

2019
(November)

CHEMISTRY
(Major)

Course : 101

(Physical, Inorganic and Organic)

The figures in the margin indicate full marks for the questions

Write the answers to the separate Sections in separate books

(New Course)

Full Marks : 80

Pass Marks : 24

Time : 3 hours

SECTION—A
(Physical Chemistry)

(Marks : 26)

1. Choose the correct answer from the following :

1×3=3

(a) Bravais lattices are of

- (i) 8 types
- (ii) 10 types
- (iii) 14 types
- (iv) 16 types

(b) Compressibility factor of an ideal gas is

- (i) 0
- (ii) 1
- (iii) infinity
- (iv) 0.9

(c) The shape of a drop of liquid is spherical due to

- (i) viscosity
- (ii) absorption
- (iii) conductivity
- (iv) surface tension

2. Answer any *three* questions from the following :

2×3=6

- (a) Write two differences between smectic and nematic liquid crystals.
- (b) What are crystalline and amorphous solids? Give one example of each.
- (c) Describe any two factors upon which the surface tension of a liquid depends.
- (d) Write the physical significances of van der Waals' constants a and b .
- (e) Prove that $P_c V_c = \frac{3}{8} RT_c$.

UNIT—I

3. Answer any *two* questions from the following :

3½×2=7

- (a) Write kinetic gas equation. From this equation, derive Boyle's law. 1+2½=3½
- (b) Derive reduced equation of states. Write its significance. 2½+1=3½
- (c) (i) Give the relationship among most probable, average and root mean square velocities. 2
- (ii) Calculate Boyle's temperature for carbon dioxide gas assuming it to be a real gas. ($a = 3.59 \text{ l}^2 \text{ atm mol}^{-2}$, $b = 0.0427 \text{ l mol}^{-1}$) 1½

UNIT—II

4. Answer any *one* question from the following : 3
- (a) Describe the method for determining the viscosity of a liquid in the laboratory. 3
- (b) What do you mean by vapour pressure of a liquid? Write any two factors upon which the vapour pressure of a liquid depends. Mention the SI unit of surface tension. 1+1+1=3

UNIT—III

5. Answer any *two* questions from the following : $3\frac{1}{2} \times 2 = 7$
- (a) What is unit cell? Calculate the number of atoms present in face-centered unit lattice and body-centered unit lattice. $\frac{1}{2} + (1\frac{1}{2} \times 2) = 3\frac{1}{2}$
- (b) (i) Derive Bragg's equation. $2\frac{1}{2}$
- (ii) Write the names of two methods by which the structure of a solid can be determined. 1
- (c) (i) At room temperature, sodium crystallizes in a body-centered cubic cell with edge length 4.24 Å. Calculate the density of sodium. (Atomic mass of sodium = 23 a.m.u.) $2\frac{1}{2}$
- (ii) What is F-centre? 1

SECTION—B

(Inorganic Chemistry)

(Marks : 27)

6. Choose the correct answer from the following : $1 \times 3 = 3$
- (a) The correct decreasing order of first ionization energy of five elements of second period is
- (i) $\text{Be} > \text{B} > \text{C} > \text{N} > \text{F}$
- (ii) $\text{N} > \text{F} > \text{C} > \text{B} > \text{Be}$
- (iii) $\text{F} > \text{N} > \text{C} > \text{Be} > \text{B}$
- (iv) $\text{N} > \text{F} > \text{B} > \text{C} > \text{Be}$

(b) The molecular geometry of SF₄ is

(i) T-shaped

(ii) seesaw

(iii) tetrahedral

(iv) square planar

(c) The bond order of C₂ molecule is

(i) 1

(ii) 2

(iii) 0

(iv) 3

7. Answer the following questions :

2×3=6

(a) The first ionization energy of C atom is greater than that of B, whereas the reverse is true for the second ionization energy. Explain.

(b) Discuss the favourable factors for the formation of ionic bond.

(c) NH₃ molecule is pyramidal but NH₄⁺ is tetrahedral though molecules involves sp³ hybridization. Explain.

