THERMODYNAMICS

1. Assuming ideal behaviour, the magnitude of log K for the following reaction at 25°C is $x \times 10^{-1}$. The value of x is _______.

(Integer answer)

$$3HC \equiv CH_{(g)} = C_6H_{6(\ell)}$$

[Given: $\Delta_f G^o(HC \equiv CH) = -2.04 \times 10^5$ J mol^{-1};

$\Delta_f G^o(C_6H_6) = -1.24 \times 10^5$ J mol^{-1};

R = 8.314 J K^{-1} mol^{-1}]

2. The reaction of cyanamide, $NH_2CN_{(s)}$ with oxygen was run in a bomb calorimeter and ΔU was found to be –742.24 kJ mol^{-1}. The magnitude of ΔH_{298} for the reaction

$$NH_2CN_{(s)} + \frac{3}{2}O_2(g) \rightarrow N_{2(g)} + O_2(g) + H_2O_{(l)}$$

is _______ kJ. (Rounded off to the nearest integer)

[Assume ideal gases and R = 8.314 J mol^{-1} K^{-1}]

3. For the reaction A(g) $\rightleftharpoons$ B(g) at 495 K, $\Delta_r G^o = -9.478$ kJ mol^{-1}.

If we start the reaction in a closed container at 495 K with 22 millimoles of A, the amount of B is the equilibrium mixture is _______ millimoles. (Round off to the Nearest Integer).

[R = 8.314 J mol^{-1} K^{-1}; ℓn 10 = 2.303]

4. At 25°C, 50 g of iron reacts with HCl to form $FeCl_2$. The evolved hydrogen gas expands against a constant pressure of 1 bar. The work done by the gas during this expansion is ____ J. (Round off to the Nearest Integer)

[Given : R = 8.314 J mol^{-1} K^{-1}. Assume, hydrogen is an ideal gas]

[Atomic mass of Fe is 55.85 u]

5. During which of the following processes, does entropy decrease ?

(A) Freezing of water to ice at 0°C

(B) Freezing of water to ice at –10°C

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

(D) Adsorption of CO(g) and lead surface

(E) Dissolution of NaCl in water

(1) (A), (B), (C) and (D) only

(2) (B) and (C) only

(3) (A) and (E) only

(4) (A), (C) and (E) only

6. The gas phase reaction

$$2A(g) \rightleftharpoons A_2(g)$$

at 400 K has ΔG^o = + 25.2 kJ mol^{-1}.

The equilibrium constant K_C for this reaction is ______ × 10^{-2}. (Round off to the Nearest integer)

[Use : R = 8.3 J mol^{-1}K^{-1} , ln 10 = 2.3

$\log_{10} 2$ = 0.30, 1 atm = 1 bar]

[antilog (–0.3) = 0.501]

7. If the standard molar enthalpy change for combustion of graphite powder is -2.48×10^2 kJ mol^{-1}, the amount of heat generated on combustion of 1 g of graphite powder is _______ kJ. (Nearest integer)

8. At 298.2 K the relationship between enthalpy of bond dissociation (in kJ mol^{-1}) for hydrogen (E_H) and its isotope, deuterium (E_D), is best described by :

(1) $E_H = \frac{1}{2} E_D$ (2) $E_H = E_D$

(3) $E_H \simeq E_D - 7.5$ (4) $E_H = 2E_D$

9. At 298 K, the enthalpy of fusion of a solid (X) is 2.8 kJ mol^{-1} and the enthalpy of vaporisation of the liquid (X) is 98.2 kJ mol^{-1}. The enthalpy of sublimation of the substance (X) in kJ mol^{-1} is _______.

(in nearest integer)

10. A home owner uses 4.00×10^3 m^3 of methane (CH_4) gas, (assume CH_4 is an ideal gas) in a year to heat his home.

Under the pressure of 1.0 atm and 300 K, mass of gas used is $x \times 10^5$ g. The value of x is _______ . (Nearest integer)

(Given R = 0.083 L atm K^{-1} mol^{-1})

11. A system does 200 J of work and at the same time absorbs 150 J of heat. The magnitude of the change in internal energy is ________ J. (Nearest integer)

12. For water at 100°C and 1 bar,

$\Delta_{vap} H - \Delta_{vap} U =$ ________ $\times 10^2$ J mol^{-1}.

(Round off to the Nearest Integer)

[Use : R=8.31 J mol^{-1} K^{-1}]

[Assume volume of $H_2O(l)$ is much smaller than volume of $H_2O(g)$. Assume $H_2O(g)$ treated as an ideal gas]

13. An average person needs about 10000 kJ energy per day. The amount of glucose (molar mass = 180.0 g mol^{-1}) needed to meet this energy requirement is _________ g.

