2017

BIOCHEMISTRY — HONOURS

Sixth Paper

(Module – XII)

Full Marks – 50

The figures in the margin indicate full marks

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

1. Answer ***any ten*** questions : 2×10

(a) Calculate the de Broglie wavelength of an electron ($m_e = 9.1\times10^{-31}$ kg) having kinetic energy equal to 1000 eV.

(Electronic charge = 1.6×10^{-19}C)

(b) The work function for sodium metal is 1.82 eV. Calculate the threshold frequency for sodium.

(c) What is the uncertainty in momentum if we wish to locate an electron within an atom so that Δx is approximately 50 pm ? (1 pm = 10^{-12}m). Comment on your answer.

(d) The peak in the Sun's emitted energy occurs at 480 nm. Estimate the temperature on its surface assuming it to be a black-body radiator.

(e) Determine the scattering angle for which the shift in wavelength would be maximum in Compton effect.

(f) Evaluate the commutator $[\hat{x}, \hat{H}]$, $\hat{H} = -\frac{h^2}{8\pi^2 m}\frac{d^2}{dx^2} + V(x)$.

(g) Explain how the effect of anharmonicity is reflected in the vibrational spectrum of a diatomic molecule.

(h) Which of the following molecules is IR active : H_2, HCl ? Give reason for your answer.

(i) Find the Miller indices of a plane that intersect the crystallograhic axes at distances a, 2b, ∞c .

(j) Potassium crystallizes as a bcc lattice with unit cell length of 533.3 pm. Given that the density of potassium is 0.8560 g cm^{-3}, calculate Avogadro number.

(k) The electrode potential for Cu/Cu^{2+}(1M) is +0.62V. At what concentration of Cu^{2+} will the potential be zero ?

(l) What is Zeta potential ?

(m) Explain photostationary state.

(n) A light of wavelength λ, having an intensity I_0 falls on a solution of concentration 'c' and pathlength 'l'. Write an expression for the intensity of light absorbed, I_a. Under what condition will I_a be proportional to 'c' ?

(o) State Schulze-Hardy rule.

Unit – I

Answer ***any one*** question

2. (a) How would you use kinetic energy of photoelctron versus frequency plot in photoelectric emission to

(i) distinguish two metals,

(ii) evaluate Planck's constant 'h'. 3

(b) With proper diagram explain fluorescence and phosphorescence. 2

(c) Find the following :

(i) value of commutator $[\hat{x}, \hat{p}_x]$

(ii) eigenvalue of the operator $\hat{p}_x$, if the eigenfunction is exp (kx). 3

(d) The wave number of the J = 1 ← 0 rotational transitions for $^1H^{35}Cl$ and $^2H^{35}Cl$ are 20.8784 and 10.7840 cm^{-1} respectively. Accurate atomic masses are 1.007825 au and 2.0140 au for ^1H and ^2H respectively. Atomic mass of ^{35}Cl is 34.96885 au. Based on this information alone can you conclude that the bond lengths are the same or different in the two molecules. 3

(e) Explain how anharmonicity in a molecule can affect the vibrational spectrum. 2

(f) "Raman but not IR or microwave spectroscopy is suitable for finding the bond length of a homonuclear diatomic molecule" — Explain. 2

3. (a) What is de Broglie hypothesis ? Starting from this hypothesis, arrive at the

(i) energy expression for a free particle confined in a one-dimentional box,

(ii) Bohr's quantisation rule, $mvr = \frac{nh}{2\pi}$. 1+2+2

(b) What is an operator ? When are the operators said to commute ? What is the importance of finding two commuting operators to characterise a quantum mechanical system ? 3

(c) What are fundamental and overtone transitions in vibrational spectroscopy of a molecule ? The fundamental and first overtone transitions of $^{14}N^{16}O$ are centered at 1876.06 cm^{-1} and 3724.20 cm^{-1} respectively. Evaluate equilibrium vibrational frequency and force constant of the molecule. 3

(d) What information of a molecule do the following of PMR spectra features provide ? 2

(i) the number of PMR peaks

(ii) their positions

(iii) peak height

(iv) finer splitting.

(e) The vibrational energy levels of A_2 molecule is given by the expression :

$$E_v(cm^{-1}) = 215\left(v+\frac{1}{2}\right)\left\{1-0.003\left(v+\frac{1}{2}\right)\right\}$$

Find :(i) anharmonicity constant

(ii) equilibrium oscillation frequency. 2

Unit – II

Answer ***any one*** question

4. (a) Derive thermodynamically (based on chemical potential) the relation between lowering of vapour pressure of a solution and mole fraction of solute in the binary solution. Mention the assumptions and approximations used in your derivation. 5

(b) The total vapour pressure at 25°C of a mixture of benzene and toluene, in which the two mole fractions are equal, is 62 mm Hg. The vapour pressure of pure benzene at 25°C is 95 mm Hg. Calculate the mole fraction of benzene in the vapour in equilibrium with the liquid mixture (assume ideal behaviour of mixture). 3

(c) A metal (M=27) crystallizes in fcc arrangement. What is the length of its unit cell ? (Density of metal = 2.7 g cm^{-3}) 3

(d) The EMF of Weston standard cell is 1.01530V at 20°C and 1.01807 V at 25°C. Calculate ΔG, ΔH, ΔS for the cell at 25°C. 4

5. (a) From the chemical potential versus temperature diagram justify that $\Delta T_f > \Delta T_b$. Assume that the solute is non-volatile and does not involve in solid solvent.

A mixture of 1 g of naphthalene (M=128) in 10g Comphor freezes at 147°C, whereas pure camphor freezes at 177.5°C. Calculate the cryoscopic constant of camphor. 5

(b) Show that vant Hoff factor, 'i' and degree of dissociation 'α' of an electrolyte A_xB_y in aqueous solution are related by the expression, $\alpha = \frac{i-1}{n-1}$, where n = x+y.

Calculate the factor 'i' and 'α' of a 0.2 molal aqueous solution of $NaNO_3$, which freezes at 0.675°C.

[Given : K_f= 1.86 K Kg $mole^{-1}$ for water]. 4

(c) Explain with diagram the Bragg equation used in crystal analysis. What is the lowest limit to the spacing of lattice planes to produce X-ray diffraction spectra for a given radiation ? Why are radiowaves unsuitable for determining crystal structure ? 3

(d) State and explain Debye Hückel Limiting law. Mention its utility. 3