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M. SC. (CHEMISTRY)/M. SC. (ANALYTICAL CHEMISTRY) (MSCCHEM/MSCANCHEM)

Term-End Examination

June, 2026

MCH-013 : GENERAL PHYSICAL CHEMISTRY

Time : 2 Hours *Maximum Marks : 50*

Note : *(i) Question No. **1** is compulsory.*

*(ii) Attempt any **four** questions from Question Nos. **2** to **7**.*

(iii) Use the following values wherever required :

$k_B = 1.38 \times 10^{-23} JK^{-1}$;

$h = 6.626 \times 10^{-34}$ J-s;

$N_A = 6.022 \times 10^{23} mol^{-1}$,

$R = 8.314\ JK^{-1}\ mol^{-1}$;

$1\ cm^{-1} = 1.98 \times 10^{-23} J$.

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1. Attempt any *five* questions from the following : 5×2=10

   (i) What is the salt effect in rate of reactions in solution ?

   (ii) What is the difference between isobaric and isothermal processes ?

   (iii) What are the amorphous materials ? Give any *two* examples.

   (iv) Describe the lock and key hypothesis of the enzyme action.

   (v) What is the relationship between molecular and canonical partition function ?

   (vi) State the law of constancy of interfacial angles.

(vii) Define coefficient of viscosity of a gas and give the expression for the viscosity coefficient of a gas under laminar flow.

2. (a) What are the random variables ? Name their types. 1+1

(b) Give the expression for rate constant as per Transition State Theory (TST) and name the terms involved. 1+1

(c) Calculate the ionic strength of a solution which is 0.1 molal in KCl and 0.2 molal in K_2SO_4. 3

(d) The rotational temperature for HI molecule in around 10 K. Calculate the moment of inertia for HI. 3

3. (a) Write the Michaelis-Menten equation for the following enzymatic reaction and define each term involved : 2

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} E + P$$

(b) How does the total entropy of the universe change for reversible and irreversible processes in an isolated system ? 2

(c) Define molar conductivity. How do we obtain the molar conductivity at infinite dilution ? 2

(d) Pollonium is assumed to crystallize in primitive cubic unit cell at room temperature. If a = 0.4 nm, calculate the theoretical density of pollonium. Molar mass of pollonium is 209 g mol^{-1}. 4

4. (a) Formulate the relationship between mean molality (m_1) and m for following electrolytes : 1+2

   (i) NaCl

   (ii) Na_2SO_4

   (b) Show that in a binary mixture, when the chemical potential of component A decreases then the chemical potential of component B will increase, if the temperature and pressure are fixed. 3

   (c) Describe stoppered flow method in brief, giving a suitable schematic diagram for the same. 2+2

5. (a) Write the expression for adsorption isotherm in terms of equilibrium constant and discuss the variation of fraction of surface uncovered as a function of the concentration (or pressure) of the gaseous adsorbate. 3

(b) Calculate the temperature at which the average velocity of oxygen equals that of hydrogen at 20 K. [Mass of O_2 = 32 g/mol]. 3

(c) Consider the following Lindemann mechanism for the unimolecular decomposition of a molecule A in the presence of a species M :

$$A + M \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} A^* + M$$

$$A^* \xrightarrow{k_2} P$$

Using the steady state approximation, derive the rate law for the formation of the product. 4

6. (a) How do we determine the values of R_{max} and K_m from Lineweaver-Burk plot ? 2

(b) Derive the following relations using appropriate expressions : 2+2

(i) $\left(\frac{\partial A}{\partial T}\right)_V = -S$ or $\left(\frac{\partial A}{\partial V}\right)_T = -P$

(ii) $\left(\frac{\partial G}{\partial P}\right)_T = V$ or $\left(\frac{\partial G}{\partial T}\right)_P = -S$

(c) Show that the chemical potential of the pure substance is equal to the molar Gibbs energy of the pure substance. 4

Or

Give the physical significance of any *two* of the following :

(i) Chemical potential

(ii) Partial molar volume

(iii) Helmholtz energy

(iv) Gibbs energy

7. (a) Write any *two* symmetry elements. Give the schoenflies notation for them. 2

(b) What are the basic assumptions of Debye-Hückel theory ? Give the mathematical expression for the Debye-Hückel limiting law and name the terms involved. 3

(c) Derive the translational partition function for a particle of mass m, confined into a one-dimensional box of length L, where the energy of the particle is given as : 5

$$\in_{n,\text{trans}} = \frac{n^2 h^2}{8 m \text{L}^2}$$

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