



CUET PG Nanoscience/Integrative Biosciences

Time Allowed : 1 hour 45 minutes	Maximum Marks : 300	Total questions : 75
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General Instructions

Read the following instructions very carefully and strictly follow them:

- (i) This question paper comprises 75 questions. All questions are compulsory.
- (ii) Each question carries 04 (four) marks.
- (iii) For each correct response, candidate will get 04 (four) marks.
- (iv) For each incorrect response, 01 (one) mark will be deducted from the total score.
- (v) Un-answered/un-attempted response will be given no marks.
- (vi) To answer a question, the candidate needs to choose one option as correct option.
- (vii) However, after the process of Challenges of the Answer Key, in case there are multiple correct options or change in key, only those candidates who have attempted it correctly as per the revised Final Answer Key will be awarded marks.
- (viii) In case a Question is dropped due to some technical error, full marks shall be given to all the candidates irrespective of the fact who have attempted it or not

1. The First Law of Thermodynamics represents:

- (1) Law of conservation of mass
- (2) Law of conservation of energy
- (3) Law of conservation of entropy
- (4) Law of conservation of momentum

Correct Answer: (2) Law of conservation of energy.

Solution:

The First Law of Thermodynamics is a statement of energy conservation, asserting that energy cannot be created or destroyed in an isolated system. The law is mathematically expressed as:

$$\Delta U = Q - W$$

where:

- 1. ΔU : Change in internal energy of the system.
- 2. Q : Heat added to the system.
- 3. W : Work done by the system.

This principle is applicable in various thermodynamic processes, including isochoric, isobaric, isothermal, and adiabatic processes. It also explains energy transfer in heat engines, refrigerators, and closed systems.

Quick Tip

The First Law ensures energy is always conserved. Heat and work are modes of energy transfer, while internal energy is a property of the system.

2. A Carnot engine is a reversible engine. It can be proved from the:

- (1) Zeroth Law of Thermodynamics
- (2) First Law of Thermodynamics
- (3) Second Law of Thermodynamics
- (4) Third Law of Thermodynamics

Correct Answer: (3) Second Law of Thermodynamics.

Solution:

The Second Law of Thermodynamics introduces the concept of entropy, which governs the direction of energy transfer and the efficiency of heat engines. A Carnot engine is a theoretical reversible engine that operates between two reservoirs and achieves maximum efficiency:

$$\eta = 1 - \frac{T_c}{T_h}$$

where:

1. T_c : Absolute temperature of the cold reservoir.
2. T_h : Absolute temperature of the hot reservoir.

The Carnot engine is reversible because it undergoes no net entropy change ($\Delta S = 0$), making it an ideal standard for evaluating real-world engines.

Quick Tip

The Carnot engine represents the theoretical limit of efficiency for any heat engine operating between two temperature reservoirs.

3. From the Hall Effect experiment, one can measure:

- (1) Carrier concentration
- (2) Nature of charge carriers
- (3) Carrier concentration and Mobility of charge carriers
- (4) Nature of charge carriers, concentration of charge carriers as well as their mobility

Correct Answer: (4) Nature of charge carriers, concentration of charge carriers as well as their mobility.

Solution:

The Hall Effect occurs when a current-carrying conductor is placed in a perpendicular magnetic field, generating a transverse voltage (Hall voltage):

$$V_H = \frac{IB}{qnd}$$

where:

1. I : Current.
2. B : Magnetic field strength.
3. q : Charge of carriers.
4. n : Carrier concentration.
5. d : Thickness of the conductor.

This experiment provides:

1. **Nature of charge carriers:** Positive (holes) or negative (electrons).
2. **Carrier concentration (n):** Determined from the Hall coefficient.
3. **Carrier mobility (μ):** Determined using conductivity ($\sigma = nq\mu$).

Quick Tip

The Hall Effect is a powerful tool to characterize electrical properties of semiconductors and conductors.

4. With the reduction in particle size, the optical absorption spectrum shows:

- (1) Blue Shift
- (2) Red Shift
- (3) Green Shift
- (4) Yellow Shift

Correct Answer: (1) Blue Shift.

Solution:

When particles are reduced to the nanoscale, quantum confinement effects dominate. The energy gap (E_g) increases as the particle size decreases, causing higher energy (shorter wavelength) absorption and emission. This phenomenon, termed "blue shift," is observed in materials like quantum dots and nanoparticles.

Quick Tip

Quantum confinement in nanoscale particles causes blue-shifted optical properties, influencing applications in sensors and displays.

5. Bragg's law of diffraction is used to determine the:

- (1) Crystallite structure
- (2) Crystal structure
- (3) Particle size
- (4) Crystalline structure as well as Particle size

Correct Answer: (2) Crystal structure.

Solution:

Bragg's law describes the diffraction of X-rays by crystal planes:

$$n\lambda = 2d \sin \theta$$

where:

- 1. n : Order of diffraction.
- 2. λ : Wavelength of X-rays.
- 3. d : Interplanar spacing.
- 4. θ : Diffraction angle.

This law is fundamental for determining the arrangement of atoms in crystals.

Quick Tip

X-ray crystallography leverages Bragg's law to reveal crystal structures, critical in material science and biochemistry.

6. A bipolar junction transistor is said to be in active mode if:

- (1) Base-emitter junction is forward biased and collector-emitter junction is reverse biased

- (2) Base-emitter junction is reverse biased and collector-emitter junction is forward biased
- (3) Both junctions are forward biased
- (4) Both junctions are reverse biased

Correct Answer: (1) Base-emitter junction is forward biased and collector-emitter junction is reverse biased.

Solution:

In active mode:

1. The base-emitter junction is forward biased, facilitating charge flow from emitter to base.
2. The collector-emitter junction is reverse biased, enabling charge collection at the collector.

This mode is essential for amplification, as the base current controls the larger collector current.

Quick Tip

Active mode operation in BJTs is the basis for signal amplification in analog circuits.

7. In a Quantum dot, the degree of confinement is:

- (1) Zero
- (2) One
- (3) Two
- (4) Three

Correct Answer: (4) Three.

