CHEMISTRY

PHYSICAL, INORGANIC, AND ORGANIC CHEMISTRY

THERMODYNAMICS

Solved examples

1. $$\begin{array}{ll} A + B \Leftrightarrow C + D & K_{1eq} = 10^3 \\ E + F \Leftrightarrow G + H & K_{2eq} = 10^{-3} \end{array}$$

Which of these reaction will attain equilibrium earlier?

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2. During an expansion of ideal gas the work done by gas is $100J$ and the heat capacity to process is found to be $+2J/^\circ C$. Find ΔE fo gas if the final temperature of gas is $25^\circ C$ higher than its initial temperature.

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3. Calculate the work performed when 2 moles of hydrogen expand isothermally and reversibly at $25^{\circ} C$ from 15 to 50 litres. (in cal)

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4. If a gas at a pressure of $10atm$ at $300K$ expands against a constant external pressure of $2atm$ from a vol. 10 litres to 20 litres find work done ? [Isothermal process]

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5. Calculate the maximum work done when pressure on $10g$ of hydrogen is reduces from $20atm$ to $1atm$ at a constant temperature of $273K$. The gas behaves ideally. Will there be any change in internal energy? Also, calculate $'q'$.

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6. A liquid of volume of $100L$ and at the external pressure of $10atm$ - Lt the liquid is confined inside an adiabatic bath. External pressure of the liquid is suddenly increased to $100atm$ and the liquid gets compressed by $1L$ against this pressure then find,

(i) Work (ii) ΔU (iii) ΔH

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7. For the combustion of 1 mole of liquid benzene at $25\,^{\circ}C$, the heat of reaction at constant pressure is given by

$$C_6H_6(l) + 7\frac{1}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l), \Delta H = -780980\text{cal}.$$

What would be the heat of reaction at constant volume ?

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8. Calculate $q, W, \Delta E$ and ΔH when $100g$ of $CaCO_3$ is converted into its aragonite form given density of caicite $= 2g/cc$ and density of aragonite $= 2.5g/cc$

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9. (a) One mole of an ideal gas expands isothermally and reversibly at $25^\circ C$ from a volume of 10 litres to a volume of 20 litres.

(i) What is the change in entropy of the gas?

(ii) How much work is done by the gas?

(iii) What is q (surroundings) ?

(iv) What is the change in the entropy of the surroundings?

(v) What is the change in the entropy of the system plus the surroundings ?

(b) Also answer the questions opening a stopcock and allowing the gas to rush into an avacuated bulb of $10L$ volume.

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10. K_a for CH_3COOH at $25^\circ C$ is 1.754×10^5. At $50^\circ C, K_a$ is 1.633×10^{-5} what are ΔH° and ΔS° for the ionisation of CH_3COOH ?

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11. Why does heat get released/ absorbed during chemical reactions?

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12. Calculate the standard enthalpy of reaction

$ZnO(s) + CO(g) \rightarrow Zn(s) + CO_2(g)$

Given,

$\Delta H_f(ZnO, s) = -350KJ/\text{mole}, \Delta H_f^\circ\left(CO_2, g\right) = -390KJ/\text{mole}, \Delta H_f^\circ(CO, g) = -$

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13. Calculate heat of the following reaction at constant pressure,

$F_2O(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g)$

The heats of formation of $F_2O(g), H_2O(g)$ and $HF(g)$ are $5.5kcal$ - $57kcal$ and $-64kcal$ repectively.

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14. A gas mixture of 4 litres of ethylene and methane on complete combustion at $25^\circ C$ produces 6 litres of CO_2. Find out the amount of heat evolved on burning one litre of the gas mixture. The heats of combustion of ethylene and methane are -1464 and $-976KJmol^{-1}$ at $25^\circ C$

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15. Enthalpy of neutralization of HCl by $NaOH$ is $-57.1J/mol$ and by NH_4OH is $-51.1KJ/mol$. Calculate the enthalpy of dissociation of NH_4OH.

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16. Calculate the standard enthalpy of solution of $AgCl(s)$ in water

$\Delta H_f^0(AgCl, s) = -127.07 kJmol^{-1}, \Delta H_f^0\left(Ag^+, aq\right) = 105.58 kJmol^{-1}, \Delta H_f^0\left(Cl^-, a$

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17. The enthalpy of formation of $H_2O(l)$ is $-285 KJmol^{-1}$ and enthalpy of neutralization of a stron acid and a strong bas is $-55 KJmol^{-1}$. What is the enthalpy of formation of OH^- ions?

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18. Calculate the enthalpy change when one mole of $HCl(g)$ is dissolved in a very large amount of water at $25\,^\circ C$. The change in state is: $HCl(g) + ar \rightarrow H^+(aq) + Cl^-(aq)$

Given: $\Delta_f H(HCl, g) - 92 KJmol^{-1}$ and $\Delta_f H^\circ\left(Cl^-, aq\right) = -167 KJmol^{-1}$

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19. Using the bond enthalpy data given below, calculate the enthalpy change for the reaction

$C_3H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

Data:	Bond	Bond enthalpy
	$C - C$	$336KJmol^{-1}$
	$C = C$	$606KJmol^{-1}$
	$C - H$	$410KJmol^{-1}$
	$H - H$	$431KJmol^{-1}$

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20. Using the bond enthalpy data given below, estimate the enthalpy of formation of gaseous isoprene

$CH_2 = C | CH_3 - CH = CH_2$

Data Bond enthalpy of $C - H$bond $= 413.38KJmol^{-1}$

Bond enthalpy of $C - C$bond $= 347.69KJmol^{-1}$

Bond enthalpy of $C = C$bond $= 615.05KJmol^{-1}$

Enthalpy of sublimation of carbon (graphite) $= 718.39KJmol^{-1}$

Enthalpy of dissociation of $H_2(g) = 435.97KJmol^{-1}$

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21. Find the bond energy of $S - S$ bond from the following data:

$C_2H_5 - S - C_2H_5(g)$ $\Delta_f H^\circ = -147 KJmol^{-1}$

$C_2H_5 - S - S - C_2H_5(g)$ $\Delta_f H^\circ = -201 KJmol^{-1}$

$S(g)$ $\Delta_f H^\circ = 222 KJmol^{-1}$

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22. Calculate the heat of formation of benzene from the following data, assuming no resonance. Bond energies :

$C - C = 83 kcal, C = C = 140 Kcal, C - H = 99 kcal$

Heat of atomisation of $C - 1709 kcal$

Heat of atomisation of $H = 6 \times 52.1 kcal$

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MISCELLANEOUS SOLVED EXAMPLES

1. Find (in terms of $'a'$) the amount of energy required to raise the temperature of a substance from $3K$ to $5K$. At low temperature. $C_p = aT^3$.

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2. A thermally isolated vessel contains $100g$ of water at $0^\circ C$. When air above the water is pumped out, some of the water freezes and some evaporates at $0^\circ C$ itself. Calculate the mass of the ice formed such that no water is left in the vessel. Latent heat of vaporization of water at $0^\circ C = 2.10 \times 10^6 J/kg$ and latent heat of fusion of ice $= 3.36 \times 10^5 J/kg$.

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3. Work done in expansion of an ideal gas from 4 litre to 6 litre against a constant external pressure of $2.1 atm$ was used to heat up 1 mole of water at $293K$. If specific heat of water is $4.2 Jg^{-1}K^{-1}$, what is the final temperature of water?

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4. 1 mole of ice at $0^{\circ}C$ and $4.6mmHg$ pressure is converted to water vapour at a constant temperature and pressure. Find ΔH and ΔE if the latent heat of fusion of ice is $80cal/g$ and latent heat of vaporisation of liquid water at $0^{\circ}C$ is $596cal/g$ and the volume of ice in comparison to that of water (vapour) in neglected.

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5. For $Ag, \bar{C}_p\left(JK^{-1}mol^{-1}\right)$ is given by $24 + 0.006T$. Calculate ΔH if $3mol$ of silver are raised from $27^{\circ}C$ to its melting point $927^{\circ}C$ under $1atm$ pressure.

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6. Calculate the amount of heat evolved during the complete combustion of 100 ml liquid benzene from the following data :

18 gm of graphite on complete combustion evolve 590 kJ heat

15889 kJ heat required to dissociate all the molecules of 1 liter water into

H_2 and O_2

The heat of formation of liquide benxene is $50kJ/\text{mol}$

Density of $C_6H_6(l) = 0.87gm/ml$

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7. For the equation

$C(\text{diamond}) + 2H_2(g) \rightarrow CH_4(g)\Delta H_1, C(g) + 5H(g) \rightarrow CH_4(g)\Delta H_2$

A. $\Delta H_1 = \Delta H_2$

B. $\Delta H_1 > \Delta H_2$

C. $\Delta H_1 < \Delta H_2$

D. $\Delta H_1 = \Delta H_2 + \Delta_{vap}H(C) + \Delta_{diss}H\left(H_2\right)$

Answer: B

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

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9. Following graph shows a single stange expansion process, then workdone by the system is

A. $-9104J$

B. $-202.6J$

C. $-506J$

D. $-101.3J$

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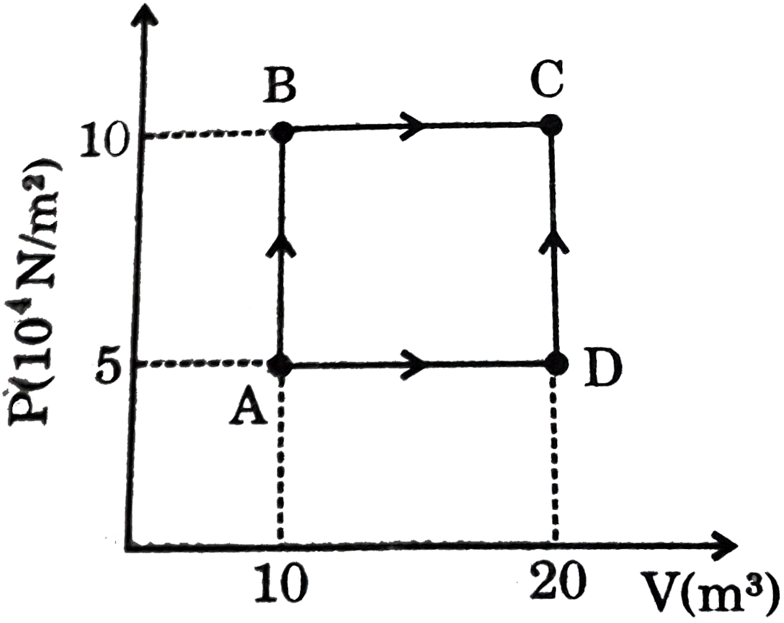
10. A sample of 2 kg of helium (assumed ideal) is taken through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC. Then, the temperature of the states A and B are : (Given $R = 8.3 J/\text{mol} - K$):



A. $T_A = 120.5K, T_B = 120.5K$

B. $T_A = 241K, T_B = 241K$

C. $T_A = 120.5K, T_B = 241K$

D.

Answer: C

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11. In an isothermal expansion of a gaseous sample the correct relation is (consider w(work) with sign according to new $IUPAC$ convention)

[The reversible and irreversible processes are carried out between same initial and final states]

A. $W_{rev} > W_{irrev}$

B. $W_{irrev} > W_{rev}$

C. $q_{rev} < q_{irrev}$

D. can not be predicted

Answer: B

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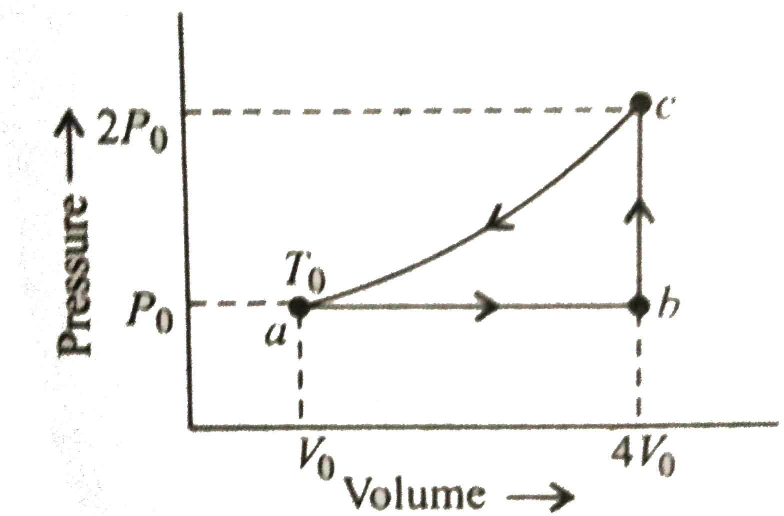
12. One mole of an ideal mono-atomic gas is caused to go through the cycle shown in the figure below. Then the change in the internal enegry in expanding the gas from a to c along the path abc is:



A. $3P_0V_0$

B. $6RT_0$

C. $4.5RT_0$

D. $10.5RT_0$

Answer: D

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

$(1 \text{Latm} \underset{-}{\sim} 100J)$

A. $\Delta H = 15KJ$

B. $\Delta H = 15.7KJ$

C. $\Delta H = 14.4KJ$

D. $\Delta H = 14.7KJ$

Answer: B

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14. One mole of an ideal monoatomic gas expands isothermally against constant external pressure of $1atm$ from intial volume of $1L$ to a state where its final pressure becomes equal to external pressure. If initial temperature of gas in $300K$ then total entropy change of system in the above process is:

$\left[R = 0.0082 Latmmol^{-1} K^{-1} = 8.3 Jmol^{-1} K^{-1}\right]$

A. 0

B. $R\ln(24.6)$

C. $R\ln(2490)$

D. $3/2 R\ln(24.6)$

Answer: B

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15. For a perfectly crystaline solid $C_{p.m} = aT^3$, where a is constant. If $C_{p.m}$ is $0.42 J/K\text{-}mol$ at $10K$, molar entropy at $10K$ is:

A. $0.42 J/K\text{-}mol$

B. $0.14 J/K\text{-}mol$

C. $4.2J/K\text{-}mol$

D. Zero

Answer: B

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16. Given the following data

Substance	$\Delta H^\circ(KJ/mol)$	$S^\circ(J/molK)$	$\Delta G^\circ(kJ/mol)$
$FeO(s)$	-266.3	57.49	-245.12
$C(\text{Graphite})$	0	5.74	0
$Fe(s)$	0	5.74	0
$CO(g)$	-110.5	197.6	-137.15

Determine at what temperature the following reaction is spontaneous?

$$FeO(s) + C(\text{Graphite}) \rightarrow Fe(s) + CO(g)$$

A. $298K$

B. $668K$

C. $966K$

D. ΔG° is $+ve$ hence the reaction will never be spontaneous

Answer: C

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17. If ΔH_f° for Ag^+ (infinitely diluted), NO_3^- (infinitely diluted), Cl^- (infinitely diluted) and $AgCl(s)$ are $10.5.579 - 207.36, -67.159$ and -127.068 respectively. Calculate the enthalpy change for the reaction

$AgNO_3(aq.) \rightarrow + HCl(aq.) \rightarrow AgCl(s) + HNO_3(aq.)$

A. $21.471KJ/mol$

B. $145.688KJ/mol$

C. $-65488KJ/mol$

D. None

Answer: C

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18. What is the work done against the atmosphere when 25 grams of water vaprorizes at $373K$ against a constant external pressure of $1atm$? Assume that steam obeys perfect gas law. Given that the molar enthalpy of vaporization is $9.72kcal/\text{mole}$, what is the change of internal energy in the above process?

A. $1294.0cal, 11247cal$

B. $921.4cal, 11074cal$

C. $1025.6cal, 12474.3cal$

D. $1129.3cal, 10207cal$

Answer: C

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A-1

1. Categorize these properties into state and path functions.

(a) Internal energy , (b) Volume , (c) Heat , (d) Enthalpy

(e) Temperature , (f) Work , (g) Molar heat capacity

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A-2

1. Categorize these properties into extensive and intensive

(a) Temperature , (b) Internal energy ,(c) Heat, (d) Density

(e) Moar volume , (f) molar enthalpy , (g) viscosity

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A-3

1. Identify the state function and path functions.

(a) The change in potential energy when a book is transferred from table to shelf.

(b) The heat evolved when a cube of sugar is oxidized to $CO_{2(g)}$ and $H_2O_{(g)}$.

(c) The work accomplished in burning a litre of gasoline.

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B-1

1. Isothermal expansion from state A to B, isochoric pressure increment from B to C, isothermal contraction from C to D, isobaric contraction from $D \rightarrow A$.

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B-2

1. Isothermal expansion from $A \rightarrow B$, isochoric pressure increase from $B \rightarrow C$, isobaric compression from $C \rightarrow D$, isochoric pressure drop from $D \rightarrow A$.

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B-3

1. Isobaric expansion from $A \rightarrow B$, isochoric pressure drop from $B \rightarrow C$, isothermal compression $C \rightarrow A$.

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C-1

1. Calculate the work done by 0.1 mole of a gas at $27^{\circ} C$ to double its volume at constant pressure $\left(R = 2 cal mol^{-1} K^{-1}\right)$

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C-2

1. Calculate the work done during isothermal reversible expansion of one mole ideal gas from $10 atm$ to $1 atm$ at $300K$.

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C-3

1. 6 moles of an ideal gas expand isothermally and reversibly from a volume of 1 litre to a volume of 10 litres at $27^{\circ} C$. What is the maximum work done.

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C-4

1. At $25^{\circ}C$, a 0.01 mole sample of a gas is compressed in volume from $4.0L$ to $1.0L$ at constant temperature. What is work done for this process if the external pressure is 4.0 bar ?

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C-5

1. Calculate work done by 1 mole of ideal gas expand isothermally and irreversibly from pressure of 5 atm to 2 atm against a constant external pressure of 1 atm at $300K$ temperature.

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D-1

1. Calculate the number of KJ necessary to raise the temperature of $60.0gm$ of aluminium from 35° to $55^\circ C$. Molar heat capcacity of Al is $24Jmol^{-1}K^{-1}$

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D-2

1. In a container, two moles of a diatomic ideal gas is allowed to expand against $1atm$ pressrue & volume change from 2 litre of 5 litre then calculate change in internal energy.

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D-3

1. $0.040g$ of He is kept in a closed container initially at $100.0^{\circ} C$. The container is now heated. Neglecting the expansion of the container, Calculate the temperature at which the internal energy is increased by $12J$.

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D-5

1. Internal energy of two moles of an ideal gas at temperature of $27^{\circ} C$ is $1200R$. Then find the molar specific heat of the has at constant pressure ?

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E-1

1. The work done by the system is 8 joule, when 40 joule heat is supplied to it. What is the increases in internal energy of system.

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E-3

1. A gas expends from $2L$ to $6L$ against a constant pressure of 0.5 atm on absobing $200J$ of heat. Calculate the change in internal energy.

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E-4

1. In given figure, when a thermodynamic system is taken from state A to state B via path ACB, 100 cal of heat given to the system and 60 cal work is done by the gas. Along the path ADB, the work done by the gas is 20 cal. Find the heat following into the system in this case ?

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F-1

1. 70 calories of heat required to raise the temperature of 2 moles of an ideal gas at constant pressure from $30^\circ C \to 35^\circ C$. The amount of heat required (in calories) to raise the temperature of the same gas through the same range $\left(30^\circ C \to 35^\circ C\right)$ at constant volume is:

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F-3

1. For a gas, $\gamma = 9/7$. What is the number of degrees of freedom of the molecules of this gas ?

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F-4

1. One mole of ideal monoatomic gas $(\gamma = 5/3)$ is mixed with one mole of diatomic gas $(\gamma = 7/5)$. What is γ for the mixture? γ Denotes the ratio of specific heat at constant pressure, to that at constant volume

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F-6

1. An ideal gas $\left(\gamma = \frac{5}{3}\right)$ is adiabatically compressed from $640 cm^3$ to $80 cm^3$. If the initial pressure is P then find the final pressure ?

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F-7

1. In an adiabatic process, the pressure is increased by $\frac{2}{3}\%$. If $\gamma = \frac{3}{2}$, then find the decreases in volume (approximately) ?

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F-8

1. 1 mole of CO_2 gas at $300K$ is expanded under reversible adiabatic condition such that its volume becomes 27 times.

(a) What is the final temperature ? , (b) What is work done ?

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F-9

1. A insulated piston freely move in a cyclinder from volume 5 lit to 10 lit then calculate work done & heat during this expansion.

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F-10

1. (a) A certain mass of gas initially at $(1L, 5atm, 300K)$ is expanded reversible and isothermally to final volume of $5L$, calculate the work done by the gas and heat supplied in this process to the gas.

(b) Now, if the gas is released to initial position by compressing it using an external constant pressure of 5 atm. Fins work done on the gas in this process and heat rejected by gas

(c) In the above two processes, what is the net gained by surroundings ?

[Note: From above question see that surrounding has done extra work on the system but system has returned that work in the form of heat to surrounding and work is considered on organized form of energy while heat as an unorganised form hence in the above process, there must be net increment in randomness of universe which be called Entropy, soon]

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G-1

1. If 1.0 kcal of heat is added to 1.2 L of O_2 in a cyclinder of constant pressure of 1 atm , the volume increase to 1.5 L . Calculate ΔU and $\Delta H$of the process.

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G-2

1. $10g$ of argon gas is cmpressed isothermally and reversibly at a temperature of $27^\circ C$ from $10L$ to $5L$. Calculate enthalpy change (ΔH) for this process $R = 2.0 cal K^{-1} mol^{-1}. \log_{10} 2 = 0.30$

Atomic mass of $Ar = 40$

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H-1

1. What is ΔU when 2.0 mole of liquid water vaporise at $100^{\circ} C$? The heat of vaporistaion , ΔH vap. of water at $100^{\circ} C$ is $40.66 kJ mol^{-1}$.

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Exercise -1 Part -II Only option correct type

1. Warming amonium chloride with sodium hydroxide in a test is an example of:

A. Closed system

B. Isolated system

C. Open system

D. None of these

Answer: C

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2. Out of boiling point (I), entropy (II), pH (III) and $e.m.f$ of a cell (IV), intensive properties are:

A. I, II

B. I, II, III

C. I, III, IV

D. All of the above

Answer: C

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3. In which case bodies become hot due to mechanical energy losses

(i) Rub our hands for sometimes

(ii) Two vehicles collied with each other

(iii) Aeroplane crases

(iv) Sliding of legs on roof surface

(v) Transfer of energy from hot energy from hot body to cold body

A. 5

B. 4

C. 3

D. 2

Answer: B

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4. Predict the total number of intensive properties:

(i) Free energy , (ii) Critical density , (iii) Viscosity , (iv) Specific heat capacity

(v) molar heat capacity , (vi) Kinetic energy , (vii) Specific gravity , (viii) Dielectric constant

(ix) pH

A. 9

B. 8

C. 7

D. 6

Answer: C

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5. An ideal gas filled at pressure $2atm$ and temp of $300K$, in a balloon is kept in vaccum with in a large container wall of balloon is punchtured then container temperature :

A. Decreases

B. Increases

C. Remain constant

D. Unpredictable

Answer: C

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6. Internal pressure of a perfect gas (ideal gas) is:

A. Zero

B. infinite

C. Calculated by $PV = nRT$

D. Can not say directally

Answer: A

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7. If the door of a refrigerator is kept open in a closed room then room :

A. heated

B. cooled

C. heated or cooled depending upon the initial temperature of the room

D. Neither cooled nor heated.

Answer: A

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8. A gaseous system changes from state $A(P_1, V_1, T_1)$ to $B(P_2, V_2, T_2)$ to $C(P_3, V_3, T_3)$ and finally from C to A. The whole process may be called :

A. Reversible process

B. Cyclic process

C. Isobaric process

D. Spontaneous process

Answer: B

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9. A well stoppered thermoflask contains some ice cubes. This is an example of a-

A. Closed system

B. Open system

C. Isolated system

D. Non-thermodynamic system

Answer: C

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10. In thermodynamics, a process is called reversible when-

A. surroundings and system change into each other

B. there is no boundary between system and surroundings

C. the surroundings are always in equilibrium with the system

D. the system changes into the surroundings spontaneously

Answer: C

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11. Five moles of gas is put through a series of changes as shown graphically in a cyclic process the $A \rightarrow B, B \rightarrow C$ and $C \rightarrow A$ respectively are

A. Isochoric, Isobaric, Isothermal

B. Isobaric, Isochoric, Isothermal

C. Isothermal, Isobaric, Isochoric

D.

Answer: A

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12. The process $\Delta U = 0$, for an ideal gas can be best represented in the form of a graph

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13. Figure shows graphs of pressure vs density for an ideal gas at two temperatures T_t and T_2

A. $T_1 > T_2$

B. $T_1 = T_2$

C. $T_1 < T_2$

D. any of the three is possible

Answer: A

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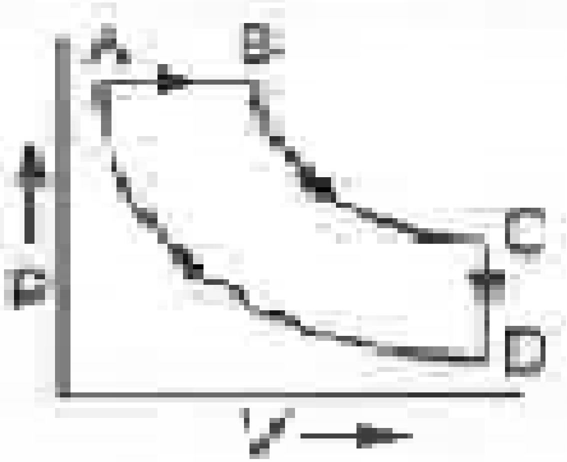

14.

A cyclic process ABCD is shown in the p-V diagram. Which of the following curves represent the same process?

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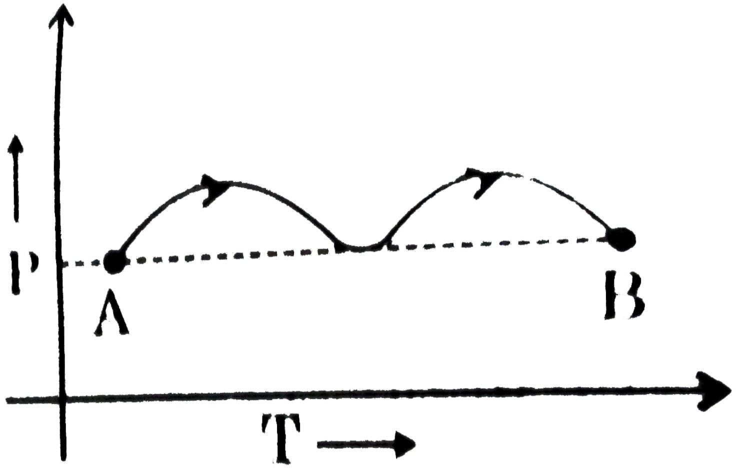
15. The P-T graph, as given below, was observed for a process on an ideal gas. Which of the statement is true ?



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

B. $w = -ve, \Delta H = -ve$

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

D. $w = +ve, \Delta H = -ve$

Answer: C

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16. In a laboratory, liquid in a thermally insulated container is stirred for one, hr, by a mechanical linkage to a in surrounding, for this process:

A. $W < 0, q = 0$

B. $W < 0, q > 0$

C. $W < 0, q > 0$

D. $W > 0, q = 0$

Answer: D

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17. Two method of an ideal gas expand spontaneously in vacuum. The work done is:

A. 2 joule

B. 4 joule

C. Zero

D. Infinite

Answer: C

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18. Temeprature of 1 mole of a gas is increased by 2° at constant pressure, then work done is :

A. R

B. $2R$

C. $R/2$

D. Data insufficient

Answer: B

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19. Mechanical work is specially important in system that contain

A. Solid-liquid

B. Liquid-Liquid

C. Solid-Solid

D. Gases

Answer: D

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20. A thermodynamic system goes from states (i) P_1, V to $2P_1, V$ (ii) P, V_1 to $P.2V_1$. Then work done in the two cases is

A. Zero,Zero

B. Zero,PV_1

C. -PV_1, Zero

D. -PV_1, P_1V_2

Answer: B

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21. The work done in ergs for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to 20 litres at $25\,^{\circ}C$ is

A. $-2.303 \times 298 \times 0.82 \log 2$

B. $-298 \times 10^{7} \times 8.31 \times 2.3031 \log 2$

C. $-2.303 \times 298 \times 0.082 \log 0.5$

D. $-8.31 \times 10^{7} \times 298 \times 2.303 \log 0.5$

Answer: B

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22. An ideal gas is taken around the cycle $ABCA$ as shown in P - V diagram. The net work done by the gas during the cycle is equal to:

A. $12P_1V_1$

B. $6P_1V_1$

C. $5P_1V_1$

D. P_1V_1

Answer: C

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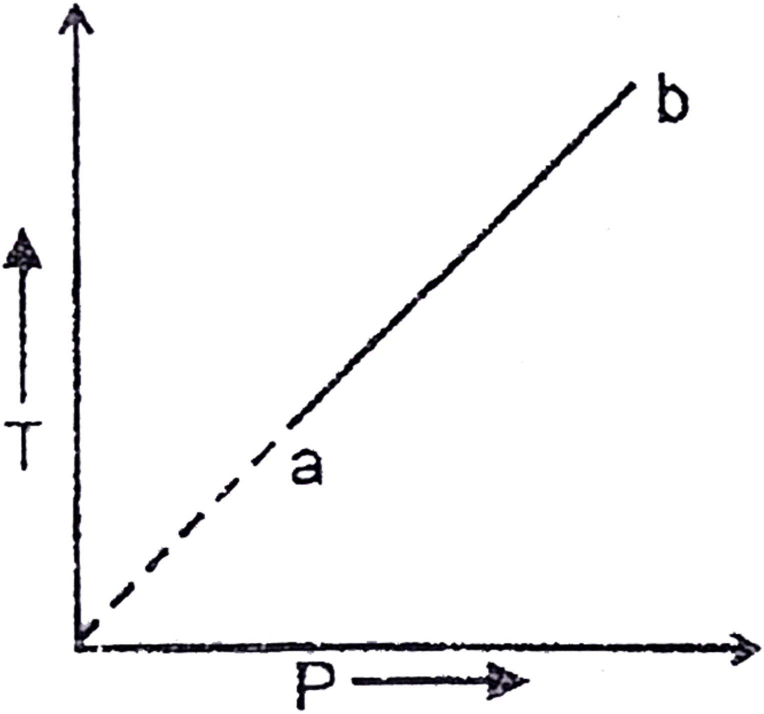
23. An ideal gas change from state a to state b as shown in Fig. what is the work done by the gas in the process?



A. Zero

B. positive

C. negative

D. Infinite

Answer: A

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24. In given figure, let ΔW and ΔW_2 be the work done by the gas in process A and B respectively then (given change in volume is same in both process)

A. $\Delta W_1 > \Delta W_2$

B. $\Delta W_1 = \Delta W_2$

C. $\Delta W_1 < \Delta W_2$

D. Nothing can be said about the relation between ΔW_1 and ΔW_2

Answer: C

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25. Freezing up liquid in a system then:

A. $q = 0$

B. $q > 0$

C. $q < 0$

D. $q > 0$ or $q < 0$ (depending on the nature of liquid)

Answer: C

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26. A piece of zinc at a temperature of $20\,^{\circ}C$ weighing $65.38g$ is dropped into $180g$ of boiling water $\left(T = 100\,^{\circ}C\right)$ The specific heat of zince is $0.4Jg^{-1}C^{-1}$ and that of water is $4.2Jg^{-1\,\circ}C^{-1}$. What is the final common temperature reached by both the zinc and water ?

A. $97.3\,^{\circ}C$

B. $33.4\,^{\circ}C$

C. $80.1\,^{\circ}C$

D. $60.0\,^{\circ}C$

Answer: A

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27. Which has maximum internal energy at $290K$?

A. Neon gas

B. Nitrogen gas

C. Ozone gas

D. All have equal value

Answer: C

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28. Let ΔU_1 and ΔU_2 be the changes in internal energy of an ideal gas in the processes A and B then

A. $\Delta U_1 > \Delta U_2$

B. $\Delta U_1 = \Delta U_2$

C. $\Delta U_1 < \Delta U_2$

D. $\Delta U_1 \neq \Delta U_2$

Answer: B

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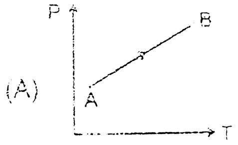
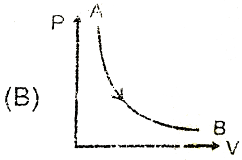
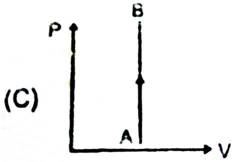
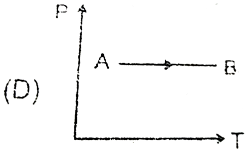
29. The process $\Delta U = 0$, for an ideal gas can be best represented in the form of a graph

A. 

B. 

C. 

D. 

Answer: B

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30. For 2 mole of an ideal gas , the relation between $C_p \& C_v$ (non-molar) are:

A. $C_p - C_v = 2R$

B. $C_v - C_p = 2R$

C. $C_p - C_v = R$

D. $C_v - C_p = R$

Answer: A

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31. When an ideal gas is heated at constant pressure, the fraction of the heat energy supplied whicn increases the internal energy of the gas is :

A. $\frac{2}{5}$

B. $\frac{3}{5}$

C. $\frac{3}{7}$

D. $\frac{5}{7}$

Answer: D

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32. Supposing the distance between the atoms of a diatomic gas to be constant, its specific heat at constant volume per mole (gram mole) is

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

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

C. R

D. $\frac{7}{2}R$

Answer: A

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33. The following sets of volume of C_v and C_p of an ideal gas have been reported by different students. The units are cal $\text{mole}^{-1}K^{-1}$. Which of these sets is most reliable ?

A. $C_v = 3, C_p = 5$

B. $C_v = 4, C_p = 5$

C. $C_v = 3, C_p = 2$

D. $C_v = 3, C_p = 4.2$

Answer: A

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34. A system absorb $600J$ of heat and work equivalent to $300J$ on its surroundings. The change in internal energy

A. $300J$

B. $400J$

C. $500J$

D. $600J$

Answer: A

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35. A sample of liquid in a thermally insulated constant (a calorimetre) is stirred for 2 hr. by a mechancal linkage to motor in the surrounding ,for this procees :

A. $w < 0, q = 0, \Delta U = 0$

B. $w > 0, q > 0, \Delta U > 0$

C. $w < 0, q > 0, \Delta U = 0$

D. $w > 0, q = 0, \Delta U > 0$

Answer: D

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36. In an isochoric process the increase in internal energy is

A. Equal to the heat absorbed

B. Equal to the heat evolved

C. Equal to the work done

D. Equal to the sum of the heat absorbed and work done

Answer: A

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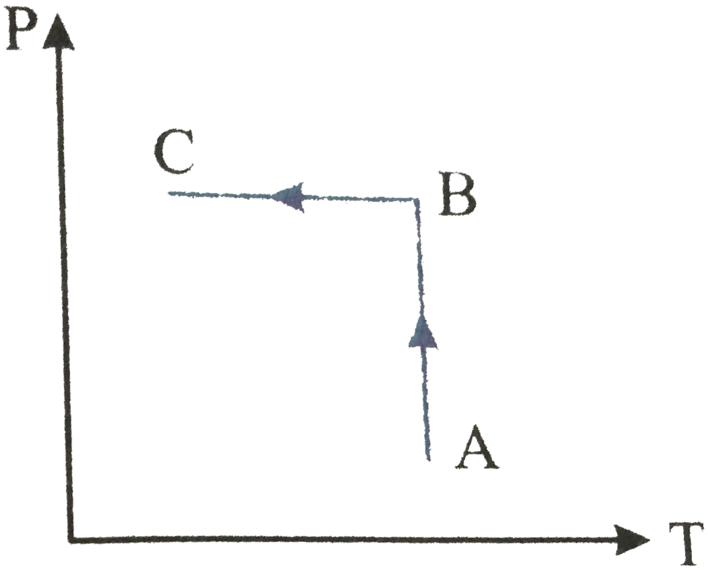
37. Ideal gas is taken through the process shown in the figure :



A. In process AB, work done by system is positive

B. In process AB, heat is rejected out of the system.

C. In process AB, internal energy increases

D. In process AB internal energy decreases and in process BC internal energy increases.

Answer: B

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38. If heat is supplied to an ideal gas in an isothermal process.

