STELLA MARIS COLLEGE (AUTONOMOUS), CHENNAI - 600 086

(For candidates admitted from the academic year 2023 & thereafter)

SUBJECT CODE: 23CH/MC/GC 14

B.Sc. DEGREE EXAMINATION, NOVEMBER 2024

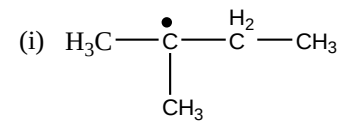
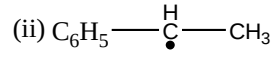
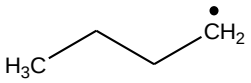
BRANCH IV – CHEMISTRY

FIRST SEMESTER

COURSE : MAJOR CORE
TITLE OF PAPER : GENERAL CHEMISTRY
DURATION : 3 HOURS **MAX. MARKS : 100**

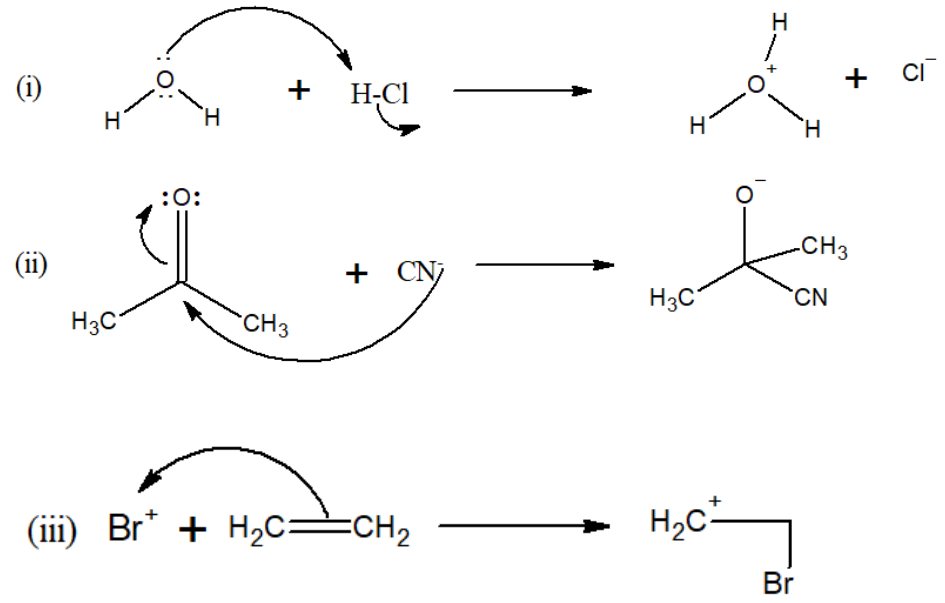
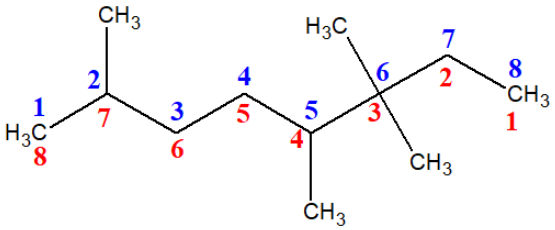
SCHEME

Q.No.	SECTION-A **MULTIPLE CHOICE QUESTIONS: (15 x 1 = 15 Marks)**	CO	KL
1.	The maximum number of electrons that can be accommodated in the third shell (M-shell) is _____ **a) 18**	CO1	K1
2.	The de Broglie wavelength is associated with _____ **b) all moving particles**	CO1	K1
3.	The mathematical expression for Heisenberg's uncertainty principle is **a)** $\Delta x . \Delta p \geq \frac{\hbar}{2}$	CO1	K1
4.	A normalized wave function satisfies the condition **(b) The integral of the square of the wave function over all space is one**	CO1	K1
5.	Which of the following pairs exhibit diagonal relationship in the periodic table? **b) Li and Mg**	CO1	K1

