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CHEMISTRY

BOOKS - CHHAYA CHEMISTRY (BENGALI ENGLISH)

CHEMICAL THERMODYNAMICS

NUMERICAL EXAMPLES

1. The volume and temperature of 2 mol of an ideal gas are 10 L & $27^{\circ}C$, respectively. The gas is allowed to expand in an isothermal reversible process to attain a final volume of 25 L. calculate the maximum work done.

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2. A 3 mol sample of an ideal gas at STP expands in an isothermal reversible process to atttain a final volume of 100 L. calculate the work done by the gas.

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3. A 2.5 mol sample of an ideal gas is compressed in reversible isothermal process from a volume of 12L to a volume of 5 L at $27^{\circ}C$. Calculate the work done on the gas.

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4. A gas is compressed by an external pressure of 5 atm. The work done in the process is 1034 J. How much volume of the gas is reduced?

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5. Work done by 3 mol of an ideal in an isothermal reversible expansion of $30^\circ C$ is 9.5 kJ. If the initial volume of the gas is 20 L, then what will be the final volume of the gas?

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6. The pressure of 3 mol of an ideal gas is 10 atm at $27^\circ C$. Calculate work done by the gas when it is expanded isothermally against an external pressure of 1 atm.

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7. The pressure of 6 mol N_2 gas kept in a cylinder is 30 atm at $30^\circ C$. Suddenly the gas comes out of the cylinder due to leakage. If the atmospheric pressure and temperature and 1 atm and $30^\circ C$, then calculate the work done by the gas. Assume that the gas behave ideally.

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8. A 5 mol sample of an ideal gas is compressed isothermally and irreversible from 1.5 atm to 15 atm at $27^{\circ} C$. Calculate the work done on the gas in calorie unit.

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9. What amount of work is done if an ideal gas expands from 10 L of 20 L at 2 atm pressure?

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10. What amount of work is done if an ideal gas is commpressed from 0.5 to 0.25 L under 0.1 atm pressure?

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11. Calculate the work done when 1 mol of water vaporises at $100^\circ C$ and 1 atm pressure. Assume water vapour behaves like an ideal gas.

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12. Iron reacts with dilute HCl quantitatively to form $H_2: Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

56g of iron is allowed to react completely with dil HCl at 25°. If this reaction is carried out seperately (1) in a closed container of fixed volume and (2) in an open breaker, then calculate the work done in each case. assume H_2 gas behaves like an ideal gas.

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13. Calculate the change in internal energy when-

(1) heat released by the system is 200 J and work done on the system is 120 J (2) heat absorbed and work done by the system are 200 J and 120 J

respectively (3) heat released and work done by the system are 200 J and 120 J respectively.

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14. In a process, the system performs 142J of work and the internal energy of the system increases by 879 J. predict the direction of heat flow and also calculate the quantity of heat transferred.

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15. A system undergoes a process in which it gives up 900 J of heat and its internal energy decreases by 300 J. of the system and its surroundings, which one does work in this process?

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16. Initial volume of a gas, condined in a cylinder fitted with a piston is 11.2 L. the final volume of the gas becomes 33.6L after expansion againsta expansion if the gas absorbs 1 kJ of heat from the surrounding then what will be the change in internal energy of that gas?

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17. An ideal gas is expanded from 1L to 6L in a closed vessel at 2 atm pressure by applying heat at fixed temperature. Calculate work done and heat absorbed by the gas. [Given: 1 L atm=24.22 cal]

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18. A cylinder fitted with a piston contains an ideal gas with a volume of 21 L. the gas is compressed isothermally to 1/3 rd of its initial volume under a constant external pressure of 3 atm. Calculate q, w and ΔU.

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19. 1 mol of a non-ideal gas undergoes the given change: (2 atm, 3L, 95 K) $\rightarrow$ (4 atm, 5L, 245 K). In this process, if increase in internal energy of the gas is 30 L $\cdot$ atm, then what will be its change in enthalpy?

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20. Determine the change in enthalpy and internal energy when 1 mole of water completely vaporises at $100^{\circ}C$ and 1 atm pressure. [Latent heat of vaporisation of water=536$cal \cdot g^{-1}$]

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21. How much heat is required to raise the temperature of 90 g of water from $30^{\circ}C$ to $100^{\circ}C$? [Molar heat capacity of water at constant pressure $= 75.3J \cdot mol^{-1} \cdot K^{-1}$]

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22. How much heat will be released when the temperature of 1 mol of water changes from $90^\circ C$ to $80^\circ C$? Given: specific heat of water $4.18 J \cdot g^{-1} \cdot K^{-1}$.

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23. Specific heat of an ideal gas at constant volume & at constant pressure are 0.015 and 0.025 $cal \cdot g^{-1} \cdot K^{-1}$ respectively. Determine molar mass of the gas.

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24. At a fixed temperature & pressure, heat released in the formation of 3 mol $SO_3(g)$ from $SO_2(g)$ and $O_2(g)$ is 291 kJ. What will be the change in enthalpies in the formation of 1 mol & 4 mol $SO_3(g)$?

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25. At a particular temperature and pressure, the heat produced in the formation of 2 mol of $C_2H_6(g)$ from the reaction between $C_2H_2(g)$ and $H_2(g)$ is 626 kJ. What amount of $H_2(g)$ will react with the required amount of $C_2H_2(g)$ to produce 939 kJ of heat at the same temperature and pressure?

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26. At a particular temperature and pressure, $N_2(g)$ and $O_2(g)$ react to form 4 mol of N_2O. The heat oabsorbed in this reaction is 328 kJ. What will be change in enthalpy be due to the formation of 2 mol of $N_2(g)$ and 1 mol of $O_2(g)$ from $N_2O(g)$ at the same temperature and pressure?

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27. The value of ΔH for the given reaction at 298K is -282.85$kJ \cdot mol^{-1}$. Calculate the change in intenral energy: $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$.

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28. Bond energy of a diatomic molecule is given as the change in internal energy due to dissociation of that molecule. Calculate the bond energy of O_2. Given: $O_2(g) \rightarrow 2O(g), \Delta H = 498.3kJ \cdot mol^{-1}, T = 298K.$

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29. Calculate the values of ΔH and ΔU in the vaporisation of 90g of water at $100^\circ C$ and 1 atm pressure. The latent heat of vaporisation of water at the same temperature and pressure $= 540cal \cdot g^{-1}$

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30. Assuming the reactant and product gases obey the ideal gas law, calculate the change in internal energy (ΔE) at $27^\circ C$ for the given reaction:

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l), \Delta H = -337$

kcal at $27^\circ C$ and R=1.987$cal \cdot K^{-1} \cdot mol^{-1}$.

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31. Calculate the standard enthalpy of reaction at $25^\circ C$ temperature for the following reaction:

$$C_6H_6(l) + \frac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$$

Given:The standard enthalpy of formation of $C_6H_6, CO_2(g)$ and $H_2O(l)$ are 49.0 kJ $\cdot mol^{-1}$, $-393.5kJ \cdot mol^{-1}$ and $-285.8kJ \cdot mol^{-1}$ respectively.

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32. Calculate standard enthalpy of reaction at $25^\circ C$ for the reaction: $CCl_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4HCl(g)$. Given: The standard heat of formation of $CCl_4(g), H_2O(g), CO_2(g)$ and $HCl(g)$ are $-25.5, -57.8, -94.1$ and $-22.1kcal \cdot mol^{-1}$.

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33. ΔH value for the given reactions at $25^\circ C$ are-

$C_3H_8(g) \rightarrow 3C(s) + 4H_2(g), \Delta H^0 = 103.8kJ \cdot mol^{-1}$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l), \Delta H^0 = -571.6kJ \cdot mol^{-1}$

$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H^0 = -1560kJ \cdot mol^{-1}$

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta H^0 = -890kJ \cdot mol^{-1}$

$C(s) + O_2(g) \rightarrow CO_2(g), \Delta H^0 = -393.5kJ \cdot mol^{-1}$

Calculate ΔH^0 for the reaction at $25^\circ C$

$C_3H_8(g) + H_2(g) \rightarrow C_2H_6(g) + CH_4(g)$

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34. Calculate ΔH^0 for the following reaction at 298K:

$C_2H_2(g) + CO(g) + H_2O(l) \rightarrow C_2H_3COOH(l)$

Given: at 298K temperature,

$C_2H_3CO_2H(l) + 3O_2(g) \rightarrow 3CO_2(g) + 2H_2O(l), \Delta H^0 = -1368kJ$

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l), \Delta H^0 = -2600kJ$

$2CO(g) + O_2(g) \rightarrow 2CO_2(g), \Delta H^0 = -566kJ.$

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35. Calculate the enthalpy change for the reaction:

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

Given:

$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H^0 = -1562.0kJ$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^0 = -286.0kJ$

$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g), \Delta H^0 = -32.0kJ$

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36. The heat of reaction for the following reaction (ΔH^0) at $25^\circ C$ temperatue is -1368 kJ:

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

If the enthalpy of formation of $CO_2(g)$ and $H_2O(l)$ at $25^\circ C$ are -393.5

and -285.8$kJ \cdot mol^{-1}$ respectively, then what will be the value of the standard enthalpy of formation of $C_2H_5OH(l)$?

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37. Calculate the standard enthalpy of formation of $C_6H_6(l)$ at $25^\circ C$ temperature using the given data:

$$C_6H_6(l) + \frac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l), \Delta H^0 = -781kcal$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^0 = -68.32kcal$$

C (s, graphite)$+O_2(g) \rightarrow CO_2(g), \Delta H^0 = -94.04kcal.$

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38. At $25^\circ C$ temperature, the heat of combustion of sucrose, carbon and hydrogen are -5644 $kJ \cdot mol^{-1}$, $-393.5kJ \cdot mol^{-1}$ & $-285.8kJ \cdot mol^{-1}$ respectively. Determine the heat of formation of sucrose at $25^\circ C$.

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39. At $25^\circ C$ temperature, the standard heat of formation of $CH_4(g), CO_2(g)$ and $H_2O(g)$ are -74.8 $kJ \cdot mol^{-1}, -393.5kJ \cdot mol^{-1} \& -241.6kJ \cdot mol^{-1}$ respectively. How much heat will be evolved during combustion of $1m^3 CH_4(g)$ at $25^\circ C$ temperature and 1 atm pressure ? Consider $CH_4(g)$ behaves like an ideal gas.

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40. Calculate the value of enthalpy of combustion of cyclopropane at $25^\circ C$ and 1 atm pressure.

Given: Standard enthalpy of formation of $CO_2(g), H_2O(l)$ & propene (g) at $25^\circ C$ are $-393.5kJ \cdot mol^{-1}, -285.8kJ \cdot mol^{-1} \& 20.4kJ \cdot mol^{-1}$ respectively. also standard enthalpy change for isomerisation reaction: Cyclopropane (g) $\Leftrightarrow$ Propene (g) is $-33.0kJ \cdot mol^{-1}$.

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41. Diborane $[B_2H_6(g)]$ is used as a very effective fuel for rockets. Calculate the heat of combustion of diborane for the following reaction:

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

Given: (1) $2B(s) + \frac{3}{2}O_2(g) \rightarrow B_2O_3(s), \Delta H^0 = -1273kJ \cdot mol^{-1}$

(2) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^0 = -285.8kJ \cdot mol^{-1}$.

(3) $H_2O(l) \rightarrow H_2O(g), \Delta H^0 = +44kJ \cdot mol^{-1}$

(4) $2B(s) + 3H_2(g) \rightarrow B_2H_6(g), \Delta H^0 = +36kJ \cdot mol^{-1}$.

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42. At $25^\circ C$, heat evolved due to complete combustion of 7.8 g of $C_6H_6(l)$ is 326.4 kJ. Calculate the heat evolved due to complete combustion of the same amount of $C_6H_6(l)$ at the same temperature and constant pressure of 1 atm.

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43. Calculate (1) the enthalpy change in the fusion of 100 g ice at $0^{\circ}C$ temperature and 1 atm pressure pressure (2) the enthalpy change in the vaporisation of 10g water at $100^{\circ}C$ temperature and 1 atm pressure. Givenn : Latent heat of ice at $0^{\circ}C$ temperature and 1 atm pressure $= 6.02kJ \cdot mol^{-1}$ and latent heat of vaporisation of water at $100^{\circ}C$ temperature=$40.4kJ \cdot mol^{-1}$.

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44. Heat required to completely vaporise 7.8g of benzene at 1 atm pressure and $80^{\circ}C$ temperature (boiling point of benzene) is 3.08 kJ. What is the value of the enthalpy of vaporisation of benzene? What will be the change in enthalpy if 54.6 g of benzene vapour is condensed at 1 atm pressure and $80^{\circ}C$ temperature ?

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45. Determine the heat of neutralisation for the following neutralisation reactions: (1) 100 L of 0.2 (M) HCl solution is mixed with 200 mL of 0.15 (M) NaOH solution. (2) 200 mL of 0.4 (M) H_2SO_4 solution is mixed with 300 mL of 0.2 (M) KOH solution.

Given: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l), \Delta H = -57.3kJ.$

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46. The heat of neutralisation of acetic and NaOH is 55.9 kJ. If the heat of neutralisation of all strong acids and strong bases is 57.3 kJ, then calculate the heat of ionisation of acetic acid.

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47. Calculate the bond energy of O-H bond in $H_2O(g)$ at the standard state from the following data:

(1) $H_2(g) \rightarrow 2H(g), \Delta H^0 = 436kJ \cdot mol^{-1}$

(2) $\frac{1}{2}O_2(g) \rightarrow O(g), \Delta H^0 = 249k \cdot mol^{-1}$

(3) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g), \Delta H_f^0[H_2O(g)] = -241.8kJ \cdot mol^{-1}$.

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48. Calculate the bond energy of S-F bond in SF_6, $S(g)$, $F(g)$ are -1100, 275, 80 $kJ \cdot mol^{-1}$ respectively.

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49. Determine the standard enthalpy of formation of isoprene(g) at 298K temperature. Given: at 298K,

$\Delta H^0(C-H) = 413kJ \cdot mol^{-1}$

$\Delta H^0(H-H) = 436kJ \cdot mol^{-1}$

$\Delta H^0(C-C) = 346kJ \cdot mol^{-1}$,

$\Delta H^0(C=C) = 611kJ \cdot mol^{-1}$,

$C(\text{graphite, s}) \rightarrow C(\text{graphite, g})$,

$\Delta H^0 = 717kJ \cdot mol^{-1}$

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50. Calculate standard enthalpy for the reaction at 298K: $C_2H_5Cl(g) \rightarrow C_2H_4(g) + HCl(g)$. Given: $\Delta H^0(C-H) = 413kJ \cdot mol^{-1}$, $\Delta H^0(C-C) = 346kJ \cdot mol^{-1}$, $\Delta H^0(C=C) = 611kJ \cdot mol^{-1}$, $\Delta H^0(C-Cl) = 339kJ \cdot mol^{-1}$, $\Delta H^0(H-Cl) = 432kJ \cdot mol^{-1}$.

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51. When 1.0g of a compound (molecular weight=28) is burnt in a bomb calorimeter, the temperature of the calorimeter rises from $25^\circ C$ to $25.45^\circ C$. Calculate the heat that evolves when 1 mol of this compound is completely burnt $\left(C_{cal} = 2.5kJ \cdot K^{-1}\right)$.

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52. At $25^\circ C$ the heat of combustion at constant volume of 1 mol of a compound is 5150 kJ. The temperature of a bomb calorimeter rises from $25^\circ C$ to $30.5^\circ C$ when a certain amount of the compound is burnt in it. If the heat capacity of the calorimeter is 9.76 $kJ \cdot K^{-1}$ then how much of the compound was taken for combustion. [Molar mass of the substance=128]

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53. Latent heat in fusion of ice at $0^\circ C$ is 6025.24$J \cdot mol^{-1}$. Calculate molar entropy of the process at $0^\circ C$.

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54. Enthalpy change for the transformation of water into vapour at the standard boiling point is 40.8 k$J \cdot mol^{-1}$. Calculate the entropy change for the process.

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55. Calculate the entropy change at 0° C for the process-

$H_2O(s) \rightarrow H_2O(l)$. Given: At

$0^2C \quad C_2O(s) \rightarrow H_2O(g), \Delta H = 51885 J \cdot mol^{-1}$ and $H_2O(l) \rightarrow H_2O(g)$

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56. The enthalpy of vaporisation of benzene at $80^\circ C$ (boiling point) is 31 $kJ \cdot mol^{-1}$. What will be the change in entropy of rthe transformation of $31.2g$ of benzene vapour into liquid benzene at $80^\circ C$?

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57. 1 mol of an ideal gas is expanded from its initial volume of 1 L to the final volume of 100 L at $25^\circ C$. What will be the change in enthalpy for this process?

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58. Pressure of 1 mol of an ideal gas confined in a cylinder fitted with a piston is 50 atm. The gas is expanded reversible when the cylinder is kept in contact to a thermostat at $25^{\circ}C$. During expansion, the pressure of the gas is decreased from 50 to 5 atm. calculate the change in entropy in this process. if the heat absorbed by the gas during expansion be 5705J, then calculate the change in entropy of the surroundings ?

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59. At 1 atm and 298 K, entropy change of the reaction, $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ is -549.4$J \cdot K^{-1}$. In this reaction, if $\Delta H = -1648kJ$, then predict whether the reaction is spontaneous or not.

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60. At 1 atm and 298K ΔH^0 value of the reaction $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ is -572 kJ. Calculate the change in entropy of the system and surroundings for this reaction. Is this reaction spontaneous at that temperature and pressure? Given: Standard molar entropies of $H_2(g), O_2(g) \& H_2O(l)$ at 298K are 130.6, 205.0 and 69.90 $J \cdot K^{-1} \cdot mol^{-1}$ respectively.

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61. The molar enthalpy of fusion and molar entropy of fusion for ice at $0^\circ C$ and 1 atm are 6.01 $kJ \cdot mol^{-1}$ and $22.0 J \cdot K^{-1} \cdot mol^{-1}$, respectively. Assuming ΔH and ΔS are independent of temperature, show that the melting of ice at 1 atm is not spontaneous, while the reverse process is spotantaneous.

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62. $Br_2(l) + Cl_2(g) \rightarrow 2BrCl(g)$, Whether the reaction is spontaneous or not at a certain pressure & 298 K? $[\Delta H = 29.3kJ \cdot mol^{-1}, \Delta S = 104.1J \cdot K^{-1} \cdot mol^{-1}]$

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63. At a certain pressure and $27^\circ C$, the values of ΔG and ΔH of a process are -400 kJ and 50 kJ respectively. (1) Is the process exothermic? (2) It is spontaneous? (3) Determine entropy change of the process.

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64. Values of $\Delta H \Delta S$ for the given reaction are -95.4 kJ and -198.3 $J \cdot K^{-1}$ respectively:

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

State whether the reaction will be spontaneous at 500 K or not. Consider ΔH and ΔS are independent of temperature.

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65. In the reaction, $A(s) + B(g) \rightarrow C(g) + D(g), \Delta H = 31kJ$ and $\Delta S = +35J \cdot K^{-1}$. State whether the reaction will be spontaneous at $100^{\circ}C$ and $1100^{\circ}C$ or not? Consider ΔH and ΔS are independent of temperature.

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66. Is the vaporisation of water at $50^{\circ}C$ and 1 atm spontaneous? Given: For vaporisation of water at what temperature and pressure, $\Delta H = 40.67kJ \cdot mol^{-1}$ and $\Delta S = 108.79J \cdot K^{-1} \cdot mol^{-1}$.

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67. At $25^{\circ}C$ and 1 atm, the heat of formatio of 1 mol of water is -285.8 kJ $\cdot mol^{-1}$. State whether formation reaction will be spontaneous at that temperature and pressure or not. Given: The molar entropies of

$H_2(s), O_2(g) \& H_2O(l)$ at $25^\circ C$ and 1 atm are 130.5, 205.0 and 69.9 $J \cdot K^{-1} \cdot mol^{-1}$ respectively.

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68. In the reaction, $A \rightarrow B + C, \Delta H = 25kJ \cdot mol^{-1}$ and $\Delta S = 62.5J \cdot K^{-1}$. At which temperature the reaction will occur spontaneously at constant pressure?