A. the internal energy of the gas will increase

B. the gas will do positive work

C. the gas will do negative work

D. the given process is not possible

Answer: C

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39. In an isothermal expansion of an ideal gas. Select wrong statement:

A. there is no change in the temperature of the gas

B. there is no change in the internal energy of the gas

C. the work done by the gas is equal to the heat supplied to the gas

D. the work done by the gas is equal to the changes in its internal energy

Answer: D

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40. A system undergoes a process which absorbed $5KJ$ of heat and undergoing an expansion againt external pressure of $1atm$, during the process change in internal energy is $300J$. Then predict the change in volume (lit)

A. 1

B. 2

C. 3

D. 4

Answer: B

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41. In an adiabatic expansion of an ideal gas -

A. $W = -\Delta U$

B. $W = \Delta U$

C. $\Delta U = 0$

D. $W = 0$

Answer: B

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42. The temperature of the system decreases in an

A. Adiabatic compression

B. Isothermal compression

C. Isothermal expansion

D. Adiabatic expansion

Answer: D

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43. $1mol$ 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. $1500K, 900cal$

B. $150K, 400cal$

C. $250K, 1000cal$

D. $200K, 800cal$

Answer: A

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44. A balloon of $1L$ volume is fill with O_2 gas, kept in a spaceship at STP. Now this spaceship is send in space & ballons is released out of the spceship. Then ballon expands upto bursting then calculate work done by balloon.

A. 0

B. 1

C. 2

D. 3

Answer: A

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45. 1 mole of an ideal diatomic gas undergoes a reversible polytropic process $\left(PV^2 = \text{constant}\right)$. The gas expand from initial volume of 1 litre and temp $300K$ to final volume 3 lit. Claculate change in internal energy (approx).

A. -$40KJ$

B. -$4.2KJ$

C. -$4.4KJ$

D. -$4.6KJ$

Answer: B

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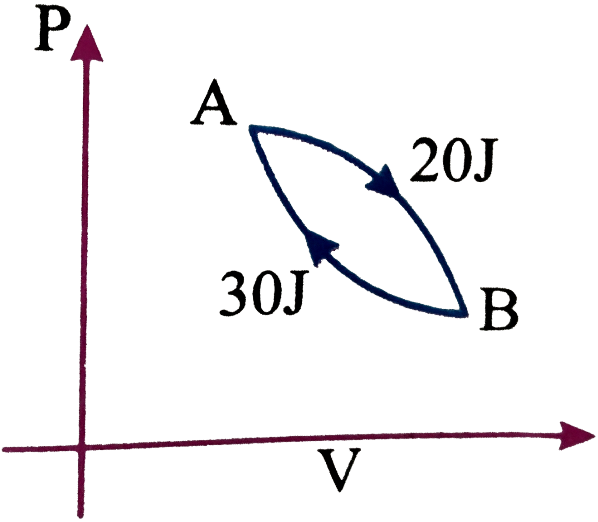
46. In a cyclic process shown in the figure an ideal gas is adiabatically taken from $B to A$, the work done on the gas during the process $B to A$ is $30, J$ when the gas is taken from A to B the heat absorbed by the gas is

$20 J$ Then change in internal energy of the gas in the process A to B is :



A. $20 J$

B. $-30 J$

C. $50 J$

D. $-10 J$

Answer: B

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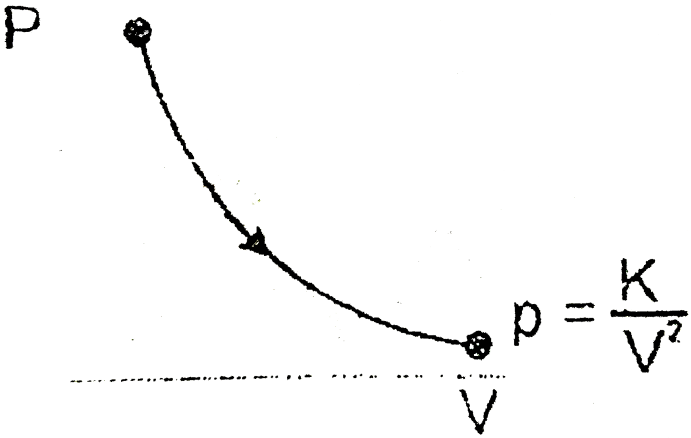
47. The molar heat capacity for the process shown in fig. is



A. $C = C_v$

B. $C = C_p$

C. $C > C_v$

D. $C < C_v$

Answer: D

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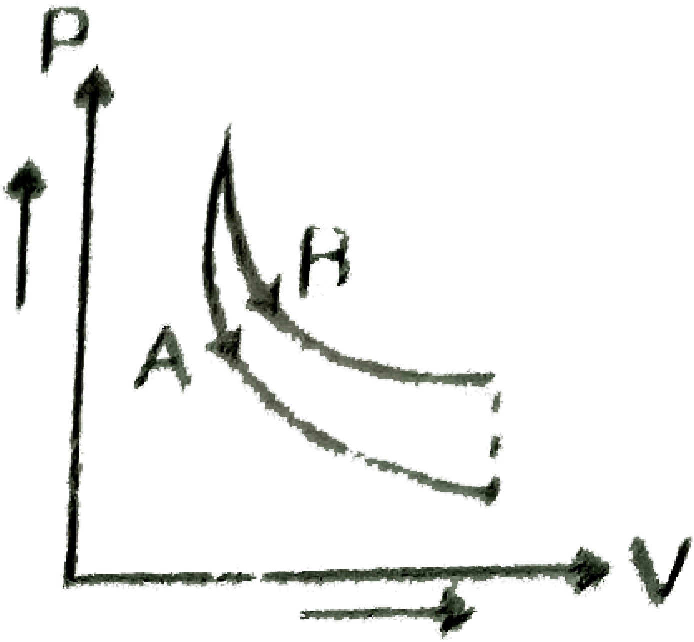
48. In figure, A and B are two adiabatic curves for two different gases. Then A and B corresponds to:



A. Ar and He respectively

B. He and H_2 respectively

C. O_2 and H_2 respectively

D. H_2 and He respectively

Answer: B

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49. 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. $W_3 > W_1 > W_2$

B. $W_3 > W_2 > W_1$

C. $W_2 > W_1 > W_3$

D. $W_1 > W_2 > W_3$

Answer: A

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50. One mole of non - ideal gas undergoes a change of state $(1.0atm, 3.0L, 200K)$ to $(4.0atm, 5.0L, 250K)$ with a change in internal energy $(\Delta U) = 40L$ - atm. The change in enthalpy of the process in L - atm,

A. 43

B. 57

C. 42

D. None of these

Answer: B

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51. A system containing real gas changes it's state from state - 1 to state - 2.

State -1$(2atm, 3L, 300K)$

State-2 $(5atm, 4L, 500K)$

If change in internal energy $= 30Latm$ then calculate change in enthalpy.

A. $44Latm$

B. $35Latm$

C. $40Latm$

D. None of these

Answer: A

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52. For the isothernmal expansion of an ideal gas

A. U and H increases

B. U increases but H decreases

C. H increases but U decreases

D. U and H are unaltered

Answer: D

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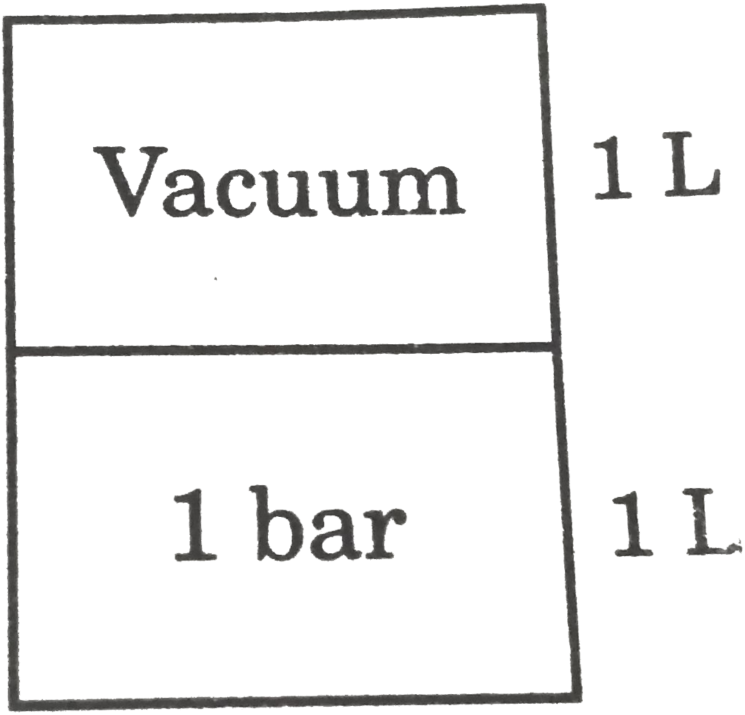
53. A container of volume 2L is seperated into equal compartments. In one compartment, one mole of an ideal monoatomic gas is filled at 1 bar pressure and the other compartment is completely evacuted. A pihole is made in the seperator so gas expands to occupy full 2 L and heat is supplied to gas so that finally pressure of gas equals 1 bar. Then :



A. $\Delta U = \Delta H = 150J$

B. $\Delta H = 250J$

C. $\Delta U = 100J$

D. $\Delta U = \Delta H = 0$

Answer: B

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54. A vessel contains 100 litres of a liquid X. Heat is supplied to the liquid in such a fashion that, Heat given $=$ change in enthalpy. The volume of the liquid increases by 2 litres. If the external pressure is one atm, and 202.6 joules of heat were supplied then, [U-total internal energy]

A. $\Delta U = 0, \Delta H = 0$

B. $\Delta U + 202.6J, \Delta H = + 202.6J, \Delta H = + 202.6J$

C. $\Delta U = - 202.6J, \Delta H = - 202.6J$

D. $\Delta U = 0, \Delta H + 202.6J$

Answer: D

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55. $H_2O_{(s)} \rightarrow H_2O_{(l)}$

This phase transition is carried out at constant temp and pressure then work done during the process:

A. $W < 0$

B. $W > 0$

C. $W = 0$

D. Can't detamined

Answer: B

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56. At $1atm$ pressure freezing of n mole of water liquid $\left(0^\circ C\right)$ then heat transfer:

A. $n\Delta H_{\text{fusion}}$

B. - $n\Delta H_{\text{combustion}}$

C. $nC_{v,m}\Delta T$

D. ΔH_{fusion}

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57. The free energy change for a reversible reaction at equilibrium is:

A. Positive

B. Negative

C. Zero

D. Can not say

Answer: (C)

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58. ΔH° for the reaction $X_{(g)} + Y_{(g)} \Leftrightarrow Z_{(g)}$ is $-4.6 kcal$, the valueof ΔU° of th e reaction at $227^\circ C$ is $\left(R = 2 cal. mol^{-1} K^{-1}\right)$:

A. $-3.6 kcal$

B. $-5.6 kcal$

C. $-4.6 kcl$

D. `-2.6 kcal

Answer: A

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59. Determine which of the following reactions at constant pressure represents surroundings that do work on the system:

I. $4NH_3(g) + 7O_2(g) \rightarrow 4NO_2(g) + 6H_2O(g)$

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

III. $C(s, \text{graphite}) + H_2O(g) \rightarrow CO(g) + H_2(g)$

IV. $H_2O \rightarrow H_2O(l)$

A. II,IV

B. II and III

C. II,IV

D. I and II,IV

Answer: D

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60. Consider the reaction at $300K$

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g), \quad \Delta H^\circ = -185kJ$

If 2 mole of H_2 completely react with 2 mole of Cl_2 to form HCl. What is ΔU° for this reaction?

A. 0

B. $-185kJ$

C. $370kJ$

D. $-370kJ$

Answer: D

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61. 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. $\Delta H < \Delta U$ only if the number of moles of the products is greater than the number of the reactants

C. ΔH is always less than ΔU

D. $\Delta H < \Delta U$ only if the number of moles of the product is less than the number of moles reactants

Answer: D

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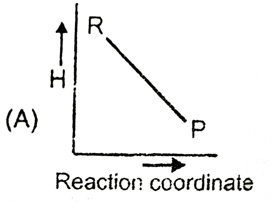
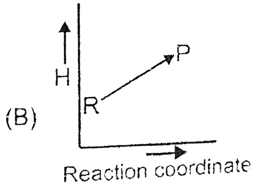
62. Which plot represent an exothermic reaction ?

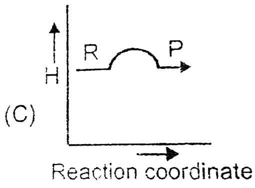
A.



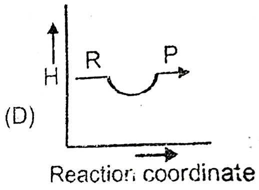
B.



C.



D.



Answer: A

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63. For which of the following change $\Delta H \neq \Delta U$?

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

B. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

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

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

Answer: D

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64. Calculate the standard internal energy of formation of liquid methyl acetate $\left(CH_3COOCH_3\right)$ from its standard enthalpy of foramtion, which is $-44.291 kJ\text{mole}^{-1}$ at $25^\circ C$

A. -433

B. $+433$

C. -452.82

D. 452.82

Answer: A

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65. $2C + O_2 \rightarrow 2CO, \Delta H = -220kJ$ which of the following statements is correct for this reaction

A. Heat of combustion of carbon is $100kJ$

B. Reaction is exothermic

C. Reaction needs no initiation

D. All of these are correct

Answer: B

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66.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -94.3 kcal/mol$$

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -67.4 kcal/mol$$

$$O_2(g) \rightarrow 2O(g) \qquad \Delta H = 117.4 kcal/mol$$

$$CO(g) \rightarrow C(g) + O(g) \qquad \Delta H = 230.6 kcal/mol$$

Calculate ΔH for $C(s) \rightarrow C(g)$ in $kcal/mol$.

A. 171

B. 154

C. 117

D. 145

Answer: D

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67. In the reaction , $CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g), \quad \Delta H = 2.8 kJ, \Delta H$ represents

A. heat of reaction

B. heat of combustion

C. heat of formation

D. heat of solution

Answer: A

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68. Given, $H_2(g) + Br_2(g) \rightarrow 2HBr(g), \Delta H_1^0$ and standard enthalpy of condensaion of bromine is ΔH_2^0, standard enthalpy of formation of HBr at $25\,^{\circ}C$ is

A. $\Delta H_1^0 / 2$

B. $\Delta H_1^0 / 2 + \Delta H_2^0$

C. $\Delta H_1^0 / 2 - \Delta H_2^0$

D. $\left(\Delta H_1^0 - \Delta H_2^0\right) / 2$

Answer: D

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69. For the following reaction,

$C(\text{diamond}) + O_2 \rightarrow CO_2(g) \qquad \Delta H = -97.6 kcal$

$C(\text{graphite}) + O_2 \rightarrow CO_2(g) \qquad \Delta H = -94.3 kcal$

The heat change for the conversion of 1 g of C (diamond) to C(graphite) is:

A. $1.59 kcal$

B. $0.1375 kcal$

C. $0.55 kcal$

D. $0.275 kacl$

Answer: D

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70. The standard heat of combustion of a solid boron is equal to:

A. $\Delta H_f^{\circ}(B_2O_3)$

B. $1/2\Delta H_f^{\circ}(B_2O_3)$

C. $2\Delta H_f^{\circ}(B_2O_3)$

D. $1/2\Delta H_f^{\circ}(B_2O_3)$

Answer: B

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71. The heat of combustion of sucrose $(C_{12}H_{22}O_{11})$ is $1350 kcal/mol$. How much of heat will be liberated when $17.1g$ of sucrose is burnt ?

A. $67.5 kcal$

B. $13.5 kcal$

C. $40.5 kcal$

D. $25.5 kcal$

Answer: A

72. If $S + O_2 \rightarrow SO_2, \Delta H = -298.2 \text{ kJ mole}^{-1}$

$SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 \Delta H = -98.7 \text{ kJ mole}^{-1}$

$SO_3 + H_2O \rightarrow H_2SO_4, \Delta H = -130.2 \text{ kJ mole}^{-1}$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2SO_4, \Delta H = -287.3 \text{ kJ mole}^{-1}$

the enthlapy of formation of H_2SO_4 at 298 K will be

A. $-814.4kJmol^{-1}$

B. $+814.4kJ\text{mole}^{-1}$

C. $-650.3kJ\text{mole}^{-1}$

D. $-433.7kJ\text{mole}^{-1}$

Answer: A

73. When a certain amount of ethylene was combusted, $5644kJ$ heat was evolved. If heat of combustion of ethylene is $1411kJ$, the volume of O_2 (at NTP) the entered into the reaction is:

A. $268.8ml$

B. $268.8L$

C. $6226 \times 22.4L$

D. $22.4L$

Answer: B

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74. The values of heat of combustion of ethane $\left(C_2H_6\right)$ and ethyne $\left(C_2H_2\right)$ are -341 and $-310Kcal$ respectively. Then which of the following is better fuel on mass basis:

A. C_2H_2

B. C_2H_6

C. Both (A) & (B)

D. None of these

Answer: A

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75. In the reaction $CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g) \Delta H = -265 kcal$

The enthalpies of formation of CO_2 and SO_2 are both negative and are in the ratio $4:3$. The enthalpy of formation of CS_2 is $+26 kcal/mol$. Calculate the enthalpy of formation of SO_2.

A. $-90 kcal/mol$

B. $-52 kcal/mol$

C. $-78 kcal/mol$

D. $-71.7 kcal/mol$

Answer: D

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76. If enthalpy of dissociation of CH_4 and C_2H_6 are 320 and 360 calories respectively then bond energy of $C - C$ bond is:

A. $80cal$

B. $40cal$

C. $60cal$

D. $120cal$

Answer: D

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77. Heat of hydronization of ethene is x_1 and that of benzene is x_2. Hence, resonance energy is :

A. $x_1 - x_2$

B. $x_1 + x_2$

C. $3x_1 - x_2$

D. $x_1 - 3x_2$

Answer: C

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78. Calculate the resonance energy of gaseous benzene from the given data

$\Delta H_{C-H} = 416, \Delta H_{C-C} = 331, \Delta H_{C=C} = 591, \Delta H_{\text{sub}}(C, \text{graphite}) = 718$

$\Delta H_{diss}\left(H_2, g\right) = 436$ and $\Delta H_f(\text{benzene}, g) = 83$ (all unit in $kJ\text{mole}^{-1}$)

A. 354

B. 271

C. 437

D. 83

Answer: B

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79. The bond dissociation energy of gaseous H_2, Cl_2 and HCl are $104, 58$ and $103 kcal mol^{-1}$ respectively. The enthalpy of formation for HCl gas will be

A. $-44.0 kcal$

B. $-22.0 kcal$

C. $22.0 kcal$

D. $44.0 kcal$

Answer: B

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80. AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, AB and B_2 are in the ratio $1:1:0.5$ and the enthalpy of formation of AB from A_2 and B_2 is $-100 kJmol^{-1}$, what is the bond enthalpy of A_2 ?

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81. One mole of anhydrous $MgCl_2$ dissolves in water and librates $25 cal/mol$ of heat. $\Delta H_{\text{hydration}}$ of $MgCl_2 = 30 cal/mol$. Heat of dissolution of $MgCl. H_2O$

A. +5 cal/mol

B. -5 cal/mol

C. 55 cal/mol

D. -55 cal/mol

Answer: A

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82. Born-Harber cycle is used to determine:

A. Lattice energy

B. Electron affinity

C. Crystal energy

D. All of these

Answer: D

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83. The enthalpy of solution of $NaOH(s)$ in water is $-41.6kJ/\text{mole}$ When $NaOH$ is dissolved in water then the temperature of water:

A. Increase

B. Decrease

C. Does not change

D. Fluctuates

Answer: A

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84. The enthalpy change for the reaction of 5 litre of ethylene with 5 litre of H_2 gas at 1.5 atm pressure is $\Delta H = -0.5kJ$. The value of ΔU will be: $(1atmLt = 100J)$

A. $-1.25kJ$

B. $+1.25kJ$

C. $0.25kJ$

D. $-0.25kJ$

Answer: C

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85. For which one of the following reaction does not the enthalpy change of a reaction corresponds to Lattice energy of KBr ?

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

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

C. $KBr(s) \rightarrow K^{+}(g) + Br^{-}(g)$

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

Answer: C

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---

86. Calculate the lattice energy of the reaction

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

from the following data:

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

$, E_A(CI) = -365.26kJmol^{-1}$ and $\Delta_f H^{\Theta}(LiCI) = -401.66kJmol^{-1}$

A. -837

B. -959

C. -1567

D. -37

Answer: A

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87. The enthalpy of neutralization of which of the following acid & base is nearly $-13.6 kcal$.

A. HCN and NaOH

B. CH_3COOH and NH_4OH

C. HCl and KOH

D. HCl and NH_4OH

Answer: C

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88. Heat of neutralization of strong acid by a strong base is a constant value due to:

A. salt formed does not hydrolysis

B. only H^+ and OH^- ions react

C. The strong base and strong acid react completely

D. The strong base and strong acid react in aqueous solution

Answer: B

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89. Equal volume of HCOOH and NaOH are mixed. If x is the heat of formation of water, then heat avolved of neutralization is:

A. more than x

B. equal to x

C. twice of x

D. less than x

Answer: D

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90. If $CH_2COOH + OH^- \to CH_3COO^- + H_2O + q_1$

$H^+ + OH^- \to H_2O + q_2$

then the enthalpy change for the equal to

A. $(q_1 + q_2)$

B. $(q_1 - q_2)$

C. $(q_2 - q_1)$

D. $-(q_1 + q_2)$

Answer: C

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91. If heat of dissocitation of $CHCl_2COOH$ is 0.7 kcal/mole then ΔH for the reaction:

$CHCl_2COOH + KOH \rightarrow CHCl_2COOK + H_2O$

A. -13 kcal

B. $+13$ kcal

C. -14.4 kcal

D. -13.7 kcal

Answer: A

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92. Enthalpy of neutralization of $H_3PO_3$with $NaOH$ is $-106.68\text{kJ}/\text{mol}$. If enthalpy of neutralization of HCL with NaOH is -$55.84\text{kJ}/\text{mole}$, then calculate enthalpy of ionization of H_3PO_3 in to its ions in kJ.

A. 50.84 kJ/mol

B. 5 kJ/mol

C. 2.5 kJ/mol

D. None of these

Answer: B

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Exercise -2 Part-I: Only one option correct type

1. Which one of the following statement is false:

A. Work is a state function

B. temperature is a state function

C. change in the state is completely defined when the intial and final states are specified

D. work appears at the boundary of the system.

Answer: A

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2. In which of the following sets, all properties belong to same category (all extensive or all intensive) ?

A. Mass, volume, pressure

B. Temperature, pressure, volume

C. Heat capacity, density, entropy

D. Enthalpy, internal energy, volume.

Answer: D

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3. Identify the state quantiy among the following

A. q

B. q - w

C. q/w

D. $q + w$

Answer: D

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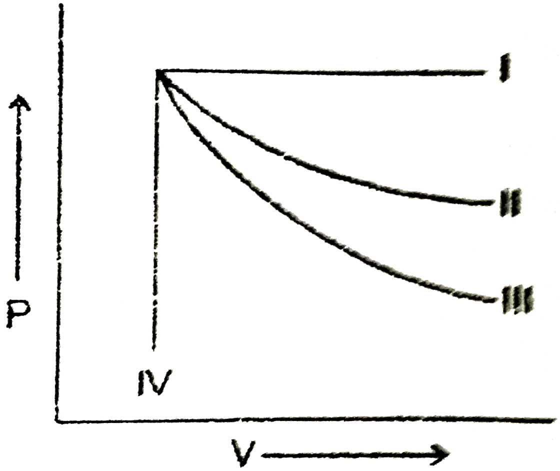

4.

The plots between P and V which represent isochoric and isobaric process respectively:

A. I,II

B. IV,I

C. I,IV

D. II,III

Answer: B

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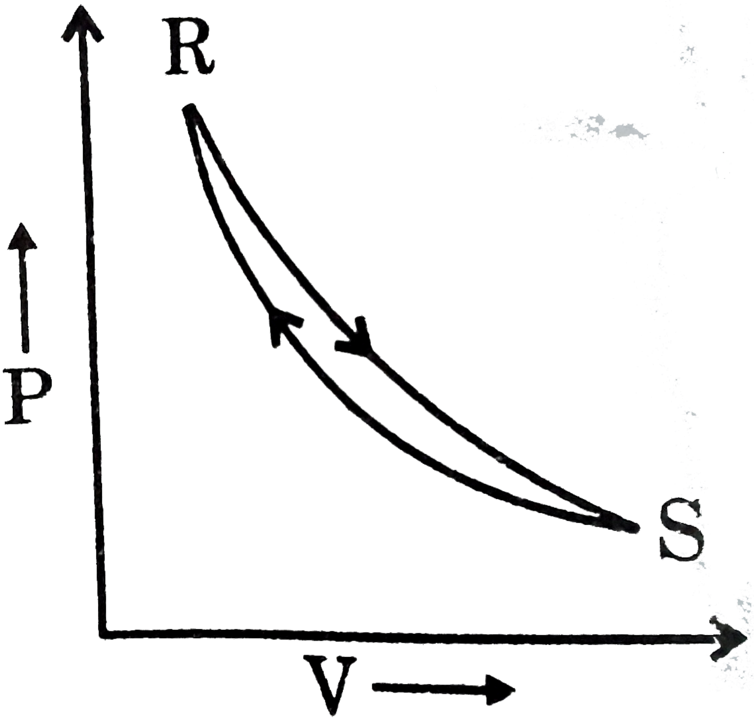
5. Consider the cyclic process $R \to S \to R$ as shown in the fig. You are told that one of the path is adiabatic and the other one isothermal. Which one of the following is (are) true ?



A. Process $R \to S$ is isothermal

B. Process $S \to R$ is adiabatic

C. Process $R \to S$ is adiabatic

D. Such a graph is not possible

Answer: D

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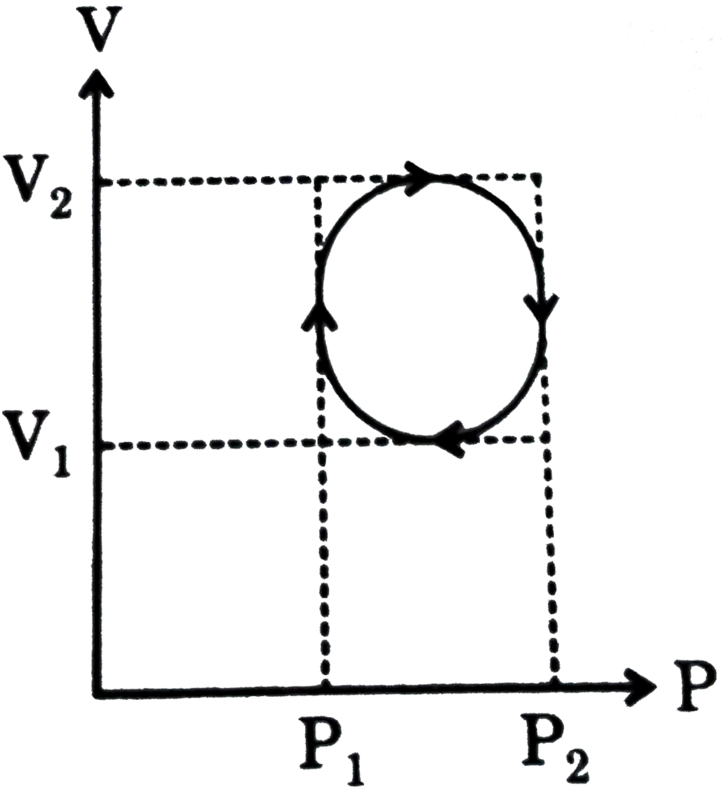
6. In the cyclic process shown in P-V diagram the magnitude of work done is :



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

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

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

D. $\pi\left(V_2 - V_1\right)^2$

Answer: C

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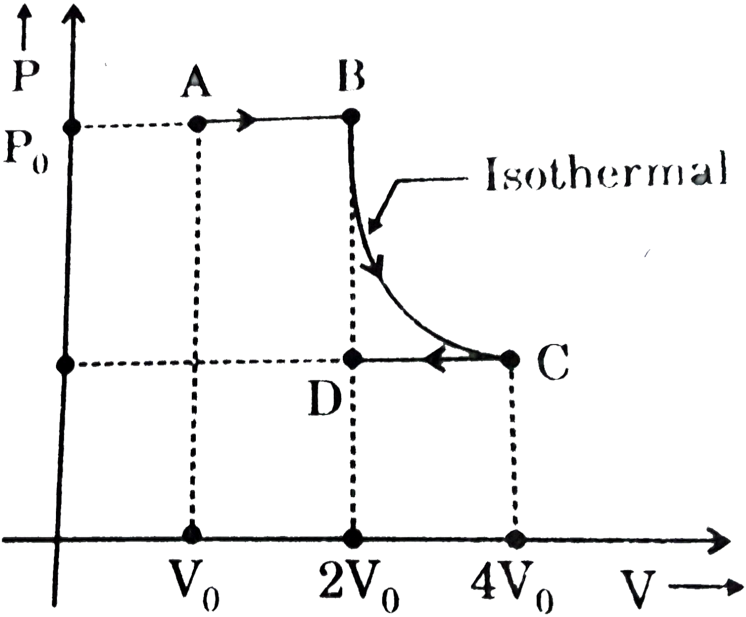
7. q.w, ΔE and ΔH for the following process ABCD on a monoatomic gas are:



A. $w = -2P_0V_0\ln 2,$

B. $w = -2P_0V_0\ln 2$

C. $w = P_0V_0(1 + \ln 2),$

D. $w = -P_0V_0\ln 2$

Answer: A

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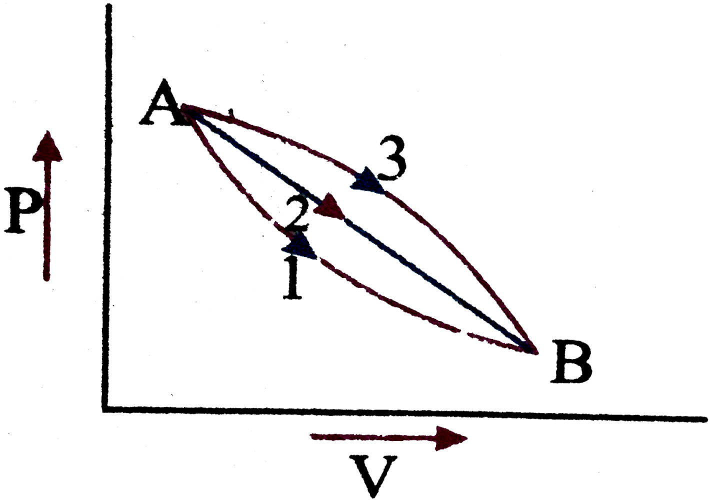
8. A given mass of a gas expands from the state A to the state B by three paths 1,2 and 3 as shown in the figure, If W_1, W_2 and W_3 respectively be the work done by the gas along the three paths then



A. $w_1 > w_2 > w_3$

B. $w_1 < w_2 < w_3$

C. $w_1 = w_2 = w_3$

D. $w_2 < w_3 < w_1$

Answer: B

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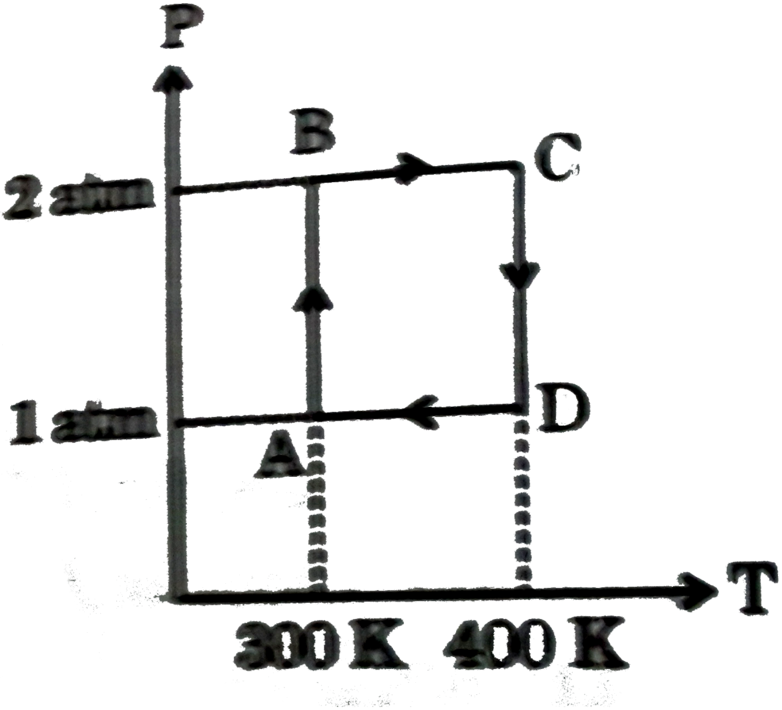
9. Two moles of Helium gas undergo a reversible cyclic process as shown in figure. Assuming gas to be ideal, what is the net work involved in the cyclic process ?



A. $-100R\ln4$

B. $+100R\ln4$

C. $+200R\ln4$

D. $-200R\ln4$

Answer: A

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10. $50L$ of a certain liquid is confined in a piston system at the external pressure $100atm$. This pressure is suddenly released and liquid is expanded against the constant atmospheric pressure, volume of the liquid increases by $1L$ and the final pressure on the liquid is $10atm$. Find the workdone.

A. $1L.\ atm$

B. $5L.\ atm$

C. $5000L.\ atm$

D. $50L.\ atm$

Answer: A

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11. In an isobaric process, the ratio of heat supplied to the system (dQ) and work done by the system (dW) for diatomic gas is

A. $1:1$

B. $7:2$

C. $7:5$

D. $5:7$

Answer: B

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12. Ice-water mass ratio is maintntained as $1:1$ in a given system containing water in equilibrium with ice at constant pressue . If C_p (ice) = C_p (water) =4.18 J $mol^{-1}K^{-1}$ molar heat capacity of such a system is :

A. zero

B. Infinity

C. $4.182JK^{-1}mol^{-1}$

D. $75.48JK^{-1}mol^{-1}$

Answer: B

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13. Two mole of an ideal gas is heated at constant pressure of one atmosphere from $27^\circ C$ to $127^\circ C$. If $C_{v,m} = 20 + 10^{-2}\text{T JK}^{-1}.\ mol^{-1}$, then q and ΔU for the process are respectively:

A. $6362.8J, 4700J$

B. $3037.2J, 4700J$

C. $7062.8, 5400J$

D. $3181.4J, 2350J$

Answer: A

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14. The increase in internal energy of 1 kg of water at 100° C when it is converted into steam at the same temperature and 1 atm (100 kPa) will be :

[The density of water and steam are $1000kg/m^3 \text{and} 0.6kg/m^3$ respectively. The latent heat of vapourisation of water is $2.25 \times 10^6 J/kg$.]

