

**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) Entropy of an ideal gas depends upon its  
(a) Pressure only (b) Temperature only  
(c) Both (a) & (b) (d) Neither (a) nor (b).
- (ii) The hybridization of the central atom in ICl<sub>3</sub> molecule is  
(a) sp<sup>2</sup> (b) sp<sup>3</sup> (c) sp<sup>3</sup>d (d) sp<sup>3</sup>d<sup>2</sup>
- (iii) The half cell reaction AgCl + e → Ag + Cl<sup>-</sup> occurs at  
(a) metal-metal ion electrode (b) Redox electrode  
(c) metal-sparingly salt electrode (d) none of these.
- (iv) The ground state energy of a particle in an one dimensional box is  
(a) zero (b) h<sup>2</sup>/8mL<sup>2</sup> (c) - h<sup>2</sup>/8mL<sup>2</sup> (d) none.
- (v) t<sub>1/2</sub> for second order reaction (2A → pdt) is  
(a) Independent of concentration of the reactant  
(b) Directly proportional to concentration of the reactant  
(c) Inversely proportional to the initial concentration of the reactant  
(d) None of the above.
- (vi) The dipole moment is highest for  
(a) Ethyl chloride (b) Ethyl bromide  
(c) Ethyl iodide (d) Ethyl fluoride.
- (vii) Which one is true?  
(a) Secondary storage cell must always be reversible  
(b) Primary batteries are rechargeable  
(c) For a spontaneous cell reaction the E<sub>cell</sub> is negative  
(d) In an electrolytic cell chemical energy is transformed to electrical energy.

- (viii) Pyrrole ( $C_4H_4NH$ ) is  
 (a) aromatic substance (b) non-aromatic substance  
 (c) anti-aromatic substance (d) none of these.
- (ix) Ostwald's dilution law is applicable in case of the solution of  
 (a) NaCl (b)  $CH_3COOH$  (c) NaOH (d)  $H_2SO_4$ .
- (x) Which of the following conformations of n-butane is the least stable?  
 (a) Gauche (b) Fully eclipsed (c) Eclipsed (d) Anti.

**Group - B**

2. (a) When the Carnot cycle efficiency will be maximum?  
 (b) What is chemical potential? Derive Gibbs Duhem relations.  
 (c) A microscope using suitable photons is employed to locate an electron in an atom within a distance of  $0.1 \text{ \AA}$ . What is the uncertainty involved in the measurement of its velocity? (mass of electron =  $9.11 \times 10^{-31} \text{ kg}$ )  
 (d) Why does  $CO_2$  absorb IR energy? What are the applications of IR spectroscopy?  
 **$1 + (1 + 4) + 3 + (1 + 2) = 12$**
3. (a) Derive the energy expression for particle in one dimensional box.  
 (b) What is the de Broglie Hypothesis? Consider a beam of electron with a speed  $5 \times 10^6 \text{ m/s}$  and calculate the de Broglie wavelength.  
 (c) Calculate the entropy of mixing 2 moles of  $N_2$  and 3 moles of  $H_2$  behaving as ideal gases.  
 (d) On passing 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.  
 **$4 + (1 + 2) + 3 + 2 = 12$**

**Group - C**

4. (a) Draw the molecular orbital energy level diagram of  $C_2$  molecule with electronic configuration and calculate the bond order.  
 (b) The bond angle in  $H_2O$  is  $104.5^\circ$  while it is  $92^\circ$  in  $H_2S$  – justify using VSEPR theory.  
 (c) Why is the first ionization potential of beryllium more than that of boron?  
 (d) Deduce the expression for pH of a solution containing salt of weak acid and weak base.  
 (e) Why does fumaric acid have a higher melting point than maleic acid?  
 **$3 + 2 + 2 + 4 + 1 = 12$**

5. (a) Draw the MO diagram for HF molecule and calculate the bond order.
- (b) In CH<sub>2</sub>F<sub>2</sub> molecule angle H-C-H is higher than angle F-C-F. Explain using Bent's rule.
- (c) Calculate the screening constant and effective nuclear charge experienced by a d-electron of Cu (29) using Slater rule.
- (d) Explain why the electronegativity of Ge is higher than Si, though the reverse is expected.
- (e) Do you expect the pH of pure water at 100°C to be less than 7 or more than 7? Explain your answer.
- (f) Why the solubility of AgCl (a sparingly soluble salt) further decreases when NaCl is present in solution?

$$3 + 2 + 2 + 2 + 2 + 1 = 12$$

### Group - D

6. (a) Derive 1<sup>st</sup> order rate equation in terms product concentration.
- (b) Consider the reaction, CH<sub>3</sub>COOC<sub>2</sub>H<sub>5</sub> + NaOH → CH<sub>3</sub>COOH + C<sub>2</sub>H<sub>5</sub>OH, which follows 2<sup>nd</sup> order kinetics. Calculate t<sub>1/2</sub> of the reaction. Given that 25% of the reaction is completed in 5 minutes.
- (c) Define ionic mobility. Ion conductance of Ag<sup>+</sup> and NO<sub>3</sub><sup>-</sup> are 53.9 and 61.84 mho cm<sup>2</sup>. Calculate the ionic mobilities and transport numbers of each ion.
- (d) What is the role of polymer electrolyte membrane in a H<sub>2</sub>-O<sub>2</sub> fuel cell? Express the anodic and cathodic reactions.

