) O_2(g) \Leftrightarrow O_3(g) at 298K$, of K_p for this conversion is 2.47×10^{-29}.

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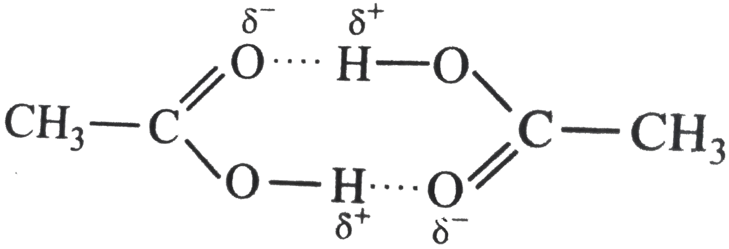
352. Acetic acid CH_3COOH can form a dimer $\left(CH_3COOH\right)_2$ in the gas phase. The dimer is held togther by two H - bonds with a total strength of $60.0kJper$ mole of dimer



If at $25\,^\circ C$, the equilibrium constant for the dimerisation is 1.3×10^3, calculate ΔS^Θ for the reaction

$2CH_3COOH(g) \Leftrightarrow \left(CH_3COOH\right)_2(g)$

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353. The standard enthalpy and entropy changes for the reaction in equilibrium for the forward direction are given below:

$CO(g) + H_2O(g) \Leftrightarrow CO_2(g) + H_2(g)$

$\Delta H^\Theta._{300K} = -41.16kJmol^{-1}$

$\Delta S^{\Theta}. 300K = -4.24 \times 10^{-2} kJmol^{-1}$

$\Delta H^{\Theta}. 1200K = -32.93 kJmol^{-1}$

$\Delta H^{\Theta}. 1200K = -2.96 \times 10^{-2} kJmol^{-1}$

Calculate K_p at each temperature and predict the direction of reaction at $300K$ and $1200k$, when $P_{CO} = P_{CO_2} = P_{H_2} = P_{H_2O} = 1$ atm at initial state.

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354. Standard Gibbs free enegry change ΔG^{Θ} for a reaction is zero. The value of the equilibrium constant will be:

A. 10

B. 1

C. 100

D. ∞

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355. What is $\Delta G^{\ominus}$ for the following reaction?

$\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \Leftrightarrow NH_3(g), K_p = 4.42 \times 10^4$ at $25\,^{\circ}C$

A. $-26.5kJmol^{-1}$

B. $-11.5kJmol^{-1}$

C. $-2.2kJmol^{-1}$

D. $-0.97kJmol^{-1}$

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356. Equilibrium constant for the reaction:

$H_2(g) + I_2(g) \Leftrightarrow 2HI(g) is K_c = 50 at 25\,^{\circ}C$

The standard Gibbs free enegry change for the reaction will be:

A. $-6.964kJ$

B. $-9.694kJ$

C. $-4.964kJ$

D. $-6.496kJ$

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357. Determine whether or not is possible for sodium to reduce aluminium oxide to aluminium at $298K$. Also, calculate equilibrium constant for this reaction at $298K$.

$\Delta_f G^{\Theta} Al_2O_3(s) = -1582 kJ mol^{-1}$

$\Delta_f G^{\Theta} Na_2O(s) = -377.7 kJ mol^{-1}$

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358. In the following equilibrium:

$N_2O_4(g) \Leftrightarrow 2NO_2(g)$

When $5 mol$ of each are taken and temperature is kept at $298K$, the total pressure was found to be 20bar. Given: $\Delta_f G^{\Theta} N_2O_4 = 100kJ$

$\Delta_f G^{\Theta} NO_2 = 50kJ$

a. Find ΔG of the reaction at $298K$.

b. Find the direction of the reaction.

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359. For the reaction:

$CO(g) + H_2O(g) \Leftrightarrow CO_2(g) + H_2(g)$

$\left(\Delta_r H\right)_{300K} = -41.2 kJmol^{-1}$

$\left(\Delta_r H\right)_{1200K} = -33.0 kJmol^{-1}$

$\left(\Delta_r S\right)_{300K} = -4.2 \times 10^{-2} kJmol^{-1}$

$\left(\Delta_r S\right)_{1200K} = -3.0 \times 10^{-2} kJmol^{-1}$

Predict the direction of spontaneity of the reaction at $300K$ and $1200K$. also calculated $\log_{10} K_p$ at $300K$ and $1200K$.

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360. Calculate $\Delta_r G^{\Theta}$ at $298K$ for the following reaction if the reaction mixtur econsists of $1atm$ of N_2, 3 atm of H_2, and $1atm$ of NH_3.

$N_2(g) + 3H_2(g)W \Leftrightarrow 2NH_3(g), \Delta_r G^{\Theta} = -33.32kJ$

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361. Thermodynamic efficiency of a cell is given by:

A. $-\Delta H / \Delta G$

B. $-nFE / \Delta G$

C. $-nFE / \Delta H$

D. $-nFE^{\Theta}$

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362. The temperature dependence of equilibrium constant of a reaction is given by $\ln K_{eq} = 4.8 - \frac{2059}{T}$. Find $\Delta_r G^{\Theta}, \Delta_r H^{\Theta}, \Delta_r S^{\Theta}$ at 298 K

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363. K_a for acetic acid at $27^\circ C$ is 2.0×10^{-5} and at $77^\circ C, K_a is 2.5 \times 10^{-5}$.

What are ΔH^Θ and ΔS^Θ for the ionisation of acetic acid?

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364. What is the sign of ΔG^Θ and the values of K for an electrochemical cell for which $E^\Theta{cell}$ = 0.80volt`?

A. $\begin{array}{cc} \Delta G^\Theta & K \\ - & > 1 \end{array}$

B. $\begin{array}{cc} \Delta G^\Theta & K \\ + & > 1 \end{array}$

C. $\begin{array}{cc} \Delta G^\Theta & K \\ + & < 1 \end{array}$

D. $\begin{array}{cc} \Delta G^\Theta & K \\ - & < 1 \end{array}$

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365. Silane $\left(SiH_4\right)$ burns in air as:

$SiH_4(g) + 2O_2(g) \rightarrow SiO_2(s) + 2H_2O(l)$

the standard Gibbs energies of formation of $SiH_4(g)$, $SiO_2(s)$, and $H_2O(l)$ are $+52.3$, -805.0, and $-228.6 kJmol^{-1}$, respectively. Calculate Gibbs energy change for the reaction and predict whether the reaction is spontaneous or not.

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366. Calculate the standard Gibbs enegry change for the combustion of $\alpha - D$ glucose at $300K$.

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

Given the standard enthalpies of formation $\left(kJmol^{-1}\right)$

$C_6H_{12}O_6 = -1274.5, CO_2 = -393.5, H_2O = -285.8.$

Entropies $\left(JKmol^{-1}\right)$

$C_6H_{12}O_6 = 212.1, O_2 = 205.0, CO_2 = 213, H_2O = 69.9$

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367. Calculate the standard free energy change for the formation of methane at $300K$:

$C(\text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$

The following data are given:

$\Delta_f H^\Theta \left(kJmol^{-1}\right): CH_4(g) = -74.81$

$\Delta_f S^\Theta \left(JK^{-1}mol^{-1}\right): C(\text{graphite}) = 5.70, H_2(g) = 130.7, CH_4(g) = 186.3$

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368. ΔH^Θ and ΔS^Θ for the reaction:

$Br_2(l) + CI_2(g) \Leftrightarrow 2BrCI(g)$

at $298K$ are $29.3kJmol^{-1}$ and $104.1JK^{-1}mol^{-1}$, respectively. Calculate the equilibrium constant for the reaction.

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369. Calculate the standard free enegry change for the reaction:

$Zn + Cu^{2+}(aq) \rightarrow Cu + Zn^{2+}(aq), E^\Theta = 1.20V$

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370. Calculate $\Delta_r G^{\Theta}$ for the following reactions using $\Delta_f G^{\Theta}$ values and and predict which reactions are spontaneous.

a. $Ca(s) + Cl_2(g) \rightarrow CaCl_2(s)$

b. $HgO(s) \rightarrow Hg(l) + \frac{1}{2}O_2(g)$

c. $NH_3(g) + 2O_2(g) \rightarrow HNO_3(l) + H_2O(l)$

$\Delta_f G^{\Theta}$ value $\left(kJmol^{-1}\right)$ are:

$CaCl_2(s) = -748.1, HgO(s) = -58.84$

$NH_3(g) = -16.45, HNO_3(l) = -80.71,$

$H_2O(l) = -237.13$

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371. $2mol$ of an ideal gas at $25^{\circ}C$ is allowed to expand reversibly at constant temperature (isothermally) form a volume of $2L$ to $10L$ by reducing the pressure slowely. Calculate the work done by the gas (w), ΔU, q, and ΔH.

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372. $71g$ of chlorine gas is allowed to expand freely into vacuum Calculate w.q ΔU and ΔH .

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373. Calculate the internal energy change in each of the following cases .

(a) A system absorbs $5kJ$ of heat and does $1kJ$ of work

(b) $5kJ$ of work is done on the system amd $1kJ$ of heat is given out by the system .

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374. The heat of combusion of benzene in a bomb calorimeter (i.e constant volume) was found to be $3263.9kJmo1^{-1}$ at $25^{\circ}C$ Calculate the heat of combustion of benzene at constan pressure .

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375. Calculate the enthalpy of combustion for the following reaction :

$2HC \equiv CH + 5O_2 \rightarrow 4CO_2 + 2H_2O$

The bond energies of $C - H, C \equiv C, O = O, C = O,$ and $O - H$ bonds are $414, 812, 494, 707,$ and $436 kJmol^{-1}$, respectively.

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376. What is the equilibrium constant K_c for the following reaction at $400K$?

$2NOCI(g) \Leftrightarrow 2NO(g) + CI_2(g)$

$\Delta H^{\ominus} = 77.2 kJmol^{-1}$ and $\Delta S^{\ominus} = 122 JK^{-1} mol^{-1} at 400K.$

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377. Calculate $\Delta G^{\ominus}$ for the following reaction at 298K:

$CO(g) + \left(\frac{1}{2}\right)O_2(g) \rightarrow CO_2(g), \Delta H^{\ominus} = -282.84 kJ$

Given,

$S^{\Theta}_{CO_2} = 213.8JK^{-1}mol^{-1}, S^{\Theta}_{CO(g)} = 197.9JK^{-1}mol^{-1}, S^{\Theta}_{O_2} = 205.0JK^{-1}mol^{-1}$,

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378. The energy change due to the reaction

$2Na(s) + CI_2(g) \rightarrow 2NaCI(s)$ is $-826kJ$

The consumption of 1 mo1 of CI_2 gas contracts the system by $22.4L$ at 1 atm

What is the enthalpy change of the reaction .

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379. From N atoms of an element A when half the atoms transfer on electron to the another atom $405kJm01^{-1}$ of energy was found to be consumed. An additional energy of $745kJmo1^{-1}$ was further required to convert all the A^{Θ} ions to $A^{\oplus}$. Calculate the ionisation energy and the electron affinity of atom A in eV .

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380. Using data (all values are in kilocalorie per mole at $25 ^\circ C$) given below, calculate the bond energy of $C - C$ and $C - H$ bonds.

ΔH^{Θ} combustion of ethane $= - 372.0$

ΔH^{Θ} combustion of propane $= - 530.0$

ΔH^{Θ} for $C($ garphite) $\rightarrow C(g) = + 172.0$

Bond enegry of $H - H$ bond $= + 104.0$

$\Delta_f H^{\Theta} of H_2O(l) = - 68.0$

$\Delta_f H^{\Theta} of CO_2(g) = - 94.0$

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381. In order to get maximum calorific output a burner should have an optimum fuel to oxygen ratio which corresponds to three times as much oxygen as is required theorectically for complete combusion of the fuel A burner which has been adjused for methane as fuel (with xLh^{-1} of CH_4 and $6xLh^{-1} of CO_2\big)$ is to be readjusted for butane C_4H_{10} in order to get the same calorific output what should be the rate of supply to butane and oxygen? Assume that losses due to incomplete combustion etc are the same for both fuels and that the gases behave ideally Heats of combustion $CH_4 = 809 kJmol^{-1}, C_4H_{10} = 2878 kJmol^{-1}$.

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382. Standard enthalpy of formation of $C_3H_7NO_2(s)$, $CO_2(g)$ and $H_2O(l)$ are $133.57, -94.05$ and $-68.32 kcalmo1^{-1}$ respectively

Standard enthalpy combustion of CH_4 at $25\,^{\circ}C$ is $-212.8 kcalmo1^{-1}$

Calculate ΔH^{Θ} for the reaction:

$2CH_4 + CO_2 + 1/2N_2 \rightarrow C_3H_7NO_2(s) + 1/2H_2$

Calculate ΔU for combustion of $C_3H_7NO_2(s)$.

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383. Calculated the energy required to excite one litre of hydrogen gas at $1 atm$ and $298 K$ to the first excited state of atomic hydorgen. The enegry for the dissociation of $H-H$ bond is $436 kJmol^{-1}$.

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384. From the following data, calculate the enthalpy change for the combustion of cyclopropane at $298K$. The enthalpy of formation of $CO_{2(g)}, H_2O_{(l)}$ and $Propene_{(g)}$ are $-393.5, -285.8$ and $20.42kJmol^{-1}$ respectively. Enthalpy of isomerization of cyclopropane to propene is $-33.0kJmol^{-1}$

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385. Preduct that anhyrous $AICI_3$ is covalent form the data given below, ionisation enegry for $AI = 5137kJmol^{-1}, \Delta_{hyd}H$ for $AI^{3+} = -4665k\text{Jmole}^{-1}, \Delta_{hyd}H$ for $CI^{\Theta} = -381kJmol^{-1})$

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386. The enthalpy change involved in the oxidation of glucose is $-2880kJmol^{-1}$. Twenty five per cent of this energy is available for muscular work . If $100kJ$ of muscular work is needed to walk one kilometre, what is the maximum distance that a person will be able to walk after eating $120g$ of glucose ?

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387. A system is provided $50J$ of heat and work done on the system is $20J$. What is the change in the internal enegry?

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388. How much work can be done by 100 calories of heat?

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389. The work done by a system is $8J$, when $40J$ heat is supplied to it. Calculate the increases in inernal enegry of system.

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390. Calculate the standard enegry change for the reaction:

$OF_2(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g) at 298K$

The standard enthalpies of formation of $OF_2(g), H_2O(g)$, and $HF(g)$ are $+20, -250$, and $-270 kJ mol^{-1}$, respectively.

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391. Heat of reaction for $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_v$ at constant pressure is $-651 kcal$ at $17^\circ C$. Calculate the heat of reaction at constant volume at $17^\circ C$.

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392. The heat of reaction for, $C_{10}H_8 + 12O_{2(g)} \rightarrow 10CO_{2(g)} + 4H_2O_{(l)}$ at constant volume is $-1228.2 kcal$ at $25^\circ C$. Calculate the heat of reaction at constant pressure at $25^\circ C$.

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393. Calculate the heat of transition for carbon from the following:

$C_{\text{Diamond}} + O_2 \rightarrow CO_2(g), \Delta H = -94.3 kcal$

$C_{\text{Amorphous}} + O_2 \rightarrow CO_2(g), \Delta H = -97.6 kcal$

Also calculate the heat required to change $1g$ of C_{Diamond} to $C_{\text{Amorphous}}$.

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394. Calculate the enthalpy of vaporisation for water form the following:

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(g), \Delta H = -57.0 kcal$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l), \Delta H = -68.3 kcal$

Also calculate the heat required to change $1gH_2O(l)$ to $H_2O(g)$

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395. The heats of combustion of $C_2H_{4(g)}, C_2H_{6(g)}$ and $H_{2(g)}$ are $-1409.4, -1558.3$ and $-285.6 kJ$ respectively. Calculate heat of hydrogenation of ethylene.

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396. At $300K$, the standard enthalpies of formation of $C_6H_5COOH_{(s)}, CO_{2(g)}$ and $H_2O_{(l)}$ are $-408, -393$ and $-286kJmol^{-1}$ respectively. Calculate the heat of combustion of benzoic acid at

(i) constant pressure,

(ii) constant volume. $\left(R = 8.31Jmol^{-1}K^{-1}\right)$

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397. Given the following standard heats of reactions:

(a) heat of formation of water $= -68.3kcal$, (b) heat of combustion of $C_2H_2 = -310.6kcal$, (c) heat of combustion of ethylene $= -337.2kcal$. Calculate the heat of reaction for the hydrogenation of acetylene at constant volume and at $25^\circ C$.

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398. Standard heat of formation of CH_4, CO_2 and $H_2O_{(g)}$ are $-76.2, \ -394.8$ and $-241.6kJmol^{-1}$ respectively. Calculate the amount of heat evolved by burning $1m^3$ of CH_4 measured under normal conditions.

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399. Calculate heat of formation of $KOH(s)$ using the following equations

$K(s) + H_2O(l) + aq \rightarrow KOH(aq) + 1/2H_2O(g), \Delta H = -48.0kcal\ldots(i)$

$H_2(g) + 2O_2(g) \rightarrow H_2O(l), \Delta H = -68.4kcal\ldots(ii)$

$KOH(s) + (aq) \rightarrow KOH(aq), \Delta H = -14.0kcal.... (iii)$

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400. For a reaction at $25^\circ C$ enthalpy change (ΔH) and entropy change $(De < sS)$ are $-11.7KJmol^{-1}$ and $-105Jmol^{-1}K^{-1}$, respectively. Find out whther this reaction is spontaneous or not?

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401. Determine the entropy change for the reaction

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

at $300K$. If standard entropies of $H_2(g), O_2(g)$ and $H_2O(l)$ are $12.6, 201.20$ and $68.0JK^{-1}\text{mole}^{-1}$ respectively.

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402. Calculate the equilibrium constnat for the reaction given below at $400K$, if $\Delta H^{\Theta} = 77.2kJ\text{mole}^{-1}$ and $\Delta S^{\Theta} = 122JK^{-1}\text{mole}^{-1}$.

$PCI_5(g) \rightarrow PCI_3(g) + CI_2(g)$

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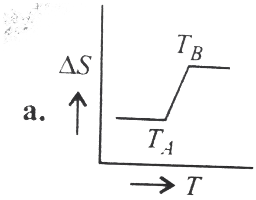
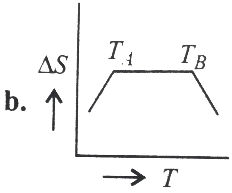
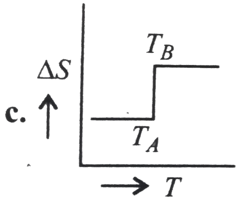
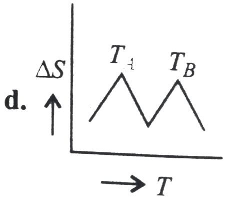
Exercise

1. If, for a given substance, T_B is the melting point and T_A is the freezing point, then the correct variation of entropy by the graph between entropy change (ΔS) and temperature is:

A. 

B. 

C. 

D. 

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Ex 6.1

1. Calculate ΔU, internal energy change of a system, if it absorbs $25kJ$ of heat and does $5kJ$ of work.

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2. In a certain process, $400J$ of work is done on a system which gives off $200J$ of heat. What is ΔU for the process?

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3. During a process, a system abdorbs $710J$ of heat and does work. The change in ΔU for the process is $460J$. What is the work done by the system?

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4. During a process, the internal energy of the system increases by $240kJ$ while the system performed $90kJ$ of work on its surroundings. How much heat was transferred between the system and the surroundings during this process. In which direction did the heat flow?

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5. Calculate the work done when 1.0 mol of water at $373K$ vaporises against an atmosheric pressure of $1.0atm$. Assume ideal gas behaviour.

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6. What will be the volume change if $607.8J$ of work is done by a system containing an ideal gas? The surroundings exert constant pressure of $20atm. (1L\text{ - }atm = 101.3J)$

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7. $500cm^3$ of a sample of an ideal gas is compressed by an average pressure of $0.1atm$ of $250cm^3$. During this process, $10J$ of heat flows out to the surroundings. Calculate the change in internal enegry of the system.

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8. Three moles of an ideal gas are expanded isothermally and reversibly at $27^\circ C$ to twice its original volume. Calculate $q, w,$ and ΔU.

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9. $2.8g$ of N_2 gas at $300K$ and $20atm$ was allowed to expand isothermally against a constant external pressure of $1atm$. Calculate $\Delta U, q,$ and W for the gas.

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10. State whther each of the following will increase or decreases the total enegry content of the system:

a. Heat transferred to the surroundings

b. Work done on the system.

c. Work done by the system.

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11. Two moles of an idela gas at $2atm$ and $27^{\circ}C$ is compressed isothermally to one-half of its volume by an external pressure of $4atm$. Calculate q, w, and ΔU.

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12. A simple of gas present in a cylinder fitted with a frictionless piston expands against constant pressure of $1atm$ from a volume fo $2L$ to $12L$. During the process, it absorbs $600J$ of heat from the surroundings. Calculate the change in internal energy of the system.

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13. One mole of an ideal mono-atomic gas at $27^{\circ}C$ expands adiabatically against a constant external pressure of $1atm$ from a value of $5dm^3$ to $15dm^3$ .calculate (a) q and (b) w.

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14. A $5L$ cylinder contained 10 moles of oxygen gas at $27^{\circ}C$. Due to sudden leakage through the hole, all the gas escaped into the atmosphere and the cylinder got empty. If the atmospheric pressure is $1.0atm$, calculate the work done by the gas.

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15. Adiabatic expansion of an ideal gas is accompanied by

A. Increase in temperature

B. Decrease in ΔS

C. Decrease in ΔU

D. No change in any one of the above properties

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16. For a cyclic process, which of the following is true?

A. $\Delta S = 0$

B. $\Delta U = 0$

C. $\Delta H = 0$

D. $\Delta G = 0$

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17. One mole of a gas is heated at constant pressure to raise its temperature by $1^\circ C$. The work done in joules is

A. -4.3

B. -8.314

C. -16.62

D. Unpredictable

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18. What work is to be done on $2mol$ of a perfect gas at $27^\circ C$ it is compressed reversibly and isothermally from a pressure of $1.01 \times 10^5 Nm^{-2} \rightarrow 5.05 \times 10^6 Nm^{-2}$?

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19. $1mol$ of an ideal gas undergoes reversible isothermal expansion form an initial volume V_1 to a final volume $10V_1$ and does $10kJ$ of work. The initial pressure was $1 \times 10^7 Pa$.

c. Calculate V_2.

b. If there were $2mol$ of gas, what must its temperature have been?

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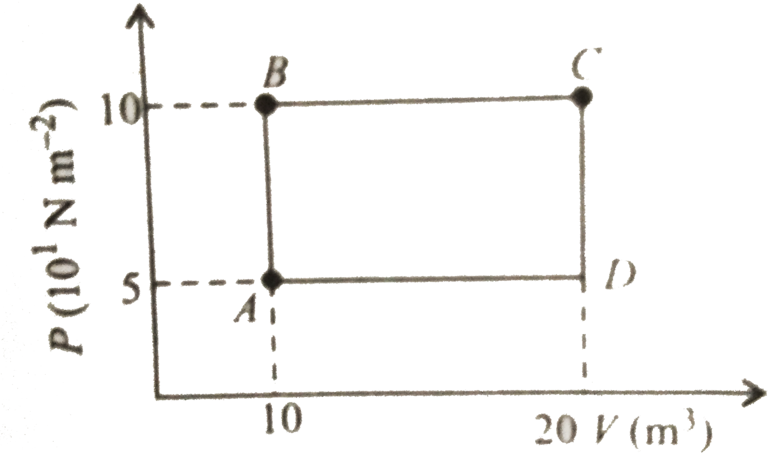
20. A sample of $2kg$ of helium (assumed ideal) is taken through the process ABC and another sample of $2kg$ of the same gas is taken through the process ADC. Then the temperature of the states A and B are (given

$R = 8.3 Jmol^{-1}K^{-1}\Big)$



A. $T_A = 220.5K, T_B = 220.5K$

B. $T_A = 241K, T_B = 241K$

C. $T_A = 120.5K, T_B = 241K$

D. $T_A = 240K, T_B = 480K$

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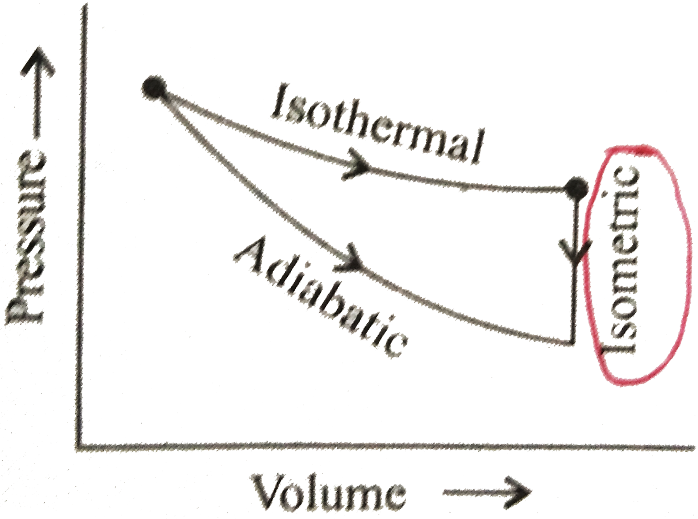
21. An ideal diatomic gas is caused to pass throguh a cycle shown on the P - V diagram in figure, where $V_2 = 3.00V_1$. If P_1, V_1,and T_1 specify the state 1, then the temperature of the state 3 is



A. $\left(T_1/3\right)^1$

B. $\left(T_1/3\right)^4$

C. $\left(T_1\right)(1/3)^{0.4}$

D. $\left(T_1/3\right)^2$

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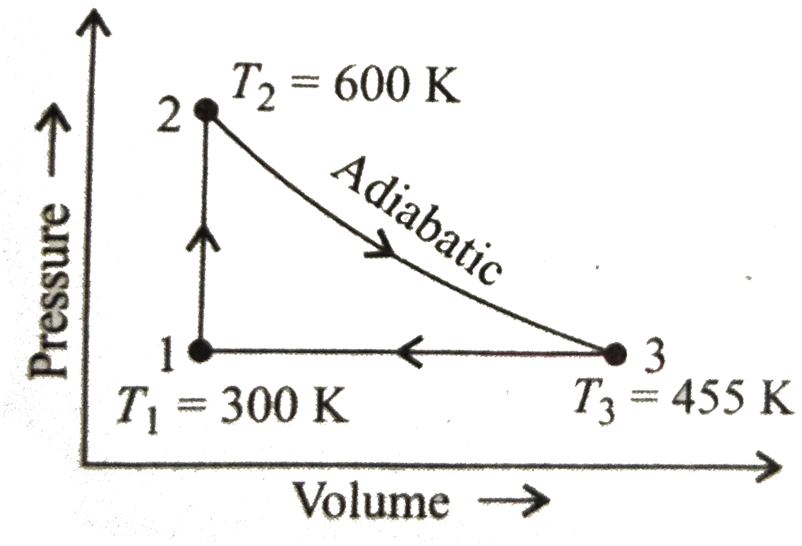
22. A heat engine carries one mole of an ideal mono-atomic gas around the cycle as shown in the figure below. Process $1 \rightarrow 2$ takes place at constant volume, process $2 \rightarrow 3$ is adiabatic and process $3 \rightarrow 1$ takes place at constant pressure. Then the amount of heat added in the process $1 \rightarrow 2$ is



A. $3740J$

B. $-3740J$

C. $2810J$

D. $3228J$

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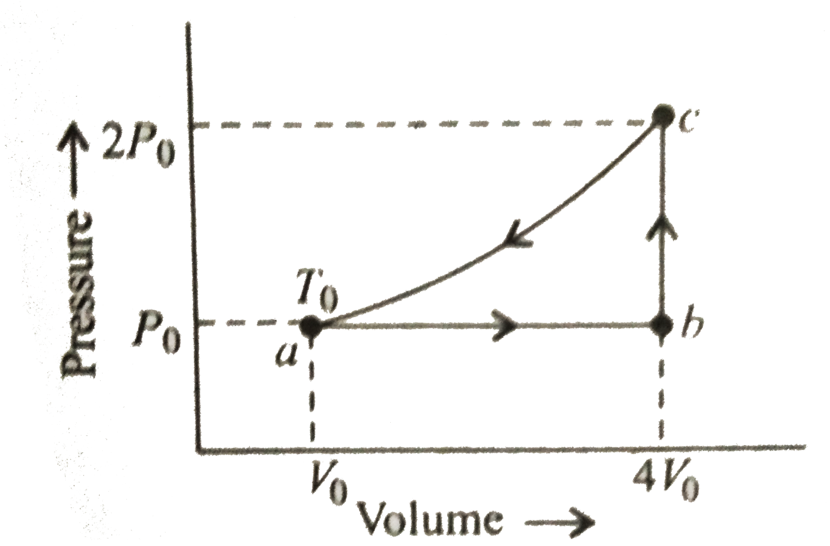
23. One mole of an ideal mono-atomic gas is caused to go through the cycle shown in the figure below. Then the change in the internal enegry in expanding the gas from a to c along the path abc is:



A. $13P_0V_0$

B. $16RT_0$

C. $14.5RT_0$

D. $10.5RT_0$

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24. Calculate the work done by $1.0 mol$ of an ideal gas when it expands at external pressure $2 atm$ from $10 atm$ to $2 atm$ at $27^{\circ} C$

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25. 3.0 moles of an ideal gas at $27^{\circ} C$ is compressed at constant temp. reversibly form a volume of $20 L$ to $10 L$ slowly increasing the external pressure calculate work done on the gas $w, q, \Delta U$ and ΔH.

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26. When 3mole of an idela gas expand reversibly and isothermally five times its initial volume $6 kJ$ heat flow into it. What must be the temperature of the gas?

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Ex 6.2

1. The enthalpy changes for the following reactions at $298k$ and $1atm$ are given below:

a. $CH_3COOH(l) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l), \Delta H = -874kJ$

b. $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H = -1363kJ$

Calculate the internal enegry changes for these recaitons.

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2. The enthalpy of combustion of benzoic acid $\left(C_6H_5COOH\right)$ at $298K$ and $1atm$ pressure is $-2500.0kJmol^{-1}$. What is ΔU for the reaction?

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3. The heat produced by the combustion of $2.0g$ of benzene in a bomb calorimeter was found to be $123.6kJ$ at $25^\circ C$. Calculate the enthalpy of combustion of benzene at $25^{\circ} C$.

