3 (Sem–2) CHM M1

2022

CHEMISTRY

(Major)

Paper : 2·1

(Physical Chemistry)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions in brief : 1×7=7

   (a) How does the mean free path define the ideal behaviour of H_2 gas at room temperature ? 1

(b) Write down the cell reaction for the cell —

$$Pt\,(s)\,|\,H_2\,(g)\,|\,H^+\,(aq)\,\|\,Cl^-\,(aq)\,|\,Hg_2Cl_2\,(s)\,|\,Hg\,(l)$$

1

(c) Define thermotropic and lyotropic liquids. 1

(d) Explain whether and aqueous solution of K_2SO_4 can be regarded as ideal or not. 1

(e) What are the advantages of reference electrodes ? 1

(f) Two van der Waals gases have the same value of '*b*' but one of them has a greater value of '*a*'. Which of the two gases would occupy greater volume under identical conditions ? 1

(g) Define refractive index. 1

2. Answer the following questions : 2×4=8

(a) Find the collision flux of O_2 at a temperature of 300 *K* and a pressure of 1 *bar*. 2

(b) Explain the origin of colligative properties. 2

(c) Gas A obeys the equation $PV_m = \frac{RT}{\left(1+\frac{b}{V_m}\right)}$ and gas B obeys $P(V_m - b) = RT$. Would it be possible to liquify either A or B? Justify your answer. 2

(d) Write a short note on fuel cells. 2

3. Answer the following questions : ***(any three)*** 5×3=15

(a) Show that for a very low concentration of a substance B

$\pi V = [B]RT$, where all symbols have their usual meaning. 5

(b) What is the importance of the principle of corresponding states ? The equation of state of a certain gas is given by

$P = RT/V_m + (a+bT)/V_m^2$, where a and b are constants. Find $\left(\frac{\partial V}{\partial T}\right)_P$. 2+3=5

(c) Define a buffer solution. Deduce the Henderson-Hasselbalch equation for both acidic and basic buffers. 1+2+2=5

(d) Discuss the Stalagmometric method for the determination of surface tension of a liquid. What is the SI unit of surface tension? 4+1=5

(e) Find a relation between the cell potential and the reaction Gibbs free energy. Calculate the ionic strength and mean activity coefficient of a 1.00 $m\ mol\ kg^{-1}$ $CaCl_2(aq)$ solution at 25°C. 3+2=5

4. (a) Answer **either** (i), (ii) and (iii) **or** (iv):

(i) For a van der Waals gas the value of P_c is $1.01\times10^7\ Pa$ and that of the van der Waals constant 'b' is $5.0\times10^{-5}\ m^3\ mol^{-1}$. Calculate its critical temperature. 2

(ii) Calculate the values of C_p and C_v for CO_2 and H_2O molecules. 1½+1½=3

(iii) Discuss the construction of a calomel electrode. Explain the reaction taking place in the electrode. 5

(iv) What is viscosity of a fluid? Discuss how exactly it arises in liquids and gases. Derive an expression for the coefficient of viscosity of a gas in terms of mean free path. Discuss the effect of temperature and pressure on viscosity of a gas and compare these with those of liquids. 1+2+4+3=10

(b) Answer ***either*** *(i)* and *(ii)* ***or*** *(iii)* and *(iv)*:

(i) Derive the Stokes-Einstein equation. The molar ionic conductance at infinite dilution of silver ions is $61.92\times10^{-4}\ Sm^2\ mol^{-1}$ at 25°C. Calculate the ionic mobility of silver ions at 25°C at infinite dilution. 3+2=5

(ii) Using the concept of chemical potential show that the relative lowering of vapour pressure of a solution containing a non-volatile, non-electrolyte solute is equal to the mole fraction of the solute. 5

(iii) Discuss briefly about the structure of liquid crystals. 5

(iv) Using the postulates of kinetic theory of gases, deduce an expression for the pressure of the gas. 5

(c) Answer *(i)* **or** *(ii)* and *(iii)* **or** *(iv)*:

(i) What do you mean by distribution of molecular speeds? Explain what information can be obtained from speed distribution curves. Using a graphical representation discuss the effect of temperature on the distribution of molecular speeds. 2+2+2=6

(ii) What is a concentration cell ? Taking the example of a hydrogen electrode, explain how concentration cells are classified. Explain the types of cells in which the liquid junction potential is maximum. 1+3+2=6

(iii) Explain briefly, how the equilibrium constant of a reaction can be calculated from the measurement of standard electrode potential. 4

(iv) Calculate the single electrode potential at 298 K for a Zn half cell electrode dipped in a 0.01M $ZnSO_4$ solution. Given that $E^{\circ}_{Zn^{2+}/Zn} = -0.763\,V$. 4