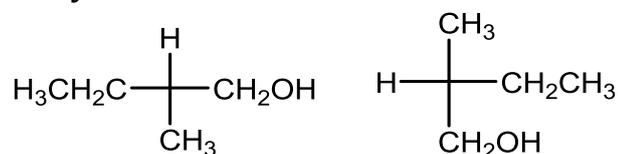
$$2 + 2 + (1 + 3) + (2 + 2) = 12$$

7. (a) What are the important criteria for collision theory in chemical transformation?
- (b) Write down the Arrhenius equation for the temperature dependence of specific rate and explain the terms used.
- (c) Give account of 'Relaxation effect' in ionic cloud theory that retards the speed of ions in solution.
- (d) Describe the Pb-acid storage cell with cell configuration and the charging discharging reaction.
- (e) Consider the cell, Cd/Cd<sup>2+</sup>//KCl/Hg<sub>2</sub>Cl<sub>2</sub>(s)-Hg  
Express the spontaneous cell reaction and find out free energy change for the reaction involved, under standard conditions.  
Given, E<sub>Cd</sub><sup>0</sup> = +0.402 V and E<sub>calomel</sub><sup>0</sup> = -0.268 V.

$$2 + 2 + 2 + 3 + 3 = 12$$

**Group - E**

8. (a) Identify the rotational axes with proper fold and write the total number of  $\sigma$  planes present in  $\text{NH}_3$  molecule.
- (b) Describe positional isomer with example.
- (c) Explain mechanistically how the acid-catalysed dehydration of 2-methyl butanol,  $[\text{CH}_3\text{CH}_2\text{C}(\text{OH})(\text{CH}_3)_2]$ , gives 2-methyl 1-butene  $[\text{CH}_3\text{CH}_2(\text{CH}_3)\text{C}=\text{CH}_2]$ , and 2-methyl 2-butene  $[\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)_2]$ . Which product is predominating and why?
- (d) Write down uses and side effects of oil of wintergreen.
- (e) Find out the absolute configuration of the each stereocentre of the following molecules and identify the relation between them.



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

9. (a) Briefly write down the synthetic route and uses of paracetamol.
- (b) Differentiate between  $\text{S}_\text{N}1$  and  $\text{S}_\text{N}2$  reactions.
- (c) Why does the orientation of HBr addition in presence of peroxide differ from that of the addition in absence of peroxide? Illustrate your answer mechanistically taking the substrate 2-methyl propene.
- (d) Why N,N-dimethylaniline is weak as a base than N,N-2,6-tetramethyl aniline?

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

Department & Section	Submission Link
BT	<a href="https://classroom.google.com/c/MjkwMTMwMTk4NjEy/a/Mzc0NDI3MDQzMTQ0/details">https://classroom.google.com/c/MjkwMTMwMTk4NjEy/a/Mzc0NDI3MDQzMTQ0/details</a>
CE - A	<a href="https://classroom.google.com/w/MzExOTI2ODQ5NDA2/tc/Mzc0NDI3MzgwNzUz">https://classroom.google.com/w/MzExOTI2ODQ5NDA2/tc/Mzc0NDI3MzgwNzUz</a>
CE - B	<a href="https://classroom.google.com/c/MzExOTAwMjQ1MDAx/a/Mzc0NDMwMTM5MzIy/details">https://classroom.google.com/c/MzExOTAwMjQ1MDAx/a/Mzc0NDMwMTM5MzIy/details</a>
CHE	<a href="https://classroom.google.com/w/MzQ0MjEzMzA4NjEz/tc/Mzc0NDUyNTg3Nzc0">https://classroom.google.com/w/MzQ0MjEzMzA4NjEz/tc/Mzc0NDUyNTg3Nzc0</a>
EE	<a href="https://classroom.google.com/w/MzEyNTE3OTcxNjE1/tc/MzcxODUzMDg5ODQ3">https://classroom.google.com/w/MzEyNTE3OTcxNjE1/tc/MzcxODUzMDg5ODQ3</a>
ME - A	<a href="https://classroom.google.com/c/MzExOTAwMjQ1MDE2/a/Mzc0NDI3MTM0MDIw/details">https://classroom.google.com/c/MzExOTAwMjQ1MDE2/a/Mzc0NDI3MTM0MDIw/details</a>
ME - B	<a href="https://classroom.google.com/c/MzEyNDI2MTQ4NzA5/a/Mzc0Mzc0NjQ3MDAz/details">https://classroom.google.com/c/MzEyNDI2MTQ4NzA5/a/Mzc0Mzc0NjQ3MDAz/details</a>
BACKLOG	<a href="https://classroom.google.com/c/Mzc0MzQ5MDQ3NTA3?cjc=6ghfxnq">https://classroom.google.com/c/Mzc0MzQ5MDQ3NTA3?cjc=6ghfxnq</a>