Solution:

Quantum dots are nanoscale particles in which electrons are confined in all three spatial dimensions, leading to discrete quantized energy levels. Unlike bulk materials with continuous energy bands, quantum dots behave like artificial atoms, showing unique optical and electronic properties. This three-dimensional confinement results in size-dependent

behavior, such as tunable fluorescence, making quantum dots valuable in applications like medical imaging, photovoltaics, and quantum computing.

Quick Tip

Quantum dots exhibit unique properties due to 3D confinement, enabling advancements in optoelectronics and nanotechnology.

8. The failure of Michelson-Morley experiment indicated:

- (1) Existence of other medium
- (2) Speed of light is directional
- (3) Speed of light is invariant
- (4) Light has dual nature

Correct Answer: (3) Speed of light is invariant.

Solution:

The Michelson-Morley experiment was conducted to detect the presence of a luminiferous ether, a supposed medium for the propagation of light. Its null result demonstrated that the speed of light is constant in all inertial reference frames, regardless of the motion of the source or observer. This pivotal discovery refuted the ether hypothesis and laid the foundation for Einstein's special theory of relativity, where the speed of light (c) is a fundamental constant.

Quick Tip

The Michelson-Morley experiment revolutionized physics by establishing the invariance of the speed of light.

9. A rigid body is dropped from a tower top. Midway it splits in two unequal parts. The centre of mass of the system:

- (1) Shifts horizontally towards the heavier part
- (2) Shifts horizontally towards the lighter part

- (3) Does not shift horizontally
- (4) Does shift depending on velocity at the time of split

Correct Answer: (3) Does not shift horizontally.

Solution:

The center of mass (COM) of a system remains unaffected by internal forces, such as those causing the body to split. Since the external force acting on the system is gravity (vertical force), there is no horizontal component to change the horizontal position of the COM. Therefore, the COM follows the same vertical path as it would if the body had not split.

Quick Tip

The motion of the center of mass is governed by external forces, remaining unaffected by internal events like splitting.

10. A system in thermodynamic equilibrium satisfies the following requirements:

- (1) A system is in mechanical equilibrium
- (2) A system is in mechanical equilibrium and chemical equilibrium
- (3) A system is in mechanical equilibrium and thermal equilibrium
- (4) A system is in mechanical equilibrium, chemical equilibrium and thermal equilibrium

Correct Answer: (4) A system is in mechanical equilibrium, chemical equilibrium and thermal equilibrium.

Solution:

For a system to be in thermodynamic equilibrium:

1. **Mechanical equilibrium:** There are no unbalanced forces; pressure is uniform throughout.
2. **Thermal equilibrium:** Temperature is uniform, with no heat flow within the system or with its surroundings.
3. **Chemical equilibrium:** No net chemical reactions occur, and there is no transfer of species between phases.

Only when all three conditions are met can the system be considered in thermodynamic equilibrium, maintaining stability over time.

Quick Tip

Thermodynamic equilibrium ensures a system remains in a steady state, with no unbalanced exchanges of energy or matter.

11. Which of the following orbitals will have a radial node?

- (1) 1s orbital
- (2) 2s orbital
- (3) 2p orbital
- (4) 3d orbital

Correct Answer: (2) 2s orbital.

Solution:

1. **Definition:** Radial nodes are spherical regions in an orbital where the probability of finding an electron is zero. They are located at specific radii from the nucleus.
2. **Formula for radial nodes:** The number of radial nodes is given by $n - l - 1$, where n is the principal quantum number and l is the azimuthal quantum number (0 for s, 1 for p, 2 for d, etc.).
3. **Calculation:**
 - (a) 1s orbital: $n = 1, l = 0$, nodes = $1 - 0 - 1 = 0$ (no radial node).
 - (b) 2s orbital: $n = 2, l = 0$, nodes = $2 - 0 - 1 = 1$ (one radial node).
 - (c) 2p orbital: $n = 2, l = 1$, nodes = $2 - 1 - 1 = 0$ (no radial node).
 - (d) 3d orbital: $n = 3, l = 2$, nodes = $3 - 2 - 1 = 0$ (no radial node).
4. Only the 2s orbital has a radial node among the given options.

Quick Tip

Radial nodes increase with higher principal quantum numbers. For s orbitals, radial nodes are always spherical, distinguishing them from angular nodes.

12. Primitive cell has ---- lattice point per unit cell:

- (1) One
- (2) Two
- (3) Three
- (4) Four

Correct Answer: (1) One.

Solution:

1. **Definition of Primitive Cell:** A primitive cell is the smallest repeating unit in a crystal lattice that can generate the entire lattice through translations.
2. **Lattice Points:** Lattice points are locations within the unit cell where atoms, ions, or molecules reside.
3. **Corner Atoms Contribution:** Each atom at a corner contributes $1/8$ to a single cell since it is shared among eight adjacent cells.
4. **Total Lattice Points:** A primitive cell has $8 \text{ corner atoms} \times 1/8 \text{ contribution} = 1 \text{ lattice point}$.

Quick Tip

Primitive cells are fundamental building blocks in crystallography, containing exactly one lattice point to represent the entire crystal.

13. Filling of electrons in degenerate orbitals is governed by:

- (1) Hund's rule
- (2) Planck's Law

- (3) de-Broglie's wave-particle duality
- (4) Photoelectric effect

Correct Answer: (1) Hund's rule.

Solution:

1. **Degenerate Orbitals:** These are orbitals with the same energy, such as the three p orbitals in a given shell.
2. **Hund's Rule:** This rule states that electrons fill degenerate orbitals singly with parallel spins before pairing. This minimizes electron repulsion and maximizes stability.
3. **Illustration:** For example, in the p orbitals, electrons will occupy p_x , p_y , and p_z singly before any pairing occurs.
4. **Relevance of Other Laws:**
 - (a) Planck's Law relates energy to the frequency of light.
 - (b) de-Broglie's theory addresses the wave-particle duality of matter.
 - (c) Photoelectric effect explains electron ejection by photons.
5. Hund's Rule is the only principle governing electron filling in degenerate orbitals.

