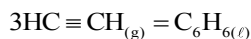


THERMODYNAMICS

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)

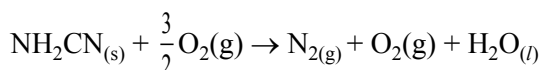


[Given: $\Delta_f G^\circ(\text{HC} \equiv \text{CH}) = -2.04 \times 10^5 \text{ J mol}^{-1}$;

$\Delta_f G^\circ(\text{C}_6\text{H}_6) = -1.24 \times 10^5 \text{ J mol}^{-1}$;

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

2. The reaction of cyanamide, $\text{NH}_2\text{CN}_{(s)}$ with oxygen was run in a bomb calorimeter and ΔU was found to be $-742.24 \text{ kJ mol}^{-1}$. The magnitude of ΔH_{298} for the reaction



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

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

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

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).

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

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 : $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$. 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) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
(D) Adsorption of $\text{CO}(\text{g})$ 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



at 400 K has $\Delta G^\circ = + 25.2 \text{ kJ mol}^{-1}$.

The equilibrium constant K_C for this reaction is _____ $\times 10^{-2}$. (Round off to the Nearest integer)

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

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

[antilog $(-0.3) = 0.501$]

7. If the standard molar enthalpy change for combustion of graphite powder is $-2.48 \times 10^2 \text{ kJ mol}^{-1}$, 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) $E_H \approx E_D - 7.5$ (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 $4.00 \times 10^3 \text{ m}^3$ 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 $x \times 10^5 \text{ g}$. The value of x is _____. (Nearest integer)
(Given $R = 0.083 \text{ L atm K}^{-1} \text{ mol}^{-1}$)
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,
 $\Delta_{\text{vap}} H - \Delta_{\text{vap}} U = \text{_____} \times 10^2 \text{ J mol}^{-1}$.
(Round off to the Nearest Integer)
[Use : $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$]
[Assume volume of $\text{H}_2\text{O}(\text{l})$ is much smaller than volume of $\text{H}_2\text{O}(\text{g})$. Assume $\text{H}_2\text{O}(\text{g})$ 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 : $\Delta_{\text{c}} H(\text{glucose}) = -2700 \text{ kJ mol}^{-1}$)

SOLUTION

1. Official Ans. by NTA (855)

Sol. $3\text{HC} \equiv \text{CH}_{(\text{g})} \rightarrow \text{C}_6\text{H}_6(\text{l}) : \Delta G^0 = -RT \ln k$

$$\Delta G_f^0 - 2.04 \times 10^5 \frac{\text{J}}{\text{mol}} - 1.24 \times 10^5 \text{ J/mol}$$

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

$$\Rightarrow -RT \ln k = 1 \times (-124 \times 10^5) - (-3 \times 2.04 \times 10^5)$$

$$\Rightarrow -2.303 \times R \times T \log k = 4.88 \times 10^5$$

$$\Rightarrow \log k = -\frac{4.88 \times 10^5}{2.303 \times R \times T} = -\frac{488000}{5705.848} = -85.52$$

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

$$\Rightarrow x = 855$$

2. Official Ans. by NTA (741)

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

$$= -742.24 + \frac{1}{2} \times \frac{8.314}{1000} \times 298$$

$$= -741 \text{ kJ/mol}$$

Hence answer is (741)

3. Official Ans. by NTA (20)

Sol. $\Delta G^0 = -RT \ln K_{\text{eq}}$

Given $\Delta G^0 = -9.478 \text{ KJ/mole}$

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

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

$$\ln K_{\text{eq}} = 2.303$$

$$= \ln 10$$

$$\text{So } K_{\text{eq}} = 10$$

Now $\text{A(g)} \rightleftharpoons \text{B(g)}$

$$t = 0 \quad 22 \quad 0$$

$$t = t \quad 22-x \quad x$$

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

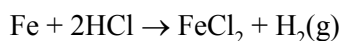
$$\text{or } x = 20$$

So millmoles of B = 20

4. Official Ans. by NTA (2218)

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

→ Chemical reaction is



$$50\text{g} \quad P = 1 \text{ bar}$$

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

→ Work done for 1 mol gas

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

$$= \Delta n_g RT$$

$$= -1 \times 8.314 \times 298 \text{ J}$$

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

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

$$= -2218.059 \text{ J}$$

$$\approx -2218 \text{ J}$$

5. Official Ans. by NTA (1)

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

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

(C) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$; $\Delta S = -ve$

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

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

6. Official Ans. by NTA (166)

Official Ans. by ALLEN (2)

Sol. Using formula

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

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

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

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

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

$$= \frac{K_c}{8.3 \times 400}$$

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

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

$$\text{Ans} = 2$$

13. Official Ans. by NTA (667)

Sol. 1 mole glucose give 2700 kJ energy

so mole of glucose needed for 10^5 kJ energy

8. Official Ans. by NTA (3)

$$\text{wt. of glucose} = 3.10 \times 180$$

$$= 666.666$$

$\approx 667 \text{ gm}$

$$\frac{Y_{\text{Benzene}}}{Y_{\text{MR}}} = \frac{P_B^0 X_B}{P_{\text{MR}}^0 X_{\text{MR}}} = \frac{70 \times 1}{20 \times 1} = \frac{7}{2}$$

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

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

10. Official Ans. by NTA (26)

Sol. $n(\text{CH}_4) = \frac{PV}{RT}$

Weight of CH₄

$$= 25.7 \times 10^5 \text{ gm}$$

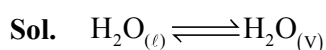
11. Official Ans. by NTA (50)

Sol. $w = -200 \text{ J}$, $q = +150$: $\Delta U = q + w$

$$\Delta U = 150 - 200 = -50 \text{ J} : \text{magnitude} = 50 \text{ J}$$

$$= |\Delta U|$$

12. Official Ans. by NTA (31)



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

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

$$\therefore \Delta n_g RT = 1 \text{ mol} \times 8.31 \text{ J/mol-K} \times 373 \text{ K}$$

$$= 3099.63 \text{ J} \cong 31 \times 10^2 \text{ J}$$