Chemistry PYQs Topicwise

A small contribution by Nikhil Mishra (CE12)

Atomic and Molecular Structure

Schrodinger equation

Q. What is the significance of Ψ and Ψ^2. (1.5)

Q. Write down the Schrodinger wave equation describing various terms involved. (1.5)

Q. What is Schrodinger wave equation? (1.5)

Particle in a box solutions and their applications for conjugated molecules and nanoparticles

Q. For a particle in a one-dimensional box, write the equation for calculating the energy values corresponding to n = 2. (1.5)

Q. Give the schrodinger wave equation for a particle in one dimensional box. (1.5)

Q. Derive the expression for E and Ψ for a particle in 1-D box. (5)

Q. Derive the equation for particles in one dimensional box. (5)

Q. Deduce the expression for total energy and normalized wave function for particle mass (m) in 1-D box with length (L) moving with potential V(x) = 0 (0 < x < L), otherwise V(x) = infinite. (5)

Forms of the hydrogen atom wave functions and the plots of these functions

Molecular orbitals of diatomic molecules and plots of the multicenter orbitals & Energy level diagrams of diatomic

Q. Prepare a molecular orbital energy-level diagram for NO, showing clearly how the atomic orbitals interact to form MOs, illustrating with explanation on difference

in electronegativity between N & O and predict the bond order and the number of unpaired electrons. (8)

Q. Draw and explain molecular orbital diagram of O_2. Compare its bond order and magnetic properties with O_2^+, O_2^-, O_2^{-2}. (5)

Q. Write down the electronic configuration and draw a molecular orbital energy level diagram for N_2 molecules. (10)

Q. Write down the electronic configuration of O_2 molecules and draw molecular orbital energy level diagrams for the same.

Q. On the basis of MOT, explain the molecular orbital energy pattern of O_2 molecules.

Equations for atomic and molecular orbitals

Pi-molecular orbitals of butadiene and benzene and aromaticity

Q. Draw Pi-molecular orbitals of 1,3 - butadiene. Also mention HOMO and LUMO. (5)
Q. Draw Pi-molecular orbitals of 1, 3, 6 - hexatriene. Also mention HOMO and LUMO. (5)

Q. Draw the pi-molecular orbitals for butadiene. (5)

Q. Predict whether cyclopropene, Cyclopropenyl cation and cyclobutadiene are aromatic or non-aromatic. (1.5)

Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties

Q. On the basis of CFT calculate spin only magnetic moment of $[Fe(NH_3)_6]^{3+}$. (1.5)

Q. Briefly discuss crystal field splitting in tetrahedral complexes. (5)

Q. Define and explain crystal field theory. (1.5)

Q. Explain crystal field splitting in octahedral complexes. (7)

Q. Give three main postulates of CFT. Explain the splitting of d orbitals under octahedral, tetrahedral and square planar ligand field. (1)

Q. What is CFSE? Calculate for d5 (H.S.) and d5 (L.S.) including pairing energy (p) in octahedral complexes. (5)

Band structure of solids and the role of doping on band structures

Q. What is meant by ‘doping’ in a semiconductor? Explain the role of doping on the band structure of solids. (7)
Q. What are the intrinsic & extrinsic semiconductors? (1.5)

Q. Explain the effect of doping on band structures of solids. (1.5)

Q. What is the role of doping on the band structures of solids? (1.5)

Q. Briefly explain the role of doping on band structure. (1.5)

Q. Draw an energy level diagram for n-type and p-type semiconductors according to Band theory. (1.5)

Spectroscopic techniques and its application

Q. Define and explain the following terms: (10)
(i) Selection rules
(ii) Chemical Shift
(iii) MRI
(iv) Diffraction
(v) Crystal Field Splitting

Principles of spectroscopy and selection rules

Q. What do you understand about the term “spectroscopy”. Discuss the various selection rules governing spectroscopy. (5)

Electronic spectroscopy

Q. Write down the selection rules for electronic spectroscopy. (1.5)

Q. Explain the theory of UV-visible spectroscopy and various types of electronic transitions. (7)

Q. What is hypsochromic shift? (1.5)

Q. Write a short note on Chemical Shift. (2)

Q. Write a short note on Beer-Lambert's Law. (2)

Q. Discuss the principle of electronic spectroscopy. Explain with reference to butadiene and carbonyl compounds. (5)

Q. Define the following term: Bathochromic shift. (2)

Fluorescence and its applications in medicine

Q. Explain the process of fluorescence using the Jablonski diagram. (5)

Q. Write a short note on Fluorescence. (2)

Q. Define the term fluorescence and give its applications in medicines. (10)
Q. Define the term fluorescence. (1.5)

Q. Define Fluorescence and Phosphorescence. (1.5)

Vibrational and rotational spectroscopy of diatomic molecules

Q. What do you mean by IR active molecule? (1.5)

Q. Write a short note on Fundamental Vibrations and Overtones. (2)

Q. What is the principle of vibrational spectroscopy? (1.5)

Q. Give the selection rule for IR spectroscopy. Explain stretching and bending vibrations in AB_2 type nonlinear molecules.

