

CHEMISTRY - I
(CHEM 1001)

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

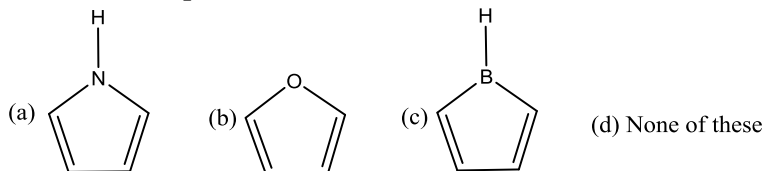
Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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) The temperature of the source and the sink of the reversible Carnot engine is increased by 10°C. The efficiency
(a) will increase
(b) will decrease
(c) will remain unchanged
(d) may increase or decrease depending on its nature of working substance.
- (ii) If the rate of a reaction ($A + B \rightarrow \text{Product}$) is expressed by, $\text{rate} = k[A]^2[B]$, the order of reaction with respect to reactant B will be
(a) 2 (b) 3 (c) 1 (d) 0.
- (iii) If pH of a HCl solution is 2 then the strength of the solution in gm/L will be
(a) 3.55 (b) 0.355 (c) 3.65 (d) 0.365.
- (iv) Which of the following statements best describes the Second Law of Thermodynamics?
(a) The internal energy of the universe is constant
(b) Energy can neither be created nor destroyed
(c) When an isolated system undergoes a spontaneous change, the entropy of the system will increase
(d) At absolute zero, the entropy of a perfect crystal is considered to be zero.
- (v) How many MOs of H₂ generate by the linear combination of the hydrogen's 1s atomic orbitals?
(a) 1 (b) 2 (c) 3 (d) 4.
- (vi) An essential condition for a molecule to be IR active is that a molecule should
(a) have an oscillating dipole moment (b) be polar
(c) have a permanent dipole (d) have large electron affinity.
- (vii) Which of the following has zero dipole moment?
(a) PF₃Cl₂ (b) XeO₃F₂ (c) SF₄ (d) ClF₃.

- (viii) In an atom the screening effect of inner electrons over the nucleus causes
 (a) decrease in the ionization energy
 (b) increase in the ionization energy
 (c) no effect on the ionization energy
 (d) increases the attraction of the nucleus on the electrons.
- (ix) Which has greater ionic mobility?
 (a) Na⁺ (b) Li⁺ (c) H₃O⁺ (d) K⁺.
- (x) Select the species which is not aromatic



Group- B

2. (a) Derive Clapeyron-Clausius equation and mention any one of its applications. [CO4/IOCQ]
- (b) Define Gibbs free energy. Establish the criterion for the spontaneity of a process in terms of Gibbs free energy change. [CO4/IOCQ]
- (c) On passing a monochromatic light through a 0.01 (M) solution in a cell of 1 cm thickness, the intensity of the transmitted light was reduced to 10%. Calculate the molar extinction coefficient. [CO5/HOCQ]
(3 + 1) + (3 + 2) + 3 = 12
3. (a) Derive the expression for entropy change of an ideal gas for change of temperature and volume. [CO4/LOCQ]
- (b) 6.42×10^{-19} J of energy is required to remove an electron from a silver atom. What is the maximum wavelength of light that can do this? [CO5/HOCQ]
- (c) How much does the entropy of an ideal gas increase when one mole is heated from 298 K to 1000 K at a constant pressure and then expanded to five times the volume at the higher temperature? ($C_p = 2.9 \text{ J K}^{-1}\text{mol}^{-1}$) [CO5/IOCQ]
- (d) CO₂ does not have a permanent dipole moment but it is IR active. Why? [CO5/IOCQ]
3 + 3 + 3 + 3 = 12

Group - C

4. (a) Draw and discuss the structure of BrF₃ molecule using VSEPR theory. Mention the hybridization pattern of the molecule also. [(CO2)(IOCQ)]
- (b) Arrange O₂, O₂⁺, O₂⁻ according to increasing bond order, bond length and bond energy using molecular orbital theory. [CO2/IOCQ]
- (c) Define electron affinity. Give reason for the very high electron affinity value of Gold (Au) compared to Silver (Ag) though it is expected from periodic trend that Au should have less electron affinity than Ag. [(CO2)(IOCQ)]

- (d) Define degree of hydrolysis. Explain why the aqueous solution of CuSO_4 solution is acidic and that of NaCl is neutral. [(CO1)(LOCQ)]
3 + 3 + 3 + (1 + 2) = 12
5. (a) Explain the structure of PCl_3F_2 molecule using Bent's rule. [CO2/LOCQ]
 (b) Using Slater's rule, calculate the shielding constant and therefore find out the effective nuclear charge experienced by the first valence electron in Ca ($Z=20$). [(CO2)(LOCQ)]
 (c) Draw molecular orbital energy level diagram of CO molecule and also write the electronic configuration. [CO2/LOCQ]
 (d) Solubility of Ag_2CrO_4 is $2.5 \times 10^{-2} \text{g/L}$. Calculate the solubility product (K_{sp}) of Ag_2CrO_4 . (Given molecular weight of Ag_2CrO_4 is 332). [(CO1)(HOCQ)]
 (e) Why phenolphthalein is not a suitable indicator for the titration of ammonium hydroxide with HCl ? Explain with the help of pH curve of the titration. [(CO1)(IOCQ)]
3 + 2 + 2 + 2 + 3 = 12