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4. The heat liberated on complete combustion of $7.8g$ benzene is $327kJ$. This heat has been measured at constant volume and at $27^{\circ} C$. Calculate heat of combustion of benzene at constant pressure at $27^{\circ} C$. $\left(R = 8.3 J mol^{-1} K^{-1}\right)$

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5. A gas expands from $3dm^3$ to $5dm^3$ against a constant pressure of $3atm$. The work done during the expansion if used to heat $10mol$ of water at temperature $290K$. Find the final temperature of water, if the specific heat of water $= 4.18 g^{-1} K^{-1}$.

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6. Determine the value of ΔH and ΔU for the reversible isothermal evaporation of $90.0g$ of water at $100\,^{\circ}C$. Assume that water behaves as an ideal gas and heat of evaporation of water is $540calg^{-1}\left(R = 2.0calmol^{-1}K^{-1}\right)$.

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7. $100mL$ of a liquid is contained in an insulated container at a pressure of 1bar. The pressure is steeply increased to 100bar. The volume of the liquid is decreased by $1mL$ at this constant pressure. Find ΔH and ΔU.

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8. The bond enthalpies of $H-H$ and $Cl-Cl$ are 430 and $242kJmol^{-1}$, respectively. If $\Delta H_f(HCl)$ is $-91kJmol^{-1}$ the bond enthalpy of HCl would be

A. $-214kJmol^{-1}$

B. $-427kJmol^{-1}$

C. $214kJmol^{-1}$

D. $427kJmol^{-1}$

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9. Two moles of a perfect gas undergo the following processes:

a. A reversible isobaric expansion from $(1.0atm, 20.0L)$ to $(1.0atm, 40.0L)$

b. A reversible isochroic change of state from $(1.0atm, 40.0L)$ to $(0.5atm, 40.0L)$

c. A reversible isothermal expansion from $(0.5atm, 40.0L) \rightarrow (1.0atm, 20.0L)$

i. Sketch with lables each of the processes on the same $P-V$ diagram.

ii. Calculate the total work (w) and the total heat change (q) involved in the above process.

iii. What will be the values of ΔH for the overall process?

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10. The enthalpy change (ΔH) for the reaction, $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3g}$ is -$92.38kJ$ at $298K$ What is ΔU at $298K$?

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11. The difference between the heats of reaction at constant pressure and a constant volume for the reaction $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ at $25^\circ C$ in kJ is

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12. A gas present in a cylinder fitted with a frictionless pistion expands against a constant pressure of $1atm$ form a volume of $2L$ to a volume of $6L$. In doing so, it absorbs $800J$ heat form the surroundings. Determine the increases in internal enegry of process.

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13. Calcualte $q, w, \Delta U$, and ΔH for the reversible isothermal expansion of one mole of an ideal gas at $127 ^\circ C$ from a volume of $20dm^3$ to $40dm^3$.

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14. A swimmer coming out from a pool is covered with a film of water weighing about $80g$. How much heat must be supplied to evaporate this water ? If latent heat of evaporation for H_2O is $40.79kJmol^{-1}$ at $100 ^\circ C$.

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15. Calculate $q, w, \Delta U$, and ΔH for this isothermal reversible expansion of 1mole of an ideal gas from an initial pressure of 1.0 bar to final pressure of 0.1bar at a constant pressure of $273K$.

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16. A sample of argon gas at $1atm$ pressure and $27^{\circ} C$ expands reversibly and adiabatically from $1.25dm^3$ to $2.50dm^3$. Calculate the enthalpy change in this process. C_{vm} for orgon is $12.48JK^{-1}mol^{-1}$.

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17. An insulated contains 1mole of a liquid, molar volume $100mL$ at 1bar. When liquid is steeply passed to 100bar, volume decreases to $99mL$. Find ΔH and ΔU for the process.

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18. $5mol$ of an ideal gas at $27^{\circ} C$ expands isothermally and reversibly from a volume of $6L$ to $60L$. The work done in kJ is

A. -14.7

B. -28.72

C. $+28.72$

D. -56.72

Answer: B

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19. $10 mol$ of an ideal gas confined to a volume of $10L$ is released into atmosphere at $300K$ where the pressure is 1bar. The work done by the gas is $\left(R = 0.083 L \text{bar} K^{-1} mol^{-1}\right)$

A. $249 L$bar

B. $259 L$ bar

C. $239 L$bar

D. $220 L$ bar

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20. A system absorbs $20kJ$ heat and also does $10kJ$ of work. The net internal enegry of the system

A. Increases by $10kJ$

B. Decreases by $10kJ$

C. Increases by $30kJ$

D. Decreases by $30kJ$

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21. One moles of an ideal gas which $C_V = 3/2R$ is heated at a constant pressure of $1atm$ from $25^{\circ} C$ to $100^{\circ} C$. Calculate $\Delta U, \Delta H$ and the entropy change during the process.

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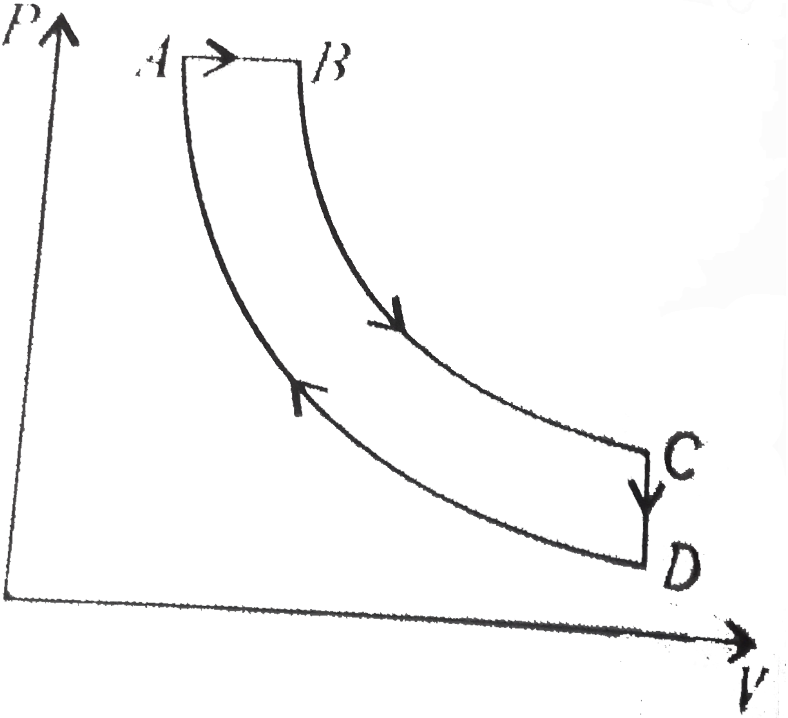
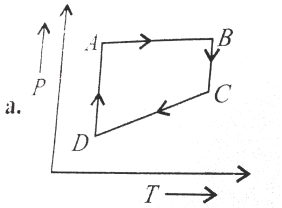
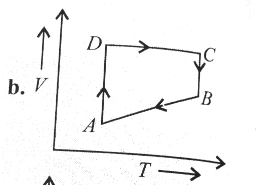
22. A cyclic process $ABCD$ is shown in the P - V diagram. Which of the following curves represents the same process?

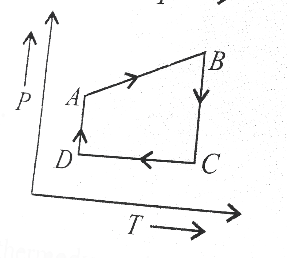


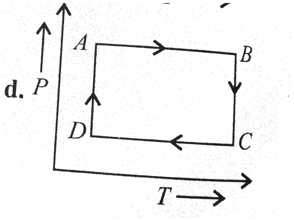
A.



B.



C. 

D. 

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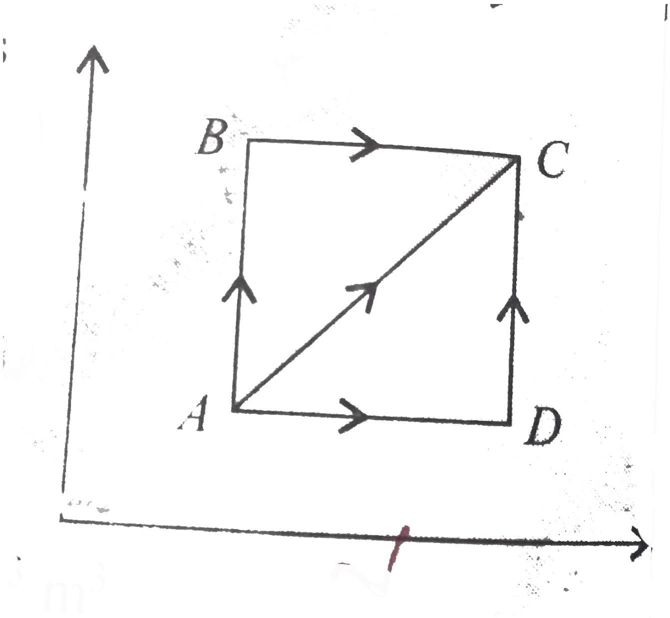
23. A thermodynamic process is shown in the following figure. The process and volumes corresponding to some points in the figure are:

$P_A = 3 \times 10^3 Pa$,

$V_A = 2 \times 10^{-3} m^{-3}$,

$P_B = 3 \times 10^4 Pa, V_D = 2 \times 10^{-3} m^3$

In process $AB, 600J$ of heat is added to the system and in the process $BC, 200J$ of heat is added to the system. the change in internla energy of the system in the process AC would be



A. $560J$

B. $800J$

C. $600J$

D. $640J$

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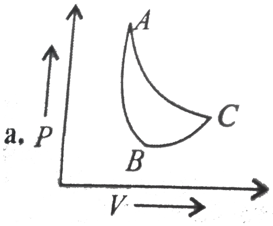
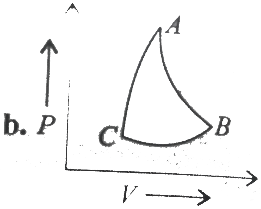
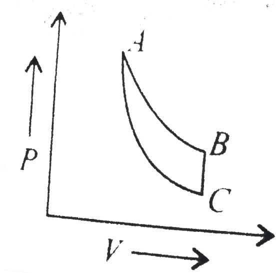
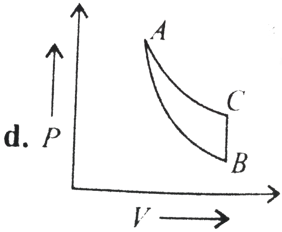
24. In which of the following indicator diagrams gives below do AB, BC, and CA represent isothermal, isochroic, and adiabatic changes, respectively?

A.


B.


C.


D.


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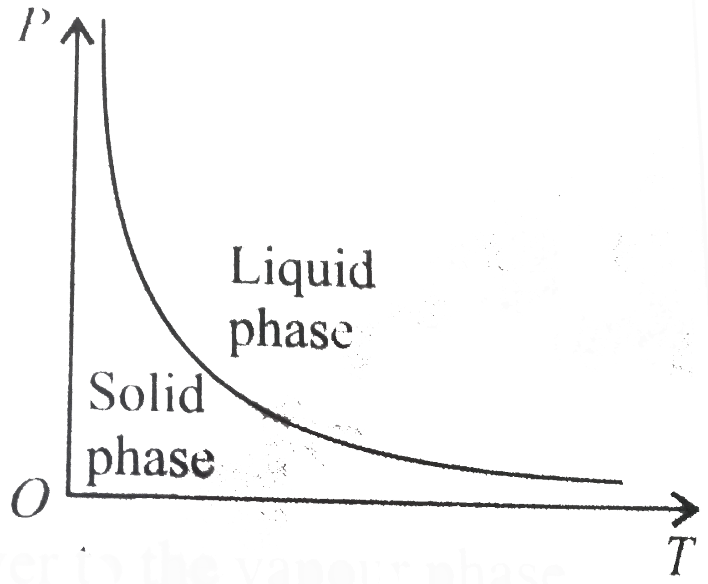
25. The pressure -temperature $(P - T)$ phase diagram shown below corresponds to the

a. Curve of fusion of solids that expand on solidification.

b. Curve of sublimation of solids that directly go over to the vapour phase.



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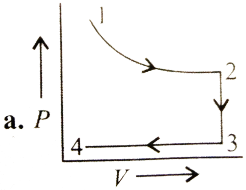
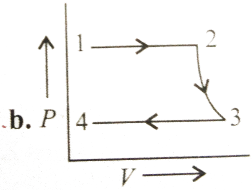
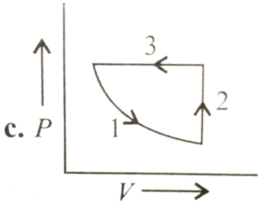
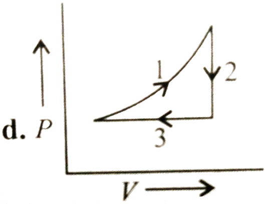
26. An ideal gas undergoes isothermal expansion followed by heat removel at constant volume and they by heat removal at constant pressure to the initial volume. The correct descripion of these steps is indicated by

A. 

B. 

C. 

D. 

Answer: D

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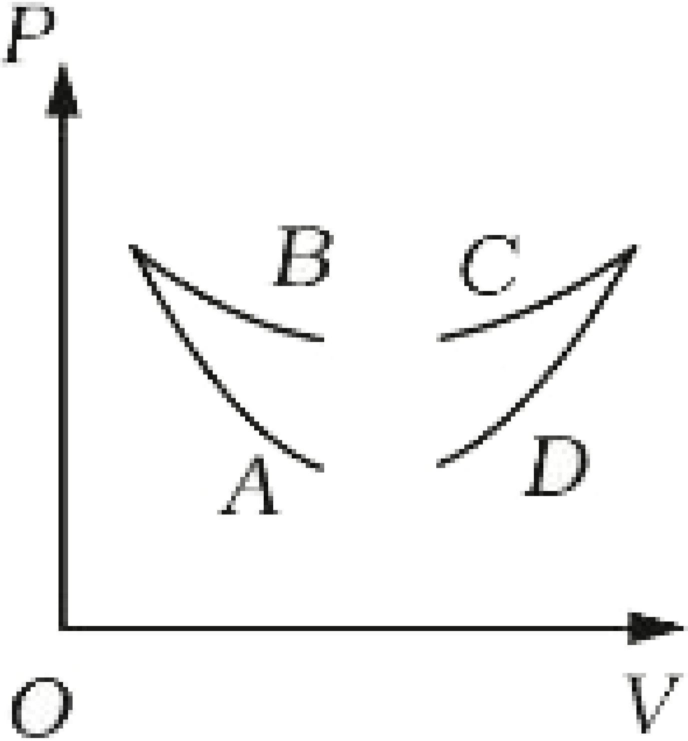
27. Four curves A, B, C and D are drawn in the figure for a given amount of gas. The curves which represent adiabatic and isothermal changes are :



A. $C$and D

B. D and C

C. A and B

D. $B$and A

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Ex 6.3

1. A mixture of hydrocarbons containing acetylene and ethane, when burned under controlled consitions produced $16.20g$ of water and $139.7kcal$ of heat. Given the molar composition of the mixture. Standard heats of combustion for acetylene and ethane are, respectively, -310.6 and $-373.8kcal$.

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2. Find the heat that of sublimation of sodium metal from the following data. Ionisation enegry of sodium $= 502.1$, bond enegry of chlorine $= 242.8$, heat of formation of $NaCI = -411.1$, lattice energy of $NaCI = -778.0$, and electorn affinity of chlorine is -365.3. All units are in $kJmol^{-1}$.

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3. An athelet takes 20 breaths per minute at room temperature. The air inhaled in each breath is $200mL$ which contains 20% oxygen by volume, while exhaled air contains 10% oxygen by volume. Assuming that all the oxygen consumed if used for converting glucose into CO_2 and $H_2O_{(l)}$, how much glucose will be burnt in the body in one hour and what is the heat produced ? (Room temperature $-27^{\circ}C$ and enthalpy of combustion of glucose is $-2822.5kJmol^{-1}at0^{\circ}C$)

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4. A gas mixture of $3.67L$ of ethylene and methane on complete combustion at $25^{\circ}C$ produces $6.11L$ of CO_2. Find out the heat evolved on buring $1L$ of the gas mixture. The heats of combustion of ethylene and methane are -1423 and $-891kJmol^{-1}$, respectively, at $25^{\circ}C$.

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5. Calculate the resonance energy of C_6H_6 using kekule formula of C_6H_6 from the following data.

a. $\Delta_f H^{\Theta}$ for $C_6H_6 = -358.5 kJmol^{-1}$

b. Heat of atomisation of $C = 716.8 kJmol^{-1}$

c. Bond enegry of $C-H, C-C, C=C$and $H-H$ are $490, 340, 620, 436.9 kJ\text{mole}^{-1}$ respectively.

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6. From the following data of Δh, of the following reactions,

a. $C(s) + 1/2O_2(g) \rightarrow CO(g), \Delta H^{\Theta} = -110 kJ$

b. $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g), \Delta H^{\Theta} = 132 kJ$

Calculate the mole composition of the mixture of steam and oxygen on being passed over coke at $1273K$, keeping the tempertaure constant.

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7. A person inhales $640g$ of O_2 per day. If all the O_2 is used for converting sugar into CO_2 and H_2O, how much sucrose $\left(C_{12}H_{22}O_{11}\right)$ is consumed in the body in one day and what is the heat evolved ?

$\left(\Delta H_{\text{combination of sucrose}} = -5645kJmol^{-1}\right)$

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8. ΔH combustion for CH_4, C_2H_6, and C_3H_8 are $-210.8, -368.4$ and $-526.3kcalmol^{-1}$, respectively. Calculate ΔH combustion for C_8H_{18}

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9. When $12.0g$ of C reacted with a limited quantity of oxygen, $57.5kcal$of heat was produced. Calculate the number of CO and number of moles of CO_2 produced.

Given $C + O_2 \rightarrow CO_2, \Delta_f H = -94.05kcal$

$C + 1/2O_2 \rightarrow CO, \Delta_f H = -21.41kcal$

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10. When $12.0g$ of C reacted with oxygen to form CO and CO_2 at $25^\circ C$ at constant pressure, $313.8kJ$ of heat was released and no carbon remained. Calculate the mass of oxygen which reacted.

$\Delta_f H^{\Theta}(CO, g) = -110.5kJmol^{-1}$ and

$\Delta_r H^{\Theta}\left(CO_2, g\right) = -393.5kJmol^{-1}$

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11. Given $CaCl_2(s) + aq \rightarrow CaCl_2(aq) : \Delta H^{\Theta} = 75kJmol^{-1}$ at $18^\circ C$ and $CaCl_2.6H_2O + aq \rightarrow CaCl_2(aq), \Delta H^{\Theta} 19kJmol^{-1}$ at $18^\circ C$. Find the heat of hydration of $CaCl_2$ to $CaCl_2.6H_2O$ by $H_2O(g)$. The Heat of vaporisation of water may be taken as $2452Jmol^{-1}at18^\circ C$.

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12. The dissociation pressure of

$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2$ gets doubled over a tempertaure range of 60 degree around the mean tempertaure of $837^\circ C$. Calculate the enthalpy of dissociation in kcal mol^{-1}.

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13. Calculate the enthalpy change for the following reaction:

$XeF_4 \rightarrow Xe^{\oplus} + F^{\Theta} + F_2 + F$. The average $Xe - F$ bond energy is $34 kcal mol^{-1}$, first IE of Xe is $279 kcal mol^{-1}$, EA of F is $85 kcal mol^{-1}$ and bond dissociation enegry of F_2 is $38 kcal mol^{-1}$

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14. The conversion of gaseous atoms K and F to $K^{\oplus}$ and $F^{\ominus}$ absorbs $0.85 eV$ of energy. If the IE and $\Delta_{eg}H^{\ominus}$ of K and F have magnitudes in the ratio of $7:6$, what is the electron gain enthalpy $\left(\Delta_{eg}H^{\ominus}\right)$ of fluorine ?

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15. While $1 mol$ of ice melts at $0^{\circ}C$ and at constant pressure of $1 atm$, $1440 cal$ of heat are absorbed by the system. The molar volume of ice and water are 0.0196 and $0.0180 L$ respectively. Calculate ΔH and ΔU.

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16. At $25^{\circ}C$, buring $0.2 \text{mole} H_2$ with 0.1 mole O_2 to produce $H_2O(l)$ in a bomb calorimeter (constant volume) raises the temperature of the apperaturs $0.88^{\circ}C$. When $0.01 mol$ toulene is burned in this calorimeter, the temperature is raised by $0.615^{\circ}C$. Calculate ΔH^{Θ} combustion of toluene. $\Delta_f H^{\Theta} H_2O(l) = -286 kJmol^{-1}$.

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17. Calculate the enthalpy of formation of aniline. The enthalpy of combustion of aniline is $837.5 kcalmol^{-1}$. The enthalpies of formation of liquid water and gaseous carbon dioxide are -68.4 and $-97.0 kcal mol^{-1}$ respectively. All values are at $298K$.

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18. Calculate the enthalpy change when infinitely dilute solution of $CaCl_2$ and Na_2CO_3 are mixed. $\Delta_f H^{\Theta}$ for $Ca^{2+}(aq), CO_3^{2-}(aq)$, and $CaCO_3(s)$ are $-129.80, \ -161.65$, and $-288.50 kcal mol^{-1}$ respectively.

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19. The sublimation energy of a metal is $100 kJ mol^{-1}$ and its Ist and IInd IEs are $4.0 eV$ and $12.0 eV$ respectively. The hydration energy of $X^{\oplus}$ is $-380 kJ mol^{-1}$ and X^{2+} is $-1280 kJ mol^{-1}$. Comment over the stability of two ions in water.

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20. The $C - H$ bond of the side chain in toluene, $C_6H_5 - CH_3$, has a dissociation energy of $77.5kcalmol^{-1}$. Calculate $\Delta_f H^{\Theta}$ of benzy1 radical and the strength of the central bond in dibenzy1$C_6H_5 - CH_2 - CH_2 - C_6H_5$ given that $\Delta_f H^{\Theta}$ to toluene vapour in $12kcalmol^{-1}$ and that of dibenzy1 vapour is $27.8kcalmol^{-1}$. BE of $H_2 = 104kcalmol^{-1}$.

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21. Calculate Δh for the eaction

$BaCO_3(s) + 2HCI(aq) \rightarrow BaCI_2(aq) + CO_2(g) + H_2O(l)$

$\Delta_f H^{\Theta}\left(BaCO_3\right) = -290.8kcalmol^{-1}, \Delta_f H^{\Theta}\left(H^{\oplus}\right) = 0$

$\Delta_f H^{\Theta}\left(Ba^{++}\right) = -128.67kcalmol^{-1},$

$\Delta_f H^{\Theta}\left(CO_2\right) = -94.05kcalmol^{-1},$

$\Delta_f H^{\Theta}\left(H_2O\right) = -68.32kcalmol^{-1}$

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22. Calculate the heat produced when $3.785L$ of octabe reacts with oxygeb to form carbon mono oxide and water vapour at $25^{\circ}C$. (Density of octane is $0.75025gmL^{-1}\Big)$. $\Delta_{comb}H^{\Theta}\left(C_8H_{18}\right) = -1302.7kcal, \Delta_fH^{\Theta}\left(CO_2\right) = -94.05kcal,$

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23. a. Cis-2-butene $\rightarrow$ trans-2-butane, ΔH_1

b. Cis-2-butane $\rightarrow$ 1-butene, ΔH_2

c. Trans-2-butene is more stable than C is-2-butene

d. Ethalpy of combustion of 1-butene, $\Delta H = -649.8kcal/mol$

e. $9\Delta H_1 + 5\Delta H_2 = 0$

f. Enthalpy of combustion of trans -2-butene, $\Delta H = -647.1kcalmol^{-1}$.

Calculate $\Delta H_1$and ΔH_2?

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24. Calculate the proton affinity of $NH_3(g)$ from the following data (in $kJmol^{-1}\Big)$:

ΔH^{Θ} dissociation: $H_2(g) = 218$

ΔH^{Θ} formation: $NH_3(g) = -46$

Lattice energy of $NH_4CI(s) = 683$

Ionisation energy of $H = 1310$

Electron affinity of $CI = -348$

Bond dissociation energy $CI_2(g) = 124$

$\Delta_f H^{\Theta}\left(NH_4CI\right) = -314$

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25. In certan areas where coal is cheap, artificial gas is produced for household use by the "water gas" raction

$C(s) + H_2O(g) \rightarrow 600^{\circ} CH_2(g) + CO(g)$

Assuming that coke is 100% carbon, calculate the maximum heat obtainable at $298K$ from the combustion of $1kg$ of coke,

GIven: $\Delta_f H^{\Theta}, H_2O(l) = -68.32 kcal/mol$

$\Delta_f H^{\Theta}, CO_2(g) = -94.05 kcal/mol$

$\Delta_f H^{\Theta}, CO(g) = -26.42 kcal/mol$

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26. Calculate the enthalpy of combustion of benzene (l) on the basis of the following data:

a. Resonance energy of benzene $(l) = -152 kJ/mol$

b. Enthalpy of hydrogenation of cyclohexene $(l) = -119 kJ/mol$

c. $\Delta_f H^{\Theta} C_6H_{12}(l) = -156 kJmol^{-1}$

d. $\Delta_f H^{\Theta} of H_2O(l) = -285.8 kJmol^{-1}$

e. $\Delta_f H^{\Theta} of CO_2(g) = -393.5 kJmol^{-1}$

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27. Find ΔH of the process

$NaOH(s) \rightarrow NaOH(g)$

Given: $\Delta_{diss} H^{\Theta} of O_2 = 151 kJmol^{-1}$

$\Delta_{diss} H^{\Theta} of H_2 = 435 kJmol^{-1}$

$\Delta_{diss} H^{\Theta} of O-H = 465 kJmol^{-1}$

$\Delta_{diss} H^{\Theta} of Na-O = 255 kJmol^{-1}$

$\Delta_{soln} H^{\Theta} of NaOH = -46 kJmol^{-1}$

$\Delta_f H^{\Theta} of NaOH(s) = -427 kJ mol^{-1}$

$\Delta_{sub} H^{\Theta} of Na(s) = 109 kJ mol^{-1}$

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Ex 6.4

1. $30.0 kJ$ of heat is required to melt $1 mol$ of sodium chloride. The entropy change during melting is $15.05 J mol^{-1} K^{-1}$. Calculate the melting point of sodium chloride.

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2. Calculate the entropy changes of fusion and vapourisation for chlorine from the following data:

$\Delta_{fus} H = 6.40 kJ mol^{-1}$, melting point $= -100 ^{\circ} C$

$\Delta_{vap} H = 20.4 kJ mol^{-1}$, boiling point $= -30 ^{\circ} C$

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3. $\Delta_{vap}S$ of acetone is $90.0JK^{-1}mol^{-1}$. If boiling point of acetone is $50^{\circ}C$, calculate the heat required for the vaporisation of $1g$ of acetone..

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4. The enthalpy of vaporisation of benzene $\left(C_6H_6\right)$ is $30.8kJmol^{-1}$ at its boiling point $\left(80.1^{\circ}C\right)$. Calculate the entropy change in going from:

a. liquid to vapour and

b. vapour to liquid at $80.1^{\circ}C$.

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5. Calculate the entropy change of n-hexane when $1mol$ of it evaporates at $341.7K\left(\Delta_{vap}H^{\Theta}=290.0kJmol^{-1}\right)$

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6. The following data is known for melting of $KCI:\Delta S^{\Theta} = 0.007kJK^{-1}mol^{-1}, \Delta H^{\Theta} = 7.25kJmol^{-1}$ Calculate the melting point of KCI.

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7. Calculate the change in entropy for the following reaction

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

Given:

$S^{\Theta}_{CO}(g) = 197.6JK^{-1}mol^{-1}$

$S^{\Theta}_{O_2}(g) = 205.03JK^{-1}mol^{-1}$

$S^{\Theta}_{CO_2}(g) = 213.6JK^{-1}mol^{-1}$

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8. Calculate the change of entropy, $\Delta_r S^{\Theta}$ at $298K$ for the reaction in which urea is formed from NH_3 and CO_2.

$2NH_3(g) + CO_2(g) \rightarrow NH_2CONH_2(aq) + H_2O(l)$

The standard entropies $\left(JK^{-1}mol^{-1}\right)$ are:

$NH_2CONH_2(aq) = 174.0, H_2O(l) = 69.9$

$NH_3(g) = 192.3, CO_2(g) = 213.7$

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9. Calculate the change in entropy for the following reaction

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

Given:

$S^{\Theta}_{CO}(g) = 197.6JK^{-1}mol^{-1}$

$S^{\Theta}_{O_2}(g) = 205.03JK^{-1}mol^{-1}$

$S^{\Theta}_{CO_2}(g) = 213.6JK^{-1}mol^{-1}$

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10. Calculate the entropy change at $298K$ for the reaction

$Br_2(l) + CI_2(g) \rightarrow 2BrCI(g)$

$\Delta H = 29.3kJat298K$. The entropies of $Br_2(l)$, $CI_2(g)$, and $BrCI(g)$ at the above temperature and $152.3, 223.0$ and $239.7Jmol^{-1}K^{-1}$ respectively.

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11. Calculate the standard molar entropy change for the formation of gaseous propane $\left(C_3H_8\right)$ at $293K$.

$3C(\text{graphite}) + 4H_2(g) \rightarrow C_3H_8(g)$

Standard molar entropies $S_m^{\Theta}\left(JK^{-1}mol^{-1}\right)$are:

$C(\text{graphite}) = 5.7, H_2(g) = 130.7, C_3H_5(g) = 270.2$

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12. Calculate the enthalpy of vaporisation per mole for ethanol. Given $\Delta S = 109.8JK^{-1}mol^{-1}$ and boiling point of ethanol is 78.5°.

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13. The change in entropy of an ideal gas during reversible isothermal expansion is

A. Negative

B. Positive

C. Zero

D. Infinite

Answer: B

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14. The total entropy change for a system and its surroundings increases, if the process is

A. Reversible

B. Irreversible

C. Exothermic

D. Endithermic

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15. The free energy change for a reversible reaction at equilibrium is

A. Zero

B. Positive

C. Negative

D. None

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16. Which statement (s) is/are true?

1. S^{Θ} values for all elements in their states are positive.

2. S^{Θ} values for all aqueous ions are positive.

3. ΔS^{Θ} values for all spontaneous reactions are positive.

A. 1 only

B. 1 and 2 only

C. 2 and 3 only

D. All

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Ex 6.5

1. Calculated the Gibbs energy change on dissolving one mole of sodium chloride at $25^{\circ} C$.

Lattice $= +777.0 kJmol^{-1}$

Hydration of $NaCI = -774.0 kJmol^{-1}$

ΔS at $25^{\circ} C = 40 JK^{-1} mol^{-1}$

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2. The values of ΔH and ΔS for two reactions are given below:

Reaction $A : \Delta H = -10.0 \times 10^3 J mol^{-1}$

$\Delta S = +30 J K^{-1} mol^{-1}$

Reaction $B : \Delta H = -11.0 \times 10^3 J mol^{-1}$

$\Delta S = -100 J K^{-1} mol^{-1}$

Decide whether these reactions are spontaneous or not at $300K$.