Q. What is the principle of rotational spectroscopy? (1.5)

Q. Discuss the differences between vibrational and rotational spectroscopy. (5)

Q. How many fundamental modes of vibration are expected for the following: (a) CO_2 (Linear) (b) H_2O (Bent) (1.5)

Applications of spectroscopy

Nuclear magnetic resonance and magnetic resonance imaging

Q. Compare the principles of NMR and MRI. (5)

Q. Define NMR spectroscopy. (1.5)

Q. Give the structural formula of C_3H_6O which gives one signal in ^1H NMR. (1.5)

Q. Write a short note on shielding and deshielding of protons in NMR spectroscopy. (5)

Surface characterization techniques

Diffraction and scattering

Intermolecular Forces and Potential Energy Surfaces

Q. What are intermolecular forces? How do they impact the physical properties of matter? (1.5)

Q. Give a detailed account for any four intermolecular forces of attraction existing in molecules. (8)

Ionic, dipolar, and van der Waals interactions

Q. What are dipole-induced dipole interactions? (1.5)

Q. Derive Van der Waals equation for real gases and extend the derivation to critical phenomenon. (8)

Q. Define the following term: Van Der Waals interactions. (2)

Q. Define and explain van der waals interactions. (1.5)

Q. Explain the following term: London forces. (2)

Equations of state of real gases and critical phenomena

Q. Define critical temperature. (1.5)

Q. Write down the equation of state for real gases. (1.5)

Q. Derive the relation between heat of reaction at constant volume and heat of reaction at constant pressure. (1.5)

Q. Explain causes of deviation of gases from ideal behavior. (1.5)
Q. Explain the following term: Critical Temperature and Compressibility factor. (4)

Potential energy surfaces of H_3, H_2F, and HCN

Q. Write a short note on the potential energy surface of the H + H_2 model. (5)

Q. Write a short note on PES diagrams. Elaborate saddle point and mountain pass in a potential energy surface diagram. (7)

Q. Discuss the potential energy surface diagram of H_2F and its trajectories. (7)

Q. Explain the following term: Potential Energy Surfaces. (2)

Trajectories on potential energy surfaces

Q. Discuss the potential energy surface diagram of H_2F and its trajectories. (7)

Use of Free Energy in Chemical Equilibria

Thermodynamic functions: energy, entropy, and free energy

Estimations of entropy and free energies

Q. How will you predict spontaneity in terms of entropy and free energy? (1.5)

Q. What do you understand by the terms entropy and free energy? Explain briefly. (1.5)

Q. Define entropy and enthalpy of a reaction. (1.5)

Free energy and emf

Cell potentials, Nernst equation, and applications

Q. Derive Nernst Equation and write down its applications. (7)

Q. Derive the Nernst equation and explain its various applications. (7)

Q. Give the equation which relates cell potential and Gibbs free energy at equilibrium. Write three main applications of Nernst equation with examples. (8)

Q. Define and explain the following terms: Free energy, Entropy. (4)

Acid-base, oxidation-reduction, and solubility equilibria

Water chemistry

Q. What is meant by the hardness of water? How are they classified? Explain any two methods for softening of hard water. (8)

Q. Give two points how scale and sludge formation can be prevented in boilers. (1.5)

Corrosion

Q. Explain electrochemical corrosion with suitable examples. (1.5)

Q. What do you understand about corrosion? Discuss its causes of happening. (5)

Q. Give the main difference between wet and dry corrosion with an example. (1.5)

Q. Define and explain the term corrosion. (1.5)

Q. What do you mean by corrosion? Explain the factors influencing corrosion. (5)

Q. Discuss in brief Wet corrosion and Dry corrosion. (5)

Use of free energy in metallurgy through Ellingham diagrams

Q. What does an Ellingham diagram signifies? (1.5)

Q. Explain Ellingham diagram listing its uses and limitations. (7)

Q. Draw a well labeled Ellingham diagram. (5)

Q. Using the Ellingham diagram explains metal extraction from its oxide. (5)

Periodic Properties

Q. What do you mean by inert pair effect? explain briefly.

Q. What do you understand about the inert pair effect? Explain giving suitable examples. (1.5)

Q. What is the role of the inert pair effect on periodic properties of elements in the periodic table. (1.5)

Q. Discuss the various periodic properties of elements and their trends in groups and periods. (15)

Effective nuclear charge (Pg. 6)