A. $2.08 \times 10^6 J$

B. $4 \times 10^7 J$

C. $3.27 \times 10^8 J$

D. $5 \times 10^9 J$

Answer: A

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15. Consider a classroom that is roughly $5m \times 10m \times 3m$. Initially $T = 27^{\circ}$C and p=1 atm. There are 50 people in a insulated class losing energy to the room at the average rate of 150 Watt per person. How long can they remain in class if the body temperature is 42° C and person feels uncomfortable above this temperature. Heat capacity of air=$(7/2)R$

A. 4.34 minutes

B. 5.91 minutes

C. 6.86 minutes

D. 7.79 minutes

Answer: B

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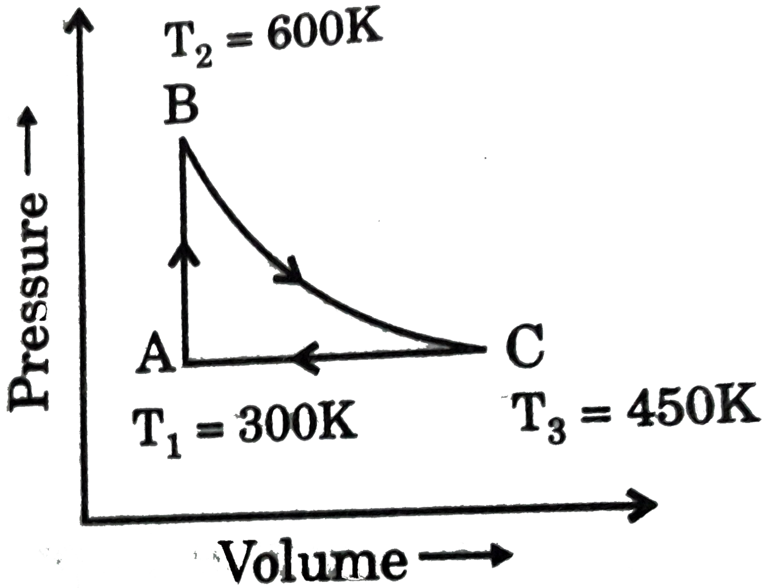
16. A heat engine carries one mole of an ideal monoatomic gas around the cycle as shown in the figure, the amount of heat added in the process

AB and heat removed in the process CA are :



A. $q_{AB} = 450R$ and $q_{CA} = -450R$

B. $q_{AB} = 450R$ and $q_{CA} = -225R$

C. $q_{AB} = 450R$ and $q_{CA} = -375R$

D. $q_{AB} = 375R$ and $q_{CA} = -450R$

Answer: C

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17. Which one of the following equations does not correctly respresents the first law of thermodynamics for the given process?

A. Isothermal process: $q = -w$

B. Cyclic process: q= -w

C. Adiabatic process: $\Delta E = q$

D. Expansion of a gas into vaccum: $\Delta E = q$

Answer: C

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18. One mole of an ideal gas $\left(C_{v,m} = \frac{5}{2}R\right)$ at 300 K and 5 atm is expanded adiabatically to a final pressure of 2 atm against a constant pressure of 2 atm. Final temperature of the gas is :

A. $270K$

B. $273K$

C. $248.5K$

D. $200K$

Answer: C

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19. There are two statement of same gas initially under similar initial state. Gases of both the samples are expanded. I^{st} sample using reversible isothermal process and II^{nd} sample using reversible adiabatic process till final pressure of both the samples becomes half of initial pressure. Then:

A. Final volume of I^{st} sample $<$ final volume of II^{nd} sample

B. Final volume of II^{nd} sample $>$ work by gas in I^{st} sample

C. Final volumes will be equal

D. Information is insufficient

Answer: B

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20. In the above problem:

A. work done by gas in I^{st} sample $>$ work done by gas in II^{nd} gas

B. work done by gas in II^{nd} sample $>$ work done by gas in I^{st} sample

C. work done by gas in I^{st} sample $=$ work done by gas in II^{th} sample

D. None of these

Answer: A

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21. The magnitude of enthalpy changes for irreversible adiabatic expansion of a gas from $1L$ to $2l$ is ΔH_1 and for reversible adiabatic expansion for the same expansion is ΔH_2. Then

A. $\Delta H_1 > \Delta H_2$

B. $\Delta H_1 < \Delta H_2$

C. $\Delta H_1 = \Delta H_2$, enthalpy being a state function $\left(\Delta H_1 = \Delta H_2\right)$

D. $\Delta H_1 = \Delta E_1 \& \Delta H_2 = \Delta E_2$ where $\Delta E_1 \& \Delta E_2$ are magnitudes of change in internal energy of gas in these expansions respectively.

Answer: B

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22. A new flourocarbon of molar mass 102 g mol^{-1} was placed in an electricity heated vessel. Whwn the pressure was 650 torr, the liquid boiled at 77° C. After the boiling point had been reached , it was found that a current of 0.25 A from a 12.0 volt supply passed for 600 sec vaporises 1.8g of the sample. The molar enthalpy and enternal energy of vaporisation of new flourocarbon will be :

A. $\Delta H = 102 KJ/mol, \Delta E = 99.1 KJ/mol$

B. $\Delta H = 95 KJ/mol, \Delta E = 100.3 KJ/mol$

C. $\Delta H = 107 KJ/mol, \Delta E = 105.1 KJ/mol$

D. $\Delta H = 92.7 KJ/mol, \Delta E = 97.4 KJ/mol$

Answer: A

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

$(1 \text{Latm} \underset{-}{\sim} 100 J)$

A. $\Delta H = 15 KJ$

B. $\Delta H = 15.7 KJ$

C. $\Delta H = 14.4 KJ$

D. $\Delta H = 14.7 KJ$

Answer: B

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Exercise-2 II: Single and double value integer type

1. How many statement are false ?

(i) Thermodynamics is concerned with total energy of the system.

(ii) 1^{st} law of thermodynamics can be applied on the individual particle enclosed in vessel.

(iii) Many thermodynamic properties can not be measured absolutely, so change in thermodynamics property is required for calculation.

(iv) Feasibility of any chemical reaction can not be explained by thermodynamics.

(v) When surrounding is always in equilibrium with the system, the process called reversible.

(vi) Thermodynamics predict the time of attain the equilibrium

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2. How many of the following physical properties are extensive:

(i) Free energy (ii) vapour pressure (iii) mole (iv) kinetic energy

(v) Entropy (vi) Internal energy (vii) Enthalpy (viii) specific heat capacity

(ix) Coefficient of viscosity

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3. How many of the following are state function:

(i) Internal energy (ii) Heat (iii) Enthalpy (iv) Entropy

(v) Pressure (vi) Temp. (vii) volume (viii) work

(ix) specific heat capacity (x) molar heat capacity

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4. Two molar of He gas $(\gamma = 5/3)$ are initially at temp $27^{\circ}C$ and occupy a volume of 20 litres. The gas is first expanded at constant pressure untill its volume is doubled. then it undergoes and reversible adiabatic change, unit the volume become $110 lit$, then predict the value of $T/1000$ (where T is the final temeperature $\left(\frac{4}{11}\right)^{2/3} = \left(\frac{1}{2}\right)$

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5. A sample of an ideal gas is expanded from $1dm^3$ to 3 in a reversible process for which $P = KV^3$, with $K = 1/5\left(atm/dm^3\right)$, what is work done by gas $(Latm)$

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6. A gas expands against a variable pressure given by $P = \frac{20}{V}$ bar. During expainsion from volume of 1 litre to 10 litre, the gas undergoes a change in internal energy of $400J$. Heat absorbed by the gas during expansion (in KJ):

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7. A sample of 4 mole He is originally confined in $20L$ at $270K$ and then undergoes adiabatic expansion against a constant pressure of untill the volume has increased by factor of 3. Calculate ΔT during process:

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8. The value on a cyclinder containing initially 1 litres of an ideal gas at $7atm$ and $25^\circ C$ is opened to the atmosphere, Whose the pressure is 760 torr and the temperature is $25^\circ C$. Assuming that the process is isothermal, how much work (in $Latm$) is done on hte atmosphere by the action of expansion ?

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9. The molar enthalpy of vaporization of benzene at its boiling point $(353K)$ is $29.7KJ/\text{mole}$. For how long minute) would a 11.4 Volt source need to supply a $0.5A$ current in order to vaporise $7.8g$ of the sample at its boiling point ?

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10. At 5×10^5 bar pressure, density of diamond and graphite are $3g/cc$ and $2g/cc$ respectively, at certain temperature T. $(1L.\,atm = 100J)$

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11. A system is provided 50 joule of heat and the change in internal energy during the process is $60J$. Magnitude of work done on the system is:

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12. A system works in a cyclic process. It absorbs 20 calories of heat and rejects $60J$ of heat during the process. The magnitude of work done (J) is $[1\text{calorie} = 4.2J]$:

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13. 1 mole of an ideal gas $A\left(C_{v.m}=3R\right)$ and 2 mole of an ideal gas B are $\left(\left(C_{v,m}=\frac{3}{2}R\right)\right.$ taken in a container and expanded reversible and adiabatically from 1 litre of 4 letre starting from initial temperature of 320 K. ΔE or ΔU for the process is :

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14. 10 litre of a monoatomic ideal gas at $0^{\circ}C$ and $10atm$ pressure is suddenly released to $1atm$ pressure and the gas expands adiabatically against this constant pressure. The final volume (L) of the gas.

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15. The work done in adiabatic compression of 2 mole of an ideal monoatomic gas by constant external pressure of $2atm$ starting from initial pressure of $1atm$ and initial temperature of $30K(R=2cal/\text{mol-degree})$

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16. 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 , $\Delta U = 30.0 L.\ atm$. Calculate change in enthalpy of the process in $L.\ atm$.

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Exercise 2- III : One or more than one options correct type

1. Which of the following properties of system are intensive ?

A. color

B. kinetic energy per mole

C. X (where $X = U + H$)

D. specific volume (volume per unit mass)

Answer: A::B::D

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2. Which of the following are incorrect ?

A. Work done by the surrounding in case of infinite stage expansion is more than single stage expansion

B. Irresversible work is always greater than reversible work. (with sign)

C. On an ideal gas in case of single stage expansion and compression system as well us surrounding are restored back to their original states

D. If a gas in thermodynamic equilibrium is taken from state A to state B, by four successive single stage expansion. Then we can plot 4 points on the P - V indicator diagram.

Answer: A::C::D

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3. Choose the correct statement:

A. system and surrounding are always separated by a real or imaginary boundary.

B. perfectly isolated system can never be created.

C. in reversible process, energy change in each step can be reversed.

D. irreversible process is also called quasi-equilibrium state.

Answer: A::B::C

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4. In an isothermal expansion of a gaseous sample, the correct relation is: (consider w(work) with sign according to new $IUPAC$ convention)

[The reversible and irreversible processes are carried out between same initial and final states.]

A. $W_{rev} > W_{irrev}$

B. $W_{irrev} > W_{rev}$

C. $q_{rev} < q_{irrev}$

D. $\Delta E_{rev} = \Delta E_{irrev}$

Answer: B::D

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5. During the isothermal of an ideal gas :

A. The internal energy remains unaffected

B. The temperature remains constant

C. The enthalpy remains unaffected

D. The enthalpy increases

Answer: A::B::C

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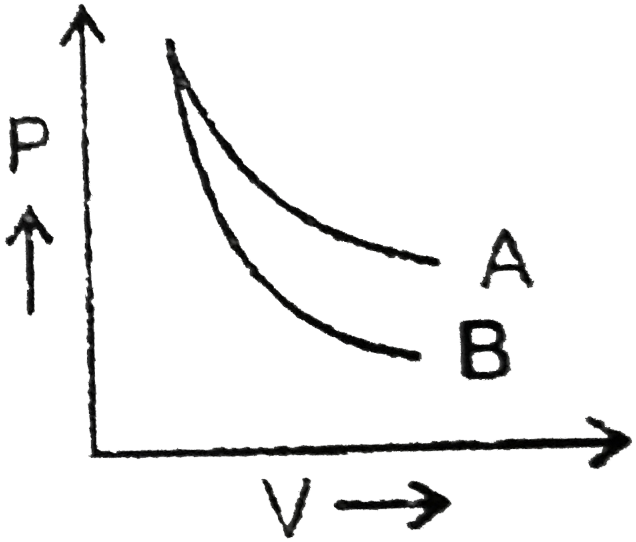
6. P - V plot for two gases (assuming ideal) during adiabatic processes are given in the figure. Plot A and Plot B should correspond respectively to:



A. He and H_2

B. H_2 and He

C. SO_3 and CO_2

D. N_2 and Ar

Answer: B::C::D

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7. When some potential difference V is applied across a resistance R then the work by the electrical field on the charge q to flow through the circuit in time t will be

A. qV

B. Vit

C. i^2Rt

D. $\frac{V^2t}{R}$

Answer: A::B::C::D

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8. 0.5 mole each of two ideal gases $A\left(C_{v,m}=\frac{5}{2}R\right)$ and $B\left(C_{v,m}=3R\right)$ are taken in a container and expanded reversibly and adiabatically, during this process temperature of gaseous mixture decreased from 350 K to 250 K. Find ΔH (in cal/mol) for the process :

A. $\Delta U = -100R$

B. $\Delta U = -275R$

C. $\Delta H = -375R$

D. $\Delta H = -300R$

Answer: B::C

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9. $4KJ$ of heat is absorbed when 1 mole of ice melts at $0^{\circ}C$ and at constant pressure $1atm$. If molar volume of ice and water are $19ml$ and $18ml$ respectively, then

[Take $1atm = 10^5 Pa$]

A. $\Delta H > \Delta U$

B. $\Delta U > \Delta H$

C. $\Delta U = 4.1 KJ$

D. $\Delta U = 4.0001 KJ$

Answer: B::D

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10. 5 moles of a liqiud L are converted into its vapour at its boiling point $\left(273^\circ C\right)$ and at a pressure of 1atm. If the value of latent heat of vapourisation of liquid L is $273 Latm/\text{mole}$, then which of the following statements is/are correct. Assume volume of liquid to be negligible and valpour of the liquid to behave ideally.

A. Work done by the system in the above process is $224 L$ atm.

B. The enthalpy change (ΔH) for the above process is $1365 L$ atm (with respect to magnitude only)

C. The internal energy of the system increases in the above process.

D. The value of ΔU for the above process is $1589L$ atm.

Answer: A::B::C

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11. An ideal gas undergoes adiabatic expansion against constant external pressure. Which of the following is incorrect.

A. Temperature of the system decreases.

B. The relation $PV^{\gamma} =$ constant will be valid (where P and V are gas variables)

C. $\Delta E + P_{ext}\Delta V = 0$

D. Enthalpy of the gas remains unchanged.

Answer: B::D

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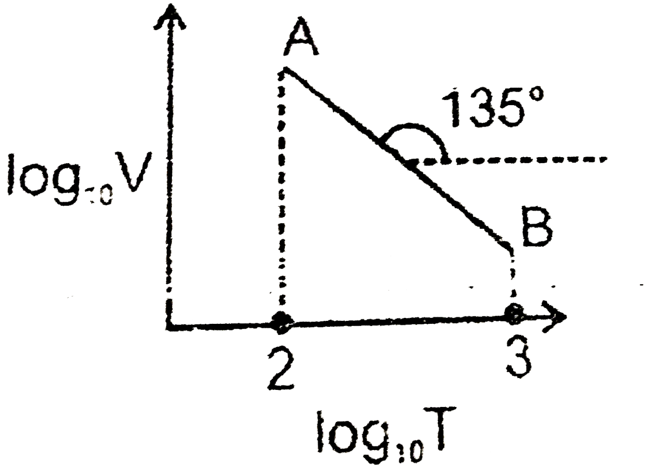
12. Three moles of an ideal diatomic gas undergoes a change in state from A to B reversibly as follows: Which of the statements is/are correct regarding the above process:



A. Work done on the gas is $2700R$

B. In the above process, pressure varies inversely with square of volume.

C. Heat supplied to the gas is $4050R$

D. Data insufficient for the calculation of work and heat supplied.

Answer: A::B::C

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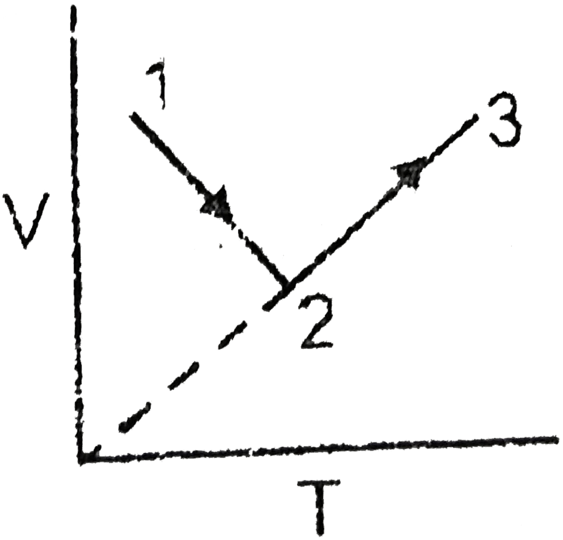
13. Following graph is constucted for the fixed amount of the gas



A. From 1 - 2 pressure will increase

B. From 2 - 3 pressure remains constant

C. Gas pressure at (3) greater at state (1)

D. From 1 - 2 pressure will decrease

Answer: A::B::C

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14. An ideal gas can be expanded form an initial state to a certain volume through two different processes $PV^2 =$ constant and (ii) $P = KV^2$ where K is a positive constant. Then

A. Final temperature in (i) will be greater then in (ii)

B. Final temperature in (ii) will be greater then in (i)

C. Total heat given to the gas in (i) case is greater than in (ii)

D. Total heat given to the gas in (ii) case is greater than in (i)

Answer: B::D

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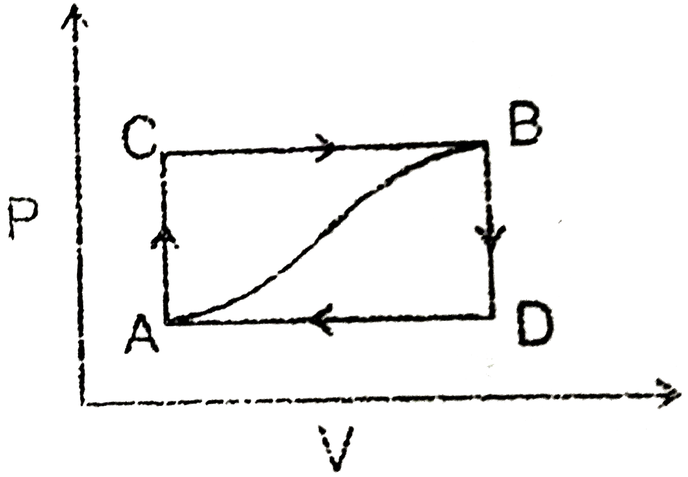
Exercise-2 part -IV : Comprehension

1. When a system is taken from state A to state B along path ACB as shown in figure below, $80J$ of heat flows into the system and the system does $30J$ of work.



How much heat flows into the system along path ADB if the work done by the system is $10J$:

A. $40J$

B. $60J$

C. $80J$

D. $100J$

Answer: B

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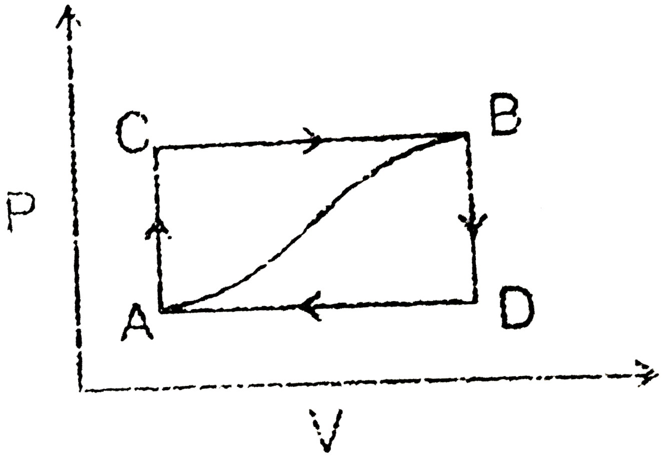
2. When a system is taken from state A to state B along path ACB as shown in figure below, $80J$ of heat flows into the system and the system does $30J$ of work.



When the system is returned from state B to A along the curve path, the work done on the system is $20J$.

Does the system absorb or literate heat and by how much ?

A. -$70J$, heat is liberated.

B. -$60J$, heat is liberated

C. $+70J$, heat is absorbed

D. $+60J$, heat is absorbed.

Answer: A

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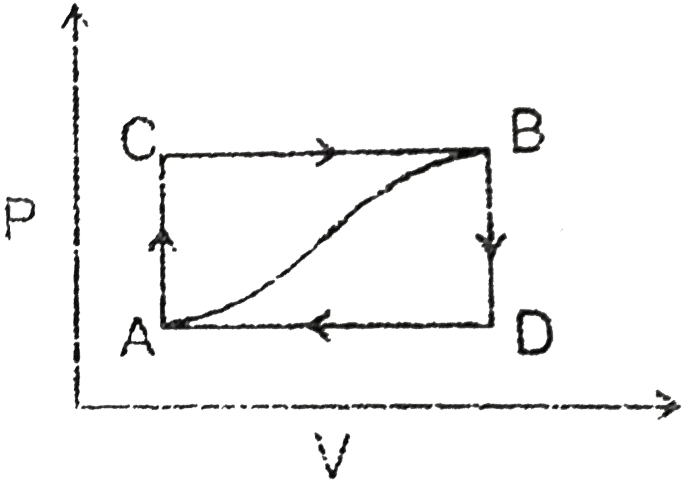

If $E_D - E_A = -40J$, the heat absorbed in the processes AD and DB are respectively

A. $q_{AD} = 30J$ and $q_{DB} = -90J$

B. $q_{AD} = -60J$ and $q_{DB} = 30J$

C. $q_{AD} = 30J$ and $q_{DB} = 90J$

D. $q_{AD} = -30J$ and $q_{DB} = 90J$

Answer: D

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4. A gaseous sample is generally allowed to do only expansion/compression type work against its surroundings The work done in case of an irreversible expansion (in the intermediate stages of expansion/compression the states of gases are not defined). The work done can be calculated using

$dw = -P_{ext}dV$

while in case of reversible process the work done can be calculated using

$dw = -PdV$ where P is pressure of gas at some intermediate stages. Like for an isothermal reversible process. Since $P = \frac{nRT}{V}$, so

$$w = \int dW = -\int_{v_i}^{v_f} \frac{nRT}{V} . dV = -nRT\ln\left(\frac{V_f}{V_i}\right)$$

Since $dw = PdV$ so magnitude of work done can also be calculated by calculating the area under the PV curve of the reversible process in PV diagram.

If four identical samples of an ideal gas initially at similar state $\left(P_0, V_0, T_0\right)$ are allowed to expand to double their volumes by four different process.

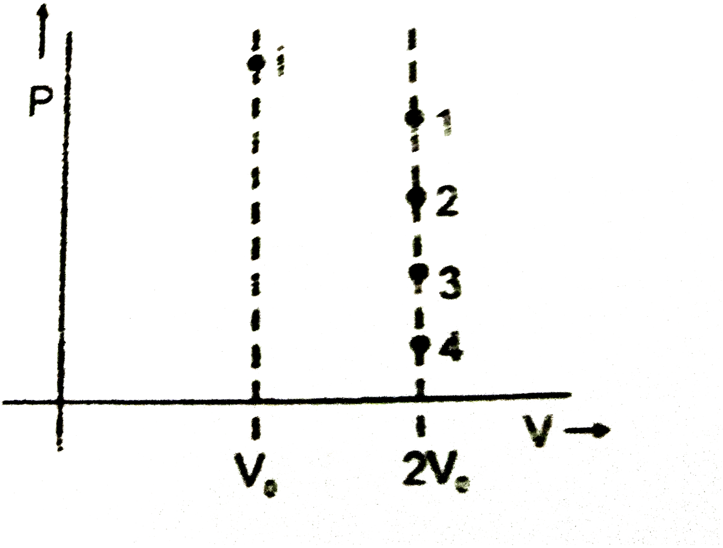
I: by isothermal irreversible process

II: by reversible process having equation $P^2V =$ constant

III. by reversible adiabatic process

IV. by irreversible adiabatic expansion against constant external pressure.

Then, in the graph shown in the final state is represented by four different points then, the correct match can be



A. work done in first process will be greater than work in second process (magnitude wise)

B. The order of values of work done can not be compared unless we know the value of K_1 and K_2.

C. Value of work done (magnitude) in second process is greater in above expansion irrespective of the values of K_1 and K_2

D. I^{st} process is not possible

Answer: C

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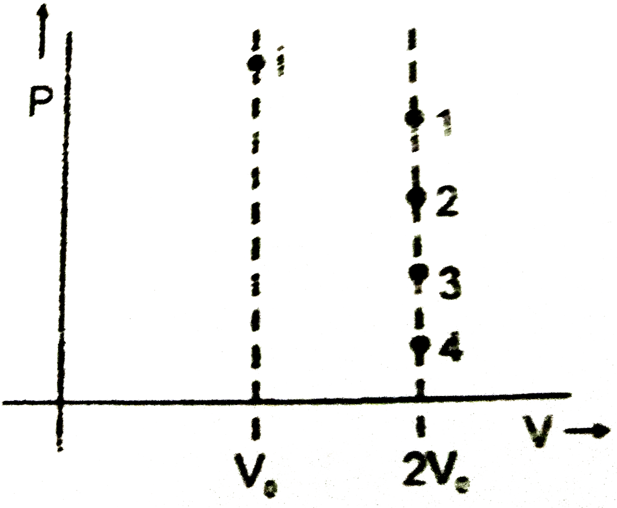

A. Final volume of both the samples $<$ final volume of II^{nd} sample

B. Final volume of II^{nd} sample $<$ final volume of I^{nd} sample

C. Final volumes will be equal

D. Information is insufficient

Answer: B

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Since $dw = PdV$ so magnitude of work done can also be calculated by calculating the area under the PV curve of the reversible process in PV diagram.

In the above problem

A. work done by the gas in I^{st} sample $>$ work done by gas in II^{nd} sample

B. work done by gas in II^{nd} sample $>$ work done by gas in I^{st} sample

C. work done by gas in I^{st} sample $=$ work done by gas in II^{nd} sample

D. None of these

Answer: A

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7. A gaseous sample is generally allowed to do only expansion/compression type work against its surroundings The work done in case of an irreversible expansion (in the intermediate stages of expansion/compression the states of gases are not defined). The work done can be calculated using

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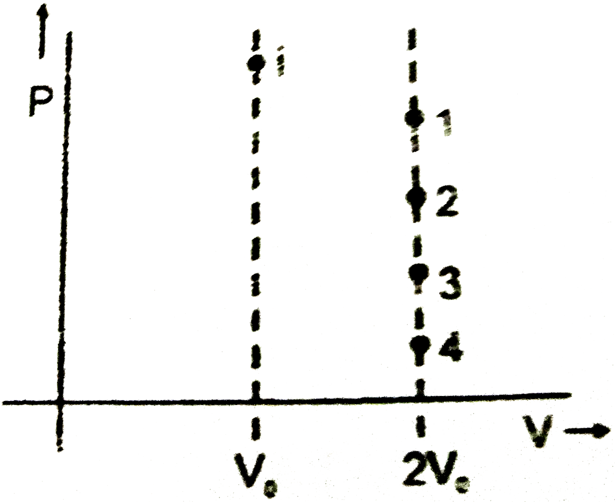

A. 1-I, 2-II,3-III,4-IV

B. I-II,2-I,3-IV,4-III

C. 2-III,3-II,4-I,1-IV

D. 3-II,1-I,3-IV,4-II

Answer: B

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8. A gaseous sample is generally allowed to do only expansion/ compression type work against its surroundings The work done in case of an irreversible expansion (in the intermediate stages of expansion/ compression the states of gases are not defined). The work done can be calculated using

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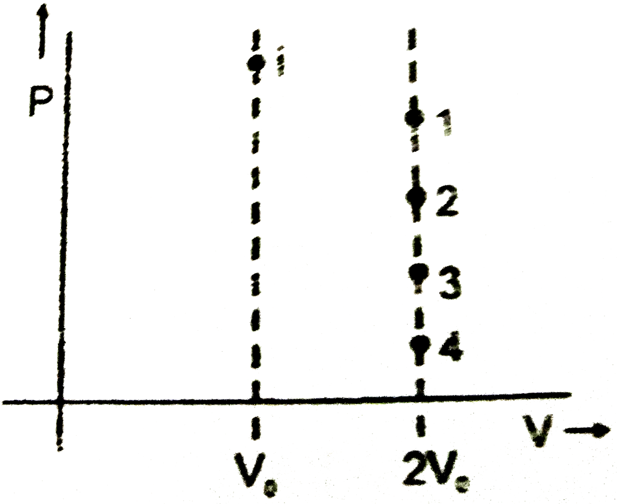

A. final temperature of both samples will be equal

B. final temperature of first sample will be greater than of second sample

C. final temperature of second sample will be greater than of first sample

D. None of these

Answer: C

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9. Phase transitions are ubiquitous in nature. We are all familiar with the different phase of water (vapour, liquid and ice) and with the change from one to another, the change of phase are called phase transitions. There are six ways a substance can change between these three phase, melting, freezing, evaporating, condensing sublimation and decomposition.

At $1atm$ pressure vaporisation of 1 mole of water from liquid $\left(75^\circ C\right)$ to vapour $\left(120^\circ C\right)$.

$C_v\left(H_2O, l\right) = 75\text{Jmole}^{-1}K^{-1}, C_p\left(H_2O, g\right) = 33.3J\text{mole}^{-1}K-^1$

ΔH_{vap} at $100^\circ C = 40.7KJ/\text{mole}$

Calculate change in internal energy when

Water liquid at $75^\circ C$ to $100^\circ C$?

A. $1875J$

B. $13125J$

C. $-1875J$

D. $-13125J$

Answer: A

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10. Phase transitions are ubiquitous in nature. We are all familiar with the different phase of water (vapour, liquid and ice) and with the change from one to another, the change of phase are called phase transitions. There are six ways a substance can change between these three phase, melting, freezing, evaporating, condensing sublimation and decomposition.

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ΔH_{vap} at $100\,^{\circ}C = 40.7KJ/\text{mole}$

Calculate change in internal energy when

Water liquid at $100\,^\circ C$ to vapour at $100\,^\circ C$?

A. $40700J$

B. $37598.878J$

C. $43801.1J$

D. $31012.\,J$

Answer: B

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11. Phase transitions are ubiquitous in nature. We are all familiar with the different phase of water (vapour, liquid and ice) and with the change from one to another, the change of phase are called phase transitions. There are six ways a substance can change between these three phase, melting, freezing, evaporating, condensing sublimation and decomposition.

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ΔH_{vap} at $100\,^{\circ}C = 40.7 KJ/\text{mole}$

Calculate change in internal energy when

Water vapour at $100\,^{\circ}C$ to $120\,^{\circ}C$?

A. $666 J$

B. $2998 J$

C. $499.72 J$

D. $166.28 J$

Answer: C

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Exercise-3 Part-1: JEE (ADVANCED)

1. The molar heat capacity , C_v of helium gas is $3/2R$ and is independent of temperature. For hydrogen gas, C_v approaches $3/2R$ at very low temperature, equal $5/2R$ at moderate temperature and is higher than

$5/2R$ at high temperatures. Give a reason for the temperature dependence of C_v in case of hydrogen, in not more than two or three sentences.

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2. 2 moles of ideal gas is expanded isothermally & reversibly from 1 litre to 10 litre. Find the enthalpy changes in $KJmol^{-1}$.

A. 0

B. 11.7

C. -11.7

D. 25

Answer: A

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3. There is $1 mol$ liquid (molar volume $100 ml$) in an adiabatic container initial, pressure being 1 bar Now the pressure is steeply increased to 100 bar, and the volume decreased by $1 ml$ under constant pressure of 100 bar. Calculate ΔH and ΔE. [Given $1\text{bar} = 10^5 N/m^2$]

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4. One mole of an ideal monoatomic gas at temperature T and volume $1L$ expands to $2L$ against a constant external pressure of one atm under adiabatic conditions, then final temperature of gas will be:

A. $T + \dfrac{2}{3 \times 0.0821}$

B. $T - \dfrac{2}{3 \times 0.0821}$

C. $\dfrac{T}{2^{5/3-1}}$

D. $\dfrac{T}{2^{5/3+1}}$

Answer: B

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5. The ratio of P to V at any instant is constant and is equal to 1, for a monoatomic ideal gas under going a process. What is the molar heat capacity of the gas

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

B. $\frac{4R}{2}$

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

D. 0

Answer: B

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6. The given reaction

$2CO\text{2moles} + O_2\text{1mole} \rightarrow 2CO_2 \quad \Delta H = -560KJ$

is carried out in one litre container, if the pressure in the container gets changes from $70atm$ to $40atm$ as reaction gets completed. Calculate ΔU of the reaction. $[Latm = 0.1KJ]$

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7. Among the following, the intensive property is (properties are):

A. Internal energy

B. Irreversible expansion work

C. Reversible expansion work

D. Molar enthalpy

Answer: A::D

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8. Among the following, the intensive property is (properties are):

A. molar conductivity

B. eletromotive force

C. resistance

D. heat capacity

Answer: A::B

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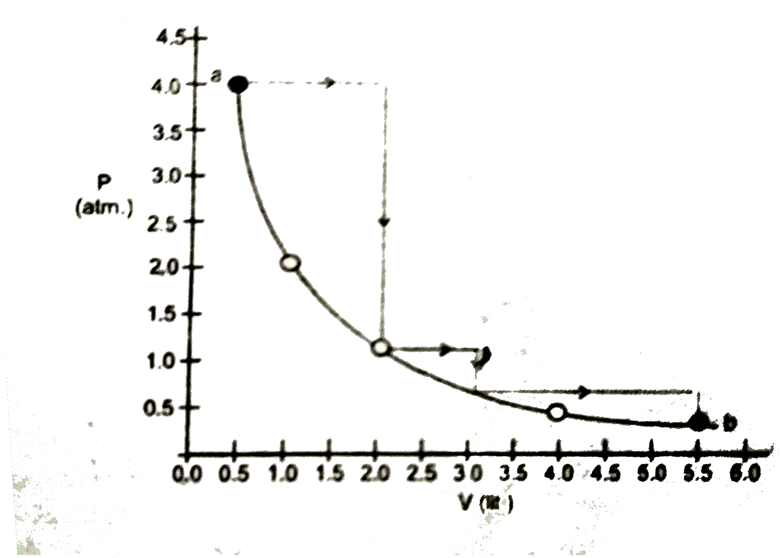
9. One mole of an ideal gas is taken from a and b along two paths denoted by the solid and the dashed line as shown in the graph below. If the work done along the solid path is w_s and that along the dotted path is w_d, then the integer closest to the ratio w_d / w_s is



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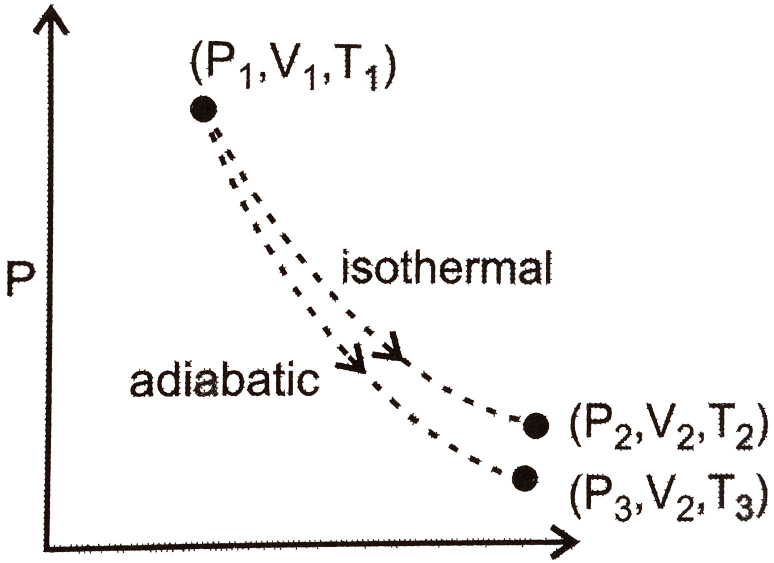
10. The reversible expansion of an ideal gas under adiabatic and isothermal conditions is shown in the figure. Which of the following

statement(s) is (are) correct?