Quick Tip

Hund's Rule ensures maximum stability by reducing electron-electron repulsion in degenerate orbitals.

14. Arrange the following radiations in terms of increasing order of their ionizing power:

- (1) X-rays
- (2) Beta-particles
- (3) Gamma-rays
- (4) Alpha-particles

Choose the correct answer from the options given below:

1. (A), (B), (C), (D)
2. (A), (B), (D), (C)
3. (B), (A), (D), (C)
4. (C), (B), (A), (D)

Correct Answer: 2. (A), (B), (D), (C)

Solution:

1. **Ionizing Power:** Ionizing power refers to the ability of radiation to ionize atoms or molecules by removing electrons. It depends on the charge, mass, and energy of the radiation.

2. **Explanation of Options:**

- (a) **X-rays:** These are high-energy photons with zero charge and low ionizing power, but they penetrate deeply into matter.
- (b) **Beta-particles:** These are fast-moving electrons or positrons with moderate ionizing power and intermediate penetration ability.
- (c) **Gamma-rays:** High-energy photons with more ionizing power than X-rays, but less than alpha particles.
- (d) **Alpha-particles:** Consist of two protons and two neutrons, making them highly ionizing but with very low penetration depth.

3. **Order of Ionizing Power:** X-rays < Beta-particles < Gamma-rays < Alpha-particles.

Quick Tip

Higher ionizing power often corresponds to lower penetration. Alpha particles are strong ionizers but travel short distances, while X-rays and gamma rays penetrate deeper but ionize less.

15. No two particles can occupy the same state is the consequence of:

- (1) Maxwell-Boltzmann distribution
- (2) Bose-Einstein Distribution

- (3) Fermi-Dirac Distribution
- (4) Classical Distribution

Correct Answer: (3) Fermi-Dirac Distribution.

Solution:

1. **Pauli Exclusion Principle:** This principle states that no two fermions (particles with half-integer spin) can occupy the same quantum state simultaneously.
2. **Fermi-Dirac Statistics:** This statistical model describes the distribution of fermions in a system and incorporates the Pauli Exclusion Principle. It is used to understand the behavior of electrons in atoms and solids.
3. **Comparison with Other Models:**
 - (a) Maxwell-Boltzmann and Classical distributions apply to distinguishable particles without quantum restrictions.
 - (b) Bose-Einstein Distribution applies to bosons (particles with integer spin) and allows multiple particles in the same state.
4. Fermi-Dirac distribution is unique in restricting identical particles (fermions) from sharing a quantum state.

Quick Tip

Fermi-Dirac statistics are vital for understanding the structure of electronic energy levels and the properties of metals and semiconductors.

16. Which of the following metals possesses the highest melting point?

- (1) Sodium (Na)
- (2) Lithium (Li)
- (3) Potassium (K)
- (4) Cesium (Cs)

Correct Answer: (2) Lithium (Li).

Solution:

- Melting Point Trends in Alkali Metals:** In Group 1 of the periodic table, melting points decrease as atomic size increases. This occurs because:
 - Larger atomic sizes lead to weaker metallic bonding.
 - Lithium, being the smallest alkali metal, has the strongest metallic bonds and the highest melting point.
- Order of Melting Points:** $\text{Li} > \text{Na} > \text{K} > \text{Cs}$.

Quick Tip

The strength of metallic bonds decreases as you move down a group, leading to lower melting points.

17. The factors that influence the ionization energy are:

- Size of the atom
- Charge of the atom
- Size and charge of the atom
- Size, charge, and type of electron involved (s, p, d, or f)

Correct Answer: (4) Size, charge, and type of electron involved (s, p, d, or f).

Solution:

- Ionization Energy:** The energy required to remove an electron from a gaseous atom or ion.
- Factors Influencing Ionization Energy:**
 - Atomic Size:** Smaller atoms have higher ionization energy due to stronger attraction between the nucleus and valence electrons.
 - Nuclear Charge:** Higher nuclear charge increases ionization energy.
 - Type of Electron:** Electrons in different orbitals (s, p, d, f) experience different shielding and attraction to the nucleus. For example, s-electrons are harder to remove than p-electrons.

Quick Tip

Ionization energy increases across a period due to increasing nuclear charge and decreases down a group due to larger atomic size and increased shielding.

18. The number of gram molecules of a substance present in unit volume is termed as:

- (1) Activity
- (2) Normal solution
- (3) Molar concentration
- (4) Active mass

Correct Answer: (3) Molar concentration.

Solution:

1. **Molar Concentration (Molarity):** The number of moles (gram molecules) of a solute present in 1 liter of solution, expressed in moles per liter (mol/L).
2. **Other Terms:**
 - (a) **Activity:** Describes the effective concentration of a species in a solution.
 - (b) **Normal Solution:** Concentration expressed in equivalents per liter.
 - (c) **Active Mass:** An older term for molar concentration, mostly used in chemical kinetics.

Quick Tip

Molarity is one of the most common ways to express concentration in chemical calculations and stoichiometry.

19. Among the following molecules, the one with the highest dipole moment is:

- (1) CH_3Cl
- (2) CH_2Cl_2
- (3) CHCl_3

(4) CCl_4

Correct Answer: (1) CH_3Cl .

Solution:

1. **Dipole Moment:** A measure of the separation of positive and negative charges in a molecule. It depends on bond polarity and molecular geometry.
2. **Analysis of Molecules:**
 - (a) **CH_3Cl :** The carbon-chlorine bond is polar, and the tetrahedral geometry results in a significant net dipole moment pointing towards chlorine.
 - (b) **CH_2Cl_2 :** Contains two C-Cl bonds; the molecular geometry partially cancels some of the dipole, leading to a lower dipole moment than CH_3Cl .
 - (c) **CHCl_3 :** Contains three C-Cl bonds, but the dipole moments partially cancel due to the 3D tetrahedral geometry, reducing the net dipole moment further.
 - (d) **CCl_4 :** Perfectly symmetrical, with all bond dipoles canceling out, resulting in a net dipole moment of zero.
3. **Conclusion:** CH_3Cl has the highest dipole moment because it has only one polar C-Cl bond, and its geometry does not allow significant cancellation of the dipole.