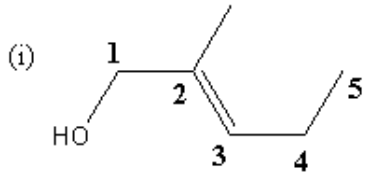
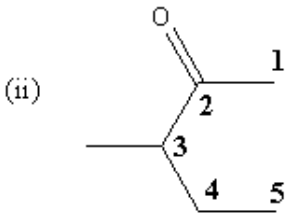
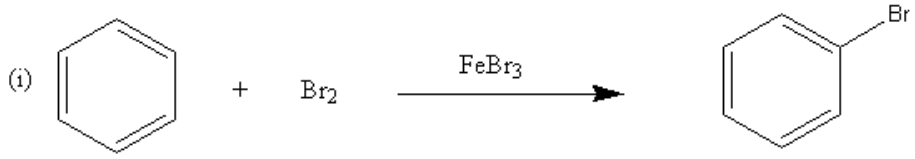
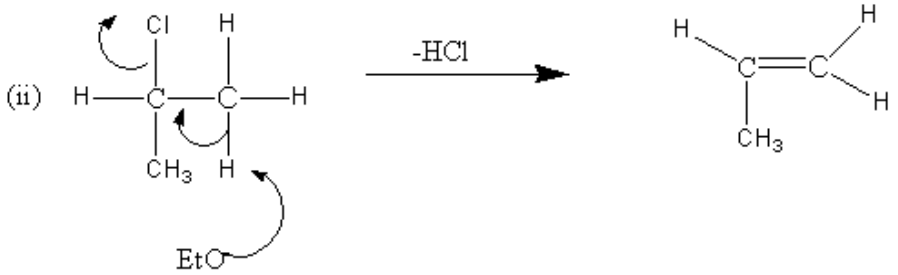
6.	Ionization energy generally increases across a period because: **c) Atomic size decreases and nuclear charge increases.**	CO1	K1
7.	A metal ion with low polarizability and high charge density is classified as **a) A hard acid**	CO1	K1
8.	_____ is an example of Lux Flood acid. **b) SO_3**	CO1	K1
9.	Which of the following is an electrophile? **c) NO_2^+**	CO1	K1
10.	_____ is an electrophilic substitution reaction **b) Bromination of benzene**	CO1	K1
11.	The cyclopropenyl cation is considered aromatic because it has **c) 2 π electrons**.	CO1	K1
12.	Which of the following is NOT true about the screening effect? **d) It remains constant as the atomic number increases in a period**	CO1	K1
13.	For a given principal quantum number n = 3, what are the possible values of the azimuthal quantum number (l)? **c) 0, 1, 2**	CO1	K1
14.	The prefix name of -$CONH_2$ is _____ **c) carbamoyal**		
14.	Identify the order of stability of the given intermediates. (i)  (ii)  (iii)  **d) (ii) > (i) > (iii)**	CO1	K1
	SECTION- B **FILL IN THE BLANKS: (5 x 1 = 5 Marks)**	**CO**	**KL**
16.	The energy required to remove an electron from an atom in its gaseous state is called **<u>ionisation energy</u>**	CO2	K2

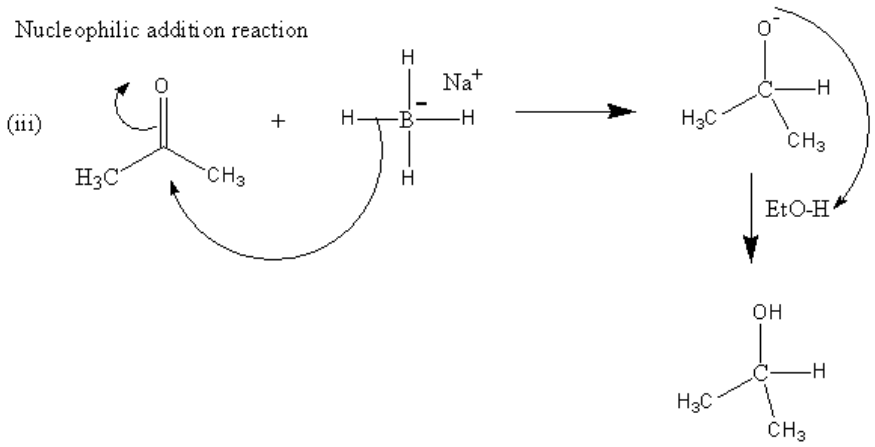
17.	An atom with atomic number 17 and mass number 35 will have **18** neutrons.	CO2	K2
18.	The time-independent Schrödinger equation is $\nabla^2\psi - \frac{2m}{\hbar^2}(E-V)\psi = 0$	CO2	K2
19.	The Compton shift depends on **the angle of scattering.**	CO2	K2
20.	The **inductive** effect involves the permanent shift of electron density through sigma bonds caused by differences in electronegativity.	CO2	K2
	MATCH THE FOLLOWING: (5 x 1 = 5 Marks)	**CO**	**KL**
21.	Ernest Rutherford A. Artificial radioactivity **(25)**	CO2	K2
22.	Thomson B. eigen values real **(23)**	CO2	K2
23.	Hermitian operator C. screening effect **(24)**	CO2	K2
24.	Slater rule D. plum pudding model **(22)**	CO2	K2
25.	Irène Joliot-Curie E. Nuclear Model **(21)**	CO2	K2
	ANSWER IN ONE OR TWO LINES: (5 x 1 = 5 Marks)	**CO**	**KL**
26.	What is hyperconjugation? It is a permanent effect in which localization of σ electrons of C-H bond of an alkyl group directly attached to an atom of the unsaturated system.	CO2	K2
27.	What are isobars? Atoms of different elements with different atomic numbers but have the same mass number.	CO2	K2
28.	What is photo electric effect? The **photoelectric effect** is a phenomenon in which electrons are ejected from the surface of a metal when light is incident on it.	CO2	K2
29.	What is tautomerism? A single chemical compound tends to exist in two or more interconvertible structures that are different in terms of the relative position of one atomic nucleus, which is generally hydrogen.	CO2	K2
30.	What is levelling effect?	CO2	K2

