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CHEMISTRY

(Major)

Paper : 2.1

(Physical Chemistry)

Full Marks : 60

Time : 3 hours

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

1. Answer the following as directed : 1×7=7

(a) State True or False :

“Gases can be liquefied by applying pressure at any temperature.”

(b) Find the critical volume of helium gas ($b = 0.01927 \text{ dm}^3 \text{ mol}^{-1}$).

(c) If c_0 is the speed of light in vacuum and c is the speed of light in a medium, then what will be the expression for refractive index of the medium?

(d) Choose the correct answer :

At the same temperature, 0.01M solution of urea is isotonic with

- (i) 0.01M NaCl solution
- (ii) 0.01M $MgCl_2$ solution
- (iii) 0.01M glucose solution
- (iv) 0.01M sodium acetate solution

(e) Choose the correct answer :

If ΔT_b is the elevation in boiling point for an electrolytic solution and ΔT_b° is elevation of the boiling point for a non-electrolyte solution of the same concentration in the same solvent, then the van't Hoff factor is given by

(i) $\Delta T_b \times \Delta T_b^\circ$

(ii) $\Delta T_b^\circ / \Delta T_b$

(iii) $\frac{\Delta T_b - \Delta T_b^\circ}{2}$

(iv) $\Delta T_b / \Delta T_b^\circ$

(f) Define molar conductivity of an electrolytic solution.

(g) Give the condition for maximum buffer capacity of a buffer solution.

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

- (a) For a monatomic ideal gas, show that the molar heat capacity at constant volume is $12.471 \text{ JK}^{-1} \text{ mol}^{-1}$.
- (b) A liquid *P* has half the surface tension of liquid *Q*. Again the density of liquid *P* is twice the density of liquid *Q*. If in a capillary tube *P* rises to 10.0 cm, what will be the rise of liquid *Q* in the same capillary tube when inserted identically at the same temperature?
- (c) Define ideal solutions. Give the values of ΔV and $\Delta_{\text{mix}}H$ for an ideal solution.
- (d) What are concentration cells? Give one suitable example of concentration cell with transference.

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

- (a) (i) Give the postulates of kinetic molecular theory of gases. 3
- (ii) Give the limitations of van der Waals equation of state. 2

- (b) What is 'degrees of freedom' of a molecule? Calculate the various degrees of freedom of the following molecules :

$$2+3=5$$

(i) CO_2

(ii) H_2O

- (c) (i) Give the principle of the stalagmometer method of determination of surface tension of a liquid. 3

(ii) The numbers of drops of water and an organic liquid in drop number method from a stalagmometer are 100 and 200 respectively. Calculate the surface tension of the organic liquid at 298 K. Given that at 298 K, the surface tension of water is $7.28 \times 10^{-3} \text{ N m}^{-1}$, density of water is 1.0 kg dm^{-3} and density of the organic liquid is 0.9 kg dm^{-3} . 2

- (d) (i) What is limiting molar conductivity? State the Kohlrausch law of the independent migration of ions. 2

(ii) The limiting molar conductances of Al^{3+} and SO_4^{2-} are $189 \text{ S cm}^2 \text{ mol}^{-1}$ and $160 \text{ S cm}^2 \text{ mol}^{-1}$ respectively. Calculate the limiting molar conductance of $\text{Al}_2(\text{SO}_4)_3$. 3

- (e) (i) Define degree of dissociation of a weak electrolyte. 1
- (ii) State Ostwald's dilution law. Explain the law with the help of a suitable example. 4
4. (a) Answer either [(i) and (ii)] or [(iii) and (iv)] :
- (i) Derive the equation of corresponding states. Justify why this equation can be considered as a generalized equation of state for a gas. 5
- (ii) Derive an expression for osmotic pressure of a dilute solution from thermodynamic consideration. 5
- (iii) What are transport properties of gas? Using kinetic theory, derive an expression for self-diffusion coefficient of a gas. 5
- (iv) Discuss the construction of a calomel electrode. Explain the reaction taking place in the electrode. 5
- (b) Answer either [(i), (ii) and (iii)] or [(iv), (v) and (vi)] :
- (i) Define the terms collision cross-section and mean free path. 3

- (ii) What are liquid crystals? Mention the uses of liquid crystals. 4
- (iii) A solution, composed of 0.05M of an organic acid and 0.5M of its sodium salt, gives a pH of 5.5 at 298 K. Calculate the dissociation constant of the acid. 3
- (iv) Explain the terms activity and activity coefficient. 2
- (v) Discuss briefly about the structure of liquid crystals. 4
- (vi) What is ionic strength of an electrolytic solution? Calculate the ionic strength of 0.01 mol kg⁻¹ H₂SO₄ solution. 1+3=4

(c) Answer either [(i) and (ii)] or [(iii) and (iv)] :

- (i) What is buffer capacity of a buffer solution? Explain the term buffer action with the help of a suitable example. 1+4=5
- (ii) Define electrode potential. Calculate the single electrode potential at 298 K of a half-cell for zinc electrode dipped in 0.01M ZnSO₄ solution. Given

$$E_{\text{Zn}^{2+}|\text{Zn}}^{\circ} = -0.763 \text{ volt} \quad 1+4=5$$

(iii) What are fuel cells? Write the electrode reactions of hydrogen-oxygen fuel cell. Calculate the standard e.m.f. of hydrogen-oxygen fuel cell. Mention one use of fuel cell.

$$1+2+2+1=6$$

(iv) Explain briefly how equilibrium constant can be calculated from the measurement of standard electrode potential.

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