Quick Tip

Dipole moments depend on both the polarity of bonds and the molecular geometry. Symmetrical molecules like CCl_4 have zero net dipole moments, even with polar bonds.

20. Toluene reacts with a halogen in the presence of iron (III) chloride giving ortho and para compounds. The reaction is:

- (1) Electrophilic addition reaction
- (2) Electrophilic substitution reaction
- (3) Free radical addition reaction
- (4) Nucleophilic substitution reaction

Correct Answer: (2) Electrophilic substitution reaction.

Solution:

1. **Electrophilic Substitution:** This reaction involves the replacement of a hydrogen atom in an aromatic ring with an electrophile.
2. **Mechanism of Reaction:**
 - (a) Toluene, an aromatic compound with a methyl group, undergoes halogenation in the presence of FeCl_3 .
 - (b) FeCl_3 acts as a Lewis acid catalyst, generating a halogen electrophile (X^+) from the halogen molecule.
 - (c) The electrophile attacks the benzene ring, replacing a hydrogen atom.
3. **Ortho-Para Directing Effect:** The methyl group ($-\text{CH}_3$) is an electron-donating group, which increases the electron density at the ortho and para positions of the benzene ring. As a result, the halogen substitutes preferentially at these positions.
4. **Conclusion:** The reaction is classified as an electrophilic substitution reaction because it involves the substitution of hydrogen by an electrophile in an aromatic system.

Quick Tip

Electrophilic substitution is the characteristic reaction of aromatic compounds. Groups like $-\text{CH}_3$ are ortho-para directing, influencing the position of incoming substituents.

21. Scanning tunneling microscope works on the principle of:

1. Quantum mechanical tunneling
2. Photoelectric effect
3. Stefan's Law
4. Meissner effect

Correct Answer: 1. Quantum mechanical tunneling.

Solution:

The scanning tunneling microscope (STM) operates using the principle of quantum mechanical tunneling. When a sharp conducting tip is brought very close to a conducting or

semiconducting surface, electrons can tunnel through the vacuum gap between the tip and the sample. This tunneling current depends on the distance between the tip and the sample and can be measured to produce atomic-resolution images of the surface.

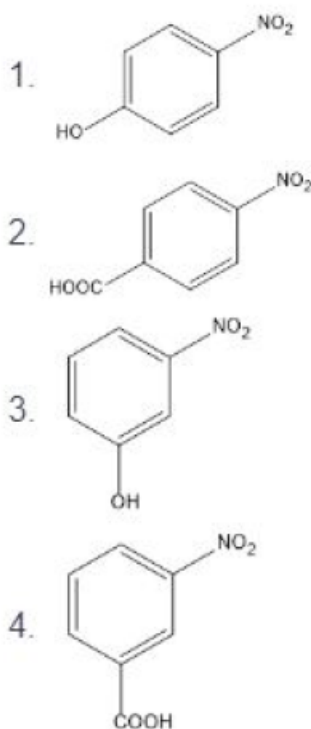
1. STM allows researchers to study surface properties at the atomic level, including individual atoms and molecules.
2. By scanning the tip across the surface and maintaining a constant tunneling current, the STM maps the topography of the surface.

Quick Tip

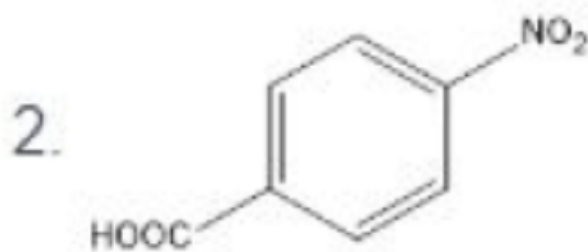
The STM provides unparalleled resolution because it utilizes quantum tunneling, a phenomenon sensitive to atomic-scale variations in distance.

22. Strongest acid among the following is:

Options:



Correct Answer:



Solution:

The structure shown as option 2 contains a nitro group ($-\text{NO}_2$), which is a strong electron-withdrawing group. This group stabilizes the conjugate base of the acid through resonance and inductive effects, significantly increasing the acid's strength.

1. Acidity is enhanced by electron-withdrawing groups as they lower the energy of the conjugate base.
2. Resonance stabilization further contributes to the acidity by delocalizing the negative charge of the conjugate base.

Quick Tip

Always identify electron-withdrawing and electron-donating groups when comparing acidity. Groups like $-\text{NO}_2$ significantly increase acidity by stabilizing the conjugate base.

23. The number of isomers for the compound with molecular formula C_2BrClFI is:

1. 3
2. 4
3. 5
4. 6

Correct Answer: 4. 6.

Solution:

Isomers are compounds with the same molecular formula but different structures. For C_2BrClFI , the possible isomers include structural and stereoisomers.

1. Structural isomers differ in the connectivity of atoms.
2. Stereoisomers differ in the spatial arrangement of atoms.
3. The molecule $C_2BrClFI$ can have 6 possible arrangements based on the different ways the substituents can be positioned around the carbon atoms.

Quick Tip

To find isomers, systematically consider all possible arrangements, including geometrical and optical isomers.

24. Which of the following statement is incorrect about sucrose?

1. Ordinary table sugar is called sucrose
2. Sucrose is a disaccharide
3. Sucrose has a molecular formula of $C_{12}H_{22}O_{11}$
4. Sucrose gives positive test with Benedict's and Tollens' solution

Correct Answer: 4. Sucrose gives positive test with Benedict's and Tollens' solution.

Solution:

Sucrose is a non-reducing sugar because it does not have a free aldehyde or ketone group. In sucrose, the glucose and fructose units are linked via their anomeric carbons, preventing the molecule from participating in redox reactions with Benedict's or Tollens' reagent.

1. Reducing sugars react with Benedict's or Tollens' solutions to form a precipitate due to the reduction of Cu^{2+} or Ag^+ ions.
2. Sucrose lacks this reactivity because its glycosidic bond prevents the opening of the sugar ring to form an aldehyde or ketone.

