

Total number of printed pages-8

4 SEM PG CHM (CBCS) IC-V 402

2025

(June)

CHEMISTRY

Paper : 402 (C)

(Inorganic Chemistry-V)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

UNIT-I

Marks : 08

1. Answer **any four** from the following :

4×2=8

- (a) What are the different forces operating inside the nucleus of an atom ? Write down the origin of the nuclear forces.

- (b) Define the term binding energy per nucleon. How does binding energy per nucleon vary with mass number ?
- (c) How does N/P ratio of a nucleus get stabilized ? Give examples.
- (d) What is meant by a chain reaction in nuclear fission ?
- (e) Discuss the various factors affecting nuclear stability.
- (f) What is Neutron Activation Analysis ? Explain.

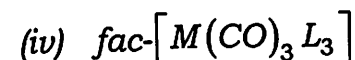
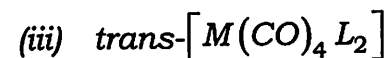
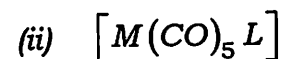
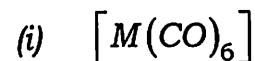
UNIT-II

Marks : 12

2. Answer **any four** from the following :
3×4=12

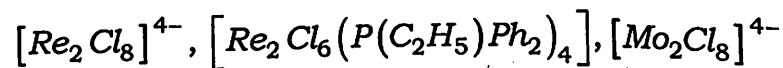
- (a) Briefly explain three factors affecting the magnitude of C-O stretching frequency in carbonyl clusters. Give examples. 3
- (b) Write a brief note on tensor surface harmonic theory of clusters. 3

- (c) Find out the number of C-O stretching bands of the following complexes in the IR spectrum. Give reasons : (any three) 1+1+1=3



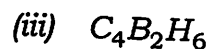
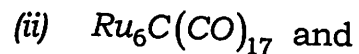
- (d) With an example, explain the structure and bonding of a binuclear cluster. 3

- (e) What are clusters ? Find out the bond order in the following binuclear clusters : (any two)



1+2=3

- (f) Give a method for preparation for carborane. Applying Wades rules predict the structure of the following:
(any two) 1+2=3



- (g) Give a method for preparation for fullerene. Discuss the various chemical reactions of fullerene. 1+2=3

UNIT-III

Marks : 06

3. (a) Illustrate the importance of molecular recognition in life processes. Write the role of supramolecular chemistry in the field of nanotechnology. 2+2=4

Or

Explain the "Host-Guest" concept of molecular recognition with examples. 4

- (b) Define chiral recognition. 2

Or

Comment on the selectivity of cryptands and crown ethers for alkali metals.

UNIT-IV (A)

Marks : 18

4. Explain the structural and functional properties of intercalated compounds with specific reference to graphite. How does this method differ from immobilization ? 3+1=4

5. What is a solid electrolyte ? How does it differ from a liquid electrolyte in terms of structure and ion mobility ? Give an example of a room temperature solid electrolyte and discuss its structure and conductivity. 1+2+2=5

Or

Write the general principle of solid-state reaction. What is coprecipitation ? Describe the steps involved in the sol-gel method for synthesizing inorganic solids. 2+1+2=5

6. Answer **any three** of the following questions : $3 \times 3 = 9$

(a) What are composites ? Discuss the applications of polymer matrix composite and carbon-car composite. $1+2=3$

(b) Define nucleation in the context of material science. Write the difference between homogeneous and heterogeneous nucleation mechanism with suitable examples. $1+2=3$

(c) What are phosphor materials ? How do activator ions contribute to their luminescence properties ? Give one example of a phosphor and its application. $1+1+1=3$

(d) What are the required properties of an autoclave used in the hydrothermal synthesis method ? Explain the pressure-temperature relationship with volume in this method. $1+2=3$

(e) Write a brief discussion on drilling muds. 3

UNI-IV (B)

Marks : 16

7. What are plasmons ? Explain with suitable example the roles of dielectric medium in surface plasmon resonance (SPR) technique. Out of S-and P-polarized light which one is important here and why ? $1+2+1=4$

8. Answer **any four** of the following questions : $3 \times 4 = 12$

(a) Write application of various solid materials in fuel cell and photovoltaic cell.

