U.G. 3rd Semester Examination-2022

CHEMISTRY

[HONOURS]

Course Code : CHEM-H-CC-T-05

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

1. Answer any **five** questions from the following: $2\times5=10$

a) Define the chemical potential of a component in a mixture of chemical species in an open system.

b) The work function of metallic Cesium is 2.14 eV. Calculate the kinetic energy of the electrons ejected by the incident light of wavelength 300 nm.

c) Define fugacity coefficient.

d) Write down the postulates of quantum mechanics.

e) Is the function Ae^{-ax} an eigen function of the operator $\frac{d^2}{dx^2}$? If yes, determine the eigenvalue.

Ae^{-ax}

f) Define specific and equivalent conductance and state their relationship.

g) Discuss the factors affecting ionic mobility of ions in solutions.

h) How can one characterize a liquid flow as turbulent or laminar?

2. Answer any **two** questions: $5\times2=10$

a) i) Calculate the uncertainty in velocity of an electron with uncertainty in position as 0.1 nm. (Mass of an electron = 9.1×10^{-31} kg and h = 6.63×10^{-34}J sec)

ii) Explain the origin of viscosity in gases.

2+3

b) i) The mobility of an acetate ion in aqueous solution at 25°C is 4.24×10^{-8} $m^2s^{-1}v^{-1}$. Calculate the molar ionic conductions.

ii) An 0.02 (N) aqueous solution of KCl placed in a conductivity cell at 25°C shows a resistance of 380 Ω. Specific conductance of the 0.02(N) aqueous solution of KCl at 25°C is 0.00276 $\Omega^{-1}cm^{-1}$. The same cell filled with 0.01 (N) acetic acid (HAc) shows a resistance of 6434 Ω. Calculate the degree of

dissociation (α) of 0.01(N) HAc at 25°c. [The equivalent conductivity of NaAc, HCl and NaCl at infinite dilution at 25°C are given as 91.0, 426.2 and 126.5 $\Omega^{-1}cm^2$ eqv^{-1} respectively] 2+3

c) i) The fugacity coefficient of a certain gas at 200 K temperature and 50 bar pressure is 0.72. Calculate the difference of its chemical potential from that of a perfect gas in the same state.

ii) Show that the linear combination A+ic and A–ic are not Hermitian if A and C are Hermitian operators. (1+2)+2

d) i) Derive Gibbs-Duhem equation and express the partial molar volume of the ith component in a mixture in an open system in terms of chemical potential.

ii) The absolute viscosity of water at 293 K is 0.01002 poise. Time taken by equal volumes of water and chloroform to flow through a capillary tube are 39.7 seconds and 15 seconds respectively. Density of water is 1.0 g/cm^3 and density of chloroform is 1.49 g/cm^3. Calculate the relative and absolute viscosities of chloroform at 293 K. 3+2

3. Answer any **two** questions: $10\times2=20$

a) i) For conductometric titrations, the concentration of the titre should be at least 10 times greater than that of the solution to be titrated— justify.

ii) The ionic mobilities ($m^2v^{-1}s^{-1}$) of the OH^- F^- and Cl^- ions are 20.50, 5.70 and 7.90, respectively— justify.

iii) Solve the time independent Schrödinger equation for a particle in a one dimensional box and derive the energy expression.

iv) Prove that the ideal mixing is not accompanied with a volume change.

$2+2+(2+2)+2$

b) i) Establish a relation between viscosity coefficient and mean free path of a gas.

ii) Depict the conductometric titration curve for the titration of a mixture of oxalic acid and HCl with NaOH solution and explain the variation of conductivity with the volume of NaOH added.

iii) If two operators α and β are Hermitian, then find out the condition for $\alpha\beta$ to be Hermitian. $4+3+3$

c) i) State the Raoult's law. Based on the law, characterize an ideal solution.

ii) At 18°C, the mobilities of NH_4^+ and ClO_4^- ions are 6.6×10^{-4} and 5.7×10^{-4} cm^2 $volt^{-1}s^{-1}$. Calculate the transport number of two ions and equivalent conductance of ammonium chlorate.

iii) 2 mol H_2 at 2 atm and 25°C and 4 mol N_2 at 3 atm and 25°C are mixed at constant volume. Calculate $\Delta_{mix}G$. What would be the value of $\Delta_{mix}G$ had the pressures been identical initially?

iv) State the law of mass action. 3+2+4+1

d) i) What is the probability of finding a particle between x=0 and $x=\frac{a}{2}$ for a one-dimensional box of length a?

ii) Consider ideal mixing of 2 moles of toluene and 2 moles of benzene at 1 atm and 300K. Calculate the values of ΔH_{mix}, ΔS_{mix} and ΔG_{mix} for the process. (ln 2 = 0.69)

x=0

$n = \frac{3}{4}$ n & n*

iii) State the Nernst's distribution law clearly mentioning the 'conditions for applicability' of the law. How one could apply the Nernst's distribution law to determine the equilibrium constant of the reaction, $I_2 + KI \rightleftharpoons KI_3$. 3+3+(1+3)