Quick Tip

Non-reducing sugars like sucrose do not react with Benedict's solution. Always check for the presence of free aldehyde or ketone groups.

25. Which of the following are called artificial atoms?

1. Electrons
2. Molecules
3. Quantum dots
4. H-atom

Correct Answer: 3. Quantum dots.

Solution:

Quantum dots are nanoscale semiconductor particles that exhibit discrete energy levels due to quantum confinement. This property makes their electronic behavior similar to that of isolated atoms, earning them the nickname "artificial atoms."

1. The size of quantum dots controls their electronic and optical properties.
2. Smaller quantum dots have higher energy gaps, resulting in unique fluorescence colors.

Quick Tip

Quantum dots are widely used in imaging, solar cells, and quantum computing due to their tunable properties.

26. Which scientist is often referred to as the Father of Nanotechnology?

1. Albert Einstein
2. Max Planck
3. Niels Bohr
4. Richard Feynman

Correct Answer: 4. Richard Feynman.

Solution:

Richard Feynman is considered the "Father of Nanotechnology" due to his groundbreaking ideas presented in his famous 1959 lecture, "There's Plenty of Room at the Bottom." In this lecture, Feynman envisioned the manipulation of individual atoms and molecules to build

devices at an atomic scale, which laid the foundation for nanotechnology as we know it today.

1. He suggested that it would be possible to write the entire Encyclopedia Britannica on the head of a pin by controlling matter at the nanoscale.
2. Feynman also introduced the concept of nanoscale machines, which are now a reality in the form of nanorobots and molecular assemblers.

Quick Tip

Feynman's visionary ideas in the 1950s inspired decades of advancements in nanoscience and nanotechnology, revolutionizing multiple fields such as medicine, electronics, and materials science.

27. X-rays are used for the determination of crystal structure because:

1. They can travel in vacuum
2. They are mechanical waves
3. Their wavelength is of the same order as interplanar spacing in crystals
4. Their speed changes with the change of medium

Correct Answer: 3. Their wavelength is of the same order as interplanar spacing in crystals.

Solution:

X-rays are ideal for determining crystal structures because their wavelengths (approximately 0.1–10 nm) are comparable to the distances between atomic planes in a crystal lattice. This allows X-rays to diffract when they interact with the crystal, following Bragg's law:

$$n\lambda = 2d \sin \theta$$

where:

1. n is the order of diffraction,
2. λ is the wavelength of X-rays,

3. d is the interplanar spacing, and
4. θ is the angle of incidence.

The diffraction pattern obtained can be analyzed to deduce the arrangement of atoms in the crystal.

Quick Tip

X-ray diffraction is a cornerstone technique in materials science, enabling the study of atomic arrangements, phase identification, and lattice defects.

28. Carbon nanotubes are ____ nanostructures:

1. Zero-dimensional
2. One-dimensional
3. Two-dimensional
4. Three-dimensional

Correct Answer: 2. One-dimensional.

Solution:

Carbon nanotubes (CNTs) are classified as one-dimensional (1D) nanostructures because their length is much greater than their diameter, typically in the range of a few nanometers.

1. CNTs can be single-walled (SWCNT) or multi-walled (MWCNT), depending on the number of graphene layers rolled into tubes.
2. Their unique 1D structure imparts exceptional electrical, mechanical, and thermal properties, such as high conductivity and tensile strength.

Quick Tip

Carbon nanotubes have diverse applications in fields like nanotechnology, materials science, energy storage, and biomedicine.

29. Tendency of an atom to attract electrons to itself when combined in a group is called:

1. Workfunction
2. Electronegativity
3. Polarization
4. Catenation

Correct Answer: 2. Electronegativity.

Solution:

Electronegativity refers to the ability of an atom to attract shared electrons in a chemical bond. This property is influenced by:

1. Atomic size: Smaller atoms have higher electronegativity because their nuclei can exert a stronger pull on bonding electrons.
2. Nuclear charge: Atoms with more protons in the nucleus have higher electronegativity.

For example, fluorine is the most electronegative element, with an electronegativity of 3.98 on the Pauling scale.

Quick Tip

Electronegativity trends: It increases across a period (left to right) and decreases down a group in the periodic table.

30. Which of the following diode is used in voltage-regulation circuits?

1. Photodiode
2. Light Emitting Diode (LED)
3. Tunnel diode
4. Zener diode

Correct Answer: 4. Zener diode.

Solution:

Zener diodes are designed to operate in the reverse breakdown region. They maintain a constant output voltage across a load by allowing current to flow in reverse when the applied voltage reaches the Zener breakdown voltage. This makes them ideal for voltage regulation in power supply circuits.

1. Zener diodes can protect sensitive electronic components by limiting voltage surges.
2. Their ability to stabilize voltage is crucial in DC power supplies and voltage reference circuits.

Quick Tip

Zener diodes are indispensable in electronics for voltage regulation and protection against voltage spikes.

31. In a bipolar junction transistor:

1. Collector Current I_C = Emitter Current I_E + Base Current I_B
2. Emitter Current I_E = Collector Current I_C + Base Current I_B
3. Base Current I_B = Emitter Current I_E + Collector Current I_C
4. Base, emitter, and collector currents are equal.

Correct Answer: 2. Emitter Current I_E = Collector Current I_C + Base Current I_B .

Solution:

In a bipolar junction transistor (BJT), the emitter current (I_E) is the sum of the collector current (I_C) and the base current (I_B). This is derived from Kirchhoff's Current Law (KCL), which states that the sum of currents entering a junction equals the sum of currents leaving the junction. For a BJT:

$$I_E = I_C + I_B$$

1. The base current is typically very small compared to the emitter and collector currents.
2. This relationship is key to understanding transistor operation and amplification.

Quick Tip

In practical terms, the emitter current is slightly larger than the collector current because of the small base current.

32. Photons are classified as:

1. Fermions
2. Bosons
3. Classical Particles
4. Nucleons

Correct Answer: 2. Bosons.

Solution:

Photons are classified as bosons because they have an integer spin ($s = 1$) and follow Bose-Einstein statistics. Unlike fermions, bosons do not obey the Pauli exclusion principle, meaning multiple photons can occupy the same quantum state.

