B.Sc. Chemistry Sem V Assignment (2024-25)

(Elective Paper: Chemical Energetics and Radiochemistry)

- **This assignment is only for Major 1 students**
- **Use fair register to answer all the questions**

Introductory Quantum Mechanics:

Q 1. (a) What is black body? Why black body radiation could not be rationalized on the basis of classical theory of radiation

(b) Explain Planck's radiation law and write its mathematical expression.

(c) Show that Planck's radiation expression is reducible to Rayleigh-Jean's equation and Wein's equation in the appropriate range of wavelength.

Q 2. Show how the Einstein extension of the idea of quantization to the radiation field could explain the photoelectric effect.

Electric and Magnetic Properties of Molecules:

Q 1. Define the following terms:

(i) Dipole moment. (ii) Induced dipole moment. (iii) Polarization of the molecule in the presence of an electrostatic field. (iv) Electronic, atomic, distortion and orientation polarizabilities.

Q 2. Deduce the following:

(i) 1 esu (or stat coulomb) = 1 $dyn^{1/2}$ cm = 1 $g^{1/2}$ $cm^{3/2}$ s^{-1}
(ii) The unit of dipole moment is esu cm or C m
(iii) I D=3.338 x 10^{-30} Cm
(iv) The unit of polarizability is cm^3 or C^2 m N^{-1}
(v) The unit of $\alpha/4\pi\varepsilon_o$ is m^3

Q 3. Derive Clausius-Mossotti equation which can be used for calculating molar polarization from measurement of dielectric constant? Explain, why Clausius-Mossotti equation is applicable for nonpolar molecules and not for polar molecules.

Q 4. Debye equation is

$$P_m = \frac{(\varepsilon/\varepsilon_0)-1}{(\varepsilon/\varepsilon_0)+2}\frac{M}{\rho} = \frac{1}{3\varepsilon_0}N_A\left(\alpha_d + \frac{p^2}{3kT}\right)$$

(a) Explain, the nature of plots of P_m versus I/T for (i) polar molecules and (ii) nonpolar molecules.

(b) Debye equation can be used to determine the dipole moment for molecules in gaseous system, whereas it cannot be used as such for molecules in condensed system. Explain.

Q 5. (a) Name various methods for determining dipole moment of the molecule and explain (i) Temperature method. (ii) Refractivity method.

(b) The permanent dipole moment of HBr is 0.79 D and internuclear distance 1.42Å. Find the percentage ionic character of HBr bond.

(c) Give reason why the dipole-moment of H_2O is 1.85 D while that of CO_2 is zero?

Q 6. Write short notes on the following:

(i) Paramagnetism. (ii) Diamagnetism. (iii) Ferromagnetism

Third law of thermodynamics, Distribution Law and Phase Rule:

Q 1. (a) Explain Nernst heat theorem. How does it lead to the enunciation of Third law of thermodynamics?

(b) Explain how absolute entropy of a substance is determined with the help of Third law of thermodynamics?

Q 2. State and derive thermodynamically "Nernst distribution law". Under what conditions it is valid? Discuss the applications of Nernst distribution law.

Q 3. (a) Derive Gibbs' phase rule equation $F = C - P + 2$
(b) Explain the terms involved in phase rule
(c) What do you understand by reactive and nonreactive system.

Q 4. (a) Why do we use reduced equation of phase rule for two component system?

(b) Discuss applications of phase rule.

Photochemistry:

Q 1. What are photochemical reactions? How do they differ from thermal reactions?

Q 2. Define the following two laws of photochemistry.

(i) The Grotthuss-Draper law. (ii) Law of photochemical equivalence.

Is there any exception to the above laws?

Q 3. Define the following:

(i) Lambert-Beer's law
(ii) Absorption coefficient.
(iii) Molar absorptivity or extinction coefficient.
(iv) Transmittance.
(v) Primary and secondary processes.
(vi) Quantum yield or quantum efficiency
(vi) Photosensitizers

Q 4. (a) Explain Fluorescence and Phosphorescence with the help of Jablonski diagram.

(b) What do you understand by non-radiative processes? Explain internal conversion (IC) and Intersystem Crossing (ISC).

(c) According to law of photochemical equivalence, the quantum yield of a primary process should be 1 or 2 or 10^{-6} or 10^{6}.

Q 5. Explain photosensitized reactions and energy transfer processes with suitable examples.

Solutions and Colligative Properties:

Q 1. Write short notes on the following:

(i) Ideal and non-ideal solutions.
(ii) Activity and activity coefficient.
(iii) Henry's law and Raoult's law
(iv) Osmotic pressure
(v) Abnormal molar mass

Q 2. (a) What is elevation of boiling point? Derive a relation between molar mass of a non-volatile solute and elevation of boiling point.

(b) Calculate the molar mass of a substance if at 27°C its solution containing 6.0 gm dm^3 has an osmotic pressure of 3 mm Hg. (Given: R= 0.08214 dm^3 atm K^{-1} mol^{-1})

Q 3. (a) Deduce thermodynamically a relationship between depression in freezing point and molecular weight of a non-volatile solute.

(b) If 0.50 gram of sodium chloride solution was dissolve in 50 grams of water, the freezing point of water was depressed by 0.60°C, calculate molecular weight and degree of dissociation of the dissolved solute. (Given K_f of water 1.86° per mole)

(c) Molar Mass of NaCl, as determined by the use of colligative properties in aqueous solution, is approximately one-half of expected value. Why?

Q 4. In a binary system in which, one component obeys Raoult's law, over a certain range of composition, then the other component must obey Henry's law in that composition range. Comment upon the statement.

Q 5. Why there is depression in freezing point when a non-volatile solute is dissolved in a solvent? What is Beckmann's thermometer and how it helps in giving value of ΔT?

Radiochemistry:

Q 1. Define or explain the following terms:

(a) Radioactivity
(b) Radioactive series
(c) Geiger counters
(d) Scintillation counters
(e) Neutron activation analysis
(f) Applications of Radioactivity

Q 2. State the laws of radioactive decay. Derive expression for half-life and mean life time of a radioactive substance.

Q 3. What is the mass of 1 Curie of U^{234} ?

Q 4. (a) Explain Gamow's theory of α-decay and derive Geiger-Nuttal law from it.
(b) Explain Radioactive dating.
(c) Explain clearly a Curie, Rutherford and Becquerel.
(d) Discuss Neutrino hypothesis of Radioactive decay.