

2026

CHEMISTRY

(Major)

Paper : CHE0600104

(Inorganic Chemistry—III)

Full Marks : 45

Time : 2 hours

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

1. Answer the following in short : 1×5=5

(a) State True or False :

Metal-halogen bonds are more labile than metal-nitrogen bonds.

(b) Give one example of a Fischer carbene complex.

(c) The rate of water exchange for $[\text{Mo}(\text{H}_2\text{O})_6]^{3+}$ is very slow. Why?

(d) Draw the active site structure of Fe_2S_2 ferridoxin.

(e) What is the role of CuCl_2 in Wacker process?

2. Answer any *five* of the following questions :

2×5=10

- (a) The second-order rate constants for formation of $[VX(OH_2)_5]^+$ from $[V(OH_2)_6]^{2+}$ and X^- for $X^- = Cl^-$, NCS^- and N_3^- are in the ratio 1:2:10. What do the data suggest about the rate-determining step for the substitution reaction?
- (b) If a substitution process is associative, why may it be difficult to characterize an aqua ion as labile or inert?
- (c) Nickel complexes are observed to undergo substitution much faster than platinum complexes. Offer an explanation.
- (d) Predict the products of the following reactions :
 - (i) $[Pt(CO)Cl_3]^- + NH_3 \longrightarrow$
 - (ii) $[Pt(NH_3)Br_3]^- + NH_3 \longrightarrow$
- (e) Explain why ferrocene is more reactive than benzene towards electrophilic aromatic substitution.

- (f) State the primary requirement for a metal-alkyl complex to undergo β -hydride elimination and draw the structure of the resulting products.
- (g) Distinguish between Fischer and Schrock carbenes based on the oxidation state of the metal and the nature of the carbene carbon.
- (h) What is chelation therapy? Name one chelating agent used in metal poisoning.
- (i) What is the role of ATP in active transport? Give one example of an active transport system.
- (j) What is the biological role of magnesium, and what happens when is it deficient?

3. Answer any *four* of the following questions :

5×4=20

- (a) (i) Octahedral complexes of metal centres with high oxidation numbers or of d metals of the second and third series are less labile than those of low oxidation number and d metals of the first series of block. Account for this observation on the basis of a dissociative rate determining step. 3

(ii) The ligand exchange in $[\text{Fe}(\text{phen})_3]^{3+}$ and in $[\text{Fe}(\text{bpy})_3]^{2+}$ is much slower than the transfer of an electron from the bipyridine complex to the phenanthroline complex. Why does this rule out an inner sphere mechanism for the electron transfer?

2

(b) A Pt(II) complex of tetramethyldiethylenetriamine is attacked by Cl^- 10^5 times less rapidly than the diethylenetriamine analogue. Explain this observation in terms of an associative rate-determining step.

(c) The rate of loss of chlorobenzene, PhCl , from $[\text{W}(\text{CO})_4\text{L}(\text{PhCl})]$ increases with increase in the cone angle of L . What does this observation suggest about the mechanism?

(d) Describe the complete catalytic cycle for the hydrogenation of alkenes using Wilkinson's catalyst $[\text{RhCl}(\text{PPh}_3)_3]$. Include the specific roles of oxidative addition and reductive elimination steps in the mechanism.

(e) Discuss the Monsanto acetic acid process for the production of acetic acid. Provide the chemical equations for the catalytic cycle and explain the role of the iodide promoter.

(f) Explain the Dewar-Chatt-Duncanson model for the bonding of ethylene to a transition metal. Use diagrams to illustrate σ -donation and π -back-bonding, and describe how this affects the C—C bond length.

(g) Discuss the mode of action of *cis*-platin as anticancer drug.

(h) Discuss about the structure and function of haemoglobin.

4. Answer any one of the following questions : 10

- (a) (i) Design two-step syntheses of *cis*- and *trans*- $[\text{PtCl}_2(\text{NO}_2)(\text{NH}_3)]^-$ starting from $[\text{PtCl}_4]^{2-}$. 5
- (ii) What is synthetic gasoline? Discuss the Fischer-Tropsch process for preparing synthetic gasoline. 1+4=5

(6)

(b) How does each of the following modifications affect the rate of a square-planar complex substitution reaction?