1. Photons are the force carriers of the electromagnetic interaction.
2. Other bosons include W and Z bosons, gluons, and the Higgs boson.

Quick Tip

Bosons enable fundamental forces in nature, with photons specifically mediating electromagnetic interactions.

33. Which of the following statement is incorrect about Silicon?

1. Its atomic number is 14
2. It has semiconducting nature
3. It is a direct band gap semiconductor
4. Silicon is the backbone of semiconductor industry

Correct Answer: 3. It is a direct band gap semiconductor.

Solution:

Silicon is an indirect band gap semiconductor, meaning the conduction band minimum and valence band maximum occur at different momentum values. This makes radiative recombination less efficient compared to direct band gap semiconductors like gallium arsenide (GaAs).

1. Silicon has an atomic number of 14 and forms the basis of the modern semiconductor industry.
2. Its properties as a semiconductor make it ideal for use in electronic devices like transistors and integrated circuits.

Quick Tip

Direct band gap materials are preferred for optoelectronic applications, while silicon dominates microelectronics due to its abundance and processability.

34. Meissner effect is a phenomenon of:

1. Perfect diamagnetism
2. Perfect paramagnetism
3. Perfect ferromagnetism
4. Perfect antiferromagnetism

Correct Answer: 1. Perfect diamagnetism.

Solution:

The Meissner effect is the expulsion of magnetic fields from a superconductor when it is cooled below its critical temperature. This results in perfect diamagnetism, where the magnetic susceptibility (χ) is -1 .

1. It demonstrates the transition of a material to the superconducting state.
2. This effect is a defining property of superconductors, alongside zero electrical resistance.

Quick Tip

The Meissner effect is crucial for applications like magnetic levitation and lossless current conduction.

35. Which of the following process is carried out at constant pressure?

1. Isothermal Process
2. Isobaric Process
3. Adiabatic Process
4. Isochoric Process

Correct Answer: 2. Isobaric Process.

Solution:

An isobaric process occurs when the pressure of the system remains constant while the volume and temperature may change. Examples include heating or cooling a gas in a piston-cylinder setup at constant external pressure.

1. In an isothermal process, temperature remains constant.
2. In an adiabatic process, no heat exchange occurs.
3. In an isochoric process, volume remains constant.

Quick Tip

The isobaric process is commonly encountered in thermodynamics, such as during phase changes at constant atmospheric pressure.

36. Which among the following would be a linear species?

1. ICl_2^-
2. IF_6^-
3. I_3^-
4. H_2O

Correct Answer: 3. I_3^-

Solution:

The I_3^- ion has a linear geometry because of the arrangement of electron pairs around the central iodine atom. According to the Valence Shell Electron Pair Repulsion (VSEPR) theory:

1. I_3^- has three iodine atoms, with the central iodine having three lone pairs of electrons.
2. The linear shape arises as the lone pairs arrange themselves to minimize repulsion, leaving the bond angle between the two bonded iodine atoms at 180° .

Quick Tip

Linear species are characterized by a bond angle of 180° and occur when the central atom has no lone pairs or when lone pairs are symmetrically arranged.

37. In gram staining, cell walls of Gram-positive bacteria become dehydrated during treatment with alcohol due to:

1. Lower Lipid Content
2. Higher Lipid Content
3. Lower Protein Content
4. Higher Protein Content

Correct Answer: 1. Lower Lipid Content.

Solution:

Gram-positive bacteria have a thick peptidoglycan layer in their cell walls, which contains very low lipid content. When treated with alcohol:

1. The alcohol dehydrates the peptidoglycan layer, causing it to shrink and trap the crystal violet-iodine complex.
2. This makes Gram-positive bacteria retain the purple stain.
3. Gram-negative bacteria, having a higher lipid content, lose the stain as the alcohol dissolves their outer membrane.

Quick Tip

Gram staining distinguishes bacteria based on their cell wall composition, a critical step in microbiological identification.

38. Which is the polymer of Fructose?

1. Starch
2. Glycogen
3. Inulin
4. Cellulose

Correct Answer: 3. Inulin.

Solution:

Inulin is a polysaccharide made up of fructose units linked by β -(2 $\rightarrow$ 1) glycosidic bonds. It serves as a storage carbohydrate in many plants, including chicory, Jerusalem artichokes, and onions.

1. Unlike starch (polymer of glucose), inulin cannot be digested by human enzymes but serves as dietary fiber.
2. It is also used as a prebiotic, promoting the growth of beneficial gut bacteria.

Quick Tip

Inulin is important in health sciences for its role in promoting digestive health and regulating blood sugar levels.

39. Which of the following is a thiol-containing amino acid?

1. Cysteine
2. Glycine
3. Serine
4. Tryptophan

Correct Answer: 1. Cysteine.

Solution:

Cysteine is a sulfur-containing amino acid with a thiol (-SH) group in its side chain. This group:

1. Enables cysteine to form disulfide bonds (-S-S-) when oxidized, which are crucial for protein structure stabilization.
2. Plays a role in enzyme active sites due to its ability to form reactive thiol intermediates.

Other amino acids listed do not contain sulfur in their side chains.

Quick Tip

Cysteine's thiol group is vital for maintaining the three-dimensional structure of proteins like keratin and insulin.

40. The antigen specificity of a particular B cell:

1. Is induced by interaction with antigen
2. Is due to light chain of antibody
3. Is due to heavy chain of antibody
4. Is determined by heavy and light chain variable region sequence

Correct Answer: 4. Is determined by heavy and light chain variable region sequence.

Solution:

The antigen-binding specificity of a B cell is determined by the unique sequence in the variable regions of the heavy and light chains of its antibodies. These regions:

1. Form the antigen-binding site and are highly diverse due to somatic recombination.
2. Allow B cells to recognize a vast array of antigens.
3. Are critical for adaptive immunity, enabling specific responses to pathogens.

Quick Tip

Antibody diversity stems from the genetic recombination of the variable regions in the heavy and light chains during B cell development.