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69.

$H_2O(g) \rightarrow H_2O(l), \Delta H = -40.4kJ \cdot mol^{-1}$ and $\Delta S = -108.3J \cdot K^{-}$

. At which temperature the process will be spontaneous at constant 1 atm?

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70. $H_2(g) + Br_2(l) \rightarrow 2HBr(g), \Delta H = -72.8kJ(1\text{ atm }, 25^\circ C)$ if molar entropies of $H_2(g), Br_2(l), HBr(g)$ are 130.5, 152. 3 & 198.3 $J \cdot K^{-1} \cdot mol^{-1}$ respectively then at which temperature the reaction will be spontaneous?

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71. For the reaction $A(g) + B(g) \rightarrow C(s) + D(l), \Delta H = -233.5kJ$ and $\Delta S = -466.1J \cdot K$. At what temperature, equilibrium will be established? In whichi directions the reaction will proceed above and below the temperature?

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72. In the given reaction, calculate the standard free energy change at $25^\circ C: N_2(g) + 3H_2(g) \rightarrow 2NH_3$ [Given that, $\Delta H^0 = -91.8kJ$ and $\Delta S^0 = -198J \cdot K^{-1}$]

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73. In the given reaction, calculate standard free energy change at $25^\circ C: 2NO(g) + O_2(g) \rightarrow 2NO_2(g)$. Is the reaction spontaneous under standard conditios?

[Given: At $25^\circ C$, $\Delta G_f^0[NO(g)] = 88.57kJ \cdot mol^{-1}$ and $\Delta G_f^0[NO_2(g)] = 51.30kJ \cdot m$

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74. At $25^\circ C$, the standard free energy change for a reaction is 5.4 kJ. Calculate the value of equilibrium constant of the reaction at the temperature.

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75. Equilibrium constant for a reaction 1.6×10^{-6} at 298K. Calculate standard free energy change (ΔG^0) and standard entropy change (ΔS^0) of the reaction wat that pressure. Given, at 298K, $\Delta H^0 = 25.34kJ$

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76. At 298K, the standard free energy of formation of $H_2O(l) = -237.13kJ \cdot mol^{-1}$. Calcualte the value of equilibrium constant at that temperature for the following reaction: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$.

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WARM UP EXERCISE

1. Define the following with examples: (i) Open system, (ii) Closed system, (iii) Isolated system.

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2. What are diathermal and adiabatic boundaries?

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3. Identify the correct statement in a chemical reaction-

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4. What is an adiabatic system? Is this an isolated system?

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5. Identify the following as an extensive or intensive property: Enthalpy, internal energy, pressure, viscosity, heat capacity, density, electric

potential, specific heat capacity, molar volume, surface tension, universal gas constant, vapour pressure, number of moles, refractive index, entropy.

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6. A closed container with impermeable diathermal walls contains some amount of gas. If the gas is considered to be a system, what type of system will it be?

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7. X is a state function of a thermodynamic system. How are its finite and infinitesimal changes denoted?

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8. What do you mean by a state function? Give some examples of state functions.

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9. Thermodynamic state functions are path-independent quantities. Explain with an example.

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10. Give two examples of path-dependent quantities. Are they properties of a system?

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11. Under what conditions will a system be in themodynamic equilibrium?

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12. Why is the change in any state function in a cyclic process zero? Is the change in any state function for both reversible and irreversible cyclic process zero?

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13. A closed system participates in the following process: $A \rightarrow B \rightarrow C$. In the step $A \rightarrow B$, heat absorbed by the system =q cal and in the step $B \rightarrow C$, heat released by the system=q cal. Therefore, in this process the sum of the heat absorbed and heat released by the system is zero. is this an adiabatic process? Given reason.

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14.

1 mol of an ideal gas participate in the process as described in the figure. (i) What type is the overall process? (ii) is this an isothermal process? (iii) Mention the isobaric and isochoric steps in this process.

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15. Are the following changes reversible or irreversible? Give proper explanations: (i) Melting of ice at $0^{\circ}C$ and 1 atm pressure (ii) The pressure of a gas enclosed in a cylinder fitted with a piston is 5 atm. The gas is expanded against an external pressure of 1 atm.

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16.

One mole of an ideal gas participates in a cylic reversible process as described in the figure. Indicate the type of the processes the system undergoes in the steps AB, BC and CA. Assume $T_2 > T_1$.

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17. Why is a process occurring in an open container considered to be an isobaric?

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18. What is the origin of internal energy of a system? Why cannot absolute value of internal energy be determined?

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19. Why is the internal energy of a system a state function?

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20. Is the internal energy of a system at $25^\circ C$ greater or less than its internal energy at $50^\circ C$?

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21. In the process $A \rightarrow B \rightarrow C$, the change in internal energy of the system in the steps $A \rightarrow B$ and $B \rightarrow C$ are -x $jK \cdot mol^{-1}$ and $ykJ \cdot mol^{-1}$, respectively. What will be the change in internal energy of the system in the step $C \rightarrow A$?

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22. What do you mean by heat and work in thermodynamics?

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23. When heat (q) is absorbed by a system, the sign of q is positive, and when it is rejected by a system, the sign of q is negative. Why?

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24. When work (w) is done by the system, the sign of w is negative. But when it is done on the system, the sign of w is positive, give reason.

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25. Which is not a state function: $(q+w)$, w, H, G ?

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26. In a process, a system absorbs 500J of heat performs 800J of work. In the process, q=_____ and w=_____.

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27. In a process, a system releases 500J of heat and work done on the system is 300J. In the process, q=___ and w=____.

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28.

A certain amount of a gas participates in the cyclic process ABCD (follow figure). Calculate the total work done in the process.

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29. Under which condition will the pressure-volume work be, $w = -\int_{V_1}^{V_2} PdV$? [P=pressure of the gas].

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30. Calculate the work done in the following process which an ideal gas undergoes.

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31. A particular amount of gas participates separately in the two process given below:

Process-I:

$$P_1V_1 \xrightarrow[\text{expansion}]{\text{constant pressure}} P_1V_2 \xrightarrow[\text{decrease in pressure}]{\text{constant volume}} P_2V_2$$

Process-II

$$P_1V_1 \xrightarrow[\text{decrease in pressure}]{\text{constant volume}} P_2V_1 \xrightarrow[\text{expansion}]{\text{constant pressure}} P_2V_2$$

For which process, work done |w| is maximum?

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32. In which of the following reactions is the work done zero? Assign the sign of w (+ve or -ve) for the cases in which work is involved.

(i) $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

(ii) $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$.

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

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33. Why does the total energy of an isolated system remains constant?

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34. Write down the mathematical form of the first law of thermodynamics for an infinitesimal change that involves only pressure-volume work. Write down the form of this equation if the above change occurs reversibly.

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35. According to the first law of thermodynamics, $\Delta U = q + w$. Write down the form of this equation for the following process: (i) cyclic process (ii) adiabatic process (iii) isothermal expansion of an ideal gas (iv) process occurring in an isolated system.

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36. Among the following processes identify those in which the change in internal energy (ΔU) is zero: (i) isothermal compression of an ideal gas (ii) adiabatic expansion of an ideal gas (iii) Free adiabatic expansion of an ideal gas (iv) reversible cyclic process (v) irreversible cyclic process.

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37. A closed system undergoes a process $A \rightarrow B$. If it occurs reversible, then the system absorbs q_1 amount of heat and performs w_1 amount of work. However, if it occurs out irreversible, then the system absorbs q_2 amount of heat and does w_2 amount of work. is $(q_1 + w_1)$ greater than, less than or equal to $(q_2 + w_2)$?

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38. For an ideal gas, the isothermal free expansion and adiabatic free expansion are basically the same processes- explain.

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39. For chemical changes, why is the change in enthalpy more useful than the change in internal energy?

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40. From the equation H=W+PV, explain what H is a state function.

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41. From the definition of enthalpy show that for n mol of an ideal gas H=U+nRT.

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42. Prove that for an ideal gas undergoing an isothermal change, $\Delta H = 0$.

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43. Under what conditions are (i) $\Delta U = q_V$& (ii) $\Delta H = q_P$?

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44. Why is the heat capacity a path-dependent quantity?

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45. Heat required to raise the temperatuer of 1 mol of a gas by $1^\circ C$ is q at constant volume and q' at constant pressure. Will q be greater than, less than or equal to q'? Explain.

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46. Why is the molar heat capacity at constant pressure greater than that at constant volume for gases?

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47.

$c_P - c_V = xJ \cdot g^{-1} \cdot K^{-1}$ and $C_{P,m} - C_{V,m} = Xj \cdot mol^{-1} \cdot K^{-1}$

for an ideal gas. If the molecular mass of the gas be M, then establish a relation among x, X and M.

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48. Why is the sign of ΔH negative for an exothermic reaction and why is it positive for an endothermic reaction?

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49. A 0.5 mol sample of $H_2(g)$ reacts with a 0.5 mol sample of $Cl_2(g)$ to form 1 mol of HCl(g). The decrease in enthalpy for the reaction is 93 kJ. Draw an enthalpy diagram for this reaction.

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50. A 1 mol sample of $N_2(g)$ reacts with 1 mol of $O_2(g)$ to form 2 mol of NO(g)„ where the increase in enthalpy is 180.6 kJ. Draw an enthalpy diagramm for this reaction.

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51. Identify the exothermic and endothermic changes:

(i) $NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g) + 57.0kJ$

(ii) $H_2O(s) + 6.02kJ \rightarrow H_2O(l)$

(iii) $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g) - 130kJ.$

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52. Write down the thermochemical equations for the following reactions:

(i) A 1 mol sample of methane gas reacts with 2 mol of oxygen gas to form 1 mol of carbon dioxide and 2 mol of water. In this reaction, 890.5 kJ of heat is produced.

(ii) A 1 mol sample of carbon (graphite) reacts with 1 mol of oxygen tof orm 1 mol fo carbon dioxide gas. the heat evolved in this reaction is 393.5 kJ.

(iii) 6 mol of carbon dioxide gas reacts with 6 mol of water to form 6 mol of oxygen gas and 1 mol of glucose. the heat absorbed in this reaction is 2200 kJ.

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53. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -285.8kJ$. What will be the value of ΔH for the reaction: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$?

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54. Show that the difference between the heat of reactionn at constant pressure $(q_P \text{ or } \Delta H)$ and that at constant volume $(q_V \text{ or } \Delta U)$ is $P\Delta V$.

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55. What do you mean by the standard state of a substance? Is $25^\circ C$ the standard temperature?

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56. Why is the concept of standard state necessary? What do you mean by the standard state of iron at $1500^\circ C$?

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57. Mention the standard states of the following elements at $25^\circ C$ and $1atm$: carbon, bromine, iodine, sulphur, oxygen, calcium,

chlorine, fluorine and nitrogen.

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58. Why is $\Delta H = \Delta U$ for the following two reactions? Explain.

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

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

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59. Why does the value of ΔH for a chemical reaction depend on the physical states of the reaction(s) and product(s)?

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60. Give an example of a reaction for each of the following relations between ΔH and ΔU: (i) $\Delta U < \Delta H$

(ii) $\Delta U > \Delta H$

(iii) $\Delta U = \Delta H$.

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61. Give an example of a physical change for each of the following relations between ΔH and ΔU:

(i) $\Delta H > \Delta U$

(ii) $\Delta H < \Delta U$

(iii) $\Delta H \approx \Delta U$.

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62. For which element in each of the following pairs has the standard heat of formation of zero? (i) $[O_2(g), O_3(g)]$

(ii) $[Cl_2(g), Cl(g)]$

(iii) $[S(\text{s, rhombic}), S(s, \text{monoclinic})]$?

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63. In which of the following reactions At $25^{\circ}C$, does the standard enthalpy change correspond to the standard enthalpy of formation of $H_2O(l)$? Give reasons.

(i) $H_2(g) + \frac{3}{2}O_3(g) \rightarrow H_2O(l)$

(ii) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

(iii) $2H(g) + O_2(g) \rightarrow H_2O(l)$.

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64. Which one of the given reactions indicates the formation reaction of the compound produced in the reaction?

(i) S (moochlinic,s)$+O_3(g) \rightarrow SO_3(g)$

(ii) C (graphite, s)$+2H_2(g) \rightarrow CH_4(g)$

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

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65. At $25^\circ C$ the standard heat of formation of liquid benzene is +49.0 $kJ \cdot mol^{-1}$-what does it mean?

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66. The standard heat of combustion of solid naphthalene $[C_{10}H_8(s)]$ at $25^\circ C$ is -5147$kJ \cdot mol^{-1}$. What does it mean?

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67. Give an example of a combustion reaction whose standard enthalpy change in equal to the standard enthalpy of formation of the compound formed in the reaction.

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68. The standard enthalpy of combustion of $C_xH_y(l)$ at $25^\circ C$ is Q $kJ \cdot mol^{-1}$. Write down the thermochemical equation for the combustion reaction of this compound.

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69. The standard heats of combustion of $CH_4(g)$ and $C_2H_6(g)$ are -890 $kJ \cdot mol^{-1}$ and -1560 $kJ \cdot mol^{-1}$, respectively. Why is the calorific value of $C_2H_6(g)$ lower than that of $CH_4(g)$?

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70. Define: (i) Enthalpy of fusion, (ii) Enthalpy of vaporisation, (iii) Enthalpy of sublimation.

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71. Identify whether the enthalpy of the initial state is greater than, less than or equal to that of the final state in the following changes: solid $\rightarrow$ liquid, vopur $\rightarrow$ solid, liquid $\rightarrow$ vapour.

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72. At a given temperature and pressure, the enthalpies of condensation and vaporisation for a given liquid, are the same but opposite in sign. Why?

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73. Why are the changes in enthalpies for the given processes the same?

(i) solid $\rightarrow$ liquid $\rightarrow$ vapour

(ii) solid $\rightarrow$ vapour. Consider identical initial and final states.

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74. What does ΔH signify in each of the following equations?

(i) $HCl(g) + 5H_2O(l) \rightarrow HCl(5H_2O), \Delta H = -64kJ$

(ii) $HCl(g) + aq \rightarrow HCl(aq), \Delta H = -75kJ$

(iii) $HCl(5H_2O) + 20H_2O(l) \rightarrow HCl(25H_2O), \Delta H = -8.1kJ.$

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75. Change in enthalpy remains the same whether a reaction is carried out in one step or in several steps under the similar reaction conditions explain the rearms.

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76. Given (at $25^\circ C$ and 1 atm pressure):

C(s, diamond)$+O_2(g) \rightarrow CO_2(g), \Delta H^0 = -393.5kJ \cdot mol^{-1}$

C(s, graphite)$+O_2(g) \rightarrow CO_2(g), \Delta H^0 = -391.6kJ \cdot mol^{-1}$

Find the standard heat of transition from graphite to diamond.

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77.

Consider the given enthalpy diagram, and calculate the unknown ΔH by applying Hess's law.

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78. For the reaction, $A + B \rightarrow D$, ΔH is -30 kJ. Suppose, D is prepared from A and B and then it is again converted into A and B by following the stages $D \rightarrow EA + B$. Calculate the total enthalpy change in these two stages ?

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79. At $25^{\circ} C$ if the standard enthalpies of formation of MX(s), $M^{+}(aq)$ and $X^{-}(aq)$ are -x, y and -z $kJ \cdot mol^{-1}$ respectively, then what will the heat of reaction be for the reaction $M^{+}(aq) + X^{-}(aq) \rightarrow MX(s)$.

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80. Draw the Born-Haber cycle for the formation of LiF(s) from its elements and using this cycle calculate the lattice enthalpy of LiF(s).

Given: $\Delta H_f^0[LiF(s)] = -617kJ \cdot mol^{-1}$,

$\Delta H_{\subset} = +161kJ \cdot mol^{-1}$, $\Delta H^0(F-F) = +159kJ \cdot moL^{-1}$,

$IE_1 = +520kJ \cdot mol^{-1}$, EA of $F = -328kJ \cdot mol^{-1}$.

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81. Define the following terms: (i) Standard enthalpy of atomisation of an element (ii) Bond dissociation energy (iii) bond enthalpy.

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82. The standard heat of sublimation of sodium metal is 108.4$kJ \cdot mol^{-1}$. What is its standard heat of atomisation?

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83. At $25^\circ C$, the bond dissociation energy of $N_2(g)$ is 946 $kJ \cdot mol^{-1}$. What does it mean ? What would be the standard atomisation enthalpy of $N_2(g)$ at $25^\circ C$?

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84. A-B bonds present in $AB_3(g)$ molecule undergo stewise dissociation by the following sequence of steps.

(i) $AB_3(g) \rightarrow AB_2(g) + B(g)$

(ii) $AB_2(g) \rightarrow AB(g) + B(g)$

(iii) $AB(g) \rightarrow A(g) + B(g)$

At $25^\circ C$, if the enthalpy changes in steps (i) and (iii) are x and z $kJ \cdot mol^{-1}$, respectively, and the bond dissociation energy of A-B bond is y $kJ \cdot mol^{-1}$, then what would be the enthalpy change in step (ii)?

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85. Will the transformation of ice into water be spontaneous at $-2^{\circ}C$ and 1 atm pressure? Will the reverse process be spontaneous at this pressure and temperature?

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86. Water remains in equilibrium with its vapour at $100^{\circ}C$ and 1 atm. Will the transformation of water into its vapour be spontaneous at this pressure and temperature?

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87. Is rusting of iron a spontaneous process?

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88. What is entropy of a system? Give its mathematical definition. What is its unit?

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89. What is meant by the entropy change of a system in a chemical reaction?

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90. Give reasons: (i) The change in entropy of a system in a cyclic process is zero. (ii) The change in entropy of a system is a reversible adiabatic process is zero.

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91. Define (i) Entropy of fusion (ii) Entropy of vaporisation (iii) Standard molar entropy of a substance.

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92. What are the signs (+ or -) of the entropy changes of the surroundings in exothermic and endothermic process?

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93. If the process $A \rightarrow B$ occurs reversible, then the change in entropy of the system be, ΔS_1. When the same process occurs irreversible, the change in entropy of the system be ΔS_2. Will the value of ΔS_1 be greater than, less than or equal to the value of ΔS_2?

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94. Heat is not exchange between the system and its surroundings during free expansion of an ideal gas. Therefore, in this process, q=0. will the change in entropy in this process be zero?

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95. What will be the sign of Δ_{sys} (+ve or -ve) in the process of-(i) vaporisation of a liquid (ii) condensation of a vapour (iii) sublimisation of a solid.

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96. The following changes are performed on 1 mol of N_2 gas-

(i) Pressure is decreased at constant at constant temperature.

(ii) volume is decreased at constant temperature.

What will be the sign of ΔS_{sys} in these changes?

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97. Write the SI unit of entropy.

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98. For a process in an isolated system, what are the conditions of spontaneity and equilibrium?

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99. Write the relationn between $\Delta S_{sy} \& \Delta S_{\text{surr}}$ when a process reaches equilibrium. What will be the value of ΔS_{univ} ?

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100. For a reversible process $\Delta S_{sys} = -20 J \cdot K^{-1}$. What will be the value of ΔS_{surr} in this process?

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101. For a spontaneous process $\Delta S_{\text{surr}} = +10J \cdot K^{-1}$. What will be the value of ΔS_{sys} ?

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102. In which case does the entropy of the surroundings increase or decrease: (i) $A \rightarrow B + C, \Delta H = x \text{ kJ}$

(ii) $2A \rightarrow A_2, \Delta H = -y \text{ kJ}$.

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103. For process under a set of condition, $\Delta S_{\text{sys}} < 0$ and $\Delta S_{\text{surr}} < 0$. Will be process the spontaneous?

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104. A spontaneous process has $\Delta S_{\text{sys}} = xJ \cdot K^{-1}$ and $\Delta S_{\text{surr}} = -yJ \cdot K^{-1}$. Compare the values of x and y.

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105. Write the second law of thermodynamics in terms of entropy.

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106. Following two reactions occur spontaneously. What will be the signs of ΔS_{sys} and ΔS_{surr} in these two reactions?

