

**CHEMISTRY - I**  
**(CHEM 1001)**

Time Allotted : 3 hrs

Full Marks : 70

*Figures out of the right margin indicate full marks.*

*Candidates are required to answer Group A and  
any 5 (five) from Group B to E, taking at least one from each group.*

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

**Group - A**  
**(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) With thermodynamics, one cannot determine  
 (a) speed of a reaction  
 (b) the direction of a spontaneous reaction  
 (c) temperature at which a reaction will be spontaneous  
 (d) the extent of a reaction.
- (ii) Carnot cycle efficiency is maximum when  
 (a) initial temperature is 0°K  
 (b) final temperature is 0°K  
 (c) difference between initial and final temperature is 0°K  
 (d) final temperature is 0°C.
- (iii) For a very weak acid with  $\alpha$  as its degree of dissociation, the value of dissociation constant is given by (C is concentration of acid in moles per litre)  
 (a)  $K_a = C\alpha$                       (b)  $K_a = C\alpha^2$                       (c)  $K_a = C^2\alpha$                       (d)  $K_a = C^2\alpha^2$
- (iv) Which statement is not correct regarding reversible process?  
 (a) It is imaginary process                      (b) It takes infinite time  
 (c) Work obtained is maximum                      (d) It is spontaneous.
- (v) Which of the following force is acting when ions from an ionic solid dissolved in a polar solvent?  
 (a) Dipole-dipole interaction                      (b) Dipole-induced dipole interaction  
 (c) Ion-dipole interaction                      (d) Ion-induced dipole interaction.
- (vi) Which of the following isomerism is shown by alkenes but not by alkanes?  
 (a) Conformational                      (b) Optical                      (c) Geometrical                      (d) Chain.
- (vii) Which of the following has zero dipole moment?  
 (a)  $PF_3Cl_2$                       (b)  $PCl_3F_2$                       (c)  $SF_4$                       (d)  $ClF_3$
- (viii) Which one of the following compounds will readily undergo  $S_N1$  reaction?  
 (a)  $CH_3Cl$                       (b)  $CH_2=CHCl$   
 (c)  $CH_3CH_2CH_2Cl$                       (d)  $CH_2=CHCH_2Cl$

- (ix) Which of the following series contains only nucleophiles?  
 (a)  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ ,  $\text{AlCl}_3$  (b)  $\text{NH}_3$ ,  $\text{ROH}$ ,  $\text{H}_2\text{O}$   
 (c)  $\text{H}_2\text{O}$ ,  $\text{H}_3\text{O}^+$ ,  $\text{SO}_3$  (d) None of these.
- (x) Which of the following is not a characteristic feature of a salt bridge?  
 (a) Salt bridge joins the two halves of an electrochemical cell  
 (b) It completes the inner circuit  
 (c) It is filled with a salt solution (or gel)  
 (d) It does not maintain electrical neutrality of the electrolytic solutions of the half-cells.

### Group - B

2. (a) Derive the expression for the efficiency of Carnot cycle. [(CO4)/LOCQ]  
 (b) One mole of an ideal diatomic gas ( $C_v=5$  cal) was initially at  $25^\circ\text{C}$  and 1 atm pressure. The gas was transferred to the state when temperature is  $100^\circ\text{C}$  and pressure 10 atm. Calculate the entropy-change. [(CO2)/LOCQ]  
 (c) Consider a beam of electron with a speed of  $5.31 \times 10^6$  m/s and calculate the de Broglie wavelength. (Mass of electron =  $9.11 \times 10^{-31}$  kg) [(CO4)/IOCQ]  
 (d) What are the applications of ultra-violet spectroscopy? [(CO5)/IOCQ]  
**5 + 3 + 2 + 2 = 12**
3. (a) Explain what is meant by chemical potential? Derive Gibbs Duhem relations. [(CO4)/LOCQ]  
 (b) Position of a chloride ion on a material can be determined to a maximum error of 1  $\mu\text{m}$ . If the mass of the chloride ion is  $5.86 \times 10^{-26}$  kg, what will be the error in its velocity measurement? [(CO3)/LOCQ]  
 (c) Write the wave function and the total energy of a particle in a one dimensional box for the ground state. [(CO6)/LOCQ]  
 (d) How is electronic spectra obtained? Write down mathematical form of Lambert-Beer Law. [(CO5)/IOCQ]  
 (e) Describe hypsochromic shift. [(CO5)/IOCQ]  
**4 + 3 + 2 + 2 + 1 = 12**

### Group - C

4. (a) With the help of molecular orbital theory, explain the paramagnetic nature of  $\text{O}_2$  molecule and diamagnetic nature of  $\text{N}_2$  molecule. Also calculate the bond order of  $\text{N}_2^-$  and  $\text{O}_2^+$ . [CO2/IOCQ]  
 (b) Find out the state of hybridisation of nitrogen atom in methylamine, pyridine and methyl cyanide. State which of these nitrogen atoms is the most electronegative? [CO2/IOCQ]  
 (c) What will be the value of dissociation constant of water at  $25^\circ\text{C}$ ? Given ionic product of water at this temperature is  $1 \times 10^{-14}$ ? [CO2/HOCQ]  
 (d) Find out the effective nuclear charge using Slater's rule for the valence 4s electron of Mn(25). [CO2/HOCQ]  
**(2 + 2) + (3 + 1) + 2 + 2 = 12**