41. Which of the following properties is not exhibited by T_H cells?

1. Stimulate division of B cells
2. Are cytotoxic for other cells
3. Stimulate division of cytotoxic T cells
4. Stimulate migration of macrophages

Correct Answer: 3. Stimulate division of cytotoxic T cells

Solution:

Helper T cells (T_H cells) play a crucial role in the immune system by regulating and coordinating immune responses. They perform several functions, including:

- **Stimulating B cell division and antibody production:** T_H cells help B cells proliferate and differentiate into plasma cells for the production of specific antibodies.
- **Activating cytotoxic T cells:** Through the secretion of cytokines like interleukin-2 (IL-2), T_H cells support the activation and expansion of cytotoxic T cells, which are directly responsible for killing infected or cancerous cells.
- **Stimulating macrophage activity:** T_H cells secrete interferon-gamma ($IFN-\gamma$), enhancing the phagocytic and microbicidal activity of macrophages.

However, **T_H cells themselves are not cytotoxic and do not kill other cells.** The cytotoxic function is exclusively performed by cytotoxic T cells (T_C cells or $CD8^+$ cells), not by helper T cells ($CD4^+$ cells). Thus, the property "cytotoxic for other cells" is not exhibited by T_H cells.

Quick Tip

Helper T cells (T_H cells) are like the "managers" of the immune system. They coordinate immune responses through cytokine signaling but do not directly attack or kill other cells. This function is carried out by cytotoxic T cells.

42. In germ line gene therapy, healthy gene is inserted into:

1. Hepatic cells
2. Fibroblast cells
3. Endothelium
4. Sperms or Eggs

Correct Answer: 4. Sperms or Eggs.

Solution:

Germ line gene therapy involves introducing a functional gene into germ cells (sperms or eggs) or embryos. This ensures that the genetic modification is inheritable and passed on to future generations, potentially eliminating genetic disorders permanently.

Quick Tip

Unlike somatic gene therapy, germ line therapy modifies reproductive cells, making the changes heritable.

43. Restriction Endonuclease type I is involved in:

1. Endonuclease and Methylase
2. Cleaving and Methylation
3. Cut DNA within palindromic sequences
4. Cut DNA within non-palindromic sequences

Correct Answer: 1. Endonuclease and Methylase.

Solution:

Type I restriction enzymes have both endonuclease and methyltransferase activities. They recognize specific DNA sequences, cleave DNA at random locations far from the recognition site, and methylate specific bases, protecting host DNA from cleavage.

Quick Tip

Type I enzymes are less precise than Type II restriction enzymes, which cut at or near their recognition sites.

44. The Ti plasmid of *Agrobacterium tumefaciens* contains a transposon called:

1. T DNA
2. R DNA
3. cDNA
4. A DNA

Correct Answer: 1. T DNA.

Solution:

The Ti (tumor-inducing) plasmid in *Agrobacterium tumefaciens* contains a segment of DNA called T DNA, which is transferred to the plant genome during infection. This causes tumor formation in plants but is widely used in genetic engineering to introduce foreign genes into plants.

Quick Tip

The Ti plasmid is a powerful tool in creating genetically modified plants for agriculture and research.

45. Nitrogenase enzyme involved in nitrogen fixation works best in:

1. Aerobic conditions
2. Anaerobic conditions
3. Insensitive to oxygen
4. Both aerobic and anaerobic conditions

Correct Answer: 2. Anaerobic conditions.

Solution:

Nitrogenase is highly sensitive to oxygen, as it is irreversibly inactivated by it. Anaerobic conditions or protective mechanisms like leghemoglobin in nitrogen-fixing nodules create an oxygen-free environment, enabling the enzyme to function effectively.

Quick Tip

Nitrogenase converts atmospheric nitrogen (N_2) into ammonia (NH_3), essential for plant growth, under anaerobic conditions.

46. Arrange the following electromagnetic radiations in the order of decreasing wavelength:

- A. Microwaves
- B. Gamma rays
- C. X-rays
- D. Visible rays

Choose the correct answer from the options given below:

- (1) (A), (D), (C), (B)
- (2) (B), (C), (D), (A)
- (3) (B), (A), (D), (C)
- (4) (C), (B), (D), (A)

Correct Answer: (1) (1), (4), (3), (2)

Solution:

Electromagnetic radiation can be ordered by wavelength as follows:

1. **Microwaves:** Longest wavelength, low energy.
2. **Visible rays:** Intermediate wavelength, can be detected by the human eye.
3. **X-rays:** Shorter wavelength than visible light, higher energy.
4. **Gamma rays:** Shortest wavelength, highest energy.

Thus, the order of decreasing wavelength is Microwaves > Visible rays > X-rays > Gamma rays.

Quick Tip

Wavelength and energy are inversely proportional; longer wavelengths correspond to lower energy and vice versa.

47. Which of the following is correct about electromagnetic waves?

- A. Sound waves are electromagnetic in nature
- B. They travel in vacuum
- C. Electromagnetic waves are longitudinal (formation of compression and rarefaction) in nature
- D. X-rays are electromagnetic in nature

Choose the correct answer from the options given below:

- (1) (A), (D), and (D) only
- (2) (A), (B), and (C) only
- (3) (B) only
- (4) (B) and (D) only

Correct Answer: (4) (B) and (D) only

Solution:

Electromagnetic waves:

1. Travel through vacuum, unlike sound waves, which require a medium.
2. Are transverse waves, characterized by oscillating electric and magnetic fields perpendicular to the direction of wave propagation.
3. Include X-rays, a high-energy form of electromagnetic radiation.

Thus, only options (B) and (D) are correct.

Quick Tip

Electromagnetic waves differ from mechanical waves (like sound), as they can propagate through a vacuum.

48. Which of the following statement is correct?

- A. The stronger the acid, the weaker will be its conjugate base
- B. The stronger the acid, the stronger will be its conjugate base
- C. The larger the pK_a of the conjugate acid, the weaker is its base
- D. The larger the pK_a of the conjugate acid, the stronger is its base

Choose the correct answer from the options given below:

- (1) D only
- (2) B and C only
- (3) A and D only
- (4) B only

Correct Answer: (3) A and D only

Solution:

1. A strong acid dissociates completely, producing a weak conjugate base with little tendency to accept protons.
2. The pK_a value indicates the strength of an acid; a larger pK_a corresponds to a weaker acid, making its conjugate base stronger.