(i) $A(s) \rightarrow B(s) + C(g), \Delta H > 0$

(ii) $2X(g) \rightarrow X_2(g), \Delta H < 0.$

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107. For a reaction $\Delta H > 0$, and for another $\Delta H < 0$. For both the relations ΔS_{sys}. Which one is likely to occur spontaneously? Which one always be occur non-spontaneous?

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108. Define: (i) Gibbs free energy (ii) the standard free energy of formation of a substance (iii) the standard free energy change in a chemical reaction.

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109. Explain: (i) Gibbs free energy is a state function. (ii) gibbs free energy is an extensive property.

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110. For a chemical reaction occurring at constant temperature and pressure show that $\Delta G = -T\Delta S_{\text{univ}}$, where $\Delta G =$ change in free energy of the system and ΔS_{univ}=change in entropy of the universe. Using this equation explain when a reaction at a constant temperature and pressure will be (i) spontaneous (ii) non-spontaneous (iii) at equilibrium.

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111. For a process at a particular temperature and pressure, $\Delta G = \Delta H - T\Delta S$. It can be written as: $-\Delta G = T\left[-\frac{\Delta H}{T} + \Delta S\right]$. What does the quantity within the bracket indicate?

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112. Consider the reaction, $A \rightarrow 2B$, if the free energy per mole of A is G_A and that of B is G_B then what will the relation be between G_A and G_B when the reaction (i) occurs spontaneously and (ii) is at equilibrium?

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113. At a particular temperature and pressure, when will the changes in entropy of the system $\left(\Delta S_{sys}\right)$ and the surroundings $\left(\Delta S_{\text{surr}}\right)$ be equal but the opposite in sign in a chemical reaction? In this condition, what will the value of ΔG be? Will the reaction be spontaneous in this condition?

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114. At a given temperature and pressure, for a chemical reaction $\Delta H < 0 \& \Delta S < 0$. Is the spontaneously of this reaction dependent upon temperature? If it depends and if the reaction reaches equilibrium at a temperature of T_e, then will the reaction be spontaneous below or above T_e?

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115. A physical change at a fixed pressure attains equilibrium at 353K. In this process, $\Delta H > 0$ and $\Delta S > 0$. What will be the direction (from left to right or right to left) of this process at 350 K and 355 K?

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116. At a given temperature and pressure, for a chemical reaction $\Delta H > 0$ and $\Delta S < 0$. The reaction is non-spontaneous at all temperature. But the reverse reaction is spontaneous at all temperature-give reason.

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117. The following reaction occurs spontaneously at 1 atm and 298K. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$. Without doing calculation predict the sign of ΔH for this process.

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118. Explain: in a chemical reaction if (i) $\Delta H < 0$ and $\Delta S > 0$, the spontaneity of the reaction is independent of temperature. (ii) $\Delta H > 0$ and $\Delta S > 0$, the spontaneity of the reaction is dependent of temperature.

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119. Write the relation betweenn ΔG^0 and the equilibrium constant (K) for a reaction at TK. Using this relation state that for what value of ΔG^0, the value of K will be $K > 1$, $K < 1$, $K = 1$.

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QUESTION ANSWER ZONE FOR BOARD EXAMINATION (VERY SHORT ANSWER TYPE)

1. Classify as open, closed or isolated system: (1) A cup of coffee placed on a table (2) Water in a beaker is boiled by heating (3) Lead nitrate is

heated in a test tube (4) Solid NH_4Cl is heated in a closed vessel (5) Substances present in a soda-water bottle (6) Mercury enclosed in the thermometer.

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2. A certain amount of a gas is enclosed ina container with permeable and diathermal walls. Which type of system does the gas belong to?

Watch Video Solution

3. Does the volume of a closed system remain fixed?

Watch Video Solution

4. Given an example of a thermodynamic quantity which is not a stable function. Is it a property of a system?

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5. A process occurring in an isolated system does not have any effect on its surrounding and the process is also not influenced by its surroundings. Why?

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6. A system participates in the following process:

What will be the change in enthalpy of the system in this process- positive, negative or zero?

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7. If the value of internal energy for 10 g water at a particular temperature be x J, then what will be the value of internal energy for 20 g water at the same temperature?

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8. In a process $A \to B \to C \to D$, the heat absorbed by the system in the steps $A \to B$ and $B \to C$ are q_1 and q_2, respetively, and the heat released by the system in the stp $C \to D$ is q_3. If $q_1 + q_2 + q_3 = 0$, then will the process be adiabatic?

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9. Why is infinite time required for the completion of an ideal reversible process?

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10. In a process, if the heat released by the system and work done on the system are 90 J and 120 J, respectively,, then what will be of q and w?

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11. If the specific heat capacity and molecular mass ofa gas are c_P and M respectively then what will be the molar heat capaciity of the gas?

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12. Given an example of a process which is simulataneously isothermal and adiabatic.

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13. At $25^\circ C$ the standard reaction enthalpy for the reaction $AB_3(g) \rightarrow \frac{1}{2}A_2(g) + \frac{3}{2}B_2(g)$ is ΔH^0. Find the standard reaction enthalpy for the reaction $A_2(g) + 3B_2(g) \rightarrow 2AB_3(g)$ at $25^\circ C$.

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14. Mention the standard state of sulphur and iodine at $25^\circ C$.

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15. At 25°C, is the standard reaction enthalpy for the reaction $2H(g) + O(g) \rightarrow H_2O(l)$ the same as the standard enthalpy of formation of $H_2O(l)$?

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16. Assuming experimental conditions are the same, compare $(\Delta H - \Delta U)$ values for the gives reaction:

(1) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

(2) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$.

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17. What do you mean by the enthalpy of solidification of water at $0^\circ C$ and 1 atm pressure $= -6.02kJ \cdot mol^{-1}$?

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18. Why are spontaneous/natural processes irreversible?

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19. Give example of two processes where ΔS is zero.

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20. In which of the following two processes, the change in entropy of the system will be negative? (1) Fusion of ice. (2) Condensation of water vapour.

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21. What will be the change in entropy in an irreversible cyclic process ?

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22. Are the given statements correct? (1) if heat is absorbed in a chemical reaction, the reaction cannot be spontaneous. (2) the entropy of the system may decrease in a reaction, but the reaction can occur spontaneously.

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23. Which of the following will have a greater entropy?

(1) 1 mol of H_2 gas (T=300K, T=5mL) (2) 1 mol of H_2 gas $(T = 300K, V = 10mL)$.

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24. For a process, $\Delta S_{sys} = -15J \cdot K^{-1}$. For what value of ΔS_{surr} will the process be non-spontaneous?

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25. Which condition does not satisfy the spontaneity criteria ofa reaction at constant temperature and pressure (1) $\Delta H < 0, \Delta S < 0,$

(2) $\Delta H > 0, \Delta S < 0$

(3) $\Delta H > 0, \Delta S > 0,$ (4) $\Delta H < 0, \Delta S > 0$?

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26. Which of the following conditions favours the spontaneity of a reaction at a constant temperature and pressure? $\Delta H > 0, \Delta H < 0, \Delta S > 0, \Delta S < 0.$

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QUESTION ANSWER ZONE FOR BOARD EXAMINATION (SHORT ANSWER TYPE)

1. According to the definition of thermodynamic system, which system does living beings belong to, and why?

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2. The change in internal energy in different steps of the process $A \rightarrow B \rightarrow C \rightarrow D$ are given: $A \rightarrow B, x \cdot kJ \cdot mol^{-1}, B \rightarrow C, -ykJ \cdot mol^{-1}, C \rightarrow D, zkJ \cdot mol^{-1}$. What will the value of ΔU be for the change $A \rightarrow D$?

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3. A gas is allowed to expand against zero external pressure. Explain with reason whether the process is reversible or irreversible.

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4. Change in enthalpy in different steps of the process $A \rightarrow B \rightarrow C \rightarrow A$ are given: $A \rightarrow B, xkJ \cdot mol^{-1}, C \rightarrow A, ykJ \cdot mol^{-1}$. Find the value of ΔH for the step $B \rightarrow C$.

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5. One mole of an ideal gas is expanded isothermally. In this process, which of the quantity (or quantities) among w, q, ΔU, ΔH is (are) zero or > 0 or < 0?

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6. Give examples of two processes by which the internal energy of a gas can be increased.

Watch Video Solution

7. Give examples of three processes in which the change in internal energy of the system is zero.

Watch Video Solution

8. Why are the standard reaction enthalpies of the following two reactions different?

(1) C(graphite, s)$+O_2(g) \rightarrow CO_2(g), \Delta H^0 = -393.5kJ$

(2) C(diamond, s)$+O_2(g) \rightarrow CO_2(g), \Delta H^0 = -395.4kJ$

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9. At $25^\circ C$, the standard reaction enthalpy for the reaction, 2C(graphite, s)$+O_2(g) \rightarrow 2CO(g)$ is -221.0kJ. Does this enthalpy change indicate the standard enthalpy of formation of CO(g) ? If not, then what would be the value of the enthalpy of formation of CO(g) at $25^\circ C$?

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10. What do you mean by the standard enthalpy of atomisation of chlorine at $25^\circ C = +121kJ \cdot mol^{-1}$?

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11. Determine the standard reaction enthalpy for the reaction:

$A_2B_3(s) + 3CB(g) \rightarrow 2A(s) + 3CB_2(g)$

Given: (1) $2A(s) + \frac{3}{2}B_2(g) \rightarrow A_2B_3(s), \Delta H^0 = -xkJ$

(2) $CB(g) + \frac{1}{2}B_2(g) \rightarrow CB_2(g), \Delta H^0 = -ykJ.$

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12. In which of the following reactions does ΔH^0 at $25^\circ C$ indicate the standard enthalpy of formation $\left(\Delta H_f^0\right)$ of the compound formed in each of the reactions?

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

(2) $\frac{1}{2}N_2(g) + \frac{1}{3}O_3(g) \rightarrow NO(g).$

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13. Discuss the change in the degree of randomness for the following cases- (1) Combustion of kerosene, (2) Sublimation of dry ice.

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14. For a spontaneous or irreversible process occurring in an isolated system, when does the entropy of the system attain maximum value ? Under this condition, what will be the change in entropy of the system?

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15. Is the entropy change of a system influenced by the change in temperature? Explain.

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16. Mention if entropy of the system increases or decreases in each of the following cases: (1) Boiling of water.

(2) $2O_3(g) \rightarrow 3O_2(g)$

(3) Sublimation of solid iodine

(4) $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$.

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17. Why does the entropy of a gaseous systemm increase with the rise in temperature?

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18. Give an example of a process for each of the given cases: (1) $\Delta G = 0, \Delta S > 0$

(2) $\Delta G = 0, \Delta S < 0$

(3) $\Delta G < 0, \Delta S > 0$

(4) $\Delta G < 0, \Delta S < 0$ in a system.

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19. At $25^\circ C$ and 1 atm pressure, for the reaction $3O_2(g) \rightarrow 2O_3(g), \quad \Delta H = 286kJ$ and $\Delta S = -137.2J \cdot K^{-1}$. Is this reaction spontaneous? Does the spontaneity of thir reaction depend

on temperature? Is the reverse reaction spontaneous ? If so, then why? does the spontaneity of the reverse reaction depend on temperature?

Watch Video Solution

20. The standard enthalpy of formation of $C_7H_5N_3O_6(s)$ is -x $kJ \cdot mol^{-1}$ at $25^\circ C$. Write the thermochemical equation for the formation reaction of the compound.

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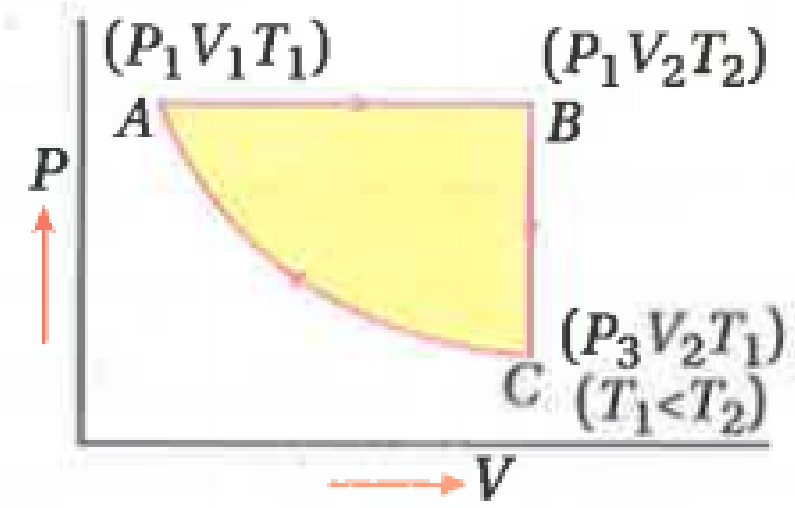
21. A particular amount of an ideal gas participates in a reversible process as given in the figure. What type of process is this ? Explain the changes

in each step.



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22. The transformation of A to B can be carried out by the following two ways in which the initial and final states are identical. (1) $A = \xrightarrow{\Delta H = -xkJ} B$,

(2) $A \xrightarrow{\Delta H = -ykJ} C \xrightarrow{\Delta H = ?} B$, What will be the value of ΔH during the transformation of C to B?

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23. Under what conditions the heat of reaction at fixed pressure is equal to that at fixed volume?

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24. The initial pressure, temperature & volume of 1 mol of a gas are P_1, T_1 and V_1 respectively. The state of the gas is changed by the following two ways. Will the internal energy change be the same in both cases?

(1) $P_1V_1T_2 \xrightarrow[\text{Process}]{\text{Reversible}} P_2V_2T_2$

(2) $P_1V_1T_1 \xrightarrow[\text{process}]{\text{Irreversible}} P_2V_2T_2.$

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25. If one mole of an ideal gas is expanded by the following two ways, then will the value of P_2 and $P_2{}'$ be greater than, less than or equal to P_1 ?

View Text Solution

26. Write three differences betweenn reversible and irreversible processes. Melting of ice at $0^\circ C$ and 1 atm pressure is a reversible process-explain.

Watch Video Solution

27. The boiling point of benzene is $80.1^\circ C$. At ordinary pressure and $70^\circ C$, the benzene vapour spontaneously transforms into liquid benzene. In this process, what will the signs of ΔH, ΔS and ΔG be?

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28. Calculate ΔU and ΔH in calories if one mole of a monoatomic ideal gas is heated at constant pressure of 1 atm from $25^\circ C$ to $50^\circ C$.

Watch Video Solution

29. How much of hard coal is required to produce the same amount of heat as is produced by the combustion of 2.0 L of gasoline (mainly isooctance, C_8H_{18}). Given: $\Delta_c H^0$ of $C_8H_{18} = -5460kJ \cdot mol^{-1}$, density of isooactane $= 0.692g \cdot mL^{-1}$ and calorific value of hard coal is $32.75kJ \cdot g^{-1}$.

Watch Video Solution

30. One kg of graphite is burnt in a closed vessel. The same amount of graphite is burnt in an oepn vessel. Will the heat evolved in the two cases be the same ? If not, in which case it would be greater?

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31. Can ΔH can be taken as a sole criterion of the spontaneity of a reaction? Justify with example.

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32. Explain, Hess's law is a consequence of first law of thermodynamics.

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33. An intimate mixture of Fe_2O_3 and Al_2O_3 is used in solid furl for rockets. Calculates the furl value per gram and fuel value per cm^3 of the mixture.

$\Delta H(Fe_2O_3) = 1669.4kJ \cdot mol^{-1}$

$\Delta H(Al_2O_3) = 832.6kJ \cdot mol^{-1}$.

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34. In a constant volume calorimeter, 3.5g of a gas with molecular mass 28 was burnt in excess oxygen at 298.0 K. the temperature of the calorimeter was found to increase from 298.0K to 298.45K, due to the combustion process. Given, that the heat capacity of the calorimeter is $2.5kJ \cdot K^{-1}$, what will be the value of enthalpy of combustion of the gas?

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35. If the bond dissociation energies of XY(g), $X_2(g)$ and $Y_2(g)$ are in the ratio of 1:1:0.5 and $\Delta_f H$ for the formation of XY(g) is -200kJ $\cdot mol^{-1}$, then what will be the bond dissociation energy of $X_2(g)$?

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SOLVED WBCHSE SCANNER

1. For the process $H_2O(l) \Leftrightarrow H_2O(g), \Delta H = 40.8kJ \cdot mol^{-1}$ at the boiling poinit of water. Calculate molar entropy change for vaporisation from liquid phase.

Watch Video Solution

2. A gas confined in a cylinder with a frictionless piston is made to expand from 1L to 5L under constant pressure of 1.5 atm. During the process, 800J of heat is supplied from external source. Calculate the change in internal energy off the gas. $(1L \cdot atm = 101.3J)$.

Watch Video Solution

3. What are meant by the terms change of entropy (ΔS) and change in free energy (ΔG) of a system. Write down the mathematical relation between them. At $0^{\circ} C$, liqiud water and ice remain in equilibrium. If 1 g of liquid water under equilibrium condition is converted to ice, explain with reason whether the process is endothermic or exothermic .

Watch Video Solution

4. Given: $C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = -393.5kJ$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g), \Delta H = -571.6kJ$

Calculate ΔH of the reaction:

$C(s) + 2H_2O(g) \rightarrow CO_2(g) + 2H_2(g)$.

Watch Video Solution

5. For the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, ΔH and ΔS are $-95.4kJand - 198.3J \cdot K^{-1}$ respectively. Assuming reaction be spontaneous at 500K ? Explain.

Watch Video Solution

6. (i) Assuing the reactant and product gases as ideal, show that for a gaseous reaction $\Delta H = \Delta E + \Delta nRT$, where ΔH and ΔE indicate the changes of enthalpy and internal energy in the reaction.

(ii) the bond energy of any diatomic molecule is defined to be the change in the internal energy for its dissociation. at 298K, $O_2(g) \rightarrow 2O_g$, $\Delta H = 498.3kJ \cdot mol^{-1}$. calculate the bond energy of O_2 molecule $R = 8.314J \cdot K^{-1} \cdot mol^{-1}$.

View Text Solution

7. (i) State the first law of thermodynamics. As ideal gas of volume 6.0 L was made to expand at constant temperature and pressure of 2 atm by supplying heat. If the final volume of the gas was 12.0L, calculate the work done and the heat supplied in joule in the process. $[1L \cdot atm = 101.3]$.

(ii) At $0^\circ C H_2O(s) \Leftrightarrow H_2O(g), \Delta H = 51885 J \cdot mol^{-1}$

$H_2O(l) \Leftrightarrow H_2O(g), \Delta H = 45860 J \cdot mol^{-1}$

Calculate the change in entropy for the process, $H_2O(s) \rightarrow H_2O(l)$ at $0^\circ C$.

View Text Solution

8. A process is always spontaneous at all temperature if the enthalpy change is ___ and entropy change is ____.

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9. Two moles of an ideal gas were expanded isothermally against opposing pressure of 1 atm from 20L to 60L. Compoute w, q, ΔE and ΔH for the process is joule. (Given $1L \cdot atm = 101.3J$)

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10. Latent heat of fusion of ice at $0^{\circ}C$ is 80cal/g. calculate the olar entropy change for the fusion process.

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11. Calculate ΔG^0 for the reaction $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ at 298K. Given, at 298K ΔH_f^0 for $H_2O(l)$ is -286 kJ $\cdot mol^{-1}$ and the molar entropies (S^0) for $H_2(g), O_2(g)$ and $H_2O(l)$ are 130.7, 205.1 and 69.9 $J \cdot K^{-1} \cdot mol^{-1}$ respectively.

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12. Above what temperature the following reaction will be spontaneous?

$2CuO(s) \rightarrow Cu_2O(s) + \frac{1}{2}O_2(g).$ Given,

$\Delta H = 144.6kJ$ and $\Delta S = 0.116kJ \cdot K^{-1}$ for the process.

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13. Calculate ΔH of the following reaction at $25^\circ C$.

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

Given:

$Fe_2O_3(s) + 3C(\text{graphite}) \rightarrow 2Fe(s) + 3CO(g), \Delta H = 117.30kcal$

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

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g), \Delta H = 67.63kcal$ at $25^\circ C$.