	It is the effect of solvent on the properties of acids and bases.		
	SECTION-C **Answer any SIX of the following: (6 x 5 = 30 Marks)**	**CO**	**KL**
31.	a) The explanation of Davisson-Germer experiment that confirms the wave nature of electrons. (3 Marks) b) Let's apply the operator $\hat{A} = d/dx$ to the function $\psi(x) = e^{kx}$ $\hat{A}(e^{kx}) = \frac{d}{dx} e^{kx} = k e^{kx}$ Since the result is proportional to e^{kx}, the function e^{kx} is an eigen function of the operator $\hat{A} = d/dx$, and the corresponding eigen value is k (2 Marks)	CO3	K3
32.	The general trends that are observed for atomic radii and ionization energy as you move down a group in the periodic table (2 ½ + 2 ½ Marks)	CO3	K3
33.	a) Iron-56 ($^{56}_{26}Fe$) has an atomic number (Z) of 26, meaning it has 26 protons. The mass number (A) is 56, which is the sum of protons and neutrons: $$A = p + n = 26 + n$$ $$n = A - p = 56 - 26 = 30$$ So, iron-56 has 30 neutrons and 26 protons. $$\frac{n}{p} = \frac{30}{26} \approx 1.15$$ The n/p ratio of 1.15 indicates that $^{56}_{26}Fe$ is stable. (3 Marks) b) Any two applications of HSAB. (2 Marks)	CO3	K3
34.	**Cyclopentadienyl cation:** (i) Structure: It is cyclic, planar, and has a conjugated system (ii) π electrons: It has 4 π electrons, which is 4n where n=1 (iii) Hückel's rule: A compound is aromatic if it has (4n + 2)π electrons but the cyclopentadienyl cation has 4 π electrons. Therefore it is **Antiaromatic** **Cyclobutadiene:** (i) Structure: It is cyclic, planar, and has a conjugated system (ii) π electrons: It has 4 π electrons, which is 4n where n=1	CO3	K3

	(iii) Hückel's rule: A compound is aromatic if it has (4n + 2)π electrons but the cyclobutadiene has 4 π electrons, it does not obey Hückel's rule. Therefore it is **Antiaromatic** **Troplyium cation :** (i) Structure: It is cyclic, planar, and has a conjugated system (ii) π electrons: It has 6 π electrons, which is not 4n (iii) Hückel's rule: A compound is aromatic if it has (4n + 2)π electrons Tropliyum cation has 6 π electrons, it obeys Huckel's rule where n=1. Therefore it is **Aromatic**		
35.	a) The curved arrow notation for the following reactions: (3 x 1 = 3 marks)  b) Apply lowest sum rule and give the IUPAC name for the given compound: (2 marks)  Case 1: The Me groups are in the 2nd , 5th , two in 6th positions. Therefore the sum of the substituent positions = 2+5+6+6 = 19 Case 2: The Me groups are two in 3rd , 4th and 7th positions. Therefore the sum of the substituent positions = 3+3+4+7 = 17	CO3	K3