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3. Calculate the temperature above which the reaction of lead oxide to lead in the following reaction become spontaneous.

$PbO(s) + C(s) \rightarrow Pb(s) + CO(g)$

Given $\Delta H = 108.4 kJ mol^{-1}$, $\Delta S = 190 J K^{-1} mol^{-1}$

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4. For the reaction,

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

$\Delta H = -95.0kJ$ and $\Delta S = -19000JK^{-1}$

Calculate the temperature in centigrade at which it will attain equilibrium.

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5. Enthalpy and entropy changes of reaction are $40.63kJmol^{-1}$ and $108.8JK^{-1}mol^{-1}$, respectively. Predict the feasibility of the reaction at $27^\circ C$.

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6. Predict whether it is possible or not to reduce magnesium oxide using carbon at $298K$ according to the reaction.

$MgO(s) + C(s) \rightarrow Mg(s) + CO(g)$

$\Delta_r H^\ominus = +491.18kJmol^{-1}$ and $\Delta_r S^\ominus = 197.67JK^{-1}mol^{-1}$

If not at what temperature, the reaction becomes spontaneous.

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7. The standard Gibbs energy change value $\left(\Delta_r G^{\Theta}\right)$ at $1773K$ are given for the following reactions:

$4Fe + 3O_2 \rightarrow 2Fe_2O_3, \Delta_r G^{\Theta} = -1487kJmol^{-1}$

$4AI + 3O_2 \rightarrow 2AI_2O_3, \Delta_r G^{\Theta} = -22500kJmol^{-1}$

$2CO + O_2 \rightarrow 2CO_2, \Delta_r G^{\Theta} = -515kJmol^{-1}$

Find out the possibility of reducing Fe_2O_3 and AI_2O_3 with CO at this temperature.

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8. In a fuel cell, methanol if used as fuel and oxygen gas is used as an oxidiser. The reaction is

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

Calculated standard Gibbs free enegry change for the reaction that can be converted into electrical work. If standard enthalpy of combustion for methanol is $-702kJmol^{-1}$, calculate the efficiency of conversion of Gibbs energy into useful work.

$\Delta_f G^{\Theta}$ for CO_2, H_2O, CH_3OH, O_2 is $-394.00,\ -237.00,\ -166.00$and $0 kJmol^{-1}$ respectively.

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9. On the basic of the following $\Delta_r G^{\Theta}$ values at $1073K$:

$S_1(s) + 2O_2(g) \rightarrow 2SO_2(g)\Delta_r G^{\Theta} = -544 kJmol^{-1}$

$2Zn(s) + O_2(g) \rightarrow 2ZnO(s)\Delta_r G^{\Theta} = -480 kJmol^{-1}$

$2Zn(s) + S_2(s) \rightarrow 2ZnS(s)\Delta_r G^{\Theta} = -293 KJmol^{-1}$

Show that roasting of zinc sulphide to zince oxide is a spontaneous process.

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10. Consider the reaction:

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)\Delta G^{\Theta} = -1010.5 kJ$

Calculate $\Delta_f G^{\Theta}[NO(g)]$ if $\Delta_f G^{\Theta}\left(NH_3\right) = -16.6 kJmol^{-1}$ and $\Delta_f G^{\Theta}\left[H_2O(l)\right] = -237.2 kJmol^{-1}$.

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11. Calculate the standard Gibbs free energy change from the free energies of formation data for the following reaction:

$$C_6H_6(l) + \frac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(g)$$

Given that $\Delta_fG^{\Theta} = \left[C_6H_6(l)\right] = 172.8kJmol^{-1}$

$\Delta_fG^{\Theta}\left[CO_2(g)\right] = -394.4kJmol^{-1}$

$\Delta_fG^{\Theta}\left[H_2O(g)\right] = -228.6kJmol^{-1}$

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12. Consider the reaction:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

Calculated the standard Gibbs energy change at $298K$ and predict whther the rection is spontaneous or not.

$\Delta_fG^{\Theta}(NO) = 86.69kJmol^{-1}, \Delta_fG^{\Theta}\left(NO_2\right) = 51.84kJmol^{-1}$.

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13. For the water gas reaction,

$C(s) + H_2O(g) \Leftrightarrow CO(g) + H_2(g)$

the standard Gobbs free energy of reaction (at $1000K$) is $-8.1 kJmol^{-1}$. Calculate its equilibrium constant.

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14. Using the following data, calculate the value of equilibrium constant for the following reaction at $298K$

$3HC \equiv CH\text{Acetylene} \Leftrightarrow C_6H_6(g)\text{Benzene}$

Assuming ideal behaviour

$\Delta_f G^{\Theta}(HC \equiv CH) = 2.09 \times 10^5 Jmol^{-1}$

$\Delta_f G^{\Theta}\left(C_6H_6\right) = 1.24 \times 10^5 Jmol^{-1}$,

$R = 8.314 JK^{-1}mol^{-1}$

Can the reaction be recommended for the synthesis of benzene?

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15. The equilibrium constant at $25^{\circ} C$ for the process:

$CO^{3+}(aq) + 6NH_3(aq) \Leftrightarrow \left[Co\left(NH_3\right)_6\right]^{3+}(aq)$ is 2×10^7.

Calculate the value of ΔG^{Θ} at $25^{\circ} Cat25^{\circ} C\left[R = 8.314JK^{-1}mol^{-1}\right]$.

In which direction the reaction is spontaneous when the recatants and proudcts are in standard state?

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16. The standard Gibbs energies $\left(\Delta_f G^{\Theta}\right)$ for the formation of $SO_2(g)$ and $SO_3(g)$ are -300.0 and $-371.0kJmol^{-1}$ at $300K$, respectively. Calculate ΔG and equilibrium constant for the following reaction at $300K$:

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17. It is planned to carry out the reaction:

$CaCO_3(s) \Leftrightarrow CaO(s) + CO_2(g)$ at $1273K$ and 1bar pressure.

$\Delta_r G^{\Theta} = 176kJmol^{-1}$ and $\Delta_r S^{\Theta} = 157.2kJmol^{-1}$

a. Is the reaction spontaneous at this temperature and pressure ?

b. Calculate the value of

i. K_p at $1273K$ for the reaction

ii. partial pressure of CO_2 at equilibrium

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18. The equilibrium constant for the reaction

$CO_2(g) + H_2(g) \Leftrightarrow CO(g) + H_2O(g) at 298K$ is 73. Calculate the value of the standard free enegry change $\left(R = 8.314JK^{-1}mol^{-1}\right)$

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19. Calculated the equilibrium constant for the following reaction at $298K$:

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

$\Delta_f G^{\Theta}\left(H_2O\right) = -237.2kJmol^{-1}, R = 8.314Jmol^{-1}K^{-1}$

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20. The equilibrium constant for the reaction:

$CH_3COOH(l) + C_2H_5OH(l) \Leftrightarrow CH_3COOC_2H_5(l) + H_2O(l)$

has been found to be equal to 4 at $25\,^{\circ}C$. Calculate the free energy change for the reaction.

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21. Calculate the entropy change for a reaction:

$X \rightarrow Y$

Given that $\Delta H^{\Theta} = 28.40kJmol^{-1}$ and equilibrium constant is $1.8 \times 10^{-7} at 298K$.

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22. Calculate the equilibrium constant for the following reaction at $298K$ and 1 atmospheric pressure:

$C(graphite) + H_2O(l) \rightarrow CO(g) + H_2(g)$

Given $\Delta_f H^{\Theta} at 298K$ for $H_2O(l) = -286.0kJmol^{-1}$

for $CO(g) = -110.5kJmol^{-1}$

ΔS^{Θ} at $298K$ for the reaction $= 252.6JK^{-1}mol^{-1}$

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23. For the equilibrium reaction:

$2H_2(g) + O_2(g) \Leftrightarrow 2H_2O(l) at 298K$

$\Delta G^{\Theta} = -474.78kJmol^{-1}$. Calculate log K for it.

$\left(R = 8.314JK^{-1}mol^{-1}\right)$.

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24. Calculate equilibrium constant for the reaction given below at $400K$, if

$\Delta H^{\Theta} = 77.2kJmol^{-1}$ and $\Delta S^{\Theta} = 122JK^{-1}mol^{-1}$

$PCI_5(g) \rightarrow PCI_3(g) + CI_2(g)$

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25. Calculate equilibrium constant for the reaction:

$2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g) at 25\,^\circ C$

Given: $\Delta_f G^{\Theta} SO_3(g) = -371.1 kJmol^{-1}$,

$\Delta_f G^{\Theta} SO_2(g) = -300.2 kJmol^{-1}$

and $R = 8.31 JK^{-1}mol^{-1}$

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26. $C_2H_4 + CI_2 \rightarrow C_2H_4CI_2$

$\Delta H = -270.6 kJmol^{-1}K^{-1}, \Delta S = -139 J$

a. Is the reaction favoured by entropy, enthalpy both or none?

b. Find ΔG if $T = 300K$.

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27. Calculate free energy change for the reaction:

$H_2(g) + CI_2(g) \rightarrow 2H - CI(g)$ by using the bond enegry and entropy data.

Bond energies of $H - H, CI - CI,$ and $H - CI$ bonds are $435, 240,$ and

$430kJmol^{-1}$, respectively. Standard entropies of H_2, CI_2, and HCI are 130.59, 222.95, and $186.68JK^{-1}mol^{-1}$, respectively.

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28. For the reaction,

$4C(gra\phi te) + 5H_2(g) \rightarrow nC_4H_{10}(g)$,

$\Delta H^{\ominus} = -124.73kJmol^{-1}, \Delta S^{\ominus} = -365.8JK^{-1}mol^{-1}$

$4C(gra\phi te) + 5H_2(g) \rightarrow iso - C_4H_{10}(g)$

$\Delta H^{\ominus} = -131.6kJmol^{-1}, \Delta S^{\ominus} = -381.079JK^{-1}mol^{-1}$

Indicate whther normal butane can be spontaneously converted to iso-butane or not.

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29. A chemical reaction cannot occur at all if its

A. ΔH values is positive and ΔS value if negative

B. ΔH value is negative and ΔS value is positive

C. ΔH and ΔS values are negative but $\Delta H < T\Delta S$

D. ΔH and ΔS values are positive but $\Delta H < T\Delta S$

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30. Calculate the standard free energy change for the reaction:

$H_2(g) + I_2(g) \rightarrow 2HI(g), \Delta H^{\Theta} = 51.9 kJmol^{-1}$

Given: $S^{\Theta}\left(H_2\right) = 130.6JK^{-1}mol^{-1}$,

$S^{\Theta}\left(I_2\right) = 116.7JK^{-1}mol^{-1}$

and $S^{\Theta}(HI) = -206.8JK^{-1}mol^{-1}$.

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Exercises (Subjective)

1. Ethylene on combustion gives carbon dioxide and water. Its heat of combustion is $1410.0kJmol^{-1}$. If the heat of formation of CO_2 and H_2O are

$393.3kJ$ and $286.2kJ$, respectively. Calculate the heat of formation of ethylene.

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2. Calculate the heat of formation of acetic acid form the following date:

a. $CH_3COOH(l) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)\Delta H^{\Theta} = -200.0kcal$

b. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H^{\Theta} = -94.0kcal$

c. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^{\Theta} = -68.0kcal$

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3. State the third law of thermodynamics.

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4. Calculate the heat of formation of anhydrous Al_2Cl_6 from the following data:

(i) $2Al + 6HCl(aq) \rightarrow Al_2Cl_6(aq) + 3H_2(g), \Delta H = -239.76kcal$

(ii) $Al_2Cl_6(s) + aq \rightarrow Al_2Cl_6(aq), \Delta H = -153.69kcal$

(iii) $H_2(g) + Cl_2(g) \rightarrow 2HCl(g), \Delta H = -44kcal$

(iv) $HCl(g) + aq \rightarrow HCl(aq), \Delta H = -17.31kcal$

A. $2AI(s) + 6HCI(aq) \rightarrow AI_2CI_6(aq) + 3H_2 + 1004.2kJ$

B. $H_2(g) + CI_2(g) \rightarrow 2HCI(g) + 184.1kJ$

C. $HCI(g) + aq \rightarrow HCI(aq) + 73.2kJ$

D. $AI_2CI_6(s) + aq \rightarrow AI_2CI_6(aq) + 643.1kJ$

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5. Calculate the heat of formation of n butane from the followinf data:

a. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l), \Delta H = -5757.2kJ$

b. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = -405.4kJ$

c. $2H_2(g) + O_2(g) \rightarrow 2H_2O(l), \Delta H = -572.4kJ$

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6. Calculate the heat of combustion of benzene form the following data:

a. $6C(s) + 3H_2(g) \rightarrow C_6H_6(l), \Delta H = 49.0kJ$

b. $H_2(g) + 1/2O_2(g) \rightarrow H_2O(l), \Delta H = - 285.8kJ$

c. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = - 389.3kJ$

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7. If $2AI(s) + 1\frac{1}{2}O_2(g) \rightarrow AI_2O_3(s), \Delta H = - 1667.8kJ$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = - 285.9kJ$

Calculate ΔH for the reaction

$AI_2O_3(s) \rightarrow 2AI(s) + 1\frac{1}{2}O_2(g)$

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8. The thermochemical equation for solid and liquid rocket fuel are given below:

$2AI(s) + 1\frac{1}{2}O_2(g) \rightarrow AI_2O_3(s), \Delta H = - 1667.8kJ$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -285.9kJ$

a. If equal masses of aluminium and hydrogen are used, which is a better rocket fuel?

b. Determine ΔH for the reaction

$AI_2O_3(s) \rightarrow 2AI(s) + 1\frac{1}{2}O_2(g)$

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9. When $1g$ liquid naphthalene $\left(C_{10}H_8\right)$ solidifies, $149J$ of heat is evolved. Calculate the enthalpy of fusion of naphthalene.

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10. a. A cylinder of gas is assumed to contain $11.2kg$ of butane. If a normal family needs $20000kJ$ of energy per day for cooking, how long will the cylinder last? Given that the heat of combustion of butane is $2658kJmol^{-1}$.

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11. The free enegry changes for the two reactions given below are

a. $SO_2(g) + CI_2(g) \rightarrow SO_2CI_2(g), \Delta G = -2270cal$

b. $S(\rho m) + O_2(g) + CI_2(g) \rightarrow SO_2CI_2(g), \Delta G = -74060cal$

Find ΔG for the reaction $S(\rho m) + O_2(g) \rightarrow SO_2(g)$

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12. Given that:

i. $C(\text{graphite}) + O_2(g) \rightarrow CO_2(g), \Delta H = -393.7kJ$

ii. $C(\text{diamond}) \rightarrow C(\text{graphite}), \Delta H = -2.1kJ$

a. Calculate ΔH for buring of diamond of CO_2.

b. Calculate the quantity of graphite that must be burnt to evolve $5000kJ$ of heta.

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13. Given:

i. $H(g) + CI(g) \rightarrow HCI(g)\Delta H = -431kJ$

ii. $HCI(g) + aq \rightarrow H^{\oplus}(aq) + CI^{\ominus}(aq)\Delta H = -75.1kJ$

iii. $H(g) \rightarrow H^{\oplus}(aq) + e^{-}\Delta H = 1317kJ$

iv. $CI(g) + e^{-} \rightarrow cI^{\ominus}(g)\Delta H = -354kJ$

a. Calculate the enthalpy of hydration of HCI

$H^{\oplus}(g) + CI^{\ominus}(g) + aq \rightarrow H^{\oplus}(aq) + CI^{\ominus}(aq)$

b. Calculate teh enthalpy of hydration of $CI^{\ominus}$ ions if enthalpy of hydration of $H^{\oplus}$ is zero.

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14. Given:

$NaCI(s) + aq \rightarrow Na^{\oplus}(aq) + CI^{\ominus}\Delta H = 3.9kJ$

$Na^{\oplus}(g) + CI^{\ominus}(g) \rightarrow NaCI(s)\Delta H = -788kJ$

$CI^{\ominus}(g) + aq \rightarrow CI^{\ominus}(aq)\Delta H = -394.1kJ$

Calculate the enthalpy of hydration of $Na^{\oplus}$ ions.

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15. What would be the heat released when:

A. 0.5 mol of HCI is neutralised with 0.5 mol of $NaOH$

B. 0.5 mol of HNO_3 is neutralised with 0.3 mol of $NaOH$

C. $100ml$ of $0.2MHCI + 200ml$ of $0.2MKOH$

D. $200ml$ of $0.1MH_2SO_4 + 150ml$ of $0.2MKOH$

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16. Enthalpy of neutralisation of acetic acid by $NaOh$ is $-50.6kJmol^{-1}$. Calculate ΔH for ionisation of CH_3COOH. Given. The heat of neutralisation of a strong acid with a strong base is $-55.9kJmol^{-1}$.

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17. The bond energies of $C = C$ and $C - C$ at $298K$ are 590 and $331kJmol^{-1}$, respectively. The enthalpy of polymerisation per mole of ethaylene is

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18. An athelete is given $100g$ of glucose $\left(C_6H_{12}O_6\right)$ of energy equivalent to $1560kJ$. He utilises 50% of this gained enegry in the event. In order to avoid storage of enegry in the body, calculate the weight of water he would need to perspire. The enthalpy of evaporation of water is $441kJ/mol$.

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19. How much heat is liberated when one mole of gaseous $Na^{\oplus}$ combines with one mole of Cl^{Θ} ion to form solid $NaCl$. Use the data given below:

$$Na(s)+\frac{1}{2}Cl_2(g)\rightarrow NaCl(s) \qquad \Delta H = -98.23kcal$$

$$Na(s)\rightarrow Na(g) \qquad \Delta H = +25.98kcal$$

$$Na(g)\rightarrow Na^{\oplus}+e^- \qquad \Delta H = +120.0kcal$$

$$Cl_2(g)\rightarrow 2Cl(g) \qquad \Delta H = +58.02kcal$$

$$Cl^{\Theta}(g)\rightarrow Cl(g)+e^- \qquad \Delta H = +87.3kcal$$

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20. State a chemical reaction in which ΔH and ΔU are equal .

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21. Which of the following is an intensive property. Surface tension, mass, volume, enthalpy, density

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22. State the first law of thermodynamics.

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23. For the reactions, $N_2(g)+3H_2(g)\rightarrow 2NH_3(g)$ predict, whether the work is done on the system or by the system.

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24. Which has larger absolute entropy per mole?

a. $H_2O(l)at298K \text{ or } H_2O(l)at350K$.

b. N_2or Ne both at$298K$

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25. The dissolution of ammonium chloride in water is an endothermic process but still it dissolves in water readily. Why ?

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26. Does an aqueous solution of Mg^{2+} ions have larger entropy before or after hydration of the ions?

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27. Predict the sign of ΔG for the reaction at a very low temperature for which $\Delta His + ve$ and ΔS is positive.

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28. ΔH and $\Delta S are + ve$. Under what conditions, process will be spontaneous?

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29. What is the limitation of the first law of thermodynamics?

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30. Which of the following is an extensive property?

A. Volume

B. Surface tension

C. Viscosity

D. Density

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31. Which one of the following is a state property/function?

A. $U + PV$

B. $q + w$

C. $\frac{q_{rev}}{T}$

D. q

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32. The heat of combustion of $H_2(g)$ at constant pressure and $300k$ is $-280kJmol^{-1}$. What will be the heat of combustion at constant volume and at $300K$?

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33. The standard absolute entropy of a substance, $\left(S^{\Theta}\right)$ is the entropy of the substance in its standard state at 1 atm, temperature being

A. $0K$

B. $298K$

C. $398K$

D. $273K$

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34. If the enthalpy of combustion of diamond and graphite are $-395.4kJmol^{-1}$ and $-393.6kJmol^{-1}$, what is enthalpy change for the $C(\text{graphite}) \rightarrow C(\text{diamond})$?

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35. For a spontaneous process, which of the following is always true?

A. $\Delta G > 0$

B. $\Delta_{\text{total}} S < 0$

C. $T\Delta S > 0$

D. $\Delta G < 0$

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36. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g) \Delta H = -242 kJmol^{-1}$

Bond energy of H_2 and O_2 is 436 and $500 kJmol^{-1}$, respectively. What is bond energy of $O - H$ bond?

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37. Which one of the following has the same value as $\Delta_f H^{\Theta}, CO$?

A. (a) $\frac{1}{2}\Delta_f H^{\Theta}\left(CO_2\right)$

B. (b) $\frac{1}{2}\Delta_c H^{\Theta}(\text{graphite})$

C. (c) $\Delta_f H^{\Theta}\left(CO_2\right)$ - $\Delta_f H^{\Theta}(\text{graphite})$

D. (d) $\Delta_c H^{\Theta}(\text{graphite})$ - $\Delta_c H^{\Theta}(CO)$

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38. For which of the following processes is ΔS negative?

A. $H_2(g) \rightarrow 2H(g)$

B. $N_2(g, 1atm) \rightarrow N_2(g, 5atm)$,

C. $2SO_3(g) \rightarrow 2SO_2(g) + O_2(g)$

D. $C(\text{diamond}) \rightarrow C(\text{graphite})$

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39. Predict $\Delta H > \Delta U$ or $\Delta H < \Delta U$.

a. $C(\text{graphite}) + O_2(g) \rightarrow CO_2(g)$

b. $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

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40. What is significance of $T\Delta S$ in $\Delta G = \Delta H - T\Delta S$?

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41. What is the physical significance of free energy?

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42. How does $T\Delta S$ determine the spontaneity of process?

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43. $N_2(g) + 3H_2(g) \rightarrow 2NH_3 : \Delta H = -92kJ$ is Haber's process for manufacture of NH_3. What is the heat of formation of NH_3?

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44. The energy released in the neutralisation of H_2SO_4 and KOH is $59.1kJ$. Calculated the value ΔH for the reaction

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

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45. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta H = -890kJ$

what is the calorific or fuel value of $1kg$ of CH_4?

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46. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g) + 185kJ$. State whether this reaction is exo or endothermic and why?

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47. The heat of neutralization of a strong acid by a strong base is a constant because :

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48. Explain why heat of neutralisation of strong acid and weak base is less than $57.1kJ$.

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49. Find the enthalpy of formation of hydrogen flouride on the basis of following data:

Bond energy of $H - H$ bond $= 434kJmol^{-1}$

Bond energy of $F - F$ bond $= 158kJmol^{-1}$

Bond enegry of $H - F$ bond $= 565kJmol^{-1}$

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50. Calculate the enthalpy of formation of water, given that the bond energies of $H - H, O = O$ and $O - H$ bond are $433kJmol^{-1}$, $492kJmol^{-1}$, and $464kJmol^{-1}$, respectively.

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51. Calculate the resonance enegry of $NO_2(:O - N = O:)$

The measured enthalpy formation of $NO_2\left(\Delta_f H^{\Theta}\right)$ is $34kJmol^{-1}$. The bond energies given are:

$N - O \Rightarrow 222kJmol^{-1}$

$N \equiv N \Rightarrow 946kJmol^{-1}$

$O = O \Rightarrow 498kJmol^{-1}$

$N = O \Rightarrow 607kJmol^{-1}$

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52. Boiling point of an organic compound is $310K$. Its enthalpy of vaporisation per mole $\Delta_{vap}H$ is $27.9kJmol^{-1}$. Calculate the entropy of vaporisation $\Delta_{vap}S$ of organic compound.

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53. Predict whether the following reaction is possible or not at $300k$.

$2CuO(s) \rightarrow Cu_2O(s) + 1/2O_2(g)$

$\Delta H = -144.6kJmol^{-1}, \Delta S = 0.116kJmol^{-1}$

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54. Calculate the standard free energy change for the reaction:

$H_2(g) + I_2(g) \rightarrow 2HI(g), \Delta H^{\Theta} = 51.9kJmol^{-1}$

Given: $S^{\Theta}\left(H_2\right) = 130.6JK^{-1}mol^{-1}$,

$S^{\Theta}\left(I_2\right) = 116.7JK^{-1}mol^{-1}$

and $S^{\Theta}(HI) = 206.8JK^{-1}mol^{-1}$.

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55. Calculate the entropy change for the following reaction

$H_2(g) + CI_2(g) \rightarrow 2HCI(g)at298K$

Given $S^{\Theta}H_2 = 131JK^{-1}mol^{-1}, S^{\Theta}CI_2 = 233JK^{-1}mol^{-1},$ and $S^{\Theta}HCI = 187JK^{-1}mol^{-1}$

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56. Heat of neutralisation between HCI and $NaOH$ is $13.7kcal$ and between HCN and $NaOH$ is 3kcal at 45 $^{\circ}C$. Calculate the heat of ionisation of HCN

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57. Find the heat of formation of ethyl alcohol for following data

$C(s) + O_2(g) \rightarrow CO_2(g)\Delta H = -94kcal$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l), \Delta H = -68kcal$

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)\Delta H = -327kcal$

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58. Enthalpy of neutralisation of acetic acid by $NaOH$ is $-50.6kJmol^{-1}$. Calculate ΔH for ionisation of CH_3COOH. Given. The heat of neutralisation of a strong acid with a strong base is $-55.9kJmol^{-1}$.

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59. The enthalpies of combustion of carbon and carbon monoxide in excess of oxygen at $298K$ and constant pressure are -393.5 and $-283.0kJmol^{-1}$, respectively. Calculate the heat of formation of carbon monoxide at constant volume.

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60. Calculate the ΔH^{Θ} for the reduction of $Fe_2O_3(s)$ by $AI(s)$ at $25^{\circ}C$. The enthalpies of formation of Fe_2O_3 and AI_2O_3 are -825.5 and $-1675.7kJmol^{-1}$ respectively.

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61. Find ΔH of the following reaction:

$OF_2(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g)$, average bond energies of $O-F, O-H, O=O$, and $H-F$ are $44, 111, 118$, and $135 kcal mol^{-1}$, respectively.

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62. The heat of formation of ethane is $-19.46 kcal$. Bond enegries of $H-H, C-H$ and $C-C$ bonds are $104.18, 99.0$ and $80.0 kcal$, respectively. Calculate the heat of atomisation of graphite.

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63. Find the electron affinity of chlorine from the following data. Enthalpy of formation of $LiCI$ is $-97.5 kcal mol^{-1}$, lattice energy of $LiCI = -197.7 kcal mol^{-1}$. Dissociation energy of chlirine is $57.6 kcal mol^{-1}$, sublimation enthalpy of lithium $= +38.3 kcal mol^{-1}$, ionisation energy of lithium $= 123.8 kcal mol^{-1}$.

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64. When $10g$ of AI is used for reduction in each of the following alumino thermic reactions.Which reaction would generate more heat & by how much?

a. $2AI + Cr_2O_3 \rightarrow AI_2O_3 + 2Cr$

b. $2AI + Fe_2O_3 \rightarrow AI_2O_3 + 2Fe$

Standard heat of formation of $AI_2O_3, Cr_2O_3,$ and Fe_2O_3 are $-1676kJ$, $-1141kJ$, and $-822.2kJ$, respectively.

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65. The heat of combustion at constant volume at $27^\circ C$ of benzene and acetylene are $-800kcal$ and $310kcal$. Find the heat of polymerisation of acetylene to benzene at constant pressure.

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66. Calculate $\Delta_f H^{\Theta} ICI(g)$ from the data

ΔH dissociation $CI_2(g) = 57.9kcalmol^{-1}$

ΔH dissociation $I_2(g) = 36.1kcalmol^{-1}$

ΔH dissociation $ICI(g) = 50.5kcalmol^{-1}$

ΔH sublimation $I_2(g) = 15.0kcalmol^{-1}$

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67. Calculate heat of dissociation for acetic acid from the following data:

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O \Delta H = -13.2kcal$

$H^{\oplus} + \overset{\Theta}{OH} \rightarrow H_2O, \Delta H = -13.7kcal$

Also calculate heat of dissociation for NH_4OH if

$HCI + NH_4OH \rightarrow NH_4CI + H_2O, \Delta H = -12.27kcal$

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68. $\Delta_f H^{\Theta}$ per mole of $NH_3(g)$. $NO(g)$, and $H_2O(l)$ are $-11.04 + 21.60$ and $-68.32 kcal$, respectively. Calculate the standard heat of reaction at constant pressure and at a constant volume for the reaction:

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

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69. From the following data, calculate the standard enthalpy of formation of propane $\Delta_f H^{\Theta} CH_4 = -17 kcal mol^{-1}$

$\Delta_f H^{\Theta} C_2H_6 = -24 kcal mol^{-1}, BE(C - H) = 99 kcal mol^{-1}$

$(C - C) = 84 kcal mol^{-1}$.

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70. $CsOH + HCI \rightarrow CsCI + H_2O, \Delta H = -13.4 kcal mol^{-1} .... (i)$

$CsOH + HF \rightarrow CsF + H_2O, \Delta H = -16.4 kcal mol^{-1} ....(ii)$

Calculate ΔH for the ionisation of HF in H_2O.

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Exercises (Linked Comprehension)

1. When $CaCO_3$ is heated to a high temperature, it undergoes decomposition into CaO and CO_2 whereas it is quite stable at room temperature. The most likely explanation of its is

A. The enthalpy of reaction (ΔH) overweighs the term $T\Delta S$ at high temperature.

B. The term $T\Delta S$ overweights the enthalpy of reaction at high temperature

C. At high temperature, both enthalpy of reaction and entropy change becomes negative.

D. None of these.

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2. Gibbs-Helmoholtz equation relates the free energy change to the enthalpy and entropy changes of the process as

$(\Delta G)_{PT} = \Delta H - T\Delta S$

The magnitude of ΔH does not change much with the change in temperature but the energy factor $T\Delta S$ changes appreciably. Thus, spontaneity of a process depends very much on temperature.

For the reaction at $25^0 C, X_2O_4(l) \rightarrow 2XO_2$

$\Delta H = 2.0kcal$and $\Delta S = 20calK^{-1}$. the reaction would be

A. Spontanoeous

B. At equilibrium

C. Unpredictable

D. Non-spontaneous

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3. Gibbs-Helmoholtz equation relates the free energy change to the enthalpy and entropy changes of the process as

$(\Delta G)_{PT} = \Delta H - T\Delta S$

The magnitude of ΔH does not change much with the change in temperature but the enrgy factor $T\Delta S$ changes appreciably. Thus, spontaneity of a process depends very much on temperature.

For the reaction at $298K$, $2A + B \rightarrow C$

$\Delta H = 100kcal$ and $\Delta S = 0.020kcalK^{-1}$. If ΔH and ΔS are assumed to be constant over the temperature range, at what temperature will the reaction become spontaneous?