(i) Changing a *trans* ligand from H to Cl

(ii) Changing the leaving group from Cl to I

(iii) Adding a bulky substituent to a *cis* ligand

(iv) Increasing the positive charge on the complex 10

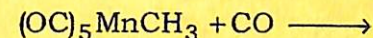
(c) (i) Discuss the structure and function of carbonic anhydrase. 5

(ii) Define the term 'oxidative addition' in organometallic chemistry. Discuss its effect on the oxidation state, coordination number, and *d*-electron count of a transition metal complex. 1+4=5

(d) (i) Discuss about the classification and key component of the catalytic cycle of the nitrogenase enzyme. 5

(7)

(ii) Complete the following reaction :



What type of reaction is this?
Write down the mechanism of this reaction. 1+1+3=5

2026

CHEMISTRY

(Major)

Paper : CHE0600204

(Organic Chemistry III)

Full Marks : 45

Time : 2 hours

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

1. Answer all questions : 1×5=5

- (a) While preparing Grignard reagent, small amount of iodine is often used. Why?
- (b) Arrange the following dienes in order of increasing reactivity towards dienophiles in Diels-Alder reaction :

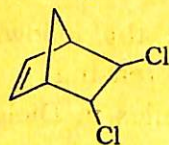


- (c) Between Grignard reagent and organo-lithium compounds, which one is more basic?

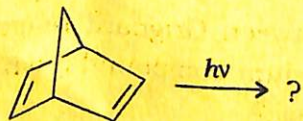
- (d) Write the name of the compound which acts as photosensitizer in photosynthesis.
- (e) What is inverse electron demand Diels-Alder reaction?

2. Answer any five questions : $2 \times 5 = 10$

- (a) Why is photochemistry of organic compounds often referred to as photochemistry of the triplet state?
- (b) What do you mean by optical pumping?
- (c) Write a reaction for the preparation of Frankland reagent.
- (d) How can you prepare unsolvated Grignard reagent?
- (e) The following compound has been prepared by Diels-Alder reaction. Identify the starting materials :



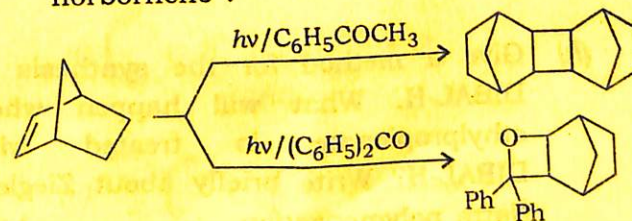
- (f) Give the product of the following reaction and classify the type of pericyclic reaction :



- (g) Suggest a reason for the greater stability of β - over α -naphthalene sulfonic acid.
- (h) Do both BH_3 and $\text{B}(\text{CH}_3)_3$ exist as a dimer? Give reasons.
- (i) What are degenerate Cope rearrangements?
- (j) Draw the π -MOs of butadiene and identify the HOMO and LUMO in the ground state.

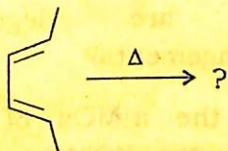
3. Answer any four questions : $5 \times 4 = 20$

- (a) Gas phase irradiation of 2-pentanone produces acetone and ethylene in about 90% yield along with 10% of 1-methylcyclobutanol. Account for the formation of those three photochemical products.
- (b) Norbornene and acetophenone have a triplet excitation energy of 74 kcal/mol and benzophenone has one of 69 kcal/mol. Use those data to explain the course of the following reactions of norbornene :



(4)

- (c) Use FMO theory to explain whether [4+2]-cycloaddition is thermally allowed or not.
- (d) Predict the product in the following reaction :



Explain the stereochemistry of the product. 1+4=5

- (e) Why do both substitution and addition take place at the 9,10-positions of anthracene? Explain with the help of suitable examples.
- (f) Write the steps involved in the Haworth synthesis of naphthalene. Why this method cannot be extended for the synthesis of anthracene? 3+2=5
- (g) What is meant by Schlenk equilibrium? What will happen when ester of formic acid is treated with Grignard reagent? Write the steps involved in the reaction. 2+3=5
- (h) Give a method for the synthesis of DIBAL-H. What will happen when ethylpropionate is treated with DIBAL-H? Write briefly about Ziegler-Natta polymerization. 1+1+3=5

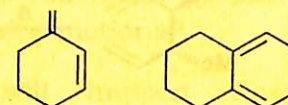
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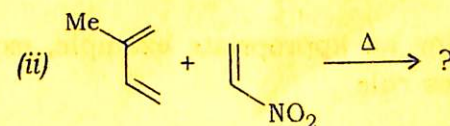
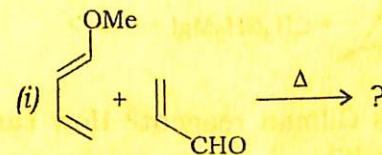
(5)