A. $T_1 = T_2$

B. $T_3 > T_1$

C. $W_{\text{isothermal}} > W_{\text{adiabatic}}$

D. $\Delta U_{\text{isothermal}} > \Delta U_{\text{adiabatic}}$

Answer: A::D

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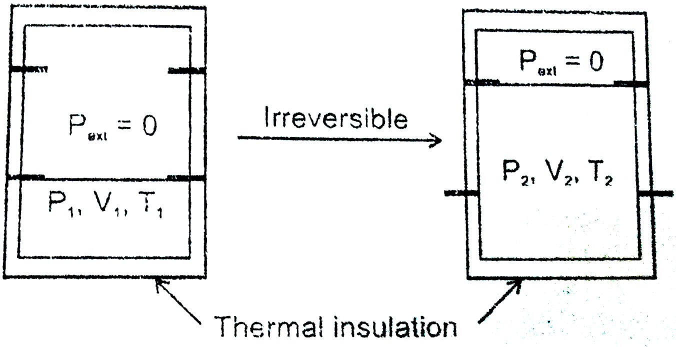
11. An ideal gas in a thermally insulated vessel at internal pressure $= P_1$, volume $= V_1$ and absolute temperature $= T_1$ expands irreversibly against zero external pressure, as shown in the diagram. The final internal pressure, volume and absolute temperature of the gas are P_2, V_2 and T_2 respectively. For this expansion.



A. $q = 0$

B. $T_2 = T_1$

C. $P_2V_2 = P_tV_1$

D. $P_2V_2^{\gamma} = P_1V_1^{\gamma}$

Answer: A::B::C

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Main

1. An ideal gas expands from $1 \times 10^{-3} m^3$ to $1 \times 10^{-2} m^3$ at $300K$ againts a constant pressure of $1 \times 10^5 Nm^{-2}$. The work done is :

A. $-900J$

B. $-900KJ$

C. $270KJ$

D. $+900KJ$

Answer: A

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2. Consider the reaction, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, carried out at constant temperature and pressure. If ΔH and ΔU are enthalpy change and internal energy change respectively, which of the following expressions is true ?

A. $\Delta H = 0$

B. $\Delta H = \Delta U$

C. $\Delta H < \Delta U$

D. $\Delta H > \Delta U$

Answer: C

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3. An ideal gas is allowed to expand both reversibly and irreversibly in an isolated system. If T_i is the initial temperature and T_f is the final temperature, which of the following statement is correct ?

A. $T_f > T_i$ for reversible process but $T_f = T_i$ for irreversible process

B. $\left(T_f\right)_{rev} = \left(T_f\right)_{irrev}$

C. $T_f = T_i$ for both reversible processes

D. $\left(T_f\right)_{irrev} > \left(T_t\right)_{rev}$

Answer: D

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4. Assuming that water vapour is an ideal gas, the internal energy change (ΔU) when $1 mol$ of water is vapourised at 1 bar pressure and $100\,^{\circ}C$, (Given: Molar enthalpy of vapourization of water at 1 bar and $373K = 41kJmol^{-1}$ and $R = 8.3Jmol^{-1}K^{-1}$) will be:

A. $37.904kJmol^{-1}$

B. $41.00kJmol^{-1}$

C. $4.100kJmol^{-1}$

D. $3.7904mol^{-1}$

Answer: A

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5. A piston filled with 0.04 mol of an ideal gas expands reversibly from $50.0mL$ to $375mL$ at a constant temperature of $37.0^{\circ}C$. As it does so, it absorbs $208J$ of heat. The value of q and w for the process will be:

$(R = 8.314J/molK)(\ln 7.5 = 2.01)$

A. $q = +208J, w = -208J$

B. $q = -208J, w = -208J$

C. $q = -208J, w = +208J$

D. $q = +208J, w = +208J$

Answer: A

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Exercise-1 Part-I Subjective question

1. A mixture of 2 moles of CO and 1 mole of O_2, in a closed vessele is ignited to convert the CO to CO_2 if ΔH is the enthalpy change and ΔU is the change in internal energy then:

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2. 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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3. For the reaction : $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

if $\Delta U^\circ = -1373 kJmol^{-1}$ at $298K$. Calculate ΔH°

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4. 2 mole of zinc is dissolved in HCl at 25° C. The work done in open vessel is :

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5. Classify the following processes as exothermic or endothermic:

(A) Burning of a match stick (B) Melting of ice

(C) Molten metal solidifies (D) Reaction between Na and H_2O

(E) Rubbing alcohol evaporates.

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6. Why is the enthalpy of sublimation equal to the sum of enthalpy of fusion and enthalpy of vaporisation ?

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7. For a chemical reaction, ΔC_p is negative $\left(\Delta C_p < 0\right)$.

The heat required to increase temperature of reactans of this reaction by a certain amount $= q_1$ and heat required to increase temperature of products of the same reaction by same amount $= q_2$, Relate q_1 and q_2

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8. Diborane is a potential rocket fuel which undergoes combustion according to the reaction,

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

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

(i) $2B(s) + \left(\frac{3}{2}\right)O_2(g) \rightarrow B_2O_3(s), \Delta H = 01273kJ/mol$

(ii) $H_2(g) + \left(\frac{1}{2}\right)O_2(g) \rightarrow H_2O(l), \Delta H = -286kJ/mol$

(iii) $H_2O(l) \rightarrow H_2O(g)\Delta H = 44kJ/mol$

(iv) $2B(s) + 3H_2(G) \rightarrow B_2H_6(g), \Delta H = 36kJ/mol$

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9. The specific heats of iodine vapour and solid are 0.031 and $0.055cal/g$ respectively. If heat of sublimation of iodinde is $24cal/g$ at $200^\circ C$, what is its value at $250^\circ C$?

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10. Predict the standard reaction enthalpy of $2NO_2(g) \rightarrow N_2O_4(g)$ at $100^\circ C$. ΔH° at $25^\circ C$ is $-57.2kj.mol^{-1}C_p\left(NO_2\right) = 37.2j.mol^{-1}K^{-1}C_p\left(N_2O_4\right) = 77.28J.mol^{-1}k^{-1}$

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11. The heat of combustion of ethyl alcohol is $-300kcal$. If the heats of formation of $CO_2(g)$ and $H_2O(l)$ are-9.3 and $-68.5kcal$ respectively, calculate the heat of formation of ehtyl alcohol.

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12. Find out the heat evolved in combustion if 112 litres (at STP) of water gas (mixture of eqal volume of $H_2(g)$ and $CO(g)$).

$H_2(g) + 1/2O_2(g) \rightarrow H_2O(g) \qquad \Delta H = -241.8kJ$

$CO(g) + 1/2O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -283kJ$

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13. If
$$\begin{array}{ll} H_2 + 1/2O_2 \rightarrow H_2O, & \Delta H = -68kcal \\ K + H_2O \rightarrow KOH(aq) + 1/2H_2, & \Delta H = -48kcal \\ KOH + \text{water} \rightarrow KOH(aq), & \Delta H = -14kcal \end{array}$$

Find the heat of formation of KOH.

Find the heat of formation of KOH.

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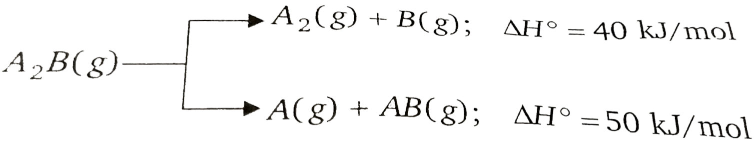
14. Substance $A_2B(g)$ can undergoes decomposition to form two set of products :



If the molar ratio of $A_2(g)$ to A(g) is $5:3$ in a set of product gases, then the energy involved in the decomposition of 1 mole of $A_2B(g)$ is :

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15. One litre sample of a mixture of CH_4 and O_2 measured at $32^\circ C$ and 760 torr, was allowed to react at constant pressure in a calorimeter. The complete combustion of CH_4 to CO_2 and water caused a temperature rise in calorimeter of $1K$. calculate mole % of CH_4 in original mixture.

[Given: Heat of combustion of CH_4 is $-210.8Kcal/mol$. Total heat capacity of the calorimeter $= 2108calK$]

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16. The standard enthalpy of decomposition of the yellow complex H_3NSO_2 into NH_3 and SO_2 is $+40kJmol^{-1}$. Calculate the standard enthalpy of formation of H_3NSO_3. $\Delta H_f^0\left(NH_3\right) = -46.17kJmol^{-1}, \Delta H_f^0(SO)_2 = -296.83$

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17. When $12.0g$ of carbon (graphite)reacted with oxygen to form CO and CO_2 at $25^\circ C$ and constant pressure, $252kJ$ of heat was released and no carbon remained. If $\Delta H_f^0(CO, g) = -110.5 kJmol^{-1}$ and $\Delta H_f^0\left(CO_2, g\right) = -393.5 kJmol^{-1}$,calculate the mass of oxygen consumed.

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18. Calculate the bond energy of $Cl - Cl$ bond from the following data:

$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g), \Delta H = -100.3 kJ.$ Also the bond enthalpies of $C - H, C - Cl, H - Cl$ bonds are $413, 326$ and $431 kJmol^{-1}$ respectively.

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19. Calculate $\Delta H^\circ \left(\text{in} kJmol^{-1}\right)$ for the reaction

$CH_2Cl_2(g) \rightarrow C(g) + 2H(g) + 2Cl(g).$

The average bond enthalpie of $C - H$ and $C - C1$ bonds are $414 kJmol^{-1}$.

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20. Calculate the enthalpy change (ΔH) of the following reaction $2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$ given average bond enthalpies of various bonds, i.e., $C - H, C \equiv C, O = O, C = O, O - H$ as $414, 814, 499, 724$ and $640 kJmol^{-1}$ respectively.

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21. Calculate change in enthalpy for the reaction at $27^\circ C$

$H_2(g) + Cl_2(g) \rightarrow 2H - Cl(g)$

by using the bond energy and energy data

Bond energies of $H - H, Cl - Cl$ and $H - Cl$ bonds are $435 kJmol - ^1$, $240 kJmol^{-1}$ and $430 kJmol^{-1}$ respectively.

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22. Estimate the average $S - F$ bond enthalpy in SF_6. The values of standard enthalpy of formation of $SF_6(g), S(g)$ and $F(g)$ are :-$1100, 274$ and $80 kJmol^{-1}$ respectively.

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23. Calculate the standard enthalpy of solution of $AgCl(s)$ in water $\Delta H_f^0(AgCl, s) = -127.07kJmol^{-1}, \Delta H_f^0\left(Ag^+, aq\right) = 105.58kJmol^{-1}, \Delta H_f^0\left(Cl^-, a$

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24. Enthalpies of solution of $BaCl_2(s)$ and $BaCl_2.2H_2O(s)$ are $-20kJ/\text{mole}$ and $8.0kJ/\text{mole}$ respectively. Calculate heat of hydration of $BaCl_2(s)$.

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25. The $\Delta H_f^0(KF, s)$ is $-563kJmol^{-1}$. The ionization enthalpy of $K(g)$ is $419kJmol^{-1}$. and the enthalpy of sublimation of potassium is $88kJmol^{-1}$. The electron affinity of $F(g)$ is $322kJmol^{-1}$ and $F-F$ bond enthalpy is $158kJmol-^{1}$. Calculate the lattice enthalpy of $KF(s)$.

The given data are as follows:

(i) $K(s) + 1/2F_2(g) \rightarrow KF(s) \quad \Delta H_f^0 = -563kJmol^{-1}$

(ii) $K(g) \rightarrow K^+(g) + e^- \quad \Delta_{\text{Ioniz}}^0 = 419kJmol^{-1}$

(iii) $K(s) \rightarrow K(g) \quad \Delta H_{\text{sub}}^0 = 88kJmol^{-1}$

(iv) $F(g) + e^- \rightarrow F^-(g) \quad \Delta H_{eg}^0 = -322kJmol^{-1}$

(v) $F_2(g) \rightarrow 2F(s) \quad \Delta H_{\text{diss}}^0 = 158kJmol^{-1}$

(vi) $K^+(g) + F^-(g) \rightarrow KF(s) \quad \Delta H_L^0 = ?$

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26. Setup of Born-Haber cycle, calculation lattice energy of $MgO_{(s)}$. The given that-enthalpy of formation of $MgO_{(s)} = -602$, sublimation of $Mg_{(s)} = 148, 1^{st}\&2^{nd}$ ionization energy of $Mg = 738\&1450$ respectively. For Oxygen bond dissocitation energy $= 498, 1^{st}\&2^{nd}$ electron gain enthalpy $= -141\&844$ respectively (all unit in $kJ\text{mole}^{-1}$).

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27. $10mL$ of each $1mLHCl$ and $1MH_2SO_4$ are neutralized by $1MNaOH$ solution that liberate the heat of a & $bkJ/$ equivalent respectively. What is relation between a and b

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28. $150mL$ of $0.5NHCl$ solution at $25^\circ C$ was mixed with $150mL$ of $0.5NNaOH$ solution at same temperature. Calculate the heat of neutralization of HCl with $NaOH$, if find temperature was recorded to be $29^\circ C$.

$$\left(\rho_{H_2O} = 1g/mL\right)$$

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

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30. The standard enthalpy of neutralization of KOH with HCN in dilute solution is $-2480 cal. mol^{-1}$ and $-13.68 kcal mol^{-1}$ respectively. Find the enthalpy of dissocitation of HCN at the same temperature.

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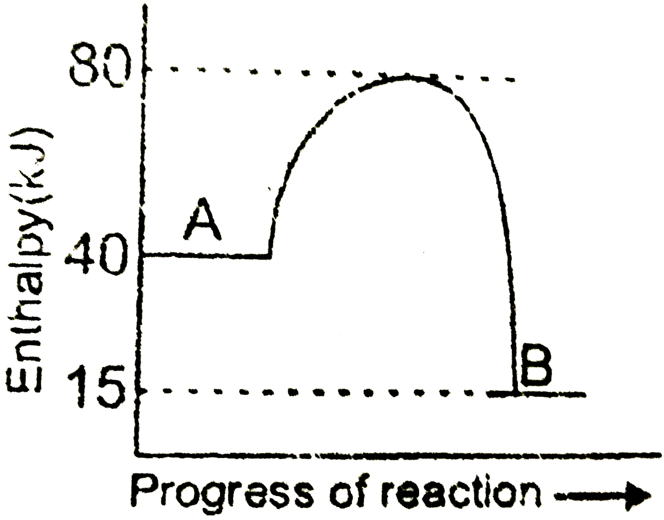
Exercise-2 Part-1: Only one option correct type

1. Look at the following diagram:



The enthalpy change for the reaction $A \rightarrow B$ will be

A. $-25kJ$

B. $-40kJ$

C. $+25kJ$

D. $-65kJ$

Answer: A

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2. The difference between ΔH and ΔE (on a molar basis) for the combustion of n-octane (l) at $25^{\circ}C$ would be:

A. $13.6kJ$

B. $-1.14kJ$

C. $-11.15kJ$

D. $+11.15kJ$

Answer: C

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3. The heat of formation of HCl at 348 K from the following data will be :

$0.5H_2(g) + 0.5Cl_2(g) \rightarrow HCl \quad \Delta H^{\circ}_{298} = -22060$ cal. The mean heat capacities over this temperature range are,

$H_2(g), \quad C_p = 6.82 \text{ cal mol}^{-1}K^{-1}$

$Cl_2(g), \quad C_p = 7.71 \text{ cal mol}^{-1}K^{-1}$

$HCl(g), \quad C_p = 6.81 \text{ cal mol}^{-1}K^{-1}$

A. -20095 cal

B. -32758 cal

C. -37725 cal

D. -22083 cal

Answer: D

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4. In Haber's process of manufacturing of ammonia:

$\left(N_2(g) + 3H_2(g), \ \rightarrow \ 2NH_3(g), , H^0_{25^\circ C} = -92.2kJ, , , , , , \right), \left(\text{molecule}, N_2(g), H_2\right.$

If C_p is independent of temperature, then reaction at $100^\circ C$ as compared to that of $25^\circ C$ will be:

A. More endothermic

B. Less endothermic

C. More exothermic

D. Less exothermic

Answer: C

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5. From the following data of ΔH, of the following reactions

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

$$C(s) + H_2O(g) \rightarrow CO(g) + H_2(g) \quad \Delta H = 132kJ$$

What is the mole composition of the mixture of steam and oxygen on passed over coke at 1273 K, to maintain constant temperature :

A. $0.5:1$

B. $1:0:6$

C. $0.8:1$

D. $1:1$

Answer: B

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6. When 12.0 g of carbon reacted with limited quantity of oxygen, 57.5 kcal of heat was produced, calculate the number of moles of CO produced $\left(\Delta_f H\left(CO_2\right) = -94.5 cal, \Delta_f H(CO) = -21.41 kcal.\right.$

A. 0.5 mol

B. 0.46 mol

C. 0.64 mol

D. 0.74 mol

Answer: A

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7. The standerd enthalpy of formation of FeO and Fe_2O_3 is -65 kcal mole^{-1} and -197 kcal mole^{-1} respectively . A mixture of two oxides containes FeO and Fe_2O_3 in the mole ratio $2:1$. If by oxidation, it is changed into a $1:2$ mole ratio mixture , How much of thermal energy will released per mole of the internal mixture ?

A. $13.4kcal/\text{mole}$

B. $14.6kcal/\text{mole}$

C. $15.7kcal/\text{mole}$

D. $16.8kcal/\text{mole}$

Answer: A

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8. In the reaction $AB_2(l) + 3X_2(g) \Leftrightarrow AX_2(g) + 2BX_2(g) + 2BX_2(g)\Delta H = -270$ kcal per mol. of $AB_2(l)$.

the enthalpies of formation of $AX_2(g) \& BX_2(g)$ are in the ratio of $4:3$ and have opposite sign. The value of $\Delta H_f^0\left(AB_2(l)\right) = +30$ kcal/mol. Then

A. $\Delta H_f^0\left(AX_2\right) = -96 kcal/mol$

B. $\Delta H_f^0\left(BX_2\right) = +480 kcal/mol$

C. $K_p = K_c \& \Delta H_f^0\left(AX_2\right) = +480 kcal/mol$

D. $K_p = K_c RT \& \Delta H_f^0\left(AX_2\right) + \Delta H_f^0\left(BX_2\right) = -240 kcal/mol$

Answer: C

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9. Reactions involving gold have been of particular intrests to alchemists.

Consider the following reactions ,

$Au(OH)_3 + 4HCl \rightarrow HAuCl_4 + 3H_2O$

$\Delta H = -28kcal$

$Au(OH)_3 + 4HBr \rightarrow HAuBr_4 + 3H_2O$

$\Delta H = -36.8kcal$

In an experiment there was an absorption of 0.44 kcal when one mole of $HAuBr_4$ was mixed with 4 moles of HCl. Then the fraction $HAuBr_4$ converted into $HAuCl_4$: (percentage conversion)

A. 0.05

B. 0.06

C. 0.07

D. 0.08

Answer: A

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10. The heat of formation of $C_2H_5OH(l)$ is $-66kcal/\text{mole}$. The heat of combustion of $CH_3OCH_3(g)$ is -348 kcal/mole. ΔH_f for H_2O and CO_2 are

-68 kcal/mole respectively. Then, the ΔH for the isomerisation reaction $C_2H_5OH(l) \rightarrow CH_3OCH_3(g)$,and ΔE for the same are at $T = 25^\circ C$

A. $\Delta H = 18$ kcal/mole,$\Delta E = 17.301$kcal/mole

B. $\Delta H = 22$ kcal/mole,$\Delta E = 21.408$ kcal/mole

C. $\Delta H = 26$ kcal/mole, $\Delta E = 25.709$ kcal/mole

D. $\Delta H = 30$ kcal/mole, $\Delta E = 28.522$ kcal/mole

Answer: B

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11. The average Xe-F bond energy is 34 kcal/mol, first I.E of Xe is 279 kcal/mol, electron affinity of F is 85 kcal/mol & bond dissocitation energy of F_2 si 38 kcal/mol. Then, the enthalpy change of the reaction $XeF_4 \rightarrow Xe^+ + F^- + F_2 + F$ will be

A. 367 kcal/mole

B. 425 kcal/mole

C. 292 kcal/mole

D. 392 kcal/mole

Answer: C

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12. Caesium chlorides is formed according to the following equation $Cs(s) + 0.5Cl_2(g) \rightarrow CaCl(s)$. The enthalpy of sublimation of Cs, enthalpy of dissocitation of chlorine, ionization energy of Cs and electron affinity of chlorine are 81.2,243.0,375.7 and -348.3 kJmol^{-1}. The energy change involved in the formation of CsCl is -388.6 kJ mol^{-}. Calculate the lattice energy of CsCl.

A. 618.7 kJ mol^{-1}

B. 1237.4 kJ mol^{-1}

C. $1237.4kJmol^{-1}$

D. $-532.7KJmol^{-1}$

Answer: D

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13. The enthalpy of neutraliztion of weak base A OH and a strong base BOH by HCl are -12250 cal/mol and -13000 cal/mol respectively . When one mole of HCl is added to a solution containting 1 mole of A OH and 1 mole of BOH , the enthalpy change was -12500 cal/mol . In what ratio is the acid distribution between A OH and BOH?

A. $2:1$

B. $2:3$

C. $1:2$

D. None of these

Answer: A

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14. Equal volumes of molar hydrochloric acid and sulphuric acid are neutralized by dil. $NaOH$ solution and x Kcal and y Kcal of heat are liberated respectively. Which of the following is true?

A. $x = y$

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

C. $x = 2y$

D. None of these

Answer: B

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15. The enthalpy of neutralization of $40.0g$ of NaOH by 60.0 g of CH_3COOH will be:

A. $57.1kJ\text{equiv}^{-1}$

B. less than $57.1kJ\text{equiv}^{-1}$

C. more than $57.1kJequiv^{-1}$

D. $13.7kJequiv^{-1}$

Answer: B

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16. Given $\Delta_{\text{ioniz}}H^{o}(HCN) = 45.2kJmol^{-1}$ and $\Delta_{\text{ioniz}}H^{o}\left(CH_3COOH\right) = 2.1kJmol^{-1}$. Which one of the following facts is ture?

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. $pK_1(HCN) = (45.17/2.07)pK_a\left(CH_3COOH\right)$

Answer: B

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17. A solution is 500 ml of 2M KOH is added to 500 ml of 2 M HCl and the mixture is well shaken. The rise in temperature T_1 is noted. The experiment is then repeated using $250 ml$ of each solution and rise in temperature T_2 is again noted. Assume all heat is taken by the solution

A. $T_1 = T_2$

B. T_1 is 2 times as large as T_2

C. T_2 is twice of T_1

D. T_1 is 4 times as large as T_2

Answer: A

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18. $50.0 mL$ of 0.10 M HCl is mixed with $50.0 mL$ of 0.10 M NaOH. The solution's temperature rises by $3.0^{\circ} C$. Calculate the enthalpy of neutralization per mole of HCl. (Assuming density of sol. $= 1g/ml$ & specifice heat of water)

A. $-2.5 \times 10^2 kJ/\text{mole}$

B. $-1.3 \times 10^2 kJ/\text{mole}$

C. $-8.4 \times 10^1 kJ/\text{mole}$

D. $-6.3 \times 10^1 kJ/\text{mole}$

Answer: A

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19. The average O-H bond energy in H_2O with the help of following data.

(1) $H_2O(l) \rightarrow H_2O(g), \Delta H = +40.6 kJmol^{-1}$

(2) $2H(g) \rightarrow H_2(g), \Delta H = -435. kJmol^{-1}$

(3) $O_2(g) \rightarrow 2O(g), \Delta H = +489.6 kJmol^{-1}$

(4) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l), \Delta H = -571.6 kJmol^{-1}$

A. $584.9 kJmol^{-1}$

B. $279.8kJmol^{-1}$

C. $462.5kJmol^{-1}$

D. $925kJmol^{-1}$

Answer: C

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20. Enthalpy of polymerisation of ehtylene, as represented by the reaction , $nCH_2 = CH_2 \rightarrow \left(-CH_2-CH_2-\right)$ is $-100kJ$ per mole of ehtylene. Given bond enthalpy of C=C bond is $600kJmol^{-1}$, enthalpy of C-C bond (in kJ mol) will be:

A. 116.7

B. 350

C. 700

D. indeterminate

Answer: B

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21. The average energy required to break a P-P bond in $P_4(s)$ into gaseous atoms is $53.2 kcal mol^{-1}$. The bond dissociation energy of $H_2(g)$ is $104.2 kcal mol^{-1}$, ΔH_f^0 of $PH_3(g)$ from $P_4(s)$ is $5.5 kcal mol^{-1}$. The P-H bond energy in kcal mol^{-1} is [Neglect presence of Van der Waals force in $P_4(s)$]

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exercise-2 Part-2: Single and double value integer type

1. If theta of reaction for the given acid-base reaction:

$$HA + NaOH \rightarrow NaA + H_2O, \Delta H = -4.7 kcal$$

The heat of dissocitation of HA is _______.

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2. The enthalpy of combustion at $25^{\circ}C$ of $H_2(g)$, cyclohexane and cyclohexene are -241, 3920 and $-3717 kJ\text{mole}^{-1}$ respectively. The heat of hydrogenation of cyclohexene is (Kcal/mole) approximate integer:

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3. When 0.36 g of glucose was burned in a bomb calorimeter (Heat capacity $600 JK^{-1}$)the temperature rise by 10 K. Calculate the standard molar enthalpy of combustion (MJ/mole).

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4. For reduction of ferric oxide by hydrogen , $Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(l)$.

$\Delta H^{o}_{300} = 26.72 kJ$. The reaction was found to be too exothermic. To be convenient, it is desirable that ΔH^{0} should be at the most $-26 kJ$. At what temperature difference it is possible ?

$C_p\left[FeO_3\right] = 105, C_p[Fe(s)] = 25, C_p\left[H_2O(l)\right] = 75, C_p\left[H_2(g)\right] = 30$ (all are in J/mol)

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5. Calculate the enthalpy change when infinitely dilute solution of $CaCl_2$ and Na_2CO_3 are mixed. ΔH_f^0 for $Ca^{+2}(aq)$.

$CO_3^{-2}(aq)$ and $CaCO_3$ are $-129.80, \ -161.7 - 288.50kcalmol^{-1}$ respectively.

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6. Calculate the enthalpy change of 1 mole of reaction

$$Na(s) + \frac{1}{2}Br_2(g) \rightarrow NaBr(s) \text{ in kcal}$$

Given :

$\Delta H_{\text{sub}}(Na) = 137kJ\text{mole}^{-1}, \Delta H_{\text{bond dissociation}}\left(Br_2(g)\right) = 144kJ\text{mole}^{-1}$

$\Delta H_{1\text{ st ionisation}}\left(Na(g) = 496kJ\text{mole}^{-1}, \Delta H_{1st\text{electron affinity}}\left(Br(g) = -325kJ\text{mole}^{-1}\right.\right.$

$\Delta H_{\text{Lattice energy}}(NaBr) = +742$

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7. Calculate the resonance energy of isoprene $\left(C_5H_8\right)$ from the data given.

The standard heat of sublimation of graphite is $718KkJ\text{mole}^{-1}$ and heat of formation $C_5H_8(g)$ is $79kJ$ mole.

(Give your answer in kcal mole^{-1}, approximate integer.)

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8. How many of the following have standard heat of formation is zero.

(i) $Br_{2(l)}$ (ii) $CO_{2(g)}$ (iii) C_{graphite} (iv) $Cl_{2(l)}$ (v) $Cl_{2(g)}$

(vi) $F_{2(g)}$ (vii) $F_{(g)}$ (viii) $l_{2(g)}$ (ix) $S_{(\text{monoclinic})}$ (x) $N_{2(g)}$

(xi) $P_{(\text{Black})}$ (xii)$P_{(red)}$ (xiii) CH_4

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9. Standard enthalpy of combustion of cyclopropane is $-2091kJ/\text{mole}$ at $25^{\circ}C$ then calculated the enthalpy formation of cyclopropane. If

$\Delta H_f^o\left(CO_2\right) = -393.5kJ/\text{mole}$ and $\Delta H_f^o\left(H_2O\right) = -285.8kJ/\text{mole}.$

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10. Bond energies of $N \equiv N, H-H$ and $N-H$ bonds are 945,463 & 391 kJ mol^{-1} respectively, the enthalpy of the following reactions is :

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

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11. The reaction of nitrogen with hydrogen to make ammonia has $\Delta H = -92kJ.$

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

What is the value of ΔU (in kJ) if the raction of correct out at a constant pressure of 40 bar and the volume changes is 1.25 litre.

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12. Calculate the amount of heat evolved during the complete combustion of $100ml$ of liquid benzene from the following data. Predict your answer as $\frac{\Delta H}{100}$ (in KJ/mol).

(i) $18gm$ of graphite on complete combustion evolve 585 KJ heat

(ii) 15540 KJ heat is required to dissociate all the molecules of 1 litre water into H_2 and O_2.

(iii) The heat of formation of liquid benzene is 48 kJ/mol

(iv) Density of $C_6H_6(l) = 0.87gm/ml$

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13. The enthalpy of neutralisation of a weak acid in $1M$ solution with a strong base is $-5.6kJmol^{-1}$. Enthalpy of ionization of the acid is $1.5kJmol^{-1}$ and enthalpy of neutralization of the strong acid with a strong base is $-57.3kJ\text{equiv}^{-1}$, what is the % ionization of the weak acid in molar solution (assume the acid to be monobasic) ?

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14. Calculate ΔU reaction for the hydrogenation of acetalence at constant volume and at $77\,^\circ C$.

Given that $-\Delta H_f(H_2O) = -678$ kcal mole , $\Delta H_{\text{comb}}(C_2H_2) = -310.1 kcal/ms^2$

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15. Calculate the C-C bond enthalpy from the following data:

(a) $C(s) \rightarrow C(g), \Delta H = 170 kcal$ (b) $\frac{1}{2}H_2(g) \rightarrow H(g), \Delta H = 52 kcal$

(c) Heat of combustion of ethane $= -20 kcal$ (d) C-H bond enthalpy $= 99 kcal$.

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exercise-2 Part-3: One or more than type one options correct type

1. Which of the following is (are) endothermicn reaction:

A. Combustion of methane

B. Decomposition of water

C. Dehydrogenation of ethane to ethylene

D. Conversion of graphite to diamond

Answer: A::C::D

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2. Heat of reaction depond upon:

A. Physical state of reactants and products

B. Whether the reaction is carried out at constant pressure or at constant volume

C. Method by which the final products are obtained from the reactants

D. Temperature of the reaction

Answer: A::B::D

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3. Select the correct statenents :

A. All conbustion reactuions are exothermic

B. heat of combustion are always exothermic

C. $N_2 + O_2 \rightarrow 2NO, \Delta H = +ve$

D. $F_2 + \frac{1}{2}O_2 \rightarrow F_2O, \Delta H = +ve$

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4. Which of the following reaction can be used to define the std enthalpy of formation of $CO_2(g)$.

A. $CO(g) + \frac{1}{2}O_2 \rightarrow CO_2(g)$

B. $C_6H_6(l) + \frac{7}{2}O^2(g) \rightarrow 6CO_2(g) + 3h_2O(l)$

C. $C(\text{diamond}) + 2O_2(g) \rightarrow CO_2(g)$

D. $C(\text{garphite}) + O_2(g) \rightarrow C)_2(g)$

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5. Heat of formation of CH_4 are:

If given heat:

$C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -394KJ$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \rightarrow 2H_2O(l) \quad \Delta H = -394KJ$

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \quad \Delta H = -394KJ$

A. $-70KJ$

B. $-16.7Kcal$

C. $-244KJ$

D. $-50Kcal$

Answer: A::B

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6. Heat of nrutralization of the acid-base reaction is 57.32 KJ for :

A. HCOOH +KOH

B. $CH_3COOH + NaOH$

C. $HNO_3 + LiOH$

D. $HCl + NaOH$

Answer: C::D

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7. For which of the following reaction $\Delta H^0_{\text{reaction}}$ of product.

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

B. $N_2(g) + O_3(g) \rightarrow N_2O_3(g)$

C. $CH_4(g) + 2Cl_2(g) \rightarrow CH_2Cl_2(l) + 2HCl(g)$

D. $Xe(g) + 2F_2(g) \rightarrow XeF_4(g)$

Answer: A::B::C

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8. The following is (are) endothermic reaction(s):

A. Combustion of mehtane

B. Decomposition of water

C. Dehydrogenation of ethane to ethylene

D. Conversion of graphite to diamond

Answer: B::C::D

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9. Which of the reaction defines molar ΔH_f^0?

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

B. $\frac{1}{2}Br_2(l) + \frac{1}{2}H_2(g) \rightarrow HBr(g)$

C. $N_2(g) + 2H_2(g) + \frac{3}{2}O_2(g) \rightarrow NH_4NO_3(s)$

D. $\frac{1}{2}I_2(s) + \frac{1}{2}H_2(g) \rightarrow HI(g)$

Answer: B::C::D

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10. Consider the reactions

$(i) \quad S(\text{rhombic}) + 3/2O_2(g) \rightarrow SO_3(g), \Delta H_1$

$(ii) \quad S(\text{monoclinic}) + 3/2O_2(g) \rightarrow SO_3(g), \Delta H_2$

$(iii) \quad S(\text{rhombic}) + O_3(g) \rightarrow SO_3(g), \Delta H_3$

$(iv) \quad S(\text{monoclinic}) + O_3(g) \rightarrow SO_3(g), \Delta H_4$

A. $\Delta H_1 < \Delta H_2 < \Delta H_4$ (magnitude only)

B. $\Delta H_1 < \Delta H_3 < \Delta H_4$ (magnitude only)

C. $\Delta H_1 < \Delta H_2 = \Delta H_3 < \Delta H_4$ (magnitude only)

D. $\Delta H_1 + \Delta H_4 = \Delta H_2 + \Delta H_3$

Answer: A::B::D

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11. If $\Delta H^0_{f\left(C_2H_6\right)}(g) = -85KJHmol^{-1}, \Delta H^0_{f\left(C_3H_8\right)}(g) = -104KJmol^{-1}, \Delta H^0$ for $C(s) \rightarrow C(g)$ is $718KJmol^{-1}$ and heat of formation of H-atom is $218KJmol^{-1}$ then :

A. $\Delta H_{C-C} = 345$ KJ

B. $\Delta H_{C-H} = 414$ KJ

C. $\Delta H_{H-H} = 436KJ$

D. $\Delta H_{H-H} = 436$ KJ

Answer: A::B::C

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exercise-2 Part-4 : Comprehension

1. Enthalpy of neutralzation is defined as the enthalpy change when 1 mole of acid $\overset{/}{-}$base is completely neutralized by base /acid in dilute solution .

For Strong acid and strong base neutralization net chemical change is

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

$\Delta_r H^\circ = -55.84 KJ/mol$

$\Delta H^\circ_{\text{ionization}}$ of aqueous solution of strong acid and strong base is zero .

when a dilute solution of weak acid or base is neutralized, the enthalpy of neutralization is somewhat less because of the absorption of heat in the ionzation of the because of the absorotion of heat in the ionization of the weak acid or base ,for weak acid /base

$\Delta H^\circ_{\text{neutrlzation}} = \Delta H^\circ_{\text{ionization}} + \Delta_r H^\circ \left(H^+ + OH^- \rightarrow H_2O\right)$

If enthalpy of neutralization of CH_3COOH by NaOH is -49.86KJ/mol then enthalpy of ionization of CH_3COOH is:

A. $5.98KJ/mol$

B. $-5.98KJ/mol$

C. $105.7KJ/mol$

D. None of these

Answer: A

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2. Enthalpy of neutralzation is defined as the enthalpy change when 1 mole of acid /base is completely neutralized by base /acid in dilute solution .