8. Answer any two questions from the following :

3×2=6

(a) Define effective nuclear charge. Calculate the effective nuclear charge at the periphery of a Cu atom.

1+2=3

(b) Define electronegativity of an element. Calculate the electronegativity of N atom using Allred-Rochow equation. (Covalent radius of N = 0.74 Å)

1+2=3

(c) Define electron affinity. The first electron affinity of oxygen is 141 kJ mol⁻¹ while that the second electron affinity is -770 kJ mol⁻¹. Account for this.

3

9. Answer any three questions from the following :

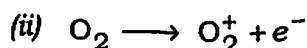
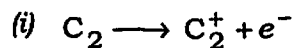
4×3=12

(a) What are the necessary conditions for the combination of atomic orbitals? Draw the molecular orbital energy level diagram for CO molecule and determine its bond order and magnetic behaviour.

2+2=4

(b) Define bond length and bond energy. What are the effects on bond order in the following ionization processes?

2+2=4



- (c) (i) Define lattice energy. Write the Born-Landé equation for the lattice energy of ionic crystal and indicate the each term of the equation. 2
- (ii) Calculate the enthalpy of formation of MgF_2 from the following data : 2
- Sublimation enthalpy of Mg = $146.4 \text{ kJ mol}^{-1}$
- Dissociation enthalpy of F = $158.8 \text{ kJ mol}^{-1}$
- Ionization enthalpy of Mg = $2186.0 \text{ kJ mol}^{-1}$
- Electron gain enthalpy of F = $-332.6 \text{ kJ mol}^{-1}$
- Lattice energy of $\text{MgF}_2 = -2922.5 \text{ kJ mol}^{-1}$
- (d) (i) Bond angles of NH_3 , PH_3 and AsH_3 are 107.5° , 93.2° and 91.5° respectively. How would you account for this? 2
- (ii) Write a note on partial ionic character in covalent bond. 2

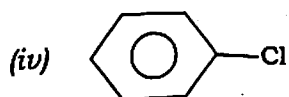
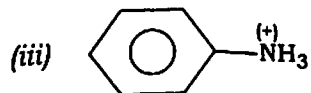
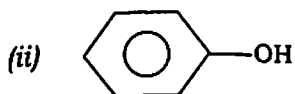
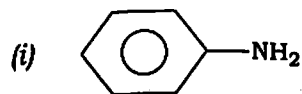
SECTION—C
(Organic Chemistry)

(Marks : 27)

10. Choose the correct answer from the following :

1×3=3

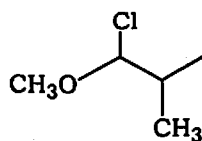
(a) In which of the following molecules resonance effect is not present?



(b) Which of the following compounds has the highest acidic strength?

- (i) *m*-nitrophenol
- (ii) Phenol
- (iii) *o*-nitrophenol
- (iv) *p*-nitrophenol

(c) The IUPAC name of the compound



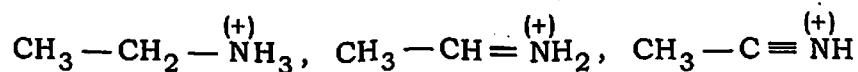
is

- (i) 3-chloro-3-methoxy-2-methylpropane
- (ii) 1-chloro-1-methoxy-2-methylpropane
- (iii) 3-chloro-2-methyl-3-methoxypropane
- (iv) None of the above

11. Answer any *three* questions from the following :

2×3=6

(a) Arrange the following compounds in order of increasing acidity with reasoning :

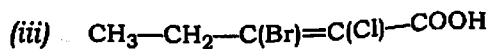
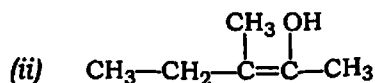
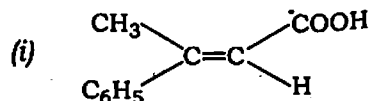


(b) The $\text{p}K_a$ value of phenol is 10 and that of cyclohexanol is 16. Explain this observation.

(c) Dipole moment of CHCl_3 is less than that of CH_2Cl_2 . Explain.