(b) Write a brief discussion on important properties and applications of nanoclusters and nanotubes.

(c) What is photo-catalysis ? Explain the role of semiconductor materials in photocatalysis. $1+2=3$

(d) What are energy bands in inorganic solid ? Compare and contrast the electronic and structural properties of graphite and graphene oxide. $1+2=3$

(e) What is meant by morphology-dependent properties ? Give examples highlighting their relevance in nanomaterials. $1+2=3$

- (f) What are the basic characterization techniques used to study structural purity and morphology of nanoparticles? Briefly explain *any two*.
- (g) What are surfactants? How does surfactant control the morphology of a nanoparticle? 1+2=3
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4 SEM PG CHM (CBCS) OC-V 404

2025

(June)

CHEMISTRY

Paper : 404 (C)

(Organic Chemistry-V)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer Unit-I and Unit-IV in one booklet and Unit-II and Unit-III in another.

UNIT-I

Marks : 15

1. Answer **any five** from the following : 3×5=15
- (a) Discuss any three types of interactions that occur between receptors and drug molecules with examples.

- (b) Discuss about phase-I and phase-II drug metabolism with example. Discuss the factors that affect drug metabolism? $1+1+1=3$
- (c) What are semisynthetic penicillins? Write about the mechanisms of antimicrobial actions of antibiotics. $1+2=3$
- (d) Write a short note on clinical trials.
- (e) Write briefly about drug absorption. Write the role of cell membrane in drug absorption. $2+1=3$
- (f) What are artemisinins? Give examples. Write the probable mechanism of actions of artemisinins. $1.5+1.5=3$
- (g) What are drug receptors? Explain G-protein coupled receptors. $1+2=3$
- (h) Write the synthesis of penicillin-I or chloramphenicol. Write briefly about structure activity relationship of penicillin. $2+1=3$
- (i) Write the synthesis and mechanism of action of chloroquine. $2+1=3$

UNIT-II

Marks : 15

2. Answer **any three** from the following questions: $2 \times 3 = 6$
- (a) "Enzymes are specific". Justify this statement using an example.
- (b) Based on the function of enzymes, describe *any two* classes of enzymes with example.
- (c) Mention few functions of ATP.
- (d) Write about the Watson and Crick double helix model of DNA.
3. Answer **any three** from the following : $3 \times 3 = 9$
- (a) Detail the mechanism of action of chymotrypsin.
- (b) Elaborate the process of biosynthesis of proteins.
- (c) Draw the structure of NAD^+ . Also elaborate the mechanism of action of NAD^+ and NADP^+ . $1+2=3$
- (d) Write a note on PCR demonstrating the temperature cycle of a typical PCR.

- (e) Write a note on different factors that affect enzyme action.
- (f) Elucidate the difference between a co-enzyme, co-factor and prosthetic groups.

UNIT-III

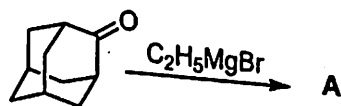
Marks : 15

4. Explain with a proper example and appropriate mechanism : **(any two)** $2 \times 2 = 4$

- (a) Suzuki coupling
 (b) Umpolung reaction
 (c) Tebbe Olefination

5. Answer **any four** from the following questions : $2 \times 4 = 8$

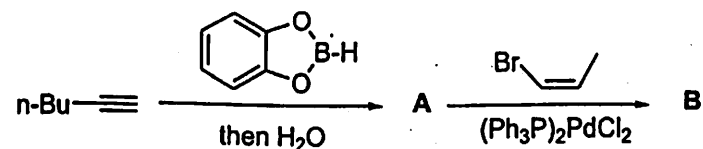
- (a) Predict the major product (A) of the following reaction and give a proper justification to it. Mention **two** drawbacks of Grignard reagent. $1 + 1 = 2$



C02F3 0008

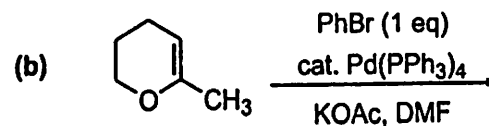
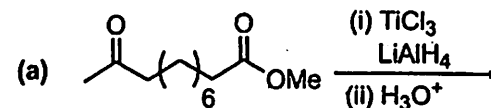
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- (b) What are stabilized and non-stabilized ylides ? Write their related isomeric product (*E* or *Z*) outcomes with proper justification and oxaphosphetane structure.
- (c) Horner-Wittig reaction with phosphine oxide can overcome the stereochemical outcome of Wittig reaction. Justify this statement citing proper example.
- (d) Predict the product (A) and (B) for the reaction below :



- (e) "The Peterson reaction is stereospecific". Write down the reaction conditions to obtain this stereospecificity.