	In above two cases the sum of the positions of the substituents is found to be minimum in Case 2. **(1 ½ Marks)** Therefore the IUPAC name of the given compound is 3,3,4,7- tetradimethyl octane. **(1/2 Marks)**		
36.	Five postulates of quantum mechanics. **(Each 1 Mark)**	CO3	K3
37.	The stability of carbocations. **(1 Mark)** Factors influence their stability **(3 Marks)** Examples of primary, secondary, and tertiary carbocations. **(1 Mark)**	CO3	K3
	SECTION-D **Answer any FOUR of the following : (4 x 5 = 20 Marks)**	**CO**	**KL**
38.	a) Calculate the mass defect and binding energy for U-235. One U-235 atom has a mass of 235.043924 amu. (3 Marks) **Solution:** **Step 1: Calculate the mass defect (2 Marks)** $\Delta m = [Z(m_p + m_e) + (A - Z)m_n] - m_{atom}$ $\Delta m = [92(1.007826\ \text{amu}) + (235 - 92)1.008665\ \text{amu}]$ $-235.043924\ \text{amu}$ $\Delta m = 1.91517\ \text{amu}$ **Step 2: Use the mass defect to calculate the BE (1 Mark)** $\text{BE} = \Delta m \left(\frac{931.5\ \text{MeV}}{1\ \text{amu}}\right)$ $\text{BE} = 1.91517\ \text{amu} \left(\frac{931.5\ \text{MeV}}{1\ \text{amu}}\right)$ $= 1784\ \text{MeV}$ If only the formula is written correctly then 1 Mark can be given. b) Correct statement for Compton effect **(2 Marks)**	CO4	K4
39.	The trend in electronegativity across the p-block elements **(2 Marks)** Its affect towards their reactivity **(3 Marks)**	CO4	K4
40.	Discussion on the shape and characteristics of d orbitals **(2 Marks)** The number of d orbitals for a given principal quantum number, and are their shapes **(3 Marks)**	CO4	K4
41.	**a) Write the structural formulae for the following : (2 x 1 = 2 Marks)**	**CO4**	**K4**

	 2-Methyl-2-penten-1-ol  3-Methylpentan-2-one **b)** Any three differences between inductive and electromeric effect. **(3 Marks)**		
42.	Soddy's radioactive displacement law. **(2 Marks)** Explaining the changes in atomic and mass numbers during alpha and beta decays **(3 Marks)**	CO4	K4
	SECTION – E **Answer any TWO of the following : (2 x 10 = 20 Marks)**	**CO**	**KL**
43.	a. Predict the product and identify the name for the following reactions: (3 x 2 = 6 Marks) Aromatic electrophilic substitution reaction  Elimination reaction 	CO5	K5



b. For analysing the radioactive disintegration of 4n and 4n+1 series. (Each 2 Marks)

(OR)

a) Geiger–Nuttall rule **(2 Marks)**
Relating the decay constant of alpha-emitting elements to the energy of the emitted alpha particles **(5 Marks)**

b) Determine the Effective Nuclear Charge for a 1s Electron in Lithium (Li). Atomic number of Li is 3 **(3 Marks)**

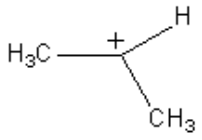
- Atomic Number $Z = 3$
- Electron Configuration: $\text{Li} : 1s^2 2s^1$

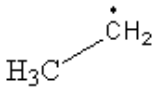
Step 1: Identify the relevant electrons for shielding.

- The relevant electron is the 1s electron.
- Electrons in the same group (1s): 1 other 1s electron.
- Electrons in the $n = 2$ shell (2s): 1 electron.

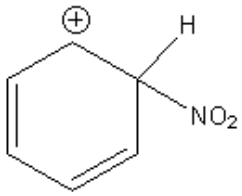
	Step 2: Apply Slater's rules to calculate the shielding constant S:
	• **1s electrons:**
	  • Other 1s electron contributes 0.35.
	$$S_{1s} = 0.35$$
	• **2s electron:**
	  • Contributes 0.00 since it is in a higher shell.
	$$S_{2s} = 0$$
	Total Shielding Constant S:
	$$S = 0.35 + 0 = 0.35$$
	Step 3: Calculate Z_{eff}:
	$$Z_{\text{eff}} = Z - S = 3 - 0.35 = 2.65$$
	Answer: The effective nuclear charge for a 1s electron in lithium is **2.65**.		

44.	a) Bohr's theory and explaining the line spectrum of hydrogen. **(2+5 Marks)** b) Polar protic solvent **(1 Mark)** Effect of protic solvent in acid- base strength **(2 Marks)** **(OR)** a) Identify the missing species and type of nuclear reactions in the following: **(3 x 2 = 6 Marks)** (i) $^{11}_{6}C \rightarrow \underline{^{11}_{7}N} + {}^{0}_{+1}e + \nu$ (positron emission) (ii) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$ (alpha emission) (iii) $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$ (neutrino emission) b) Evaluate the intermediates formed in the given reactions: **(4 x1 = 4 Marks)**	CO5	K5

(i)  secondary cation intermediate

(ii)  primary free radical intermediate

(iii)  Phenyl carbanion intermediate

(iv)  Phenyl carbocation intermediate