Q. What do you mean by effective nuclear charge? Write Slater's rule to find out effective nuclear charge. (5)

Q. What is Effective nuclear charge? Calculate the Z_{eff} felt by valence electrons of chromium atoms (Z = 24). (6)

Q. Define and explain the following term: Effective nuclear charge. (2)

Penetration of orbitals

Q. What do you understand about orbital penetration? On what factors it depends? Give the trend of its variation in the orbital of the same shell?

Variations of s, p, d, and f orbital energies of atoms in the periodic table

Electronic configurations

Atomic and Ionic sizes

Ionization energies (Pg. 18)

Q. Differentiate ionization energy and electron affinity. (1.5)

Electron affinity

Q. Differentiate ionization energy and electron affinity. (1.5)

Electronegativity (pg. 28)

Q. What do you understand by the term electronegativity? Explain the factors affecting the magnitude of Electronegativity? (2)

Q. What do you understand about electronegativity? Explain its variation across the periodic table. How does it affect other properties of elements/molecules? (5)

Q. Explain the periodic trend for electronegativity. (4)

Q. What is electronegativity? Write the factor affecting the electronegativity. (3)

Q. Explain the Allred Rochaw scale of electronegativity. (2)

Polarizability (Pg. 31)

Q. Define the terms polarizing power and polarizability? Also, discuss the fajans rule for ionic and covalent character of a bond? (2)

Solution: Polarizing power: The power of cation to polarize an anion is known as polarizing power, it depends on two factors:
(i) Charge on cation: bigger the charge, bigger the polarizing power.

(ii) Size of cation: smaller the charge, bigger the polarizing power.

Polarizability: The ability of an anion to get polarized is known as polarizability. It depends on two factors:
(i) Charge on anion: bigger the charge, more will be the ability to get polarized.
(ii) Size of cation: bigger the size, more will be the ability to get polarized.

Higher polarizing power and polarizability = forms strong covalent bonds.

Q. Explain Fajan's rule of polarizability and its significance. (5)

Q. Briefly explain polarization and polarizability. Discuss the factor influencing polarizability and consequences of polarizability. (5)

Q. What do you understand about polarizability? How does it polarize power? Discuss the Fajans rule for ionic and covalent character of a bond. (8)

Oxidation states

Coordination numbers

Q. What is the coordination number? Give two examples of complexes having coordination numbers of 2 and 4.

Q. Explain in detail on coordination numbers and geometries with examples for each. (5)

Geometries & Molecular geometries

Q. Discuss the geometry of ClO_3^- and PCl_5. (5)

Q. Give the geometries possible for coordination number 4. Using VSPER theory predicts the shape of a AB_3 molecule having 2 lone pairs of electrons on central atom A. (5)

Hard soft acids and bases

Q. Differentiate between hard and soft acids? (1.5, 2)

Q. What is the difference between hard acid and soft acid with an example?

Q. Define the following term: (iii) Arhenius acids and bases. (2)

Q. Explain any two applications of the HSAB principle. (1.5)

Q. What are soft acids and soft bases according to the HSAB concept? (1.5)

Q. Explain Bronsted-Lowry concept or protonic concept for acid and base with examples. (1.5)

Q. Explain how acetic acid acts as an acid aqueous solution according to the Bronsted-Lowry acid base concept. (1.5)

Q. Define and explain the following term: HSAB concept. (2)

Q. Explain Bronsted-Lowry concept or protonic concept for acid and base with examples. (1.5)

Stereochemistry

Q. Define the following terms: (10)
(i) Geometrical isomerism
(ii) Optical Activity
(iii) Absolute configuration
(iv) Fischer projection
(v) Chiral center

