2024

(CBCS)

(5th Semester)

CHEMISTRY

SEVENTH PAPER

(Physical Chemistry—II)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(Use of calculator is allowed)

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. For one mole of an ideal gas, the kinetic energy is given by

(a) $\frac{1}{2}(RT)$ ( )

(b) $\frac{3}{2}(RT)$ ( )

(c) $\frac{5}{2}(RT)$ ( )

(d) $\frac{7}{2}(RT)$ ( )

2. The numbers of translational, rotational, vibrational degrees of freedom respectively for CO_2 molecules are

(a) 3, 2, 4 ( )

(b) 3, 3, 3 ( )

(c) 2, 2, 3 ( )

(d) 2, 3, 4 ( )

3. Which of the following unit cells has all the angles at 90° but the sides are of unequal length?

(a) Triclinic unit cell ( )

(b) Monoclinic unit cell ( )

(c) Hexaclinic unit cell ( )

(d) Orthorhombic unit cell ( )

4. Which of the following rays are used in the powder method of crystal determination?

(a) Beta rays ( )

(b) Gamma rays ( )

(c) Monochromatic X-rays ( )

(d) Alpha rays ( )

5. If activation energy (E_a) of a reaction is 0, then k is equal to

(a) 0 ( )

(b) A ( )

(c) ∞ ( )

(d) A^{-1} ( )

6. How does a catalyst increase the rate of a reaction?

(a) By forming an intermediate complex ( )

(b) By increasing activation energy ( )

(c) By lowering the activation energy ( )

(d) By changing equilibrium constant ( )

7. The molal chemical potential is given by

(a) $\delta S / \delta V$ ( )

(b) $\delta U / \delta V$ ( )

(c) $\delta U / \delta S$ ( )

(d) $\delta U / \delta n$ ( )

8. As per the third law of thermodynamics, as $T \rightarrow 0$,

(a) $G = 0$ ( )

(b) $S = 0$ ( )

(c) $U = 0$ ( )

(d) $H = 0$ ( )

9. The unit of molar conductance is given by

(a) $S\,m^{-1}\,mol^{-1}$ ( )

(b) $S\,m^{-2}\,mol^{-1}$ ( )

(c) $S\,m^{2}\,mol^{-1}$ ( )

(d) $S\,m^{-2}\,mol^{-2}$ ( )

10. Upon dilution, specific conductance of a solution

(a) decreases ( )

(b) increases ( )

(c) remains unchanged ( )

(d) increases then decreases ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following questions : 3×5=1

UNIT—I

1. Discuss the translational degrees of freedom.

OR

2. Calculate the root-mean-square speed and average speed of H_2 gas molecules at 0 °C.

UNIT—II

3. Discuss the three types of Bravais lattice for cubic system.

OR

4. Differentiate between isotropy and anisotropy. Give two examples each for isotropy and anisotropy.

UNIT—III

5. Write the difference between order and molecularity of a reaction.

OR

6. Define *(a)* threshold energy, *(b)* activation energy and *(c)* turn-over number.

UNIT—IV

7. Discuss the variation of molar conductance with dilution for weak and strong electrolytes.

OR

8. Write the physical significance of chemical potential.

UNIT—V

9. Write a note on electrophoretic effect.

OR

10. Define *(a)* equivalent conductivity and *(b)* molar conductivity.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following questions : 10×5=50

UNIT—I

1. *(a)* Derive Maxwell-Boltzmann distribution law of molecular velocities. 5

   (b) Discuss the effect of temperature on the distribution of molecular velocities. 3

   (c) Explain the effect of temperature on the kinetic energy of an ideal gas. 2

OR

2. *(a)* Define most probable velocity and average velocity. Derive the expression for root-mean-square velocity from Maxwell distribution of molecular velocities. 5