(d) Draw the Fischer projection of mesotartaric acid and convert it into Newman projection.

(e) Write down the *E* and *Z* nomenclature of the following compounds (any two) :



UNIT—I

12. Answer any *three* questions from the following :

2×3=6

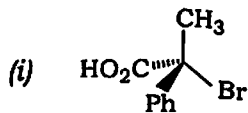
- Draw the energy profile diagram of a three-step exothermic reaction in which the first step is the rate determining step.
- What do you understand by the term 'resonance'? Write two conditions necessary for resonance.
- What are nitrenes? What happens when an alkylnitrene reacts with a carbon-carbon double bond?
- Discuss the structure of a carbocation or a carbanion.
- Explain why π -insertion of singlet carbene gives stereospecific addition product.

UNIT—II

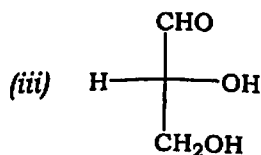
13. Answer any *six* questions from the following :

2×6=12

- Staggered conformation of *n*-butane is more stable than in eclipsed conformation. Explain with the help of their structures.
- Sketch the Newman projection of *meso*-2-3-butanediol.
- Assign *R* and *S* designation to the following compounds (any *two*) :



(ii) *D*-glyceraldehyde



- (d) What is Walden inversion? Give one example.
- (e) Draw the Fischer's projection formula of the following :
- (i) (R)-3-methylpentan-1-ol
 - (ii) (S)-2,3-dimethyl hexane
- (f) Draw the three stereoisomers of tartaric acid in Fischer's projection formula. Which of them are enantiomers and which one is the *meso* form?
- (g) Sketch the flying wedge and sawhorse projections of *trans*-2-butene.
- (h) What do you mean by the term 'racemization'? Active mandelic acid undergoes racemization when treated with NaOH. Give an explanation.

(Old Course)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

SECTION—A

(Physical Chemistry)

(Marks : 26)

1. Choose the correct answer from the following :

1×3=3

(a) Which of the following is a *p*-type semiconductor?

(i) Ge doped with As

(ii) Ge doped with Ga

(iii) Ge doped with P

(iv) All of the above

(b) The compressibility factor *Z* for ideal gas is

(i) 1

(ii) 0

(iii) >1

(iv) None of the above

(c) Which of the following liquids will have the lowest viscosity?

(i) Methanol

(ii) Glycol

(iii) Glycerol

(iv) Water

2. Answer any three questions from the following :

2×3=6

(a) Calculate the most probable speed of N_2 molecule at 288 K.

(b) What type of stoichiometric defect is shown by AgI, AgBr, ZnS and CsCl?

(c) Explain the effects of temperature and pressure on viscosity of liquid.

- (d) Prove that $C_p - C_v = R$ (for 1 mol of ideal gas).
- (e) What are Weiss and Miller indices for the intercepts of a plane a , $2b$, c along three crystallographic axes?

UNIT—I

3. Answer any *two* questions from the following : 3½×2=7
- (a) (i) Define mean free path, collision diameter and collision frequency of gas molecules. What is the effect of temperature on mean free path? 1½+1=2½
- (ii) What is Boyle's temperature? 1
- (b) Deduce van der Waals' equation of real gas. Under what conditions a real gas behaves ideally? 2½+1=3½
- (c) (i) With the help of kinetic gas equation, deduce Boyle's law. 1½
- (ii) Write the SI unit and physical significance of van der Waals' constant b . 1
- (iii) State the law of equipartition of energy. 1

UNIT—II

4. Answer any *one* question from the following : 3
- (a) Describe a method for determination of viscosity of a liquid in laboratory. 3
- (b) (i) Define coefficient of viscosity of a liquid. What is its SI unit? 1½+½=2
- (ii) Write two uses of liquid crystal. 1

UNIT—III

5. Answer any *two* questions from the following : 3½×2=7
- (a) (i) Calculate the number of particle present in different types of cubic unit cell. 1½
- (ii) Deduce Bragg's equation. 2