(Use : $\Delta_C H$(glucose) = –2700 kJ mol^{-1})

SOLUTION

1. Official Ans. by NTA (855)

Sol. $3HC\equiv CH_{(g)} \rightarrow C_6H_6(\ell) : \Delta G^0 = -RT\ln k$

$\Delta G_f^0 - 2.04\times10^5 \frac{J}{mol} - 1.24\times10^5 J/mol$

$\Rightarrow \Delta G^0 = \sum(\Delta G_f^0)_P - \sum(\Delta G_f^0)_R$

$\Rightarrow -RT\ell nk = 1\times(-124\times10^5) - (-3\times2.04\times10^5)$

$\Rightarrow -2.303\times R\times T\log k = 4.88\times10^5$

$\Rightarrow \log k = -\frac{4.88\times10^5}{2.303\times R\times T} = -\frac{488000}{5705.848} = -85.52$

$= 855 \times 10^{-1}$

$\Rightarrow x = 855$

2. Official Ans. by NTA (741)

Sol. $\Delta H = \Delta U + \Delta n_g RT$

$= -742.24 + \frac{1}{2}\times\frac{8.314}{1000}\times298$

$= -741$ kJ/mol

Hence answer is (741)

3. Official Ans. by NTA (20)

Sol. $\Delta G° = -RT\ \ell n\ K_{eq}$

Given $\Delta G° = -9.478$ KJ/mole

$T = 495K \quad R = 8.314\ J\ mol^{-1}$

So $-9.478 \times 10^3 = -495 \times 8.314 \times \ell n\ K_{eq}$

$\ell n\ K_{eq} = 2.303$

$= \ell n\ 10$

So $K_{eq} = 10$

Now $A(g) \rightleftharpoons B(g)$

t = 0 22 0

t = t 22–x x

$K_{eq} = \frac{[B]}{[C]} = \frac{x}{22-x} = 10$

or x = 20

So millmoles of B = 20

4. Official Ans. by NTA (2218)

Sol. $T = 298$ K, $R = 8.314 \frac{J}{mol\,K}$

$\rightarrow$ Chemical reaction is

$Fe + 2HCl \rightarrow FeCl_2 + H_2(g)$

50g P = 1 bar

$= \frac{50}{55.85}$ mol $\frac{50}{55.85}$ mol

$\rightarrow$ Work done for 1 mol gas

$= -P_{ext} \times \Delta V$

$= \Delta ng\ RT$

$= -1 \times 8.314 \times 298$ J

$\rightarrow$ Work done for $\frac{50}{55.85}$ mol of gas

$= -1.8314 \times 298 \times \frac{50}{55.85}$ J

$= -2218.059$ J

$\simeq -2218$ J

5. Official Ans. by NTA (1)

Sol. (A) Water $\xrightarrow{0°C}$ ice; $\Delta S = -ve$

(B) Water $\xrightarrow{-10°C}$ ice; $\Delta S = -ve$

(C) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$; $\Delta S = -ve$

(D) Adsorption; $\Delta S = -ve$

(E) $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$; $\Delta S = +ve$

6. Official Ans. by NTA (166)

Official Ans. by ALLEN (2)

Sol. Using formula

$\Delta_r G^0 = -RT\ln K_p$

$25200 = -2.3 \times 8.3 \times 400 \log(K_p)$

$K_p = 10^{-3.3} = 10^{-3} \times 0.501$

$= 5.01 \times 10^{-4}\ Bar^{-1}$

$= 5.01 \times 10^{-9}\ Pa^{-1}$

$= \frac{K_C}{8.3\times400}$

$K_C = 1.66 \times 10^{-5}\ m^3/mole$

$= 1.66 \times 10^{-2}$ L/mol

Ans = 2

7. **Official Ans. by NTA (21)**

Sol. 1 mol graphite = 12 gm C

$\text{Ans.} = \frac{248}{12} = 20.67\text{kJ / gm heat evolved}$

8. **Official Ans. by NTA (3)**

Sol. Enthalpy of bond dissociation (kJ/mole) at 298.2K

For , hydrogen = 435.88

For , Deuterium = 443.35

$\therefore E_H \simeq E_D - 7.5$

9. **Official Ans. by NTA (101)**

Sol. $\Delta H_{sub} = \Delta H_{fus.} + \Delta H_{vap.}$

= 2.8 + 98.2

= 101 kJ/mol

10. **Official Ans. by NTA (26)**

Sol. $n(CH_4) = \frac{PV}{RT}$

$= \frac{1 \times 4 \times 10^3 \times 1000}{0.083 \times 300}$

Weight of CH_4

$= \frac{40 \times 16 \times 10^5}{0.083 \times 300} \text{gm}$

= 25.7×10^5 gm

11. **Official Ans. by NTA (50)**

Sol. w = –200 J, q = +150 : ΔU = q + w

ΔU = 150 – 200 = –50 J : magnitude = 50 J

= |ΔU |

12. **Official Ans. by NTA (31)**

Sol. $H_2O_{(\ell)} \rightleftharpoons H_2O_{(V)}$

$\Delta H = \Delta U + \Delta n_g RT$

for 1 mole waters ; $\Delta n_g = 1$

$\therefore \Delta n_g RT$ = 1 mol × 8.31 J/mol-k × 373 K

= 3099.63 J $\cong 31 \times 10^2$ J

13. **Official Ans. by NTA (667)**

Sol. 1 mole glucose give 2700 kJ energy

so mole of glucose needed for 10^5 kJ energy

$= \frac{10000}{2700}$ = 370 moles

wt. of glucose = 3.10 × 180

= 666.666

≈ 667 gm

$$\frac{Y_{Benzene}}{Y_{M.B}} = \frac{P_B^0 X_B}{P_{MB}^0 X_{MB}} = \frac{70 \times 1}{20 \times 1} = \frac{7}{2}$$

$$Y_{Benzene} = \frac{7}{9} = 77.77 \times 10^{-2}$$

$= 78 \times 10^{-12}$