A. $1000K$

B. $3500K$

C. $5000K$

D. $1500K$

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4. Gibbs-Helmoholtz equation relates the free energy change to the enthalpy and entropy changes of the process as

$(\Delta G)_{PT} = \Delta H - T\Delta S$

The magnitude of ΔH does not change much with the change in temperature but the energy factor $T\Delta S$ changes appreciably. Thus, spontaneity of a process depends very much on temperature.

A reaction has value of $\Delta H = 20kcal$ at $200K$, the reaction is spontaneous, below this temperature, it is not. the values ΔG and ΔS at $200K$ are, respectively

A. $10, -0.1calK^{-1}$

B. $-10kcal, -100calK^{-1}$

C. $0, 10.0calK^{-1}$

D. $0, 100calK^{-1}$

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5. Gibbs-Helmoholtz equation relates the free energy change to the enthalpy and entropy changes of the process as

$(\Delta G)_{PT} = \Delta H - T\Delta S$

The magnitude of ΔH does not change much with the change in temperature but the enrgy factor $T\Delta S$ changes appreciably. Thus, spontaneity of a process depends very much on temperature.

The enthalpy change for a certain reaction at $300K$ is $-15.0kcalmol^{-1}$. The entropy change under these conditions is $-7.2calK^{-}mol^{-1}$. The free enegry change for the reaction and its spontaneous//nonspontaneous character will be

A. $-12.84kcalmol^{-1}$, spontaneous

B. $-12.16kcalmol^{-1}$, spontaneous

C. $12.84kcalmol^{-1}$, non spontaneous

D. $12.0kcalmol^{-1}$, spontaneous

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6. Gibbs-Helmoholtz equation relates the free energy change to the enthalpy and entropy changes of the process as

$(\Delta G)_{PT} = \Delta H - T\Delta S$

The magnitude of ΔH does not change much with the change in temperature but the energy factor $T\Delta S$ changes appreciably. Thus, spontaneity of a process depends very much on temperature.

The dissolution of $CaCl_2.6H_2O$ in a large volume of water is endothermic to the extent of $3.5 kcalmol^{-1}$. For the reaction. $CaCl_2(s) + 6H_2O(l) \rightarrow CaCl_2.6H_2O(s) \Delta H is - 23.2 kcal$. The heat of solution of anhydrous $CaCI_2$ in large quantity of water will be

A. $-16.7 kcalmol^{-1}$

B. $-19.7 kcalmol^{-1}$

C. $19.7 kcalmol^{-1}$

D. $16.7 kcalmol^{-1}$

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7. Given that ,

$A(s) \rightarrow A(l) \Delta H = x$

$A(l) \rightarrow A(g), \Delta H = y$

The heat of sublimation of A will be :

A. $x - y$

B. $x + y$

C. $x \text{ or } y$

D. $-(x + y)$

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8. The enthalpy change for chemical reaction is denoted aas $\Delta H^{\ominus}$ and $\Delta H^{\ominus} = H_P^{\ominus} - H_R^{\ominus}$. The relation between enthalpy and internal energy is expressed by equation:

$\Delta H = \Delta U + \Delta nRT$

where $\Delta U =$ change in internal enegry $\Delta n =$ change in number of moles,

$R =$ gas constant.

$H_2(g) + \left(\frac{1}{2}\right)O_2(g) = H_2O(l), \Delta H_{298K} = -68.00kcal$

Heat of voporisation of water at 1 atm and $25\,^\circ C$ is $10.00kcal$. The standard heat of formation (in kcal) of 1 mole vapour a $25\,^\circ C$ is

A. -78.00

B. 78.00

C. $+58.00$

D. -58.00

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9. The enthalpy change for chemical reaction is denoted as $\Delta H^{\ominus}$ and $\Delta H^{\ominus} = H_P^{\ominus} - H_R^{\ominus}$. The relation between enthalpy and internal enegry is expressed by equation:

$\Delta H = \Delta U + \Delta nRT$

where $\Delta U =$ change in internal enegry $\Delta n =$ change in number of moles,

$R =$ gas constant.

For the change, $C_{\text{diamond}} \rightarrow C_{\text{graphite}}, \Delta H = -1.89kJ$, if $6g$ of diamond and $6g$ of graphite are seperately burnt to yield CO_2 the heat liberated in first case is

A. Less than in the second case by $1.89kJ$

B. Less than in the second case by $11.34kJ$

C. Less than in the second case by $14.34kJ$

D. More than in the second case by $0.945kJ$

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10. Which of the following equations corresponds to the definition of enthalpy of formation at $298K$?

A. $C(\text{graphite}) + 2H_2(g) + \frac{1}{2}O_2(l) \rightarrow CH_3OH(g)$

B. $C(\text{diamond}) + 2H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(l)$

C. $2C(\text{graphite}) + 4H_2(g) + O_2(g) \rightarrow 2CH_3OH(l)$

D. $C(\text{graphite}) + 2H_2(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(l)$

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11. The enthalpy change for chemical reaction is denoted as $\Delta H^{\ominus}$ and $\Delta H^{\ominus} = H_P^{\ominus} - H_R^{\ominus}$. The relation between enthalpy and internal energy is expressed by equation:

$\Delta H = \Delta U + \Delta nRT$

where $\Delta U =$ change in internal energy $\Delta n =$ change in number of moles, $R =$ gas constant.

Enthalpy of the system is given as

A. $H = PV$

B. $U + PV$

C. $U - PV$

D. $H = - PV$

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12. The enthalpy change for chemical reaction is denoted aas ΔH^{Θ} and $\Delta H^{\Theta} = H_P^{\Theta} - H_R^{\Theta}$. The relation between enthalpy and internal enegry is expressed by equation:

$\Delta H = \Delta U + \Delta nRT$

where $\Delta U =$ change in internal enegry $\Delta n =$ change in number of moles, $R =$ gas constant.

For a reaction, $2X(s) + 2Y(s) \rightarrow 2C(l) + D(g), \Delta H$ at $27^{\circ} C$ is $-28 kcal mol^{-1}$. ΔU is .....$kcal mol^{-1}$

A. -25.5

B. $+25.5$

C. -28.6

D. 28.4

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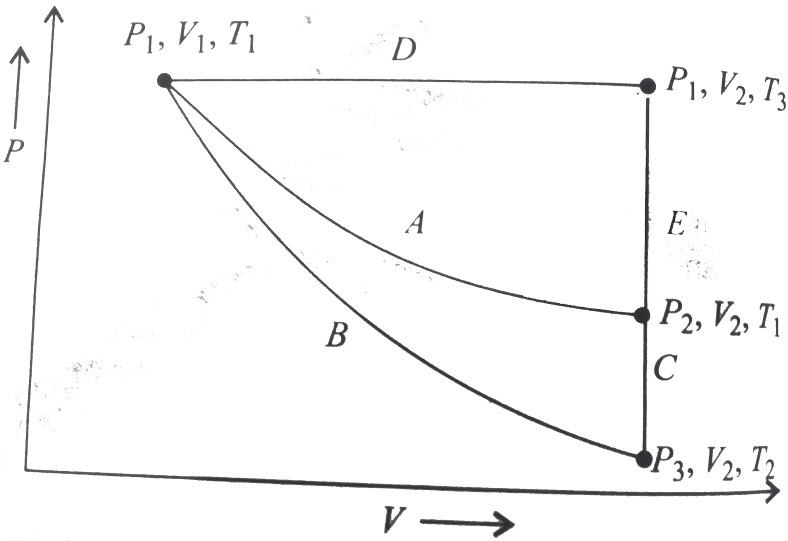
13. For an ideal gas, an illustratio of three different paths $A(B + C)$ and $(D + E)$ from an initial state P_1, V_1, T_1 to a final state P_2, V_2, T_1 is shown in the given figure.



Path Arepresents a reversible isothermal expansion form P_1, V_1 to P_2, V_2, Path $(B + C)$ represents a reversible adiabatic expansion (B) from $P_1, V_1, T_1 \rightarrow P_3, V_2, T_2$ followed by reversible heating the gas at constant volume $(C)$from P_3, V_2, T_2 to P_2, V_2, T_1. Path $(D + E)$ represents a reversible expansion at constant pressure $P_1(D)$ from P_1, V_1, T_1 to P_1, V_2, T_3 followed by a reversible cooling at constant volume $V_2(E)$ from

$P_1, V_2, T_3 \rightarrow P_2, V_2, T_1$.

What is q_{rev}, for path (A)?

A. $P\left(V_2 - V_1\right)$

B. $-nRT_1 In\frac{V_2}{V_1}$

C. $-nRIn\frac{V_2}{V_1}$

D. $-nRT_1 In\frac{V_2}{V_1}$

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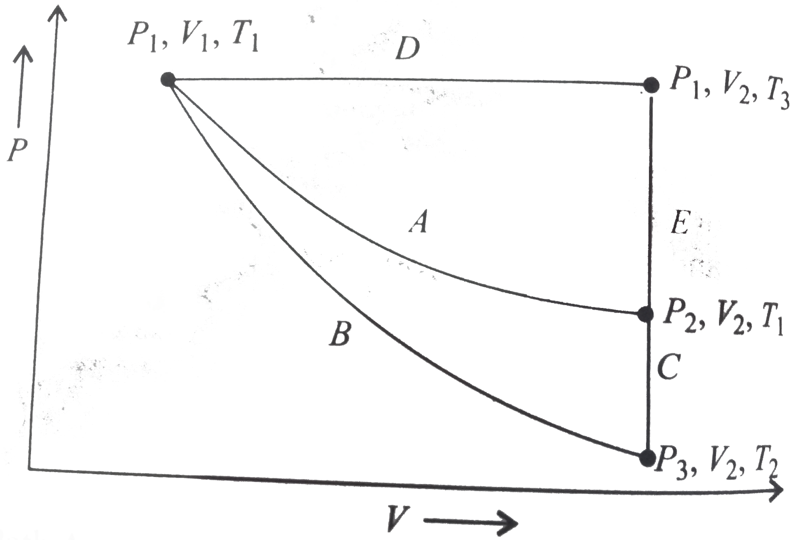
14. For an ideal gas, an illustration of three different paths $A, (B + C)$ and $(D + E)$ from an initial state P_1, V_1, T_1 to a final state P_2, V_2, T_1 is shown in the given figure.



Path Arepresents a reversible isothermal expansion form P_1, V_1 to P_2, V_2, Path $(B + C)$ represents a reversible adiabatic expansion (B) from $P_1, V_1, T_1 \rightarrow P_3, V_2, T_2$ followed by reversible heating the gas at constant volume $(C)$from P_3, V_2, T_2 to P_2, V_2, T_1. Path $(D + E)$ represents a reversible expansion at constant pressure $P_1(D)$ from P_1, V_1, T_1 to P_1, V_2, T_3 followed by a reversible cooling at constant volume $V_2(E)$ from $P_1, V_2, T_3 \rightarrow P_2, V_2, T_1$.

What is q_{rev}, for path A?

A. $nRIn\frac{V_2}{V_1}$

B. $-nRIn\frac{V_2}{V_1}$

C. zero

D. $nRT_1 In\frac{V_2}{V_1}$

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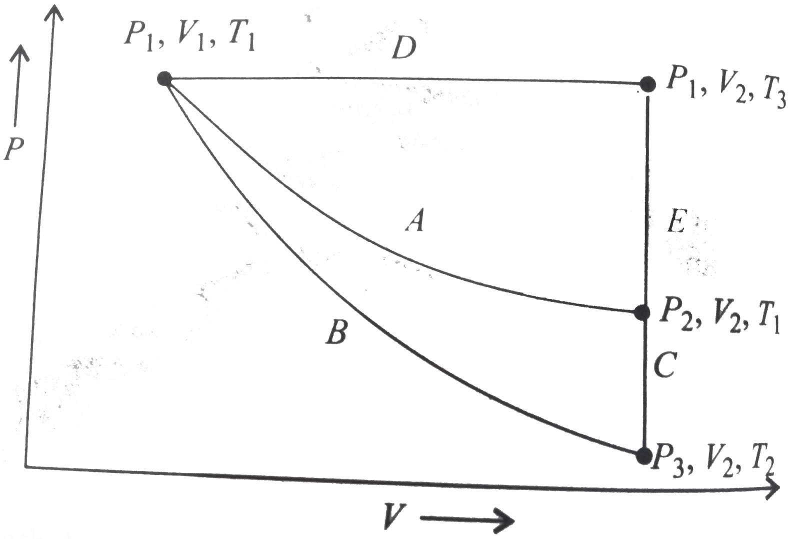
15. For an ideal gas, an illustratio of three different paths $A(B+C)$ and $(D+E)$ from an initial state P_1, V_1, T_1 to a final state P_2, V_2, T_1 is shown in the given figure.



Path Arepresents a reversible isothermal expansion form P_1, V_1 to P_2, V_2, Path $(B+C)$ represents a reversible adiabatic expansion (B) from

$P_1, V_1, T_1 \rightarrow P_3, V_2, T_2$ followed by reversible heating the gas at constant volume $(C)$from P_3, V_2, T_2 to P_2, V_2, T_1. Path $(D+E)$ represents a reversible expansion at constant pressure $P_1(D)$ from P_1, V_1, T_1 to P_1, V_2, T_3 followed by a reversible cooling at constant volume $V_2(E)$ from $P_1, V_2, T_3 \rightarrow P_2, V_2, T_1$.

What is ΔS for path A?

A. $nRIn\dfrac{V_2}{V_1}$

B. $P\left(V_2 - V_1\right)$

C. $-P\left(V_2 - V_1\right)$

D. $nR\left(V_2 - V_1\right)$

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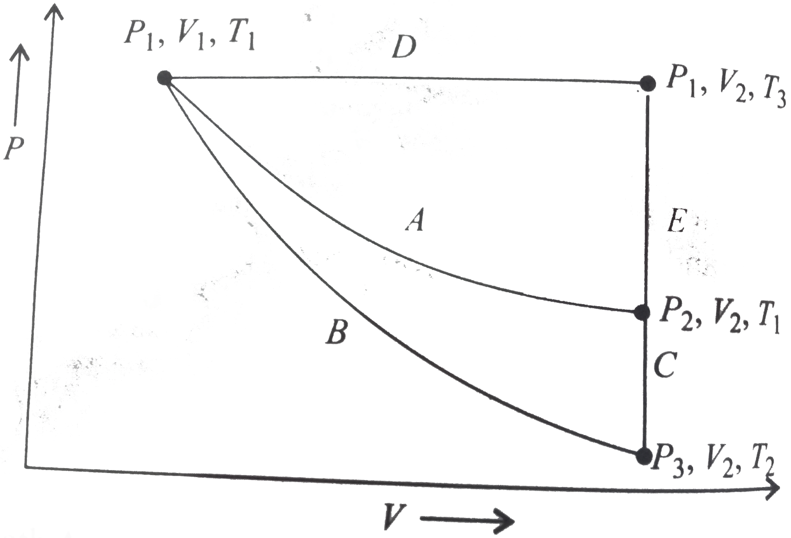
16. For an ideal gas, an illustratio of three different paths $A(B+C)$ and $(D+E)$ from an initial state P_1, V_1, T_1 to a final state P_2, V_2, T_1 is shown in the given figure.



Path Arepresents a reversible isothermal expansion form P_1, V_1 to P_2, V_2, Path $(B + C)$ represents a reversible adiabatic expansion (B) from $P_1, V_1, T_1 \rightarrow P_3, V_2, T_2$ followed by reversible heating the gas at constant volume $(C)$from P_3, V_2, T_2 to P_2, V_2, T_1. Path $(D + E)$ represents a reversible expansion at constant pressure $P_1(D)$ from P_1, V_1, T_1 to P_1, V_2, T_3 followed by a reversible cooling at constant volume $V_2(E)$ from $P_1, V_2, T_3 \rightarrow P_2, V_2, T_1$.

What is q_{rev}, for path $(D + E)$?

A. $P\left(V_2 - V_1\right)$

B. $\int_{T_3}^{T_1} \frac{C_V(T)}{T} dT$

C. $nRIn\frac{V_2}{V_1}$

D. $\int_{T_1}^{T_3} C_V(T)dT$

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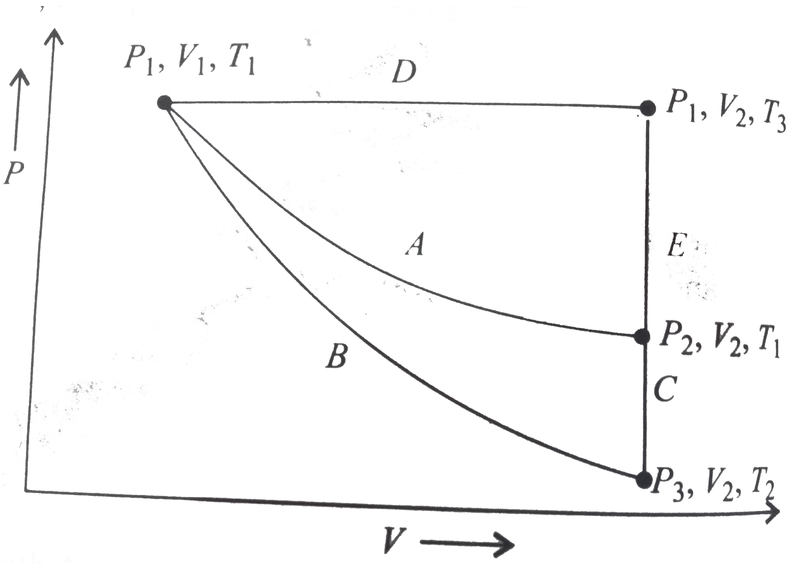
17. For an ideal gas, an illustratio of three different paths $A(B+C)$ and $(D+E)$ from an initial state P_1, V_1, T_1 to a final state P_2, V_2, T_1 is shown in the given figure.



Path Arepresents a reversible isothermal expansion form P_1, V_1 to P_2, V_2, Path $(B+C)$ represents a reversible adiabatic expansion (B) from

$P_1, V_1, T_1 \rightarrow P_3, V_2, T_2$ followed by reversible heating the gas at constant volume $(C)$from P_3, V_2, T_2 to P_2, V_2, T_1. Path $(D + E)$ represents a reversible expansion at constant pressure $P_1(D)$ from P_1, V_1, T_1 to P_1, V_2, T_3 followed by a reversible cooling at constant volume $V_2(E)$ from $P_1, V_2, T_3 \rightarrow P_2, V_2, T_1$.

What is ΔS for path $(D + E)$?

A. $-P\left(V_2 - V_1\right)$

B. $-nRIn\frac{V_2}{V_1}$

C. $+P\left(V_2 - V_1\right)$

D. $nRIn\frac{V_2}{V_1}$

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18. Concrete is produced form a mixture of cement, water and small stones. Small amount of gypsum, $CaSO_4.2H_2O$ is added in cement production to improve the subsequent hardening of concrete. The elevated temperature during the production of cement may lead to the formation of unwanted hemihydrate $CaSO_4\frac{1}{2}H_2O$ according to reaction.

$CaSO_42H_2O(s) \rightarrow CaSO_4\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$

The $\Delta_fH^{\Theta} of CaSO_2.2H_2O(s), CaSO_4\frac{1}{2}H_2O(s), H_2O(g)$ are $-2021.0kJmol^{-1}$, $-1575.0kJmol^{-1}$ and $-241.8kJmol^{-1}$, respectively. The respective values of their standard entropies are $194.0, 130.0$ and $188.0JK^{-1}mol^{-1}$. The values of $R = 8.314JK^{-1}mol^{-1} = 0.0831L$ bar $mol^{-1}K^{-1}$.

Answer the following questions on the basis of above information.

Heat change occurring during conversion of $1kg$ of $CaSO_4.2H_2O(s)$ (molar mass $172gmol^{-1}$) of $CaSO_4\frac{1}{2}H_2O(s)$ is equal to

A. $484kJmol^{-1}$

B. $400kJ$

C. $-484.0kJmol^{-1}$

D. $-1000kJ$

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19. Concrete is produced form a mixture of cement, water and small stones. Small amount of gypsum, $CaSO_4.2H_2O$ is added in coment production to impove the subsequent hardening of concrete. The elevated temperature during the production of cement may lead to the formation of unwanted hemihydrate $CaSO_4\frac{1}{2}H_2O$ according to reaction.

$CaSO_42H_2O(s) \rightarrow CaSO_4\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$

The $\Delta_fH^\Theta of CaSO_2.2H_2O(s), CaSO_4\frac{1}{2}H_2O(s), H_2O(g)$ are $-2021.0kJmol^{-1}$, $-1575.0kJmol^{-1}$ and $-241.8kJmol^{-1}$, respectively. The respective values of their standard entropies are $194.0, 130.0$ and $188.0JK^{-1}mol^{-1}$. The values of $R = 8.314JK^{-1}mol^{-1} = 0.0831L$ bar $mol^{-1}K^{-1}$.

Answer the following questions on the basis of above information.

The value of ΔG^Θ for the reaction at $298K$ is

A. $120kJmol^{-1}$

B. $17.92kJmol^{-1}$

C. $-180kJmol^{-1}$

D. $10kJmol^{-1}$

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20. Concrete is produced form a mixture of cement, water and small stones. Small amount of gypsum, $CaSO_4.2H_2O$ is added in coment production to impove the subsequent hardening of concrete. The elevated temperature during the production of cement may lead to the formation of unwanted hemihydrate $CaSO_4\frac{1}{2}H_2O$ according to reaction.

$CaSO_42H_2O(s) \rightarrow CaSO_4\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$

The $\Delta_fH^\Theta ofCaSO_2.2H_2O(s), CaSO_4\frac{1}{2}H_2O(s), H_2O(g)$ are $-2021.0kJmol^{-1}$, $-1575.0kJmol^{-1}$ and $-241.8kJmol^{-1}$, respectively. The respective values of their standard entropies are $194.0, 130.0$ and $188.0JK^{-1}mol^{-1}$ at 298K. The values of $R = 8.314JK^{-1}mol^{-1} = 0.0831L$ bar $mol^{-1}K^{-1}$.

Answer the following questions on the basis of above information.

The value of equilibrium for reaction is

A. $= 0$

B. < 1

C. > 1

D. $= 1$

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21. Concrete is produced form a mixture of cement, water and small stones. Small amount of gypsum, $CaSO_4.2H_2O$ is added in coment production to impove the subsequent hardening of concrete. The elevated temperature during the production of cement may lead to the formation of unwanted hemihydrate $CaSO_4\frac{1}{2}H_2O$ according to reaction.

$CaSO_42H_2O(s) \rightarrow CaSO_4\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$

The $\Delta_f H^{\Theta} of CaSO_2.2H_2O(s), CaSO_4\frac{1}{2}H_2O(s), H_2O(g)$ are $-2021.0kJmol^{-1}$, $-1575.0kJmol^{-1}$ and $-241.8kJmol^{-1}$, respectively. The respective values of their standard entropies are $194.0, 130.0$ and $188.0JK^{-1}mol^{-1}$. The values of $R = 8.314JK^{-1}mol^{-1} = 0.0831L$ bar $mol^{-1}K^{-1}$.

Answer the following questions on the basis of above information.

The equilibrium pressure of water vapour in closed vessel containing

$CaSO_42H_2O(s), CaSO_4\frac{1}{2}H_2O(s)$ and $H_2O(g)$ at $298K$ (Antilog $-3.14 = 7.24 \times 10^{-4}$) is

A. $\left(17.24 \times 10^{-4}\right)$ bar

B. $\left(-7.24 \times 10^{-4}\right)^3$ bar

C. $\left(18 \times 10^{-4}\right)^{2/3}$bar

D. $\left(7.24 \times 10^{-4}\right)^{2/3}$bar

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22. Concrete is produced form a mixture of cement, water and small stones. Small amount of gypsum, $CaSO_4.2H_2O$ is added in coment production to impove the subsequent hardening of concrete. The elevated temperature during the production of cement may lead to the formation of unwanted hemihydrate $CaSO_4\frac{1}{2}H_2O$ according to reaction.

$CaSO_42H_2O(s) \rightarrow CaSO_4\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$

The $\Delta_fH^\Theta ofCaSO_2.2H_2O(s), CaSO_4\frac{1}{2}H_2O(s), H_2O(g)$

are $-2021.0kJmol^{-1}$, $-1575.0kJmol^{-1}$ and $-241.8kJmol^{-1}$, respectively. The respective values of their standard entropies are $194.0, 130.0$ and $188.0JK^{-1}mol^{-1}$. The values of $R = 8.314JK^{-1}mol^{-1} = 0.0831L$ bar $mol^{-1}K^{-1}$. Answer the following questions on the basis of above information.

The formation of $CaSO_4\frac{1}{2}H_2O$at $298K$ is

A. Spontanoeous

B. Endothermic and non-spontaneous

C. Endothermic and non-spontaneous

D. Endothermic and non-spontaneous

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23. A sample of ideal gas undergoes isothermal expansion in a reversible manner from volume V_1 to volume V_2. The initial pressure is P_1 and the final pressure is P_2. The same sample is then allowed to undergoes reversible expansion under adiabatic conditions from volume $V_1 \rightarrow V_2$. The initial pressure being same but final pressure is P_3.

The work of expansion in adiabatic process $\left(w_{adi}\right)$ is related to work of expansion in isothermal process $\left(w_{iso}\right)$ is

A. $w_{adi} = w_{iso}$

B. $w_{adi} < w_{iso}$

C. $w_{adi} = 2w_{iso}$

D. $w_{adi} > w_{iso}$

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24. A sample of ideal gas undergoes isothermal expansion in a reversible manner from volume V_1 to volume V_2. The initial pressure is P_1 and the final pressure is P_2. The same sample is then allowed to undergoes reversible expansion under adiabatic conditions from volume $V_1 \rightarrow V_2$. The initial pressure being same but final pressure is P_3.

Which of the following is correct?

A. $P_1V_1 = P_2V_2$

B. $P_1/P_2 = V_1/V_2$

C. $P_1/P_2 = P_1/P_3$

D. $P_1 = P_2$

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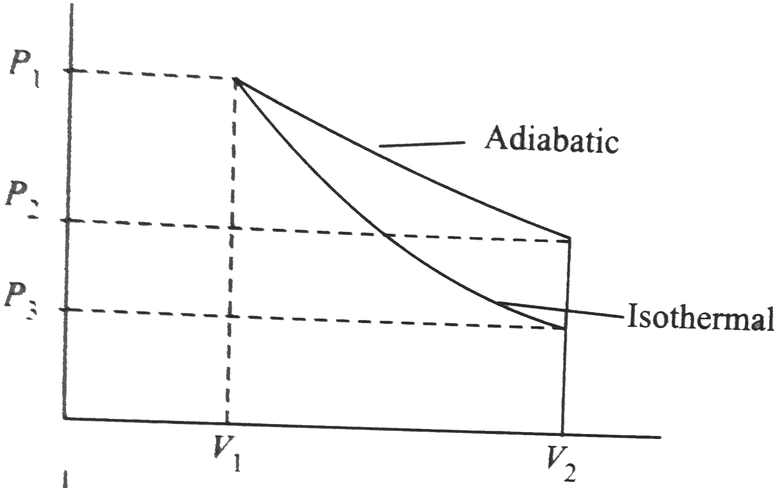
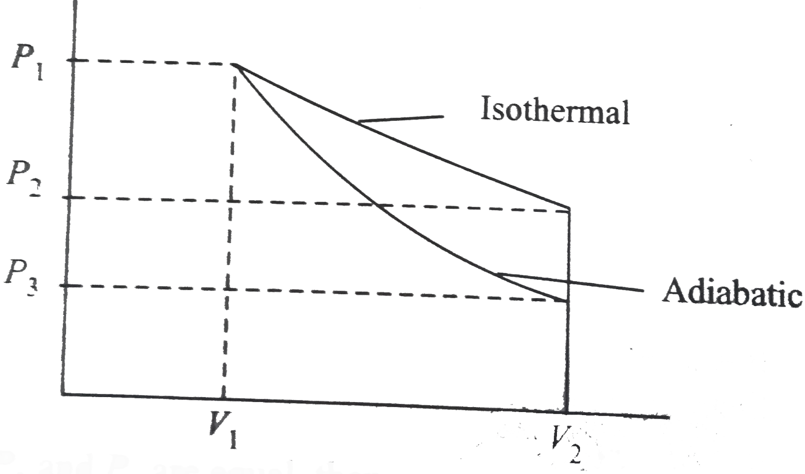
25. A sample of ideal gas undergoes isothermal expansion in a reversible manner from volume V_1 to volume V_2. The initial pressure is P_1 and the final pressure is P_2. The same sample is then allowed to undergoes reversible expansion under adiabatic conditions from volume $V_1 \rightarrow V_2$. The initial pressure being same but final pressure is P_2.

Which graphic representation is correct





a.

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26. A sample of ideal gas undergoes isothermal expansion in a reversible manner from volume V_1 to volume V_2. The initial pressure is P_1 and the final pressure is P_2. The same sample is then allowed to undergoes reversible expansion under adiabatic conditions from volume $V_1 \rightarrow V_2$. The initial pressure being same but final pressure is P_2.

If P_3 and P_2 are equal, then

A. $V_{2(adi)} = V_{2(iso)}$

B. $V_{2(adia)} < V_{2(iso)}$

C. Both $V_{2(adi)} = V_{2(iso)} < V_1$

D. $V_{2(adi)} > V_{2(iso)}$

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27. A sample of ideal gas undergoes isothermal expansion in a reversible manner from volume V_1 to volume V_2. The initial pressure is P_1 and the final pressure is P_2. The same sample is then allowed to undergoes reversible expansion under adiabatic conditions from volume $V_1 \rightarrow V_2$. The initial pressure being same but final pressure is P_3.

Which relation is correct $\left(\gamma = \frac{C_P}{C_V}\right)$?

A. $P_1V_1 = P_2V_3$

B. $P_2V_1 = P_2V_2$

C. $P_1V_1^{\gamma} = P_3V_2^{\gamma}$

D. $\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{\gamma - 1}$

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28. Free enegry , $G = H - TS$, is state function that indicates whther a reaction is spontaneous or non-spontaneous. If you think of TS as the part of the system's enegry that is disordered already, then $(H - TS)$ is the part of the system's energy that is still ordered and therefore free to cause spontaneous change by becoming disordered.

Also, $\Delta G = \Delta H - T\Delta S$ From the second law of thermodynamics, a reaction is spontaneous if $\Delta_{\text{total}}S$ is positive, non-spontaneous if $\Delta_{\text{total}}S$ is negative, and at equilibrium if $\Delta_{, \to tal}S$ is zero.

Since, $-T\Delta S = \Delta G$ and since ΔG and ΔS have opposite sings, we can restate the thermodynamic criterion for the spontaneity of a reaction carried out a constant temperature and pressure.