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14. Discuss whether the difference between the heats of reaction at constant pressure and constant volume will depend on temperature for

the following reaction.

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

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15. Which of the following is an example of a closed system-

A. a hot water filled thermoflask

B. an ice water filled airtight metallic bottle

C. a water filled stainless steel bowl

D. a hot water filled glass beaker

Answer: B

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16. Which is an intensive property of a system-

A. internal energy

B. entropy

C. mass

D. density

Answer: D

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17. In a process, 600J of heat is absorbed by a system and 300J of work is done by the system. Calculate the change in internal energy of the system.

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18. Latent heat of vaporisation of water at normal boiling point is $40.75kJ \cdot mol^{-1}$. Calculate the change in entropy of vaporisation.

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19. Calculate the enthalpy of formation of liquid ethyl alcohol from the following data.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H = -1368kJ$$

$$C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = -393kJ$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -287kJ.$$

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20. State the condition of spontaneity and equilibrium in terms of Gibbs free energy change of a system.

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21. Assuming the reactant and product gases of chemical reaction as ideal, show that for a gaseous reaction $\Delta H = \Delta U + \Delta nRT$ where ΔH and ΔU indicate the changes of enthalpy and internal energy, in the reaction.

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22. Which variable is kept constant in an isochoric process?

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23. Calculate the change in internal energy of the gas when it expands from 2L to 8L at a constant pressure of 2 atm absorbing 400 J of heat in the process. (1L $\cdot\ atm = 101.35J$).

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24. Calculate the work done for a reversible isothermal compression of 1 mol ideal gas 20 L to half of its volume at 400K $\left[R = 8.314J \cdot K^{-1} \cdot mol^{-1}\right]$.

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25. At $25^\circ C$ the standard heat of formation of liquid H_2O is -286.0 $kJ \cdot mol^{-1}$. Calculate the change in standard internal energy for this formation reaction.

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26. The temperature of 4 mol of a gas decreases from $40^\circ C$ to $-60^\circ C$ on adiabatic reversible expansion. The molar specific heat of the gas at constant volume being $12J \cdot K^{-1} \cdot mol^{-1}$, determine the change in internal energy and work done in this process.

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27. Which one is the correct unit of entropy-

A. $K^{-1} \cdot mol^{-1}$

B. $J \cdot K^{-1} \cdot$

C. $J \cdot mol^{-1}$

D. $J^{-1} \cdot K^{-1} \cdot mol^{-1}$.

Answer: B

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28. For the reversible reaction A =+ 2B $\leftrightarrow$ C+ Heat the forward raction will proceed at

A. low temperature and low pressure

B. low pressure

C. high pressure and low temperature

D. high pressure and high temperature

Answer: C

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29. Which one of the following is true for a spontaneous process-

A. $\Delta G = 0$

B. $\Delta H = T\Delta S$

C. $\Delta G > 0$

D. $\Delta G < 0$

Answer: D

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30. (i) Why is the enthalpy change for a chemical reaction more important than internal energy change?

(ii) What is meant by isolated system?

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31. Find out the heat of formation of CH_3COOH. Given that the heat of combusion of CH_3COOH is -867 KJ mol^{-1} and the heat of formation of CO_2 and H_2O are - 393.5 and - 285.9 KJ mol^{-1} respectively.

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32. Which one of the following relation shows spontaneity-

A. $\Delta H = T\Delta S$

B. $\Delta H > T\Delta S$

C. $\Delta H < T\Delta S$

D. $\Delta H \neq T\Delta S$

Answer: C

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33. For which of the following chemical equation has $\Delta H = \Delta U -$

A. $C(s) + 2H_2O(g) \rightarrow 2H_2(g) + CO_2(g)$

B. $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

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

D. $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$.

Answer: D

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34. Write the definition of entropy.

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35. If the standard formation enthalpy of CS_2, CO_2 and $SO_2 are 117 kJ mol^{-1} - 393 kJ mol^{-1}$ and $-297 kJ mol^{-1} r$ CS_2 + 30_2 rarr CO_2 2SO_3`.

Watch Video Solution

36. (i) State Hess's law.

(ii) Judge the spontaneity of the following reaction at 298K temperature and at a particular pressure:

$Br_2(l) + Cl_2(g) \rightarrow 2BrCl(g)$

Given: $\Delta H = 29.3kJ \cdot mol^{-1}$ and

$\Delta S = 104.1J \cdot K^{-1} \cdot mol^{-1}$.

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37. At $25^\circ C$ which of the following has enthalpy of formation zero-

A. $HCl(g)$

B. $O_2(g)$

C. $O_3(g)$

D. $NO(g)$

Answer: B

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38. For which of the following reactions, $\Delta S > 0$-

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

B. $HCl(g) + NH_3(g) \Leftrightarrow NH_4Cl(s)$

C. $NH_4NO_3(s) \Leftrightarrow \ \rightarrow N_2O(g) + 2H_2O(g)$

D. $MgO(s) + H_2(g) \Leftrightarrow Mg(s) + H_2O(g).$

Answer: C

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39. Write down the statement of third law of thermodynamics.

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40. Heat of combustion of benzene is xJ $\cdot mol^{-1}$. Heat of formation of carbon dioxide and water are $yJ \cdot mol^{-1}$ and $zJ \cdot mol^{-1}$ respectively. Calculate the heat of formation of benzene.

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41. (i) State the second law of thermodynamics ono the basis of entropy.

(ii) Boiling point of ethanol is $78.4^{\circ}C$. Change in enthalpy during vaporisation of ethanol is $96J \cdot mol^{-1}$, calculate the change in entropy of vaporisation of enthanol.

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42. An amount of work w is done by the system and q amount of heat is supplied to the system. By which the following relations the change in internal energy of the system can be expressed-

A. $\Delta U = q - w$

B. $\Delta U = q + w$

C. $\Delta U = q$

D. $\Delta U = w - q$

Answer: A

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43. Which one of the following indicates a spontaneous process-

A. $\Delta G = 0$

B. $\Delta H = T\Delta S$

C. $\Delta G > 0$

D. $\Delta G < 0$

Answer: D

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44. What is meant by an isolated systemm in thermodynamics?

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45. Write SI unit of entropy.

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46. (i) State hess's law.

(ii) For the following reaction at 298K

$2X + Y \rightarrow Z$

$\Delta H = 300kJ \cdot mol^{-1}$ and $\Delta S = 0.2kJ \cdot K^{-1} \cdot mol^{-1}$

At what temperature will the reaction become spontaneous considering

ΔH and ΔS to be constant over the temperature range?

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SOLVED NCERT EXERCISE

1. A thermodynamics state function is a quantity-

A. used to determine heat changes

B. whose value is independet of path

C. used to determine pressure-volume work

D. whose value depends on temperature only

Answer: B

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2. For the process to occur under adiabatic conditions, the correct conditions is-

A. $\Delta T = 0$

B. $\Delta P = 0$

C. $q = 0$

D. $w = 0$

Answer: C

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3. Enthalpies of all elements in standard states are-

A. unity

B. zero

C. < 0

D. different for each element

Answer: B

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4. ΔU^0 for combustion of methane is $-XkJ \cdot mol^{-1}$. The value of ΔH^0 is-

A. $= \Delta U^0$

B. $> \Delta U^0$

C. $< \Delta U^0$

D. 0

Answer: C

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5. The enthalpy of combustion of methane, graphite and dihydrogen at 298K are -890.3$kJ \cdot mol^{-1}$, -393.5$kJ \cdot mol^{-1}$ and $-285.8 kJ \cdot mol^{-1}$ respectively. Enthalpy of formation of $CH_4(g)$ will be-

A. $-74.8 kJ \cdot mol^{-1}$

B. $-52.27 kJ \cdot mol^{-1}$

C. $+74.8 kJ \cdot mol^{-1}$

D. $+52.26 kJ \cdot mol^{-1}$

Answer: A

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6. A reaction, $A + B \rightarrow C + D + q$ is found to have a positive entropy change. The reaction will be-

A. possible at high temperature

B. possible only at low temperature

C. not possible at any temperature

D. possible at any temperature

Answer: D

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7. In a process, 701J 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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8. The reaction of cyanamide, $NH_2CN(s)$, with dioxygenn was carried out in a bomb calorimeter, and ΔU was found to be -742.7$kJ \cdot mol^{-1}$ at 298K. Calculate enthalpy change for the reaction at 298K:

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

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9. Calculate the number of kJ necessary to raise the temperature of 60g of aluminium from $35^\circ C$ to $55^\circ C$. Molar heat capacity of Al is $24J \cdot mol^{-1} \cdot K^{-1}$.

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10. Calculate the enthalpy change on freezing of 1.0 mole of water at $10^\circ C$ to ice at $-10^\circ C$, $\triangle_{fus} H = 6.03 kJmol^{-1}$ at $0^\circ C$,

$C_p[H_2O(l)] = 75.3 Jmol^{-1}K^{-1}$

$C_p[H_2O(s)] = 36.8 Jmol^{-1}K^{-1}$

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11. Enthalpy of combustion of C to CO_2: $-393.5 kJ \cdot mol^{-1}$. Calculate the heat released upon formation of 35.2g of CO_2 from carbon and dioxygen gas.

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12. Enthalpies of formation of CO(g),$CO_2(g)$, $N_2O(g)$ and $N_2O_4(g)$ are -110,-393,81 and $9.7 KJmol^{-1}$ respectively calculate ΔH_r for the reaction :$N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3CO_2(g)$

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13. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta_r H^0 = -92.4kJ \cdot mol^{-1}$

What is the standard enthalpy of formation of NH_3 ?

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14. Calculate the standard enthalpy of formation of $CH_3OH(l)$ from the following data:

(1)

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta_r H^0 = -726kJ \cdot mol^{-1}$

(2) $C(s) + O_2(g) \rightarrow CO_2(g), \Delta_c H^0 = -393kJ \cdot mol^{-1}$

(3) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta_f H^0 = -286kJ \cdot mol^{-1}$.

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15. Calculate the enthaply change for the process :

CCl_4(g) $\rightarrow$ C(g)+$4Cl(g)$ and calculate the bond enthalpy of $C - Cl$ in $CCl_4(g)$

$\triangle$ $(vap))H^\circ(CCl_4)$= 30.5 kJ mol^{-1}

$\triangle fH^{\circ}(CCl_4)$ = 135.5 kJ mol^{-1}

$\triangle_a H^{\circ}(C) = 715.0kJ\, mol^{-1}$

$\triangle_a H^{\circ}(Cl_2)(\text{atomisation}) = 242kJmol^{-1}$

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16. For an isolated system, $\Delta U = 0$, what will be ΔS ?

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17. For the reaction, $2A + B \rightarrow C, \Delta H = 400kJ \cdot mol^{-1}$ & $\Delta S = 0.2kJ \cdot K^{-1} \cdot mol^{-1}$ at 298K. At what temperature will the reaction become spontaneous considering $\Delta H, \Delta S$ to be constant over the temperature range?

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18. For the reaction $2Cl(g) \rightarrow Cl_2(g)$, what are the signs of ΔH and ΔS?

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19. For the reaction, $2A(g) + B(g) \rightarrow 2D(g), \Delta U^0 = -10.5kJ$ and $\Delta S^0 = -44.1J \cdot K^{-1}$. Calculate ΔG^0 for the reaction and predict whether it may occur spontaneously.

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20. Equilibrium consistant for a reaction is 10. find the value of ΔG^0? $R = 8.314J \cdot K^{-1} \cdot mol^{-1}, T = 300K.$

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21. Comment on the thermodynamic stability of NO(g).

Given:

$$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g), \Delta_r H^0 = 90kJ \cdot mol^{-1}, NO(g) + \frac{1}{2}O_2(g)$$

.

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22. Calculate the entropy change in the surrounding when 1,00 mol of $H_2O(l)$ is formed under standard conditions. $\Delta_f H^0 = -286kJ \cdot mol^{-1}$

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HIGHER ORDER THINKING SKILLS (HOTS) QUESTIONS

1. The results obtained by applying the mathematical form of the first law of thermodynamics for different process are given below. Identify the process (w=P-V work only): $\Delta U = 0, q + w = 0$

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2. The entropy of the system decreases on condensation of a vapour though it occurs spontaneously. Explain.

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3. The formation of ice from water is exothermic in nature, but water does not convert into ice spontaneously at ordinary temperature and pressure, why?

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4. "The amount of heat present in hot water is greater than that in cold water"- explain whether the statement is correct or not.

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5. Give examples of two processes involving only P-V work, where the system does not perform any work.

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6. For the reaction, $CH_4(g) + \frac{1}{2}O_2(g) \rightarrow CH_3OH(g), \Delta H^0 =$ negative at $25^\circ C$. If the standard enthalpies of combustion of $CH_4(g)$ and $CH_3OH(g)$ at $25^\circ C$ are $-xkJ \cdot mol^{-1} \& -ykJ \cdot mol^{-1}$ respectively, then will the value of x be less than, greater than or equal to the value of y?

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7. A plant is growing . What do you think of the entropy changes of the plant and its surroundings?

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8. When does an adiabatic process become isentropic?

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9. At a certain temperature and pressure, $\Delta H = 0$ for the reaction: X+X= X_2. Show that the reaction is non-spontaneous at this temperature and pressure.

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10. The magnitude of work done by a gas is a reversible expansion is greater than that in an irreversible expansion provided the initial and final state are identical in both processes-explain.

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11. 1 mol of an ideal gas is freely expanded at constant temperature. In this process, which of the quantity or quantities among w,q, ΔU, ΔH are 0 or >0 or <0?

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12. A gas cools down during adiabatic expansion and it becomes hot during adiabatic compression-explain.

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13. Given: (1) $A(s) + B_2(g) \rightarrow AB_2(g), \Delta H^0 = -xkJ$

(2) $A(s) + \frac{3}{2}B_2(g) \rightarrow AB_3(g), \Delta H^0 = -ykJ$

Using above equations, determine standard reaction enthalpy for the reaction:

$2AB_3(g) \rightarrow 2AB_2(g) + B_2(g).$

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14. At $25^\circ C$ the standard enthalpy of formation of freon gas $(CHClF_2)$ is -480.0 $kJ \cdot mol^{-1}$. Wirte down of therrmochemical equation representing the formation reaction of the compound.

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15. For each of the given changes, state whether the final enthalpy is greater or less than the initial enthalpy:

(1) $H_2O(s) \rightarrow H_2O(l)$

(2) $H_2O(g) \rightarrow H_2O(l)$.

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16. Give two examples of spontaneous processes in which disorderliness of the system decreases.

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17. There occurs no exchange of heat between a system and its surroundings in an adiabatic process. So, the change in entropy of the system is zero in this process. Justify the statement.

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18. $A(g) + A(g) \rightarrow A_2(g)$, these type of reaction are generally exothermic. Explain.

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19. What do you mean by perpetual motion machine of the second kind?

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20. At ordinary temperature and pressure, solid NH_4Cl dissolves in water to form $NH_4^+(aq)$ and $Cl^-(aq)$ions. The process is endothermic. Indicate the signs ($+$ or $-$) of ΔS_{sys}, ΔS_{surr}, ΔH and ΔG.

Watch Video Solution

ENTRANCE QUESTION BANK

1. Which of the following statement is true-

A. entropy increases when water vaporises

B. randomness decreases in the fusion of ice

C. randomness increases in the condensation of water vapour

D. randomness remains unchanged during vaporisation of water

Answer: A

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2. Identify the correct statement in a chemical reaction-

A. the entropy always increases

B. the change in entropy along with suitable change in enthalpy decides the rate of reaction

C. the enthalpy always decreases

D. both the enthalpy and the entropy remains constant

Answer: B

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3. The condition for spontaneity of a process is-

A. lowering of entropy at constant temperature & pressure

B. lowering of gibbs free energy of the system at constantn temperature and pressure

C. Increase in entropy of the system at constant temperature and pressure

D. increase in Gibbs free energy of the universe at constant temperature and pressure.

Answer: B

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4. $P \cdot V$ Work done by an ideal gaseous system at constant volume is (E is internal energy of the system)-

A. $-\frac{\Delta P}{P}$

B. zero

C. $-V\Delta P$

D. $-\Delta E.$

Answer: B

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5. Mixing of two different ideal gases under isothermal reversible condition will lead to-

A. increase in gibbs free energy of the system

B. no change of entropy of the system

C. increase in entropy of the system

D. increase in enthalpy of the system

Answer: C

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6. For an isothermal expansion of an ideal gas, the correct combination of the thermodynamic parameters will be-

A. $\Delta U = 0, Q = 0, w \neq 0 \text{ and } \Delta H \neq 0$

B. $\Delta U \neq 0, Q \neq 0, w \neq 0 \text{ and } \Delta H = 0.$

C. $\Delta U = 0, Q \neq 0, w = 0 \text{ and } \Delta H \neq 0$

D. $\Delta U = 0, Q \neq 0, w \neq 0$ and $\Delta H = 0$

Answer: D

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7. The change in entropy (dS) is defined as-

A. $dS + \frac{\delta q}{T}$

B. $dS = \frac{dH}{T}$

C. $dS = \frac{\delta q_{rev}}{T}$

D. $dS = \frac{(dH - dG)}{T}$.

Answer: C

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8. ΔH for cooling 2 mol ideal monoatomic gas from $225^\circ C$ to $125^\circ C$ at constant pressure will be $\left[C_P = \frac{5}{2}R\right]$-

A. 250R

B. $-500R$

C. $500R$

D. $-250R$

Answer: B

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9. For a spontaneous process, correct statement (s) is (are)-

A. $\left(\Delta G_{sys}\right)_{T,P} > 0$

B. $\Delta S_{sys} + \Delta S_{\text{surr}} > 0$

C. $\left(\Delta G_{\text{sys}}\right)_{T,P} < 0$

D. $\left(\Delta U_{sys}\right)_{T,V} > 0$

Answer: B::C

Watch Video Solution

10. Given: $C + O_2 \rightarrow CO_2, \Delta H^0 = -xkJ$

$2CO + O_2 \rightarrow 2CO_2, \Delta H^0 - y$ kJ

Heat of formation of carbon monoxide will be-

A. $\frac{y - 2x}{2}$

B. $y + 2x$

C. $2x - y$

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

Answer: A

Watch Video Solution

11. The enthalpy of vaporisation of a certain liquid at its boiling point off $35^\circ C$ is $24.64kJ \cdot mol^{-1}$. The value of change in entropy for the process is-

A. $704J \cdot K^{-1} \cdot mol^{-1}$

B. $80J \cdot K^{-1} \cdot mol^{-1}$

C. $24.64J \cdot K^{-1} \cdot mol^{-1}$

D. $7.04J \cdot K^{-1} \cdot mol^{-1}$

Answer: B

Watch Video Solution

12. ΔH and ΔS of a certain reaction are -400 $kJ \cdot mol^{-1}$ and $-20kJ \cdot mol^{-1} \cdot K^{-1}$ respectively. The temperature below which the reaction is spontaneous is-

A. 100K

B. $20^\circ C$

C. $20K$

D. $120^{\circ}C$

Answer: C

Watch Video Solution

13. For the reaction $X_2Y_4(l) \rightarrow 2XY(g)$ at 300K the values of ΔU and ΔS are 2kcal and $20cal \cdot K^{-1}$ respectively. The value of ΔG for the reaction is-

A. $-3400cal$

B. $3400cal$

C. $-2800cal$

D. 2000 cal

Answer: C

Watch Video Solution

14. For the reaction $2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$ at 300K, value of ΔG^0 is $-690.9R$. The equilibrium constant value for the reaction at that temperature is (R is gas constant) -

A. $10atm^{-1}$

B. 10 atm

C. 10

D. 1

Answer: C

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15. The condition for a reaction to occur spontaneously is -

A. ΔH must be negative

B. ΔS must be netagive

C. $(\Delta H - T\Delta S)$ must be negative

D. $(\Delta H + T\Delta S)$ must be negative.

Answer: C

Watch Video Solution

16. During a reversible adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio $\frac{C_P}{C_V}$ for the gas is-

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

B. $\frac{7}{2}$

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

D. $\frac{9}{7}$

Answer: A

Watch Video Solution

17. The heat of neutralisation of a strong base and a strong acid is 13.7 kcal. The heat released when 0.6 mol HCl solution is added to 0.25 mol of NaOH is-