Answer any *one* question : 10

4. (a) State whether the following dienes is likely to participate in Diels-Alder reaction or not. Explain : 2



- (b) What are Cope rearrangements? Propose a mechanism for the Cope rearrangement. 3
- (c) Describe the structure of MeLi. 2
- (d) Suggest a reaction sequence for the photoreduction of benzophenone in the presence of 2-propanol. 3
5. (a) What is Paterno-Buchi reaction? Discuss the mechanism of the reaction. 1+3=4
- (b) Predict the major product in the following reactions : 1×2=2



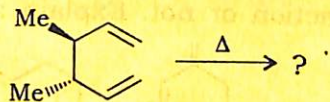
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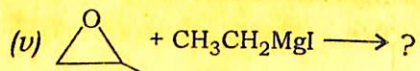
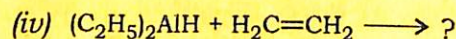
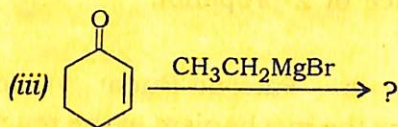
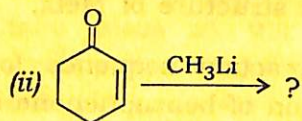
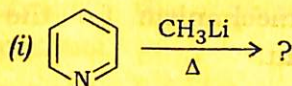
(6)

- (c) Give the product of the following reaction with correct stereochemistry and propose a mechanism to justify its formation :

4



6. (a) Complete the following reactions : 1×5=5



- (b) What is Gilman reagent? How can you prepare it?

1+1=2

- (c) Using an appropriate example, explain Fries rule.

3

26A/290

(Continued)

(7)

7. (a) How can you convert *p*-bromotoluene to *p*-toluic acid? Write the reactions involved.

2

- (b) What do you mean by conrotatory and disrotatory motions?

2

- (c) What will happen when 2-cyclohexenone is treated with lithium dimethylcuprate?

2

- (d) What is Norrish type I reaction? Write the mechanism.

1+3=4

26A-2500/290

1 (Sem-6/FYUGP) CHE 62 MJ

2026

CHEMISTRY

(Major)

Paper : CHE0600304

(Equilibria and Electrochemistry)

Full Marks : 45

Time : 2 hours

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

1. Answer the following as directed : 1×5=5

- (a) For a one-component system, the maximum number of phases that can exist in equilibrium is three.

(State True or False)

- (b) An aqueous solution of Na_2CO_3 is basic. Explain.

- (c) Under what conditions, pK_a is equal to the pH of solution?
- (d) How does equivalent conductance vary with dilution?
- (e) Nernst distribution law is used to
- (i) determine the extent of dissociation or association in a solvent
 - (ii) determine the solubility of a solute in a solvent
 - (iii) study equilibrium of reactions involving complex ions
 - (iv) All of the above

(Choose the correct answer)

2. Answer any *five* of the following questions :

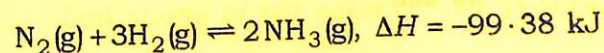
2×5=10

- (a) State the law of mass action. Derive the expression of equilibrium constant for a general reaction $aA + bB \rightleftharpoons mM + nN$.
- (b) State and explain the phase rule for a non-reactive system.
- (c) What is meant by azeotropic mixture? Explain why azeotropes are not considered as definite compounds.

- (d) The molar conductances at infinite dilution of NaOH, NaCl and $BaCl_2$ are $2.48 \times 10^{-2} \text{ Sm}^2 \text{ mol}^{-1}$, $1.27 \times 10^{-2} \text{ Sm}^2 \text{ mol}^{-1}$ and $2.8 \times 10^{-2} \text{ Sm}^2 \text{ mol}^{-1}$ respectively. Calculate the molar conductance of $Ba(OH)_2$ at infinite dilution.
- (e) Can there be a quadruple point on a phase diagram of a one-component system? Explain.
- (f) Explain the following :
- (i) Relaxation effect
 - (ii) Electrophoretic effect
- (g) Which out of silver and aluminium metal is capable of displacing H_2 when dipped in HCl? Given that—

$$E^\circ_{Ag^+/Ag} = +0.80 \text{ V and } E^\circ_{Al^{3+}/Al} = -1.66 \text{ V}$$

- (h) With the help of Le Chatelier's principle, work out the condition which would favour the formation of ammonia in the following reaction.



(4)

(i) In the precipitation of cations of group II of qualitative analysis, H_2S gas is passed through acidified solution of the salt by HCl . Explain using common-ion effect.

(j) State Nernst distribution law. Under what conditions is the law valid?