IF $\Delta G < 0$, the reaction is spontaneous.

If $\Delta G > 0$, the reaction is non-spontaneous.

If $\Delta G = 0$, the reaction is at equilibrium.

Read the above paragraph carefully and answer the following questions based on the above comprehension.

For the spontaneity of a reaction, which statement is true?

A. $\Delta G = +ve, \Delta H = +ve$

B. $\Delta H = +ve, \Delta G = -ve$

C. $\Delta G = -ve, \Delta S = -ve$

D. $\Delta H = -ve, \Delta S = +ve$

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29. Free enegry , $G = H - TS$, is state function that indicates whther a reaction is spontaneous or non-spontaneous. If you think of TS as the part of the system's enegry that is disordered already, then $(H - TS)$ is the part of the system's energy that is still ordered and therefore free to cause spontaneous change by becoming disordered.

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Since, $-T\Delta S = \Delta G$ and since ΔG and ΔS have opposite sings, we can restate the thermodynamic criterion for the spontaneity of a reaction carried out a constant temperature and pressure.

IF $\Delta G < 0$, the reaction is spontaneous.

If $\Delta G > 0$, the reaction is non-spontaneous.

If $\Delta G = 0$, the reaction is at equilibrium.

Read the above paragraph carefully and answer the following questions based on the above comprehension.

A particular reaction has a negative value for the free energy change. Then at ordinary temperature

A. It has a large $(- ve)$ value for the entropy change

B. It has large $(+ ve)$ value for enthalpy change

C. It has a small $(+ ve)$ value for enthalpy change

D. It has a $(+ ve)$ value for the entropy change and a $(- ve)$ value for enthalpy change.

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30. Free enegry , $G = H - TS$, is state function that indicates whther a reaction is spontaneous or non-spontaneous. If you think of TS as the part of the system's enegry that is disordered already, then $(H - TS)$ is the part of the system's energy that is still ordered and therefore free to cause spontaneous change by becoming disordered.

Also, $\Delta G = \Delta H - T\Delta S$ From the second law of thermodynamics, a reaction is spontaneous if $\Delta_{\text{total}}S$ is positive, non-spontaneous if $\Delta_{\text{total}}S$ is negative, and at equilibrium if $\Delta_{' \rightarrow tal}S$ is zero.

Since, $-T\Delta S = \Delta G$ and since ΔG and ΔS have opposite sings, we can restate the thermodynamic criterion for the spontaneity of a reaction carried out a constant temperature and pressure.

IF $\Delta G < 0$, the reaction is spontaneous.

If $\Delta G > 0$, the reaction is non-spontaneous.

If $\Delta G = 0$, the reaction is at equilibrium.

Read the above paragraph carefully and answer the following questions based on the above comprehension.

Which of the following is true for the reaction?

$H_2O(l) \Leftrightarrow H_2O(g) at 100^\circ C$ and 1 atmosphere

A. $\Delta S = 0$

B. $\Delta U = \Delta H$

C. $\Delta H = 0$

D. $\Delta H = T\Delta S$

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31. Free enegry , $G = H - TS$, is state function that indicates whther a reaction is spontaneous or non-spontaneous. If you think of TS as the part of the system's enegry that is disordered already, then $(H - TS)$ is the part of the system's energy that is still ordered and therefore free to cause spontaneous change by becoming disordered.

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IF $\Delta G < 0$, the reaction is spontaneous.

If $\Delta G > 0$, the reaction is non-spontaneous.

If $\Delta G = 0$, the reaction is at equilibrium.

Read the above paragraph carefully and answer the following questions based on the above comprehension.

If an endothermic reaction is non-spontaneous at freezing point of water and becomes feasible at its boiling point, then

A. $\Delta His(- ve)$ and $\Delta Sis(+ ve)$.

B. ΔH and ΔS both are $(+ ve)$.

C. ΔH and ΔS both are $(- ve)$.

D. ΔH is (+ve) and DeltaS is (-ve)`.

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32. Free enegry , $G = H - TS$, is state function that indicates whther a reaction is spontaneous or non-spontaneous. If you think of TS as the part of the system's enegry that is disordered already, then $(H - TS)$ is the part of the system's energy that is still ordered and therefore free to cause spontaneous change by becoming disordered.

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Since, $-T\Delta S = \Delta G$ and since ΔG and ΔS have opposite sings, we can restate the thermodynamic criterion for the spontaneity of a reaction carried out a constant temperature and pressure.

IF $\Delta G < 0$, the reaction is spontaneous.

If $\Delta G > 0$, the reaction is non-spontaneous.

If $\Delta G = 0$, the reaction is at equilibrium.

Read the above paragraph carefully and answer the following questions based on the above comprehension.

One mole of ice si converted to liquid at $273K, H_2O(s)$ and $H_2O(l)$ have entropies 38.20 and $60.03 Jmol^{-1}dg^{-1}$. Enthalpy change in the conversion will be

A. $59.59 Jmol^{-1}$

B. $593.95 Jmol^{-1}$

C. $5959.5 Jmol^{-1}$

D. $59595 Jmol^{-1}$

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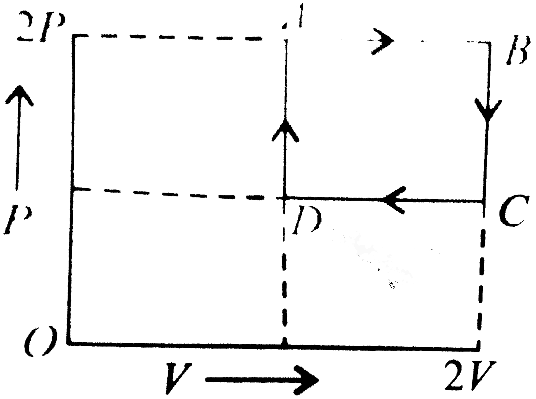
33. The state of a mole of an ideal gas changed from state A at pressure $2P$ and volume V follows four different processes and finally returns to initial state A reversibly as shown below in the graph. By interpreting the graph, answer the following questions.



Which is the kind of process followed from state A to state, B?

A. Isochoric expansion

B. Isobaric expansion

C. Isothermal reversible expansion

D. Isothermal irreversible compression

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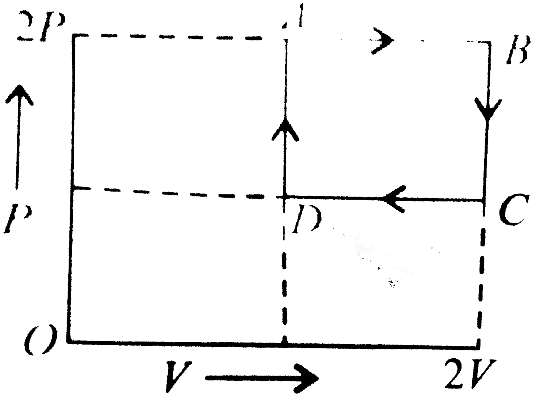
34. The state of a mole of an ideal gas changed from state A at pressure $2P$ and volume V follows four different processes and finally returns to initial state A reversibly as shown below in the graph. By interpreting the graph, answer the following questions.



In state D to state A, what kind of process is followed?

A. Isobaric expansion

B. Isobaric compression

C. Isochoric process

D. Isothermal compression

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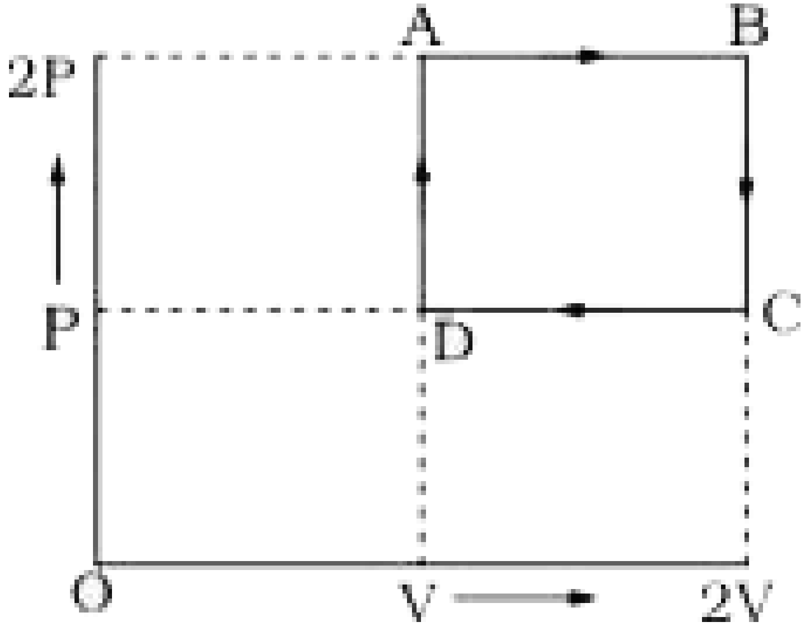
35. The state of a mole of an ideal gas changed from state A at pressure 2P and volume V follows four different processes and finally returns to initial state A reversibly as shown below in the graph. By interpreting the graph, answer the following questions



What would the be total work done by the gas?

A. -PV

B. PV

C. 0

D. None of these

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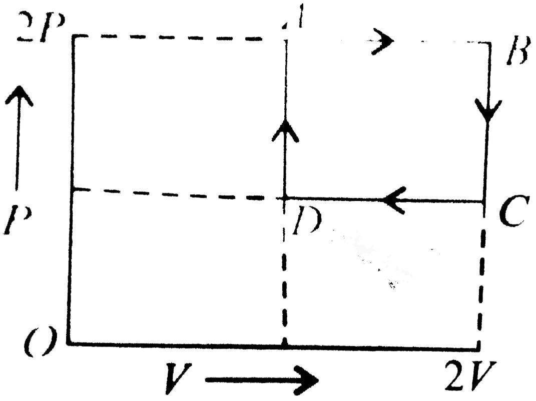
36. The state of a mole of an ideal gas changed from state A at pressure $2P$ and volume V follows four different processes and finally returns to initial state A reversibly as shown below in the graph. By interpreting the graph, answer the following questions.



What would be the work done in state $B \rightarrow C$?

A. -PV

B. PV

C. $2PV$

D. Zero

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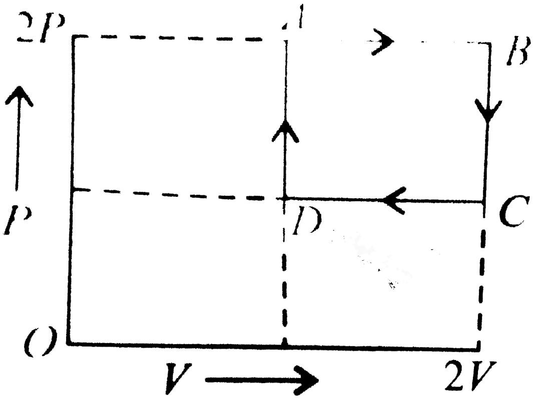
37. The state of a mole of an ideal gas changed from state A at pressure $2P$ and volume V follows four different processes and finally returns to initial state A reversibly as shown below in the graph. By interpreting the graph, answer the following questions.



What would be the heat absorbed by the system in this cyclic process?

A. $-2PV$

B. Zero

C. $2PV$

D. PV

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38. The second law of thermodynamics is a fundamental law of science. In this problem, we consider the thermodynamics of an ideal gas, phase transition, and chemical equilibrium.

Three moles of CO_2 gas expands isothermally (in thermal contact with the surroundings, temperature $= 15.0^\circ C$) against a fixed external pressure of $1.00\overset{-}{\ }$. The initial and final volumes of the gas are $10.0L$ and $30.0L$, respectively.

Select the correct order of the entropy change.

A. $\Delta_{sys}S > 0, \Delta_{surr}S = 0$

B. $\Delta_{sys}S < 0, \Delta_{surr}S > 0$

C. $\Delta_{sys}S > 0, \Delta_{surr}S < 0$

D. $\Delta_{sys}S > 0, \Delta_{surr}S = 0$

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39. The second law of thermodynamics is a fundamental law of science. In this problem, we consider the thermodynamics of an ideal gas, phase transition, and chemical equilibrium.

Three moles of CO_2 gas expands isothermally (in thermal contact with the surroundings, temperature $= 15.0\,^{\circ}C$) against a fixed external pressure of $1.00\,\overline{}$. The initial and final volumes of the gas are $10.0L$ and $30.0L$, respectively.

Assuming CO_2 to be an ideal gas, $\Delta_{sys}S$ is

A. $27.4JK^{-1}$

B. $9.1JK^{-1}$

C. $-27.4JK^{-1}$

D. $-9.1JK^{-1}$

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40. The second law of thermodynamics is a fundamental law of science. In this problem, we consider the thermodynamics of an ideal gas, phase transition, and chemical equilibrium.

Three moles of CO_2 gas expands isothermally (in thermal contact with the surroundings, temperature $= 15.0\,^{\circ}C$) against a fixed external pressure of 1.00 bar. The initial and final volumes of the gas are $10.0L$ and $30.0L$, respectively.

$\Delta_{surr}S$ is

A. $27.4JK^{-1}$

B. $+6.94JK^{-1}$

C. $0.00JK^{-1}$

D. $-6.94JK^{-1}$

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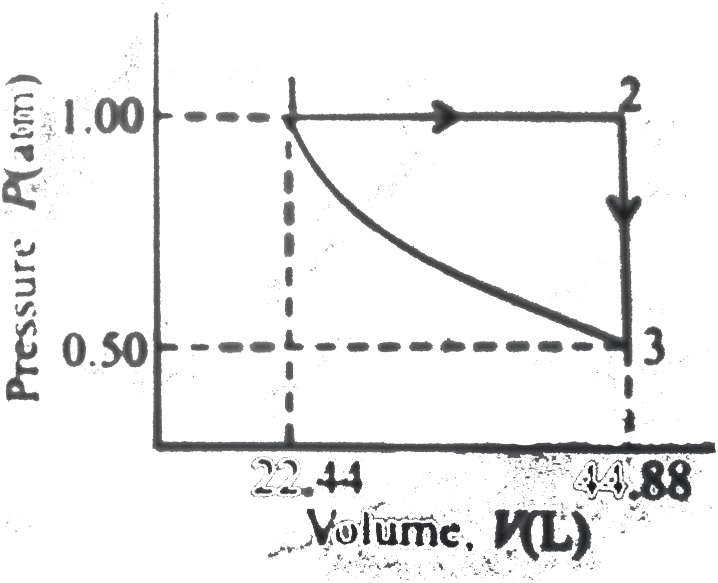
41. A sample consisting of $1 mol$ of a mono-atomic perfect gas $\left(C_V = \frac{3}{2}R\right)$ is taken through the cycle as shown.



Temperature at points (1), (2) and (3) respectively is

A. $273K, 546K, 273K$

B. $546K, 273K, 273K$

C. $273K, 273K, 273K$

D. $546K, 546K, 273K$

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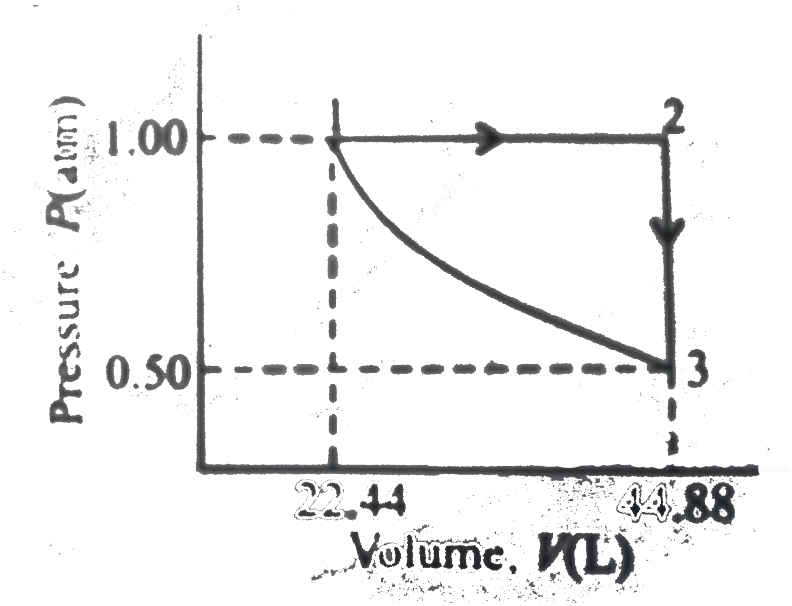
42. A sample consisting of $1 mol$ of a mono-atomic perfect gas $\left(C_V = \frac{3}{2}R\right)$ is taken through the cycle as shown.



ΔH for the overall cycle is

A. $+5.67 \times 10^3 J$

B. $-5.67 \times 10^3 J$

C. $-11.34 \times 10^3 J$

D. Zero

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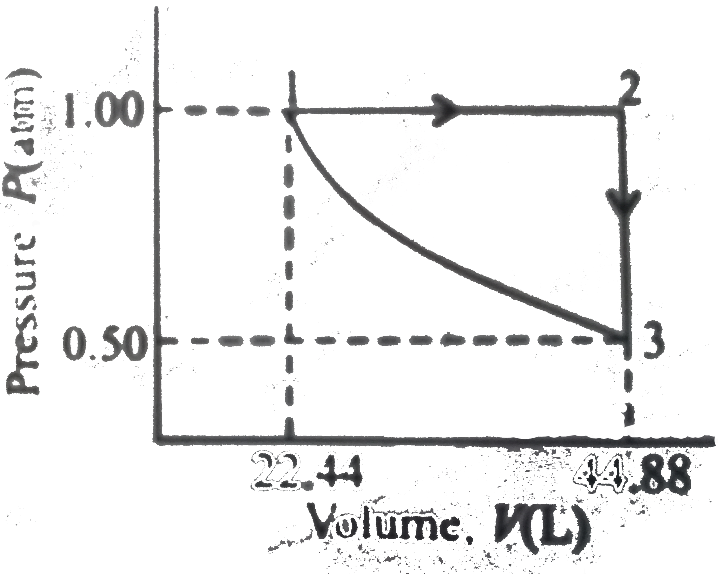
43. A sample consisting of $1mol$ of a mono-atomic perfect gas $\left(C_V = \frac{3}{2}R\right)$ is taken through the cycle as shown.



ΔU for the process$(1 \rightarrow 2)$ is

A. $0.00J$

B. $+3.40 \times 10^3 J$

C. $-3.40J$

D. - $3.40 \times 10^3 J$

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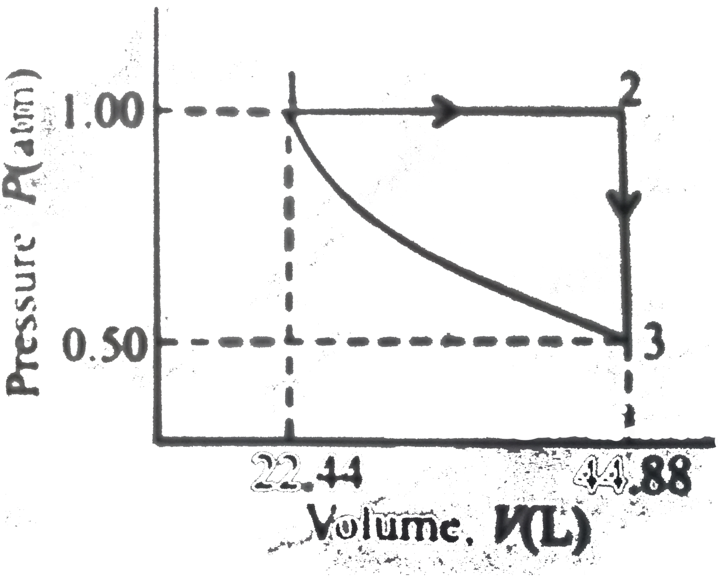
44. A sample consisting of $1 mol$ of a mono-atomic perfect gas $\left(C_V = \frac{3}{2}R\right)$ is taken through the cycle as shown.



ΔU for the process $(2 \rightarrow 3)$ is

A. $0.00 J$

B. $+3.40kJ$

C. -$3.40kJ$

D. None of these

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45. Chemical reactions are invariably associated with the transfter of energy either in the form of heat or light. In the laboratory, heat changes in physical and chemical processes are measured with an instrument called calorimeter. Heat change in the process is calculated as

$$\begin{aligned} q &= ms\Delta T \qquad s = \text{Specific heat} \\ &= c\Delta T \qquad c = \text{Heat capacity} \end{aligned}$$

Heat of reaction at constant volume is measured using bomb calorimeter.

$q_V = \Delta U =$ Internal energy change

Heat of reaction at constant pressure is measured using simple or water calorimeter.

$q_p = \Delta H$

$q_p = q_V + P\Delta V$

$\Delta H = \Delta U + \Delta nRT$

The heat capacity of a bomb calorimeter is $500 JK^{-1}$. When $0.1g$ of methane was burnt in this calorimeter, the temperature rose by $2^{\circ} C$. The value of ΔU per mole will be

A. $+2kJ$

B. $-2kJ$

C. $+260kJ$

D. $-160kJ$

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46. Chemical reactions are invariably associated with the transfter of energy either in the form of heat or light. In the laboratory, heat changes in physical and chemical processes are measured with an instrument called calorimeter. Heat change in the process is calculated as

{:(q = ms DeltaT,,s =Specific heat),(=cDeltaT,,c =Heat capacity)

Heatofreactionatconstantvolumeismeasuredusingbombcal or *imeter*. q_(V) = DeltaU = *Internale* ≠ *rgychan* ≥ *Heatofreactionatconstantpressureismeasuredusingsimp* ≤ o

q_(p) = DeltaHq_(p) = q_(V) +P DeltaVDeltaH = DeltaU +DeltanRT

F or *whichreactionwill*DeltaH = DeltaU`? Assume each reaction is carried out in an open container.

A. $4CO(g) + 2O(g) \rightarrow 4CO_2(g)$

B. $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$

C. $C(s) + 2H_2O(g) \rightarrow 2H_2(g) + CO_2(g)$

D. $2PCI_5(g) \rightarrow 2PCI_3(g) + 2CI_2(g)$

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47. Chemical reactions are invariably associated with the transfter of energy either in the form of heat or light. In the laboratory, heat changes in physical and chemical processes are measured with an instrument called calorimeter. Heat change in the process is calculated as

$q = ms\Delta T$ s = Specific heat
$= c\Delta T$ c = Heat capacity

Heat of reaction at constant volume is measured using bomb calorimeter.

$q_V = \Delta U =$ Internal energy change

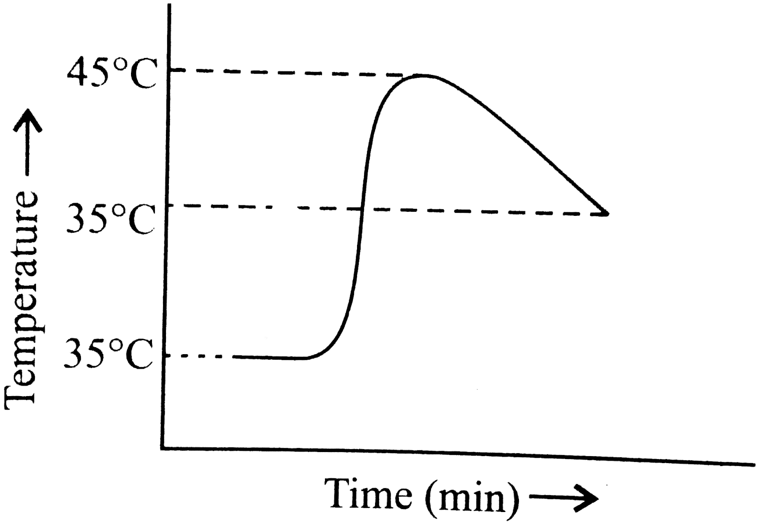
Heat of reaction at constant pressure is measured using simple or water calorimeter.

$q_p = \Delta H$

$q_p = q_V + P\Delta V$

$\Delta H = \Delta U + \Delta nRT$

What value of ΔT should be used for the calorimetry experiment that gives the following graphical results?



A. $30^{\circ} C$

B. $45^{\circ} C$

C. $20^{\circ} C$

D. $35^{\circ} C$

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48. Chemical reactions are invariably associated with the transfter of energy either in the form of heat or light. In the laboratory, heat changes in physical and chemical processes are measured with an instrument called calorimeter. Heat change in the process is calculated as

$$\begin{aligned} q &= ms\Delta T \qquad & s &= \text{Specific heat} \\ &= c\Delta T \qquad & c &= \text{Heat capacity} \end{aligned}$$

Heat of reaction at constant volume is measured using bomb calorimeter.

$q_V = \Delta U =$ Internal energy change

Heat of reaction at constant pressure is measured using simple or water calorimeter.

$q_p = \Delta H$

$q_p = q_V + P\Delta V$

$\Delta H = \Delta U + \Delta nRT$

The enthalpy of fusion of ice is $6.02 kJmol^{-1}$. The heat capacity of water is $4.18 Jg^{-1}C^{-1}$. What is the smallest number of ice cubes at $0^{\circ} C$, each containing one molw of water, the are needed to cool $500g$ of liquid water from $20^{\circ} C \rightarrow 0^{\circ} C$?

A. 8

B. 7

C. 140

D. 120

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49. Bond energies can be obtained by using the following relation: $\Delta H(reaction) = \sum$ Bond energy of bonds, broken in the reactants - $\sum$ Bond energy fo bonds, formed in the products

Bond enegry depends on three factors:

a. Greater is the bond length, lesser is the bond energy.

b. Bond energy increases with the bond multiplicity.

c. Bond enegry increases with electronegativity difference between the bonding atoms.

Arrange $N-H, O-H$, and $F-H$ bonds in teh decreasing order of bond enegry.

A. $F-H > O-H > N-H$

B. $N-H > O-H > F-H$

C. $O-H > N-H > F-H$

D. $F-H > N-H > O-H$

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50. Bond energies can be obtained by using the following relation: $\Delta H(reaction) = \sum$ Bond energy of bonds, broken in the reactants - $\sum$ Bond energy fo bonds, formed in the products

Bond enegry depends on three factors:

a. Greater is the bond length, lesser is the bond enegry.

b. Bond energy increases with the bond multiplicity.

c. Bond enegry increases with electronegativity difference between the bonding atoms.

Bond enegry of differene halogen molecules will lie in the sequences

A. $F_2 > CI_2 > Br_2 > I_2$

B. $CI_2 > Br_2 > Fe_2 > I_2$

C. $I_2 > CI_2 > Br_2 > I_2$

D. $Br_2 > Fe_2 > I_2 > CI_2$

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51. Bond energies can be obtained by using the following relation: $\Delta H(reaction) = \sum$ Bond energy of bonds, broken in the reactants - $\sum$ Bond energy fo bonds, formed in the products

Bond energy depends on three factors:

a. Greater is the bond length, lesser is the bond enegry.

b. Bond energy increases with the bond multiplicity.

c. Bond enegry increases with electronegativity difference between the bonding atoms.

Which among the following sequences is correct about the bond enegry of $C - C, C = C$ and $C \equiv C$ bonds?

A. $C = C > C \equiv C > C - C$

B. $C \equiv C < C = C < C - C$

C. $C \equiv C > C = C > C - C$

D. $C \equiv C > C - C > C = C$

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52. Bond energies can be obtained by using the following relation: $\Delta H(reaction) = \sum$ Bond energy of bonds, broken in the reactants - $\sum$ Bond energy fo bonds, formed in the products

Bond enegry depends on three factors:

a. Greater is the bond length, lesser is the bond enegry.

b. Bond energy increases with the bond multiplicity.

c. Bond enegry increases with electronegativity difference between the bonding atoms.

In CH_4 molecule, which of the following statement is correct about the C - H bond enegry?

A. All C - H bonds of methane have same enegry.

B. Average of all C - H bond energies is considered.

C. Fourth C - H bond required highest enegry to break.

D. None of the above

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53. Bond energies can be obtained by using the following relation: $\Delta H(reaction) = \sum$ Bond energy of bonds, broken in the reactants - $\sum$ Bond energy fo bonds, formed in the products

Bond enegry depends on three factors:

a. Greater is the bond length, lesser is the bond enegry.

b. Bond energy increases with the bond multiplicity.

c. Bond enegry increases with electronegativity difference between the bonding atoms.

Use the bond enegries to estimate ΔH for this reaction:

$H_2(g) + O_2(g) \rightarrow H_2O_2(g)$

Bond	Bond energy
$H - H$	$436 kJmol^{-1}$
$O - O$	$142 kJmol^{-1}$
$O = O$	$499 kJmol^{-1}$
$H - O$	$460 kJmol^{-1}$

A. $-127 kJ$

B. $-109 kJ$

C. $-400 kJ$

D. $-800 kJ$

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54. Bond energies can be obtained by using the following relation: $\Delta H(reaction) = \sum$ Bond energy of bonds, broken in the reactants - $\sum$ Bond energy fo bonds, formed in the products

Bond enegry depends on three factors:

a. Greater is the bond length, lesser is the bond enegry.

b. Bond energy increases with the bond multiplicity.

c. Bond enegry increases with electronegativity difference between the bonding atoms.

The heat of formation of NO from its elements is $+90kJmol^{-1}$, What is the approximate bond dissociation enegry of the bond in NO?

$BE_{N=N} = 941kJmol^{-1}BE_{O=O} = 499kJmol^{-1}$

A. $630kJmol^{-1}$

B. $700kJmol^{-1}$

C. $860kJmol^{-1}$

D. $810 kJmol^{-1}$

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55. A change in the free energy of a system at constant temperature and pressure will be:

$\Delta_{sys}G = \Delta_{sys}H - T\Delta_{sys}S$

At constant temperature and pressure

$\Delta_{sys}G < 0$ (spontaneous)

$\Delta_{sys}G = 0$ (equilibrium)

$\Delta_{sys}G > 0$ (non-spontaneous)

The free enegry for a reaction having $\Delta H = 31400 cal, \Delta S = 32 cal K^{-1} mol^{-1} at 1000^{\circ} C$ is

A. $-9336 cal$

B. $-7006 cal$

C. $-2936 cal$

D. $+9006cal$

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56. A change in the free energy of a system at constant temperature and pressure will be:

$\Delta_{sys}G = \Delta_{sys}H - T\Delta_{sys}S$

At constant temperature and pressure

$\Delta_{sys}G < 0$ (spontaneous)

$\Delta_{sys}G = 0$ (equilibrium)

$\Delta_{sys}G > 0$ (non-spontaneous)

For a spontaneous reaction ΔG, equilibrium K and E^{Θ}_{cell} will be, respectively

A. $-ve, \ > 1, \ + ve$

B. $-ve, \ < 1, \ - ve$

C. $+ve, \ > 1, \ - ve$

D. $-ve, \ > 1, \ - ve$

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57. A change in the free energy of a system at constant temperature and pressure will be:

$\Delta_{sys}G = \Delta_{sys}H - T\Delta_{sys}S$

At constant temperature and pressure

$\Delta_{sys}G < 0$ (spontaneous)

$\Delta_{sys}G = 0$ (equilibrium)

$\Delta_{sys}G > 0$ (non-spontaneous)

For a system in equilibrium, $\Delta G = 0$, under conditions of constant

A. Temperature and pressure

B. Pressure and volume

C. Temperature and volume

D. Energy and volume

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58. A change in the free energy of a system at constant temperature and pressure will be:

$\Delta_{sys}G = \Delta_{sys}H - T\Delta_{sys}S$

At constant temperature and pressure

$\Delta_{sys}G < 0$ (spontaneous)

$\Delta_{sys}G = 0$ (equilibrium)

$\Delta_{sys}G > 0$ (non-spontaneous)

If both ΔH and Δs are negative, the reaction will be spontaneous

A. At high temperature

B. At all temperatures

C. At low temperature

D. At high pressure

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59. Identify the correct statement for change of Gibbs free energy for a system $\left(\Delta G_{\text{system}}\right)$ at constant temperature and pressure.