Group - D

6. (a) The values of Arrhenius factor and activation energy are $4 \times 10^{13} \text{ sec}^{-1}$ and 98.6kJ/mol , respectively for a first order reaction. Calculate the temperature at which its half-life is 10 mins. [(CO1)(HOCQ)]
 (b) Considering Debye-Onsager equation $\lambda = \lambda_o - (A+B\lambda_o)\sqrt{C}$. Illustrate the significance of A and B. [(CO1)(LOCQ)]
 (c) Consider an electrochemical cell whose potential (E_{cell}) is 0.601 V. Given the potential of the two electrodes are $E^0_{\text{Ni} / \text{Ni}^{+2}} = 0.25 \text{ V}$ & $E^0_{\text{Cu}^{+2} / \text{Cu}} = 0.34 \text{ V}$ and concentration of Cu^{+2} in solution is 0.75 (M), find out the concentration of Ni^{+2} in the cell. Express the full cell configuration. [CO1/HOCQ]
 (d) Ratio of the mobility of cation and anion of a strong electrolyte is 0.5. What are the transport numbers of each of the ions? [CO1/HOCQ]
3 + 4 + 3 + 2 = 12
7. (a) Deduce the expression for the rate constant of a 2nd order reaction where the initial concentrations of the two reactants are different. If any one of these two reactants is taken as excess then what should be the order of this type of reaction? [(CO1)(IOCQ)]
 (b) Give one example of metal-metal sparingly soluble salt electrode. Express the configuration of the electrode and the corresponding half cell reactions. [CO1/IOCQ]
 (c) Specific conductance of SrSO_4 in a saturated solution at 25°C is 1.5×10^{-4} and that of water is $1.5 \times 10^{-6} \text{ mho cm}^{-1}$. What is the solubility of the salt? Given that the equivalent conductance of SrSO_4 is $139 \text{ ohm}^{-1} \text{ cm}^2$ per gm equivalent. [CO1/HOCQ]
 (d) Write cell representation of the following cell reaction:
 $\text{Mg(s)} + 2\text{Ag}^+(\text{aq}) = \text{Mg}^{2+}(\text{aq}) + 2\text{Ag(s)}$. [(CO1)(IOCQ)]

- (e) Write down the electrochemical reactions involved in rusting of iron mentioning oxidation and reduction process. [(CO1)(LOCQ)]

$$4 + 2 + 2 + 2 + 2 = 12$$

Group - E

8. (a) Depict the Synthetic route and uses of aspirine. [CO6/LOCQ]
 (b) Explain mechanistically the major product formation when HBr is added to 1-propene in presence of benzoyl peroxide. Identify the product if the reaction carried out in absence of benzoyl peroxide. [(CO6)(IOCQ)]
 (c) Which of the following carbanion is most stable and also arrange them in order of stability? [(CO6)(HOCQ)]
 (d) Assign R, S notation of the following compounds: [CO6/IOCQ]
- (e) Among CH_3NH_2 and $\text{C}_6\text{H}_5\text{NH}_2$, identify the stronger base with proper justification. [(CO6)(IOCQ)]

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

9. (a) Explain why formic acid is stronger acid than phenol? [CO6/ IOCQ]
 (b) Arrange the functional groups attached with the marked chiral-centre according to their priority applying standard sub rules followed by determination of the absolute configuration of this stereo centre. [(CO6)(IOCQ)]

- (c) What do you mean by racemic mixture? Explain with example. [CO6/LOCQ]
 (d) Explain why $\text{S}_{\text{N}}1$ leads to racemic mixtures where as $\text{S}_{\text{N}}2$ gives rise to inverted products. [(CO6)(HOCQ)]
 (e) Draw the structure of anti-staggered and fully eclipsed conformation of meso tartaric acid in Newman projection formula. [(CO6) (IOCQ)]
 (f) Identify the major product in the following reaction. Justify your answer.

[(CO6) (IOCQ)]

$$2 + 2 + 2 + 2 + 2 + 2 = 12$$

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	23.96	53.12	22.92

Course Outcome (CO):

After the completion of the course students will be able to learn about the topic and apply in their respective fields:

The subject code CHEM1001 corresponds to chemistry theory classes for the first year B. Tech students, which is offered as Engineering Chemistry and is common for all branches of engineering subjects. The course provides basic knowledge of theory based subjects like quantum mechanics, thermodynamics, reaction dynamics, electrochemistry, structure and reactivity of molecules with the following outcome:

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