- (b) (i) What are extrinsic and intrinsic semiconductors? Give examples. $1+1=2$
(ii) Conductivity of semiconductor increases with increasing temperature. Explain with the help of band theory. $1\frac{1}{2}$
- (c) (i) Discuss the crystal structure of NaCl crystal. 2
(ii) Calculate the packing efficiency of simple cubic crystal. $1\frac{1}{2}$

SECTION—B
(Inorganic Chemistry)

(Marks : 27)

6. Choose the correct answer from of the following : $1 \times 3 = 3$
- (a) The effective nuclear charge (Z^*) for 3d-electron of copper atom is
(i) 21.15
(ii) 17.2
(iii) 7.85
(iv) None of the above
- (b) The hybridization of atomic orbitals of nitrogen in NH_4^+ , NO_3^- and NO_2^+ are respectively
(i) sp , sp^3 , sp^2
(ii) sp , sp^2 , sp^3
(iii) sp^3 , sp^2 , sp
(iv) sp^3 , sp , sp^2
- (c) The shape of ClF_3 molecule is
(i) tetrahedral
(ii) seesaw
(iii) T-shaped
(iv) triangular planar

7. What do you mean by electronegativity of an element? Calculate the electronegativity of fluorine using Allred-Rochow equation. (Given, covalent radius of fluorine = 0.72 Å) $1+2=3$

8. Answer any two questions from the following : 2½×2=5

(a) What do you mean by effective nuclear charge? Using Slater's rules, calculate the effective nuclear charge for 3p-electron of phosphorous. 1+1½=2½

(b) Explain with reason : 1+1½=2½

(i) EA of Cl is higher than F.

(ii) IE₁ of N is higher than oxygen but IE₂ of N is lower than oxygen.

(c) (i) The values of EA₁ and EA₂ of oxygen are 141 kJ/mol and -770 kJ/mol respectively. Explain. 1½

(ii) Define the term 'covalent radii'. 1

9. Answer any four questions from the following : 2×4=8

(a) Explain the shape of SF₄ molecule using VSEPR theory.

(b) The melting and boiling points of o-nitrophenol are lower than m- and p-nitrophenol. Explain.

(c) N₂ molecule is diamagnetic but O₂ molecule is paramagnetic having two unpaired electrons. Explain in the light of MOT.

(d) Geometry of XeF₂ is linear. Explain in the light of VSEPR theory.

(e) Explain the term 'partial ionic' character in covalent bonds'.

10. Explain in the light of Fajans' rule : 1½+1½=3

(a) Polarizing power of Cu⁺ ion is greater than Na⁺ ion.

(b) Melting point of CaF₂ is 1392 °C and CaCl₂ is 772 °C.

11. Answer any two questions from the following : 2½×2=5

(a) Draw the MO energy level diagram of NO molecule and state its magnetic property. 2+½=2½

(b) Explain in the light of molecular orbital theory that the bond dissociation energy of C₂ (599 kJ/mol) decreases slightly on forming C₂⁺ (513 kJ/mol) and increases greatly on forming C₂[⊖] (818 kJ/mol).

(c) Discuss the valence bond theory of covalent bond. Give the valence bond wave function ψ_{AB} for hydrogen molecule. 2½

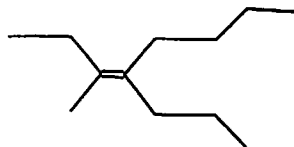
2½

SECTION—C
(Organic Chemistry)
(Marks : 27)

12. Choose the correct answer from the following :

1×3=3

(a) The IUPAC name of the following compound

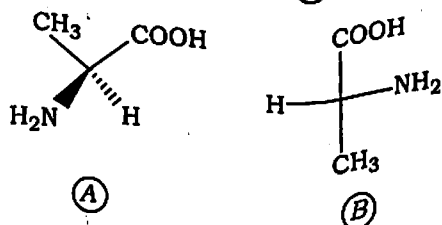


is

- (i) Z-2 ethyl 3-propyl 2-heptene
 - (ii) E-3 methyl 4-propyl 3-octene
 - (iii) Z-3 methyl 4-propyl 3-octene
 - (iv) E-2 ethyl 3-propyl 2-heptene
- (b) The hybridization of each carbon in $\text{CH}_2 = \text{CH} \cdot \text{CN}$ is

- (i) sp^2 sp^2 sp^3
- (ii) sp^3 sp^2 sp^3
- (iii) sp^2 sp^2 sp^2
- (iv) sp^2 sp^2 sp

(c) What is the relation between (A) and (B) ?