3. Answer any four of the following questions :

5×4=20

(a) Derive van't Hoff equation. Discuss the effect of temperature on K_p . 3+2=5

(b) Draw and interpret the phase diagram of water system.

(c) For a weak monobasic acid, show that the degree of ionization at a given temperature is inversely proportional to the square root of the initial concentration of the acid.

(d) What is buffer action? Derive the Henderson-Hasselbalch equation for a buffer mixture of weak acid and its salt. 1+4=5

(5)

(e) What is meant by electrochemical series? Can a solution of 1 M CuSO_4 solution be stored in a nickel metal vessel? Explain. Given that—

$$E^\circ_{\text{Ni}/\text{Ni}^{2+}} = +0.25 \text{ V and } E^\circ_{\text{Cu}/\text{Cu}^{2+}} = -0.34 \text{ V}$$

1+4=5

(f) Derive Gibbs - Duhem - Margules equation.

(g) What is ionic mobility? The H^+ ion, because of its heavy hydration and consequent large size should have low mobility, but the mobility of H^+ ion is very high. Explain. 1+4=5

(h) Explain how ionic product of water can be determined with the help of conductance measurement.

4. Answer any one of the following questions : 10

(a) (i) Define pH of a solution. Calculate the pH of a solution obtained by mixing 50 mL 0.2 mol dm^{-3} HCl solution with 50 mL 0.1 mol dm^{-3} NaOH solution at 298 K. Give the limitations of pH scale. 1+3+1=5

(6)

(ii) Calculate the solubility of Mg(OH)_2 in pure water at 298 K. Given, K_{sp} for Mg(OH)_2 at 298 K is 1.20×10^{-11} . 3

(iii) Explain the application of buffer solutions in qualitative analysis of salt sample. 2

(b) (i) Derive Clausius-Claypeyron equation for liquid-vapour equilibria. 5

(ii) What is eutectic point? Draw and explain the phase diagram of lead-silver system with a eutectic mixture of composition 2.6% of Ag. The melting points of silver, lead and the eutectic mixture are 961°C , 327°C and 303°C respectively. 1+4=5

(c) Derive the expressions for E_{cell} of an electrolyte concentration cell—

(i) with transference;

(ii) without transference.

What is the e.m.f. of a concentration cell consisting of two hydrogen electrodes represented as follows?

$\text{Pt, H}_2(5 \text{ atm}) | \text{HCl (aq)} | \text{H}_2(2.5 \text{ atm}), \text{Pt}$
8+2=10

(7)

(d) Discuss the principle of potentiometric titration for

(i) acid-base titration;

(ii) redox titration.

How would you titrate a solution of AgNO_3 against NaCl ? 7+3=10

2026

CHEMISTRY

(Major)

Paper : CHE0600404

(Industrial Chemistry)

Full Marks : 45

Time : 2 hours

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

1. Answer the following questions : 1×5=5

- (a) Which industrial gas is produced via Haber process?
- (b) Name the key raw material used in the contact process for sulphuric acid manufacture.
- (c) Which type of glass contains boron oxide (B_2O_3)?
- (d) What is the primary component of urea fertilizer?
- (e) Name one phase transfer catalyst commonly used in industry.

2. Answer any *five* of the following questions :

2×5=10

- (a) Mention one hazard associated with chlorine gas.
- (b) What is meant by glassy state?
- (c) Define quick setting cement.
- (d) Give one example of a non-ferrous alloy.
- (e) What is the role of fillers in paints?
- (f) State one application of hydrogen peroxide.
- (g) What is electroless plating?
- (h) Define catalyst deactivation.
- (i) What is superphosphate fertilizer?
- (j) Name one component used in firecracker composition.

3. Answer any *four* of the following questions :

5×4=20

- (a) Describe the large-scale production and storage hazards of hydrogen gas.
- (b) Explain the manufacture of nitric acid (Ostwald process).
- (c) Discuss the composition and properties of borosilicate glass.

- (d) Explain the manufacture and setting process of cement.
- (e) Describe the manufacture of urea fertilizer with reactions.
- (f) Discuss the formulation and components of paints.
- (g) Explain the properties and composition of stainless steel.
- (h) Describe the industrial applications of zeolite catalysts.

4. Answer any *one* of the following questions : 10

- (a) Discuss the industrial production, applications and hazards of any two major industrial gases.
- (b) Give a detailed account of the silicate industries, including glass manufacture, types and ceramic materials.
- (c) Explain the classification, manufacture and environmental impact of fertilizers.
- (d) Discuss surface coating in detail, including types of paints, pigments, and metallic coating techniques.