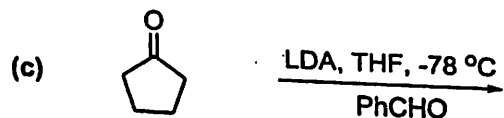
6. Write the major product/reagents for the following reactions : $1 \times 3 = 3$



C02F3 0008

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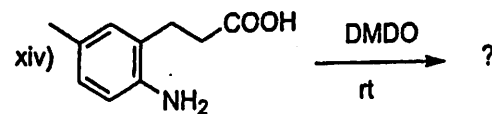
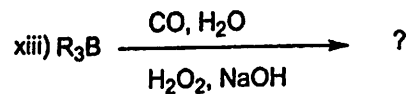
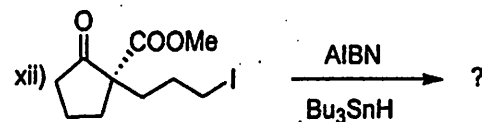
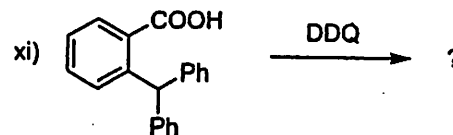
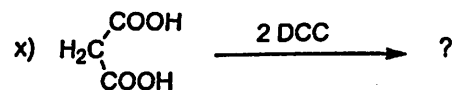
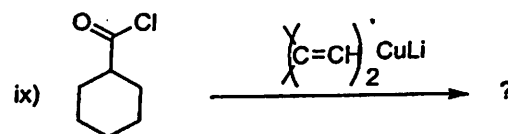
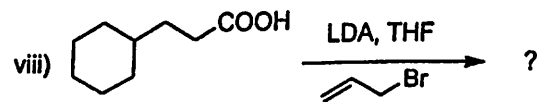
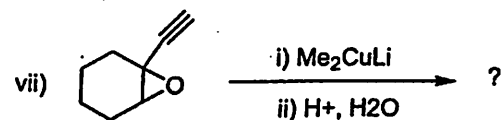
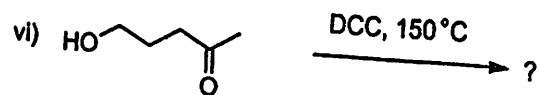
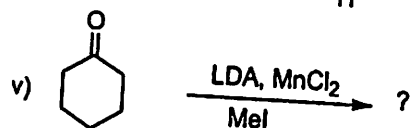
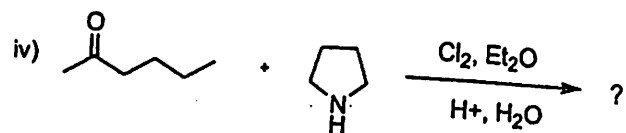
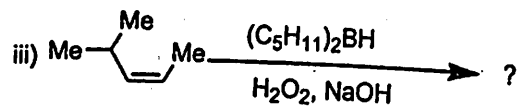
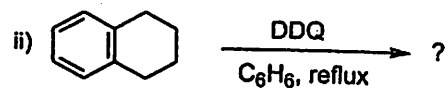
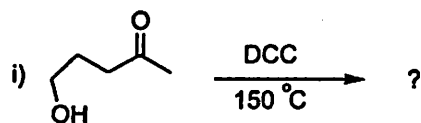
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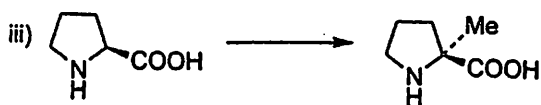
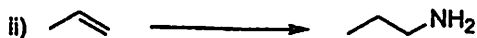
UNIT-IV