Representations of 3-dimensional structures

Q. Draw the Fischer projection formula for (2R) - 2 - Bromobutane. (1.5)

Structural isomers and stereoisomers

Q. Discuss taking examples of organic molecules types of structural and stereoisomerism. (5)

Configurations

Q. Explain the difference between conformational and configurational isomers? (1.5)

Symmetry and Chirality

Q. Explain the symmetry operations existing in square planar $[PtCl_4]^{2-}$. (2)

Q. Define the following terms: (i) Chirality (ii) Chiral Axis (4)

Q. Define and explain the following term: Symmetry elements. (2)

Q. Define Chirality and explain how it leads to the phenomenon of optical activity. (1.5)

Enantiomers, Diastereomers

Q. Differentiate between the following pairs with suitable examples of each - (i) Enantiomers and diastereomers. (ii) Racemic mixture and meso compounds. (5)

Q. What do you mean by meso compounds? Explain using suitable examples. (1.5)

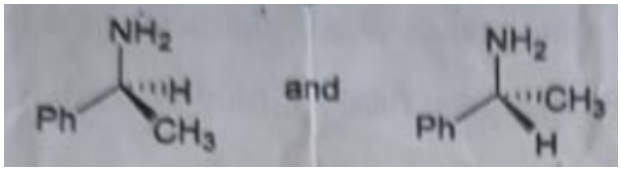
Q. Give examples for (i) Enantiomers (ii) Diastereomers (iii) Metamers (iv) Conformational isomers. (5)

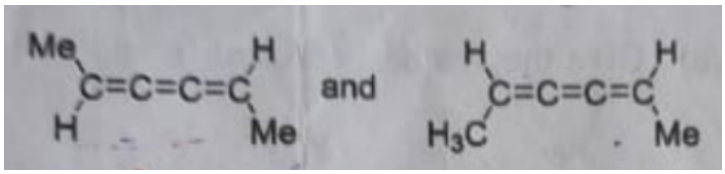
Q. Differentiate between enantiomers and diastereomers. (1.5)

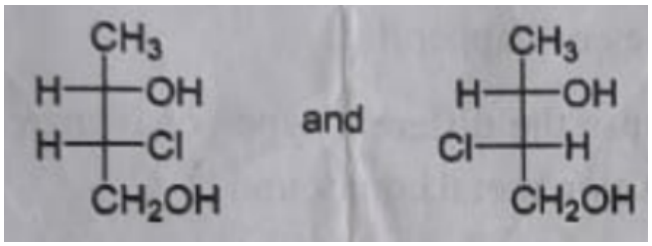
Q. Why do enantiomers have the same physical and chemical properties while diastereomers have different? (1.5)

Q. What are Anomers? (2)

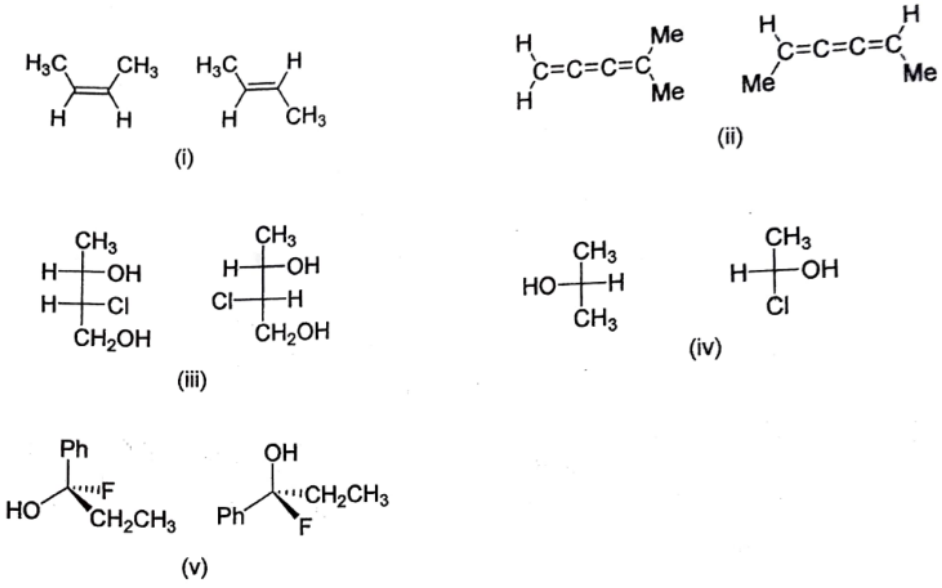
Q. Indicate the following compounds as enantiomers/diastereomers/identical or none. (9)







Q. Indicate the following compounds as enantiomers / diastereomers / identical or none.



Optical activity

Q. Write a short note on Optical activity. (1.5)

Q. What are optical active compounds? Discuss the essential conditions for optical isomerism, elaborate with examples. (5)