A. Must be spontaneous at any temperature

B. Cannot be spontaneous at any temperature

C. Will be spontaneous only at low temperture

D. Will be spontaneous only at high temperature

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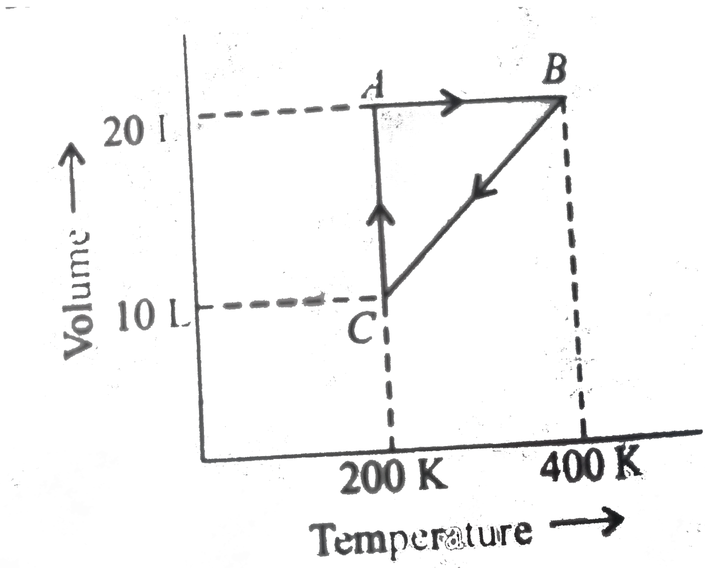
60.



Process $A \rightarrow B$ represents

A. Isobaric

B. Isochoric

C. Isothermal

D. Isoentropic

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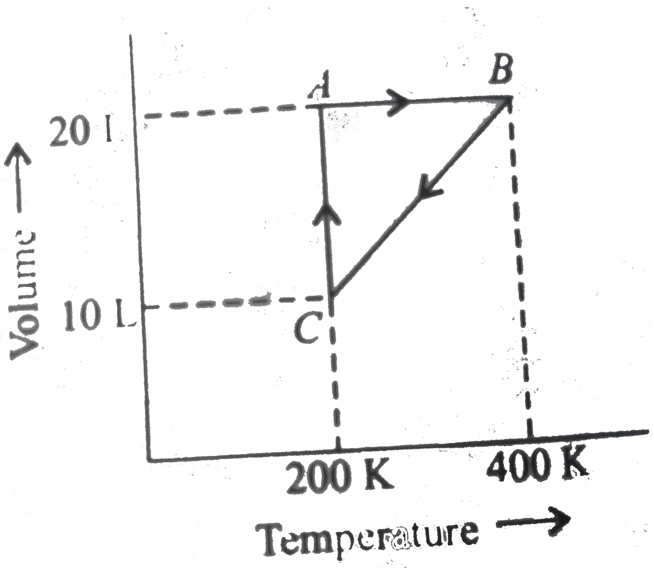

61.

The pressure at C is

A. $3.284 atm$

B. $1.642 atm$

C. $1.0821 atm$

D. $1.821 atm$

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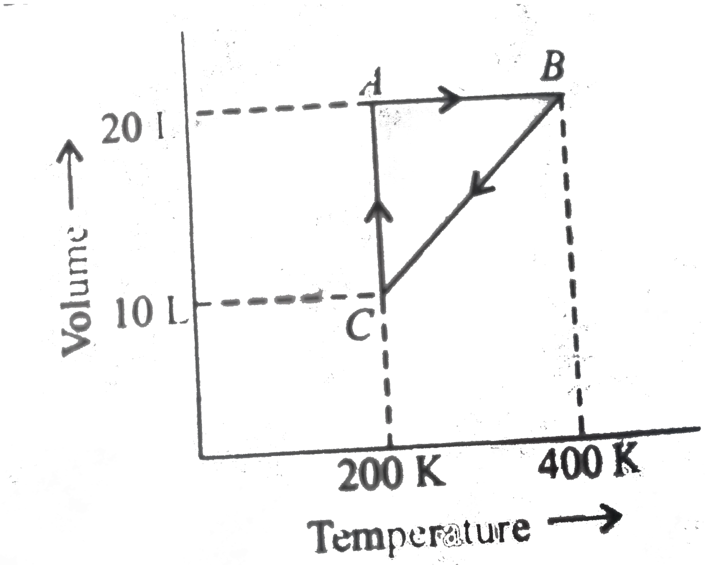
62.



Work done in the process $C \rightarrow A$ is

A. $20.0L$ - atm

B. $8.21L$ - atm

C. $26.2L$ - atm

D. $25.0L$ - atm

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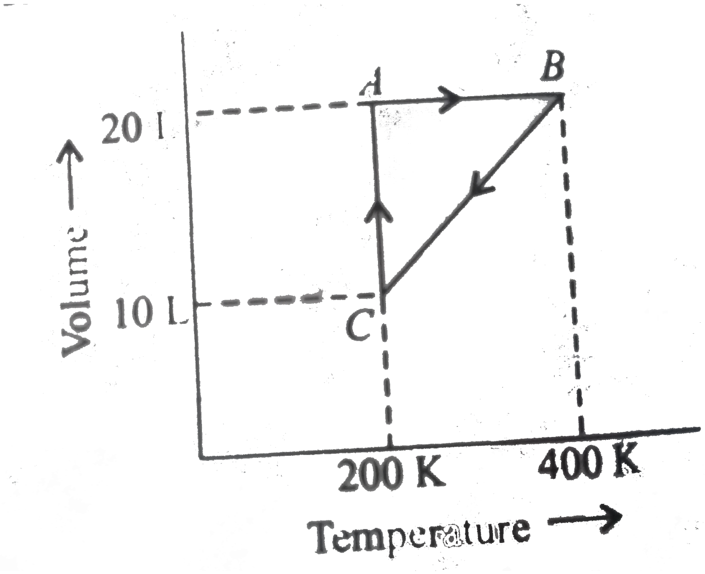
63.



The process which occurs in going from $B \rightarrow C$ is

A. Isothermal

B. Adiabatic

C. Isobaric

D. Isochoric

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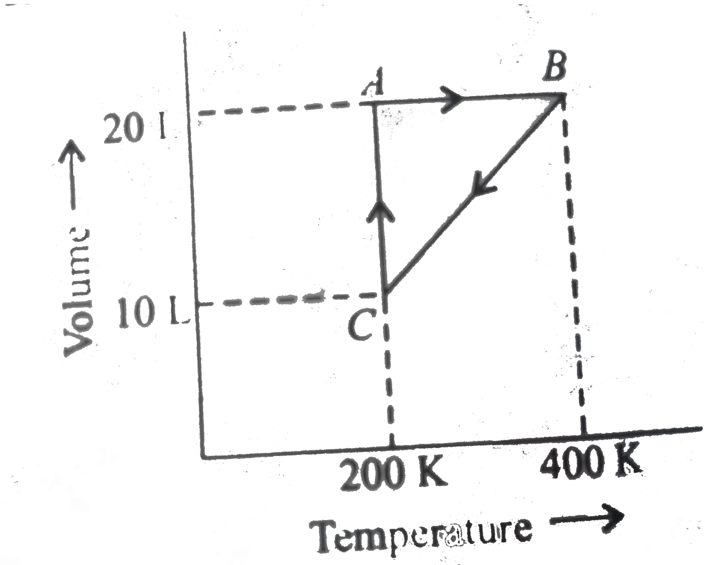
64. 

The pressures at A and B in the atmosphere are, respectively,

A. 0.821 and 1.642

B. 1.642 and 2

C. 2 and 3

D. 3 and 4

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65. The thermodynamic property that measures the extent of molecular disorder is called entropy. Entropy change of phase transformation can be calculated using Trouton's formula ($\Delta S = \Delta H / T$). In the reversible adiabatic process, however, ΔS will be zero. the rise in temperature in isobaric and isochoric conditions is found to increase the randomness or entropy of the system.

$$\Delta S = 2.303 C \log \left(T_1 / T_2\right)$$

The entropy change in an adiabatic process is

A. Zero

B. Positive

C. Negative

D. Remains same

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66. The thermodynamic property that measures the extent of molecular disorder is called entropy. Entropy change of phase transformation can be calculated using Trouton's formula ($\Delta S = \Delta H / T$). In the reversible adiabatic process, however, ΔS will be zero. the rise in temperature in isobaric and isochoric conditions is found to increase the randomness or entropy of the system.

$\Delta S = 2.303 C \log \left(T_1 / T_2 \right)$

The entropy change in an adiabatic process is

A. $+20 J K^{-1} mol^{-1}$

B. $-10 J K^{-1} mol^{-1}$

C. Zero

D. Same to that of surroundings

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67. The thermodynamic property that measures the extent of molecular disorder is called entropy. Entropy change of phase transformation can be calculated using Trouton's formula ($\Delta S = \Delta H / T$). In the reversible adiabatic process, however, ΔS will be zero. the rise in temperature in isobaric and isochoric conditions is found to increase the randomness or entropy of the system.

$\Delta S = 2.303 C \log \left(T_1 / T_2\right)$

The melting point of a solid is $200K$ and its latent heat of fusion is $400 cal mol^{-1}$. The entropy changes for the fusion of 1 mole of the solid (in cal K^{-1}) at the same temperature would be

A. 800

B. 2

C. 0.2

D. 80

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68. For which of the following cases, $\Delta S = \frac{\Delta H}{T}$?

A. A process of which $\Delta C_p = 0$, but $\Delta C_v = 0$

B. An isothermal process

C. An isobaric process

D. An isothermal reversible phase transition process

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69. The thermodynamic property that measures the extent of molecular disorder is called entropy. Entropy change of phase transformation can be calculated using Trouton's formula ($\Delta S = \Delta H / T$). In the reversible adiabatic process, however, ΔS will be zero. the rise in temperature in isobaric and isochoric conditions is found to increase the randomness or entropy of the system.

$\Delta S = 2.303 C \log \left(T_1 / T_2\right)$

When 1 mol of an ideal gas is compressed to half of its volume, its temperature becomes half. Then the change in entropy (ΔS) would be

A. C_VIn4

B. C_PIn2

C. C_VRIn4

D. $\left(C_V - R\right)In4 \times C_P$

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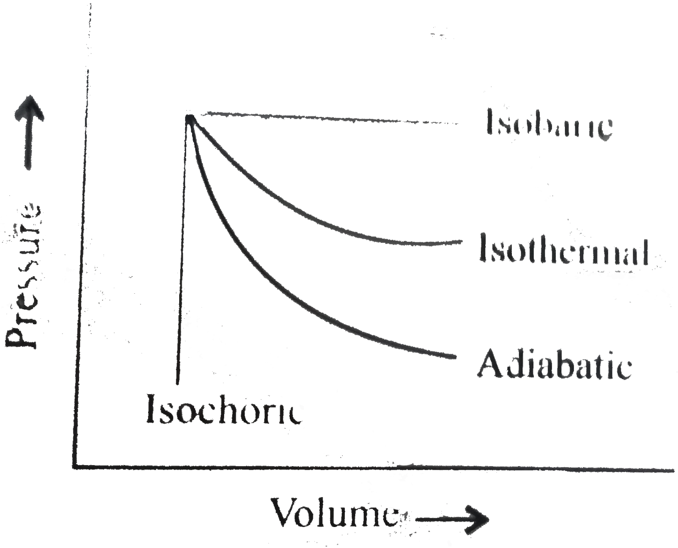
70. The pressure-volume of varies thermodynamic process is shown in graphs:



Work is the mole of transference of energy. It has been observed that reversible work done by the system is the maximum obtainable work.

$w_{rev} > w_{irr}$

The works of isothermal and adiabatic processes are different from each other.

$$w_{\text{isothermal reversible}} = 2.303nRT\log_{10}\left(\frac{V_2}{V_1}\right)$$

$$= 2.303nRT\log_{10}\left(\frac{P_2}{P_1}\right)$$

$$w_{\text{adiabatic reversible}} = C_V\left(T_1 - T_2\right)$$

If w_1, w_2, w_3 and w_4 are work done in isothermal, adiabatic, isobaric, and isochoric reversible processes, respectively then the correct sequence (for expansion) would be

A. $w_1 < w_2 < w_3 < w_4$

B. $w_3 = w_2 = w_1 = w_4$

C. $w_3 < w_2 < w_4 < w_1$

D. $w_3 > w_1 > w_2 > w_4$

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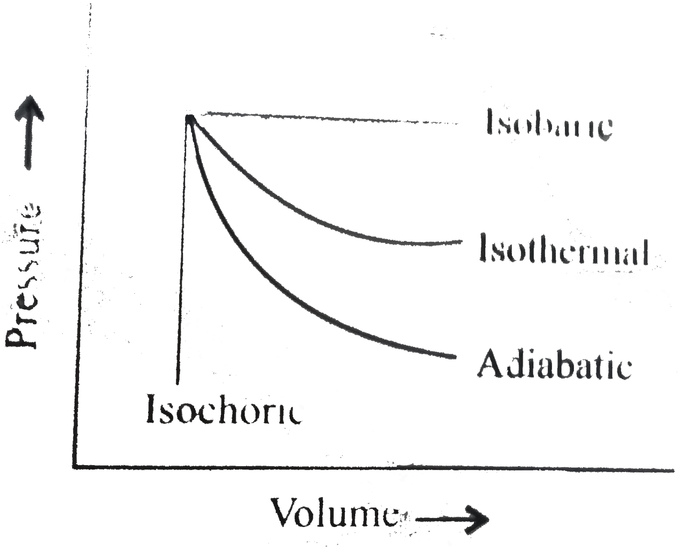
71. The pressure-volume of varies thermodynamic process is shown in graphs:



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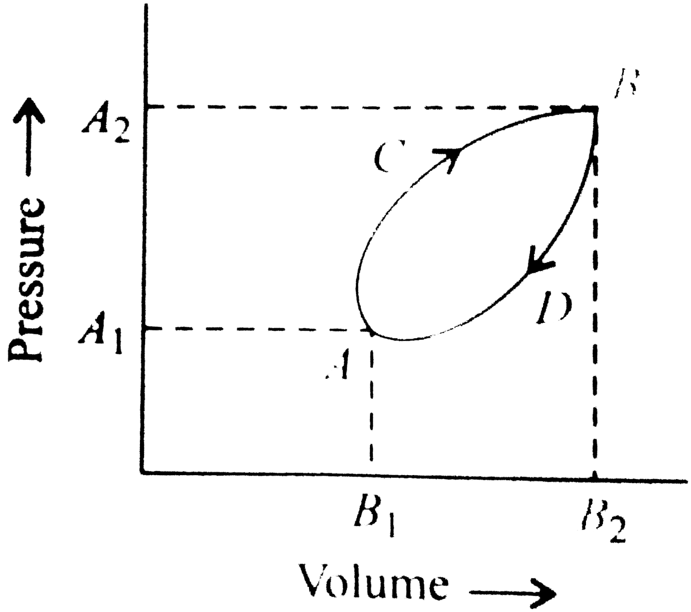
$$= 2.303nRT\log_{10}\left(\frac{P_2}{P_1}\right)$$

$$w_{\text{adiabatic reversible}} = C_V\left(T_1 - T_2\right)$$

A thermodynamic system goes in a cyclic process as represented in the following $P - V$ diagram:



The network done during the complete cycle is given by the area

A. Cycle $ACBDA$

B. AA_2B_2BDA

C. AA_2B_2B

D. Area not bounded by curve

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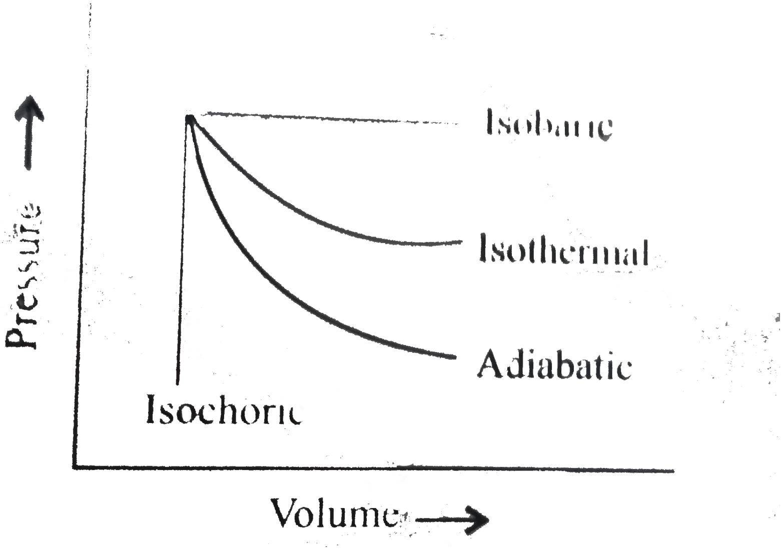
72. The pressure-volume of varies thermodynamic process is shown in graphs:



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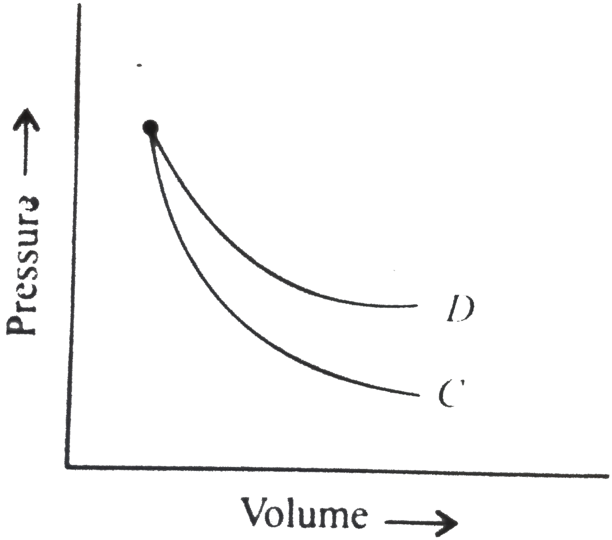
$$= 2.303nRT\log_{10}\left(\frac{P_2}{P_1}\right)$$

$w_{\text{adiabatic reversible}} = C_V\left(T_1 - T_2\right)$

P - V plots for two gases during adiabatic processes are given in the given figure:



Plot D and Plot C should correspond to

A. He and O_2

B. He and Ar

C. O_2 and He

D. O_2 and N_2

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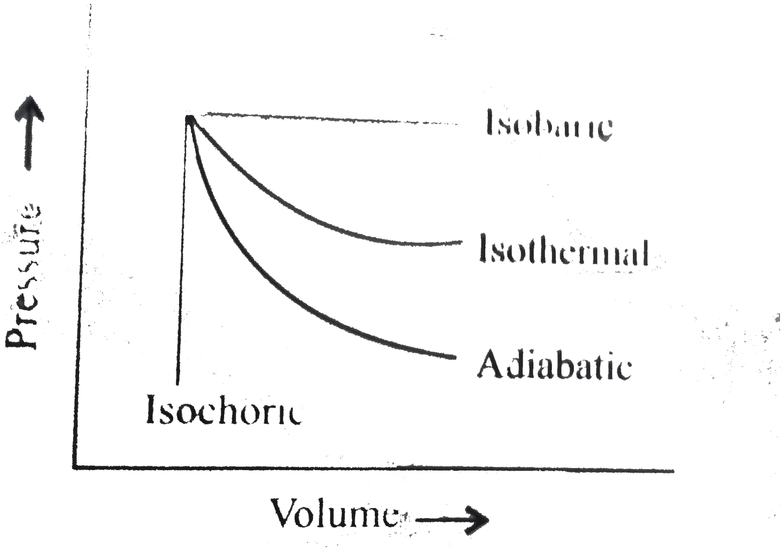
73. The pressure-volume of varies thermodynamic process is shown in graphs:



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$w_{rev} > w_{irr}$

The works of isothermal and adiabatic processes are different from each other.

$$w_{\text{isothermal reversible}} = 2.303nRT\log_{10}\left(\frac{V_2}{V_1}\right)$$

$$= 2.303nRT\log_{10}\left(\frac{P_2}{P_1}\right)$$

$w_{\text{adiabatic reversible}} = C_V(T_1 - T_2)$

The q value and work done in isothermal reversible expansion of one mole of an ideal gas from initial pressure of 1 bar to final pressure of 0.1 bar at constant temperature $273K$ are:

A. $5.22kJ, \ -5.22kJ$

B. $+6.22kJ, 6.22kJ$

C. $5.22J, 5.22J$

D. $-6.22J, \ -6.22J$

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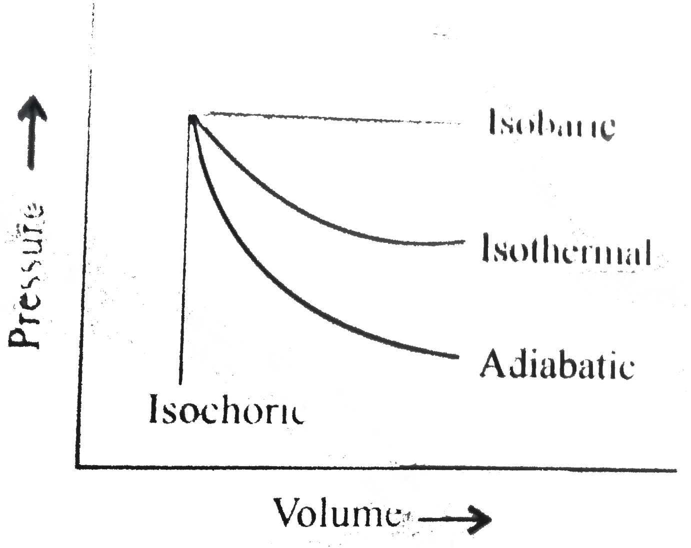
74. The pressure-volume of varies thermodynamic process is shown in graphs:



Work is the mole of transference of energy. It has been observed that reversible work done by the system is the maximum obtainable work.

$w_{rev} > w_{irr}$

The works of isothermal and adiabatic processes are different from each other.

$$w_{\text{isothermal reversible}} = -2.303nRT\log_{10}\left(\frac{V_2}{V_1}\right)$$

$$= 2.303nRT\log_{10}\left(\frac{P_2}{P_1}\right)$$

$$w_{\text{adiabatic reversible}} = C_V\left(T_1 - T_2\right)$$

Calculate work done when 1 mole of an ideal gas is expanded reversibly from $30L$ to $60L$ at a constant temperature of $300K$

A. $8.78kJ$

B. $-1.73kJ$

C. $10.73kJ$

D. $-9.78kJ$

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Paragraph for Problem

1. Three moles of CO_2 gas expands isothermally (in thermal contact with the surroundings, temperature $= 15.0^{\circ} C$) against a fixed external pressure of 1.00 bar. The initial and final volumes of the gas are $10.0L$ and $30.0L$, respectively. ltbr. Change in entropy of the universe is

A. $34.34JK^{-1}$

B. $-34.34JK^{-1}$

C. $20.46JK^{-1}$

D. $-20.46JK^{-1}$

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Exercises (Multiple Correct)

1. Select the correct statement

A. (a) There is a natural asymmetry between converting work to heat and converting heat to work.

B. (b) No process is possible in which the sole result is the absorption of heat from a reservoir and its complete conversion into work.

C. (c) For energy chemical reaction at equilibrium, standard change in Gibbs free energy is zero.

D. (d) At constant temperature and pressure, chemical reactions are spontaneous in the direction of decreasing Gibbs energy..

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2. Which of the following are intensive properties?

A. Heat capacity

B. Refractive index

C. Specific volume

D. Entropy

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3. Which of the following are extensive properties ?

A. Elevation in boiling point

B. Boiling point

C. emf of cell

D. E^{Θ} of cell

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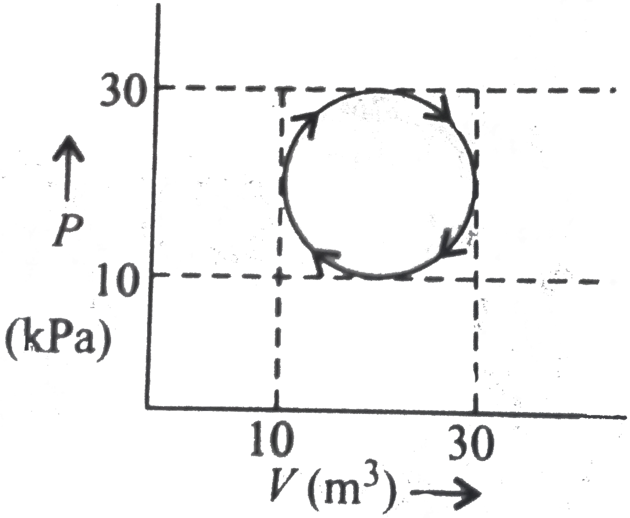
4. Which one is not correct for a cyclic process as shown in the figure ?



A. $dU = 0$

B. $q = -w$

C. w = $314J$

D. w = $31.4J$

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5. If $w_1 . w_2, w_3$ and w_4 are work done in isothermal, adiabatic, isobaric, and isochoric reversible expansion for an ideal gas, respectively, then

A. $w_3 > w_1$

B. $w_1 > w_2$

C. $w_2 > w_4$

D. $w_4 > w_2$

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6. Average value of poisson's ratio for a mixture of 2 mole of each gas A and B is 1.66, then

A. Gases are mono-atomic

B. Gases are diatomic

C. Average molar heat capacity at constant volume is $4cal$

D. Average molar heat capacity at constant V is $3cal$

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7. A reaction attains equilibrium state under standard conditions, then:

A. Equilibrium constant $K = 0$

B. Equilibrium constant $K = 1$

C. $\Delta G^{\Theta} = 0$ and $\Delta H^{\Theta} = T\Delta S^{\Theta}$

D. $\Delta G = 0$ and $\Delta H = T\Delta S$

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8. The poisson's ratio for O_2 is 1.4. Which of the following are correct for O_2 ?

A. $C_V = 5cal$/mol K

B. $C_V = 0.156cal$/mol K

C. $C_P = \frac{R\gamma}{\gamma - 1}$

D. $C_V = \frac{R}{(\gamma - 1)}$

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9. Select the correct statements.

A. The magnitude of work involved in an intermediate irreversible expansion is less than that involved in reversible expansion.

B. Heat absorbed during intermediate irreversible expansion is more than that in intermediate reversible expansion.

C. The magnitude of work involved in an intermediate reversible compression is more than that involved in intermdiate irreversible compression.

D. Heat released during intermediate irreversible compression is more than that in intermediate reversible compression.

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10. Select the correct statements for the equilibrium under standard conditions.

$H_2O(s) \Leftrightarrow H_2O(l), \Delta S_1^{\Theta}$

$H_2O(l) \Leftrightarrow H_2O(v), \Delta_2^{\Theta}$

$H_2O(s) \Leftrightarrow H_2O(v), \Delta S_3^{\Theta}$

A. $\Delta S_1^{\Theta} > \Delta S_2^{\Theta}$

B. $\Delta S_2^{\Theta} > \; > \; > \Delta S_1^{\Theta}$

C. $\Delta S_3^{\Theta} > \Delta S_2^{\Theta}$

D. $\Delta S_3^{\Theta} > \Delta S_1^{\Theta}$

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11. Which is intensive property ?

A. Mass

B. Mass/volume

C. Volume

D. Volume/mass

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12. Which of the following statements are correct?

A. Absolute value of enthalpy cannot be determined.

B. Absolute value of internal energy cannot be determined.

C. Absolute value of entropy can be determined.

D. Internal energy, enthalpy, and entropy are intensive properties.

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13. Following enthalpy changes are given:

$\alpha\text{ - }Dglucose(s) \rightarrow \alpha\text{ - }Dglucoes(aq), \Delta H = 10.72kJ$

$\beta\text{ - }Dglucose(s) \rightarrow \beta\text{ - }Dglucose(aq), \Delta H = 4.68kJ$

$\alpha\text{ - }Dglucose(aq) \rightarrow \beta\text{ - }Dglucose(aq), \Delta H = 1.16kJ$

Calculate enthalpy change in

$\alpha\text{ - }Dglucose(s) \rightarrow \beta\text{ - }Dglucose(s)$

A. $14.24kJ$

B. $16.56kJ$

C. $7.2kJ$

D. $4.88kJ$

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14. If x and y are arbitrary extensive variables, then

A. $(x + y)$ is an extensive variable.

B. x/y is an intensive variable.

C. dx/dy is an intensive variable

D. Both (b) and (c).

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15. If x and y are arbitrary intensive variables, then

A. xy is an intensive variable.

B. x/y is an intensive variable.

C. $(x+y)$ is an extensive property.

D. dx/dy is an intensive property.

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16. For which process does $\Delta U = 0$ holds true?

A. Cyclic process

B. Isothermal expansion

C. Isochoric process

D. Adiabatic process

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17. Which is correct about ΔG?

A. $\Delta G = \Delta H - T\Delta S$

B. At equilibrium, $\Delta G^{\Theta} = 0$

C. At equilibrium $\Delta G = -RT\log K$

D. $\Delta G = \Delta G^{\Theta} + RT\log K$

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18. Which is not correct relationship between ΔG^{Θ} and equilibrium constant K_P.

A. $K_P = -RT\log\Delta G^{\Theta}$

B. $K_P = [e/RT]^{\Delta G^{\Theta}}$

C. $K_P = -\dfrac{\Delta G^{\Theta}}{RT}$

D. $K_P = e^{-\Delta G^{\Theta}/RT}$

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19. Which is not correct relationship?

