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)   Which statement is not correct regarding reversible process?
            (a) it is an imaginary process
            (b) it takes infinite time for completion
            (c) work obtained is maximum
            (d) it is spontaneous.

   (ii)   The Clausius inequality is expressed as
            (a) $dS > \frac{dq}{T}$ (b) $dS \geq \frac{dq}{T}$
            (c) $dS < \frac{dq}{T}$ (d) $dS \leq \frac{dq}{T}$

   (iii)   Which type of radiation has the highest energy?
            (a) UV   (b) IR
            (c) Microwave   (d) X-ray

   (iv)   Identify the correct answer:
            Nafion membrane is used in H_2-O_2 fuel cell as
            (a) Semipermeable gas diffusion membrane
            (b) Proton exchange membrane
            (c) Hydrophobic membrane
            (d) Anion exchange membrane

   (v)   Identify the correct answer
            Corrosion of an iron rod (rusting) exposed to atmosphere is
            (a) Oxidation reaction   (b) Reduction reaction
            (c) Precipitation reaction   (d) None of the above

   (vi)   Identify the incorrect answer:

(a) A catalyst remains unchanged in chemical composition during the course of reaction.
(b) A catalyst lowers the activation energy of a reaction.
(c) A catalyst raises the activation energy of a reaction.
(d) A catalyst is more effective when finely divided than in coarse state.

(vii) Which of the following statements best explains why the normal melting point of ICl (27.2°C) is much higher than that of Br_2(-7.2°C)
(a) Iodine in ICl is more electronegative than bromine in Br_2
(b) The ICl molecules have a lower molecular weight
(c) The ICl molecules are more polar
(d) The ICl molecules undergo hydrogen bonding

(viii) The boiling point of neo pentane is less than that of n-pentane due to
(a) H-bond   (b) ion-dipole interaction
(c) London dispersion force   (d) dipole-dipole interaction

(ix) Consider the following bromides.

I

II
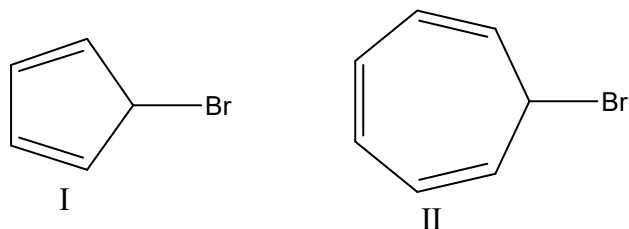
(a) Both decomposes to form Br-
(b) Both decomposes to form Br+
(c) I decomposes to form Br+ and II decomposes to form Br-
(d) I decomposes to form Br- and II decompose to form Br+

(x) Identify the chiral molecule among the following
(a) 3-pentanol   (b) 2-pentanol   (c) 1-pentanol   (d) Ethanol

Group- B

2. (a) Derive the expression for the efficiency of a Carnot engine. [(CO4)(LOCQ)]
   (b) 2 moles of an ideal gas expands reversibly and isothermally from a volume of 2 liters to 20 liters at 300K. Calculate ΔS. [Given, R = 8.314 J/K/mol] [(CO4)(HOCQ)]
   (c) The Kinetic energy of an electron is 4.55×10^{-25} J. The mass of electron is 9.1×10^{-31} kg. Calculate velocity, momentum and the wavelength of the electron. (h = 6.625×10^{-34} J) [(CO4)(HOCQ)]
   (d) What is meant by a hypsochromic shift? Mention two applications of UV-Vis Spectroscopy. [(CO5) (IOCQ)]

$$4 + 3 + 3 + (1 + 1) = 12$$

3. (a) Explain what is meant by chemical potential? Derive the Gibbs Duhem Equation. [(CO4)(LOCQ)]
   (b) Write the two statements of the Second law of thermodynamics. [(CO4)(LOCQ)]

(c) What is the de Broglie Hypothesis? [(CO5)(LOCQ)]

(d) Write without derivation the expression for the wave function and the energy of a particle in a one dimensional box. [(CO4)(IOCQ)]

(e) What are the objectives of IR spectroscopy? Why does CO_2 absorb in the IR region? [(CO5)(IOCQ)]

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

Group - C

4. (a) Draw the molecular orbital energy level diagram of HF molecule and explain its dipolar character using MOT. [(CO2)(IOCQ)]

(b) What is meant by a buffer solution? Calculate the pH of a buffer solution containing a mixture of 0.1 (M) NH_4Cl and 0.3 (M) of NH_4OH solution. Given pK_b of NH_4OH 4.74. [(CO2)(HOCQ)]

(c) The first ionization energy of elements increases from left to right in a given period of the periodic table but Be (IE = 899 KJ mol^{-1}) has higher ionization energy than B (IE = 801 KJ mol^{-1}) – Explain.   [(CO2)(HOCQ)]

(d) Explain the inert pair effect taking one example. [(CO2)(LOCQ)]

(e) Predict the shape and hybridization of ClF_3. [(CO2)(LOCQ)]

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

5. (a) Evaluate the Slater's Z^* for 4S electron of K (19) and Cu (29). Predict about the ionisation energies of the respective electrons. [(CO2)(HOCQ)]

(b) Draw and explain the structure of SOF_4 molecule and indicate the state of hybridization of the central atom. Why CCl_4 behaves as non-polar molecule though individual C-Cl bond has dipole moment? [(CO2)(LOCQ)]

