WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 3rd Semester Examination, 2021-22

CEMACOR05T-CHEMISTRY (CC5)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer any *three* questions taking *one* from each unit

UNIT-I

1. (a) To measure the viscosity of a liquid using Ostwald viscometer the Poiseuille equation, which is used, can be expressed as 3

$\eta = A\,\rho\,\Delta t$ where η is the coefficient of viscosity of the liquid, ρ is the liquid density, $\Delta t =$ time of flow of specific volume of the liquid and A is the viscometer constant which depends on the geometry of the viscometer. Find *A*.

(b) In an electrolysis experiment, a current of 0.10 A flows through a solution of conductivity, κ = 0.010 $ohm^{-1}\ cm^{-1}$ and cross-sectional area 10 cm^2. Find the electric field strength applied through the solution. 3

(c) At a certain temperature, the transport number of chloride ion in KCl solution is less than that in HCl solution having same concentration. Explain. 2

(d) A liquid is allowed to fall from a burette. Can Poiseuille's equation be applied in this case? Explain. 2

(e) State the Walden's rule. This rule is more accurate for large ions. — Justify. 2

2. (a) The time of efflux of H_2O through an Ostwald viscometer is 1.52 min. For the same volume of an organic liquid of density 0.800 g/cc the time is 2.25 min. Find the viscosity of the liquid relative to that of water, and its absolute viscosity in millipoises. Experiment was performed at 25°C, at which water viscosity is 0.00089 Pa.s and density is 0.997 g/cc. 3

(b) Give the schematic conductometric titration curve for titration of aqueous solution of sodium acetate by hydrochloric acid conductometrically. Give explanation. 3

(c) Why should equivalent conductance of a weak electrolyte at a finite concentration be less than that at infinite dilution? 2

(d) The conductivity of pure water was estimated to be 0.0384×10^{-6} $ohm^{-1}\ cm^{-1}$ at 18°C. If equivalent conductivity of hydrogen and hydroxyl ions at infinite dilution are 315.2 and 173.8 $ohm^{-1}\ cm^2\ g.eq^{-1}$ respectively at 18°C then find the ionic product of water at that temperature. 2

(e) Liquids of high viscosity have high boiling points and higher heats of vapourisation. Explain. 2

UNIT-II

3. (a) Show that for an open system chemical potential of i^{th} constituent, μ_i, in a mixture can be expressed as $\mu_i = \left(\frac{\partial H}{\partial n_i}\right)_{S,\ P,\ n_{j\neq i}}$ where $H =$ enthalpy of the system. 3+1

Can this μ_i be defined as partial molar enthalpy of the i^{th} constituent? Explain.

(b) Show that if the equation of state for a gas is $p(\bar{V} - b) = RT$, at pressure p, where b is a constant, f is the fugacity of the gas, the relation is given by $f = p \times \exp(bp/RT)$. 3

(c) For a binary mixture of ideal gases, A and B, show by a schematic plot the variation of the Gibbs energy of mixing of the gases (ΔG_{mix}), as a function of mole fraction of A (X_A). Using the expression of ΔG_{mix}, justify the composition at the minimum of the plot. 1+3

(d) In a mixture of 1 part of N_2 to 3 parts of H_2, the mole per cent of NH_3 at equilibrium was found to be 1.20 at 500°C at a total pressure of 10 atm. Calculate the value of the equilibrium constant K_P at that temperature. 3

(e) The value of the equilibrium constant of a given reaction depends on its stoichiometry. Explain. 2

4. (a) Define chemical potential of a constituent 'i' in a homogeneous mixture. Is the chemical potential an extensive or intensive property? Give its SI unit. 1+1+1

(b) Draw the plot of $\ln K_P$ versus $1/T$ of an endothermic reaction with $\Delta C_P = 0$ for the reaction. Mention the importance of such a plot. 2+1

(c) For a given species, transport will occur from a region of high chemical potential to low chemical potential. Justify. 2

(d) In connection to chemical potential of an ideal gas, often we write $\mu = \mu^0 + RT \ln P$ Explain the terms. Is there any dimensional mismatch? Arrive at the dimensionally correct relation. 1+1+2

(e) The value of $K_P(T)$ (based on standard of one bar) for the reaction described by $NH_3(g) \rightleftharpoons \frac{3}{2}H_2\ (g) + \frac{1}{2}\ N_2\ (g)$ is 1.36×10^{-3} at 298.15 K. Determine the corresponding value $K_C(T)$ (based upon a standard state of one mol L^{-1}). 1+3

UNIT-III

5. (a) Prove that the de Broglie wavelength, λ, of an electron accelerated through a potential of V volts is given by 3

$$\lambda = \frac{12.25}{\sqrt{V}}\ \text{Å}\ \ (\text{Å= angstrom})$$

(b) Stopping potential for photo electrons emitted from surface irradiated by light of λ = 3000 Å is 1.91V. What is the new λ for which the potential is 0.9 V. 3

(c) A free particle of mass, *m*, is confined within a cubical box of side, *a*. The potential energy is zero inside the box and infinity elsewhere. If the energy of the particle at an excited level is three times to that at the ground level, then show that the excited level is three-fold degenerate. 3

(d) Calculate the zero-point energy of simple harmonic oscillator. Is your obtained result violating Uncertainty principle or not — Explain. 1+2

6. (a) Assume that a particle is confined to a box of length *a*, and that the system wave function is 1+3

$$\psi(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{\pi x}{a}\right)$$

(i) Is this state an eigenfunction of the position operator?

(ii) Calculate the average value of the position, $\langle x \rangle$ that would be obtained for a large number of measurements. Interpret your result.

(b) Find out $\langle p_x \rangle$ for a harmonic oscillator in its ground energy level, $\psi_0 = (\alpha/\pi)^{1/4} e^{-a x^2/2}$. Will the result remain the same for excited levels? 3

(c) Show that if $\hat{A}$ and $\hat{B}$ are Hermitian then $\hat{A}\hat{B}$ is also Hermitian only if $\hat{A}$ and $\hat{B}$ commute. 3

(d) In the Compton effect while photons are scattered from electrons initially at rest, the Compton shift is maximum when photons are backscattered (θ=180°). Justify. 2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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