[Time : 2 ½ hrs.] **[Marks : 60]**

Please check whether you have got the right question paper.

N.B.: 1. All questions are compulsory.
2. Figure to the right indicates full marks.
3. Use of non – programmable scientific calculator is allowed.

Useful constants

$c = 2.998 \times 10^{8}$ m.s^{-1} | $e = 1.602 \times 10^{-19}$ C
$R = 8.314$ J.K^{-1}mol^{-1} | $k = 1.3811$ x 10-23 J.K^{-1}
$= 2.0$ cal.K^{-1} mol^{-1}
$h = 6.626 \times 10^{-34}$ Js | $1J = 6.24 \times 10^{18}$ eV
$m_e = 9.110 \times 10^{-31}$ kg | $1eV = 8.06 \times 10^{3}$ cm^{-1}
$N_A = 6.022 \times 10^{23}$ mol^{-1} | 1 amu $= 1.66 \times 10^{-27}$ kg
Atomic mass of H = 1, C = 12, N = 14, O = 16, S = 32, Cl = 35.5

1. A) Attempt ***any two*** of the following:

i) State the third law of thermodynamics. How will you determine absolute entropy with the help of the heat capacity? **4**

ii) Using Maxwell's relation for van der Waal's gas. Show that **4**

$$\frac{\partial C_P}{\partial P} = \frac{2a}{RT^2}$$

iii) What is the standard molar entropy? How does it depends on the molar mass and molecular structure of a substance. **4**

iv) What is Joule – Thomson effect? Explain the consequences of this effect on real and ideal gases. **4**

1. B) Attempt ***any one*** of the following:

i) Evaluate the change in entropy when 9 g Hydrogen gas is heated from 30^0C to 730^0C at a constant pressure of 2 atm. The molar heat capacity of hydrogen gas is 29.07 JK^{-1}mol^{-1}. **4**

ii) Calculate the joule Thomson coefficient for N_2 gas at 298K and 100 atmospheric pressure if the van der Waal's constant a and b for N_2 are 1.41 Nm^{4}mol^{-2} and 3.92×10^{-5} m^{3}mol^{-1} respectively. (Cp for N_2 = 29.04 JK^{-1}mol^{-1}) **4**

2. A) Attempt ***any two*** of the following:

i) What is linear harmonic oscillator? Derive Hermite equation for one dimensional simple harmonic oscillator. **4**

ii) What are the characteristics of a wave function to be acceptable? Show that the normalized wave function of a particle in a dimensional box is given by, **4**

$$\psi_{(n)} = \left(\frac{2}{a}\right)^{1/2} \sin\left(\frac{n\pi x}{a}\right)$$

iii) Derive the Hermite's differential from the relation **4**

$$\frac{\partial^2 \psi}{\partial y^2} + \left(\frac{\alpha}{\beta} - y^2\right)\psi = 0$$

iv) State the postulates of quantum mechanics. **4**

2. B Attempt ***any one*** of the following:

i) An electron is confined in a one – dimensional box of length 1 Å. Calculate its ground state energy in electron volts (eV). Is quantization of energy level observable? **4**

ii) $\hat{A} = \frac{d}{dx}$ and $\hat{B} = \frac{d^2}{dx^2}$ and $f(x) = \sin x$. Show that A and B are commutative each other. **4**

3. A) Attempt ***any two*** of the following:

i) In the case of the organic decomposition of ethane, use the steady state equations for the reaction scheme and show that the rate of production of ethylene is given by $\frac{d}{dx}[C_2H_4] = k[C_2H_6]$ **4**

ii) Show that the rate of polymerization reaction is proportional to square root of its initial concentration of the monomer. **4**

iii) Explain the Rice – Ramsperger – Kassel (RRK) theory. **4**

iv) Explain the formation and decomposition of phosgene. **4**

3. B) Attempt ***any one*** of the following:

i) The rate of formation of C in the reaction, $2A + B \rightarrow C$ is 0.25 mol L^{-1} s^{-1}. State the reaction rate and the rates of consumption of A and B. **4**

ii) For the consecutive first order reaction: **4**

$$X \xrightarrow{K_1} Y \xrightarrow{K_2} Z$$

the ratio of $k_1 : k_2$ are 3 : 1 and the value of k_1 is 9×10^{-3} sec^{-1}. How much time will be required for the concentration of Y to reach a maximum?

4. A) Attempt ***any two*** of the following:

i) State Debye-Huckel-Onsager equation. Discuss its validity for aqueous and non-aqueous solutions. **4**

ii) Explain in brief relaxation effect and electrophoretic effect for conductance of strong electrolytes. **4**

iii) With the help of well labelled diagram explain construction and working of solid oxide fuel cell. **4**

iv) Explain the structure and functions of the cell membrane. **4**

4. B) Attempt ***any one*** of the following:

i) Calculate the molality and mean ionic activity coefficient of Na_2SO_4 whose ionic strength is the same as that of 0.09m NaCl at 298K, (Given: A = 0.509 at 298K) **4**

ii) Calculate the resting membrane potential for the following: **4**

Ion Species	Intracellular concentration in mM	Extracellular concentration in mM
K^+	0.002	2
Cl^-	150	10

(Given that $\frac{2.303RT}{F}$ at 298K = 60.8)

5. Attempt ***any four*** of the following

a) What are the characteristics of exact differential equation? **3**

b) Derive the relation, **3**

$$\left[\frac{\partial V}{\partial T}\right]_P = -\left[\frac{\partial S}{\partial P}\right]_T$$

c) What is meant by normalization of wave function? **3**

d) Describe linear momentum operator. **3**

e) Discuss the gas phase combustion reaction between H_2 and O_2. Explain the term explosion limit. **3**

f) Explain the principle of microscopic reversibility. **3**

g) Explain the effect showing the dispersion of conductance at high frequencies **3**

h) Explain in brief the theory behind membrane potential. **3**