(c) Explain why -The first ionisation potentials of the coinage metals follow the order Ag< Cu< Au. [(CO2)(IOCQ)]

(d) Calculate pH of a mixture of 164 ml (N/10) acetic acid and 36 ml of (N/10) sodium acetate. The dissociation constant of acetic acid is 1.8×10^{-5}. [(CO3)(HOCQ)]

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

Group - D

6. (a) The thermal decomposition of N_2O_5 is a 1st order reaction. Calculate the specific reaction rate (k) at 100^oC if the half life period for the decomposition is 4.6 second. [(CO1)(HOCQ)]

(b) Give brief account of the asymmetric effect of ion-atmosphere under applied potential?   [(CO1)(LOCQ)]

(c) Define Galvanic cells. What are Primary and Secondary batteries? Give examples. [(CO1)(LOCQ)]

(d) Give a schematic of H_2-O_2 (PEM) fuel cell. [(CO1)(IOCQ)]

(e) Calculate ionic conductance and mobility of Ag^+ and NO_3^- ions. Given that at $18°C$, $\lambda_{eq}(AgNO_3)$ = 115.8 mho cm^2 and $t_+(Ag^+)$ = 0.466. [(CO1)(HOCQ)]

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

7.   (a)   A cell is represented as Mg|Mg^{+2} (0.01M) || Sn^{+2}(0.1M) | Sn; write down the half cell reactions. Express the Nernst equation for the complete cell. If the E° for anodic and cathodic electrodes are 2.34 volts and - 0.138 volts, calculate the E$_{cell}$ at 25°C. [(CO1)(HOCQ)]

(b)   Define transport number and mobility (μ) of ions in solution. [(CO1)(IOCQ)]

(c)   Explain why $\mu_{H^+} \gg \mu_{Na^+}$ and $\mu_{Cs^+} > \mu_{Na^+}$
What are the electrodes and electrolyte components of a Pb-acid battery? Give the cell configuration and write down the charging-discharging reactions. [(CO1)(IOCQ)]

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

Group - E

8.   (a)   Which of the following pair is suitable for ether formation? Justify your answer.

   tBuO$^-$ Na$^+$ +   MeI $\longrightarrow$

   MeO$^-$ Na$^+$ +   tBuI $\longrightarrow$
   [(CO6)(IOCQ)]

(b)   Arrange the functional groups attached with the marked chiral centres according to their priority applying standard sub rules and determine the absolute configuration of these stereocenters.
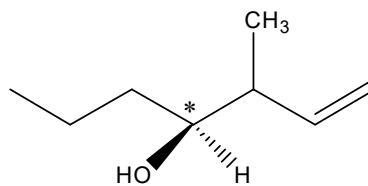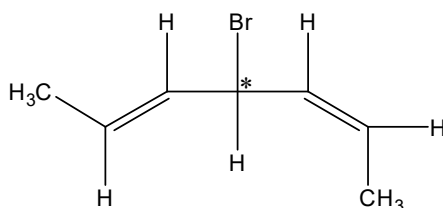
[(CO6)(IOCQ)]

(c)   Draw the geometrical isomers of 1, 2 dimethyl cyclohexane. [(CO6)(LOCQ)]

(d)   Which common functional group is present in sulpha-drugs? Exemplify one sulpha drug and write down itsuses. (CO6)(LOCQ)]

3 + 4 + 2 + 3 = 12

9.   (a)   Depict all the resonating structures of CH$_2$= CH-CHO and arrange them in the increasing order of stability. [(CO6)(LOCQ)]

(b)   Identify the major product on the dehydration of neopentyl alcohol [(CH$_3$)$_3$CH$_2$OH]. Explain mechanistically. [(CO6)(IOCQ)]

(c)   For a particular nucleophilic substitution reaction (S$_N$1) of tert-butyl bromide, it was found that, the rate of the reaction 3X10^4 times faster in 50% aqueous ethanol than 100% ethanol. Justify the observation. [(CO6)(IOCQ)]

(d)   How chain isomerism differs from position isomerism? [(CO6)(IOCQ)]

(e)   Analyze the reason for the more acidity of CHCl$_3$ than CHF$_3$. [(CO6)(IOCQ)]

3 + 3 + 2 + 2 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	32.3%	39.6%	28.1%

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

Department & Section	Submission Link
AEIE	https://classroom.google.com/c/NDA2ODUzODc0MDcy/a/NDc0ODM1OTU2MjAw/details
CSBS	https://classroom.google.com/c/NDE1MDQyMDM5NzU0/a/NDY3OTg5MjAzNjMx/details
CSE - A	https://classroom.google.com/c/NDEwMDA1NTQwOTE3/a/NDc0ODM0OTYwMDc5/details
CSE - B	https://classroom.google.com/c/NDEwMDA1NTQxMTg2/a/NDc0ODM1MDIxNjUw/details
CSE - C	https://classroom.google.com/c/NDE1MDQyMDM5Nzk5/a/MjI3ODkwOTYzMTQ5/details
ECE - A	https://classroom.google.com/c/NDA1MzQ0ODEyODIy/a/MjI3ODg4MTk2NjI2/details
ECE - B	https://classroom.google.com/c/NDA1MzQ0ODEyODky/a/MjI3ODg4MTk2NjI4/details
ECE - C	https://classroom.google.com/c/NDE2MDI5NTkxNzQy/a/NDc0ODQyODI4NTAy/details
IT	https://classroom.google.com/w/NDE2NzE1ODEwODMw/tc/MjI3OTMwNzk5MDM4