2023

(CBCS)

(1st Semester)

CHEMISTRY

FIRST PAPER

(Inorganic Chemistry—I)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. Which of the following sets of quantum number is feasible?

(a) $n = 2,\ l = 2,\ m = -2,\ ms = -1/2$ ( )

(b) $n = 2,\ l = 1,\ m = -1,\ ms = +1/2$ ( )

(c) $n = 2,\ l = 0,\ m = -1,\ ms = 0$ ( )

(d) $n = 2,\ l = 3,\ m = +1,\ ms = +1/2$ ( )

2. The radial wave function of an orbital determines

(a) size of the orbital ( )

(b) size and orientation of the orbital ( )

(c) orientation of the orbital ( )

(d) None of the above ( )

3. In the modern periodic table, the physical and chemical properties of the elements are periodic functions of their

(a) atomic weight ( )

(b) mass number ( )

(c) electronic configurations ( )

(d) atomic number ( )

4. What is the oxidation number of chlorine atom in $HClO_2$?

(a) +1 ( )

(b) +2 ( )

(c) +3 ( )

(d) −1 ( )

5. What is the geometrical shape of H_3O^+ ion according to VSEPR theory?

(a) Trigonal bipyramidal ( )

(b) Tetrahedral ( )

(c) Square planar ( )

(d) Linear ( )

6. Which of the following molecules has least tendency to form H-bonding?

(a) H_2O ( )

(b) HCl ( )

(c) HF ( )

(d) NH_3 ( )

7. Which of the following is a bidentate ligand?

(a) CN^- ( )

(b) O_2^- ( )

(c) $H_2N—CH_2—CH_2—NH_2$ ( )

(d) NH_3 ( )

8. What is the coordination number of cobalt in $[Co(en)_2(NH_3)_2]Cl_3$?

(a) 3 ( )

(b) 9 ( )

(c) 4 ( )

(d) 6 ( )

9. During a β-decay, the atomic number increases by

(a) 2 units ( )

(b) 1 unit ( )

(c) 4 units ( )

(d) 0 unit ( )

10. Heavy water is used in nuclear reactor as

(a) a coolant ( )

(b) a moderator ( )

(c) both coolant and moderator ( )

(d) a control rod ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following : $3 \times 5 = 15$

UNIT—I

1. Write down the mathematical form of Schrödinger wave equation and explain the terms involved in it.

OR

2. Explain why filling of 4s orbital takes place before 3*d* orbital.

UNIT—II

3. Define ionization energy and state its trend in a group of periodic table.

OR

4. Define oxidation number. Find the oxidation number of chromium atom in $K_2Cr_2O_7$ and $[Cr(H_2O)_6]Cl_3$.

UNIT—III

5. Write the hybridization and shapes of the BeF_2 and SF_6 using VSEPR theory.

OR

6. Explain why H_2O is a liquid whereas H_2S is a gas.

UNIT—IV

7. What are primary and secondary valences in a coordination compound? Explain the terms with examples.

OR

8. What do you mean by chelate effect? Give one example of a chelating ligand.

UNIT—V

9. Explain artificial radioactivity by giving suitable example.

OR

10. Write the group displacement law of radioactivity.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. *(a)* Calculate the wavelength of an electron of mass $9 \cdot 11 \times 10^{-31}$ kg moving with a speed of $2 \cdot 5 \times 10^{-7}$ m/s. (Given : $h = 6 \cdot 63 \times 10^{-34}$ J-s) 3

(b) Write a brief note on Hund's rule of maximum multiplicity and apply it to write the electronic configuration of nitrogen and chromium. 1½+1½=3

(c) State and explain Pauli's exclusion principle. 2

(d) Write down the Heisenberg's uncertainty principle and explain the terms involved in it. 2

OR

2. *(a)* What is effective nuclear charge (Z_{eff})? Calculate the effective nuclear charge for 3s-electron of cobalt. (Atomic Number = 27). 1+3=4

(b) Draw the radial probability distribution curve for 1s and 2p orbitals. 3

(c) Find the values for the principal quantum number (n), azimuthal quantum number (l) and magnetic quantum number (m) of seventh electron in oxygen atom. 3

UNIT—II

3. (a) Why is electron affinity of chlorine higher than that of fluorine? Explain. 3

(b) Why is second ionization potential usually higher than the first IP of elements? 3

(c) Balance the following redox reaction by ion-electron method showing all the steps involved : 4

$$MnO_4^- + H^+ + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$$

OR

4. (a) Define the equivalent weight of reducing agent. Calculate the equivalent weight of $Na_2S_2O_3$ in the following equation (mass = 248) : 1+3=4

$$I_2 + Na_2S_2O_3 \rightarrow Na_2S_4O_6 + I^-$$

(b) Explain how ionic and atomic radii vary in a group and in a period. 3

(c) What do you understand by the term 'electronegativity'? How does it change along a period in the periodic table? 3

UNIT—III

5. (a) Define coordinate bond. Explain its formation with the help of one example. 3

