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**Chapter-04**

# Chemical Thermodynamics      **Marks 6- with option 08**

**Multiple choice questions (1 Mark)**

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i.    An intensive property amongst the following is………….

    a)  Mass                                     b)     Volume

    c)  Number of moles                   **d) Temperature**

ii.    The value of $1 dm^3$ bar is ………..

    a) 10 J                                **b) $10^2$ J**

    c) $10^3$ J                           d) $10^{-2}$ J

iii.    The work done in the dm3 bar when 200 mL of ethylene gas and 150 mL of HCl gas were allowed to react  at 1 bar pressure is….

    a)  0.10                               **b)  0.15**

    **c)** 0.20                              d)  0.2

iv.    The work done in vacuum when 300 m mole of an ideal gas expands until its volume is increased by 2.3 $dm^3$ at 1 bar pressure is…….

    **a) Zero**                             b) One

    c)  Two                                d) Three

v)    For an Isothermal process

    **a) W = - Q**                          b) $\Delta U = W$

    c)  $\Delta U = Q + W$              d)  $\Delta U = Q$

vi    For an Isochoric process

    a)  $\Delta U = 0$                     **b)  $\Delta V = 0$**

    c)  $\Delta P = 0$                    d)  $Q = 0$

vii.    The change in internal energy in a reaction when 2kJ of heat is released by the system and 6 kJ of work is done on the system will be……

    a) +3 kJ            b) -4kJ            **c) +4 kJ**              d) – 8 kJ

## Very short answer questions (1 Mark)

1) Write the expression to calculate maximum work done when 1 mole of an ideal gas expands isothermally and reversibly from $V_1$ to $V_2$.

2) Write the mathematical relation between $\Delta H$ and $\Delta U$ during formation of one mole of $CO_2$ under standard conditions.

3) Standard enthalpy of formation of water is -286 kJ $mol^{-1}$.Calculate the enthalpy change for formation of 0.018 kg of water. **(Ans: -286kJ)**

4) Write the expression of the first law of thermodynamics for an isothermal process.

5) What is the sign convention when work is done on the system by the surrounding?

6) Write the expression showing relation between enthalpy change and internal energy change for gaseous phase reaction

7) Calculate enthalpy of formation of HCl if Bond enthalpies of $H_2$, $Cl_2$ and HCl are 434 kJ $mol^{-1}$, 242 kJ $mol^{-1}$ and 431 kJ $mol^{-1}$ respectively. **(Ans: -93kJ/mol)**

8) Write the condition of $\Delta G$ for Spontaneous reaction.

## Short answer questions (Type- I) (2 Marks)

1) Define the terms: (i) Standard enthalpy of combustion (ii) Enthalpy of sublimation.

2) State and explain Hess's law of constant heat summation.

3) Write the features of reversible processes.

4) Derive an expression for pressure- volume work.

5) The enthalpy change of the following reaction

$CH_4 (g) + Cl_2 (g) \rightarrow CH_3Cl (g) + HCl (g)$, $\Delta H^0 = -104$ kJ. Calculate C-Cl bond enthalpy.

The bond enthalpies are

| Bond | C-H | Cl-Cl | H-Cl |
|------|-----|-------|------|
| $\Delta H^0$/kJ $mol^{-1}$ | 414 | 243 | 431 |

**(Ans: 330 kJ $mol^{-1}$ )**

6) Calculate the standard enthalpy of combustion of $CH_4(g)$ if $\Delta_f H^0$ ($CH_4$ ) = -74.8 kJ $mol^{-1}$,

$\Delta_f H^0(CO_2$ ) = -393.5 kJ $mol^{-1}$ and $\Delta f H^0(H_2O)$ = -285.8 kJ $mol^{-1}$ **(Ans: -890.3 kJ $mol^{-1}$)**

7) Define: a) Extensive property b) Intensive property with examples.

8) Write relationship between $\Delta G$ and $\Delta S_{total}$

## Short answer questions (Type- II) (3 Marks)

1) a. Define an isolated system.

   b. Three moles of an ideal gas are expanded isothermally from 15 $dm^3$ to 20 $dm^3$ at constant external

      pressure of 1.2 bar, calculate the amount of work in Joules. **(Ans: -600J)**

2) Define enthalpy of fusion. Derive an expression for the maximum work.

3) Derive the expression $\Delta H=\Delta U+P\Delta V$. Write the relationship between Q *and* $\Delta U$ for an isochoric process.

4) Define standard enthalpy of formation. Derive the relationship between standard enthalpy of reaction

   $aA + bB \rightarrow cC + dD$ and enthalpies of formation of reactants and products.

5) 0.022 kg of $CO_2$ is compressed isothermally and reversibly at 298 K from initial pressure of 100 kPa when

   the work obtained is 1200 J, calculate the final pressure. **(Ans=263.4kPa)**

6) Define the following terms:-

   (i) Enthalpy of vaporization (ii) Standard enthalpy of combustion.

      Why is work done in vacuum zero

## Long answer questions (4 Marks)

1) Define the following terms:-

   (i) Enthalpy of atomization    (ii) Extensive properties

   Write mathematical statement of first law of thermodynamics for following processes

      a) Isothermal process              b) adiabatic process.

2) Define the following terms:        i) Bond Enthalpy        ii) Enthalpy of ionization.
   Calculate the standard enthalpy of the reaction. **(Ans = -822.4kJ)**

$$2Fe_{(s)} + \frac{3}{2}O_{2(g)} \longrightarrow Fe_2O_3(s)$$

**Given** (*i*) $2Al_{(s)} + Fe_2O_{3(s)} \longrightarrow 2Fe_{(s)} + Al_2O_{3(s)}$,    $\Delta_r H^0 = -847.6$ kJ

(ii) $2Al(s) + 3/2\ O_2(g) \longrightarrow Al_2O_3(s)$,                $\Delta_r H^0 = -1670$ kJ

3) The amount of heat evolved when 12 g of CO reacts with $NO_2$? The reaction is

   $4CO(g) + 2NO_2(g) \rightarrow 4CO_2(g) + N_2(g)$ $\Delta_r H^0 = -1200$ kJ **(Ans:128.5 kJ of heat is evolved)**
   Write an application of Hess's law.

   Does the following reaction represent a thermochemical equation?

   $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ $\Delta_r H^0 = -900$ kJ/mol

4) Classify the following into intensive and extensive properties.Pressure, volume, mass, temperature.

   Define state function and write two examples of it.

5) Write sign conventions of W and Q

   Calculate the standard enthalpy of the reaction **(Ans: 624.7 kJ)**

$$SiO_2(s) + 3C \text{ (graphite)} \rightarrow SiC(s) + 2CO(g) \text{ from the following reactions}$$

   i) $Si(s) + O_2(g) \rightarrow SiO2 \text{ (s)}$,         $\Delta_r H^0 = -911 \text{ kJ}$

   ii) $2C(\text{graphite}) + O_2(g) \rightarrow 2CO(g)$,   $\Delta_r H^0 = -221 \text{ kJ}$

   iii) $Si \text{ (s)} + C \text{ (graphite)} \rightarrow SiC(s)$,   $\Delta_r H^0 = -65.3 \text{ kJ}$