Marks : 15

7. Write the products of the following reactions :
(any ten) $1 \times 10 = 10$



8. Write the reagents and suggest probable mechanism for the following conversions :
(any two) 2×2=4



9. Write the synthesis of DDQ and DCC.
0.5+0.5=1
-

Total number of printed pages-7

4 SEM PG CHM (CBCS) PC-V 406

2025

(June)

CHEMISTRY

Paper : 406 (C)

(Physical Chemistry-V)

Full Marks : 60

Time : Three hours

***The figures in the margin indicate
full marks for the questions.***

Use separate booklets for UNIT-I and UNIT-II

UNIT-I

(Advanced Quantum Chemistry)

Marks : 30

1. What are basis vectors ? 1

2. What is meant by "Computational Chemistry" ? 1

3. What is a Hartree product ? 1

4. Answer **any four** questions : 3×4=12

(a) What is a Slater determinant ? How does the Slater determinant take care of the antisymmetry principle ?

(b) Derive an expression for the *one*-electron and *two*-electron integrals.

(c) Name and prove the theorem that relates the vertical ionization energy to the orbital energy in a molecule.

(d) What are Coulomb and Exchange operators ? Which of these is a local and a *non-local* operator ? 2+1=3

(e) Show that the sum of orbital energies is not equal to the total energy.

(f) Show that the general matrix element of the fock operator has the form

$$\langle \chi_i | f | \chi_j \rangle = \langle i | h | j \rangle + \sum_b \langle ib || jb \rangle$$

Answer **any three** questions : 5×3=15

5. (a) What are the coordinate representations of a molecule ? Demonstrate one representation by taking an example of a SO₂ molecule. 3

(b) What kinds of stationary points are of interest to chemists, and how do they differ ? 2

6. Write an expression for the closed-shell Fock operator ($f(r_1)$) in terms of the permutation operator \hat{P}_{12} . Use that expression to show that (where $P_{\lambda\sigma}$ is the density matrix)

$$f(r_1) = h(r_1) + \frac{1}{2} \sum_{\lambda\sigma} P_{\lambda\sigma} \left[\int dr_2 \phi_\sigma^*(r_2) (2 - \hat{P}_{12}) r_{12}^{-1} \phi_\lambda(r_2) \right]$$

2+3=5

7. What are the Roothaan equations ? How can it be solved ? 5
8. What are spin orbitals ? Derive the closed-shell expression for the orbital energy of spin orbitals. 1+4=5
9. Define an electron density. What is Density Functional Theory, and what are its advantages ? 2+3=5

UNIT-II

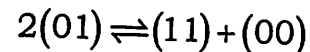
(Advanced Statistical Mechanics)

Marks : 30

10. Answer **any three** of the following questions : 4×3=12
- (a) Derive the Maxwell-Boltzmann velocity distribution.
- (b) For a one dimensional lattice gas prove that

$$\frac{(\theta - \alpha)(1 - \theta - \alpha)}{\alpha^2} = e^{-w/k_B T}$$

- (c) Derive the Langmuir isotherm and prove the symmetry property $y(\theta)y(1-\theta)=1$ from the following equilibrium



- (d) For a one component imperfect gas prove that, $3!Vb_3 = Z_3 - 3Z_1Z_2 + 2Z_1^3$.
- (e) Discuss in detail the technique of truncation of interaction in molecular simulations.

11. Briefly discuss **any three** of the following : 3×3=9

- (a) Periodic Boundary Condition
- (b) Random number generators
- (c) Importance Sampling
- (d) Andersen Thermostat

12. Answer **any three** of the following questions : 3×3=9

- (a) Find the expression of $B_2(T)$ for a one component classical monoatomic gas using Lennard Jones potential.
- (b) For one-dimensional harmonic oscillator show that the area of phase space per quantum state in h .
- (c) What is Mayer f-function ? Draw all possible cluster diagrams for 3 particles, also indicate the corresponding cluster integrals. 1+2=3
- (d) Discuss one algorithm to integrate the equations of motion in Molecular Dynamics simulation.

(e) Discuss the benefits of using reduced units in a computer simulation. For a Lennard Jones Argon system

(given : $\frac{\epsilon}{k_B} = 119.8K$) if the reduced

temperature $T^* = 2$, what is the real temperature of the system ? 2+1=3