For Strong acid and strong base neutralization net chemical change is

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

$\Delta_r H^\circ = -55.84KJ/mol$

$\Delta H^\circ_{\text{ionization}}$ of aqueous solution of strong acid and strong base is zero .

when a dilute solution of weak acid or base is neutralized, the enthalpy of neutralization is somewhat less because of the absorption of heat in the ionzation of the because of the absorotion of heat in the ionization of the weak acid or base ,for weak acid /base

$$\Delta H^{\circ}_{\text{neutrlzation}} = \Delta H^{\circ}_{\text{ionization}} + \Delta_r H^{\circ}\left(H^{+} + OH^{-} \rightarrow H_2O\right)$$

What is ΔH° for complate neutralization of strong diacidic base $A(OH)_2 by HNO_3$?

A. $55.84 KJ$

B. $-111.68 KJ$

C. $545.86 KJ/mol$

D. None of these

Answer: B

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3. Enthalpy of neutralization is defined as the enthalpy change when 1 mole of acid/base is completely neutralized by base/acid in dilute solution.

For strong acid and strong base neutralization net chemical change is

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l), \quad \Delta_r H^\circ = -55.84 KJ/mol$$

$\Delta H^\circ_{\text{ionization}}$ of aqueous solution of strong acid and strong base is zero.

When a dilute solution of a weak acid or base is neutalized, teh enthalpy of neutralization is some what less because of the absorption of heat in the ionization of the weak acid or base, for weak acid/base

$$\Delta H^2_{\text{neutrilization}} = \Delta H^\circ_{\text{ionization}} + \Delta_r H^\circ \quad \left(H^+ + OH^- \rightarrow H_2O\right)$$

Under the same condition how many mL of 0.1 M NaOH and 0.05 M H_2A (strong diprotic acid) solution should be mixed for a total volume of 100 mL produce the highest rise in temperature:

A. $25:75$

B. $50:50$

C. $75:25$

D. $66.66:33.33$

Answer: B

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4. A gaseous mixture of propane, acetylene and CO_2 is burnt in excess of air. Total 4800 KJ heat is evolved . The volume of CO_2 formed during combustion is 224 liters at STP.

The total evolved heat is used to perform two separate process:

(i) Vapourising 87.5% of water (liquid) obtained in the process of burning the original mixture.

(ii) Forming 3808 litres ethylene measured at STP from its elements.

$\Delta H_{H-H} = 435KJ/mol \quad \Delta H_{C-H} = 416KJ/mol \quad \Delta H_{C-C} = 347KJ/mol$

$\Delta H_{C-C} = 615KJ/mol, \quad \Delta H_{C-C} = 812KJ/mol \quad \Delta H_{\text{sublimation}}\text{of }(C, s) = 718KJ/m$

$\Delta H_f^\circ\left(C_2 g\right) = -394KJ/mol \quad \Delta H_f^\circ\left(H_2O, l\right) = -286KJ/mol. \quad \Delta H_f^\circ\left(H_2O, g\right) =$

$\Delta H^\circ_{r\times n}\text{for}C_2H_2(g) + H_2g \rightarrow C_2H_4(g)$

A. $-220kJ/mol$

B. $-180KJ/mol$

C. $-250KJ/mol$

D. $-200KJ/mol$

Answer: D

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5. A gaseous mixture of propane, acetylene and CO_2 is burnt in excess of air. Total 4800 KJ heat is evolved . The volume of CO_2 formed during combustion is 224 liters at STP.

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$\Delta H_f^\circ\left(C_2g\right) = -394KJ/mol \quad \Delta H_f^\circ\left(H_2O, l\right) = -286KJ/mol. \quad \Delta H_f^\circ\left(H_2O, g\right) =$

Sum of enthalpies of combustion of $C_3H_8(g)$ and $C_2H_2g\big)$ is :

A. -2198 KJ/mol

B. -3499 KJ/mol

C. -2798 KJ/mol

D. -3099 KJ/mol

Answer: B

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6. A gaseous mixture of propane, acetylene and CO_2 is burnt in excess of air. Total 4800 KJ heat is evolved . The volume of CO_2 formed during combustion is 224 liters at STP.

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$\Delta H_f^\circ \left(C_2g\right) = -394KJ/mol \quad \Delta H_f^\circ \left(H_2O, l\right) = -286KJ/mol. \quad \Delta H_f^\circ \left(H_2O, g\right) =$

Total moles of hydrocarbon gases taken in the initial mixture

A. 3

B. 4

C. 2

D. 5

Answer: A

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exercise-3 Part-1 :(previous years)

1. Which of the following equation gives the values of heat of formation $\left(\Delta H_f^{\circ}\right)$?

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

D. $H_2(g) + F_2(g) \rightarrow 3HF(g)$

Answer: B

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2. In a constant volume calorimeter, 3.5 g of a gas with moleular weight 28 was burnt in excess oxygen at 298.0 K . The temperature of the calorimeter was found to increase from 298.0 K to 298.45 K due to the combustion process. Given that the heat capacity of the calorimeter is $2.5 KJK^{-1}$, the numerical value for the enthalpy of combustion of the gas in KJ mol^{-1} is .

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3. The species which by definition has zero standard molar enthalpy of formation at $298K$ is

A. $Br_2(g)$

B. $Cl_2(g)$

C. $H_2O(g)$

D. $CH_4(g)$

Answer: B

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4. The bond energy (in Kcal mol^{-}) of a C-C single bond is approximately:

A. 1

B. 10

C. 100

D. 1000

Answer: C

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5. Using the data provided, calculate the multiple bond energy $\left(kJmol^{-1}\right)$ of a $C \equiv C$ bond in C_2H_2. That energy is (take the bond energy of a $C - H$ bond as $350kJmol^{-1}\right)$.

$2C_{(s)} + H_{2(g)} \rightarrow C_2H_{2(g)}, \Delta = 225kJmol^{-1}$

$2C_{(s)} \rightarrow 2C_{g}\Big), \Delta H = 1410kJmol^{-1}$

$H_{2(g)} \rightarrow 2H_{(g)}, \Delta H = 330kJmol^{-1}$

A. 1165

B. 837

C. 865

D. 815

Answer: D

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6. The standard enthalpies fo formation of $CO_2(g), H_2O(1)$, and glucose (s) at $25^{\circ}C$ are $-400kJmol^{-1}$, $-300kJmol^{-}$, and $-1300kJmol^{-1}$, respectively. The standard enthalpy of combustion per gram of glucose at $25^{\circ}C$ is

A. +2900 KJ

B. -2900 KJ

C. -16.11 KJ

D. $+16.11$KJ

Answer: C

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7. When $100mL$ of $1.0MHCl$ was mixed with $100mL$ of $1.0MNaOH$ in an insulated beaker at constant pressure, a temperature increase of $5.7\,^{\circ}C$ was measured for the beaker and its contents (Expt.1). Because the enthalpy of neutralisation of a strong acid with a strong base is constant $\left(-57.0kJmol^{-1}\right)$ this experiment couldbe used to measure the calorimeter constant. In a second experiment (Expt.2), $100mL$ of $2.0M$ acetic acid $K_a = 2.0\times10^{-5}\big)$ was mixed with $100mL$ of $1.0MNaOH$ (under identical conditions to Expt. 1) where a temperature rise of $5.6\,^{\circ}C$ was measured.

Enthalpy of dissociation (in $kJmol^{-1}$) of acetic acid obtained from the Expt. 2 is

A. 1.0

B. 10.0

C. 24.5

D. 51.4

Answer: A

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8. When $100mL$ of $1.0MHCl$ was mixed with $100mL$ of $1.0MNaOH$ in an insulated beaker at constant pressure, a temperature increase of $5.7^{\circ}C$ was measured for the beaker and its contents (Expt.1). Because the enthalpy of neutralisation of a strong acid with a strong base is constant $\left(-57.0kJmol^{-1}\right)$ this experiment couldbe used to measure the calorimeter constant. In a second experiment (Expt.2), $100mL$ of $2.0M$ acetic acid $K_a=2.0\times10^{-5}\Big)$ was mixed with $100mL$ of $1.0MNaOH$ (under identical conditions to Expt. 1) where a temperature rise of $5.6^{\circ}C$ was measured.

The pH of the solution after Expt. 2 ils

A. 2.8

B. 4.7

C. 5.0

D. 7.0

Answer: B

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exercise-3 Part-2 :(previous years)

1. The enthalpies of combustion of carbon and carbon monoxide are -393.5 and -283 kJ mol^{-1} respectively. The enthaly of formation of carbon monoxide per mole is :

A. $110.5kJ$

B. $676.5KJ$

C. $-676.5KJ$

D. $-110.5kJ$

Answer: D

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2. If the bond dissociation energies of XY, X_2 and Y_2(all diatomic molecules) are in the ratio $1:1:0.5$ and $\Delta_f H$ of XY is $-200kJmol^{-1}$. The bond dissociation energy of X_2 will be :

A. $100KJmol^{-1}$

B. $200KJmol^{-1}$

C. $300KJmol^{-1}$

D. $800KJmol^{-1}$

Answer: D

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3. The enthalpy changes for the following process are listed below :

$Cl_2(g) = 2Cl(g), \quad 242.3 \ \text{kJ}mol^{-1}$

$I_2(g) = 2I(g), \quad 151.0 \ \text{kJ}mol^{-1}$

$ICl(g) = 2I(g) + Cl(g), \quad 211.3 \ \text{kJ}mol^{-1}$

$I_2(s) = I_2(g), \quad 62.76 \ \text{kJ}mol^{-1}$

Given that standard states for iodine and chlorine are $I_2(s)$ and $Cl_2(g)$, the standerd enthalpy of formation for ICl(g) is :

A. $-16.8KJmol^{-1}$

B. $+16.8KJmol^{-1}$

C. $+244.8KJmol^{-1}$

D. $-14.6KJmol^{-1}$

Answer: B

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

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

A. $1238.78Jmol^{-1}$

B. $2477.57Jmol^{-1}$

C. $2477.57Jmol^{-1}$

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

Answer: A

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5. The standard enthalpy of formation $\left(\Delta H_f^{\circ}\right)$ at 398 K fir methane , $CH_{4(g)}$ is $748KJmol^{-1}$. The additional information required to determine the average energy for $C - H$ bond formation would be :

A. the dissociation energy of H_2 and enthalpy fo sublimation of carbon

B. latent heat of vapourisation of methane

C. the first four ionization energies of carbon and electron gain enthalpy of hydrogen

D. the dissociation energy of hydrogen molecule , H_2

Answer: A

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6. On the basis of the following thermochemical data : $\left(\Delta_f G^\circ H^+_{(aq.)} = 0\right)$

$$H_2O_{(l)} \rightarrow H^+_{(aq.)} + OH^-_{(aq.)}, \Delta H = 57.32kJ$$

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}, \Delta H = -286.20kJ$$

The value of enthalpy of formation of OH^- ion at $25^\circ C$ is :

A. $-228.88KJ$

B. $+228.88KJ$

C. $-343.52KJ$

D. $-22.88KJ$

Answer: A

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7. The standard enthalpy of formation of NH_3 is -46.0 kJ mol^{-1}. If the enthalpy of formation of H_2 from its atoms is -436 kJ mol^{-1} and that of N_2 is -712kJ mol^{-1}, the average bond enthalpy of N-H bond in NH_3 is :-

A. $-964KJmol^{-1}$

B. $+352KJmol^{-1}$

C. $+1056KJmol^{-1}$

D. $-1102KJmol^{-1}$

Answer: B

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8. The value of enthalpy change (ΔH) for the reaction

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

at $27^\circ C$ is $-1366.5 kJmol^{-1}$.

The value of internal energy change for the above reactio at this temperature will be

A. 1369.0 KJ

B. -1364.0KJ

C. $-1361.5 KJ$

D. -1371.5 KJ

Answer: B

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9. Consider the reaction,

$4NO_2(g) + O_2(g) \rightarrow 2N_2O_5(g), \Delta_r H = -111 kJ.$ If $N_2O_5(s)$ is formed instead of $N_2O_5(g)$ in the above reaction, the $\Delta_r H$ value will be

(Given, ΔH of sublimation for N_2O_5 is $54 kJmol^{-1}$)

A. $+54KJ$

B. $+219$ KJ

C. -219 KJ

D. -165 KJ

Answer: C

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10. For the complete combustion of ethanol, $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ the amount of heat produced as measured in bomb calorimeter is $1364.47 KJmol^{-1}$ at $25^{\circ} C$. Assuming ideality, the enthalpy of combustion, ΔH_C, for the reaction will be

$\left[R = 8.314JK^{-1}mol^{-1}\right]$

A. $-1366.95KJmol^{-1}$

B. $-1361.95KJmol^{-1}$

C. $-1460.50KJmol^{-1}$

D. $-1350.50KJmol^{-1}$

Answer: A

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11. the heat of atomization of methane and ethane are 360 KJ/mol and 620 KJ/mol , respectively . The longest Wavelength of light capable of breaking . The c-c bond is :

(Avogadro number $= 6.02 \times 10^{23}, h = 6.62 \times 10^{-34}Js\big)$

A. 2.48×10^{-3} nm

B. 1.49×10^{3} nm

C. 2.49×10^4 nm

D. 2.48×10^4 nm

Answer: B

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exercise-3 Part-3 :(Subjective questions)

1. The entropy of a gas increases on its expansion . Why?

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2. Entropy of the solutions is higher than that of pure liquid . Why?

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3. What are the signs of ΔS for the system and for the surrounding in each of the following processes?

(a) Water boils in a teakettle on a hot stove.

(b) Ice in an ice cube tray, left an a table melts.

(c) A cup of coffee is reheated in a microwave oven.

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4. State second law of thermodynamics.

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5. Write statement of III^{rd} law of thermodynamics?

Watch Video Solution

6. State the thermodynamic condition of spontaneous occurance of a process?

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exercise-3 Part-3 :(Subjective questions)Section A

1. If ΔH for a reaction has a positive value, how would you know the sign requirement of ΔS for it so that the reaction is spontaneous?

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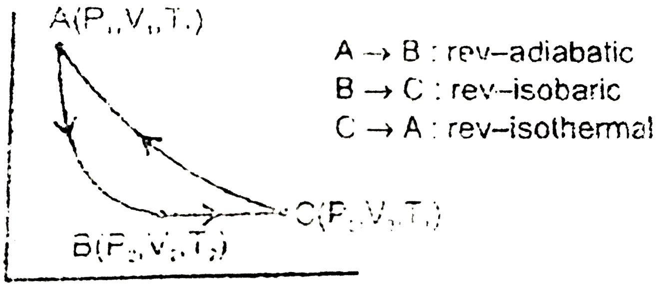
exercise-3 Part-3 :(Subjective questions)Section B

1. One mole of monoatomic has was taken through a cyclic process as shown in figure.

Calculate $\frac{dq_{\text{rev}}}{T}$



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2. The entropy if vaporisation of benzene is $85JK^{-1}mol^{-1}$. When 117g benzene vaporizes at its's normal boiling point, the entropy change in surrounding is:

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3. One mole of ideal monatomic gas was taken through isochoric heating from 100 K to 1000 K. Calculate ΔS_{system}, Δ_{surr} and ΔS_{total} in

(i) When the process carried out reversibly (ii) When the process carried out irreversibly (one step)

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4. Calculate standard entropy change in the reaction

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

Given : $S_{m_0}\left(Fe_2O_3.\ S\right) = 87.4, S_m^\circ(Fe, S) = 27.3$

$S_m^\circ\left(H_2, g\right) = 130.7, S_m^\circ\left(H_2O, l\right) = 69.9JK^{-1}mol^{-1}$

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5. One mole of solid iron was vaporized in an oven at 3500 K . If iron boils at 3133K abd enthalpy of vaporization is $349KJmol^{-1}$, determine $\Delta S_{\text{system}}, \Delta S_{\text{surrounding}}$ and $\Delta S_{\text{universe}}$. (Oven is considered as surroundings).

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6. Calculate the entropy change in surroundings when 1.00 mol of $H_2O(l)$ is formed under standard conditions, $\Delta_r H^\Theta = -286kJmol^{-1}$.

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7. Order of increasing of entropy ammong given condition of substance is :

$(I)1$mole of $H_2O(I)$ at $298K$ and $0.101M$pa

$(II)1$ mole of ice at 273 K and 0.101 M Pa

$(III)1$ mole of $H_2(g)$ at 298 K and 1atm

$(IV)1$ mole of $C_2H_6(g)$ at 398 K abd 1 atm

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8. Oxygen & ozone are gases at standard temperature. Their molar entropies are in the sequence $O_2 < O_3$. Using molecular properties , explain why ozone is more disordered than oxygen.

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exercise-3 Part-3 :(Subjective questions)Section C

1. Comment on the following statements:

(a) An exothermic reaction is always thermodynamically spontaneous.

Reaction with $\Delta G < O$ always have an equilibrium constant greater than 1

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2. What will be the states of a chemical reaction when:

$\Delta G = 0 \quad (ii) \Delta G > 0 \quad \Delta G < 0$

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3. A gaseous reactant A forms two different product, in parallel reaction , B and C as follows:

$A \rightarrow B, \Delta H^\circ = -3KJ, \Delta S^\circ = 20JK^{-1}, A \rightarrow C, \Delta H^\circ = -3.6KJ, \Delta S^\circ = 10JK^{-}$

Discuss the relative stability of B and C on the basis of Gibb's free energy change at $27^\circ C$.

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4. With the following infromations, determine standard Gibb's free energy of formation of $N_2O_4(g)$.

$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g) \quad \Delta G^\circ = 86.6KJ \quad .....(i)$

$NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g) \quad \Delta G_{\circ} = 34.82KJ \quad .....(ii)$

$2NO_2(g) \rightarrow N_2O_4(g)$ G= 5.77 $.....(iii)$

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5. Following reaction occurs at 25° :

$2NO\left(g, 1 \times 10^{-5}atm\right) + CI_2\left(g, 1 \times 10^{-2}atm\right) \Leftrightarrow 2NOCI\left(g, 1 \times 10^{-2}atm\right)$

Calculate ΔG° $[R = 8J/\text{mole}K]$

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6. For the equilibrium,

$PCI_5(g) \Leftrightarrow PCI_3(g) + CI_2(g) at 25\,^\circ C K_c = 1.8 \times 10^{-7}$

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

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exercise-3 Part-3 :(Only one option correct type) section A

1. In which state, the matter have highest entropy

A. Solid

B. Liquid

C. Gas

D. Equal in all

Answer: C

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2. Predict which of the following reaction(s) has a positive entropy change?

$I \quad Ag^{+}(aq) + CI^{-}(aq) \rightarrow AgCI(s)$

$I \quad NH_4CI(s) \rightarrow NH_3(g) + HCI(g)$

$III \quad 2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

$IV \quad 2NH_3 \rightarrow N_2(g) + 3H_2(g)$

A. I and II

B. III

C. II and III

D. II

Answer: C

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3. Mixing of non-reacting gases is generally accompanied by

A. Decreases in entropy

B. Increases in entropy

C. Change in enthalpy

D. Change in free energy

Answer: B

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4. Which of the following reactions is associated with the most negative change in entropy?

A. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

B. $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

C. $C(\text{s, graphite}) + O_2 \rightarrow CO_2(g)$

D. $3C_2H_3(g) \rightarrow C_6H_6(l)$

Answer: D

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5. For the gas - phase decomposition , $PCI_5(g) \overset{\Delta}{\Leftrightarrow} PCI_3(g) + CI_2(g)$:

A. $\Delta H < 0, \Delta S < 0$

B. $\Delta H > 0, \Delta S > 0$

C. $\Delta H > 0, \Delta S < 0$

D. $\Delta H < 0, \Delta S > 0$

Answer: B

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6. Which one of the following has ΔS° greater than zero

A. $CaO(s) + CO_2(g) \Leftrightarrow CaCO_3(s)$

B. $NaCI(aq) \Leftrightarrow NaCI(s)$

C. $NaNO_3(s) \Leftrightarrow Na^{+}(aq) + NO_3^{-}(aq)$

D. $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$

Answer: C

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7. For which reaction from the following , will be maximum entropy change:

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

Answer: B

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8. Which of the following statement is true. The entropy if the universe

A. Increases and tends towards maximum value

B. Decreases and tends to be zero

C. Remains constant

D. Decreases and increases with a periodic rate

Answer: A

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exercise-3 Part-3 :(Only one option correct type) section B

1. An isolated system comprises the liquid in equilibrium with vapours . At this stage the molar entropy of the vapour is :

A. Less than that of liquid

B. more than that of liquid

C. Equal to zero

D. Equal to that of liquid

Answer: D

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2. When two mole of an ideal gas $\left(C_{p.m}=\frac{5}{2}R\right)$ heated from $300K$ to $600K$ at constant pressure. The change in entropy of gas (ΔS) is:

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

B. -$\frac{3}{2}$ R In 2

C. 5R In2

D. $\frac{5}{2}$R In2

Answer: C

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3. In previous problem calculate ΔS_{gas} if process is carried out at constant volume:

A. $5RIn2$

B. $\frac{3}{2}RIn2$

C. $3RIn2$

D. - $3RIn2$

Answer: C

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4. When one mole of an ideal gas is compressed to half of its initial volume and simultaneously heated to twice its initial temperature , the change in entropy of gas (ΔS) is :

A. $C_{p.m}In2$

B. $C_{v.m}In2$

C. $RIn2$

D. $\left(C_{v.m} - R\right)In2$

Answer: D

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5. The entropy change when two moles of ideal monatomic gas is heated from $200to300\ ^{\circ}C$ reversibly and isochorically ?

A. $\frac{3}{2}RIn\left(\frac{300}{200}\right)$

B. $\frac{5}{2}RIn\left(\frac{573}{273}\right)$

C. $3RIn\left(\frac{573}{473}\right)$

D. $\frac{3}{2}RIn\left(\frac{573}{473}\right)$

Answer: C

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6. If one mole of an ideal gas $\left(C_{p.m}=\frac{5}{2}R\right)$ is expanded isothermally at $300K$ until it's volume is tripled , then change in entropy of gas is:

A. zero

B. infinity

C. $\frac{5}{2}RIn3$

D. $RIn3$

Answer: D

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7. Two mole of an ideal gas is expanded irreversibly and isothermally at 300K until it's volume is doubled and $3.41KJ$ heat is absorbed from surrounding ΔS_{surr} (system + surrounding) is:

A. $-0.57J/K$

B. $0.52J/K$

C. $22.52J/K$

D. 0

Answer: B

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8. 1 mole of an ideal gas at 25° C is subjected to expand reversibly and adiabatically to ten times of its initial volume. Calculate the change in entropy during expansion (in $JK^{-1}mol^{-1}$)

A. 19.15

B. -19.15

C. 4.7

D. zero

Answer: D

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9. What is the change in entropy when 2.5 mole of water is heated from 27° to $87^\circ C$? Assume that the heat capacity is constant . $\left(C_{p.m}\left(H_2O\right) = 4.2J/g - k In(1.2) = 0.18\right)$

A. 16.6 J/K

B. 9 J/K

C. 34.02 J/K

D. 1.89 J/k

Answer: C

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10. Calculate the total entropy change for the transition at 368K of 1mol of sulphur from the monoclinic to the rhombic solid state, if $\Delta H = -401.7J, mol^{-1}$ "for the transition". Assume the surroundings tio be an ice-water bath at $0^\circ C$:

A. $-1.09JK^{-1}$

B. $1.477Jk^{-1}$

C. $0.38JK^{-1}$

D. None of these

Answer: C

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11. Given $\Delta_r S^\circ = -266$ and the listed [S_m° value]

calculate S° for $Fe_3O_4(s)$:

$$4Fe_3O_4[\ldots\ldots\ldots\ldots\ldots] + O_2[205] \rightarrow 6Fe_2O_3(s)[87]$$

A. $+111.1$

B. $+122.4$

C. 145.75

D. 248.25

Answer: C

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12. $C_2H_6(g) + 3.5O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

$\Delta S_{\text{vap}}\left(H_2O, l\right) = x_1 calK^{-1}$ (boiling point $= T_1$)

$\Delta H_f\left(H_2O, l\right) = x_2$

$\Delta H_f\left(CO_2\right) = x_3$

$\Delta H_f\left(C_2H_6\right) = x_4$

Hence , ΔH for the reaction is-

A. $2x_3 + 3x_2 - x_4$

B. $2x_3 + 3x_2 - x_4 + 3x_1T_1$

C. $2x_3 + 3x_2 - x_4 - 3x_1T_1$

D. $x_1T_1 + X_2 + X_3 - x_4$

Answer: B

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exercise-3 Part-3 :(Only one option correct type) section C

1. which of the following is incorrect regarding gibbs free energy

A. it is a state function

B. it is extensive property

C. it is maenoscopic property

D. it is intensive property

Answer: D

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2. Which of the following conditions regarding a chemical process ensures its spontaneity at all temperature

A. $\Delta H > 0, \Delta S < O$

B. $\Delta H < 0, \Delta S > O$

C. $\Delta H < 0, \Delta S < O$

D. $\Delta H > 0, \Delta S < O$

Answer: B

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3. When reaction is at standard state at equilibrium , then:

A. $\Delta H^{\circ} = 0$

B. $\Delta S^{\circ} = 0$

C. equilibrium constant $K = 0$

D. equilibrium constant $K = 1$

Answer: D

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4. Which of the natural process is spontaneous

A. Formation of curd from milk after doing initation

B. Conversion of C (graphite) $\rightarrow$ C(Diamond) at25 $^\circ C$ and latex.

C. Formation of $H_2(g)$ and $O_2(\text{g})\text{o}mH_2O(l)$

D. Formation of CrO_5 from H_2O_2 and $K_2Cr_2O_7$ in basic medium

Answer: A

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5. What is the free energy change (ΔG) When 1.0 mole of water at $100\,^\circ C$ and 1 atm pressure is converted into steam at $100\,^\circ C$ and 1 atm pressure?

A. $80cal$

B. $540cal$

C. $620cal$

D. zero

Answer: D

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6. 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 negative but numerically larger than $X/298$

B. can be negative bu numerically smaller than $X/298$

C. cannot be negative

D. cannot be positive

Answer: B

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7. A reaction has $\Delta H = - 33KJ$ and $\Delta SJ/k$. This reaction would be:

A. spontaneous at all temperatures

B. non- spontaneous at all temperatures

C. spontaneous above a certain temperature

D. Spontaneous below a certain temperature

Answer: D

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8. For a reaction $A(g) \Leftrightarrow B(g)$ at equilibrium . The partial pressure of B is found to be one fourth of the partial pressure of A . The value of ΔG° of the reaction $A \to B$ is

A. RT ln 4

B. $- \mathrm{RTln4}$

C. $\mathrm{RTlog4}$

D. $- RT\log 4$

Answer: A

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9. Consider the ΔG_f° (kJ/mol) for the following oxides. Which oxide can be most easily decomposed to form the metal and oxygen gas?

A. $ZnO\left(\Delta G^\circ = -318.4, \Delta H^\circ = -348.3\right)$

B. $Cu_2O\left(\Delta G^\circ = -146.0, \Delta H^\circ = -168.8\right)$

C. $HgO\left(\Delta G^\circ = -58.5, \Delta H^\circ = -90.8\right)$

D. $PbO\left(\Delta G^\circ = -187.9, \Delta H^\circ = -217.3\right)$

Answer: C

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10. If $\Delta G = -177$K cal for $(1) 2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$

and $\Delta G = -19$ K cal for $(2) 4Fe_2O_3(s) + Fe(s) \rightarrow 3Fe_3O_4(s)$

What is the Gibbs free energy of formation fo $Fe_3O_4(s)$?

A. $+229.6$ Kcal/mol

B. -242.3 Kcal/mol

C. -727 Kcal/mol

D. -229.6 Kcal/mol

Answer: B

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11. For a particular reaction $\Delta H^\circ = -76.6KJ$ and $\Delta S^\circ JK^{-1}$. This reaction is :

A. spontaneous at the temperatures

B. non- spontaneous at all temperatures

C. Spontaneous at temperature below $66\,^{\circ}C$

D. Spontaneous at temperature above $66\,^{\circ}C$

Answer: C

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exercise-3 Part:(III) : Match the column

1.

column-1	Column-2
$(A)\left(\Delta G_{\text{system}}\right)_{T.P}=0$	(p)Process is in equilibrium
$(B)\Delta S_{\text{system}}+\Delta S_{\text{surrounding}}>0$	(q)Process is nonspontaneous
$(C)\Delta S_{\text{system}}+\Delta S_{\text{surroumding}}<0$	(r)Process is spontaneous
$(D)\left(\Delta G_{\text{system}}\right)_{T.P}>0$	(s)System is unable to do useful work

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2.

	Column-I		Column-II
(a)	Reversible adiabatic compression	(p)	Process in equilibrium
(b)	Reversible vaporisation of liquid	(q)	$\Delta S_{system} < 0$
(c)	$2N(g) \rightarrow N_2(g)$	(r)	$\Delta S_{\text{surrounding}} < 0$
(d)	$MgCO_3(s) \xrightarrow{\Delta} Mg(s) + CO_2(g)$	(s)	$\Delta S_{\text{sublimation}} = 0$

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3. Match column -I to column-II standard entropy in J/K-molar at 298 K

column-1	Column-2
(A)C(s, diamond)	$(p)5.7$
(B)C(s, graphite)	$(q)2.37$
$(C)H_2(g)$	$(r)117.6$
$(D)H(g)$	$(s)130.6$

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exercise-2 Part:(I) :Only one option correct

1. If a refrigerator's door is opened , then we get

A. Room heated

B. Room Cooled

C. More amount of heat is passed out

D. No effect on room

Answer: A

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2. Which of the following statement (s) is correct?

Statement-I: The entropy of isolated system with P-V work only, is always maximized at equillibrium.

Statement-2: It is possible for the entropy of closed system to decrease substantialy in an irreversible process.

Statemet-3: Entropy can be crearted but not destroyed.

Statement-4 ΔS_{system} is zero for reversible process in an isolated system.

A. Statement (I, ii, iii)

B. Statement ii, iv

C. Statement I, ii, iv

D. All of these

Answer: D

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3. During winters , moisture condenses in the form of dew and can be seen on plant leaves and grass, The entropy of the system in such cases decreases as liquids process lesser disorder as compared to gases. With reference to the second law, which statement is correct , for the above process?

A. The randomeness of the universe decreases

B. The randomness of the surrounding decreases

C. Increase is randomness of surrounding equals to the decrease in randomness of system

D. The increase in randomness of the surroundings in greater as compared to the decrease in randomness of the system.

Answer: D

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4. Which of the following option the first compound has less entropy than second:

A. (i) aqueous solution of $1\text{M of} MgCI_2 (ii)$ aqueous solution of $1\text{M of} NaCI$

B. $(1) Br_2$ liquid at $25^\circ (ii) Br_2$ liquid at $20^\circ C$

C. $(i) HgO$ solid $(ii) HgS$ solid

D. $(i) Br_2$ liquid $(ii) I_2$ solid

Answer: C

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5. Select the correct statenent (s) :

$S_1 : AICI_3$ when dissolve in H_2O its entropy increases althrough it is a spontaneous process .

S_2: When H_2 gas adsrobed at the surface of Pd , some amount of heat is released.

S_3: Entropy of D_2 gas is greater than H_2 gas.

A. $S_1, S_2 \& S_3$

B. $S_1 \& S_3$

C. $S_2 \& S_3$

D. $S_1 \& S_2$

Answer: C

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6. When $CH_3OH(l)$ is mixed in water:

A. degree of Randomness (entropy) decreases due to formation of Hydrogen bond.

B. Entropy of surrounding decreases

C. Mixing is spontaneous and reversible process

D. All of the above are correct

Answer: B

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7. Although graphite is thermodynamically most stable allotrope of Carbon but it has more entropy than diamond Because:

A. It has layer structure which slides on each other .

B. In diamond Carbon is bonded with covalent bond.

C. In graphite covalent bond only present within sheet and weak vanderwaal froce present between sheets which allow sliding easily.

D. Two types of bond lengths are present in graphite.

Answer: C

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8. Isoentropic process is

A. adiabatic and irreversible process

B. isothermal and reversible process

C. Adiabatic and reversible process

D. isothermal and reversible for which $Q = 0$

Answer: C

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9. According to third law of thermodynamics

A. The entropy of a substance at OK is zero

B. Entropy of hydrogen ion is zero at OK.

C. Net change in entropy in converssion $H_{2(g)}(130K) \rightarrow H_{2(g)}(200K)$ is zero.

D. Entropy generally decreases in combustion reactions.

Answer: B

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10. One mole of an ideal diatomic gas $\left(C_v = 5cal\right)$ was transformed from initial 25° and $1L$ to the state when temperature is 100° C and volume 10 L. The entropy change of the process can be expressed as $(R = 2$ calories /mol/K)

A. $3\text{In}\frac{298}{373} + 2\text{In}10$

B. $5\text{In}\frac{373}{298} + 2\text{In}10$

C. $7\text{In}\frac{373}{298} + 2\text{In}\frac{1}{10}$

D. $5\text{In}\frac{373}{298}+2\text{In}\frac{1}{10}$

Answer: B

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11. By how much does the entropy of 3 mole of an ideal gas change in going from a pressure of 2 bar to a pressure of 1 bar without any change in Temperature . If the surrounding is at 1 bar and 300 K (Expansion is again of the cosntant extenal pressure of surrounding).

A. $+7.29J\text{-}K^{-1}$

B. $+4.82J\text{-}K^{-1}$

C. $-5.29J\text{-}K^{-1}$

D. $-8.35J\text{-}K^{-1}$

Answer: B

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12. For a perfectly crystalline solid $C_{p.m.} = aT^3 + bT$,where a and b constant . If $C_{p.m.} is 0.40 J/Kmol$ at 10K and $0.92 J/\text{Kmol} at 20K$ then molar entropy at 20k is:

A. $0.92 J/Kmol$

B. 8.66J/k mol

C. $0.813 J/Kmol$

D. None of these

Answer: D

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13. The hydrolysis of Adienosine triphisphate [ATP] to give adienosine diphosphate [ADP] is represented by ATP hArr ADP. This reaction is expthermic zero[K] . The entropy change for the reaction is 982 J/K at 310 K . The free energy for the reaction is:

A. 31.01 KJ

B. 9.188KJ

C. -9.188 KJ

D. 31.012KJ

Answer: D

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14. Select correct statements:

S_1 : For every chemical reaction at equilibrium , standard gibbs energy of reaction is zero

S_2 : At constant temperature and pressure , chemical reactions are spontaneous in the direction of decreasing gibbs energy.

S_3: Spontancity is related to change in entropy if universe.

A. S_1, S_2, S_3

B. only S_1

C. S_2, S_3

D. $S_1 \& S_3$

Answer: C

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15. Combustion of sucrose is used by aerobic organisms for providing energy for the life sustaining process. If all the capturing of energy from the reaction is done through electrical process (non P-V work), then calculate, maximum available energy which can be captured by combustion of 34.2 g of sucrose :

(Given : $\Delta H_{\text{combustion}}(\text{sucrose}) = -6000 kJmol^{-1}$

$\Delta S_{\text{combustion}} = 180 j / K - mol$ and bodyntemperature is 300 K)

A. 600 KJ

B. 5.94.6KJ

C. 5.4 KJ

D. 605.4 KJ

Answer: D

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16. Given the following data:

Substance	ΔH° (KJ//mol)	S° (J//mol K)	ΔG° (KJ//mol)
$FeO(s)$	-266.3	57.49	-245.12
C(Graphite)	0	5.74	0
$Fe(s)$	0	27.28	0
$CO(g)$	-110.5	197.6	-137.15

Determine at what temperature the following reaction is spontaneous?

$$FeO(S) + C(\text{Graphite}) \rightarrow Fe(s) + CO(g)$$

A. 298 k

B. 668 K

C. 964 K

D. ΔG° is $+$ ve, hence the reaction will never be spontaneous

Answer: C

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17. For the hypothetical reaction $A_2(g) + B_2(g) \Leftrightarrow 2AB(g)$

If $\Delta_r G^\circ$ and $\Delta_r S^\circ$ are $20 JK^{-1} mol^{-1}$ respectively at 200 K.