(b) What are the hybridizations shown by the following molecules? Discuss the bond angles using VSEPR theory : 3

$$CH_4,\ NH_3,\ H_2O$$

(c) Define hydrogen bonding. Write the two types of H-bonding with suitable examples. 2+2=4

OR

6. (a) Write the factors that cause the polarity in a covalent bond. 3

(b) Predict the shapes of BF_3 and PCl_5 using VSEPR theory. 4

(c) Define dipole moment. Explain why BH_3 does not have dipole moment whereas NH_3 has a dipole moment. 1+2=3

UNIT—IV

7. *(a)* Write the important postulates of Werner's theory. Write the different compositions of $Co(NH_3)_6 \cdot Cl_3$ according to Werner's theory. 4

(b) Write the IUPAC name for the following compounds : 1×3=3

(i) $[Co(NH_3)_6]Cl_3$

(ii) $K_3[Fe(CN)_6]$

(iii) $[PtCl_2(NH_3)_4][PtCl_4]$

(c) Define geometrical isomerism. Draw the *cis-* and *trans-*isomers of $[PtCl(py)_2NH_3]$, where py = C_5H_5N. 3

OR

8. *(a)* Differentiate between double salt and coordination compound with suitable examples. 3

(b) What is effective atomic number (EAN)? Calculate the EAN of the central atom in $K_3[Fe(CN)_6]$. 1+2=3

(c) Define the following terms : 1×4=4

(i) Ambident ligand

(ii) Coordination sphere

(iii) Coordination number

(iv) Bidentate ligand

UNIT—V

9. *(a)* Explain neutron-proton ratio of a nucleus and its implication on nuclear stability. 3

(b) Write a brief note on nuclear fusion reaction. 3

(c) Define half-life and average life of radioactive elements. How is the average life related to the half-life? 2+2=4

OR

10. *(a)* Write a short note on nuclear fission reaction. 3

(b) Complete the following nuclear reactions : 1×3=3

(i) $^{10}_{5}B + ^{4}_{2}He \rightarrow \_\_\_\_ + ^{1}_{0}n$

(ii) $^{27}_{13}Al + ^{1}_{1}H \rightarrow \_\_\_\_ + \gamma$

(iii) $^{6}_{3}Li + ^{2}_{1}H \rightarrow \_\_\_\_ + ^{1}_{0}n$

(c) Define mass defect and nuclear binding energy. How is the binding energy per nucleon related to the nuclear stability? 2+2=4

★ ★ ★

2023

(CBCS)

(1st Semester)

CHEMISTRY

FIRST PAPER

(Inorganic Chemistry—I)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. Which of the following sets of quantum number is feasible?

(a) $n = 2,\ l = 2,\ m = -2,\ ms = -1/2$ ( )

(b) $n = 2,\ l = 1,\ m = -1,\ ms = +1/2$ ( )

(c) $n = 2,\ l = 0,\ m = -1,\ ms = 0$ ( )

(d) $n = 2,\ l = 3,\ m = +1,\ ms = +1/2$ ( )

2. The radial wave function of an orbital determines

(a) size of the orbital ( )

(b) size and orientation of the orbital ( )

(c) orientation of the orbital ( )

(d) None of the above ( )

3. In the modern periodic table, the physical and chemical properties of the elements are periodic functions of their

(a) atomic weight ( )

(b) mass number ( )

(c) electronic configurations ( )

(d) atomic number ( )

4. What is the oxidation number of chlorine atom in $HClO_2$?

(a) +1 ( )

(b) +2 ( )

(c) +3 ( )

(d) −1 ( )

5. What is the geometrical shape of H_3O^+ ion according to VSEPR theory?

(a) Trigonal bipyramidal ( )

(b) Tetrahedral ( )

(c) Square planar ( )

(d) Linear ( )

6. Which of the following molecules has least tendency to form H-bonding?

(a) H_2O ( )

(b) HCl ( )

(c) HF ( )

(d) NH_3 ( )

7. Which of the following is a bidentate ligand?

(a) CN^- ( )

(b) O_2^- ( )

(c) $H_2N—CH_2—CH_2—NH_2$ ( )

(d) NH_3 ( )

8. What is the coordination number of cobalt in $[Co(en)_2(NH_3)_2]Cl_3$?

(a) 3 ( )

(b) 9 ( )

(c) 4 ( )

(d) 6 ( )

9. During a β-decay, the atomic number increases by

(a) 2 units ( )

(b) 1 unit ( )

(c) 4 units ( )

(d) 0 unit ( )

10. Heavy water is used in nuclear reactor as

(a) a coolant ( )

(b) a moderator ( )

(c) both coolant and moderator ( )

(d) a control rod ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following : $3 \times 5 = 15$