Q. Define Chirality and explain how it leads to the phenomenon of optical activity. (1.5)

Conformational analysis

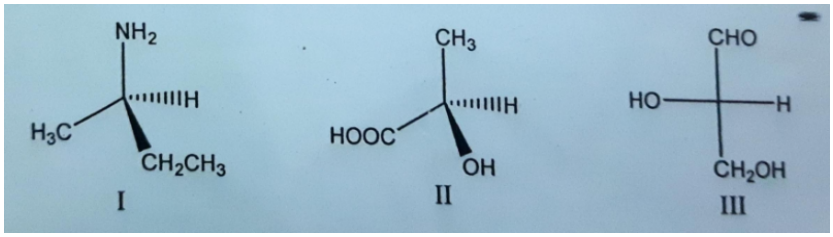
Q. Draw and discuss energy diagram for different conformational isomers of butane. (5)

Q. Draw Newmann projection of chair conformation of cyclohexane. (1.5)

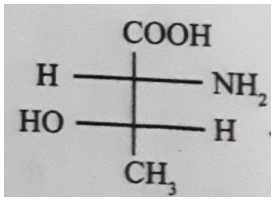
Q. Explain the difference between conformational and configurational isomers? (1.5)

Absolute configurations

Q. What are the absolute configurations of following molecules: (5)



Q. What is/are the absolute configuration/s of the chiral carbon atom/s in



Explain in detail. (5)

Isomerism in transitional metal compounds

Q. What are fac- and mer- isomers in transition metal compounds? Explain with examples. (2)

Q. Explain the structural isomerism in transition metal compounds with suitable examples. (5)

Q. Discuss stereoisomerism in transitional metal compounds with suitable examples. (5)

Q. Discuss the different types of isomerism possible in transition metal compounds. (5)

Q. Discuss the different types of structural isomers in transition metal complexes with suitable examples. (5)

Q. What do you understand about the term epimerism? Explain briefly giving suitable examples. (1.5)

Organic Mechanism and Synthesis of a Drug Molecule

Substitution

Q. Explain Nucleophilic substitution reactions? Differentiate between SN1 and SN2. (3)

Q. Explain the types, mechanisms and factors affecting Nucleophilic substitution reactions? (4)

Q. Explain the mechanism of Nucleophilic bimolecular substitution reaction with an example. (1.5)

Q. Define Walden Inversion. (1.5)

Q. Explain elimination reaction with detailed mechanism by taking suitable examples along with rules governing major product formation. Describe how elimination reaction competes with substitution reaction. (8)

Q. Allyl halides rapidly undergo nucleophilic substitution reactions while vinyl halides do not. Explain. (1.5)

Q. Nucleophilic substitution and elimination reactions often compete with each other. Justify this statement giving the conditions when substitution is preferred over elimination. (5)

Q. Define and explain briefly the term racemisation. (1.5)

Q. Why does benzene undergo electrophilic substitution rather than addition reaction? (1.5)

Q. Write the difference between S_N1 and S_N2 reactions. (1.5)

Addition

Q. Why does benzene undergo electrophilic substitution rather than addition reaction? (1.5)

Q. What is diel's Alder cycloaddition reaction? Explain with at least one example. (3)

Q. Give the Wurtz method for the preparation of alkane. (1.5)

Elimination

Q. Give examples for elimination reactions and compare the E1 and E2 reactions mechanisms. (7)

Q. Explain elimination reactions with detailed mechanisms by taking suitable examples along with rules governing major product formation. Describe how elimination reaction competes with substitution reaction. (8)

Q. Nucleophilic substitution and elimination reactions often compete with each other. Justify this statement giving the conditions when substitution is preferred over elimination. (5)

Q. Differentiate between elimination and condensation reactions giving suitable examples. (1.5)

Oxidation

Q. Write down three reducing and three oxidizing agents in organic synthesis. (5)

Q. What is ozonolysis? Explain with at least one suitable example. (2)

Reduction

Q. Write down three reducing and three oxidizing agents in organic synthesis. (5)

Cyclization

Q. What do you understand by the term cyclization reaction? Give an example. (1.5)

Ring Openings

Synthesis of Drug Molecules

Q. Describe the synthesis of Aspirin. (2)

Q. What are the uses and synthesis of aspirin? (4)

Q. Explain in detail about synthesis of commonly used drug molecules Ibuprofen with reactions. (8)

Q. Give synthesis of an antihistamine and antipyretic drug. (7)

Q. Give the synthesis of aspirin and its medical uses. (5)

Q. Discuss the synthesis of a commonly used analgesic drug molecule taking a suitable example. (5)