A. 3.425 kcal

B. 8.22 kcal

C. 11.645 kcal

D. 13.7 kcal

Answer: A

Watch Video Solution

18. The entropy change involved in the isothermal reversible expansion of 2 mol of an ideal gas from a volume of 10 cm^3 to a volume of 100 cm^3 at $27^\circ C$ is-

A. $38.3 J \cdot mol^{-1} \cdot K^{-1}$

B. $35.8 J \cdot mol^{-1} \cdot K^{-1}$

C. $32.3 J \cdot mol^{-1} \cdot K^{-1}$

D. $42.3 J \cdot mol^{-1} \cdot K^{-1}$

Answer: A

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19. Among the following expressions which one is incorrect-

A. $w_{\text{rev, iso}} = -nRT\ln\frac{V_f}{V_i}$

B. $\ln \mathrm{K} = \frac{\Delta H^0 - T\Delta S^0}{RT}$

C. $K = e^{-\Delta G^0 / RT}$

D. $\frac{\Delta G_{sys}}{\Delta S_{\text{total}}} = -T$

Answer: B

Watch Video Solution

20. A cylinder filled with 0.04 mol of ideal gas expands reversible from 50 mL to 375 mL at a constant temperature of $37.0^{\circ}C$. As it does so, it absorbs 208 J heat, q and w for the process will be $(R8.314J \cdot mol^{-1} \cdot K^{-1})$-

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

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

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

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

Answer: B

Watch Video Solution

21. For complete combustion of enthanol,

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

The amount of heat produced as measured in bomb calorimeter, is $1364.47kJ \cdot mol^{-1}$ at $25^{\circ}C$. Assuming ideally the enthalpy of

combustion, $\Delta H_c(kJ \cdot mol^{-1})$ for the reaction will be $(R = 8.314 J \cdot K^{-1} \cdot mol^{-1})$-

A. -1350.50

B. -1366.95

C. -1361.95

D. -1460.50

Answer: B

Watch Video Solution

22. The following reaction is performed free energy of formation of $NO(g)$ is 86.6 kJ/mol at 298K. What is the standard free energy of formation of $NO_2(g)$ at 298K $(K_p = 1.6 \times 10^{12})$-

A. $8660 - \dfrac{\ln(1.6 \times 10^{12})}{R(298)}$

B. $0.5[2 \times 86600 - R(298)\ln(1.6 \times 10^{12})$

C. $R(298)\ln(1.6 \times 10^{12}) - 86600$

D. $86600 + R(298)\ln\left(1.6 \times 10^{12}\right)$

Answer: B

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23. The standard Gibbs energy change at 300K for the reaction $2A \Leftrightarrow B + C$ is 2494.2 J. at a given time, composition of the reaction mixture is $[A] = \frac{1}{2}, [B] = 2 \text{ and } [C] = \frac{1}{2}$. The reaction proceeds in the $[R = 8.314 J/K/mol, c = 2.718]$-

A. forward direction because $Q < K_c$

B. reverse direction because $Q < K_c$

C. forward direction because $Q > K_c$

D. reverse direction because $Q > K_c$.

Answer: D

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24. The heats of combustion of carbon and carbon monoxide are -393.5 and -283.5 $kJ \cdot mol^{-1}$ respectively. The heat of formation (in kJ) of carbon monoxide per mole is-

A. 110.5

B. 676.5

C. -676.5

D. -110.5

Answer: D

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25. Given, C(graphite)+$O_2(g) \rightarrow CO_2(g), \Delta_r H^0 = -393.5kJ \cdot mol^{-1}$

$H_2(g) + \frac{1}{2}(g) \rightarrow H_2O(l), \Delta_r H^0 = -285.8kJ \cdot mol^{-1}$

$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g), \Delta_r \Delta H^0 = +890.3kJ \cdot mol^{-1}$

Based on the above thermochemical equations, the value of $\Delta_r H^0$ at

298K for the reaction,

C(graphite)$+2H_2(g) \rightarrow CH_4(g)$, will be-

A. $-74.8kJ \cdot mol^{-1}$

B. $-144.0kJ \cdot mol^{-1}$

C. $+74.8kJ \cdot mol^{-1}$

D. $+144.0kJ \cdot mol^{-1}$

Answer: A

Watch Video Solution

26. The combustion of benzene (l) gives $CO_2(g)$ and $H_2O(l)$. Given that heat of combustion of benzene at constant volume is -3263.9 $kJ \cdot mol^{-1}$ at $25^\circ C$, heat of combustion (in $kJ \cdot mol^{-1}$) of benzene at constant pressure will be $(R = 8.314J \cdot K^{-1} \cdot mol^{-1})$-

A. 4152.6

B. -452.46

C. 3260

D. -3267.6

Answer: D

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27. If

$\frac{1}{2}A \rightarrow B, \Delta H = +150kJ \cdot mol^{-1}, 3B \rightarrow 2C + D, \Delta H = -125kJ \cdot mo$

then ΔH of the reaction $B + D \rightarrow E + 2C$ will be-

A. $525kJ \cdot mol^{-1}$

B. $-175kJ \cdot mol^{-1}$

C. $-325kJ \cdot mol^{-1}$

D. $325kJ \cdot mol^{-1}$

Answer: B

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28. Which is correct option for free expansion of an ideal gas under adiabatic condition-

A. $q = 0, \Delta T \neq 0, w = 0$

B. $q \neq 0, \Delta T = 0, w = 0$

C. $q = 0, \Delta T = 0, w = 0$

D. $q = 0, \Delta T < 0, w \neq 0.$

Answer: C

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29. Enthalpy change for the reaction, $4H(g) \rightarrow 2H_2(g)$ is $-869.5kJ$. The dissociation energy of H-H bond is-

A. $-434.8kJ$

B. $-869.6kJ$

C. $+434.8kJ$

D. $+217.4kJ$

Answer: C

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30. If the enthalpy change for the transition of liquid water to steam is $30kJ \cdot mol^{-1}$ at $27^{\circ}C$, the entropy change in $J \cdot mol^{-1} \cdot K^{-1}$ for the process would be-

A. 10

B. 1.0

C. 0.1

D. 100

Answer: D

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31. In which of the given reactions, standard reaction entropy change (ΔS^0) is positive and standard Gibbs energy change (ΔG^0) decreases sharply with increasing temperature-

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

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

C. $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s)$

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

Answer: A

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32. For the reaction, $X_2O_4(l) \rightarrow 2XO_2(g), \Delta U = 2.1$ kcal, $\Delta S = 20cal \cdot K^{-1}$ at 300K, hence, ΔG is -

A. 2.7 kcal

B. $-2.7ckcal$

C. 9.3 kcal

D. -9.3 kcal

Answer: B

Watch Video Solution

33. Heat of combustion of carbon to CO_2 is -393.5 kJ/mol. The heat released upon the formation of 35.2 kg of CO_2 from carbon and oxygen gas is-

A. $-315kJ$

B. $+315kJ$

C. $-630kJ$

D. $-3.15kJ$

Answer: A

Watch Video Solution

34. For a sample of perfect gas when the pressure is changed isothermally from p_i to p_f the entropy change is given by-

A. $\Delta S = nRT \ln\left(\frac{p_f}{p_i}\right)$

B. $\Delta S = nR \ln\left(\frac{p_i}{p_f}\right)$

C. $\Delta S = nRT \ln\left(\frac{p_f}{p_i}\right)$

D. $\Delta S = RT \ln\left(\frac{p_i}{p_f}\right)$.

Answer: B

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35. Consider the following liquid-vapour equilibrium.

liquid $\Leftrightarrow$ vapour

which of the following relations is correct-

A. $\frac{d \ln P}{dT^2} = -\frac{\Delta H_v}{T^2}$

B. $\frac{d \ln P}{dT} = \frac{\Delta H_v}{RT^2}$

C. $\frac{d \ln G}{dT^2} = \frac{\Delta H_v}{RT^2}$

D. $\frac{d \ln P}{dT} = -\frac{\Delta H_v}{RT}$

Answer: B

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36. The correct thermodynamic conditios for the spontaneous reaction at all temperature is-

A. $\Delta H < 0 \text{ and } \Delta S > 0$

B. $\Delta H < 0 \text{ and } \Delta S < 0$

C. $\Delta H < 0 \text{ and } \Delta S = 0$

D. $\Delta G > 0 \text{ and } \Delta S < 0$

Answer: A

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37. A gas is allowed to expand in a well insulated container against a constant external pressure of 2.5 atm from an initial volume of 2.50 L to a final volume of 4.50 L. the change in internal energy ΔU of the gas in joules will be-

A. $-500J$

B. $-505J$

C. $+505J$

D. $1136.25J$

Answer: B

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38. For a given reaction, $\Delta H = 35.5kJ \cdot mol^{-1}$ and $\Delta S = 83.6J \cdot mol^{-1}$. The reaction is spontaneous at (assume that

ΔH and ΔS do not vary with temperature)-

A. $T > 425K$

B. all temperature

C. $T > 298K$

D. $T < 425K$.

Answer: A

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39. The bond dissociation energies of X_2, Y_2 and XY are in the ratio of $1:0.5:1$. ΔH for the formation of XY is -200 $kJ \cdot mol^{-1}$. The bond dissociationn energy of X_2 will be-

A. $200kJ \cdot mol^{-1}$

B. 100 $kJ \cdot mol^{-1}$

C. 800 $kJ \cdot mol^{-1}$

D. 400 $kJ \cdot mol^{-1}$

Answer: C

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40. Which of the following is intensive property-

A. enthalpy

B. entropy

C. specific heat

D. volume

Answer: C

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41. Which of the following is not a thermodynamic function-

A. internal energy

B. work done

C. enthalpy

D. entropy

Answer: B

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42. For adiabatic process, which is correct-

A. $\Delta T = 0$

B. $\Delta S = 0$

C. $q = 0$

D. $q_P = 0$

Answer: C

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43. The enthalpy of formation of $CO(g), CO_2(g), N_2O(g)$ and $N_2O_4(g)$ is -110, -393, +811 and 10kJ/mol respectively.

for the reaction, $N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3CO_2(g) \Delta H_r(kJ/mol)$ is-

A. -212

B. $+212$

C. $+48$

D. -48

Answer: D

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44. Bond dissociation energy of CH_4 is 360 kJ/mol and C_2H_6 is 620 kJ/mol. Then bond dissociation energy of C-C bond is-

A. 170 kJ/mol

B. 50kJ/mol

C. 80kJ/mol

D. 220kJ/mol

Answer: C

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45. Which thermodynamic parameter is not a state function-

A. q at constant pressure

B. q at constant volume

C. w at adiabatic

D. w at isothermal

Answer: D

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46. A diatomic gas at pressure P, compressed adiabatically to half of its volume, what is the final pressure-

A. $(2)^{1.4}P$

B. $P/(2)^{1.4}$

C. $(2)^{\frac{5}{3}}P$

D. $P/(2)^{5/3}$

Answer: A

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47. For the reaction of one mole of zinc dust with one mole of sulphur acid in a bomb calorimeter, ΔU and w correspond to-

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

B. $\Delta U < 0, w < 0$

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

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

Answer: A

Watch Video Solution

48. The heat liberated when 1.89g of benzoic acid is burnt in a bomob calorimeter at $25^\circ C$ and it increases the temperature of 18.94 kg of water by $0.632^\circ C$. If the specific heat of water at $25^\circ C$ is $0.998 cal \cdot g^{-1} \cdot {}^\circ C^{-1}$, the value of the heat of combustion of benzoic acid is-

A. 881.1 kcal

B. 771.124 kcal

C. 981.1 kcal

D. 871.2 kcal

Answer: B

Watch Video Solution

49. The heat liberated when 1.89 g of benzoic acid is burnt in a bomb calorimeter at $25^\circ C$ increase the temperature of 18.94 kg of water by $0.632^\circ C$. If the specific heat of water at $25^\circ C$ is 0.998 cal/g-deg, the value of the heat of combustion of benzoic acid is

A. 881.1 kcal

B. 771.124 kcal

C. 981 kcal

D. 871.2 kcal

Answer: B

Watch Video Solution

50. What is the entropy change in 2 mol N_2, when its temperature is taken from 400 K to 800 K, at constant pressure-

A. 30J/K

B. 60J/K

C. 40J/K

D. 20J/K

Answer: C

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51. 1 mole of an ideal gas expands isothermally reversible from 2 litre to 4 litre and 3 moles of the same gas expands from 2 litre to x litre and doing same work, what is 'x'-

A. $(8)^{1/3}$

B. $(4)^{2/3}$

C. 2

D. 4

Answer: B

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52. Which of the following are extensive properties-

A. volume and enthalpy

B. volume and temperature

C. volume and specific heat

D. pressure and temperature

Answer: A

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53. If one monoatomic gas is expanded adiabatically from 2L to 10L at 1 atm external pressure then the value of ΔU (in $atm \cdot L$) is-

A. -8

B. 0

C. -66.7

D. 58.2

Answer: A

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MCQ HOTSPOT (SINGLE CORRENT TYPE)

1. The equation of state for 'n' mol of an ideal gas is PV=nRT. In this equation, the respective number of intensive and extensive properties are-

A. 2,3

B. 3,2

C. 1,4

D. 4,1

Answer: B

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2. $H_2O(l) \rightarrow H^+(aq) + OH^-(aq), \Delta H^0 = 57.32kJ \cdot mol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^0 = -285.8kJ \cdot mol^{-1}$ at $25^\circ C$. If $\Delta H_f^0[H^+(aq)] = 0$, then the standard heat of formation $(kJ \cdot mol^{-1})$ for $OH^-(aq)$ at $25^\circ C$ is-

A. -142.9

B. -228.48

C. -343.12

D. -253.71

Answer: B

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3. For a reaction at TK $\Delta H > 0$ and $\Delta S > 0$. If the reaction attains equilibrium at a temperature of $T_1 K$, (assume ΔH and ΔS are independent of temperature) then the reaction is spontaneous

A. $T < T_1$

B. $T > T_1$

C. $T = T_1$

D. $T \geq T_1$.

Answer: B

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4. The change in entropy for 2 mol ideal gas in an isothermal reversible expansion from 10 mL to 100 mL at $27^\circ C$ is-

A. $26.79 J \cdot K^{-1}$

B. $38.29 J \cdot K^{-1}$

C. $59.07J \cdot K^{-1}$

D. $46.26J \cdot K^{-1}$

Answer: B

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5. Which of the statements is true-

A. a reaction, in which $\Delta H < 0$ is always spontaneous

B. a reaction, in which $\Delta H > 0$ can never occur spontaneously

C. for a spontaneous process in an isolated system, $\Delta S_{sys} > 0$

D. for a spontaneous process in an isolated system, $\Delta S_{sys} = 0$

Answer: C

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6. For the reaction, $CaCO_3(s) \rightarrow CaO(s) + CO_2(g), \Delta H^0 = +179.1kJ \cdot mol^{-1}$ and $\Delta S^0 = 160.2J \cdot K^{-1}$. If ΔH^0 and ΔS^0 are temperature independent, then temperature above which the reaction will be spontaneous is equal to-

A. 1008 K

B. 1200 K

C. 845 K

D. 1118 K

Answer: D

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7. When a gas (molar mass $= 28g \cdot mol^{-1}$) of mass 3.5 is burnt completely in presence of excess oxygen in a bomb calorimeter, the temperature of the calorimeter increases from 298 K to 298.45 K. the heat

of combustion at constant volume for the gas (Given: heat capacity of the calorimeter $= 2.5kJ \cdot K^{-1}$) is-

A. $4.5kJ \cdot mol^{-1}$

B. $8.0kJ \cdot mol^{-1}$

C. $9.0kJ \cdot mol^{-1}$

D. $9.5kJ \cdot mol^{-1}$

Answer: C

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8. For the reaction, $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$-

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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9. Which of the following pairs is true for the process $C_6H_6(g)[1atm, 80.1^\circ C] \rightarrow C_6H_6(l)[1atm, 80.1^\circ C]$-

A. $\Delta G < 0, \Delta S > 0$

B. $\Delta G < 0, \Delta S < 0$

C. $\Delta G = 0, \Delta S < 0$

D. $\Delta G = 0, \Delta S > 0$

Answer: C

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10. The internal energy change when a system goes from state P to Q is 30 $kJ \cdot mol^{-1}$. If the system goes from P to Q by a reversible path and

returns to state P by an irreversible path, what would be the net change in internal energy-

A. 30kJ

B. $< 30kJ$

C. zero

D. $> 30kJ$

Answer: C

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11. If at normal pressure and $100^\circ C$ the changes in enthalpy and entropy for the process, $H_2O(l) \rightarrow H_2O(g)$, are ΔH and ΔS respectively, then $\Delta H - \Delta U$ is-

A. $5.6kJ \cdot mol^{-1}$

B. $6.2kJ \cdot mol^{-1}$

C. $3.1kJ \cdot mol^{-1}$

D. $4.8kJ \cdot mol^{-1}$.

Answer: C

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12. At $25^{\circ}C$, the standard heat of formation for $Br_2(g)$ is $30.9kJ \cdot mol^{-1}$. At this temperature, the heat of vaporisation for $Br_2(l)$ is-

A. $< 30.9kJ \cdot mol^{-1}$

B. $30.9kJ \cdot mol^{-1}$

C. $> 30.9kJ \cdot mol^{-1}$

D. cannot be predicted

Answer: B

Watch Video Solution

13. At $25^\circ C$, when 0.5 mol of HCl reacts completely with 0.5 mol of NaOH in a dilute solution, 28.65 kJ of heat is liberated. If at $25^\circ C$ $\Delta H_f^0[H_2O(l)] = -285.8kJ \cdot mol^{-1}$, then $\Delta H_f^0 OH^-(aq)$ is-

A. $-314.45kJ \cdot mol^{-1}$

B. $-228.5kJ \cdot mol^{-1}$

C. $-257.15kJ \cdot mol^{-1}$

D. $-343.1kJ \cdot mol^{-1}$

Answer: B

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14. On combustion $C_xH_y(l)$ forms $CO_2(g)$ and $H_2O(l)$. At a given temperature and pressure, the value of $\left(\frac{\Delta H - \Delta U}{RT}\right)$ in this combustion reaction is-

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

B. $\frac{x+y}{5}$

C. $-\frac{y}{4}$

D. $\frac{x-y}{4}$

Answer: C

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15. An ideal gas is compressed isothermaly at $25^{\circ}C$ from a volume of 10 L to a volume of 6L. Which of the following is not true for this process-

A. $q < 0$

B. $w > 0$

C. $\Delta U = 0$

D. $\Delta H > 0$

Answer: D

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16. At $27^\circ C$, for the reaction $aA(g) + B(g) \rightarrow 2C(g)$, $P\Delta V = -2.5kJ$. The value of 'a' is-

A. 1

B. 2

C. 3

D. 4

Answer: B

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17. When 1 mol of an ideal gas is compressed in a reversible isothermal process at T K, the pressure of the gas changes from 1 atm to 10 atm. In the process, if the work done by the gas be 5.744kJ, then T is-

A. 400K

B. 300K

C. 420 K

D. 520K

Answer: B

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18. For 0.5 mol of an ideal gas, 15 cal of heat is required to raise its temperature by 10K at constant volume. The molar heat capacity for the gas at constant pressure is-

A. $3cal \cdot K^{-1} \cdot mol^{-1}$

B. $4cal \cdot K^{-1} \cdot mol^{-1}$

C. $5cal \cdot K^{-1} \cdot mol^{-1}$

D. $4.5cal \cdot K^{-1} \cdot mol^{-1}$

Answer: C

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19. 1 mol of an ideal gas is enclosed in a cylinder fitted with a frictionless and weightless piston. The gas absorbs x kJ heat and undergoes expansion. If the amount of expansion work done by the gas is x kJ, then the expansion is-