$\Delta_r C_p$ is $20 JK^{-1} mol^{-1}$ then $\Delta_r H^\circ$ $\text{at}400K$ is :

A. 20 KJ/mol

B. 7.98 KJ/mol

C. 28 KJ/mol

D. None of these

Answer: A

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18. $NH_4CI(s) + aq \rightarrow NH_4^+(aq) + CI^{-1}(aq)$

$\Delta H = +15.1 KJmol^{-1} NH_4CI(s)$ dissolves in water according to above equation

A. Dissolution of $NH_4CI(s)$ in water in a spontaneous reverssible process

B. Gibbs free energy and entropy both are negative.

C. Above process is reverssible in which driving force for dissolution is increasing in entropy

D. ΔG, ΔH and ΔS all are positive.

Answer: C

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exercise-2 Part:(II): Single and Double value integer type

1. The equilibrium constant for a reaction is 10. What will be the value of ΔG^{Θ}? $R = 8.314 JK^{-1} mol^{-1}, T = 300K$.

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2. Two moles of an ideal gas is expanded isothermally and irreversibly at $27^{\circ}C$ from volume V_1 $\text{to}2.5V_1\text{and}4.17KJ$ heat is absorbed from surroundings. Determine ΔS_{sys}?

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3. For the reaction at 298K

$A(g) + B(g) \Leftrightarrow C(g) + D(g)$

If $\Delta H^{\circ} = -29.8$ Kcal and $\Delta S^{\circ} KcalK^{-1}$ then calculate reaction constant (k)

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4. One mole of an ideal gas is expanded isothermally at 300 K until its volume is tripled . Find the values of ΔS_{sys} under the condition.

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5. Calculate the magnitude of free energy in $KJmol^{-1}$ when 1 mole of a an ionic salt MX (s) is dissolved in water at $27^{\circ}C$. Given

Lattice energy of MX $= 780KJmol^{-1}$

Hydration energy of MX $= -775.0KJmol^{-1}$

Entropy change of dissolution at $27^{\circ}C = 40Jmol^{-1}K^{-1}$

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6. For the formation of $C(g)$at300 K.

$A(g) + 3B(g) \rightarrow 2C(g)$

Calculate the magnitude of ΔG° (Kcal) if given data:

$$\begin{array}{lccc} & A & B & C \\ \Delta H_f^{\circ}\left(\text{Kcal mol}^{-1}\right) & 0 & 0 & -10 \\ \Delta S_f^{\circ}\left(\text{Cal K}^{-1}\text{mol}^{-1}\right) & 40 & 30 & 45 \end{array}$$

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7. The entropies of $H_2(g)$ and $H(g)$ are 60 and $50J\text{mole}^{-1}K^{-1}$ respectively at 300 K. Using the data given below calcualate the bond enthalpy of $H_2(g)$ in Kcal mole^{-1}.

$H_2(g) \rightarrow 2H(g), \quad \Delta G^{\circ} = 21.6KJ\text{mole}^{-1}$

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8. The standard free energy change for a reaction is $-213.3KJmol^{-1}\text{at}25^{\circ}C.$ If the enthalpy change of the reaction is $-217.77KJ\text{mole}^{-1}$. Calculate the magnitude of entropy change for the reaction in Joule mole^{-1}

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9. The vapour pressure of liquid Hg at 433 K is5 mm Hg . Calculate the free energy change accompanying the expansion of one mole of Hg vapour in equilibrium with liquid at 433 K to a pressure of 750 mm Hg at the same temperature assuming the vapour bahaves like an ideal monoatomic gas in KJ mole^{-1}. (Approximate integer and $e^5 = 150$)

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10. Calculate the magnitude of standard entropy change for reaction $X \Leftrightarrow Y$ if $\Delta H^\circ = 25KJ$ and $K_{\text{eq}}\text{is}10^{-7}$ at 300 K.

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11. Two mole of an ideal gas originally at a volume of 8 L at 1000 K, is allowed to expand adiabatically until final volume is 24 L. For the gas $C_v = 1.5R$. Calculate values of ΔS for the process when:

(i) The expansion takes place reversibly.

(ii) The change in volume involves a free expansion.

Sum of ΔS of these two case is ________.

(Used :$e^{1.09} = 3$ and $1.09 \times 8.314 = 9$)

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12. Calculate the magnitude of standard free energy of formation of ammonium chloride at $25\,^{\circ}C$ (approximate integer in Kcalmol^{-1}), the equation showing the formation of NH_4CI from its elements is

$$\frac{1}{2}NH_4(g) + 2H_2(g) + \frac{1}{2}CI_2(g) \rightarrow NH_4CI(s)$$

For $NH_4CI, \Delta H_f^{\circ}$ is $-313KJmol^{01}$, Also given that

$$S^{\circ}_{N_2} = 191.5JK^{-1}mol^{-1} \quad S^{\circ}_{N_2} = 130.6JK^{-1}mol^{-1}$$

$$S^{\circ}_{CI_2} = 223.0JK^{-1}mol^{-1} \quad S^{\circ}_{NH_4CI} = 94.6JK^{-1}mol^{-1}$$

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13. For the reaction $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g), \Delta H = -30$ KJ to be at equilibrium at 477 ° C. If standard entropy of $N_2(g)$ and $NH_3(g)$ are 60 and $50\text{Jmole}^{-1}K^{-1}$ respectively then calculate the standard entropy of $H_2(g)$ in $\text{J mole}^{-1}K^{-1}$.

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exercise-2 Part:(III): One or more than one options correct

1. In which of the following entropy increases?

A. Rusting of iron

B. Melting of ice

C. Crystallisation of sugar form solution

D. Vapourisation of camphor

Answer: A::B::D

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2. When a liquid , generally , there is :

A. Decreases in enthalpy

B. Decrease in entropy

C. Increase in enthalpy

D. Increase in entropy

Answer: A::B::D

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3. Which of the following is false about molar entropy?

A. it is same for all type of gases

B. For the gas of comparable mass. It decreases with the increases in atomicity

C. Under identical condition, it is greater for heavier gas.

D. For ideal gas of comparable molar mass it decreases with the increase in thermo molecular attractions.

Answer: A::B::D

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4. Which of the following option show more entropy of first compound than second:

A. (i) 1-hexene at 273 K and 1 atm (ii) Cyclohexane at 273 K and 1 atm

B. $(i)\,^{12}CH_4$ at NTP (ii) $^{14}CH_4$ at NTP

C. $(1)SO_2(g)\text{at}300$ K and 0.1 atm $(ii)SO_2(g)\text{at}300\,^{\circ}$ C and 0.1 atm

D. $(i)C_2H_5OH(l)\text{at}46\,^{\circ}C$ and 1 atm $(ii)CH_3OH(l)\text{at}46\,^{\circ}$ C and 1 atm

Answer: A::B::D

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5. Choose the correct statement(s):

A. Temperature , enthalpy and entropy are state functions

B. For reversible and irreversible both isothermal expansion of an ideal gas, change in internal energy and enthalpy is zero

C. for a reaction in which $\Delta n_2 = 0$, entropy change is not always zero

D. The entropy change associated with reversible isothermal expansion of an ideal gas is equal to 2.303 R $\log_{10}\frac{P_1}{P_2}$

Answer: A::B::C::D

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6. One mole of an ideal diatomic gas $\left(C_v = 5cal\right)$ was transformed from initial $25\,^\circ$ and $1L$ to the state when temperature is $100\,^\circ$ C and volume 10 L. Then for this process(R=$2\text{calories}/\text{mol}/K$)(take calories as unit of energy and kelvin for temp)

A. $\Delta H = 525$

B. $\Delta S = 5\text{In}\frac{373}{298} + 2\text{In}10$

C. $\Delta E = 525$

D. ΔG of the process can not be calculate using given information.

Answer: A::B::D

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7. Which of the following statement is/are correct

A. Reversible adiabetic process is iso entropie process

B. ΔS_{system} for irreversible adiabelic compression is greater than zero

C. ΔS_{system} for free expension in zero

D. $\Delta S_{\text{surrounding}}$for irreversible isothermal compression is greater than zero

Answer: A::B::D

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8. In previous problem if expansion is carried out freely $\left(P_{\text{ext}} = 0\right)$, then:

A. $W = 0$

B. $W = \text{RT In3}$

C. $\Delta S = \text{R In3}$

D. $Q = \text{Rt In3}$

Answer: A::C

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9. The normal boiling point of a liquid X is 400 K. Which of the following statement is true about the process $X(l) \rightarrow X(g)$?

A. at 400 K and 1 atm pressure $\Delta G = 0$

B. at 400 K and 2 atm pressure $\Delta G = +ve$

C. at 400 K and 0.1 atm pressure $\Delta G = -ve$

D. at 410 K and 1 atm pressure $\Delta G = +ve$

Answer: A::B::C

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10. For isothemal expansion in case of an ideal gas:

A. $\Delta H = 0$

B. $\Delta E = 0$

C. $\Delta G = -T\Delta S$

D. $T_{\text{final}} = T_{\text{initial}}$

Answer: A::B::C::D

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exercise-2 Part:(IV): comprehension

1. Entropy is a state function and its value depends on two or three variable temperature (T), Pressure(P) and volume (V). Entropy change for an ideal gas having number of moles(n) can be determined by the following equation.

$$\Delta S = 2.303nC_v \log\left(\frac{T_2}{T_1}\right) + 2.303nR \log\left(\frac{V_2}{V_1}\right)$$

$$\Delta S = 2.303nC_P \log\left(\frac{T_2}{T_1}\right) + 2.303nR \log\left(\frac{P_1}{P_2}\right)$$

Since free energy change for a process or a chemical equation is a deciding factor of spontaneity , which can be obtained by using entropy change (ΔS) according to the expression, $\Delta G = \Delta H - T\Delta S$ at a temperature T

What would be the entropy change involved in thermodynamic expansion of 2 moles of a gas from a volume of 5 L to a volume of 50 L at 25 ° C [Given $R = 8.3 J/\text{mole - }K$]

A. 38.23 J/K mol

B. 26.76 J/K

C. 20 J/k

D. 28.23 J/K

Answer: A

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2. Entropy is a state function and its value depends on two or three variable temperature (T), Pressure(P) and volume (V). Entropy change for an ideal gas having number of moles(n) can be determined by the following equation.

$$\Delta S = 2.303\text{n}C_v\log\left(\frac{T_2}{T_1}\right) + 2.303\text{nR}\log\left(\frac{V_2}{V_1}\right)$$

$$\Delta S = 2.303\text{n}C_P\log\left(\frac{T_2}{T_1}\right) + 2.303\text{nR}\log\left(\frac{P_1}{P_2}\right)$$

Since free energy change for a process or a chemical equation is a deciding factor of spontaneity , which can be obtained by using entropy change (ΔS) according to the expression, $\Delta G = \Delta H - T\Delta S$ at a temperature T

An isobaric process having one mole of ideal gas has entropy change 23.03 J/K for the temperature range $27\,^\circ$ C to $327\,^\circ$ C . What would be the molar specific heat capacity $\left(C_v\right)$?

A. $\frac{10}{\log 2} J/Kmol$

B. $\frac{10}{\log 2} - 8.3 J/K$ mol

C. $10 \times \log 2 J / K mol$

D. $10 \log 2 + 8.3 J / k$ mol

Answer: B

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3. Entropy is a state function and its value depends on two or three variable temperature (T), Pressure(P) and volume (V). Entropy change for an ideal gas having number of moles(n) can be determined by the following equation.

$$\Delta S = 2.303\mathrm{nC}_v \log\left(\frac{T_2}{T_1}\right) + 2.303\mathrm{nR}\log\left(\frac{V_2}{V_1}\right)$$

$$\Delta S = 2.303\mathrm{nC}_P \log\left(\frac{T_2}{T_1}\right) + 2.303\mathrm{nR}\log\left(\frac{P_1}{P_2}\right)$$

Since free energy change for a process or a chemical equation is a deciding factor of spontaneity , which can be obtained by using entropy change (ΔS) according to the expression, $\Delta G = \Delta H - T\Delta S$ at a temperature T

For a reaction $M_2O(s) \rightarrow 2M(s) + \frac{1}{2}O_2(g), \Delta H = 30KJ/mol$ and $\Delta S = 0.07K\frac{J}{m}o \leq at1$ atm. Calculate upto which temperature the reaction would not be spontaneous.

A. $T > 428.6$ K

B. $T > 300.8$ K

C. $T < 300.8$ K

D. $T < 428.6$ K

Answer: D

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4. Dependence of Spontaneity on Temperature:

For a process to be spontaneous , at constant temperature and pressure , there must be decrease in free energy of the system in the direction of the process , i.e. $\Delta G_{P.T} < 0$. $\Delta G_{P.T} = 0$ implies the equilibrium condition and $\Delta G_{P.T} > 0$ corresponds to non- spontaneity.

Gibbs- Helmholtz equation relates the free energy change to the enthalpy and entropy changes of the process as : $\Delta G_{P.T} = \Delta H - T\Delta S$ ...(1)

The magnitude of ΔH does not change much with the change in temperature but the entropy factor $T\Delta S$ change appreciably . Thus, spontaneity of a process depends very much on temperature.

For endothermic process, both ΔH and ΔS are positive . The energy factor, the first factor of equation, opposes the spontaneity whereas entorpy factor favours it. At low temperature the favourable factor $T\Delta S$ will be small and may be less than $\Delta H, \Delta G$ will have positive value indicated the nonspontaneity of the process. On raising temperature , the factor $T\Delta S$ Increases appreciably and when it exceeds $\Delta H, \Delta G$ would become negative and the process would be spontaneous .

For an expthermic process, both ΔH and ΔS would be negative . In this case the first factor of eq.1 favours the spontaneity whereas the second factor opposes it. At high temperature , when $T\Delta S > \Delta H, \Delta G$ will have positive value, showing thereby the non-spontaneity fo the process . However , on decreasing temperature , the factor ,$T\Delta S$ decreases rapidly and when $T\Delta S < \Delta H, \Delta G$ becomes negative and the process occurs spontaneously. Thus , an exothermic process may be spontaneous at low temperature and non-spontaneous at high temperature.

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 it, is

A. The enthalpy of reaction (ΔH) overweighs the term $T\Delta S$ at high temperature.

B. The term $T\Delta S$ overweighs the enthalpy of reaction at high temperature.

C. At high temperature , both enthalpy of reaction and entropy change become negative.

D. None of these

Answer: B

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5. Dependence of Spontaneity on Temperature:

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For the reaction at $25\,^{\circ}$, $X_2O_4(l) \rightarrow 2XO_2(g)$

$\Delta H = 2.1Kcal$ and $\Delta S = 20calK^{-1}$. The reaction would be

A. Spontaneous

B. non-spontaneous

C. at equilibrium

D. Unpredictable

Answer: A

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6. Dependence of Spontaneity on Temperature:

For a process to be spontaneous , at constant temperature and pressure , there must be decrease in free energy of the system in the direction of the process , i.e. $\Delta G_{P.T} < 0$. $\Delta G_{P.T} = 0$ implies the equilibrium condition and $\Delta G_{P.T} > 0$ corresponds to non- spontaneity.

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For the reaction at $298K, 2A + B \rightarrow C$

$\Delta H = 100kcal$ and $\Delta S = 0.050kcalK^{-1}$. If ΔH and ΔS are assumed to be constant over the temperature range, above what temperature will the reaction become spontaneous?

A. 1000 K

B. 1500 K

C. 2000 K

D. 2500 K

Answer: C

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7. Dependence of Spontaneity on Temperature:

For a process to be spontaneous , at constant temperature and pressure ,

there must be decrease in free energy of the system in the direction of the process , i.e. $\Delta G_{P.T} < 0$. $\Delta G_{P.T} = 0$ implies the equilibrium condition and $\Delta G_{P.T} > 0$ corresponds to non- spontaneity.

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A reaction has a value of $\Delta H = -40 Kcal$ at 400 k cal mol^{-1}. The reaction is spontaneous, below this temperature , it is not . The values fo ΔG and ΔS at 400 k are respectively

A. $0, -0.1 calK^{-1}$

B. $0, 100 calK^{-1}$

C. -10 Kcal, $-100\text{cal}K^{-1}$

D. $0, -100 calK^{-1}$

Answer: D

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8. Dependence of Spontaneity on Temperature:

For a process to be spontaneous , at constant temperature and pressure ,

there must be decrease in free energy of the system in the direction of the process , i.e. $\Delta G_{P.T} < 0$. $\Delta G_{P.T} = 0$ implies the equilibrium condition and $\Delta G_{P.T} > 0$ corresponds to non- spontaneity.

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The enthalpy change for a certain rection at 300 K is -15.0 K cal mol^{-1} . The entropy change under these conditions is -7.2 cal $K^{-1}mol^{-1}$. The free energy change for the reaction and its spontaneous/ non-spontaneous character will be

A. -12.84 Kcalmol^{-1}, spontaneous

B. -12.84 Kcalmol^{-1},non-spontaneous

C. -17.16 Kcalmol^{-1}, spontaneous

D. None of these

Answer: A

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exercise-3 Part:(I)

1. $\Delta H = 30 kJmol^{-1}, \Delta S = 75 J / K / mol$. find boiling temperature at $1 atm$:

A. 400K

B. 300K

C. 150 K

D. 425 K

Answer: A

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2. Spontaneous adsorption of a gas on a solid surface is exothermic process because

A. enthalpy of the system increase.

B. enthropy increases.

C. entropy decreases

D. free energy change increase.

Answer: C

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3. For the reaction: $N_2O_4(g) \Leftrightarrow 2NO_2(g)$

(i) In a mixture of $5molNO_2$ and 5 mol N_2O_4 and pressure of 20 bar. Calculate the value of ΔG for the reaction. Given $\Delta G_f^{\circ}\left(NO_2\right) = 50$ KJ/mol, $\Delta G_f^{\circ}\left(\left(N_2O_4\right) = 100\right.$ KJ/mol and T=298 K. (ii) Predict the direction in which the reaction will shift, in order to attain equilibrium

[Given at $T = 298K, 2.303\text{RT} = 5.7$KJ/mol.]

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4. The direct conversion of A to B is difficult, hence is carried out by the following shown path:

$\Delta(A \rightarrow C) = 50, \Delta S(C \rightarrow D) = 30, \Delta S(B \rightarrow D) = 20$ The entropy change for the process $A \rightarrow B$ is :

A. 100

B. -60

C. -100

D. 60

Answer: D

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5. $N_2 + 3H_2 \Leftrightarrow 2NH_3 \quad K = 4 \times 10^6 \text{at} 298$

$K = 41 \text{at} 400k$

Which statements is correct?

A. If N_2 is added at equlibrium condition, the equilibrium will shift to the forward direction because according to II^{nd} law of thermodynamics the entropy must increases in the direction of spontaneous reaction .

B. The condition for equlibrium is $2\Delta G_{NH_3} = 3\Delta G_{N_2} + \Delta G_{N_2}$ where G is Gibbs free energy per mole of the gaseous species measured at that partial pressure.

C. Addition of catalyst does not change K_p but changes ΔH.

D. At 400 K addition of catalyst will increase forward reaction by 2 times while reverse reaction rate will be changed by 1.7 times.

Answer: B

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6. The value of $\log_{10}K$ for a reaction $A \Leftrightarrow B$ is (Given:
$\Delta_f H^{\Theta}_{298K} = -54.07 kJmol^{-1}$,
$\Delta_r S^{\Theta}_{298K} = 10JK^{=1}mol^{-1}$, and $R = 8.314JK^{-1}mol^{-1}$

A. 5

B. 10

C. 95

D. 100

Answer: B

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7. 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. $\Delta G = -ve, \Delta S = +ve$

Answer: A

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8. Statement -1: For every chmical reaction at equilibrium , standard Gidds energy of reaction is zero

Statement-2: At constant temperature and pressure , chemical reactions are spontaneious in the direction of decreasing gibbs energy.

A. Statement-1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1

B. Statement-1 is True, Statement-2 is True, Statement-2 is not a correct explanation for Statement-1

C. Statement-1 is True, Statement-2 is false

D. Statement-1 is False, Statement-2 is True

Answer: D

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9. Statement-1: There is a natural asymmetry between work to heat and converting heat to work .

Statement-2: No process is possible in which the sole result is the absorption of heat from a reservoir and its complaete conversion into work .

A. Statement-1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-2

B. Statement-1 is True, Statement-2 is True, Statement-2 is not a correct explanation for Statement-2

C. Statement-1 is True, Statement-2 is false

D. Statement-1 is False, Statement-2 is True

Answer: A

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10. Match the transformation in colums I with appropriate options in column II.

Column I	Column II
$(A) CO_2(s) \rightarrow CO_2(g)$	(p)phase transition
$(B) CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$	(q)allotropic change
$(C) 2H. \rightarrow H_2(g)$	$(r)\Delta H$is positive
$(D) P_{(\text{white, solid})} \rightarrow P_{(\text{red,solid})}$	$(s)\Delta S$is positive
	$(t)\Delta S$is negative

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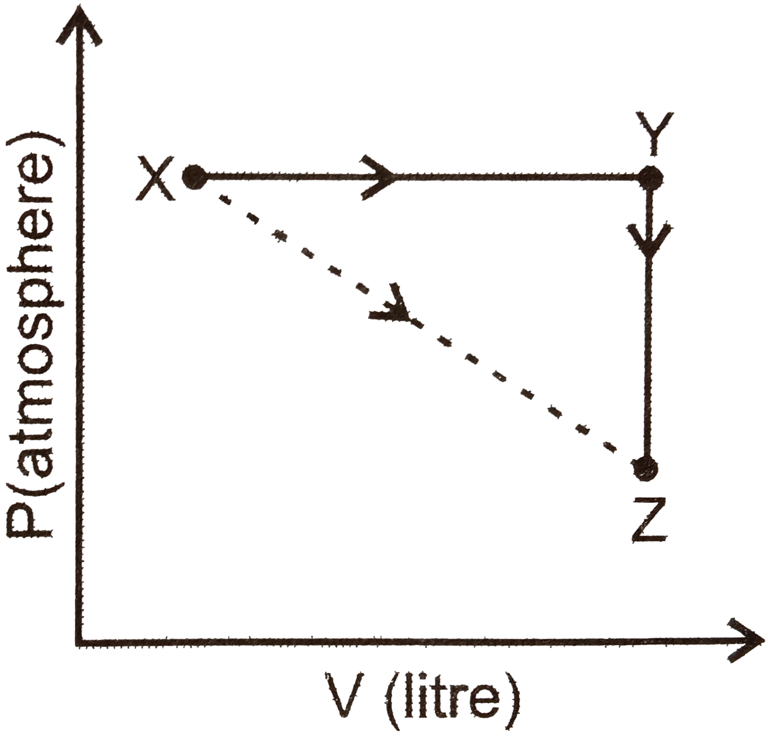
11. For an ideal gas, consider only P - V work in going from an initial state X to the final state Z. The final state Z can be reached by either of the two paths shown in the figure. Which of the following choice(s) is (are) correct? [Take ΔS as change in entropy and w as work done]



A. $\Delta S_{X \to Z} = \Delta S_{X \to Y} + \Delta S_{x \to z}$

B. $W_{x \to z} = W_{x \to y} + W_{y \to z}$

C. $W_{x \to y \to z} = W_{x \to y}$

D. $\Delta S_{x \to y \to z} = \Delta S_{x \to y}$

Answer: A::C

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12. For the process $H_2O(l) \rightarrow H_2O(g)$ at $t = 100\,^{\circ}C$ and 1 atmosphere pressure, the correct choice is:

A. $\Delta S_{\text{system}} > 0$ and $\Delta S_{\text{surrounding}} > 0$

B. $\Delta S_{\text{system}} > 0$ and $\Delta S_{\text{surrounding}} < 0$

C. $\Delta S_{\text{system}} < 0$ and $\Delta S_{\text{surrounding}} > 0$

D. $\Delta S_{\text{system}} < 0$ and $\Delta S_{\text{surrounding}} < 0$

Answer: B

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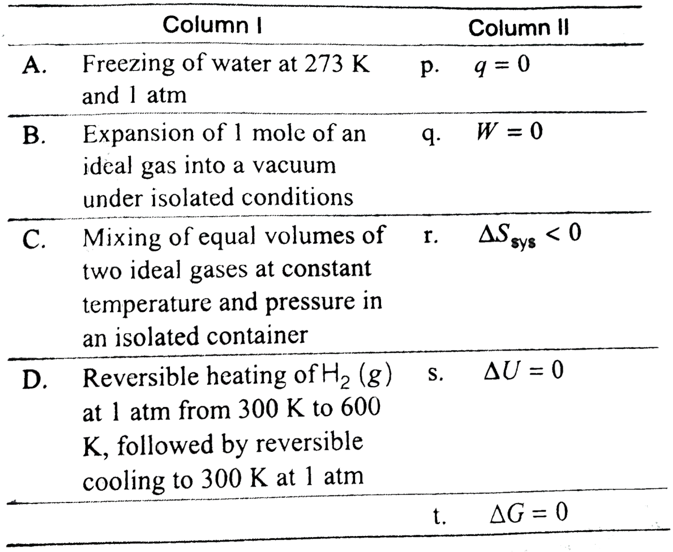
13. Match the thermodynamic processes given under column I with the expressions given under column II.



	Column I		Column II
A.	Freezing of water at 273 K and 1 atm	p.	$q = 0$
B.	Expansion of 1 mole of an ideal gas into a vacuum under isolated conditions	q.	$W = 0$
C.	Mixing of equal volumes of two ideal gases at constant temperature and pressure in an isolated container	r.	$\Delta S_{sys} < 0$
D.	Reversible heating of $H_2(g)$ at 1 atm from 300 K to 600 K, followed by reversible cooling to 300 K at 1 atm	s.	$\Delta U = 0$
		t.	$\Delta G = 0$

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14. For a spontaneous reaction the ΔG, Equilibrium cosntant (K) and E°_{cell} will be respectively :

A. $-\text{ve}, \ > 1, \ +\text{ve}$

B. $+\text{ve}, \ > 1, \ -\text{ve}$

C. $-\text{ve}, \ < 1, \ -\text{ve}$

D. $-\text{ve}, \ > 1, \ -\text{ve}$

Answer: A

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15. Identify the correct statement regarding a spontaneous process:

A. Exothermic processes are always spontaneous .

B. Lowering of energy in the reaction process is the only criterion for spontaneity.

C. For a spontaneous process in an isolated system , the change in entropy is positive.

D. Endothermic processes are never spontaneous.

Answer: C

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16. In conversion of lime-stone to lime,

$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$ the values of ΔH° and ΔS° are $+179.1 kJmol^{-1}$ and $160.2 J/K$ respectively at $298K$ and 1 bar. Assuming that ΔH° and ΔS° do not change with temperature, temperature above which conversion of lime-stone to lime will be spontaneous is :

A. 847 K

B. 1118 K

C. 1008

D. 1200 K

Answer: B

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17. Standard entropy of X_2 , Y_2 and XY_3 are $60, 40$ and $50 JK^{-1} mol^{-1}$, respectively. For the reaction, $\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightarrow XY_3, \Delta H = -30KJ$, to be at equilibrium, the temperature will be:

A. 500 K

B. 750 K

C. 1000 K

D. 1250 K

Answer: B

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18. In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is :

$$CH_3OH_{(l)} + \frac{3}{2}O_{2(g)} \rightarrow CO_2((g)) + 2H_2O_{(l)}$$

At $298K$ standard Gibb's energies of formation for $CH_3OH(l), H_2O(l)$ and $CO_2(g)$ are -166.2, -237.2 and $-394.4kJmol^{-1}$ respectively. If standard enthalpy of combustion of methanol is $-726kJmol^{-1}$, efficiency of the fuel cell will be :

A. 0.87

B. 0.9

C. 0.97

D. 0.8

Answer: C

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19. For a particular reversible reaciton at temperature T, ΔH and ΔS were found to be both $+ve$. If T_e is the temperature at equilibrium, the reaciton would be spontaneous when :

A. $T_e > T$

B. $T > T_e$

C. T_e is 5 times T

D. $T = T_e$

Answer: B

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20. The entropy change involved in the isothermal reversible expansion of 2 moles of an ideal gas from a volume of $10dm^3$ to a volume of $100dm^3$ at $27^\circ C$ is

A. $38.3Jmol^{-1}K^{-1}$

B. $35.8Jmol^{-1}K^{-1}$

C. $32.3Jmol^{-1}K^{-1}$

D. $42.3Jmol^{-1}K^{-1}$

Answer: A

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21. In view of the signs of $\Delta_r G^0$ for the following reactions

$PbO_2 + Pb \rightarrow 2PbO, \Delta_r G^0 < 0$

$SnO_2 + Sn \rightarrow 2SnO, \Delta_r G^0 > 0$

Which oxidation state are more characteristic for lead and tin?

A. For lead +2 , for tin +2

B. For lead +4 , for tin +4

C. For lead +2 lead +2 , for tin +4

D. For lead +4 , for tin +2

Answer: C

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22. The incorrect expression among the following is

A. $\frac{\Delta G_{\text{system}}}{\Delta S_{\text{total}}} = - T$

B. In isothermal process, $w_{\text{reversible}} = - nRT\text{In}\frac{V_f}{V_i}$

C. Ink $= \frac{\Delta H^{\circ} - T\Delta S^{\circ}}{RT}$

D. $K = e^{- \Delta G^{\circ} / RT}$

Answer: C

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23. The following reaction is performed at 298K

$2NO(g) + O_2(g) \Leftrightarrow 2NO_2(g)$

The standard free energy of formation of NO(g) is 86.6 KJ/mol at 298 K. What is the standard free energy formation of $NO_2(g)\text{at}298?$ $\left(K_p = 1.6 \times 10^{12}\right)$

A. R(298) in $\left(1.6 \times 10^{12}\right)$ -86600

B. 86600 + R(298) In $\left(1.6 \times 10^{12}\right)$

C. $86600 - \dfrac{\text{In}\left(1.6 \times 10^{12}\right)}{R(298)}$

D. $0.5\left[2 \times 86,600 - R(298)\text{In}\left(1.6 \times 10^{12}\right)\right]$

Answer: D

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exercise-3 part-1 Advanced level Solutions

1. Among them intensive property is

A. Mass

B. Volume

C. Surface tension

D. Enthalpy

Answer: C

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2. Which of the following is true for an adiabatic process:

A. $\Delta H = 0$

B. $\Delta W = 0$

C. $\Delta Q = 0$

D. $\Delta V = 0$

Answer: C

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3. Which of the following is not a state function

A. ΔS

B. ΔG

C. ΔH

D. ΔQ

Answer: D

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4. The relation between ΔU and ΔH:

A. $\Delta H = \Delta U - P\Delta V$

B. $\Delta H = \Delta U + P\Delta V$

C. $\Delta H = \Delta V + \Delta H$

D. $\Delta U = \Delta H + P\Delta V$

Answer: B

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5. The workdone in ergs for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to 20 litres at $25\,^{\circ}C$ is

A. $2.303 \times 298 \times 0.082 \log 2$

B. $298 \times 10^{7} \times 8.31 \times 2.303 \log 2$

C. $2.303 \times 298 \times 0.082 \log 0.5$

D. $8.31 \times 10^{7} \times 298 - 2.303 \log 0.5$

Answer: B

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6. A coffee cup calorimeter initially contains 125 g of water , at a temperature of $24.2\ ^\circ C$.8g of ammonium nitrate $\left(NH_4NO_3\right.$, also at $24.2\ ^\circ$, is added to the water, and the final temperature is $18.2\ ^\circ C$. What is the heat of solution fo ammonium nitreate in KJ/mol? The specfic heat capacity of the solution is 4.2 $J/\ ^\circ C$ g.

A. 33.51 KJ/mol

B. 39.5 KJ/mol

C. 32.2 KJ/mol

D. 37.3 KJ/mol

Answer: A

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7. The molar heat capacities at constant pressure (assumed constant with respect to temperature) of A,B and C are in ratio 3:1.5:2.0. the enthyalpy change for the exothermic reaction $A + 2B \rightarrow 3c$ at 300k and 310 K is ΔH_{300} and ΔH_{310} respectively then:

A. $\Delta H_{300} > \Delta H_{310}$

B. $\Delta H_{300} < \Delta H_{310}$

C. $\Delta H_{300} = \Delta H_{310}$

D. if $T_2 > T_1$ then $\Delta H_{310} > \Delta H_{300}$ and if $T_2 < T_1$ then $\Delta H_{310} < \Delta H_{300}$

Answer: C

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8. Heat of combustion of ethanol at constant pressure and at temperature T K(=298 K) is found to be -qJ mol^{-1}. Hence , heat of combustion (in J mol^{-1}) of ehtanol at the same temperature at constant volume will be:

A. RT-q

B. -$(q + RT)$

C. q-RT

D. q+RT

Answer: A

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9. When 1.0 g of oxalic acid $\left(H_2C_2O_4\right)$ is burnt in a bomb calorimeter whose capacity is 8.75 KJ/K, the enthalpy of combustion of oxalic acid at $27^\circ C$ is :

A. -$245.7KJ/mol$

B. -$244.452KJ/mol$

C. -$246.947KJ/mol$

D. None of these

Answer: C

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10. Benzene burns according to the following equations at 300K (R=8.314 J mole$^{-1}K^{-1}$)

$$2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l) \quad \Delta H^\circ = -6542KJ$$

What is the ΔE° for the combustion of 1.5 mol of benzene

A. $-3271KJ$

B. $-9812KJ$

C. -4906.5KJ

D. None of these

Answer: D

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11. Ethyl chloride $\left(C_2H_5Cl\right)$, is prepared by reaction of ethylene with hydrogen chloride:

$C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g) \quad \Delta H = -72.3 KJ/\text{mol}$

What is the value of $\Delta E(\text{in KJ})$, if 98 g fo ethylene and 109.5 g if HCl are allowed to react at 300K

A. -64.81

B. -190.71

C. -209.41

D. -229.38

Answer: C

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12. Which statement regarding entropy is correct?

A. A completely ordered deck of cards has more entropy than a shuffled deck in which cards are arranged ramdomly.

B. A perfect ordered crystal of solid nitrous oxide has more entropy than a disordered crystal in which the molecules are oriented randomly.

C. 1 mole N_2 gas at STP has more entropy than 1 mole N_2 gas at 273 K in a volume of 11.2 litre.

D. 1mole N_2 gas at STP has more entropy than 1 mole N_2 gas at 273 K and 0.25 atm

Answer: C

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13. One mole of solid Zn is placed in excess of dilute H_2SO_4 at $27^\circ C$ in a cylinder fitted with a piston . Find the work done for the process of the area of piston is $500 cm^2$ and it moves out by 50 cm against a pressure of

1 atm during the reaction.

$Zn(s) + 2H^{+}(aq) \Leftrightarrow Zn^{2+}(aq) + H_2(g)$

A. $-1.53KJ$

B. $-2.53KJ$

C. Zero

D. 2.53 KJ

Answer: B

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14. The enthy change for the reaction of 50 ml of ethylene with 50. 0 ml of H_2 at 1.5 atm pressure is $\Delta H = -0.31KJ$. What is the ΔU ?

A. -0.3024

B. 0.6048

C. $0.1.2$

D. None

Answer: A

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15. When1 mole of ice melt at 0° C and at constant pressure of 1 atm . 1440 calories of heat are absorbed by the system. The molar volumes of ice and water are 0.0196 and 0.0180 litres respectively. Calculate ΔH and ΔE for the reaction.