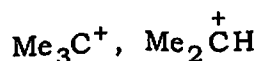
- (i) They are diastereomers
- (ii) They are enantiomers
- (iii) They are identical
- (iv) They are epimers

13. Answer any *three* questions from the following : 2×3=6

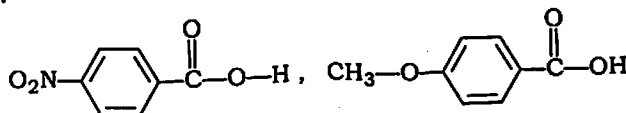
(a) Explain—why cyclopentadienyl anion shows aromatic character whereas cyclopentadienyl cation does not. 2

(b) Define benzyne. How is it generated? Give one chemical reaction of benzyne. $\frac{1}{2} + \frac{1}{2} + 1 = 2$

(c) Explain the stability of the following carbocation with the concept of hyperconjugation : 1+1=2



(d) Compare the acidity of the following compounds on the basis of resonance : 1+1=2



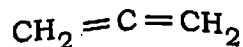
(e) Represent 2,3,4-trihydroxybutanal in 3-D Newman projection.

UNIT—I

14. Answer any *three* questions from the following : 2×3=6

(a) Draw the energy profile diagram of an exothermic reaction involving two reaction intermediates in which second step is rate determining. 2

(b) Draw the orbital picture of the following compound : 2



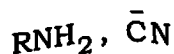
(c) Give proper reasons for the following facts (any one) : 2

(i) Salicylic acid is more acidic than *p*-hydroxybenzoic acid.

(ii) 2,6-dimethyl derivative of *N,N* dimethylaniline is stronger than *N,N* dimethylaniline.

(d) Singlet carbene adds to alkenes in a stereospecific manner whereas triplet carbenes do not. Explain with examples. 2

(e) What are hard base and soft base? Classify the following as hard and soft base : 1+1=2



(f) Write a note on either non-classical carbonium ion or ambident nucleophile. 2

UNIT—II

15. Answer any six questions from the following : 2×6=12

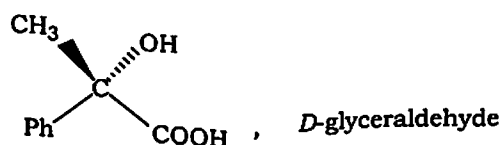
(a) Sketch the following : 1+1=2

(i) Newman projection of (*R*)-mandelic acid ($C_6H_5 - CH(OH)COOH$)

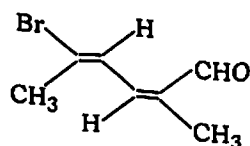
(ii) Flying wedge and Newman projections of *trans*-butene-2

(b) Define centre of symmetry and alternating axis of symmetry giving one example for each. 2

(c) (i) Assign *R/S* (any one) : 1



(ii) Allocate *E/Z* : 1

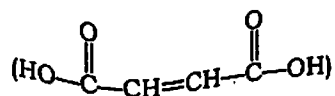


(d) The monoester of one of the tartaric acids is optically active but gives inactive product when hydrolyzed. Identify the acid. 2

(e) Discuss the phenomenon of chirality without chiral carbon atom giving two suitable examples. 1+1=2

(f) You are given a racemic alcohol (\pm) $RR'CHOH$ and a pure optically active organic base ($-$) brucine. How would you proceed to resolve the alcohol? Explain the principle. 2

(g) How would you determine the configuration of diastereomers of butenedioic acid



by using chemical methods? 2

(h) What do you mean by the term 'racemization'? Active mandelic acid undergoes racemization when treated with NaOH. Offer an explanation. 2