A. $\left[\frac{dH}{dT}\right]_P$ - $\left[\frac{dU}{dT}\right]_V = (+ve)$

B. $\left[\frac{dU}{dV}\right]_T = 0$(for ideal gas)

C. $\left[\frac{dV}{dT}\right]_P = \frac{nR}{P} =$ (for ideal gas)

D. All of these

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20. Which of the following are endothermic processes?

A. Combustion of glucose

B. Decomposition of water

C. Dehydrogenation of ethane to ethene

D. Conversion of graphite to diamond

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21. For an ideal gas undergoing isothermal reversible expansion

A. $\Delta U = 0$

B. $\Delta H = 0$

C. $\Delta S = 0$

D. $w = 0$

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22. In which of the following reactions, $\Delta H > \Delta U$?

A. $H_2(g) + I_2(g) \rightarrow 2HI(g)$

B. $PCI_5(g) \rightarrow PCI_3(g) + CI(g)$

C. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

D. $C(s) + O_2(g) \rightarrow CO_2(g)$

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23. Which of the following are not correct at $298K$?

A. $\Delta_f G^{\Theta}$ element $= 0$

B. $\Delta_f H^{\Theta}$ element $= 0$

C. $\Delta_f S^{\Theta}$ element $= 0$

D. $\Delta_f G^{\Theta}$ compound $= 0$

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24. Under which of the conditions the process will be spontaneous?

A. $\Delta G = -ve$

B. $\Delta_{\text{Total}} S = +ve$

C. $\Delta_{\text{Total}} S = -ve$

D. $\Delta_{\text{Total}} S = 0$

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25. The correct expressions for an adiabatic process are

A. $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1}$

B. $\frac{P_2}{P_1} = \left(\frac{T_1}{T_2}\right)^{\frac{\gamma - 1}{\gamma}}$

C. $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

D. $P_1 V_1^{\gamma - 1} = P_2 V_2^{\gamma - 1}$

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26. During an adiabatic reversibly expansion of an ideal gas

A. Internal energy of the system decreases.

B. Temperature of the system decreases.

C. The value of γ changes

D. Pressure increases.

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27. The intensive property/properties is/are

A. Temperature

B. Pressure

C. Internal energy

D. Heat capacity

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28. The second law of thermodynamics states that

A. All spontaneous processes are thermodynamically irreversible.

B. Entroy of the universe is continuously increasing.

C. Energy can neither be created nor destroyed.

D. Enegry of the universe remain constant.

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29. The criteria for sponaeity of a process is/are

A. $(dG)_{TP} < 0$

B. $(dE)_{SV} < 0$

C. $(dH)_{SP} < 0$

D. $(dS)_{EV} < 0$

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30. Which of the following are endothermic processes?

A. Combustion of methane

B. Decomposition of water

C. Dehydrogenation of ethane to ethylene

D. Conversion of graphite to diamond

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31. For the adiabatic expansion of an ideal as

A. $PV^{\gamma} =$ constant

B. $TV^{\gamma - 1} =$ constant

C. $TP^{1 - \gamma}$ =constant

D. None of the above

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32. In which of the following entropy increases?

A. Rusting of iron

B. Melting of ice

C. Crystallisation of sugar from solution

D. Vaporisation of camphor

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33. Which of the following are irreversible processes

A. Mixing of two gases.

B. Evaporation of water at $373K$ and $1atm$ in a closed system.

C. Dissolution of $NaCI$ in water

D. $H_2O(s)$ at -4 $^\circ C$

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34. Which of the options give below are correct?

A. (a) $\begin{array}{lll} \Delta H & \Delta S & \text{Nature of reaction} \\ (-) & (+) & \text{Spontaneous at all temperature} \end{array}$

B. (b) $\begin{array}{lll} \Delta H & \Delta S & \text{Nature of reaction} \\ (+) & (-) & \text{Nonspontaneous regardless of temperature} \end{array}$

C. (c) $\begin{array}{lll} \Delta H & \Delta S & \text{Nature of reaction} \\ (+) & (+) & \text{Spontaneous only at high temperature} \end{array}$

D. (d)

ΔH	ΔS	Nature of reaction
(-)	(-)	Spontaneous only at low temperature

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35. Which of the following are thermodynamically stable?

A. $C(\text{diamond})$

B. $C(\text{graphite})$

C. $P_4(white)$

D. $P_4(black)$

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36. Which of the following affect the heat of reaction?

A. (a) Physical states of reactants and products

B. (b) Allotropic forms of elements

C. (c) Temperature

D. (d) Reaction carried out at constant pressure or constant volume

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37. Which of the following type of energies are involved in Born Haber's cycle?

A. (a) $\Delta_{\text{sub}}H$

B. (b) Ionisation energy

C. (c) Bond dissociation energy

D. (d) Lattice energy

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38. Which of the following are true about resonance enegry?

A. Resonance enegry =Experimental heat of formation -Calculated heat of formation.

B. Resonance enegry =Calculated heat of formation -Experimental heat of formation.

C. Greater the resonance enegry, more the compound will be stable.

D. Lesser the resonance energy, more the compound will be stable.

39. Hess' law is applicable for determination of enthalpy of

A. Reaction

B. Formaiton

C. Transition

D. None of these

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40. Indicate in which case/cases the spontaneity of a change is favoured when

A. $\Delta H \text{ is } + ve$

B. $\Delta H \text{ is } - ve$

C. $\Delta S \text{ is } + ve$

D. $\Delta G \text{ is } - ve$

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41. Endothermic reactions, having $\Delta S = \ + ve$ masy be spontaneous if

A. $\Delta H > T\Delta S$

B. $\Delta H < T\Delta S$

C. $\Delta H = T\Delta S$

D. T is very high

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42. If ΔH is the enthalpy change and ΔU the change in internal energy accompanying a gaseous reaction, then

A. ΔH is always greater than ΔU.

B. ΔH is always less than ΔU.

C. $\Delta H < \Delta U$ only if the number of mole of the products is less than that of the reactants.

D. $\Delta U < \Delta H$ only if the number of mole of the reactants is less than that of the products.

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43. An isolated system is that system in which

A. Can exchange matter with the surroundings.

B. Can exchange energy with the surroundings.

C. Can exchange both matter and energy with the surroundings.

D. Cannot exchange either matter or energy with the surroundings.

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44. In a reaction, ΔH and ΔS both are more than zero. In which of the following cases, the reaction would not be spontaneous?

A. $\Delta H > T\Delta S$

B. $T\Delta S > \Delta H$

C. $\Delta H = T\Delta S$

D. $\Delta G < 0$

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45. State the first law of thermodynamics.

A. $\Delta U = \Delta q$ - W

B. $q = \Delta U$ - W

C. $qd + dW = 0$

D. $\Delta Uq + W$

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46. In which reaction(s), ΔS in negative?

A. $H_2O(l) \rightarrow H_2O(s)$

B. $3O_2(g) \rightarrow 2O_3(g)$

C. $H_2O(l) \rightarrow H_2O(g)$

D. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

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47. The heat evolved in the combustion of benzene is given by

$$C_6H_6(l) + 7\frac{1}{2}O_2(g) \rightarrow 3H_2O(l) + 6CO_2(g), \Delta H = -781.0kcalmol^{-1}$$

When $156g$ of C_6H_6 is burnt in a open container, the amount of heat energy released will be

A. $15.02kcalmol^{-1}$

B. $1562.0kcalmol^{-1}$

C. $6528.2kJmol^{-1}$

D. $2448.5kJmol^{-1}$

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48. The heat of neutralization for a strong acid by a strong base is a constant

A. $-57.1kJmol^{-1}$

B. $-13.7kcalmol^{-1}$

C. $-5.7 \times 10^4 Jmol^{-1}$

D. $-13.7 \times 10^3 calmol^{-1}$

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49. The enthalpy change for the process

$C(\text{graphite}) \rightarrow C(g)$is called

A. Heat of vaporisation

B. Heat fo sublimation

C. Heat of allotropic change

D. Heat of atomisation

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50. Enthalpy change equal internal energy change when

A. All the reactants and products are in solution

B. Reaction is carried out in a closed vessel

C. Number of moles of gaseous reactants and that of products is equal

D. Reaction is carried out at constant pressure

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Multiple correct Answer Type

1. Which is an irreversible process ?

A. Mixing of two gases by diffusion

B. Evaporation of water at $373K$ and $1atm$ pressure

C. Dissolution of $NaCI$ in water

D. All of the above

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2. which of the following statements is/are incorrect?

A. The entropy of the universe decreases and increases at a periodic rate.

B. The entropy of the universe increases

C. For endothermic spontaneous processes the total entropy change decrease.

D. The entropy of the universe decreases and tends to zero.

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Exercises (Single Correct)

1. $CsOH + HCI \rightarrow CsCI + H_2O, \Delta H = -13.4 kcal mol^{-1} .... (i)$

$CsOH + HF \rightarrow CsF + H_2O, \Delta H = -16.4 kcal mol^{-1} ....(ii)$

Calculate ΔH for the ionisation of HF in H_2O.

A. $3.0 kcal$

B. - $3.0kcal$

C. $6.0kcal$

D. $0.3kcal$

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2. For the reaction,

$X_2O_4(l) \rightarrow 2XO_2(g), \Delta E = 2.1Kcal$,

$\Delta S = 20cal/K$ at $300K$. Hence ΔG is

A. $2.7kcal$

B. - $2.7kcal$

C. $9.3kcal$

D. - $9.3kcal$

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3. For the given reactions

$SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O, \Delta H = -10.17 kcal$

$SiO_2 + 4HCI \rightarrow SiCI_4 + 2H_2O, \Delta H = 36.7 kcal$

It may be concluded that

A. HF will attack SiO_2 and HCI will not

B. HCI will attack SiO_2 and HF will not

C. HF and HCI both attack SiO_2

D. None attacks SiO_2

4. $\Delta G = \Delta H - T\Delta S$ and $\Delta G = \Delta H + T\left[\frac{d(\Delta G)}{dT}\right]_p$, then $\left(\frac{dE_{cell}}{dT}\right)$ is

A. $\frac{\Delta H}{nF}$

B. $\frac{\Delta G}{nF}$

C. $\frac{\Delta S}{nF}$

D. - $\frac{\Delta S}{nF}$

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5. Which of the following are the intensive properties?

A. Boiling point

B. Refractive index

C. Molarity

D. Volume

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6. $1gH_2$ gas STP is expanded so that the volume is doubled. Hence, work done is

A. $22.4L$ - atm

B. $5.6L$ - atm

C. $11.2L$ - atm

D. $44.8L$ - atm

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7. $1mol$ of NH_3 gas at $27\,^{\circ}C$ is expanded under adiabatic condition to make volume 8 times $(\gamma = 1.33)$. Final temperature and work done, respectively, are

A. $150K$, $909cal$

B. $150K$, $400cal$

C. $250K, 100cal$

D. $200K, 800cal$

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8. Temperature of $1mol$ of a gas is increased by 1° at constant pressure. The work done is

A. R

B. $2R$

C. $R/2$

D. $3R$

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9. The standard heat of combustion of Al is $-837.8 kJmol^{-1}$ at $25^{\circ} C$. If Al reacts with O_2 at $25^{\circ} C$, which of the following release $250 kJ$ of heat?

A. The reaction of $0.624 mol of AI$

B. The formation fo $0.624 mol of AI_2O_3$

C. The reaction of $0.312 mol of AI$

D. The formation of $0.150 mol of AI_2O_3$

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10. $C_P - C_V = R$. This R is

A. Change in KE.

B. Change in rotation energy

C. Work done which system can do on expanding the gas per mol per degree increases in temperature.

D. All correct

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11. Carnot's cycle is said to have 25% efficiency when it operates between T (source) and $300K$ (sink). Temperature T is

A. $300K$

B. $350K$

C. $375K$

D. $400K$

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12. The heat of neutralisation of oxalic acid is $-25.4 kcal mol^{-1}$ using strong base, $NaOH$. Hence, the enthalpy change of the process is

$H_2C_2O_4 \Leftrightarrow 2H^{\oplus} + C_2O_4^{2-}$ is

A. (a) $2.0kcal$

B. (b) $-11.8kcal$

C. (c) $1.0kcal$

D. (d) $-1.0kcal$

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13. If a gas absorbs $200J$ of heat and expands by $500cm^3$ against a constant pressure of $2 \times 10^5 Nm^{-2}$, then the change in internal energy is

A. (a) $-300J$

B. (b) $-100J$

C. (c) $+100J$

D. (d) $+300J$

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14. Inversion temperature is

A. $\frac{Rb}{2a}$

B. $\frac{2a}{Rb}$

C. $\frac{Rb}{a}$

D. $\frac{a}{Rb}$

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15. Assertion (A): The Joules -Thomon coefficient for an ideal gas is zero.

Reason (R) : There are no intermlecular attactive forces in an ideal gas.

A. Positive

B. Negative

C. Zero

D. Dependent on molecular weight

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16. $\Delta_f H\left(H_2O\right) = -68 kcal mol^{-1}$ and ΔH of neutralisation is $-13.7 kcal mol^{-1}$, then the heat of formation of $\overset{\Theta}{OH}$ is

A. $-68 kcal mol^{-1}$

B. $-54.3 kcal mol^{-1}$

C. $54.3 kcal mol^{-1}$

D. $-71.7 kcal mol^{-1}$

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17. Heat of hydrogenation of ethene is x_1 and that of benzene is x_2 . Hence resonance energy of benezene is

A. $x_1 - x_2$

B. $x_1 + x_2$

C. $3x_1 - x_2$

D. $x_1 - 3x_2$

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18. $A(l) \overset{1atn}{\Leftrightarrow} A(g), \Delta_{vap}H = 460.6 cal mol^{-1}$, boiling point $-50K$. What is the boiling point at 10 atm

A. $150K$

B. $75K$

C. $100K$

D. None is correct

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19. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

$BE(H - H) = x_1, BE(O = O) = x_2$

$BE(O - H) = x_3$

Latent heat of vaporisation of water liquid into water vapour $= x_4$, then

$\Delta_f H$ (heat of formation of liquid water) is

A. (a) $x_1 + \frac{x_2}{2} - x_3 + x_4$

B. (b) $2x_3 - x_1 - \frac{x_2}{2} - x_4$

C. (c) $x_1 + \frac{x_2}{2} - 2x_3 - x_4$

D. (d) $x_1 + \frac{x_2}{2} - 2x_3 + x_4$

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20. If a certain mass of gas is made to undergo separately adiabatic and isothermal expansions to the same pressure, starting form the same initial conditions of temperature and pressure, then, as compared to that of isothermal expansion, in the case of adiabatic expansion, the final

A. Volume and temperature will be higher.

B. Volume and temperature will be lower.

C. Temperature will be lower but the final volume will be higher.

D. Volume will be lower but the final temperature will be higher.

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21. The dissolution of NH_4CI in water is endothermic even though NH_4CI dissolves in water spontaneously. Which one of the following best explains this behaviour?

A. The bonds in solid NH_4CI are weak

B. The entropy-driving force causes dissolution.

C. Endothermic processes are energetically favourable

D. The dissolving process is unrelated to enegry.

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22. The enthalpy of formation of hypothetical $MgCl$ is $-125kJmol^{-1}$ and for $MgCl_2$ is $-642kJmol^{-1}$. What is the enthalpy of the disproportionation of $MgCl$.

A. $392kJmol^{-1}$

B. $-392kJmol^{-1}$

C. $-767kJmol^{-1}$

D. $-517kJmol^{-1}$

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23. The product of combustion of an aliphatic thiol (RSH) at $298K$ are :

A. $CO_2(g), H_2(g)$, and $SO_2(g)$

B. $CO_2(g), H_2O(l)$, and $SO_2(g)$

C. $CO_2(l), H_2O(l)$, and $SO_2(g)$

D. $CO_2(g), H_2O(l)$, and $SO_2(l)$

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24. The enthalpy change for chemical reaction is denoted aas ΔH^{Θ} and $\Delta H^{\Theta} = H_P^{\Theta} - H_R^{\Theta}$. The relation between enthalpy and internal energy is expressed by equation:

$\Delta H = \Delta U + \Delta nRT$

where $\Delta U =$ change in internal energy $\Delta n =$ change in number of moles, $R =$ gas constant.

Which of the following equations corresponds to the definition of enthalpy of formation at $298K$?

A. $C(\text{graphite}) + 2H_2(g) + 1/2O_2(l) \rightarrow CH_3OH(g)$

B. $C(\text{diamond}) + 2H_2(g) + 1/2O_2(g) \rightarrow CH_3OH(l)$

C. $2C(\text{graphite}) + 4H_2(g) + O_2(g) \rightarrow 2CH_3OH(l)$

D. $C(\text{graphite}) + 2H_2(g) + 1/2O_2(g) \rightarrow CH_3OH(l)$

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25. Which of the following equations corresponds to the enthalpy of combustion at $298K$?

A. (a) $C_2H_6(g) + 7/2O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

B. (b) $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

C. (c) $C_2H_6(g) + 7/2O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

D. (d) $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$

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26. For the combustion reaction at $298K$

$2Ag(s) + 1/2O_2(g) \rightarrow Ag_2O(s)$

Which of the following alternatives is correct?

A. $\Delta H = \Delta U$

B. $\Delta H > \Delta U$

C. $\Delta H < \Delta U$

D. ΔH and ΔU bear no relation with each other

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27. For the equations

$C(\text{diamond}) + 2H_2(g) \rightarrow CH_4(g)\Delta H_1$

$C(g) + 4H(g) \rightarrow CH_4(g)\Delta H_2$ Predict whther

A. $\Delta H_1 = \Delta H_2$

B. $\Delta H_1 > \Delta H_2$

C. $\Delta H_1 < \Delta H_2$

D. $\Delta H_1 = \Delta H_2 + \Delta_{vap}H(C) + \Delta_{diss}H\left(H_2\right)$

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28. The expression $\Delta_{\text{sub1}}H^{\Theta} = \Delta_{fus}H^{\Theta} + \Delta_{vap}H^{\Theta}$ is true at al

A. Temperatures

B. Pressure

C. Temperature and pressure

D. Temperatures and $1atm$ pressure conditions

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29. The word 'standard' in standard molar enthalpy change implies

A. Temperature $298K$

B. Pressure $1atm$

C. Temperature $298K$ and pressure $1atm$

D. All temperatures and all pressure

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30. For which of the following equations, will ΔH be equal to ΔU?

A. $H_2(g) + 1/2O_2(g) \rightarrow H_2O(l)$

B. $H_2(g) + I_2(g) \rightarrow 2HI(g)$

C. $2NO_2(g) \rightarrow N_2O_4(g)$

D. $4NO_2(g) + O_2(g) \rightarrow 2N_2O_5(g)$

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31. The enthalpy change for chemical reaction is denoted aas ΔH^{Θ} and $\Delta H^{\Theta} = H_P^{\Theta} - H_R^{\Theta}$. The relation between enthalpy and internal enegry is expressed by equation:

$\Delta H = \Delta U + \Delta nRT$

where $\Delta U =$ change in internal enegry $\Delta n =$ change in number of moles, $R =$ gas constant.

Enthalpy of the system is given as

A. $H + PV$

B. $U + PV$

C. $U - PV$

D. $H - PV$

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32. Enthalpy chane of a reaction with be equal to

A. $\Delta U + P\Delta V$

B. $\Delta U + V\Delta P$

C. $\Delta U + \Delta(PV)$

D. $\Delta U + \left(\Delta n_g\right)\Delta(PV)$

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33. The molar enthalpies of combustion of $C_2H_2(g)$, $C(\text{graphite})$ and $H_2(g)$ are -1300, -394, and $-286kJmol^{-1}$, respectively. The standard enthalpy of formation of $C_2H_2(g)$ is

A. $-226kJmol^{-1}$

B. $-626kJmol^{-1}$

C. $226kJmol^{-1}$

D. $626 kJmol^{-1}$

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34. The relationship between enthalpy and internal energy change is

A. $\Delta U = \Delta H + P\Delta V$

B. $\Delta H = \Delta U + P\Delta V$

C. $\Delta H = \Delta U - P\Delta V$

D. $P\Delta V = \Delta U + \Delta H$

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35. The equilibrium state is attained when the reversible reaction is carried out in .... space.

A. $q_p < q_v$

B. $q_p > q_v$

C. $q_p = q_v$

D. $q_v = 0$

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36. The relationship between the free energy change (ΔG) and entropy change (ΔS) at constant temperature (T) si

A. $\Delta G = \Delta H - T\Delta G$

B. $\Delta H = \Delta G + T\Delta S$

C. $T\Delta S = \Delta G + \Delta H$

D. $\Delta G = -\Delta H - T\Delta S$

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37. For the gaseous reaction involving the complete combustion of isobutane

A. $\Delta H = \Delta U$

B. $\Delta H > \Delta U$

C. $\Delta H = \Delta U = 0$

D. $\Delta H < \Delta U$

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38. Entropy of system depends upon

A. Volume only

B. Temperature only

C. Pressure only

D. Pressure, volume, and temperature

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39. For the gaseous reaction: $N_2O_4 \rightarrow 2NO_2$

A. $\Delta H > \Delta U$

B. $\Delta H < \Delta U$

C. $\Delta H = \Delta U$

D. $\Delta H = 0$

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40. For the reversible process, the value of ΔS is given by the expression:

A. $\Delta H / \Delta T$

B. $T/q(rev)$

C. $q(rev) \times T$

D. $q(rev)/T$

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41. For a process $H_2O(s) \rightarrow H_2O(l)at273K$

A. $G(ice) = G(\text{water}) = 0$

B. $G(ice) = G(\text{water})1 = 0$

C. $G(ice) > G(water)$

D. $G(ice) < G(water)$

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42. i. At absolute zero the entropy of a perfect crystal is zero. This statement corresponds to which law of thermodynamics?

A. First law

B. Zeroth law

C. Third law

D. Second law

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43. In which of the following process ΔH and ΔU are of same magnitude

A. Evaporation of $CCl_4(l)$

B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

C. $NH_4Cl(s) \rightarrow NH_4Cl(g)$

D. $2HI(g) \rightarrow H_2(g) + I_2(g)$

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44. Energy can transfer from system to surroundings as work if

A. There is thermal equilibrium between system and surrounding.

B. There is mechanical equilibrium between system and surrounding.

C. If pressure of system is greater than atmospheric pressure.

D. None of these.

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45. The state of equilibrium refers to

A. $\Delta_{\text{total}} S > 0$

B. $\Delta_{\text{total}} S < 0$

C. $\Delta_{\text{total}} S = 0$

D. Unpredicable

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46. For hypothetical reversible reaction

$1/2A_2(g) + 3/2B_2(g) \rightarrow AB_3(g), \Delta H = -20kJ$ if standard entropies of A_2, B_2, and AB_3 are $60, 40$ and $50JK^{-1}mol^{-1}$ respectively. The above reaction will be equilibrium at

A. (a) $400K$

B. (b) $500K$

C. (c) $250K$

D. (d) $200K$

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47. If values of $\Delta_f H^{\ominus}$ of $ICl(g)$, $Cl(g)$, and $I(g)$ are, respectively, 17.57, 121.34, and $106.96 Jmol^{-1}$. The value of $I-Cl$ (bond energy) in $Jmol^{-1}$ is

A. (a) $35.15 Jmol^{-1}$

B. (b) $106.69 mol^{-1}$

C. (c) $210.73 Jmol^{-1}$

D. (d) $420.0 Jmol^{-1}$

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48. If $S + O_2 \rightarrow SO_2, \Delta H = -298.2 \text{ kJ mole}^{-1}$

$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 \Delta H = -98.7 \text{ kJ mole}^{-1}$

$SO_3 + H_2O \rightarrow H_2SO_4, \Delta H = -130.2 \text{ kJ mole}^{-1}$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O, \Delta H = -287.3 \text{ kJ mole}^{-1}$

the enthlapy of formation of H_2SO_4 at 298 K will be

A. $-814.4kJ$

B. $-650.3kJ$

C. $-320.5kJ$

D. $-233.5kJ$

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49. Under which of the following condition is the relation $\Delta H = \Delta U + P\Delta V$ valid for a closed system at

A. Constant pressure

B. Constant temperature

C. Constant temperature and pressure

D. Constant temperature, pressure, and composition

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50. Evaporation of water is

A. An exothermic change

B. An endothermic change

C. A process where no heat changes occur

D. A process accompained by chamical reaction.

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51. Which of the following reaction is endothermic?

A. $CaCO_3 \rightarrow CaO + CO_2$

B. $Fe + S \rightarrow FeS$

C. $NaOH + HCI \rightarrow NaCI + H_2O$

D. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

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52. Which of the following is an endothermic reaction?

A. $2H_2 + O_2 \rightarrow 2H_2O$

B. $N_2 + O_2 \rightarrow 2NO$

C. $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

D. $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

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53. Calculate heat of formation of $KOH(s)$ using the following equations

$K(s) + H_2O(l) + aq \rightarrow KOH(aq) + 1/2H_2(g), \Delta H = -48.0 kcal \ldots (i)$

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(l), \Delta H = -68.4 kcal \ldots (ii)$

$KOH(s) + (aq) \rightarrow KOH(aq), \Delta H = -14.0 kcal.... (iii)$

A. $-68 + 48 - 14$

B. - 68 - 48 + 14

C. 68 - 48 + 14

D. 68 + 48 + 14

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54. Since the enthalpy of elements in their natural state is taken to be zero, the heat of formation $\left(\Delta_f H\right)$ of compounds

A. Is always negative

B. Is always positive

C. May be negative or positive

D. Is zero

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55. A reaction $A + B \rightarrow C + D + q$ is found to have a positive entropy change, the reaction will be:

A. Possible at high temperature

B. Possible only at low temperature

C. Not possible at any temperature

D. Possible at any temperature

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56. Molar heat capacity of water in equilibrium with the ice at constant pressure is :

A. Zero

B. Infinity (∞)

C. $40.45kJK^{-1}mol^{-1}$

D. $75.48JK^{-1}mol^{-1}$

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57. Standard molar enthalpy of formation of CO_2 is equal to :

A. Zero

B. The standard molar enthalpy of combustion of gaseous carbon.

C. The sun of standard molar enthalpies of formation of CO and O_2.

D. The standard molar enthalpy of combustion of carbon (graphite)

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58. A process is called reversible when

A. The surroundings and system change into each other.

B. There is no boundary between the system and surroundings.

C. The surroundings are always in equilibrium with the system.

D. The system changes into the surroundings spontaneously.

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59. Which one of the following statements is false?

A. Work is a state function.

B. Temperature is a state funciton.

C. Change in the state is completely defined when the initial and final states are specified.

D. Work appears at the boundary of the system.

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60. Identify intensive property from the following

A. Enthalpy

B. Temperature

C. Volume

D. Refractive index

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61. The product of combustion of an aliphatic thiol (RSH) at $298K$ are :

A. $CO_2(g), H_2(g)$, and $SO_2(g)$

B. $CO_2(g), H_2O(l)$, and $SO_2(g)$

C. $CO_2(l), H_2O(l)$, and $SO_2(g)$

D. $CO_2(g), H_2O(l)$, and $SO_2(l)$

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62. For an endothermic reaction, ΔH represents the enthalpy of the reaction in kJ mol^{-1}. The mininum amount of activation energy will be

A. Less than ΔH

B. Zero

C. More than ΔH

D. Equal to ΔH

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Exercises (Assertion-Reasoning)

1. Each question contains STATEMENT-1 (Assertion) and STATEMENT-2(Reason).

Examine the statements carefully and mark the correct answer according to the instruction given below:

STATEMENT-1: The endothermic reaction are favoured at lower temperature and the exothermic reactions are favoured at higher temperature.

STATEMENT-2: When a system in equilibrium is distributed by changing the temperature, it will tend to adjust itself so as to overcome the effect of change.

A. both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. (A) is correct, but (R) is incorrect.

D. (A) is incorrect, but (R) is correct.

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2. Assertion: $C_P - C_V = R$ for an ideal gas.

Reason: $\left(\frac{\partial E}{\partial V}\right)_T = 0$ for an ideal gas.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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3. Assertion (A): When hydrogen gas at high pressure and room temperature expands adiabatically into a region of low pressure, there is a decrease in temperature.

Reason (R) : Hydrogen gas at room temperature is above its inversion temperature.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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4. Assertion (A): The thermodynamic factor which determines the spontaneity of a process is the free energy. For a process to be spontaneous the free energy must be-ve.

Reason (R) : The change in free energy is related to the change in a process must always be positive if its is spontaneous.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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5. Assertion (A): The Joules -Thomon coefficient for an ideal gas is zero.

Reason (R) : There are no intermlecular attactive forces in an ideal gas.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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6. Assertion (A): Enthalpy of graphite is lower than that of diamond.

Reason (R) : Entropy of graphite is lower than that of diamond.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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7. Assertion: The enthalpy of formation of gaseous oxygen molecules at $298K$ and under1 atm is zero.

Reason: The entropy of formation of gaseous oxygen molecules under the same condition is zero.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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8. Assertion (A): Heat of neutralisation for both HNO_3 and HCI with $NaOH$ is $53.7kJpermol^{-1}$.

Reason (R) : $NaOH$ is a strong electrolyte/base.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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9. Assertion (A): Decrease in free energy causes spontaneous reaction

Reason (R) : Spontaneous reactions are invariably exothermic.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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10. Many endothermic reactions that are not spontaneous at room temperature become spontaneous at high temperture.

ΔH° of the endothermic reaction may increases with increase in temperature.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

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11. Assertion (A): The enthalpy of formation of $H_2O(l)$ is greater than that of $H_2O(g)$.

Reason (R) : Enthalpy change is negative for the condensation reaction $H_2O(g) \rightarrow H_2O(l)$.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

12. Assertion (A): For a particular reaction, heat of combustion at constant pressure $\left(q_P\right)$ is always greater than that at constant volume $\left(q_V\right)$.

Reason (R) : Combustion reactions are invariably accomplished by increase in number of moles.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

▶ Watch Video Solution

13. Assertion (A): The enthalpy of both graphite and diamond is taken to be zero, being elementary substances

Reason (R) : The enthalpy of formation of an elementary substance in any state is taken as zero.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

▶ Watch Video Solution

14. Assertion (A): The heat of neutralisation of perchloric acid, $HClO_4$, with $NaOH$ is same as that of HCl with $NaOH$.

Reason (R) : Both HCl and $HClO_4$ are strong acids.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

15. Assertion (A): The Heat of ionisation of water is equal to the heat of neutralistion of a strong acid with a strong base.

