2018

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 ($b = 0{\cdot}01927\ dm^3\ mol^{-1}$).

(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 $JK^{-1}\,mol^{-1}$.

(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 $\Delta_{mix} H$ 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 $7 \cdot 28 \times 10^{-3}$ N m^{-1}, density of water is $1 \cdot 0$ kg dm^{-3} and density of the organic liquid is $0 \cdot 9$ 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 S cm^2 mol^{-1} and 160 S cm^2 mol^{-1} respectively. Calculate the limiting molar conductance of $Al_2(SO_4)_3$. 3

(Continued)

(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 0·05*M* of an organic acid and 0·5*M* 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} H_2SO_4 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 0·01*M* $ZnSO_4$ solution. Given

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

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(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. 4

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