A. adiabatic

B. cyclic

C. isothermal

D. cannot be predicted

Answer: C

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20. Given (at $25^\circ C$):

$$Ca(s) + \frac{1}{2}O_2(g) \rightarrow CaO(s), \Delta H^0 = -635.2kJ \cdot mol^{-1}$$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^0 = -285.8kJ \cdot mol^{-1}$

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s),$

$\Delta H^0 = -65.6kJ \cdot mol^{-1}$

The heat of formation (in $kJ \cdot mol^{-1}$) for $Ca(OH)_2$(s) is-

A. -855.4

B. -673.9

C. -986.6

D. -731.7

Answer: C

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21. Given (at $25^\circ C$):

$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g), \Delta H^0 = 340.1kJ$

$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s), \Delta H^0 = -824.2kJ$

S(s, rhombic)$+ O_2(g) \rightarrow SO_2(g), \Delta H^0 = -296.8kJ$

$SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g), \Delta H^0 = -98.9kJ$

Heat of formation (in kJ mol^{-1}) of $FeSO_4(s)$ at $25^\circ C$ is-

A. -879.9

B. -789.6

C. -976.5

D. -928.4

Answer: D

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22. At $25^\circ C$, the standard heats of formation of $H_2O(g), H_2O_g, H(g)$ and $O(g)$ are -241.8, -135.66, 218 and $248.17kJ \cdot mol^{-1}$ respectively. The bond energy (in $kJ \cdot mol^{-1}$) of O-O bond in $H_2O_2(g)$ molecule is-

A. 179.23

B. 160.19

C. 142.6

D. 157.16

Answer: C

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23. Given (at $25^\circ C$):

C(s, graphite)$+\frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H^0 = -110.5kJ \cdot mol^{-1}$

$\frac{1}{2}O_2(g) \rightarrow O, \Delta H^0 = +249.1kJ \cdot mol^{-1}$

$CO(g) \rightarrow C(g) + O(g), \Delta H^0 = 1073.24kJ \cdot mol^{-1}$

The standard enthalpy change for the process, C(s, graphite) $\rightarrow C(g)$ at $25^\circ C$ is-

A. $+934.64kJ \cdot mol^{-1}$

B. $713.64kJ \cdot mol^{-1}$

C. $962.74kJ \cdot mol^{-1}$

D. $652.39kJ \cdot mol^{-1}$

Answer: B

Watch Video Solution

24. At $25^\circ C$, for the reaction, $H^+(aq) + OH^-(aq) \rightarrow H_2O(l), \Delta H^0 = -57.3kJ \cdot mol^{-1}$. If the ionisation enthalpy of HCN in water by 45.2 $kJ \cdot mol^{-1}$, then the standard heat of reaction (in $kJ \cdot mol^{-1}$) for the reaction, $HCN(aq) + NaOH(aq) \rightarrow NaCN(aq) + H_2O(l)$, in dilute aqueous solution is-

A. -113.5

B. -12.1

C. -102.5

D. -35.7

Answer: B

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25. The temperature of a bomb calorimeter changes from $25^\circ C$ to $32.7^\circ C$ when w g of naphthalene (molar mass $= 128g \cdot mol^{-1}$) is burnt completely in the calorimeter. If the heat of combustion at constant volume for naphthalene is $-5152kJ \cdot mol^{-1}$, then w is (heat capacity of the calorimeter $= 8.19kJ \cdot K^{-1}$)-

A. 0.87 g

B. 1.91 g

C. 2.37 g

D. 1.57 g

Answer: D

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26. In which of the following processes the change in entropy for the system is zero-

A. irreversible adiabatic processes

B. reversible adiabatic process

C. a spontaneous process occurring is an isolated system

D. isothermal expansion of an ideal gas

Answer: B

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27. A system undergoes the process: $A \rightarrow B \rightarrow C \rightarrow D$. In this process, the change in a state function (X) of the system is x. in the steps $A \rightarrow B$ and $B \rightarrow C$ of the process, if the changes in X are y and z respectively, then the change in X in step $D \rightarrow C$ is-

A. $x - y - z$

B. $x - z + y$

C. $y + z - x$

D. $y - z - x$

Answer: C

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28. At $27^\circ C, \Delta H = +6kJ$ for the reaction $A + 2B \rightarrow 3C$. In the reaction, if $\Delta S_{\text{univ}} = 2J \cdot K^{-1}$ then ΔS_{sys} (in $J \cdot K^{-1}$) is-

A. $+2$

B. $+3$

C. $+20$

D. $+22$

Answer: D

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29. An LPG cylinder contains 14 kg of butane. A family requires $2 \times 10^4 kJ$ of heat for their cooking purpose everyday. By how many days will the

butane in the cylinder be used up (Given: heat of combustion for butane= $-2658kJ \cdot mol^{-1}$)-

A. 15 days

B. 20 days

C. 32 days

D. 40 days

Answer: C

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30. For a reaction involving 1 mol of Zn and 1 mol of H_2SO_4 in a bomb calorimeter-

A. $\Delta U > 0, w > 0$

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

C. $\Delta U < 0, w < 0$

D. $\Delta U < 0, w = 0$

Answer: D

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31. Assuming that water vapour is an ideal gas, the internal energy change (ΔU) when 1 mol of water is vaporised at 1 bar pressure and $100^{\circ} C$, will be (Given: at 1 bar and 373 K, molar enthalpy of vaporisation of water is $41 kJ \cdot mol^{-1}$, $R = 8.3 J \cdot mol^{-1} \cdot K^{-1}$)-

A. $4.100 kJ \cdot mol^{-1}$

B. $3.7904 kJ \cdot mol^{-1}$

C. $37.904 kJ \cdot mol^{-1}$

D. $41.00 kJ \cdot mol^{-1}$

Answer: C

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32. At $25^\circ C$ and 1 atm pressure, ΔH and pressure-volume work for the reaction, $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$, are $-483.7kJ$ and $2.47kJ$ respectively. In this reaction the value of ΔU is-

A. $-486.17kJ$

B. $-481.23kJ$

C. $-400.23kJ$

D. $-492.6kJ$

Answer: B

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33. The initial state of 1 mol of an ideal gas is (P_1, V_1, T_1). The gas is expanded by a reversible isothermal process and also by a reversible adiabatic process separately. If final volume of the gas is same in both the processes, and changes in internal energy in the isothermal and adiabatic processes are ΔU_1 and ΔU_2 respectively, then-

A. $\Delta U_1 = \Delta U_2$

B. $\Delta U_1 < \Delta U_2$

C. $\Delta U_1 > \Delta U_2$

D. cannot be predicted

Answer: C

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34. At a constant pressure the amount of heat required to raise the temperature of 1 mol of an ideal gas by $10^\circ C$ is x kJ. If the same increase in temperature were carried out at constant volume, then the heat required would be-

A. $> x$ kJ

B. $< x$ kJ

C. $= x$ kJ

D. $\geq$ x kJ

Answer: A

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35. Enthalpy of fusion of ice at $0^\circ C$ and 1 atm is 6.02 kJ $\cdot mol^{-1}$. The change in entropy $\left(J \cdot K^{-1}\right)$ of the surroundings when 9 g of water is frozen at $0^\circ C$ and 1 atm pressure is-

A. $+11.02$

B. -11.02

C. -20.27

D. $+23.09$

Answer: B

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36. At given pressure and a temperature of 300K, ΔS_{sys} and ΔS_{surr} for a reaction are $8.0J \cdot K^{-1}$ and $4.0J \cdot K^{-1}$ respectively. ΔG for this reaction is-

A. $-3.0kJ$

B. $-3.6kJ$

C. $3.0kJ$

D. $-4.2kJ$

Answer: B

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37. In a reversible process, if changes in entropy of the system and its surroundings are $\Delta S_1 \& \Delta S_2$ respectively, then-

A. $\Delta S_1 + \Delta S_2 > 0$

B. $\Delta S_1 + \Delta S_2 < 0$

C. $\Delta S_1 + \Delta S_2 = 0$

D. $\Delta S_1 + \Delta S_2 \geq 0.$

Answer: C

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38. A flask of volume 1L contains 1 mol of an ideal gas. The flask is connected to an evacuated flask, and as a result the volume of the gas becomes 10 L. the change in entropy $\left(J \cdot K^{-1}\right)$ of the gas is this process is-

A. 9.56

B. 19.14

C. 11.37

D. 14.29

Answer: B

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39. The heats of neutralisation of four acids A, B, C and D are 13.7, 9.4, 11.2 and 12.4 kcal respectively when they are neutralised against a common base. The weakest acid among A,B,C and D is-

A. A

B. B

C. C

D. D

Answer: B

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40. In a closed insulated container, a liquid is stirred with a paddle to increase the temperature. Which is true-

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

B. $\Delta U = w = q \neq 0$

C. $\Delta U = 0, w = q \neq 0$

D. $w = 0, \Delta U = q \neq 0$`

Answer: A

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41. How many calories are required to increase the temperature of 40g of Ar from $40^\circ C$ to $100^\circ C$ at a constant volume $(R = 2cal \cdot mol^{-1} \cdot K^{-1})$-

A. 120

B. 2400

C. 1200

D. 180

Answer: D

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42. Water is supercooled to $-4^\circ C$. The enthalpy (H) of the supercooled water is-

A. same at ice at $-4^\circ C$

B. more than ice at $-4^\circ C$

C. same as ice at $0^\circ C$

D. less than ice at $-4^\circ C$.

Answer: D

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43. Standard entropy of X_2, Y_2 and XY_3 are 60, 40 and $50J \cdot K^{-1} \cdot mol^{-1}$ 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. 1250K

B. 750 K

C. 500K

D. 1000K

Answer: B

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44. Two moles of a gas of volume 50L and pressure 1 atm are compressed adiabatically and reversibly to 10 atm. What is the atomicity of the gas $(T_1/T_2 = 0.4)$ -

A. 1

B. 2

C. 3

D. 4

Answer: A

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45. Given (at $25^\circ C$):

C (s, graphite) $\rightarrow C(g), \Delta H^0 = +713.64 kJ mol^{-1}$

$\frac{1}{2}H_2(g) \rightarrow H(g), \Delta H^0 = +218 kJ \cdot mol^{-1}$

6C(s, graphite)$+3H_2(g) \rightarrow C_6H_6(g), \Delta H^0 = +82.93 kJ \cdot mol^{-1}$

At $25^\circ C$, if the energy of C_H and C-C bonds are 418 and 347 $kJ \cdot mol^{-1}$

respectively, then the $C = C$ bond energy is-

A. $+679.8 kJ \cdot mol^{-1}$

B. $+652.63 kJ \cdot mol^{-1}$

C. $+808.75 kJ \cdot mol^{-1}$

D. $+763.39 kJ \cdot mol^{-1}$

Answer: B

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46. ΔH value for the given reactions at $25^\circ C$ are-

$C_3H_8(g) \rightarrow 3C(s) + 4H_2(g), \Delta H^0 = 103.8kJ \cdot mol^{-1}$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l), \Delta H^0 = -571.6kJ \cdot mol^{-1}$

$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H^0 = -1560kJ \cdot mol^{-1}$

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta H^0 = -890kJ \cdot mol^{-1}$

$C(s) + O_2(g) \rightarrow CO_2(g), \Delta H^0 = -393.5kJ \cdot mol^{-1}$

Calculate ΔH^0 for the reaction at $25^\circ C$

$C_3H_8(g) + H_2(g) \rightarrow C_2H_6(g) + CH_4(g)$

A. $+98.45kJ$

B. $-55.70kJ$

C. $62.37kJ$

D. $-47.25kJ$

Answer: B

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47. At $0^\circ C$ and normal pressure, the enthalpy of fusion of ice is $334.7 J \cdot g^{-1}$. At this temperature and pressure, if 1 mol of water iis converted into 1 mol ice, then the change in entropy of the system will be-

A. $16.7 J \cdot K^{-1}$

B. $-16.7 J \cdot K^{-1}$

C. $22.06 J \cdot K^{-1}$

D. $-22.06 J \cdot K^{-1}$

Answer: D

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48. Given: $NH_3(g) + 3Cl_2(g) \rightarrow NCl_3(g) + 3HCl(g), \ -\Delta H_1$

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

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g), \Delta H_3$

Heat of formation (ΔH_f) of NCl_3 in terms of $\Delta H_1, \Delta H_2$ and ΔH_3 is-

A. $-\Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

B. $\Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

C. $\Delta H_1 - \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

D. none of these

Answer: A

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49. When 1 g of graphite is completely burnt in a bomb calorimeter, the temperature of the bomb and water rises from $25^\circ C$ to $30.5^\circ C$. If the heat capacity of the calorimeter is $5.96 kJ \cdot {}^\circ C^{-1}$, then the heat of combustion per mole of graphite at constant volume is-

A. $-357.13 kJ \cdot mol^{-1}$

B. $-289.71 kJ \cdot mol^{-1}$

C. $-393.36 kJ \cdot mol^{-1}$

D. $-307.94 kJ \cdot mol^{-1}$

Answer: C

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50. The volume of a gas is reduced to half from its original volume. The specific heat will -

A. reduce to half

B. double

C. remain constant

D. increase four times

Answer: C

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51. For which molar specific heat is temperature independent-

A. argon

B. hydrogen

C. nitrogen

D. carbon dioxide

Answer: A

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52. Which of the following quantities are stable functiond-

A. q

B. q+w

C. w

D. U+PV

Answer: B::D

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53. Which of the following comments are true-

A. only for an ideal gas, $C_{P,m} > C_{V,m}$

B. for any gas, $C_{P,m} > C_{V,m}$

C. for a solid substance, $C_{P,m} \approx C_{V,m}$

D. for 'n' mol of ideal gas, $C_{P,m} - C_{V,m} = nR$

Answer: B::C::D

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54. When 3g of ethane gas is brunt at $25^\circ C$, 156 kJ of heat is liberated. If the standard enthalpies of formation for $CO_2(g)$ and $H_2O(l)$ are -393.5 and -285.8 $kJ \cdot mol^{-1}$ respectively, then for ethane gas-

A. standard heat of combustion $= -1560 kJ \cdot mol^{-1}$

B. standard heat of formation $= -67.9 kJ \cdot mol^{-1}$

C. standard heat of combustion=-832$kJ \cdot mol^{-1}$

D. standard heat of formation =-84.4$kJ \cdot mol^{-1}$.

Answer: A::D

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55. A reaction is spontaneous at a temperature of 300K, but it is non-spontaneous at a temperature of 400K. If ΔH and ΔS for the reaction do not depend on temperature, then-

A. $\Delta H > 0$

B. $\Delta H < 0$

C. $\Delta S > 0$

D. $\Delta S < 0$

Answer: B::D

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56. The reaction, $3O_2(g) \rightarrow 2O_3(g)$, is non-spontaneous at any temperature. Hence-

A. the reverse reaction is spontaneous at any temperature

B. $\Delta H < 0$ and $\Delta S < 0$ for the reverse reaction

C. $\Delta H > 0, \Delta S > 0$ for the reverse reaction

D. $\Delta H < 0$ and $\Delta S > 0$ for the reverse reaction

Answer: A::D

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57. For isothermal free expansion of an ideal gas-

A. $\Delta U = 0$

B. $\Delta S < 0$

C. $\Delta S > 0$

D. $\Delta H > 0$

Answer: A::C

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58. The changes in which of the following quantities are zero for a cyclic process-

A. enthalpy

B. work

C. entropy

D. internal energy

Answer: A::C::D

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59. Which of the following relations are true for the reaction, $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$-

A. $\Delta H < 0$

B. $\Delta G > 0$

C. $\Delta S < 0$

D. $\Delta S > 0$

Answer: B::D

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60. Identify the correct statement-

A. standard state of bromine $(25^\circ C, 1atm)$ is $Br_2(g)$

B. C(graphite, s) $\rightarrow C$ (diamond, s), here $\Delta H \neq 0$

C. standard enthalpy change for the reaction $N_2(g) + O_2(g) \rightarrow 2NO(g)$ at $25^\circ C$ and 1 atm is standard

enthalpy of formation of NO(g)

D. at a particular temperature and pressure, if $\Delta H = xkJ$ for the reaction $A + 3B \rightarrow 2C$ then $\Delta H = -\frac{x}{2}$ kJ for the reaction $C \rightarrow \frac{1}{2}A + \frac{3}{2}B$

Answer: B::D

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61. Which of the following statement are correct-

A. in any adiabatic process, $\Delta S_{sys} = 0$

B. in isothermal expansion of an ideal gas, $\Delta H = 0$

C. an endothermic reaction will be spontaneous if in this reaction $\Delta S_{sys} > 0$

D. heat capacity is a path depend quantity

Answer: B::C::D

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62. Correct statements are-

A. $A + B \rightarrow D, \Delta H = xkJ.$ This reaction is performed in the following two steps: (i) $A + B \rightarrow C$

(ii) $C \rightarrow D$. If in step (i) $\Delta H = ykJ$, then $\Delta H = (x - y)J$ in step (ii)

B. For a spontaneous process occuring in an isolated system $\Delta S_{sys} > 0$ at equilibrium

C. in a spontaneous chemical reaction at constant temperature and pressure, $\Delta G = -T\Delta S_{\text{surr}}$

D. in a chemical reaction $\Delta H > 0$ and $\Delta S > 0$. The reaction attains equilibrium at temperature, T_c. At constant pressure and constant temperature TK the reaction will be spontaneous, if $T > T_c$.

Answer: A::D

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63. Some reaction and their ΔH^0 values are given below:

C(graphite, s)$+\frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H^0 = a$ kJ

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g), \Delta H^0 = b$ kJ

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H^0 = c$ kJ

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta H^0 = d$ kJ

2C(gaphite, s)$+3H_2(g) \rightarrow C_2H_6(g), \Delta H^0 = m$ kJ

Which of the following statements are correct-

A. standard heat of formation of $CH_4(g) = (a + b + 2c - d)kJ \cdot mol^{-1}$

B. standard heat of combustion of $C_2H_6 = (2a + 2b + 3c - m)kJ \cdot mol^{-1}$

C. standard heat of combustion of carbon $= akJ \cdot mol^{-1}$

D. standard heat of formation of $CO_2(g) = (a + b)kJ \cdot mol^{-1}$.

Answer: A::B::D

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64. At $25^\circ C$, in which of the given reactions do standard enthalpies of reactions indicate standard enthalpies of formation of the product in the respective reactions-

A. $H_2(g) + \frac{1}{3}O_3(g) \rightarrow H_2O(l)$

B. $Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$

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

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

Answer: B::D

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

II. $SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$

III. $PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

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

For which of these reactions, P-V work is negative-

A. I

B. II

C. III

D. IV

Answer: A::C

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66. Which of the given reactions are endothermic in nature-

A. combustion of methane

B. decomposition of water

C. dehydrogenation of ethane to ethene

D. conversion of graphite to diamond

Answer: B::C::D

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67. At constant volume and 298K, 1 mol of a gas is heated and the final temperature is 308K. If heat supplied to the gas is 500J, then for the overall process-

A. w=0

B. $w = -500J$

C. $\Delta U = 500J$

D. $\Delta U = 0$

Answer: A::C

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68. True for spontaneous dissolution of KCl in water are-

A. $\Delta G < 0$

B. $\Delta H > 0$

C. $\Delta S_{\text{surr}} < 0$

D. $\Delta H < 0$

Answer: A::B

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69. When a bottle of perfume is opened, odorus molecules mix with air and diffuse gradually throughout the room. The correct facts about the process are-

A. $\Delta S = 0$

B. $\Delta G < 0$

C. $\Delta S > 0$

D. $\Delta S < 0$

Answer: B::C

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70. At $0^{\circ} C$ and 10 atm pressure 14g of oxygen is subjected to undergo a reversible adiabatic expansion to a pressure of 1 atm. Hence in this process-

A. final temperature of the gas is 141.4K

B. final temperature of the gas is 217.3K

C. work done=293.2 cal

D. work done=-286 cal

Answer: A::D

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71. Choose the reactions in which the standard reaction enthalpy (at $25^\circ C$) represent the standard formation enthalpy of the product-

A. $H_2(g) + \frac{1}{3}O_3(g) \rightarrow H_2O(l)$

B. $Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$

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

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

Answer: B::D

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VERY SHORT TYPE QUESTIONS

1. (i) Which type of system does not interact with its surroudings?