A. $\Delta H = 720$ Joule

B. $\Delta H = 1440$ cal

C. $\Delta H = 1.4$ Kcal

D. $\Delta H = 0$

Answer: B

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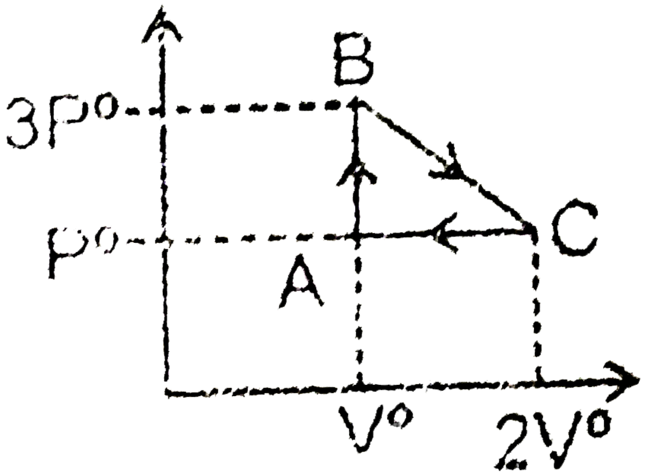
16. One mole of ideal monoatmic gas is carried throught the reversible cyclic process as shown in figure. Calculate net heat absorbed by the gas in the path BC



A. $\frac{1}{2}P^{\circ}V^{\circ}$

B. $\frac{7}{2}P^{\circ}V^{\circ}$

C. $2P^{\circ}V^{\circ}$

D. $\frac{5}{2}P^{\circ}V^{\circ}$

Answer: A

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17. 130 g of Zn is dissolved in dilute sulphuric acid in an open beaker . Find the work done in the process assuming isothermal operation.

A. -1200 cal

B. -1800 cal

C. $+1800$ cal

D. $+1200$ cal

Answer: A

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18. The enthalpy of combustion of propance $\left(C_3H_8\right)$ gas in temes of given of geven data is , Bond energy (kJ/mol)

$.^{\varepsilon}C - H + x_1.^{\varepsilon}O - O + x_2.^{\varepsilon}C - O + x_3.^{\varepsilon}O - H + x_4.^{\varepsilon}C - C + x_5$

[Resonance energy of CO_2 is -z KJ/mol and $\Delta H_{\text{vaporization}}\left[H_2O(l)\text{ is y }KJ/mol\right]$

A. $8X_1 + 2X_5 + 5X_2 - 6X_3 - 8X_4 - 4Y - 3Z$

B. $6X_1 + X_5 + 5X_2 - 3X_3 - 4X_4 - 4Y - 3Z$

C. $8X_1 + 2X_5 + 5X_2 - 6X_3 - 8X_4 - Y - Z$

D. $8X_1 + X_5 + 5X_2 - 6X_3 - 8X_4 - 4Y + 3Z$

Answer: A

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19. If x_1, x_2 and x_3 are enthalpies of H-H , O=O and O-H bonds respectively , and x_4 is the enthalpy of vaporisation of water , estimate the standard enthalpy of combustion of hydrogen:

A. $X_1 + \frac{X_2}{2} - 2X_3 + X_4$

B. $X_1 + \frac{X_2}{2} - 2X_3 - X_4$

C. $X_1 + \frac{X_2}{2} - X_3 + X_4$

D. $2X_3 - X_1 - \frac{X_2}{2} - X_4$

Answer: B

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20. $NH_3(g) + 3Cl_2(g) \rightarrow NCl_3(g) + 3HCl(g), \quad \Delta H_1$

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

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g), \quad \Delta H_3$

The heat of formation of NCl_3 in the terms of $\Delta H_1, \Delta H_2 \text{and} \Delta H_3$ is

A. $\Delta H_f = -\Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

B. $\Delta H_f = \Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

C. $\Delta H_f = -\Delta H_1 - \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

D. None

Answer: A

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21. The enthalpy of formation of $H_2O(l)$ is $-285KJmol^{-1}$ and enthalpy of neutralization of a stron acid and a strong bas is $-55KJmol^{-1}$. What is the enthalpy of formation of OH^{-} ions?

A. $-228.5KJ\text{mol}^{-1}$

B. $228.5KJ\text{mol}^{-1}$

C. $114.5KJ\text{mol}^{-1}$

D. $-114.5KJ\text{mol}^{-1}$

Answer: A

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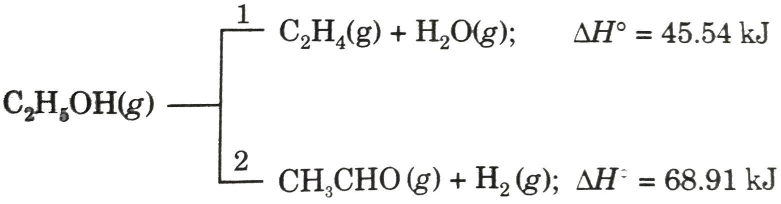
22. Ethanol can undergo decompostion to form two sets of products.

If the molar ratio of $C_4H_4\text{to}CH_3CHO$ is 8:1 in a set of product gases, then the energy involved in the decomposition of 1 mole of ethanol is:



$$C_2H_5OH(g) \xrightarrow{1} C_2H_4(g) + H_2O(g); \quad \Delta H^\circ = 45.54 \text{ kJ}$$

$$C_2H_5OH(g) \xrightarrow{2} CH_3CHO(g) + H_2(g); \quad \Delta H^\circ = 68.91 \text{ kJ}$$

A. 65.98 KJ

B. 48.137 KJ

C. 48.46 KJ

D. 57.22 KJ

Answer: B

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23. Find bond enthalpy of S-S bond from the following data:

$C_2H_5 - S - C_2H_5, \quad \Delta H_f^\circ = -147.2kJ \quad mol^{-1}$

$C_2H_5 - S - S - C_2H_5, \quad \Delta H_f^\circ = -201.9kJ \quad mol^{-1}$

$S(g), \quad \Delta H_f^\circ = 222.8kJ \quad mol^{-1}$

A. $-168.1 KJ/\text{mol}$

B. $+168.1 KJ/\text{mol}$

C. $-277.5 KJ/\text{mol}$

D. $+277.5 KJ/\text{mol}$

Answer: D

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24. Given the following equations and ΔH° values, determine the enthalpy of reaction at 298 K for the reaction :

$C_2H_4(g) + 6F_2(g) \rightarrow 2HF_4(g) + 4HF(g)$

$H_2(g) + F_2(g) \rightarrow 2HF(g) + 2HF(g), \quad \Delta H_1^\circ = -537 \text{ kJ}$

$C(s) + 2F_2(g) \rightarrow CF_4(g), \quad \Delta H_2^\circ = -680 \text{ kJ}$

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g), \quad \Delta H_3^\circ = 52 \text{ kJ}$

A. -1165

B. -2486

C. $+1165$

D. $+2486$

Answer: B

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25. Animals operate under conditons of constant pressure and most of the process tht maintain life are isothermal (in a broad sense) . How much energy is available for sustaining this type of muscular and nervous activity from the combustion of 1mol of glucose molecules under standard conditons at 37° C (blood temperature) ? The entropy change is $+182.4JK^{-1}$ for the reaction stated above

$\Delta H_{\text{combustion}}$[glucose]=-2808 KJ

A. $-2754.4KJ$

B. $2864.5KJ$

C. $-56.5KJ$

D. $-2808KJ$

Answer: B

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26. From the given table answer the following question:

	$CO(g)$	$CO_2(g)$	$H_2O(g)$	$H_2(g)$
$\Delta H^{\circ}_{298}(-\text{KCal/mole})$	-26.42	-94.05	-57.8	0
$\Delta G^{\circ}_{298}(-\text{KCal/mole})$	-32.79	-94.24	-54.64	0
$S^{\circ}_{298}(-\text{Cal/k mol})$	47.3	51.1	$?$	31.2

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

Calculate $S^{\circ}_{298}\left[H_2O(g)\right]$

A. -119.47 Cal/k mole

B. $+119.47$ Cal/k mole

C. -45.13 Cal/k mole

D. $+45.13$ Cal/k mole

Answer: D

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27. Calculate the free energy change at 298 K for the reaction, $Br_2(l) + Cl_2(g) \rightarrow 2BrCl(g)$. For the reaction $\Delta H^\circ = 29.3$ KJ & the entropies of $Br_2(l), Cl_2(g)$ & $BrCl(g)$ at the 298 K are 152.3,223.0,239.7 J $mol^{-1}K^{-1}$ respectively.

A. $-1721.8J$

B. $-60321.8J$

C. $+60321.8J$

D. $+1721.8J$

Answer: A

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28. One gram sample of oxygen undergoes free expansion from 0.75L to 3.0 L at 298 K. Calculate ΔS, q,w $\Delta H \text{and} \Delta E$

A. $\Delta S = 0.36JK^{-1}$

B. W=227.97 J

C. q=-227.97 J

D. $\Delta H = 107.28J$

Answer: A

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29. Given that:

$\Delta G_F^{\circ} (CuO) = -30.4\text{Kcal/mole}$

$\Delta G_f^{\circ} \left(Cu_2O\right) = -34.98Kcal/\text{mole} \quad T = 298K$

Now on the basis of above data which of the following predications will be most appropriate under the standard conditons and reversible reaction.

A. Finely divided form fof CuO Kept in excess O_2 would be completely converted to Cu_2O

B. Finely divided form of Cu_2O kept in excess O_2 would be Completely converted to CuO

C. Finely divided form of CuO kept in excess O_2 would be converted to a mixture of CuO and Cu_2O (having more of CuO)

D. Finely divided form of CuO kept in excess O_2 would be converted to a mixture of CuO and Cu_2O (having more of Cu_2O)

Answer: B

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30. Calcualate $\Delta_f G^\circ \text{ for}\left(NH_4Cl, s\right)$ at 310 K.

Given : $\Delta_f H^\circ \left(NH_4Cl, s\right) = -314.5KJ/\text{mol}, \Delta_r C_p = 0$

$S^\circ_{N_2(g)} = 192JK^{-1}, \quad S^\circ_{H_2(g)} = 130.5JK^{-1}mol^{-1},$

$S^{\circ}_{Cl_2}(g) = 233 JK^{-1} \text{mol}^{-1}, \quad S^{\circ} NH_4Cl(s) = 99.5 JK_1 \text{mol}^{-1}$

All given data are at 300K.

A. $-198.56 KJ/\text{mol}$

B. $-426.7 KJ/\text{mol}$

C. $-202.3 KJ/\text{mol}$

D. None of these

Answer: A

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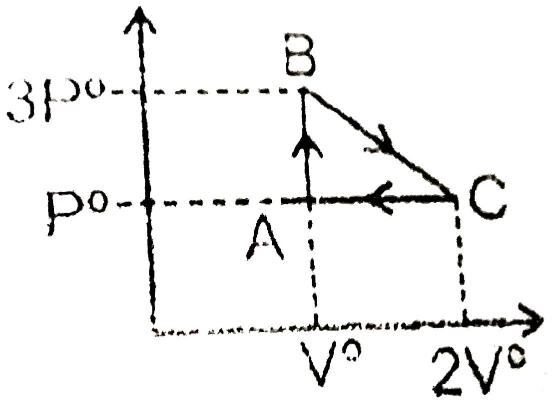
exercise-3 part-2 Advanced level Solutions

1. One mole of ideal monatomic gas is carried through the reversible cyclic process as shown in figure. Calculate the max temperature attained by the gas during the cycle.



A. $\frac{25}{8}\left(\frac{P^{\circ}V^{\circ}}{R}\right)$

B. - $\frac{25}{8}\left(\frac{P^{\circ}V^{\circ}}{R}\right)$

C. $\frac{35}{8}\left(\frac{P^{\circ}V^{\circ}}{R}\right)$

D. - $\frac{35}{8}\left(\frac{P^{\circ}V^{\circ}}{R}\right)$

Answer: A

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2. Determine ΔU° at 300K for the following reaction using the listed enthalpies of reaction :

$$4CO(g) + 8H_2(g) \rightarrow 3CH_4(g) + CO_2(g) + 2H_2O(l)$$

$$C(\text{graphite}) + \frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H_1^{\circ} = -110.5KJ$$

$$CO(g)\frac{1}{2}O_2(g) \rightarrow CO_2(g), \Delta H_2^{\circ} = -282.9KJ$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H_3^{\circ} = -285.8KJ$$

$$C(\text{graphite}) + 2H_2(g) \rightarrow CH_4(g), \Delta H_4^{\circ} = -74.8KJ$$

A. $-653.5KJ$

B. $-686.2KJ$

C. $-747.4KJ$

D. None of these

Answer: D

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3. Determine enthalpy of formation for $H_2O_2(l)$, using the listed enthalpies of reactions:

$$N_2H_4(l) + 2H_2O_2(l) \rightarrow N_2(g) + 4H_2O(l), \Delta_rH_1^{\circ} = -818KJ/\text{mol}$$

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l), \Delta_rH_2^{\circ} = -622KJ/\text{mol}$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta_rH_3^{\circ} = -285KJ/\text{mol}$$

A. $-383KJ/\text{mol}$

B. $-187KJ/\text{mol}$

C. $-498KJ/\text{mol}$

D. None of these

Answer: B

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4. The enthalpy of neutralization of a Weak monoprotic acid (HA) in 1 M solution with a strong base is -55.95 KJ/mol . If the unionized acid required 1.4 KJ/mol heat for it's comptate ionzatation and enthalpy of netralization of the strong monobasic acid with a strong monoacidic base is -57.3 KJ/mol . What is the % ionzation of the weak acid in molar solution ?

A. 0.01

B. 0.0357

C. 35.7 %

D. 0.1

Answer: B

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5. Calculate $\Delta_r G^\circ$ for (NH_4Cl, s) at 310K.

Given :$\Delta_r H^\circ (NH_4Cl, s)$ =-314 kj/mol,$\Delta_r C_p = 0$

$S^\circ_{N_2(g)} = 192JK^{-1}mol^{-1}, S^\circ_{H_2(g)} = 130.5JK^{-1}mol^{-1},$

$S^\circ_{Cl_2(g)} = 233JKmol^{-1}, S^\circ_{NH_4Cl(s)} = 99.5JK^{-1}mol^{-1}$

All given data at 300K

A. $-198.56KJ/\text{mol}$

B. $-426.7KJ/\text{mol}$

C. $-202.3KJ/\text{mol}$

D. None of these

Answer: A

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6. For a perfectly crystalline solid $C_{p.m.} = aT^3$, where ais constant. If $C_{p.m.}$ is 0.42.J//K-"mol" at 10K, molar entropy at 10K is:

A. 0.42 J/k-mol

B. 0.14 J/K-mol

C. 4.2 J/K-mol

D. zero

Answer: B

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7. The molar entropy content of 1 mole of oxygen $\left(O_2\right)$ gas at $300K$ and $1atm$ is $250Jmole^{-1}K^{-1}$. Calculate ΔG when 1 mole of oxygen is expanded reversibility and isothermally from $300K$, 1 atm to double its volume (Take $R = 8.314Jmole^{-1}K^{-1}, \log e = 2.303\big)$

A. 1.728 KJ $\text{mole}^{-1}K^{-1}$

B. 0

C. $-1.728KJ\text{mole}^{-1}K^{-1}$

D. $0.75KJ\text{mole}^{-1}K_1$

Answer: A

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8. Fixed amount of an ideal mono atomic gas contained in a sealed rigid vessel (V=24.6 litres) at 1.0 bar is heated reversibly form $27^\circ C$ to $127^\circ C$.

Determine change in Gibb's energy (in Joule) if entropy of gas

$S = 10 + 10^{-2} T(J/K)$

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9. Which of the following statement (s) is /are true?

A. $\Delta E = 0$ for combustion of $C_2H_6(g)$ in a sealed rigid adiabatic container

B. $\Delta_r H^\circ$ (S, monoclinic) $\neq$ 0

C. If dissociation energy of $Ch_4(g)$ is 1656 KJ/mol and $C_2H_6(g)$ is 2812 KJ/mol, then value of C-C bond energy will be 328 KJ/mol

D. If $\Delta H_r\left(H_2O, g\right)$ =-242 KJ/mol, $\Delta H_{\text{vap}}\left(H_2O, l\right)$ =44 KJ/mol then $\Delta_e H^\circ\left(OH^-, aq\right)$ will be -142 KJ/mol

Answer: A::B::C

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10. From the following date , mark the opation(s) where ΔH is correctly written for the given reaction .

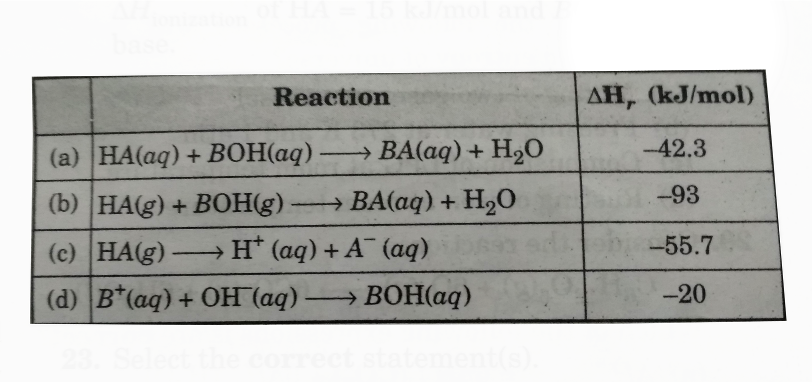
Given: $H + (aq) + OH - (aq) \rightarrow H_2O(l),$

$\Delta H = -57.3kJ$

$\Delta H_{solution} HA(g) = -70.7kJ\text{mole}$

$\Delta H_{solution} BOH(g) = -20kJ\text{mole}$

$\Delta H_{\text{ionzatoin}}$ of $HA = 15kJ/\text{mole}$ and BOH is a strong base.



	Reaction	ΔH_r (kJ/mol)
(a)	$HA(aq) + BOH(aq) \longrightarrow BA(aq) + H_2O$	–42.3
(b)	$HA(g) + BOH(g) \longrightarrow BA(aq) + H_2O$	–93
(c)	$HA(g) \longrightarrow H^+(aq) + A^-(aq)$	–55.7
(d)	$B^+(aq) + OH^-(aq) \longrightarrow BOH(aq)$	–20

A. Reaction $\Delta H_r(KJ/\text{mol})$

$HA(aq) + BOH(aq) \rightarrow BA(aq) + H_2O$ -42.3

B. Reaction $\Delta H_r(KJ/\text{mol})$

$HA(q) + BOH(q) \rightarrow BA(aq) + H_2O$ -93

C. Reaction $\Delta H_r(KJ/\text{mol})$

$HA(q) \rightarrow H^+(aq) = A^-(aq)$ -55.7

D. Reaction $\Delta H_r(KJ/\text{mol})$

$B^+(aq) + OH^-(aq) \rightarrow BOH(aq)$ -20

Answer: A::B::C

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11. The value of $\Delta H_{\text{transition}}$ of C (graphite) → C (diamond) is 1.9 kJ/mol at $25^\circ C$. Entropy of graphite is higher than entropy of diamond. This implies that :

A. C(diamond) is more themodynamically stable then C(graphite) at 25° C

B. C(graphite)is more thermodynamically stable than C (diamond) at $25^\circ C$

C. diamond will provide more heat on complete conbustion at $25^\circ C$

D. $\Delta G_{\text{transition}}$ of C(diamond) → C(graphite) is -ve

Answer: B::C::D

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12. Which of the following statement(s) is/are false?

A. All adiabatic processes are isoentropic (or isenthermic) processes

B. When $\left(\Delta G_{\text{system}}\right)_{TP} < 0$, the reaction must be exothermic

C. $dG = VdP - SdT$ is applicable for closed system, both PV and non-PV work

D. the heat of vaporisation of water at $100\,^{\circ}C$ is 40.6 KJ/mol . When 9 gm of water vapour condenses to liquid at $100\,^{\circ}C$ of 1 atm , then $\Delta S_{\text{system}} = 54.42J/K$

Answer: A::B::C::D

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13. For the reaction $2Ag_2O(s) \rightarrow 4Ag(s) + O_2(g)$, ΔH is 61.17 $KJ\text{mol}^{-1}$ and ΔS is 132 $JK^{-1}\text{mol}^{-1}$. Compute the temperature above which the given reaction will be spontaneous.

A. $T > 463.4K$

B. $T > 190.25\,^{\circ}C$

C. $T < 190.25\,^{\circ}C$

D. $T < 463.4K$

Answer: A::B

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14. Select the correct enthalpy at corresponding temperature using following datas

(i) Heat capacity of solid from 0K to normal melting point 200K

$C_{p.m}(s) = 0.035T \quad JK^{-1}\text{mol}^{-1}$

(ii) Enthalpy of fusion $= 7.5KJ\text{mol}^{-1}$

(iii) Enthalpy of vaporisation $= 30KJ\text{mol}^{-1}$

(iv) Heat capacity of liquid form 200K to normal boiling point 300K

$C_{p.m}(l) = 60 + 0.016T \quad JK^{-1}\text{mol}^{-1}$

(v) Heat capacity of gas from 300 K to 600 K at 1 atm

$C_{p.m}(g) = 50.0 \quad JK^{-1}\text{mol}^{-1}$

A. $S_{200(s)}$=7

B. $S_{300(l)}$=70.43

C. $S_{300(g)} = 170.43$

D. $S_{600(g)} = 205.09$

Answer: A::B::C::D

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15. 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 , 40.0L) to (0.5 atm , 40.0 L)

(c) a reversible isothermal compression from (0.5 atm,40.0 L) to (1.0atm, 20.0L)

Calculate the magnitude of work (W) done in L.atm

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16. The enthalpy of combustion of mol. Wt. 180 glucose is -2808 KJ mol^{-1} at 25° C . X and Y grams of glucose do you need to consume respectively cases [Assume wt=62.5 Kg].

(a) to climb a flight of stairs rising through 3M.

to climb a mountain of altitude 3000 M?

Assume that 25% of enthalpy can be converted to useful work.

X and Y are related as X=mY, then find m.

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17. A sample of certain mas s of an ideal polyatomic gas is expanded against constant pressure of 1 atm adiabatically from volume 2L , pressure 6 atm and temperature 300K to state where its final volume is 8L . Then calculate entropy change (in J/k) in the process.(Neglect vibrational degress of freedom)[1 L atm = 100 J ,log 2 =0.3 , log 3 = 0.48 , log e = 2.3] (approximate integer)

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18. The heat of combustion of acetylene is 312 Kcal . If heat of formation of $CO_2 \& H_2O$ are -94 & -68 Kcal respectively . Given that heat of atomisation of C& H are 150 & 50 Kcal respectively and C-H bond energy is 93 Kcal . Calculate $\frac{\Delta H_{C=C}}{6}$

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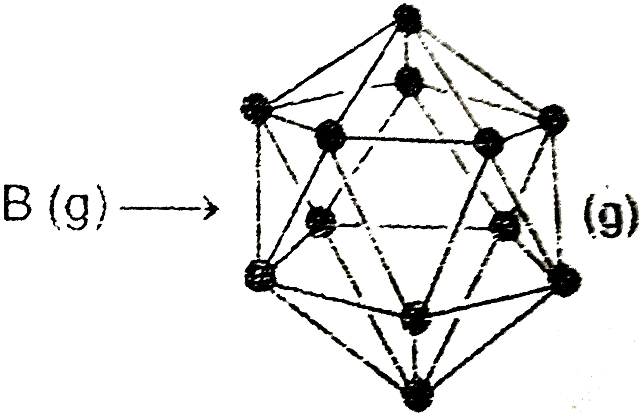
19. Boron exist in different allotropic forms. All allotropic form contains icosahedral units (icosahedral is regular shape with 12 corner & 20 faces) with boron atoms at all 12 corners and all bonds are equivalent.



Calculate heat evolved at constant pressure (in KJ) per mole of boron atoms undergoing above change it $\Delta H_{BE}(B - B) = 200KJ/\text{mol}$. Report you answer after dividing by 100

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20. 1 mole of an ideal gas is allowed to expand isothermally at 27°C till its volume is tripled . If the expansion iscarried out reversibly then the $\Delta S_{\text{universe}}$ will be?

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21. Concerete is produced from a mixture of cement , water, sand and small stones. It consists primarily of calcium silicates and calcium aluminates formed by heating and grinding of clay and limestone. In later steps of cement production a small amount of gypsym , $CaSO_4.2H_2O$ is added to improve subsequent hardening of concrete . The use of elevated temperature during the final production may lead to formation of unwanted hemihydrate, $CaSO_4.1/2H_2O$. Consider the following reaction:

$$CaSO_4.2H_2O(s) \rightarrow CaSO_4.\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$$

The following themodynamic data apply at $25^{\circ}C$ standard pressure : 1 bar

Compound	$\Delta H^{\circ}_{f(KJ/mol)}$	$S^{\circ}\left(JK^{-1}mol^{-1}\right)$
$CaSO_4.2H_2O(s)$	-2021.0	194.0
$CaSO_4.\frac{1}{2}H_2O(s)$	-1575.0	130.5
$H_2O(g)$	-242.8	188.6

R=8.314 $JK^{-1}mol^{-1}$

ΔH° for the formation of 1.00 kg of $CaSO_4.\frac{1}{2}H_2O(s)$ from $CaSO_4.2H_2O(s)$ is

A. $+446KJ$

B. $+484KJ$

C. $-446KJ$

D. $-484KJ$

Answer: B

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22. Concerete is produced from a mixture of cement , water, sand and small stones. It consists primarily of calcium silicates and calcium aluminates formed by heating and grinding of clay and limestone. In later steps of cement production a small amount of gypsym , $CaSO_4.2H_2O$ is added to improve subsequent hardening of concrete . The use of elevated temperature during the final production may lead to formation of unwanted hemihydrate, $CaSO_4.1/2H_2O$. Consider the following reaction:

$$CaSO_4.2H_2O(s) \rightarrow CaSO_4.\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$$

The following themodynamic data apply at $25^\circ C$ standard pressure : 1 bar

Compound	$\Delta H^{\circ}_{f(KJ/mol)}$	$S^{\circ}\left(JK^{-1}mol^{-1}\right)$
$CaSO_4.2H_2O(s)$	-2021.0	194.0
$CaSO_4.\frac{1}{2}H_2O(s)$	-1575.0	130.5
$H_2O(g)$	-242.8	188.6

R=8.314 $JK^{-1}mol^{-1}$

Equillibrium pressure (in bar) of water vapour in closed vessel containing $CaSO_4.2H_2O(s), CaSO_4.\frac{1}{2}H_2O(s), H_2O(g)$ at 25°C

A. 17.35×10^{-4} bar

B. 2.15×10^{-4} bar

C. 8.10×10^{-3} bar

D. 7.00×10^{-4} bar

Answer: C

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23. Concerete is produced from a mixture of cement , water, sand and small stones. It consists primarily of calcium silicates and calcium aluminates formed by heating and grinding of clay and limestone. In later steps of cement production a small amount of gypsym , $CaSO_4.2H_2O$ is added to improve subsequent hardening of concrete . The use of elevated temperature during the final production may lead to formation of unwanted hemihydrate, $CaSO_4.1/2H_2O.$ Consider the following reaction:

$$CaSO_4.2H_2O(s) \rightarrow CaSO_4.\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$$

The following themodynamic data apply at $25\,^\circ C$ standard pressure : 1 bar

Compound	$\Delta H^\circ_{f(KJ/mol)}$	$S^\circ\left(JK^{-1}mol^{-1}\right)$
$CaSO_4.2H_2O(s)$	-2021.0	194.0
$CaSO_4.\frac{1}{2}H_2O(s)$	-1575.0	130.5
$H_2O(g)$	-242.8	188.6

R=8.314 $JK^{-1}mol^{-1}$

Temperature at which the equillibrium water vapour pressure is 1.00 bar

A. $107\,^\circ$ C

B. $380\,^\circ C$

C. $215\,^\circ C$

D. $240\,^\circ C$

Answer: A

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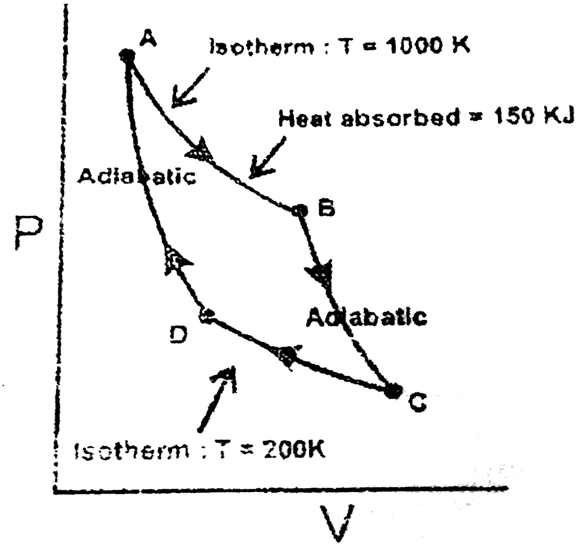
24. The accompanying diagram represents a reversible cannot cycle for an ideal gas:



How many heat is rejected at the lower temperature, 200K, during the isothermal compression?

A. 150 KJ

B. 30KJ

C. 120KJ

D. data are not sufficient to calculate exact value

Answer: B

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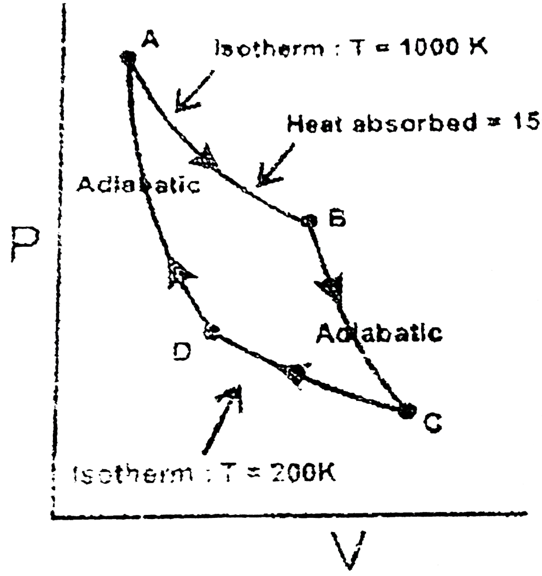
25. The accompanying diagram represents a reversible cannot cycle for an ideal gas:



What is the entropy increase during isothermal at 1000K?

A. $0.15KJ^{-1}$

B. $150KJK^{-1}$

C. $150JK^{-1}$

D. $750JK^{-1}$

Answer: C

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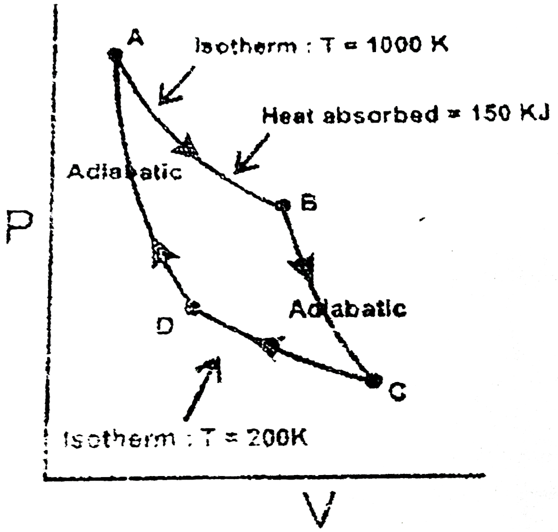
26. The accompanying diagram represents a reversible cannot cycle for an ideal gas:



What is the Gibbs free energy change during the process $A \rightarrow B$?

A. 150 KJ

B. - $150KJ$

C. 30 KJ

D. data are not sufficient

Answer: B

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27. Match column-I to column-II standard entropy in KJ/k-molar at $25\,^{\circ}C$

Column-I	Column-II
1. ΔH_{C-C}	$(p)733.48$
2. ΔH_{C-H}	$(q)97.81$
3. $\Delta H_{C=C}$	$(r)434.3$
4. $\Delta H_{C\equiv C}$	$(s)454.64$
5. $\Delta H_{C=O}$	$(f)804.22$

Using the dat (all values are in KJ/mol at $25\,^{\circ}$C) given below:

$$\left(\Delta H^{\circ}_{\text{combustion}}(\text{ethane}) = -1559.8 \quad , \quad \Delta H_{\text{combustion}}(\text{ethane}) = -1410.9\right), \left(\Delta H^{\circ}_{\text{con}}\right.$$

A. $\begin{array}{cccccc} & 1 & 2 & 3 & 4 & 5 \\ (A) & q & s & r & p & t \end{array}$

B. $\begin{array}{cccccc} & 1 & 2 & 3 & 4 & 5 \\ (B) & r & p & t & q & s \end{array}$

C. $\begin{array}{cccccc} & 1 & 2 & 3 & 4 & 5 \\ (C) & q & p & s & r & t \end{array}$

D. $\begin{array}{cccccc} & 1 & 2 & 3 & 4 & 5 \\ (D) & p & s & q & r & t \end{array}$

Answer: A

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exercise-3 part-III Advanced level Solutions (STAGE-I)

1. which of the following expression is correct?

A. E=H+PV

B. H=E+PV

C. H=E-PV

D. P=E+ HV

Answer: B

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2. Iron metal is produced commercially by reducing iron (III) oxide in iron ore with carbon monoixde :

A. Write down the balanced chemical equation for the above reduction of iron (III) oxide?

B. Enthalpies of formation for various substance at $25^{\circ} C$ are given in the following table.

	$FeO_{3(g)}$	CO_g	Fe_g	$CO2_g$
$\Delta H_f^\circ (KJ/\text{mol})$	-824.2	-110.5	0	-393.5
$S[J/(K.\text{mol})]$	87.5	197.6	27.3	213.6

Calculate the standard free-energy change for this reaction at 25°C

?

C. Is the reaction spontaneous at 25°C ?

D. Does the reverse reaction become spontaneous at higher temperature? Explain.

Answer: A::B::C::D

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3. If the bond energies are as follows (i) $C - h = 413.8KJ$ (ii) Cl-Cl=238.0 KJ) (iii) C-Cl=327.2 KJ (iv) H-Cl=429.8 KJ

the enthalpy of the reaction : $CH_4 + 2Cl_2 \rightarrow CH_2Cl_2 + 2HCl$ will be

A. $+202.6kJ$

B. $-202.6KJ$

C. $+220.1KJ$

D. $+870KJ$

Answer: B

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4. The enthalpy change for the following reactions are:

$C_{\text{diamond}} + O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta H = -395.3KJ\text{mol}^{-1}$

$C_{\text{graphite}} + O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta H = -393.4KJ\text{mol}^{-1}$

The enthalpy change for the transition

$C_{\text{diamond}} \rightarrow C_{\text{graphite}}$ will be :

A. $-3.8KJ\text{mol}^{-1}$

B. $+3.8KJ\text{mol}^{-1}$

C. $-1.9KJ\text{mol}^{-1}$

D. $+1.9KJ\text{mol}^{-1}$

Answer: C

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5. For a chemical reaction,ΔH is negative and ΔS is negative and ΔS is negative . This reaction is

A. spontaneous al all temperatures

B. nonspontaneous at all temperature

C. spontaneous only at high temperature

D. spontaneous only at low temperature

Answer: A

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6. 6.24 g of ethanol are vaporized by supplying 5.89 KJ of heat energy . What is the ebnthalpy of vapourisation of ethanol?

A. 43.42 KJ

B. 47.0 KJ

C. 21.75 KJ

D. 435.0 KJ

Answer: A

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exercise-3 part-III Advanced level Solutions (STAGE-II)

1. Greenhouse gas CO_2 can be converted to $CO(g)$ by the following reaction

$CO_2(g) + H_2(g) \rightarrow CO_2 + H_2O(g)$, termed as water gas reaction.

Calculate ΔG for the reaction at 1000K $\left(\Delta H_{1000K} = 35040 J\text{mol}^{-1} \Delta S_{1000K} = 32.11 J\text{mol}^{-1} K^{1}\right)$.