   (b) Discuss the law of equipartition of energy. 3

   (c) Calculate the various degrees of freedom for the following : 2

   (i) C_6H_6

   (ii) C_2H_2

UNIT—II

3. *(a)* Describe the rotating crystal technique for the determination of crystals. 5

(b) Define the following : 3

(i) Axis of symmetry

(ii) Plane of symmetry

(iii) Centre of symmetry

(c) Calculate the interplanar distance in a crystal in which a series of planes produces a first-order reflection from a copper X-ray tube ($\lambda = 1{\cdot}539$ Å) at an angle of $22{\cdot}5°$. 2

OR

4. *(a)* Derive Bragg's equation for X-ray crystallography. 5

(b) What are Miller indices? How are they determined? 3

(c) What is meant by rational indices and interfacial angle? 2

UNIT—III

5. *(a)* What are the types of catalysis? Describe some characteristics of catalysis. 5

(b) Derive the integrated form of Arrhenius equation. 3

(c) The values of the rate constant (k) for the reaction $2N_2O_5\,(g) \rightarrow 4NO_2\,(g) + O_2\,(g)$ were determined at several temperatures. A plot of $\ln k$ versus $1/T$ gave a straight line of which the slope was found to be $-1{\cdot}2 \times 10^4$ K. What is the activation energy of the reaction? 2

OR

6. *(a)* Discuss the mechanism of enzyme catalysis and derive Michaelis-Menten equation for an enzyme substrate reaction. 5

(b) The value of rate constant for the decomposition of nitrogen pentoxide ($N_2O_5 \rightarrow N_2O_4 + \frac{1}{2}O_2$) is $4{\cdot}346 \times 10^{-5}$ at 25 °C and $4{\cdot}87 \times 10^{-3}$ at 65 °C. Calculate the energy of activation for the reaction. ($R = 8{\cdot}314\ JK^{-1}\ mol^{-1}$) 3

(c) Write a short note on temperature coefficient of a chemical reaction. 2

UNIT—IV

7. *(a)* State the third law of thermodynamics. Describe Nernst heat theorem. 1+4=5

(b) What do you mean by partial molar quantities? How is it related to chemical potential? 3

(c) Show that the entropy of any substance at very low temperatures ($0 > T > 20\,K$) is 1/3rd of the molar heat capacity. 2

OR

8. *(a)* What is meant by chemical potential? Derive the Gibbs-Duhem equation. 1+4=5

(b) Derive the expression for the variation of chemical potential with temperature and pressure. 3

(c) Calculate the standard entropy change for the reaction $N_2\,(g) + O_2\,(g) \rightarrow 2NO$. Given, standard entropies for $N_2\,(g) = 191{\cdot}62\ JK^{-1}\ mol^{-1}$, $O_2\,(g) = 205{\cdot}01\ JK^{-1}\ mol^{-1}$ and $NO\,(g) = 210{\cdot}45\ JK^{-1}\ mol^{-1}$. 2

UNIT—V

9. *(a)* What is meant by the term 'transport number'? Describe the determination of transport number by moving boundary method. 1+4=5

(b) The resistance of 0·5 *M* solution of an electrolyte in a cell was found to be 45 Ω. Calculate the molar conductance of the solution if the electrodes in the cell are 2·2 cm apart and have an area of 3·8 cm^2. 3

(c) Discuss asymmetric effect. 2

OR

10. *(a)* What is meant by ionic mobility? Derive Kohlrausch law of independent migration of ions. 1+4=5

(b) If the molar conductivities at infinite dilution of NaCl, HCl and CH_3COONa are $126{\cdot}45 \times 10^{-4}$ S m^2 mol^{-1} , $426{\cdot}16 \times 10^{-1}$ S m^2 mol^{-1} and $91{\cdot}0 \times 10^{-1}$ S m^2 mol^{-1} respectively, then what will be the molar conductivity of acetic acid at infinite dilution? 3

(c) Define the terms 'specific conductance' and 'equivalent conductance' of a solution. 2

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