(ii) Classify the following systems into open, closed and isolated sysstem:

(a) a plant (b) certain amount of a liquid enclosed in a container with rigid, impermeable and adiabatic wall.

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2. If the volume and density of 5g of pure iron sample are 'V' and 'd' respectively then what will be the volume and density of 10 g of the same sample?

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3. Why is the enthalpy (but not molar enthalpy) of a systemm an extensive property?

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4. Show that the unit of 'PV' is the unit of work or energy.

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5. Specific heat capacity of 10g of a simple of aluminium is x cal $\cdot g^{-1} \cdot K^{-1}$. Is the vlaue of specific heat capacity of 5g of that sample $\frac{x}{2} cal \cdot g^{-1} \cdot K^{-1}$?

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6. On which factors does the change in a state function depend?

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7. The initial state of a system is A. this system participates in the following process: $A \rightarrow B \rightarrow C \rightarrow A$. What will be the change in internal energy of the system is this process?

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8. Which of the following is (are) not a state function?

(i) Enthalpy (ii) Heat capacity (iii) Heat (iv) Work done.

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9. Among pressure of the system and the surroundings, which one is represented by 'P' in the equation $H = U + PV$? What would be the change in enthalpy for the reaction $A_2(s) + B_2(g) \rightarrow 2AB(g)$?

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10. At T K, what will be the value of (H-U) for 1 mol of ideal gas?

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11. In an isothermal expansion of an ideal gas both ΔH and ΔU are zero. What will be the values of ΔU and ΔH in isothermal compression

in an isolated system?

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12. What will be the value of the change in internal energy of a process occurring in an isolated system?

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13. In a process, q cal heat is absorbed by a closed system. If work done by the system is w cal, then what will be the value of the change in internal energy (ΔU) in this process?

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14. For a process occurring in a closed system, $\Delta U = q$. If only pressure-volume work is performed by the system then which type of process is this?

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15. The amount of heat released by a system at constant pressure is 20 kJ. What will be the value of ΔH in this process?

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16. For an ideal gas $C_{V,m} = 12.47 J \cdot mol^{-1} \cdot K^{-1}$. What will be the value of $C_{P,m}$?

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17. A liquid in a closed adiabatic container is stirred. Among $\Delta U, w$ and q , which one will be zero?

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18. If the temperature of 1 mol of an ideal gas is doubled then what will be the change in value of internal energy? Will it increase, decrease or remain the same?

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19. $2H_2 + O_2 \rightarrow 2H_2O, \Delta H = -571.6kJ$. Does this equation express the thermochemical equation for the formation of H_2O?

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20. What temperature and pressure are usually considered as the standard state of a substance?

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21. Which allotropic form of carbon is considered as a source of carbon in the formation reactions of carbon compounds at $25^\circ C$ and 1 atm ?

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22. Which of the following two reactions indicates the formation reaction of HI(g) at $25^\circ C$ and 1 atm?

(i) $\frac{1}{2}H_2(g) + \frac{1}{2}I_2(g) \rightarrow HI(g)$

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

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23. Between $O_2(g)$ and $O_3(g)$, whose standard enthalpy of formation $\left(\Delta H_f^0\right)$ is taken as zero at 1 atm and $25^\circ C$?

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24. In which of the following reactions the standard heat of reaction is equal to the standard heat of formation of $CaBr_2(s)$ at $25^\circ C$?

(i) $Ca(s) + Br_2(l) \rightarrow CaBr_2(s)$

(ii) $Ca(s) + Br_2(g) \rightarrow CaBr_2(g)$.

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25. Heat required to vaporise 1 g of water at $100^\circ C$ and 1 atm is 2.26 kJ. What is the enthalpy of vaporisation of water at this temperature and pressure?

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26. 1 mol of $H_2O(l)$ is formed when 1 mol of H^+ ions and 1 mol of OH^- ions react together is aqueous solution. Does this reaction represent the formation reaction of water?

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27. Consider the reaction:

(i) $A_2(s) + B_2(g) \rightarrow A_2(g) + B_2(g), \Delta H = -x$ kJ

(ii) $A_2(g) + B_2(g) \rightarrow 2AB(g), \Delta H = -y$ kJ

What is the value of the change in enthalpy for the following reaction

$A_2(s) + B_2(g) \rightarrow 2AB(g)$?

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28. S(monoclinic, s) $\rightarrow S$(rhombic, s)`. What is enthalpy change of this process called?

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29.

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H^+(aq) + OH^-(aq), \Delta H^0 = -228.5kJ \cdot mol^{-1}$

. If $\Delta H_f^0[H^+] = 0$, then what will be the value of $\Delta H_f^0[OH^-]$?

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30. The bond dissociation energies of three A-B bonds in $AB_3(g)$ molecule are x,y and z $kJ \cdot mol^{-1}$ respectively. What is the bond energy of A-B bond?

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31. Why is the heat of reaction of a reaction occurring in a bomb calorimeter equal to the change in internal energy of the reaction system?

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32. For which type of molecule the bond energy is equal to the bond dissociation energy?

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33. What will be the difference between ΔH and ΔU in the combustion reaction of $C_{10}H_8(g)$ at $25^\circ C$?

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34. Write down the relation between ΔH and ΔU for the following reaction:

$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COON(aq) + H_2O(l).$

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35. If the bond energy of C-H bond is +416.18 $kJ \cdot mol^{-1}$, then what will be the enthalpy of formation of C-H bond?

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36. What is the most important feature of Hess's law?

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37. The standard bond dissociation energy of $A_2(g), B_2(g)$ and $AB(g)$ molecules are x, y and z $kJ \cdot mol^{-1}$ respectively. What will be the standard enthalpy of formation of AB(g)?

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38. At temperature TK the difference between ΔH and ΔU for the following reaction is $+\frac{1}{2}RT: A + \frac{1}{2}B_2(g) \rightarrow AB(g)$.

What is the physical state of A (solid or gas)?

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39. Give an example of a spontaneous process in which the change in enthalpy of the system is positive.

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40. What will be the sign of enthalpy change and entropy change for a process to be spontaneous at all temperature?

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41. What will be the signs of ΔG for melting of ice at 267 K and 276K temperature and 1 atm pressure?

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42. Water and ice remain in equilibrium at $0^{\circ} C$ and 1 atm pressure. What will be the value of ΔG and the sign of ΔS_{system} at this equilibrium?

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43. Which one of the following relation or expression is true for a spontaneous process of $\Delta G = 0$, $\Delta H = T\Delta S$, $\Delta G > 0$, $\Delta G < 0$?

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44. What will be the sign of entropy change for the process $I_2(g) \rightarrow I_2(s)$?

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45. What will be the change in entropy of the surroundings in a spontaneous process occurring in an isolated system?

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46. Is the entropy of the universe constant?

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47. Given an example of a process in which the change in enthalpy of the system is negative.

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48. What sign (+ or -) of entropy change in an endothermic reaction makes the reaction non-spontaneous at any temperature?

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49. In which case the ΔS_{sys} will be maximum between the following two processes-

(i) ice $\rightarrow$ water

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

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50. Predict the sign of ΔS^0 for the given reaction?

$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g).$

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51. Does the Gibbs free energy of a substance decrease or increase if the amount of the substance is increased?

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52. In a process, the value of the change in entropy of the system and its surroundings are x and -y $J \cdot K^{-1}$. If $x > y,$ then will the process be spontaneous?

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53. The change in entropy of the system in a process $A \rightarrow B \rightarrow C$ is $25J \cdot K^{-1}$. If the change in entropy of the system in the step $B \rightarrow C$ is 15 $J \cdot K^{-1}$, then what will be the change in entropy of the system in the step $B \rightarrow A$?

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FILL IN THE BLANKS

1. Sign of ΔU in adiabatic expansion of a gas is ____.

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2. In a process q>0, but w=0. so, the internal energy of the system will (increase/decrease)_____.

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3. According to first law, for a cyclic process q+w=_____.

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4. Volume of a substance is an ____property while molar volume of a substance in an ____ property.

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5. Specific heat capacity of a substance is x cal $\cdot g^{-1} \cdot {}^{\circ}C^{-1}$. Specific heat capacity of 100g of that substance will be ____.

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6. Molar heat capacity of a substance at constant pressure is _____than that at constant volume.

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7. In Vaporisation of water, the signs of q and w are ____ and ____respectively.

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8. For a process occurring at constant volume, $\Delta U = +10kJ$. In this process, q=_____.

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9. In isothermal expansion of 1 mol of an ideal gas, $q = +12kJ$. The value of w=_____ and ΔU=_____.

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10. In a chemical reaction, if the total enthalpies of reactants and products are H_R and H_P respectively then $H_P > H_R$ for _____ reaction

and $H_R > H_P$ for ____ reaction.

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11. At $25^\circ C$, the standard state of liquid ethanol means ___ethanol at $25^\circ C$ and ___pressure.

Watch Video Solution

12. Given:

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ and $C_3H_8(g) + 5O_2(g) \rightarrow 3C$

. At a fixed temperature and pressure between these two reactions the heat evolved in the second reaction is ____ than that in the first one.

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13. At $25^\circ C$ and 1 atm, the standard reaction enthalpy for the reaction C(graphite, s)$+O_2(g) \rightarrow CO_2(g)$ is the ____ of $CO_2(g)$.

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14. At $25^\circ C$ and 1 atm, standard reaction enthalpy for the reaction, $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ is ____ of $CH_4(g)$.

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15. At $25^\circ C$, for the reaction, $H^+(aq) + OH^-(aq) \rightarrow H_2O(l), \Delta H^0 = -57.3 kJ \cdot mol^{-1}$. If the ionisation enthalpy of HCN in water by 45.2 $kJ \cdot mol^{-1}$, then the standard heat of reaction (in $kJ \cdot mol^{-1}$) for the reaction, $HCN(aq) + NaOH(aq) \rightarrow NaCN(aq) + H_2O(l)$, in dilute aqueous solution is-

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16. The change in entropy for the process $KCl(s) + 100H_2O(l) \rightarrow KCl(100H_2O)$ is called_____.

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17. At $25^\circ C$ and 1 atm if the bond energy of $Cl_2(g)$ is $242kJ \cdot mol^{-1}$, then the standard enthalpy of atomisation of chlorine at the same temperature+____.

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18. In the reaction $\Delta S_{sys} = xJ \cdot K^{-1}$ and $\Delta S_{\text{surr}} = -yJ \cdot K^{-1}$. The reaction will be spontaneous if _____.

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19. In the cyclic process $A \xrightarrow{I} \overset{II}{BC} \xrightarrow{III} A$ the change in entropy of the system are $\Delta S_1, \Delta S_2 \& \Delta S_3$. $\Delta S_1 + \Delta S_2 + \Delta S_3 =$ _____.

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20. $NH_4Cl(s) + H_2O(l) \rightarrow NH_4^+(aq) + Cl^-(aq)$. it is an endothermic process. In this process the signs (+ or -) of ΔS_{sys} and ΔS_{surr} are____ and ___ respectively.

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21. A reaction is non-spontaneous at all temperature but the reverse reaction is spontaneous at all temperature. The signs (+ or -) of ΔH and ΔS_{sys} for the reverse reaction are _____ and _____respectively.

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22. In an exothermic process $\Delta S_{sys} < 0$. In this reaction the sign (+ or -) of ΔS_{surr} is_____. This reaction will be spontaneous if the numerical value of ΔS_{sys} is ____ than that of ΔS_{surr} .

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23. In a spontaneous process occurring at constant pressure and at temperature TK, $\Delta H > 0$, $\Delta S > 0$. In this process the numerical value of ΔH is____ than that of ____.

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SHORT TYPE QUESTIONS

1. Assuming the system performs only pressure-volume work, show that heat absorbed by a closed system at constant volume is equal to the increase in its internal energy.

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2. Assuming the system performs only pressure-volume work, show that heat evolved by a closed systemm at constant pressure is equal to the decrease in its enthalpy.

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3. Show that the total energy of ann isolated system always remains constant.

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4. Why is the temperature of a system a state function?

Watch Video Solution

5. What are the conditions for a system to be in thermodynamic equilibrium?

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6. Give one example for each of an isobaric and isothermal process.

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7. Why is the sudden expansion or compression of a gas considered to be an adiabatic process ?

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8. Give thermodynamic definition of heat and work.

Watch Video Solution

9. Internal energy is a property of a system, but heat is not- explain.

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10. Show that both heat and work are path dependent quantities.

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11. Why does the internal enegy of a system increases with rise in temperature?

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12. What does pressure-volume work mean? Why is it considered that work done by a system is negative but work done on the system is positive?

Watch Video Solution

13. Show that for an ideal gas the difference between the molar heat capacities at constant pressure and at constant volume is equal to the universal gas constant (R).

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14. In case of a solid or a liquid substance $C_{P,m} \approx C_{V,m}$, but in case of gaseous substances $C_{P,m} > C_{V,m}$. Explain.

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15. For liquid ethanol at $25^\circ C$, $\Delta H_f^0 = -277.69 kJ \cdot mol^{-1}$. Represent the thermochemical equation showing the formation reaction of liquid ethanol.

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16. Reaction enthalpy for an exothermic reaction is negative- why?

Watch Video Solution

17. For which of the following reactions does the standard enthalpy of reaction represent the standard enthalpy of formation of $CH_4(g)$?

Explain it.

(a) C(diamond, s)$+4H_2(g) \rightarrow CH_4(g)$

(b) C(graphite, s)$+O_2(g) \rightarrow CH_4(g)$.

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18. Given: C(graphite, s)$+O_2(g) \rightarrow CO_2(g), \Delta H^0 = x_1$

C(graphite, s)$+\frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H^0 = x_2$

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g), \Delta H^0 = x_3$

Express x_3 in terms of x_1 and x_2.

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19. At $25^\circ C$, $\Delta H_f^0 = 0$ for graphite, but for diamond $\Delta H_f^0 \neq 0$. Why?

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20. Mention two applications of Hess's law.

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21. "At $25^\circ C$, the standard heat of combustion of graphite is $-94300 cal \cdot mol^{-1}$"-what does it mean?

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22. "At $25^\circ C$, the standard heat of formation of $H_2O(l)$ is $-285.83 kJ \cdot mol^{-1}$"-What does it mean?

Watch Video Solution

23. $\frac{1}{2}A_2(g) + \frac{1}{2}B_2(g) \rightarrow AB(g), \Delta H = -50 kcal.$ If the bond energies of $A_2(g), B_2(g)$ and $AB(g)$ are x $kcal \cdot mol^{-1}$ $\frac{x}{2} kcal \cdot mol^{-1}$ and x kcal $\cdot mol^{-1}$ respectively then what will be the value of x?

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24. $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g), \Delta H = -110.4kJ.$ Does this ΔH represent enthalpy of combustion of carbon?

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25. Give two examples of spontaneous process.

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26. When an adiabatic process is said to be an isoentropic process ?

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27. An exothermic reaction associated with decrease in entropy takes place spontaneously at high temperature, but does not occur spontaneously at low temperature, explain.

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28. What are the conditions of spontaneity and equilibrium for a process in an isolated system?

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29. $Cl(g) + Cl(g) \rightarrow Cl_2(g)$. What will be the sign of ΔH and ΔS in this reaction?

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30. Why is soild NaCl soluble in water although enthalpy of solution for NaCl in water is positive?

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31. Why is the entropy of ice less than that of water?

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32. Does the entropy of the system increase or decrease in the reaction: $2O_3(g) \rightarrow 3O_2(g)$? Explain with reason.

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33. Why is $\left(\Delta S_{\text{system}} + \Delta S_{\text{surroundings}}\right)$ zero is a reversible process?

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34. Many spontaneous processes are accompanied by decrease in entropy-explain.

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35. Why is the entropy of any pure and perfectly crystalline substance at 0 K temperature zero?

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36. Why solidification of water does not occur spontaneously although it is an exothermic process?

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37. Why is Gibbs free energy called 'free energy' ?

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LONG TYPE QUESTIONS

1. For a closed system, determine the change in internal energy (ΔU) when (a) q cal of heat is absorbed by the system and w cal of work is performed on the system (b) q cal of heat is absorbed by the system and w cal of work is performed by the system (c) q cal of heat is evolved by the system and w cal of work is performed on the system (d) heat is not

absorbed or evolved by the system, but w cal of work is performed by the system.

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2. 1 mol of an ideal gas participates in the following process:

$$P, V \rightarrow P, 2V \rightarrow \frac{P}{2}, 2V \rightarrow \frac{P}{2}, V \rightarrow P, V$$

Calculate the total work done in this process.

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3. Identify the following processes each of which occurs in a closed system. Consider only pressure-volume work is perforemd in these processes.

(a) $q = 0, w > 0, \Delta U = 0$

(b) $q > 0, \Delta U > 0, w = 0.$

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4. $C_6H_6(l) \rightarrow C_6H_6(g)$, in this transformation what will be the signs (+ or -) of the given quantities: q,w , ΔH, ΔU. Explain.

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5. For an ideal gas, $C_V = \frac{3}{2}R$. (a) What will be the change in internal energy (ΔU) of 1 mole of an ideal gas if its temperature is increased by 4K at constant volume ? What would be ΔU if the temperature of this gas is increased by the same amount of constant pressure? keeping pressure constant if the temperature of that same amount of gas is increased by 4K then what will be the change in internal energy (ΔU) of that gas? (c) give reason for different values of ΔU and ΔH ?

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6. Give one example for each of the following processes-

(i) ΔP (system)=0 (ii) ΔV(system)=0

(iii) ΔT (system)=0

(iv) q=0

(v) ΔU(system)=0.

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7. Give definition: (i) closed system (ii) adiabatic system (iii) open system (iv) isolated system.

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8. Explain with examples: (i) enthalpy of a system is an extensive property (ii) boiling point of a liquid is an intensive property (c) concentration is an intensive property.

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9. (i) 1 mol of an ideal gas expands isothermally and reversible from (P_1V_1T) to (P_2V_2T). Write down the equation showinig the amount of

heat absorbed by the given ideal gas.

(ii) In an isothermal expansion of an ideal gas, the pressure of the gas decreases from P_1 to P_2. write down the equation of work done by the gas in this process.

(iii) The temperature of 1 mol of an ideal gas is increased from T_1 and T_2. write down the equations for the changes in enthalpy and internal energy.

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10. State the condition at which $\Delta H = \Delta U$. For which reactions-(i) $\Delta H > \Delta U$

(ii) $\Delta H < \Delta U$?

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11. (i) What do you mean by standard enthalpy of formation?

(ii) Is the standard enthalpy of reaction of the following reaction equal to

the standard enthalpy off formation of $H_2O(l)$ at $25^\circ C: H_2(g) + \frac{1}{3}O_3(g) \rightarrow H_2O(l)$? Explain.

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12. What do you mean by enthalpy of fusion? Explain it with example. What is its significance?

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13. What is enthalpy of vaporisation? Explain it with example. What is its significance?

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14. Give definition with example: (i) integral heat of solution (ii) heat of dilution.

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15. The lattice enthalpy of an ionic compound MX is ΔH_L and the total enthalpy of hydration of M^+ and X^- ions is ΔH_{hyd}. Show that heat of solution of this ionic compound $\Delta H_{sol} = \Delta H_L + \Delta H_{\text{hyd}}$.

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16. (i) According to Hess's law it is possible to determine the enthalpy of formation of a substance which cannot be measured directly-explain.

(ii) What do you mean by heat of transition?

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17. (i) What are bond energy and bond dissociation energy?

(ii) Why average value is always taken for the determination of bond energy?

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18. (i) What is the difference betweenn the enthalpy of formation and the enthalpy of reaction? Explain with proper explain.

(ii) what do you understand by the standard state of liquid benzene at $25^{\circ} C$?

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19. What do you mean by heat of reaction or enthalpy of reaction? What are the factors on which heat of reaction depends?

Watch Video Solution

20. (i) What do you mean by heat of reaction at constannt volume and heat of reaction at constant pressure?

(ii) Establish the relation $\Delta H = \Delta U = \Delta nRT$ for a chemical reaction in gaseous state.