UNIT—I

1. Write down the mathematical form of Schrödinger wave equation and explain the terms involved in it.

OR

2. Explain why filling of 4*s* orbital takes place before 3*d* orbital.

UNIT—II

3. Define ionization energy and state its trend in a group of periodic table.

OR

4. Define oxidation number. Find the oxidation number of chromium atom in $K_2Cr_2O_7$ and $[Cr(H_2O)_6]Cl_3$.

UNIT—III

5. Write the hybridization and shapes of the BeF_2 and SF_6 using VSEPR theory.

OR

6. Explain why H_2O is a liquid whereas H_2S is a gas.

UNIT—IV

7. What are primary and secondary valences in a coordination compound? Explain the terms with examples.

OR

8. What do you mean by chelate effect? Give one example of a chelating ligand.

UNIT—V

9. Explain artificial radioactivity by giving suitable example.

OR

10. Write the group displacement law of radioactivity.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. *(a)* Calculate the wavelength of an electron of mass $9 \cdot 11 \times 10^{-31}$ kg moving with a speed of $2 \cdot 5 \times 10^{-7}$ m/s. (Given : $h = 6 \cdot 63 \times 10^{-34}$ J-s) 3

   (b) Write a brief note on Hund's rule of maximum multiplicity and apply it to write the electronic configuration of nitrogen and chromium. 1½+1½=3

   (c) State and explain Pauli's exclusion principle. 2

   (d) Write down the Heisenberg's uncertainty principle and explain the terms involved in it. 2

OR

2. *(a)* What is effective nuclear charge (Z_{eff})? Calculate the effective nuclear charge for 3s-electron of cobalt. (Atomic Number = 27). 1+3=4

   (b) Draw the radial probability distribution curve for 1s and 2*p* orbitals. 3

   (c) Find the values for the principal quantum number (*n*), azimuthal quantum number (*l*) and magnetic quantum number (*m*) of seventh electron in oxygen atom. 3

UNIT—II

3. *(a)* Why is electron affinity of chlorine higher than that of fluorine? Explain. 3

(b) Why is second ionization potential usually higher than the first IP of elements? 3

(c) Balance the following redox reaction by ion-electron method showing all the steps involved : 4

$$MnO_4^- + H^+ + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$$

OR

4. *(a)* Define the equivalent weight of reducing agent. Calculate the equivalent weight of $Na_2S_2O_3$ in the following equation (mass = 248) : 1+3=4

$$I_2 + Na_2S_2O_3 \rightarrow Na_2S_4O_6 + I^-$$

(b) Explain how ionic and atomic radii vary in a group and in a period. 3

(c) What do you understand by the term 'electronegativity'? How does it change along a period in the periodic table? 3

UNIT—III

5. *(a)* Define coordinate bond. Explain its formation with the help of one example. 3

(b) What are the hybridizations shown by the following molecules? Discuss the bond angles using VSEPR theory : 3

$$CH_4,\ NH_3,\ H_2O$$

(c) Define hydrogen bonding. Write the two types of H-bonding with suitable examples. 2+2=4

OR

6. *(a)* Write the factors that cause the polarity in a covalent bond. 3

(b) Predict the shapes of BF_3 and PCl_5 using VSEPR theory. 4

(c) Define dipole moment. Explain why BH_3 does not have dipole moment whereas NH_3 has a dipole moment. 1+2=3

UNIT—IV

7. *(a)* Write the important postulates of Werner's theory. Write the different compositions of $Co(NH_3)_6 \cdot Cl_3$ according to Werner's theory. 4

(b) Write the IUPAC name for the following compounds : 1×3=3

(i) $[Co(NH_3)_6]Cl_3$

(ii) $K_3[Fe(CN)_6]$

(iii) $[PtCl_2(NH_3)_4][PtCl_4]$

(c) Define geometrical isomerism. Draw the *cis*- and *trans*-isomers of $[PtCl(py)_2NH_3]$, where $py = C_5H_5N$. 3

OR

8. *(a)* Differentiate between double salt and coordination compound with suitable examples. 3

(b) What is effective atomic number (EAN)? Calculate the EAN of the central atom in $K_3[Fe(CN)_6]$. 1+2=3

(c) Define the following terms : 1×4=4

(i) Ambident ligand

(ii) Coordination sphere

(iii) Coordination number

(iv) Bidentate ligand

UNIT—V

9. *(a)* Explain neutron-proton ratio of a nucleus and its implication on nuclear stability. 3

(b) Write a brief note on nuclear fusion reaction. 3

(c) Define half-life and average life of radioactive elements. How is the average life related to the half-life? 2+2=4

OR

10. *(a)* Write a short note on nuclear fission reaction. 3

(b) Complete the following nuclear reactions : 1×3=3

(i) $^{10}_{5}B + ^{4}_{2}He \rightarrow \_\_\_\_ + ^{1}_{0}n$

(ii) $^{27}_{13}Al + ^{1}_{1}H \rightarrow \_\_\_\_ + \gamma$

(iii) $^{6}_{3}Li + ^{2}_{1}H \rightarrow \_\_\_\_ + ^{1}_{0}n$

(c) Define mass defect and nuclear binding energy. How is the binding energy per nucleon related to the nuclear stability? 2+2=4

★ ★ ★