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2. Greenhouse gas CO_2 can be converted to $CO(g)$ by the following reaction

$CO_2(g) + H_2(g) \rightarrow CO_2 + H_2O(g)$, termed as water gas reaction.

Calculate equilibrium constants $K_p$for the water gas reaction at 1000K .H=35040J/mol & S=32.11J/ mol/k

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3. Greenhouse gas CO_2 can be converted to $CO(g)$ by the following reaction

$CO_2(g) + H_2(g) \rightarrow CO_2 + H_2O(g)$, termed as water gas reaction.

A mixture of gases containing 35 vol% of H_2,45 vol.% of CO and 20 vol. % H_2O is heated to 1000K . What is the composition of the mixture at equilibrium?

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4. Greenhouse gas CO_2 can be converted to $CO(g)$ by the following reaction

$CO_2(g) + H_2(g) \rightarrow CO_2 + H_2O(g)$, termed as water gas reaction.

Calculate ΔH at 1400 K using the given data for 1000K, assuming the C_p° values remain constant in the given temoeerature range.

$\Delta H = 35040 J\text{mol}^{-1}, C_p^{\circ}\left(CO_2\right) = \left(42.31 + 10.09 \times 1^{-3}T\right)J\text{mol}^{-1}K_1$

$C_P^{\circ}\left(H_2\right) = \left(27.40 + 3.20 \times 10^{-3}T\right)J\text{mol}^{-1}K_1$

$C_P^{\circ}(CO) = \left(28.34 + 4.14 \times 10^{-3}T\right)J\text{mol}^{-1}K^{-1}$

$C_P^{\circ}\left(H_2O\right) = \left(30.09 + 10.67 \times 10^{-3}T\right)Jmol^{-1}K^{-1}$

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5. Greenhouse gas CO_2 can be converted to $CO(g)$ by the following reaction

$CO_2(g) + H_2(g) \rightarrow CO_2 + H_2O(g)$, termed as water gas reaction.

Based on your answer in 3,4 mark the correct box:

(a) K_p will increase with increase in temperature

(b) K_p will not change with increase in temperature

(c) K_p will decrease with increase in temperature

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6. Carbon monoxide emitted by automobiles is an environmental hazard . A car has an engine of four cylinders with a total cylinder volume of 1600 cc and a fuel consumption fo 7.0 dm^3 per 100 Km , when driving at an average speed of 80 km/hr . In one second , each cylinder goes through 25 burn cycles and consumes 0.400g of fuel . The compression ratio, which is the ratio between the smallest and largest volume within the cylinder as the piston moves forward and backward is 1:8.

Calculate the air intake of the engine $\left(m^3S^{-1}\right)$, if the gaseous fuel and air are introduced into the cylinder when its volume is largest until the pressure is 101.0 KPa. the temperature of both incoming air and fuel is $100\ ^\circ$C. (Assume the fuel to be isoctane , C_8H_{18})

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7. Carbon monoxide emitted by automobiles is an environmental hazard . A car has an engine of four cylinders with a total cylinder volume of 1600 cc and a fuel consumption fo 7.0 dm^3 per 100 Km , when driving at an average speed of 80 km/hr . In one second , each cylinder goes through 25 burn cycles and consumes 0.400g of fuel . The compression ratio, which is the ratio between the smallest and largest volume within the cylinder as the piston moves forward and backward is 1:8.

The gasified fuel and air are compressed to their lowest volume and then ignited .

The overall stoichiometric equation for the combustion reaction is

$$C_8H_{18} = 12.10_2 \rightarrow 0.8CO + 7.2CO_2 + 9H_2O$$

Calculate the temperature of the

i) gases just at the time of maximum compression and

ii) exhaust gases leaving the cylinder if the final pressure in the cylinder is 200 Kpa.

Relevant data needed for one burn cycle is given below.

compound	$\Delta H_f(KJmol^{-1})$	$C_P(Jmol^{-1}K^{-1})$	Composition of gases after comb
$N_2(g)$	0.0	29.13	101.91
$O_2(g)$	0.0	29.36	10.1
$CO(g)$	-110.53	29.14	1.12
$CO_2(g)$	-395.51	37.11	10.11
$H_2(g)$	-241.82	33.58	12.36
Isocotane	-187.82		

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8. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g) .... (i)$$

The energy of one mole of a photon of wave lenght is known as one Einstein.

48 Einsteins of 650nm are absorbed by a plant for the production of 1 mole of glucose as given in equation (i). Calculate the % efficiency for the production of glucose by photosynthsis. The energy requried for the formation of 1 mole of glucose is 2870 KJ.

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9. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)$.......... (i)

The energy of one mole of a photon of wave lenght is known as one Einstein.

On an average , solar radiation 7×10^{14} kg of glucose annually on earth . Calculate the annual decrease in the CO_2 level in the troposphere in ppm , due to photosynthesis. (1 ppm=1 g of CO_2 per 10^3 kg of air in troposhere). Assume that the total mass of air envolope surrounding the earth is 5.0×10^{15} kg and 80% of its is present in the tropsphere.

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10. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)$.......... (i)

The energy of one mole of a photon of wave lenght is known as one Einstein.

Heats of combustion of graphite and hydrogen at 298K are $-393.5KJ\text{mol}^{-1}$ and $-285.8KJ\text{mol}^{-1}$ respectively. If on combustion 1 g of glucose releases 15.58 KJ of energy , Calcualate the heat of formation of glucose at 298 K.

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11. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)$.......... (i)

The energy of one mole of a photon of wave lenght is known as one Einstein.

Write balanced equation for the reaction of glucose with O_2 in which O_2 is converted to H_2O_2

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12. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)$.......... (i)

The energy of one mole of a photon of wave lenght is known as one Einstein.

A weight lifter lifts a weight of 160Kg through of 2.4 m . Assuming all the energy required for this task is obtained by the combustion of glucose , calculate the change in the current produced by a sample of blood of the weight lifter . Same volume of blood (5mL) is tested both before and after lifting the weight and the total volume of blood in his body is 5L. (1 g of glucose releases 15.58 KJ of energy)

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13. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)..........(i)$

The energy of one mole of a photon of wave lenght is known as one Einstein.

Write balanced equations for the half cell reactions corresponding to oxidation of glucose.

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14. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)..........(i)$

The energy of one mole of a photon of wave lenght is known as one Einstein.

Calculate the emf of this fuel cell at 25° C if ΔH° and ΔS° of photosynthesis are $2.82 \times 10^6 \text{J mol}^{-1}$ and -182 $J\text{mol}^{-1}$ respectively.

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15. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g) \text{..........} (i)$

The energy of one mole of a photon of wave lenght is known as one Einstein.

Variation of emf of an electrochemical cell with temprature is known as the temperature coefficient of the cell .If $\delta(\Delta G/\delta T)_p = -\Delta S$, calcualte the temperature coefficient fo the glucose fuel cell at 25°C from the data given in 3.7.

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16. Photosysthesis si a bio process by which plants make energy rich molecules from low energy molecules with the help of energy from sunlight . The photosysthesis of glucose can be represented as:

$6CO_{2(g)} + 6H_2O_g + hv \rightarrow C_5H_{12}O_{6(s)} + 6O_2(g)$......... (i)

The energy of one mole of a photon of wave lenght is known as one Einstein.

A glucose fuel cell was designed to generate 4000 Watts which was used to heat of $5m \times 5m \times 3m$ dimensions . The room is perfectly insulated and no heat flows out of the room Calculate the time needed to increase the temperature of the room by $20\,^\circ C$, if the room was initially at $10\,^\circ C$ and 1 atm pressure . Assume that the air in the room behaves like an ideal gas and its molar heat capacity is 2.5R.

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17. The rapid depletion of fossil fuels has inspired extensive research in the area of alternative and renewale energy sources. Of these, hydroden is the most Contemplated fuel of the future . Howevercost effective production and hazard free storage are major issuses is using H_2 (Note : use the data in table-1 given at the end of partA, whenever necessary.)

A cylinder contains hydrogen at a pressure of 80Moa at $25^\circ C$, Assuming ideal behaviour , Calculate the density of hydrogen in the cylinder in Kg/m^3 .

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18. The rapid depletion of fossil fuels has inspired extensive research in the area of alternative and renewale energy sources. Of these, hydroden is the most Contemplated fuel of the future . Howevercost effective production and hazard free storage are major issuses is using H_2 (Note : use the data in table-1 given at the end of partA, whenever necessary.)

Assuming complete combustion, calculate heat of combustion when

(i)1 g of hydrogen and (ii) 1 g of carbon are burnt.

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19. The rapid depletion of fossil fuels has inspired extensive research in the area of alternative and renewale energy sources. Of these, hydroden is the most Contemplated fuel of the future . Howevercost effective production and hazard free storage are major issuses is using H_2 (Note : use the data in table-1 given at the end of partA, whenever necessary.)

1kg of hydrogen is burnt with oxgyen at $25^{\circ}C$ and the heat energy is used for different purpose . Using this heat calculate

(i) the maximum theoretical work.

(ii) work that can be produced by a heat engine working between $25^{\circ}C$ to 300° C. (The efficiency of a heat engine =work done /heat absorbed = $\left[1 - 9T_{\text{low}}/T_{\text{high}}\right]$ where T is in K)

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20. The rapid depletion of fossil fuels has inspired extensive research in the area of alternative and renewale energy sources. Of these, hydroden is the most Contemplated fuel of the future . Howevercost effective production and hazard free storage are major issuses is using H_2 (Note :

use the data in table-1 given at the end of partA, whenever necessary.)

If the miximum theoretical work (calculate in 4.3 (i))0 is used to run an electric motor of 1 watt, under standard potential conditons.

(i) for how many months the motor will be run?

(ii) What is the value of the current produced by this motor? (Assume 30 days in all months.)

Table-1:

	$H_2(g)$	$O_2(g)$	$H_2O(I)$
$S^{\circ}_{298}K/\text{JMolK}^{-1}$	131	205	70
	$H_2O(l)$	$CO_2(g)$	
$\Delta H_f^{\circ}/\text{KMol}^{-1}$	$-266KJ\text{mol}^{-1}$	$-394KJ\text{mol}^{-1}$	

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21. One method to produce hydrogen on an industrial on an industrial scale is the reaction of methane with overheated water vapour at 1100 K to form hydrogen and carbon monoxide . The reaction is known as steam reforming

Write the balanced equations for the steam reforming of methane .

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22. One method to produce hydrogen on an industrial on an industrial scale is the reaction of methane with overheated water vapour at 1100 K to form hydrogen and carbon monoxide . The reaction is known as steam reforming

The K_p of the reforming reaction at 1100K is 28.6 When 1 mol of methane and 1 Kmol fo water are reacted at 1100 K , calculate the percentage conversion of methane at equilibrium at a total pressure of 1.6 bar. In another experiment 1.0 Kmol of CH_4 and 1.0 mol of H_2O are taken in a sealed vessel at 400 K and 1.6 bar. The temperature is raised to 1100K.

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23. One method to produce hydrogen on an industrial on an industrial scale is the reaction of methane with overheated water vapour at 1100 K to form hydrogen and carbon monoxide . The reaction is known as steam reforming

Calcuate the pressure in the vessel at 1100K and the % conversion of methane.

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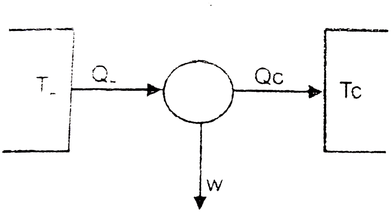
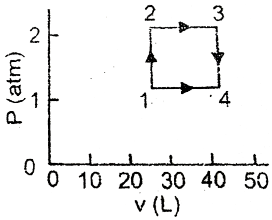
24. A heat engine is a system that converts heat into mechanical work. A heat "source" generates thermal energy that brings a working substance to a high temperature. The working substance then generates work in the engine while transferring heat to a sink at a lower temperature . The working of a heat engine is shownn figure 1.



(Figure–1)



(Figure–2)

Heat engines can be modelled using themodynamic cycles. The heat engine given in Figure -2 is of a working substance which is 1.00 mol of a monoatomic ideal gas . The thermodynamic cycle begins at the point designated as '1' and goes clockwise and the values of P and l or V at each point is as given below Fig-2

$\left(P_1 = 1.00 atm \text{ and } V_1 = 24.6L, P_2 = 2.00 atm, V_3 = 49.2L, P_4 = 1.00 atm\right)$

Calculate $T_1, T_2, T_3 \text{and} T_4$

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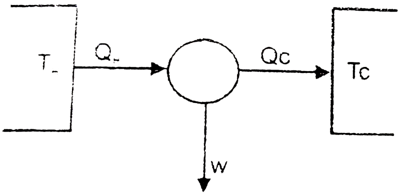
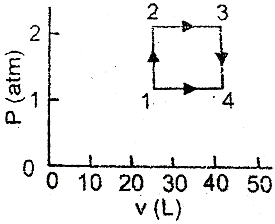


(Figure–1)



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$\left(P_1 = 1.00 atm and V_1 = 24.6L, P_2 = 2.00atm, V_3 = 49.2L, P_4 = 1.00atm\right)$

Calculate ΔE for the paths

$(i)2 \rightarrow 2 \quad (ii)2 \rightarrow 3 \quad (iii)3 \rightarrow 4 \quad (iv)4 \rightarrow 1$

The heal engine depicted in this problem is a 'camot heat engine' and the themodynamic cycleof operations of this engine is known as a 'camot cycle' named after Saudi camot , an engine cum thermodynamist . The efficiency of a camot engine as $\left(1 - T_1/T_2\right)$ where T_1 and T_2 are the temperature of the sink and the source.

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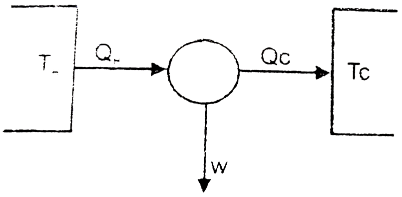
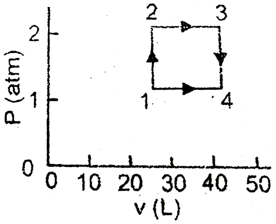
26. A heat engine is a system that converts heat into mechanical work. A heat "source" generates thermal energy that brings a working substance to a high temperature. The working substance then generates work in the engine while transferring heat to a sink at a lower temperature . The working of a heat engine is shownn figure 1.



(Figure–1)



(Figure–2)

Heat engines can be modelled using themodynamic cycles. The heat engine given in Figure -2 is of a working substance which is 1.00 mol of a monoatomic ideal gas . The thermodynamic cycle begins at the point designated as '1' and goes clockwise and the values of P and l or V at each point is as given below Fig-2

$$\left(P_1 = 1.00atm\text{and}V_1 = 24.6L, P_2 = 2.00atm, V_3 = 49.2L, P_4 = 1.00atm\right)$$

Calculate the efficiency of the cycle given in figure 2.

Another system completes a cycle consistings of six quasi-static steps, during which the total work done by the system is 100J During step 1 the system absorbs 300J of heat form a reservior at 300K , during step 3 the system absorbs 200J of heat from a reservior at 400K, and during step5 it abosrbs heat from a reservior at temperature T_3 steps 2,4,6 are adiabatic such that the temperature of one reservoir changes to that of next.

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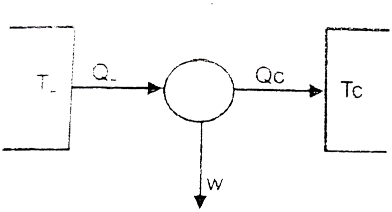
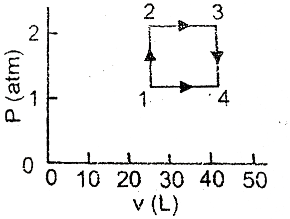


(Figure–1)



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Heat engines can be modelled using themodynamic cycles. The heat engine given in Figure -2 is of a working substance which is 1.00 mol of a monoatomic ideal gas . The thermodynamic cycle begins at the point designated as '1' and goes clockwise and the values of P and l or V at each point is as given below Fig-2

$$\left(P_1 = 1.00 atm \text{and} V_1 = 24.6L, P_2 = 2.00 atm, V_3 = 49.2L, P_4 = 1.00 atm\right)$$

(a) What is the entropy change of the system for the complete cycle?

(b) If the cycle is reversible , what is the temperature T_3?

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28. One mole of $Cl_{2(g)}$ which may be assumed to obey the ideal gas law, initially at 300 K and 1.01325×10^7 Pa, is expanded against a constant exteranl pressure of 1.01325×10^5 Pa to a final pressure of 1.01325×10^6 Pa . As a result of the expansion , the gas cooled to a temperature of 239 K (which is the normal boiling point of Cl_2) and 0.100 mol of Cl_2 condensed.

The enthalpy of vaporization of $Cl_{2(l)}$ is 20.42 $KJ\text{mol}^{-1}$ at the normal volume is $C_v = 28.66JK^{-1}\text{mol}^{-1}$ and the density of $Cl_{2(l)}$ is 1.56 g cm^{-1} (at 239 K) . Assume that the molar heat capacity at constant pressure for $Cl_{2(g)}$ is $C_p = C_v + R$.

$\left(1atm = 101325 \times 10^5 Pa, R = 8.314510Jk^{-1}\text{mol}^{-1} = 0.0820584LatmK^{-1}\text{mol}^{-1}\right)$

(i) Either draw a complete molecular orbital energy diagram or write the complete electronic configuration of Cl_2 Predict the bond order of Cl_2 and thus whether this molecules will be diamagnetic , ferromagnetic ,or paramagnetic.

(ii) For the changes decribed above, calculate the change in the internal energy (ΔE) and the change in the entropy $\left(\Delta S_{\text{sys}}\right)$ of the system.

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29. For the following reaction occuring in dilute aqueous solution at 298K.

$$\left[Ni\left(H_2O\right)_6\right]^{2+} + 2NH_3 \Leftrightarrow \left[Ni\left(NH_3\right)_2\left(H_2O\right)_4\right]^{2+} + 2H_2O \quad \ldots\ldots.(i)$$

In $K_c = 11.60$ and $\Delta H^\circ = -33.5KJ\text{mol}^{-1}$

$$\left[Ni\left(H_2O\right)_6\right]^{2+} + en \Leftrightarrow \left[NI(en)\left(H_2O\right)_4\right]^{2+} + 2H_2O \quad \ldots\ldots.(ii)$$

In K_c =17.78 and $\Delta H^\circ = -37.2KJ\text{mol}^{-1}$

Note : en is ethylenediamine (a neutral bidentate ligand)

$\left(R = 8.314510JK - 1\text{mol}^{-1} = 0.0820584LatmK_1\text{mol}^{-1}\right)$

Calculate the value of $\Delta G^\circ, \Delta S^\circ$ and ΔS° . at 298 K for reaction(iii) occuring in a dilute equeous solution:

$$\left[Ni\left(NH_3\right)_2\left(H_2O\right)_4\right]^{2+} + en \Leftrightarrow \left[Ni(en)\left(H_2O\right)_4\right]^{2+} + 2NH_3 \quad \ldots\ldots.(iii)$$

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30. Oxygen is of vital importance for all of us . Oxygen enters the body via the lungs and is transported to the tissues in our body by blood . There it can deliver energy by the oxidation of sugars.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

This reaction releases 400 KJ of energy per mole of oxygen O_2 uptake by blood is at four heme (Hm) group in this protein hemoglobin (Hb).

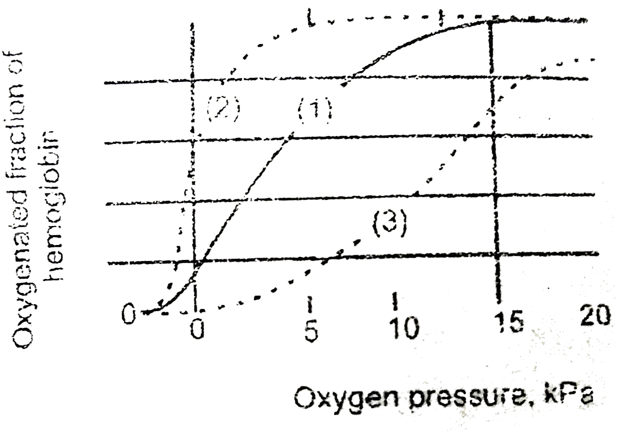
Free Hm consists of an Fe^{2+} giving HmO_2 complex. Carbon monoxides can be complexed similarily giving a Hm CO complex . CO is poison as it bonds more strongly to Hm than O_2 does. The equilibrium constant K_f for the reaction:

$$Hm + CO \Leftrightarrow HCO \quad \ldots\ldots. (i)$$

is 1000 times larger than the equilibrium constant K_2 for the reaction:

$$Hm + CO_2 \Leftrightarrow HmO_2 \quad \ldots\ldots. (ii)$$

Each Hb molecules can take up four molecules of O_2 absorbs a fraction of this amount, depending on the oxygen pressure , as shown in figure1 (curve 1) . Also shown are the curve (2) and (3) for blood with two kinds of dificient Hb . These occur in patients with certain hereditary diseases.



Relevant data , O_2 pressure in lungs is 15 KPa , in the muscles it is 2KPa . The maximum flow of blood through heart and lungs is $4 \times 10^{-4} m^{-3} s^{-1}$. The red cells in blood occupy 40% of the volume, inside the cells the concentration of Hb has a molar mass of 64 kg mol^{-1} R=8.314 $J\text{mol}^{-1} K^{-1}$, T=298k . Using the relation between K and the standard Gibbs energy ΔG° for a reaction, calculated the difference between the ΔG° values for the home reactions (i) and (ii).

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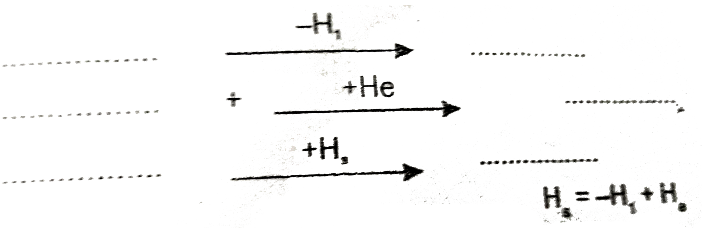
31. Since 1891 lighting lamps have been manufactured in the Netherlands. The improvement today in comparison to the first lamp is enormous , especially with the intorduction of the gas discharge lamps. The life- time has increased by orders of magnitude . the colour is also an important aspect. Rare earth metal compunds like $CeBr_3$ are now included to reach a colour temperature of 6000K in the lamp the compounds are ionic solids at room temperature , and upon heating they sublime partially to give a vapour of neutral metal halide molecules . To achieve a high vapour pressure, the sublimation enthalpy should be as low as possible.

Give a thermochemical cycle (law of Hess) for sublimation of $CeBr_3$, via vapour of mononucler ions ($H_1 = H_{\text{lattice}}, H_e = H_{\text{electrostatic}}, H_s = H_{\text{sublimation}},$ H is not absolute , H means ΔH)



$$H_s = -H_1 + H_e$$

The lattice energy of the solid can be calculated using the Baron -Lande formula,

$$H_1 = d\frac{Z + Z - Ae^2}{r_+ + r_-}\left(1 - \frac{1}{n}\right)$$

The factor Fe^2 (necessary in order to calculate the lattice is 2.985. The Borm exponent n is 11. The charge of the ions Z_+ and Z_- are integer number (Z is negative). For the calculation of the energy of gaseous $CeBr_3$ (when formed from ions) the same Born- Lande formula can be used without A. The structure of $CeBr_3$ in the gas phase is planer triangular . The radius of Ce^{3+} is 0.115 nm and of Br is 0.182nm.

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32. Since 1891 lighting lamps have been manufactured in the Netherlands. The improvement today in comparison to the first lamp is enormous , especially with the intorduction of the gas discharge lamps. The life- time has increased by orders of magnitude . the colour is also an important aspect. Rare earth metal compunds like $CeBr_3$ are now included to reach a colour temperature of 6000K in the lamp the compounds are ionic solids at room temperature , and upon heating they sublime partially to give a vapour of neutral metal halide molecules . To achieve a high vapour pressure, the sublimation enthalpy should be as low as possible.

Calculate the enthalpy of sublimation of $CeBr_3$ (in intergers, be aware of signs).

Attemps to make a better lamp have been undertaken by adding a stoichiometric amount of $CsBr$ to the $CeBr_3$ in the lamp leading at room temperature to solid $CsCeBr_4$ lattice has a NaCl structure with Cs as cations and tetrahedral $CeBr_4^-$ as complex anions. Sublimation of $CsCeBr_4$ leads to a vapour of CsBr and $CeBr_3$ molecules.

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33. Since 1891 lighting lamps have been manufactured in the Netherlands. The improvement today in comparison to the first lamp is enormous , especially with the intorduction of the gas discharge lamps. The life- time has increased by orders of magnitude . the colour is also an important aspect. Rare earth metal compunds like $CeBr_3$ are now included to reach a colour temperature of 6000K in the lamp the compounds are ionic solids at room temperature , and upon heating they sublime partially to give a vapour of neutral metal halide molecules . To achieve a high vapour pressure, the sublimation enthalpy should be as low as possible.

Give the reaction equations of the thermochemical cycle (Law of Hess) for this process in which some steps involve $CeBr_4^-$ ions monmelecular ions and /or neutral molecules in the phase.

Step 1: $\xrightarrow{+H_1}$ +

Step 2 : + $\xrightarrow{+H_2}$

Step 3 : + $\xrightarrow{+H_3}$

Step 4: + $\xrightarrow{+H_4}$

Total : $\left(CsCeBr_4\right)_{\text{lattice}} \xrightarrow{+H_{\text{total}}}$ $\left(CeBr_3\right)_{\text{molecules}} + (CsBr)_{\text{molecules}}$

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34. Since 1891 lighting lamps have been manufactured in the Netherlands. The improvement today in comparison to the first lamp is enormous , especially with the intorduction of the gas discharge lamps. The life- time has increased by orders of magnitude . the colour is also an important aspect. Rare earth metal compunds like $CeBr_3$ are now included to reach a colour temperature of 6000K in the lamp the compounds are ionic solids at room temperature , and upon heating they sublime partially to give a vapour of neutral metal halide molecules . To achieve a high vapour pressure, the sublimation enthalpy should be as low as possible.

Calculate the enthalpy of sublimation fo $CsCeBr_4$ (in integers) Use the Born-Lande formula for all steps in the process and report the separate energies also (be aware of the signs). The $CeBr_4^-$ anion is a teteahedron and in which the ratio between the edge and the destance between a corner of the tetrahedron and the centre of gravity (body - radius) amounts to $\left(2\sqrt{6}\right)/3 = 1.33$. The Born exponent of the CsBr is 11. The radius of Cs is 0.181 nm.

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35. Since 1891 lighting lamps have been manufactured in the Netherlands. The improvement today in comparison to the first lamp is enormous , especially with the intorduction of the gas discharge lamps. The life- time has increased by orders of magnitude . the colour is also an important aspect. Rare earth metal compunds like $CeBr_3$ are now included to reach a colour temperature of 6000K in the lamp the compounds are ionic solids at room temperature , and upon heating they sublime partially to give a vapour of neutral metal halide molecules . To achieve a high vapour pressure, the sublimation enthalpy should be as low as possible.

Conclusion in relation to the previous answers. was adding CsBr a good idea ? Mark the correct answer.

⇒ Adding CsBr is counterproductive.

⇒ Adding CsBr has no influence

⇒ Adding CsBr is advantageous

⇒ From these data no clear answer can be given.

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36. A very large swimming pool filled with water of temperture equal to $20^\circ C$ is heated by a resistor with a heating power of 500 W for 20 minutes. Assuming the water in the pool is not in any contact with anything besides the resistor, determine the following quanties.

The heat delivered to the water.

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37. A very large swimming pool filled with water of temperture equal to $20^\circ C$ is heated by a resistor with a heating power of 500 W for 20 minutes. Assuming the water in the pool is not in any contact with anything besides the resistor, determine the following quanties.

Is the change of entropy of the resistor positive , negative or zero?

$(i)\Delta S_{\text{rev}} > 0 \quad (ii)\Delta S_{\text{rev}} = 0 \quad (iii)\Delta S_{\text{rev}} < 0$

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38. A very large swimming pool filled with water of temperture equal to 20°C is heated by a resistor with a heating power of 500 W for 20 minutes. Assuming the water in the pool is not in any contact with anything besides the resistor, determine the following quanties.

Is the change of entropy of the water positive, negative or zero?

$(i)\Delta S_{\text{pool}} > 0 \quad (ii)\Delta S_{\text{pool}} = 0 \quad (iii)\Delta S_{\text{pool}} < 0$

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39. A very large swimming pool filled with water of temperture equal to 20°C is heated by a resistor with a heating power of 500 W for 20 minutes. Assuming the water in the pool is not in any contact with anything besides the resistor, determine the following quanties.

Is the change of entropy of the system positive , negative or zero?

$(i)\Delta S_{\text{total}} > 0 \quad (ii)\Delta S_{\text{total}} = 0 \quad (iii)\Delta S_{\text{total}} < 0$

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40. A very large swimming pool filled with water of temperture equal to 20 °C is heated by a resistor with a heating power of 500 W for 20 minutes. Assuming the water in the pool is not in any contact with anything besides the resistor, determine the following quanties.

Is the process reversible ? (Y/N)

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41. For his 18th birthday in February Peter plants to turn a hut in the garden of his parents into a swimming pool with an artifical beach. In order to estimate the consts for heating the water and the house , peter obtains the data for the natural gas combustion and its price.

Write down the chemical equations for the complete conbustion of the main components of natural gas, methane and ethane , given in table-1. Assume tht nitrogen is inert under the chosen conditions. Calculate the reaction enthalpy , the reaction entropy , and the Gibbs energy under standard conditons $\left(1.013 \times 10^5 Pa, 25.0\,^{\circ}C\right)$ for the combustion of methane and ethane according to the equations above assuming that all products are gaseous .

The thermodynamic properties and the composition of natural gas can be found in table 1.

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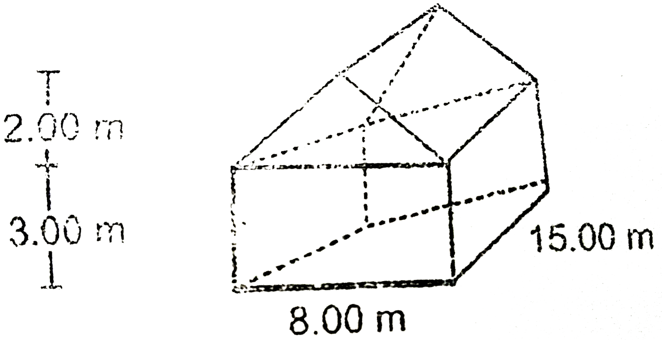
42. For his 18th birthday in February Peter plants to turn a hut in the garden of his parents into a swimming pool with an artifical beach. In order to estimate the consts for heating the water and the house , peter obtains the data for the natural gas combustion and its price.

The desity of natural gas is $0.740 gL^{-1}\left(1.013 \times 10^5 Pa, 25\,^{\circ}C\right)$ specified by PUC , the public utility company. (a) Calculate the amount of methane and ethane (in moles) in $1.00 m^3$ of natural gas (natural gas, methane and ethane are not ideal gases).

(b) Calculate the combustion energy which is released as thermal energy during the buring of $1.00m^3$ of natural gas under standard conditions assuming that all products are gaseous .(if you do not have the amount from 1.2 a) assume that $1.00m^3$ natural gas corresponds to 40.00 mol natural gas)

According to the PUC the combustion energy will be 9.981K Wh per m^3 of natural gas if all products are gaseous . How large is the deviation (in percent) from the value you obtained in b?

The swimming pool inside the house is 3.00 m wide ,5.00 m long and 1.50 m deep (below the floor) . The tap water temperature is $8.00\,^\circ C$ and the air temperature in the house (dimensions given in the figure) is $10.0\,^\circ C$. Assuming a water density of $\rho = 1.00KgL^{-1}$ and air behaving like an ideal gas.



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43. For his 18th birthday in February Peter plants to turn a hut in the garden of his parents into a swimming pool with an artifical beach. In order to estimate the consts for heating the water and the house , peter obtains the data for the natural gas combustion and its price.

Calculate the energy (in MJ) which is requried of heat the water in the pool to $22.0^\circ C$ and the energy which is required of heat the initial amount of air $\left(21.0\% ofO_2, 79\% ofN_2\right)$ to $30.0^\circ C$at a pressure of 1.013×10^5 Pa.

In February , the outside temperature is about 5° C in Northern Germany. Since the concrete walls and the cost of the house are relatively thin (20.0cm) there will be a loss of energy . This energy is released to the surroundings (heat loss released to water and/or ground should be neglected). The heat conductivity of the wall and the roof is $1.00WK^{-1}M^{-1}$

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44. For his 18th birthday in February Peter plants to turn a hut in the garden of his parents into a swimming pool with an artifical beach. In order to estimate the consts for heating the water and the house , peter obtains the data for the natural gas combustion and its price.

Calculate the energy (in MJ) which is needed to maintain the temperature inside the house at $30.0^\circ C$ during the party (12 hours) .

$1.00m^3$ of natural gas as delivered by PUC costs 0.40 € and $1.00k$ Wh of electricity costs 0.137 € . The rent for the equipment for gas heating will cost him about 150.00 € while the corresponding electrical heaters will only cost 100.00 €.

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45. For his 18th birthday in February Peter plants to turn a hut in the garden of his parents into a swimming pool with an artifical beach. In order to estimate the consts for heating the water and the house , peter obtains the data for the natural gas combustion and its price.

What is the total energy (in MJ) needed for Peter's "winter swimming pool" calculated in 1.3 and 1.4? How much natural gas will he need, if the gas heater has an efficiency of 90.0% ?

What are the different costs for the use of either natural gas or electricity ? Use the values given by PUC for your calculations and assume 100% efficiency for the electric heater.

Table 1: Composition of natural gas

Chemical substance	mol fraction x	$D_1H^\circ \left(KJmol^{-1}\right)^{-1}$	$S^\circ \left(Jmol^{-1}K^{-1}\right)^{-1}$
$CO_{2(g)}$	0.0024	-393.5	213.6
$N_{2(g)}$	0.0134	0.0	191.6
$CH_{2(g)}$	0.9732	-74.6	186.3
$C_2H_{3(g)}$	0.0110	-84.0	229.2
H_2O_g	-	-285.8	70.0
H_2O_g	-	-241.8	188.8
H_2O_g	-	0.0	205.2

Equation

$J = E(A.\,\Delta t)^{-1} = !!\lambda\text{wall}.\,\Delta T.\,d^{-1}$, where

J= energy flow E along a temperature gradient (wall direction Z) par area A and time Δt, d-wall thickness , λwall -heat conductivity , ΔT - difference in temperature between the inside and the outside of the house.

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Others

1. What are state variables ?

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2. For the process to occur under adiabatic condition write the correct condition.

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3. In a process, $701 J$ of heat is absorbed by a system and $394 J$ of work is done by the system. What is the change in internal energy for the process?

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4. How many the state of thermodynamic system be defined?

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5. Calculate the number of KJ necessary to raise the temperature of $60.0g$ of aluminium from 35° to $55^{\circ}C$. Molar heat capcacity of Al is $24Jmol^{-1}K^{-1}$

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6. (a) Write any six thermodynamic state functions

(b) Reversible isothermal expansion work formula.

(c) Irreversible isothermal expansion work formula.

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7. Calculate the enthalpy change of freezing of 1.0 mol of water at $10^{\circ}C$ to ice at $-10^{\circ}C$, $\Delta_{fus}H = 6.03kJmol^{-1}$ at $0^{\circ}C$.

$C_P\left[H_2O(l)\right] = 75.3 Jmol^{-1}K^{-1}$

$C_P\left[H_2O(s)\right] = 36.8 Jmol^{-1}K^{-1}$

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