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21. (i) Show that heat of reaction at constant volume is equal to the change in internal energy of the system.

(ii) Show that heat of reaction at constant pressure is equal to the change in enthalpy of the system.

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22. (i) State annd explain with example the Hess's law of constant heat summation.

(ii) Show that Hess's law is simply a corollary of first law of thermodynamics.

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23. Define: (i) Heat of combustion, (ii) Heat of formation, (iii) Heat of neutralisation.

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24. Give reason for the necessity of second law of thermodynamics.

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25. Write down the Clausius and Planck-Kelvin statement of the second law off thermodynamics.

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26. Define entropy from molecular point of view. At a particular temperature the entropy of a substance in its gaseous state is greater than that in liquid state which is in turn greater than in solid state- explain.

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27. What do you mean by entropy of fusion and entropy of vaporisation? Give the mathematical expression of each.

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28. What is the physical significance of entropy ? Write the second law of thermodynamics in terms of entropy.

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29. Show that in a process at constant temperature and pressure, the Gibbs free energy change of a system, $\Delta G = -T\Delta S_{\text{total}}$.

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30. (i) What is the relation between Gibbs free energy change and spontaneity of a process?

(ii) Write down the relation between standard free energy change and equilibrium constant.

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31. If the value of ΔH and ΔS are of following type, then at what condition a reaction will occur spontaneously?

(i) $\Delta H > 0$ and $\Delta S > 0$

(ii) $\Delta H < 0$ and $\Delta S > 0$

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32. Under which of the following conditions a reaction will occur spontaneously?

(i) $\Delta H < 0$ and $\Delta S < 0$

(ii) $\Delta H > 0$ and $\Delta S < 0$.

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33. How does the spontaneity of an endothermic reaction depend on temperature when (i) $\Delta S > 0$ and (ii) $\Delta S < 0$?

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34. How does the spontaneity of an exothermic reaction depend on temperature when (i) $\Delta S > 0 \text{ and } (ii) \Delta S < 0$?

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35. There is not certainty that the reaction will be spontaneous even if ΔH is negative-explain it, state its limitation and exception.

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36. Give the mathematical definition of entropy change. Discuss the relationship between entropy change & spontaneity of a process.

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37. (i) Spontaneity of a process can be determined from the entropy change and also from the Gibbs free energy change. But the Gibbs free energy change in more useful than entropy change to determine the spontaneity of a process. Explain it.

(ii) Show that Gibbs energy change of a system at certain temperature and pressure, $\Delta G = \Delta H - T\Delta S$.

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Numerical Problems

1. A certain amount of gas is expanded from a volume of 20 mL to 42.6 mL by the following three processes (i) against zero pressure (ii) against constant external pressure of 1.2 atm (iii) against constant external pressure of 2.0 atm. Calculate the work done in each of the above three processes.

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2. At $27^\circ C$, $4.0g$ of He is expanded reversibly and isothermally when the pressure drops from 10 to 1.0 atm. Calculate the work done in calorie, assuming an ideal behavior of the gas.

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3. At $27^\circ C$, 2 mol of an ideal gas is expanded from a volume of 10 L to 100 L. In this case what will be the maximum value of work done ?

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4. At $27^\circ C$, $4.2gN_2$ gas is expanded reversibly and isothermally from a pressure of 10 atm to 1 atm. Calculate $q, \Delta U, \Delta H$ and w for this expansion. Assume N_2 gas behaves ideally.

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5. 1 mol of an ideal gas is expanded from volume $V_1 \text{ to } 10V_1$. If work done by the gas is 10 kJ and the initial pressure of the gas is $1 \times 10^7 Pa$, then calculate V_1. What will be the temperature of the gas if the amount is 2 mol ?

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6. 2 mol of an ideal gas participates in the following process -

(a) Calculate total work done and total heat change.

(b) Calculate $\Delta U \text{ and } \Delta H$ of the overall process.

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7. (i) The pressure and temperature of 0.8 g of He gas are 1 atm and 298 K respectively. If 400 J of heat is applied to the gas at constant volume, what will be change in internal energy and the final temperature of the gas ?

(ii) If the same amount of heat is applied to the gas at constant pressure, then what will be the change in internal energy and the final temperature of the gas ? For both the cases, assume He gas behaves ideally and its $C_V = \frac{3}{2}R.$

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8. The temperature of 1 mol of an ideal monoatomic gas at constant pressure of 1 atm changes from $25^\circ C$ and $50^\circ C.$ Calculate ΔU and ΔH in this process, $\left(C_V = \frac{3}{2}R\right).$

Watch Video Solution

9. In a reaction 4 kJ of heat is released. If the same amount of heat is supplied to 200 g of water at 25°, what will be the final temperature of water ? [Given : molar heat capacity of water $= 75.24 J.\ K^{-1}\ \ \text{mol}^{-1}$]

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10. How much heat is required for the following transformation - Given : Specific heat capacities of water and ice are $4.18J.\,g^{-1}.\,K^{-1}$ and $2.09J.\,g^{-1}.\,K^{-1}$.

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11. The amount of work done when a gas is expanded from a volume of 5 L to 10 L against a constant external pressure of 2 atm is used to heat 15 g of water present at a temperature of 300 K. Calculate the final temperature of water. (Given : molar heat capacity of water $= 75.6J.\,K^{-1}.\quad \mathrm{mol}^{-1}$).

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12. 2 mol of an ideal gas is compressed by an isothermal reversible process at $27^{\circ}C$. As a result, pressure of the gas increases from 1 to 10 atm. Calculate w, q, ΔU and ΔH for the process.

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13. 100 ml of a liquid is present in an insulated container at a pressure of 1 bar. The pressure is steeply increased to 100 bar. The volume of the liquid is decreased by 1 ml at this constant pressure. Find the values of ΔH and ΔU.

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14. For the reaction, $2CO + O_2 \rightarrow 2CO_2, \Delta H = -560kJ$. 2 mol CO and 1 mol of O_2 are taken in container of volume 1L. They completely form two moles of CO_2. The gases deviate apreciably form ideal behaviour. If the pressure in the vessel changes from 70 to 40 atm, find the magnitude (absolute value) of ΔU at 500 K.

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15. A sample of argon gas at 1 atm pressure and $27^\circ C$ expands reversibly and adiabatically from $1.25 dm^3 \rightarrow 2.50 dm^3$. Calculate the enthalpy change in this process $\left(C_V, m\right.$ for argon is $12.48 J.\ K^{-1}.\ \ \mathrm{mol}^{-1}\left.\right)$.

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16. At $25^\circ C$, the heat of combustion of naphthalene at constant volume is $-1230\ \ \mathrm{kcal\ mol}^{-1}$. Calculate the heat of reaction at constant pressure and $25^\circ C$.

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17. The change in enthalpy due to combustion of glucose is $2880\ \ \mathrm{kJ\ mol}^{-1}$. 25% of this energy is utilised by the body muscles to do physical work. If 100 kJ of energy is used by the muscles to walk 1 km then what will be the maximum distance a person can walk after consuming 120 g of glucose ?

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18. Calculate the standard enthalpy of formation of n- butane. Given : standard enthalpy of combustion of n- butane, C (graphite) and $H_2(g)$ are $-2878.5\ \text{kJ mol}^{-1}$, $-393.5\ \text{kJ mol}^{-1}$ and $-285.8\ \text{kJ mo}$ respectively.

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19. Calcaulte reaction enthalpy of the following reaction at $25^\circ C$.

$SO_2(g) + 2H_2S(g) \rightarrow 3S(\text{rhombic}) + 2H_2O(l)$.

Given : ΔH_f^0 of $SO_2(g), H_2S(g)$, S (rhombic) and $H_2O(l)$ at $25^\circ C$ are $-70.96, -4.82, 0$ and $-68.32\ \text{kcal mol}^{-1}$ respectively.

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20. Al(s) and Fe(s) are oxidised by oxygen to form $Al_2O_3(s)$ and $Fe_2O_3(s)$ respectively. If the standard enthalpy of formation of $Al_2O_3(s)$ and $Fe_2O_3(s)$ are $-1669.8\ \text{kJ mol}^{-1}$ and $-824.2\ \text{kJ mol}^{-1}$ respectively, calculate the change in enthalpy of the given reaction :

$2Al(s) + Fe_2O_3(s) \rightarrow 2Fe(s) + Al_2O_3(s)$

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21. Determine standard heat of formation of MnO_2 from the following data : $2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s), \Delta H^0 = -1670kJ$

$3MnO_2(s) + 4Al(s) \rightarrow 3Mn(s) + 2Al_2O_3(s), \Delta H^0 = -1792kJ$

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22. At $25^\circ C$ and 1 atm, heat of formation of $C_2H_4(g), CO_2(g)$ and $H_2O(l)$ are

52 kJ mol^{-1}, -394 kJ mol^{-1} and -286 kJ mol^{-1} respectively. Calculate the heat of combustion of $C_2H_4(g)$.

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23. Standard molar heat of formation of ethane, CO_2 and water are -21.1, -94.1 and -68.3 kcal respectively. Calculate the molar heat of combustion of ethane.

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24. At $25^\circ C$, standard enthalpy of combustion of combustion of hydrogen, cyclohexene (C_6H_{10}) and cyclohexane (C_6H_{12}) are -241, -3800 and $-3920 \text{ kj mol}^{-1}$ respectively. Determine the heat of hydrogenation of cyclohexene.

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25. The amount of heat evolved during complete combustion of 7.8 g benzene at constant volume and $27^\circ C$ is 3270 kJ. Calculate heat of combustion of benzene at constant pressure and $27^\circ C$.

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26. Heat of neutralisation of NH_4OH and HCl is $-51.46\ \text{kJ mol}^{-1}$ .Calculate the ionization enthalpy of NH_4OH . [Enthalpy of neutralisation of strong acid-strong base is -57.35kJ mol^{-1}]

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27. Standard enthalpy of combustion of $CH_4(g)$ is $802.8\ \text{kJ mol}^{-1}$. If the bond dissociation energies of $C-H, O=O$ and $O-H$ bonds are 416.2, 493.7 and $464.4\ \text{kJ mol}^{-1}$ respectively then calculate the bond dissociation energy of C=O bond.

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28. Determine the standard enthalpy of formation of FeO(s) and $Fe_2(O_3(s)$ from the following data :

$3C(\text{graphite}, s) + Fe_2O_3(s) \rightarrow 2Fe(s) + 3CO(g), \Delta H^0 = 492.6kJ$

$C(\text{graphite}, s) + FeO(s) \rightarrow Fe(s) + CO(g), \Delta H^0 = 155.8kJ$

$C(\text{graphite}, s) + O_2(g) \rightarrow CO_2(g), \Delta H^0 = -393.51kJ$

$CO(g) + \frac{1}{2}O_2(s) \rightarrow CO_2(g), \Delta H^0 = -282.98kJ$

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29. Given that (at $25^\circ C$) :

$\frac{1}{2}H_2(g) + \frac{1}{2}O_2(g) \rightarrow OH(g), \Delta H^0 = 38.95 \text{ kJ mol}^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g), \Delta H^0 = -241.8 \text{ kJ mol}^{-1}$

$H_2(g) \rightarrow 2H(g), \Delta H^0 = 436.0 \text{ kJ mol}^{-1}$

$O_2(g) \rightarrow 2O(g), \Delta H^0 = 498.3 \text{ kJ mol}^{-1}$

Calculate ΔH^0 for the following reaction -

$(a) OH(g) \rightarrow H(g) + O(g)$

(b) $H_2O(g) \rightarrow 2H(g) + O(g)$

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30. Molar heats of combustion of $C_2H_2(g), C$ (graphite) and $H_2(g)$ are -310.62 kcal , -94.05 kcal and -68.32 kcal respectively. Calculate the standard heat of formation of $C_2H_2(g)$.

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31. Given that : (i) heat of formation of water = -68.3 kcal (ii) heat of combustion of acetylene = - 310.6 kcal (iii) heat of combustion of ethylene = - 337.2 kcal. Calculate the heat of reaction for the hydrogenation of acetylene at constant volume $(25^\circ C)$.

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

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33. An intimate mixture of ferric oxide, (Fe_2O_3) and aluminium, (Al) is used in solid fuel rockets. Calculate the fuel value per gram and fuel value per cc of the mixture. Heats of formation and densities are as follows :

$\Delta H_f^0(Al_2O_3) = 399 \ \text{kcal mol}^{-1}$, $\Delta H_f^0(Fe_2O_3) = 199 \ \text{kcal mol}^{-1}$,

Density of $Fe_2O_3 = 5.2g/cc$, Density of $Al = 2.7g/cc$.

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34. Show that the reaction, $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ at 300 K is spontaneous and exothermic, when the standard entropy change is $-0.094 \ \text{kJ mol}^{-1}K^{-1}$. Standard Gibbs fre energies of formation for CO_2 and CO are -394.4 and $-137.2 \ \text{kJ mol}^{-1}$ respectively.

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35. The melting point and boiling point of sulphur dioxide are $-75^\circ C$ and $-10^\circ C$ respectively. If the change in enthalpy of fusion and vaporisation of sulphur dioxide are 7.4 kJ mol^{-1} and 25.2 kJ mol^{-1} respectively, calculate the change in entropy of fusion and vaporisation of SO_2 ?

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36. Find ΔS^0 of the reaction :

$CH_4(g) + CO_2(g) \rightarrow 2CO(g) + 2H_2(g)$

Given : $S^0(CH_4) = 188 \text{ J mol}^{-1} K^{-1}$,

$S^0(CO_2) = 213.8 \text{ J mol}^{-1}. K^{-1}$,

$S^0(CO) = 197.6 \text{ J mol}^{-1}. K^{-1}$

$S^0(H_2) = 130.7 \text{ J mol}^{-1}. K^{-1}$

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37. The change in enthalpy of vaporisation of 1 mol of water is 40850 J mol^{-1} at $100^\circ C$ and 1 atm pressure. What is the difference between molar entropy of water and water vapour at that temperature and pressure ?

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38. If the change in entropy of reversible isothermal expansion of 1 mol of an ideal gas is $9.135 \text{ J mol}^{-1}. K^{-1}$, what will be the entropy change of the surroundings and universe ? If the above expansion of gas is allowed to occur against zero pressure, what will be the entropy change of the system and surroundings ?

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39. Calculate the change in entropy for the following process : 2 mol of N_2 (l , 1 atm, $-195.6^\circ C) \rightarrow 2$ mol of $N_2(g, 1 \text{ atm } -195.6^\circ C)$

[Given that, change in molar enthalpy for the vaporisation of $N_2 = 5.586 \text{ kJ mol}^{-1}$]

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40. The values of ΔH and ΔS in vaporisation of water at 1 atm pressure are $40.63 \text{ kJ mol}^{-1}$ and $108.8 J. K^{-1}. \text{ mol}^{-1}$ respectively. At what temperature the free energy change of the reaction will be zero ? What will be the sign of ΔG below that temperature ?

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41. At 300 K, the enthalpy change and entropy change of a reaction are -10 kcal and $-30 \text{ cal}. K^{-1}$ respectively. Does the reaction occur spontaneously at 400 K ? If not, then calculate the maximum temperature at which the reaction will occur spontaneously ?

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42. $H_2O(l) \rightarrow H_2(g) + \frac{1}{2}O_2(g)$ Does the above reaction occur spontaneously at 298 K ? Given that standard enthalpy of formation of water $= -285.83 \text{ kJ mol}^{-1}$, standard entropy of $H_2(g), O_2(g)$ and $H_2O(l)$ are 130.57, 205.04 and $69.95 J. K^{-1}. \text{ mol}^{-1}$ respectively.

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43. At 298 K, the equilibrium constant of a reaction is 1.8×10^{-7}. If ΔH^0 of the reaction is 28.6 kJ, calculate the value of ΔS^0.

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44. At 298 K, ΔH and ΔS for a reaction are $-65.49 \text{ kJ and } -145 J. K^{-1}$ respectively. Calculate $\Delta G, \Delta S_{\text{univ}}$ and ΔS_{surr} at that temperature.

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45. For a reactio, $\Delta H = -10000 \text{ J. mol}^{-1}$ and $\Delta S = -33.3 \text{ J. mol}^{-1}. K^{-1}$.

At what temperature will the reaction procees spontaneously from (i) left to right : (ii) right to left ?

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46. Two moles of a perfect gas undergoes the following process : (i) a reversible isobaric expansion from (1.0 atm, 20.0 L) to (1.0 atm, 40.0 L). (ii) a reversible isochoric change of state from (1.0 atm, 40.0 L) to (0.5 atm, 40.0 L). (iii) a reversible isothermal expansion from (0.5 atm, 40.0 L)to (1.0 atm, 20.0 L)

(i) Sketch with labels each procsses on the same P- V diagram.

(ii) Calculate the total work (w) and the total heat (Q) involved in the above process.

(iii) What will be values of ΔU, ΔH and ΔS for overall process ?

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47. At $25^\circ C, \Delta H^0$ for the reaction , $N_2(g) + \frac{1}{2}O_2(g) \rightarrow N_2O(g)$, is $+82kJ$. At this temperature if the standard molar entropies for $N_2(g), O_2(g)$ and $N_2O(g)$ are 191.6, 205.2 and $219.9J.K^{-1}. \text{ mol}^{-1}$ respectively, calculate ΔS^0_{univ} for the reaction.

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Practice Set 6

1. The condition for spontaneity of process is

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2. Which of the following statement is true

A. entropy increases when water vaporises

B. randomness decreases in the fusion of ice

C. randomness increases in the condensation of water vapour

D. randomness remain unchanged during vaporisation of water

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3. Which is an intensive property of a system

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4. In which of the following processes change in entropy for the system is zero-

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5. Which relation is correct -

A. dG = VdP-SdT

B. dG=PdV+TdS

C. dH= -VdP+TdS

D. dG = VdP+SdT

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6. Mixing of two different ideal gases under isothermal reversible condition will lead to

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7. A spontaneous process has $\Delta S_{\text{sys}} = xJ.K^{-1}$ and $\Delta S_{\text{surr}} = -yJ.K^{-1}$. Compare the values of x and y.

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8. Give two examples which are path dependent quantities. Are they properties of the system ?

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9. What do you mean by the enthalpy of solidification of water at $0^\circ C$ and 1 atm pressure $= -6.02 \text{ kJ mol}^{-1}$?

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10. Why is infinite time required for the completion of an ideal reversible process ?

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11. 2 mol of an ideal gas is compressed by an isothermal reversible process at $27^\circ C$. As a result, pressure of the gas increases from 1 to 10 atm. Calculate w, q, ΔU and ΔH.

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12. Find out the heat of formation of CH_3COOH . Given that the heat of Combustion of CH_3COOH is $-867\ \text{kJ mol}^{-1}$ and the heat of formation of CO_2 and H_2O are -393.5 and $-285.9\ \text{kJ mol}^{-1}$ respectively.

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13. (a) At $25^\circ C$, standard reaction enthalpy for the reaction 2 C(graphite, s) $+O_2(g) \rightarrow 2CO(g)$ is -221.0 kJ. Does this value indicate the standard enthalpy of formation of CO(g) ? If not, then what would be the value of enthalpy of formation of CO(g) at $25^\circ C$?

(b) A gas is allowed to expand against zero external pressure. Explain with reason whether the procss is reversible or not.

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14. Calculate enthalpy change on freezing 1 mol water at $10^\circ C$ to ice at $-10^\circ C$. $\Delta_{\text{fus}}H = 6.03 \ \text{kJ mol}^{-1}$ at $0^\circ C$.

$C_p[H_2O(l)] = 75.3 \ \text{J. mol}^{-1}. K^{-1}$,

$C_p[H_2O(s)] = 36.8 \ \text{J mol}^{-1}. K^{-1}$.

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15. (a)

$C_p - C_V = xJ. g^{-1}. K^{-1}$ and $C_{p,m} - C_{V,m} = X \ \text{J mol}^{-1}. K^{-1}$ for an ideal gas. If the molecular mass of the gas be M, then establish a realation among x, X and M. (b) Give an example of a process which is simultaneosuly isothermal and adiabatic.

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