Reason (R) : Water ionises to a very small extent while $H^{\oplus}$ ions from from an acid combine very rapidly with $\overset{\ominus}{OH}$ from a base to form H_2O.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

16. Assertion (A): The enthalpy of formation of HCI is equal to the bond energy of HCI.

Reason (R) : The enthalpy of formation and the bond enegry both involve formation of one mole of HCI from the elements.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

Watch Video Solution

17. Assertion (A): Pressure, volume, and temperature are all extensive properties.

Reason (R) : Extensive properties depend upon the amount and nature of the substance.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

Watch Video Solution

18. Assertion (A): When a gas at high pressure expands against vacuum, the work done is maximum.

Reason (R) : Work done in expansion depends upon the pressure inside the gas and increase in volume.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

Watch Video Solution

19. Assertion: When a real gas is allowed to expand adiabatically through a fine hole from a region of high presssure to a region of low pressure, the temperature of gas falls in a completely insulated container.

Reason: Work is done at the cost of internal energy of the gas.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

20. Assertion : There is no change in internal energ in a cyclic process.

Reason : Internal energy is a state function.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

21. Assertion (A): An exothermic process, non-spontaneous at high temperature, may become spontaneous at low temperature.

Reason (R) : With decrease in temperature, randomness (entropy) decreases.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

22. Assertion (A): There is no reaction known for which ΔG is positive, yet it is spontaneous.

Reason (R) : For photochemical reaction, ΔG is negative.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

Watch Video Solution

23. A reaction which is spontaneous and accompanied by decrease of randomness must be exothermic.

All exothermic reactions are accompanied by decrease of randomness.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If (A) is incorrect, but (R) is correct.

Watch Video Solution

Exercises (Interger)

1. $\Delta_f H^{\Theta}$ of Cyclohexene (l) and benzene at $25^{\circ}C$ is -156 and $+46 kJmol^{-1}$, respectively. $\Delta_{\text{hydrogenation}} H^{\Theta}$ of cyclohexene $(l) at 25^{\circ} C is - 119 kJmol^{-1}$. Reasonance energy of benzene is found to be $-38x kJmol^{-1}$. Find the value of x.

Watch Video Solution

2. The bond dissociation energies of X_2, Y_2 and XY are in the ratio of $1:0.5:1. \Delta H$ for the formation of XY is -200 kJ mol^(-1) $. Thebonddissociatione \ne rgyof$X_2` will be

A. and Y_2 (all diatomic molecules) are in the ratio of $1:1:0.5$ and $\Delta H_f of XY$ is $-100 kJ mol^{-1}$. The bond dissociation enegry of X_2 is $100x$. Find the value of x.

B.

C.

D.

Watch Video Solution

3. The polymerisation of propene to linear polypropene is represented by the reaction

where n has intergral value, the average enthalpies of bond dissociation for $(C = C)$ and $(C - C)$ at $298K$ are $+509$ and $+331kJmol^{-1}$, respectively. the enthalpy of polymerisation is $-360kJ$. Find the value of n.

Watch Video Solution

4. $\Delta_f H^{\Theta}$ of hypothetical $MgCl$ is $-125kJmol^{-1}$ and for $MgCl_2$ is $-642kJmol^{-1}$. The enthalpy of disporportionation of $MgClis - 49x$. Find the value of x.

Watch Video Solution

5. The lattice energy of solid KCl is $181kcalmol^{-1}$ and the enthalpy of solution of KCl in H_2O is $1.0kcalmol^{-1}$. If the hydration enthalpies of $K^{\oplus}$ and Cl^{Θ} ions are in the ratio of $2:1$ then the enthalpy of hydration of $K^{\oplus}$ is $-20xKcalmol^{-1}$. Find the value of x.

Watch Video Solution

6. A heated irron block at $127^{\circ}C$ loses $300J$ of heat to the surroundings which are at a temperature of $27^{\circ}C$. This process is $0.05xJK^{-1}$. Find the value of x.

Watch Video Solution

7. Amongst the following, the total number of reactions/processes in which the entropy increases are:

a. $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$

b. A liquid cyrstallises into a solid.

c. Temperature of cystalline solid is raised from zero K to $100K$.

d. Hard boiling of an egg.

e. Devitrfication of glass.

f. Straching of a rubber band.

g. Desalination of water.

h. $NH_3(g, 10atm) \rightarrow NH_3(g, 1a \rightarrow m)$

Watch Video Solution

8. Amongst the following,total number of physical properties which are extensive are:

a. Density b. Viscosity c. Surface tension

d. Dipole moment e. Volume

f. Refrative index g. ΔG

h. ΔH i. ΔU j. ΔS.

Watch Video Solution

9. Amongst the following in above mention the total number of intensive physical properties. Density, volume ,viscosity

Watch Video Solution

10. Calculate the entropy change accompanying the following change of state

$H_2O\left(s, -10^\circ C, 1atm\right) \rightarrow H_2O\left(l, 10^\circ C, 1atm\right)$

C_P for ice $= 9caldeg^{-1}mol^{-1}$

C_P for $H_2O = 18 cal deg^{-1} mol^{-1}$

Latent heat of fustion of ice $= 1440 cal mol^{-1} at 0^\circ C$.

Watch Video Solution

Exercises (Fill In The Blanks)

1. While dealing with thermochemical reactions, the temperature and pressure of a reactant must be............as those of products.

Watch Video Solution

2. In an exothermic reaction, the total enthalpy of reactant is ....than that of products.

Watch Video Solution

3. The heat content of the products is more than that of the reactants in an................reaction.

Watch Video Solution

4. The standard molar enthalpy of a substance is the enthalpy of the substance at.............pressure and at specified temperature.

Watch Video Solution

5. The conventional standard molar enthalpy of an element in its stable state of aggregation at $298K$ is taken to be ....

Watch Video Solution

6. The heat released when the requisite amounts of iron in the gaseous state combine to gie $1mol$ of crystal lattice is known is.............

Watch Video Solution

7. The products of combustion of hydrocarbon at $298K$ are .... and ....

Watch Video Solution

8. The products of combustion of hydrocarbon at $298K$ are .... and ....

Watch Video Solution

9. Which of the following reactions will have the value of enthalpy of neutralisation as -57.1kJ mol^{-1} ?

Watch Video Solution

10. The enthalpy of neutralisation of a weak acid is .... than that of a strong acid. The difference of the latter form the former is known as enthalpy of...............of the weak acid.

Watch Video Solution

11. The enthalpy of fusion of KCl is.............than that of naphthalene.

Watch Video Solution

12. The enthalpy change of the reaction:

$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4.5H_2O(s)$ is known as the enthalpy of...............

Watch Video Solution

13. The enthalpy change when $1mol$ of graphite is converted into diamond is known as the enthalpy of............

Watch Video Solution

14. The stable state of aggregation of carbon at $298K$ and $1atm$ pressure is...............

Watch Video Solution

15. The stable state of aggregation of sulphur at $298K$ and $1atm$ pressure is................sulphur.

Watch Video Solution

16. The part of the universe chosen for study of enegry changes is called ....whereas the rest of the universe is called ....

Watch Video Solution

17. The energy stored within a substance is called its.............

Watch Video Solution

18. A reaction in which heat is absorbed is called an..................

Watch Video Solution

19. The enthalpy of elements in their standard states are taken as zero .The enthalpy of formation of a compound:

Watch Video Solution

20. Why is heat of neutralisation for a strong acid and strong base constant ?

Watch Video Solution

21. $\Delta_{\text{sub}}H$ = ……………… + ……………… .

Watch Video Solution

22. The heat of combustion of benzene is $-3264 kJ mol^{-1}$. The heat evolved in the combustion of $39g$ of benzene will be……………… .

Watch Video Solution

23. A process which can take place by itself or by initiation is called a……….. .

Watch Video Solution

24. For a process to be spontaneous at constant T and P :

Watch Video Solution

25. An endothermic process is non-spontaneous at some temperature . It can be spontaneous at............temperature.

Watch Video Solution

26. Coal and petrolem are called................fuels.

Watch Video Solution

27. In an endothermic reaction, the total enthalpy of reactant is.................than that of products.

Watch Video Solution

28. $H_2(g)+\frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -286kJ$

$2H_2(g)+O_2(g) \rightarrow 2H_2O(l).............kJ(\pm ?)$

Watch Video Solution

29. $C_4H_{10} + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l), \Delta H = -2878kJ$

ΔH is the heat of..........of butane gas.

Watch Video Solution

30. $HCI + NaOH \rightarrow NaCI + H_2O, \Delta H = -57.1kJmol^{-1}$

ΔH is the heat of ....of HCI and $NaOH$ solution.

Watch Video Solution

31. $C(s) \rightarrow C(g), \Delta H = 716.7kJ$

ΔH is the heat of .... of graphite.

Watch Video Solution

32. $C(s) \rightarrow C(g), \Delta H = 716.7kJ$

ΔH is the heat of .... of graphite.

Watch Video Solution

33. $H_2O(s) \rightarrow H_2O(l), \Delta H = 6.01kJ$

ΔH is the heat of ....of ice.

Watch Video Solution

34. $H_2O(l) \rightarrow H_2O(s), \Delta H = -6.01kJ$

ΔH is the heat of ....of water.

Watch Video Solution

35. $H_2O(l) \rightarrow H_2O(g), \Delta H = +40.7kJ$

ΔH is the heat of ....of water.

Watch Video Solution

36. $H_2O(g) \rightarrow H_2O(l), \Delta H = -40.7kJ$

ΔH is the heat of...................of water.

Watch Video Solution

37. What is the sign convention for heat ?

Watch Video Solution

38. A system is..................if it cannot exchange matter and energy with the surroundings.

Watch Video Solution

39. The entropy of gases is always...................than that of liquids.

Watch Video Solution

40. Heat of reaction at constant pressure is............. .

Watch Video Solution

41. A bomb calorimeter is used to measure the value of..................at constant.................... .

Watch Video Solution

42. $\Delta^{\Theta}G$(standard free energy change) is free energy change for the process at a temperature of.................when reactants react completely to form products.

Watch Video Solution

43. $H_2(g) + Br_2(g) \rightarrow 2HBr(g), \Delta H^{\Theta} = -72.40kJ$

$\Delta G^{\Theta} = -106.49kJ, T = 298K$

The value ΔS is ....

Watch Video Solution

44. If ΔS is ....the reaction does not proceed in the forward direction.

Watch Video Solution

45. For the process, normal egg $\rightarrow$ hard boiled egg, the sign of ΔS is

....

Watch Video Solution

46. In...................process, no heat is exchanged between the system and the surroundings.

Watch Video Solution

47. In the combustion of $CO, \Delta H$ is...............than ΔU.

Watch Video Solution

48. Gibbs-Helmholtz equation is.............. .

Watch Video Solution

49. At equilibrium, the entropy change is................... .

Watch Video Solution

50. In an isothermal process,......................remains constant.

Watch Video Solution

51. A stable compound has.............................heat of formation.

Watch Video Solution

52. All combustion reactions are................... .

Watch Video Solution

Exercises (True/False)

1. The first law of thermodynamics is not adequate in predicting the direction of a process.$(True/False)$

Watch Video Solution

2. In an exothermic reaction, the total enthalpy of products is greater than that of reactants.

Watch Video Solution

3. In an endothermic reaction, the total enthalpy of products is greater than that of reactants.

Watch Video Solution

4. The standard enthalpy of diamond is zero at $298K$ and $1atm$ pressure.

Watch Video Solution

5. The standard enthalpy of $Br_2(g)$ is taken to be zero at standard conditions of $298K$ and $1atm$.

Watch Video Solution

6. The magnitude of enthalpy of neutralisation of a weak acid is smaller than that of a strong acid. (T/F)

Watch Video Solution

7. In the relation $\Delta H = \Delta U + \left(\Delta n_g\right)RT$ the units of Δn_g is mol. (T/F)

Watch Video Solution

8. The terms bond enthalpy and bond dissociation enthalpy stand for one and the same thing. (T/F)

Watch Video Solution

9. At $298K$, the enthalpy of combustion of CH_4 corresponds to the reaction

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Watch Video Solution

10. For an exothermic reaction, ΔH is positive.

Watch Video Solution

11. For an edothemic reaction, ΔH is positive.

Watch Video Solution

12. Calorific value of fat

Watch Video Solution

13. It is possible to calculate the value of ΔH for the reaction

$H_2(g) + Br_2(l) \rightarrow 2HBr(g)$ from the bond enthalpy data alone.

Watch Video Solution

14. The enthalpy of combustion of dimond and enthalpy of formation of carbon dioxide has the same value.

Watch Video Solution

15. The SI unit of heat is 'calorie'.

Watch Video Solution

16. Can we measure the absolute value of internal enegry?

Watch Video Solution

17. w is positive when the work is done on the system. (T/F)

Watch Video Solution

18. Heat of combustion is the amount of heat evolved when the number of moles as represented by the balanced equation have been completely oxidised.

Watch Video Solution

19. The heat of neutralisation of HCI with $NaOH$ is same as that of HNO_3 with KOH.

Watch Video Solution

20. The heat of neutralisation becomes large if either the acid or the base is weak.

Watch Video Solution

21. The total amount of heat evolved or absorbed in a reaction depends upon the number of steps in which the reaction takes place.

Watch Video Solution

22. A spontaneous process is a process which is instaneous.

Watch Video Solution

23. A process which is accompained by decrease of energy is not always spontaneous.

Watch Video Solution

24. The dissolution of ammonium chloride in water is an endothermic process. What is the effect of temperature on its solubility?

Watch Video Solution

25. For the equilibrium , $\Delta G = - RTInK$.

Watch Video Solution

26. For the combustion of benzene to gaseous carbon dioxide and liquid water, ΔH is more than ΔU.

Watch Video Solution

27. Melting of ice involves increases in randomness and increase in enthalpy.

Watch Video Solution

28. Show that in an isothermal expansion of an ideal gas, a $\Delta U = 0$ and b. $\Delta H = 0$.

Watch Video Solution

29. A pack of cards randomly shuffled has more entropy than a pack of arranged cards.

Watch Video Solution

30. For adiabatic process, $\Delta H = 0$

Watch Video Solution

31. Neither q nor w is a state function but $q + w$ is a state function. Explain why?

Watch Video Solution

32. In the reaction:

$2CO(g) + O_2(g) \Leftrightarrow 2CO(g)$, entropy decreases.

Watch Video Solution

True/False Type

1. For a reaction involving condensed phases, $\Delta H = \Delta U$.

Watch Video Solution

2. Heat of solution is always positive.

Watch Video Solution

3. The heat of combustion of carbon (graphite) is not equal to that of carbon (diamond).

Watch Video Solution

Archives (Multiple Correct)

1. Identify the intensive quantities from the following.

A. Enthalpy

B. Temperature

C. Volume

D. Refractive index

Watch Video Solution

2. The following is not an endothermic reactions:

A. Combustion of methane

B. Decomposition of water

C. Dehydrogenation of enthane of diamond

D. Conversion of graphite to diamond

Watch Video Solution

3. Which one of the following statements is false?

A. Work is a state function.

B. Temperature is a state funciton.

C. Change in the state is completely defined when the initial and final states are specified.

D. Work appears at the boundary of the system.

Watch Video Solution

Archives (Single Correct)

1. Difference between the heats of reaction at constant pressure and a constant volume for the reaction $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ at $25^\circ C$ in kJ is

A. -7.43

B. $+3.72$

C. -3.72

D. $+7.43$

Watch Video Solution

2. For an endothermic reaction, ΔH represents the enthalpy of the reaction in kJ mol^{-1}. The mininum amount of activation energy will be

A. Less than ΔH

B. Zero

C. More than ΔH

D. Equal to ΔH

Watch Video Solution

3. ΔH_1° for $CO_2(g)$, $CO(g)$ and $H_2O(g)$ are -393.5, -110.5 and $-241.8 kJmol^{-1}$ respectively. Standard enthalpy change for the reaction

$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$ is

A. 524.1

B. $+41.2$

C. -262.5

D. -41.2

Watch Video Solution

4. A process is called reversible when

A. The surroundings and system change into each other.

B. There is no boundary between the system and the surroundings.

C. The surroundings are always in equilibrium with the system.

D. The system changes into the surroundings spontaneously.

Watch Video Solution

5. One mole of a non-ideal gas undergoes a change of state $(2.0 atm, 3.0 L, 95 K) \rightarrow (4.0 atm, 5.0 L, 245 K)$

With a change in internal energy $\Delta E = 30 L$ atm. The change in enthalpy (ΔH) in the process in L-atm is

A. 40.0

B. 42.3

C. 44.0

D. Not defined because the pressure is not constant.

Watch Video Solution

6. Which of the following reactions is defines $\Delta_f H^{\Theta}$?

A. $C(\text{diamond}) + O_2(g) \rightarrow CO_2(g)$

B. $\frac{1}{2}H_2(g) + \frac{1}{2}F_2(g) \rightarrow HF(g)$

C. $N_2(s) + 3H_2(g) \rightarrow 2NH_3(g)$

D. $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

Watch Video Solution

7. $\Delta_{vap}H = 30kJmol^{-1}$ and $\Delta_{vap}S = 75Jmol^{-1}K^{-1}$. Find the temperature of vapour, at 1 atm.

A. $400K$

B. $350K$

C. $298K$

D. $250K$

Watch Video Solution

8. Sponetaneous adsorption of a gas on solid surface is an exothermic process because

A. ΔH increases for system.

B. ΔS increases for gas.

C. ΔS decreases for gas.

D. ΔG increases for gas.

Watch Video Solution

9. Two moles of an ideal gas expanded isothermally and reversibly from $1L$ to $10L$ at $300K$. What is the enthalpy change?

A. $4.98kJ$

B. $11.47kJ$

C. - $11.47kJ$

D. $0kJ$

Watch Video Solution

10. When $1mol$ of a monoatomic ideal gas at TK undergoes adiabatic change under a constant external pressure of $1atm$, changes volume from $1L \rightarrow 2L$. The final temperature (in K) would be

A. $\frac{T}{2^{2/3}}$

B. $T + \frac{2}{3 \times 0.0821}$

C. T

D. $T - \frac{2}{3 \times 0.0821}$

Watch Video Solution

11. $N_2 + 3H_2 \Leftrightarrow 2NH_3$

Which of the following statements is correct if N_2 added at equilibrium condition?

A. The equilibrium will shift in the forward firection because according to the second law of thermodynamics, the entropy must increase in the direction of the spontaneous reaction.

B. The condition of equilibrium is $G_{N_2} + 3G_{H_2} = 2G_{NH_3}$, where G is the Gibbs frre energy per mole of the gaseous species measured at partial pressure. The condition of equilibrium is unafected by the use of catlyst which increases the rate of both the forward and backward reactions to the same extent.

C. The catalyst will increase the rate of forward reaction by α and that of backward reaction by β.

D. The catalyst will not alter the rate of either of the reactions.

Watch Video Solution

12. The direct conversion of A to B is difficult, hence it is carried out as

$A \rightarrow C \rightarrow D \rightarrow B$

Given, $\Delta S_{\left(A \rightarrow C\right)} = 50eU, \Delta S_{\left(C \rightarrow D\right)} = 30eU, \Delta S_{(B \rightarrow D)} = 20eU$, where eU is entropy unit. Thus the change in entropy in $(A \rightarrow B)$ is:

A. $+100eu$

B. $+60eu$

C. $-100eu$

D. $-60eu$

Watch Video Solution

13. A monoatomic ideal gas undergoes a process in which the ratio of P to V at any istant is constant and equal to unity. The molar heat capacity of the gas is

A. $\frac{4R}{2}$

B. $\frac{3R}{2}$

C. $\frac{5R}{2}$

D. 0

Watch Video Solution

14. For the process $H_2O(l)(1\text{bar}, 373K) \rightarrow H_2O(g)(1\text{bar}, 373K)$ the correct set of thermodynamic parameters is

A. $\Delta G = 0, \Delta S = +ve$

B. $\Delta G = 0, \Delta S = -ve$

C. $\Delta G = +ve, \Delta S = 0$

D. $\Delta G = -ve, \Delta S = +ve$

Watch Video Solution

15. The value of $\log_{10}K$ for a reaction $A \Leftrightarrow B$ is (Given: $\Delta_f H^{\Theta}_{298K} = -54.07 kJmol^{-1}$,

$\Delta_r S^{\Theta}_{298K} = 10 JK^{=1} mol^{-1}$, and $R = 8.314 JK^{-1} mol^{-1}$

A. 5

B. 10

C. 95

D. 100

Watch Video Solution

16. The bond energy (in kcal mol^{-1}) of a $C-c$ single bond is approximately

A. 1

B. 10

C. 100

D. 1000

Watch Video Solution

17. The species which by definition has zero standard molar enthalpy of formation at $298K$ is

A. $Br_2(g)$

B. $CI_2(g)$

C. $H_2O(g)$

D. $CH_4(g)$

Watch Video Solution

Archives (Assertion-Reasoning)

1. Assertion (A): For every chemical reaction at equilibrium, standard Gibbs enegry of the reaction is zero.

Reason (R) : At constant temperature and pressure chemical reactions are spontaneous in the direction of the decreasing Gibbs energy.

A. Both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. Both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. (A) is correct, but (R) is incorrect.

D. (A) is incorrect, but (R) is correct.

Watch Video Solution

2. Assertion (A) : There is a natural asymmetry between converting work to heat and converting heat of work.

Reason (R) : No process is possible in which the sole result is the absorption of heat from a reservoir and its complete conversion into work.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

3. The heat absorbed during the isothermal expansion of an ideal gas against vacuum is zero.

The volume occupied by the molecules of an ideal gas is zero.

A. If both (A) and (R) are correct, and (R) is the correct explanation for (A).

B. If the both (A) and (R) are correct, but(R) is not a correct explanation for (A).

C. If (A) is correct, but (R) is incorrect.

D. If both (A) and (R) are incorrect.

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Archives (Interger)

1. In a constant volume calorimeter, $3.5g$ of a gas with molecular weight 28 was burnt in excess oxygen at $298.0K$. The temperature of the calorimeter was found to increase from $298.0K \rightarrow 298.45K$ due to the combustion process. Given that the heat capacity of the calorimeter is $2.5kJK^{-1}$, find the numerical value for the enthalpy of combustion of the gas in $kJmol^{-1}$

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Archives (Fill In The Blanks)

1. C_P - C_V for an ideal gas is.............. .

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2. The total energy of $1mol$ of an ideal monatomic gas at $27\ ^\circ C$ is....... .

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3. A system is.................if it cannot exchange matter and energy with the surroundings.

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4. In an endothermic reaction, the total enthalpy of reactant is.................than that of products.

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5. Enthalpy is an .... property.

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Archives (True/False)

1. The first law of thermodynamics is adequate in predicting the direction of a process.

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2. The heat capacity of a diatomic gas is higher than that of a monatomic gas.

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Archives (Subjective)

1. The enthalpies for the following reactions $\left(\Delta H^{\Theta}\right)$ at $25^{\circ} C$ are given below.

a. $\frac{1}{2}H_2(g) + \frac{1}{2}O_2(g) \rightarrow OH(g)$

$\Delta H = 10.06 kcal$

b. $H_2(g) \rightarrow 2H(g), \Delta H = 104.18 kcal$

c. $O_2(g) \rightarrow 2O(g), \Delta H = 118.32 kcal$

Calculate the O - H bond energy in the hydroxyl radical.

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2. The standard enthalpies of formation at $298K$ for $CC1(g), H_2O(g), CO_2(g)$ and $HC1(g)$ are $-106.7, -241.8, -393.7,$ and $-92.5kJmol^{-1}$, respectively. Calculate $\Delta H^{\Theta}{}_{298K}$ for the reaction

$CC1_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4HCI_g$

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3. Given that:

i. $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = -94.05kcal$

ii. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -68.32kcal$

iii.$C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l), \Delta H = -310.62kcal$

The heat of formation fo acetylene is

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4. The following statement is true only under some specific conditions. Write the conditions for the following statement in not more than two sentences. The heat energy q absorbed by a gas is ΔH.

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5. The bond dissociation energies of gaseous H_2, Cl_2, and HCl are $100, 50$, and $100 kcal mol^{-1}$, respectively. Calculate the enthalpy of formation of $HCl(g)$.

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6. The standard molar heat of formation of ethane, carbon dioxide and water (liquid) are -21.1, -94.1 and -68.3 kcal respectively. Calculate the standard heat of the following reaction :

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

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7. An intimate mixture of ferric oxide and aluminium is used as solid fuel in rockets. Calculate the fuel value per cm^3 of the mixture.

Heats of formation and densities are as follows:

$H^{\Theta}_{f\left(Al_2O_3\right)} = -399kcalmol^{-1}, H^{\Theta}_{f\left(Fe_2O_3\right)} = -199kcalmol^{-1}$

Density of $Fe_2O_3 = 4.0gcm^{-3}$, Density of $Al = 2.0gcm^{-3}$

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8. The enthalpy of combustion of H_2, cyclohexene $\left(C_6H_{10}\right)$ and cyclohexane $\left(C_6H_{12}\right)$ are -241, -3800 and -3920 KJ per mol respectively . Heat of hydrogenation of cyclohexene is

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9. $CsOH + HCI \rightarrow CsCI + H_2O, \Delta H = -13.4kcalmol^{-1}.........(i)$

$CsOH + HF \rightarrow CsF + H_2O, \Delta H = -16.4kcalmol^{-1}........(ii)$

Calculate ΔH for the ionisation of HF in H_2O.

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10. Determine enthalpy change for,

$$C_3H_{8(g)} + H_{2(g)} \rightarrow C_2H_{6(g)} + CH_{4(g)}$$

at $25\,^\circ C$ using heat of combustion values under standard condition.

$Compounds$	$H_{2(g)}$	$CH_{4(g)}$	$C_2H_{6(g)}$	$C_{(Graphite)}$
$\Delta H^\circ\ in kJ/mol$	-285.8	-890.0	-1560.0	-393.5

The standard heat of formation of $C_3H_{8(g)}$ is $-103.8kJmol^{-1}$.

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11. Compute the heat of formation of liquid methyl alcohol in kilojoule per mol using the following data. Heat of vaporisation of liquid methyl alcohol $= 38kJ/mol$. Heat of formation of gaseous atoms from the elements in their standard states $: H = 218kJ/mol, C = 715kJ/mol, O = 249kJ/mol$.

Average bond energies :

$C - H415kJ/mol, C - O356kJ/mol, O - H463kJ/mol$.

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12. From the following data, calculate the enthalpy change for the combustion of cyclopropane at $298K$. The enthalpy of formation of $CO_{2(g)}, H_2O_{(l)}$ and $Propene_{(g)}$ are -393, -285.8 and $20.42kJmol^{-1}$ respectively. The enthalpy of isomerisation of cyclopropane to propene is $-33.0kJmol^{-1}$

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13. The standard heat of formation values of $SF_6(g), S(g)$, and $F(g)$ are $-1100, 275$, and $80kJmol^{-1}$, respectively. Then the average $S-F$ bond energy in SF_6

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14. Show that the reaction

$$CO(g) + (1/2)O_2(g) \rightarrow CO_2(g)$$

at $300K$ is spontaneous and exothermic, when the standard entropy change is $-0.094 kJ mol^{-1} K^{-1}$. The standard Gibbs free energies of formation for CO_2 and CO are $-394.4$and $-137.2 kJ mol^{-1}$, respectively.

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15. A sample of argon gas at $1 atm$ pressure and $27^\circ C$ expands reversibly and adiabatically from $1.25 dm^3$ to $2.50 dm^3$. Calculate the enthalpy change in this process. $C_{v,m}$ for argon is $12.48 JK^{-1} mol^{-1}$.

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16. Determine the enthalpy of formation of B_2H_6(g) in kJ/mol of the following reaction :

$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 3H_2O(g),$

Given : $\Delta_r H^\circ = -1941 \text{ kJ/mol}, \quad \Delta H_f^\circ \left(B_2O_3, s\right) = -1273 \text{ kJ/mol},$

$\Delta H_f^\circ \left(H_2O, g\right) = -241.8 \text{ kJ/mol}$

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17. The standart potential of the following cell is 0.23 at $15^\circ C$ and $0.21 V at 35^\circ C$

$Pt\left|H_2(g)\right|HCI(aq)|AgCI(s)|Ag(s)$

(i) Write the cell reaction

(ii) Calculate ΔH° and ΔS° for the cell reaction by assuming that these quantites remain unchanged in the range $15^2 C \rightarrow 35^\circ C$

[Given SRP of $Ag^+(aq) \mid Ag(s) is 0.80 V at 25^\circ C\Big]$

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18. When 1pentyne (A) is treated with $4N$ alcoholic KOH at $175^\circ C$, it is slowly converted into an equilibrium mixture of 1.3% of 1pentyne (A), 95.2% 2-pentyne (B) and 3.5% of 1, 2-pentandiene (C). The equilibrium was maintained at $175^\circ C$. calculate ΔG^Θ for the following equilibria:

$B \Leftrightarrow A, \Delta G^\Theta = 1?$

$B \Leftrightarrow C, \Delta G^\Theta = 2?$

From the calculated value of $\Delta G^\Theta 1$and $\Delta G^\Theta 2$, indicate the order of stability of A, B and C.

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19. Two moles of a perfect gas undergo the following processes:

a. A reversible isobaric expansion from $(1.0 atm, 20.0 L)$ to $(1.0 atm, 40.0 L)$.

b. A reversible isochroic change of state from $(1.0 atm, 40.0 L)$ to $(0.5 atm, 40.0 L)$

c. A reversible isothermal expansion from $(0.5 atm, 40.0 L) \rightarrow (1.0 atm, 20.0 L)$.

i. Sketch with lables each of the processes on the same P - V diagram.

ii. Calculate the total work (w) and teh total heat change (q) involved in the above process.

iii. What will be the values of ΔG and ΔH for the overall process?

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20. C_v values of He is always $\frac{3R}{2}$ but C_v values of H_2 is $\frac{3R}{2}$ at low temperature and $\frac{5R}{2}$ at higher temperature explain .

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21. In the reaction equilibrium

$N_2O_4 \Leftrightarrow 2NO_2(g)$

When 5 mol of each is taken and the temperature is kept at $298K$, the total pressure was found to be 20 bar.

Given : $\Delta_f G^{\ominus}_{n_2O_4} = 100kJ, \Delta_f G^{\ominus}_{NO_2} = 50KJ$

a. Find $\Delta G^{\ominus}$ of the reaction at $298K$.

b. Find the direction of the reaction.

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22. $100mL$ of a liquid is contained in an insulated container at a pressure of 1bar. The pressure is steeply increased to 100bar. The volume of the liquid is decreased by $1mL$ at this constant pressure. Find ΔH and ΔU.

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23. For the reaction

$2CO + O_2 \rightarrow 2CO_2, \Delta H = -560kJ,$

$2mol$ of CO and $1mol$ of O_2 are taken in a container of volume $1L$. They completely form $2mol$ of CO_2. If the pressure in the vessel changes from 70 to $40atm$, find the magnetic (absolute) value of $\Delta U at 500K$. $(1L\text{ - }atm = 0.1kJ)$

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