5. (a) Draw the energy level diagram of  $\pi$  molecular orbitals of 1, 3-butadiene. Indicate HOMO and LUMO level. [(CO2)/LOCQ]
- (b) On the basis of Band theory, differentiate between conductors, semiconductors and insulators. [(CO2)/LOCQ]
- (c) Define electron affinity. Which of the following elements has the highest electron affinity? Give reasons. [X]  $3s^23p^3$ , [Y]  $3s^23p^4$ , [Z]  $3s^23p^5$ . [(CO2)/IOCQ]
- (d) What do you mean by a buffer solution? A solution composed of 0.01 molar propionic acid and 0.02 molar sodium propionate gives a pH of 5.17 at 25°C. Find the dissociation constant of the acid. [(CO1)/IOCQ]
- 3 + 3 + 3 + (1 + 2) = 12**

### Group - D

6. (a) The rate constant for a 2<sup>nd</sup> order reaction ( $2A \rightarrow \text{Product}$ ) is k. Show that  $t_{1/2} = \frac{1}{ak}$ ; where, a is the initial concentration of A and  $t_{1/2}$  is the half life period of A for this reaction. [CO1/HOCQ]  
Write down the expression for k in terms of  $\Delta G^\ddagger$ , according to Activated Complex theory of reaction rates and give the significance of each term in the equation. [CO1/IOCQ]
- (b) Give brief account of primary & secondary batteries giving example of each and describe each of the electrode components. [CO1/IOCQ]
- (c) What is the function of Polymer Electrolyte Membrane (PEM) in  $H_2$ - $O_2$  fuel cell? Express the half cell reactions and give a schematic of the cell. [CO1/HOCQ]
- (2 + 2) + (3 + 2) + 3 = 12**
7. (a) According to Debye-Huckel 'Ionic Cloud Theory' what is ion atmosphere? How its shape is distorted while the ion moves toward a particular electrode under electrostatic force? [CO1/LOCQ]  
Following conductance parameters at 18°C are given as:  
 $\lambda_0(\text{NaNO}_3) = 105.2 \text{ mho cm}^2$        $l_0(\text{NO}_3^-) = 61.7 \text{ mho cm}^2$   
Calculate the transport numbers and motilities of  $\text{Na}^+$  and  $\text{NO}_3^-$  ions. [CO1/HOCQ]
- (b) The rate of a reaction at 27 °C becomes doubled for 10° rise in temperature. Derive the activation energy of the reaction. [CO1/HOCQ]
- (c) Give examples of metal/metal ion electrode and redox electrode and write down the half-cell reaction in each case. [CO1/LOCQ]
- (d) Calculate the  $\Delta G^\circ$  for the following cell:  
$$\text{Ni}_{(s)} \mid \text{Ni}^{2+}_{(aq)} \parallel \text{Pb}^{2+}_{(aq)} \mid \text{Pb}_{(s)}$$
  
Given  $E^0_{\text{Ni}^{2+}/\text{Ni}} = 0.24\text{V}$  and  $E^0_{\text{Pb}^{2+}/\text{Pb}} = 0.13\text{V}$ . Also find the equilibrium constant for the cell reaction. [CO1/HOCQ]
- (3 + 2) + 2 + 2 + 3 = 12**

### Group - E

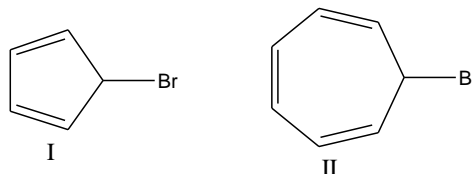
8. (a) Which common functional group is present in sulpha-drugs? Exemplify one sulpha drug with its uses. [CO6/LOCQ]
- (b) Which of the following undergoes  $S_N2$  reaction and why?  
 $\text{CH}_3\text{Br}$ ,  $(\text{CH}_3)_3\text{CBr}$ ,  $\text{PhCH}_2\text{Br}$  [CO6/IOCQ]

- (c) Differentiate between enantiomer and diastereomer with example. [CO6/LOCQ]  
 (d) Analyze the reason for the more acidity of  $\text{CHCl}_3$  than  $\text{CHF}_3$ . [CO6/HOCQ]  
 (e) Define plane of symmetry. Identify the rotational axes with proper fold and the total number of  $\sigma$  planes present in  $\text{H}_2\text{O}$  molecule. [CO6/IOCQ]

$$(1 + 1 + 1) + 2 + 2 + 2 + (1 + 2) = 12$$

9. (a) Identify the absolute configuration of the each stereocentres of the following structures. [CO6/IOCQ]

- (b) Predict the decomposition of the following compounds individually. Justify your answer. [CO6/HOCQ]



- (c) Identify the products of the following reaction. Which one is the major product? Justify your answer.

[CO6 / HOCQ]

- (d) Arrange the different conformations of n-butane in terms of their stability. Justify your answer. [CO6/IOCQ]

$$(2 + 1) + (2 + 1) + 3 + (1 + 2) = 12$$

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	34.37	40.63	25

### Course Outcome (CO):

After the completion of the course students will have

Basic knowledge of theory based subjects like quantum mechanics, thermodynamics, reaction dynamics, electrochemistry, structure and reactivity of molecules. The course outcomes of the subject are

1. Knowledge of understanding the operating principles and reaction involved in batteries and fuel cells and their application in automobiles as well as other sectors to reduce environmental pollution.
2. An ability to analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces for engineering applications.
3. Have knowledge of synthesizing nano materials and their applications in industry, carbon nano tube technology is used in every industry now-a-days.
4. Understanding of bulk properties and processes using thermodynamic considerations.
5. Elementary knowledge of IR, UV, NMR and X-ray spectroscopy is usable in structure elucidation and characterisation of various molecules.
6. Knowledge of electronic effect and stereochemistry for understanding mechanism of the major chemical reactions involved in synthesis of various drug molecules.

\*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question