Thus, statements (A) and (D) are correct.

Quick Tip

The relationship between acids and their conjugate bases is inversely proportional: stronger acids yield weaker conjugate bases.

49. All the metal halides have negative enthalpies of formation. Thermodynamically feasible from them. Arrange the following halides from most to least negative enthalpies of formation for any given metal:

- A. Iodide
- B. Chloride

C. Bromide

D. Fluoride

Choose the correct answer from the options given below:

(1) (A), (C), (B), (D)

(2) (A), (B), (C), (D)

(3) (D), (B), (C), (A)

(4) (D), (C), (B), (A)

Correct Answer: (3) (D), (B), (C), (A)

Solution:

The enthalpy of formation of metal halides depends on several factors, including lattice energy and the size of the halide ion. Lattice energy is the energy released when oppositely charged ions combine to form a lattice.

- **Fluoride (D):** Fluoride ions are the smallest halide ions, leading to a very high lattice energy when combined with metals. This results in the most negative enthalpy of formation among the halides.
- **Chloride (B):** Chloride ions are larger than fluoride ions, but they still have a relatively high lattice energy compared to bromide and iodide, resulting in the next most negative enthalpy of formation.
- **Bromide (C):** Bromide ions are larger than chloride ions, so the lattice energy decreases further, leading to a less negative enthalpy of formation.
- **Iodide (A):** Iodide ions are the largest halide ions, resulting in the lowest lattice energy and, consequently, the least negative enthalpy of formation.

Thus, the order of enthalpies of formation from most to least negative is **Fluoride** > **Chloride** > **Bromide** > **Iodide**.

Quick Tip

Smaller ions form stronger ionic bonds, resulting in more negative enthalpies of formation.

50. Arrange the following oxoacids in the order of their increasing acidic strength:

- A. HOCl
- B. HOClO
- C. HOClO₂
- D. HOClO₃

Choose the correct answer from the options given below:

- (1) (D), (C), (A), (B)
- (2) (B), (A), (C), (D)
- (3) (A), (B), (C), (D)
- (4) (C), (A), (B), (D)

Correct Answer: (3) (A), (B), (C), (D)

Solution:

The acidic strength of oxoacids increases with the number of oxygen atoms attached to the central atom, as these increase the stability of the conjugate base through resonance: $\text{HOCl} < \text{HOClO} < \text{HOClO}_2 < \text{HOClO}_3$.

Quick Tip

More oxygen atoms in oxoacids enhance conjugate base stability, leading to increased acidity.

51. Arrange the following in the order of increasing basic strength:

- (A) NH₃
- (B) PH₃
- (C) AsH₃
- (D) BiH₃

Choose the correct answer from the options given below:

- 1. (A), (C), (B), (D)
- 2. (A), (B), (C), (D)

3. (B), (D), (C), (A)

4. (D), (C), (B), (A)

Correct Answer: (4) (D), (C), (B), (A)

Solution:

The basic strength of group 15 hydrides decreases down the group as the atomic size increases and the lone pair of electrons becomes less available for donation. Ammonia (NH_3) is the strongest base because it is small, and the lone pair is highly accessible. As we move down the group, the atoms (P, As, Bi) get larger, and the lone pair becomes more diffuse and less effective in bonding. Therefore, the order of increasing basic strength is: $\text{BiH}_3 < \text{AsH}_3 < \text{PH}_3 < \text{NH}_3$.

Quick Tip

The availability of the lone pair for bonding determines basic strength. Smaller atoms with concentrated lone pairs are stronger bases.

52. Arrange the following in decreasing order of nucleophilicity:

(A) H_2O

(B) NH_3

(C) OH^-

(D) NH_2^-

Choose the correct answer from the options given below:

1. (A), (B), (C), (D)

2. (D), (C), (B), (A)

3. (C), (D), (B), (A)

4. (D), (B), (C), (A)

Correct Answer: (2) (D), (C), (B), (A)

Solution:

Nucleophilicity refers to the tendency of a species to donate its lone pair to form a bond.

Factors affecting nucleophilicity include charge, electronegativity, and the solvent. Anionic

species like NH_2^- and OH^- are stronger nucleophiles than neutral species like NH_3 and H_2O because the negative charge increases their electron density. NH_2^- is the strongest nucleophile as nitrogen is less electronegative than oxygen, making its lone pair more available for bonding. Therefore, the order is $\text{NH}_2^- > \text{OH}^- > \text{NH}_3 > \text{H}_2\text{O}$.

Quick Tip

Nucleophilicity increases with negative charge and decreases with increasing electronegativity and solvent effects.

53. The correct order of steps in PCR is:

- (A) Annealing
- (B) Denaturation
- (C) Extension

Choose the correct answer from the options given below:

1. (A), (B), (C)
2. (B), (A), (C)
3. (B), (C), (A)
4. (C), (B), (A)

Correct Answer: (2) (B), (A), (C)

Solution:

Polymerase Chain Reaction (PCR) involves three main steps:

1. **Denaturation:** The reaction mixture is heated to approximately 95°C to separate the double-stranded DNA into single strands.
2. **Annealing:** The temperature is lowered to $50\text{--}65^\circ\text{C}$ to allow primers to bind to their complementary sequences on the single-stranded DNA.
3. **Extension:** The temperature is raised to around 72°C , the optimum temperature for Taq DNA polymerase, which synthesizes the new DNA strand by adding nucleotides to the primers.

These steps are repeated in cycles to exponentially amplify the DNA sequence of interest.

Quick Tip

PCR amplification depends on the precise temperature cycling for denaturation, annealing, and extension.

54. Which of the following enzymes of Krebs' cycle is also involved in the mitochondrial electron transport system?

- (A) Citrate synthase
- (B) Succinate dehydrogenase
- (C) Malate dehydrogenase
- (D) Isocitrate dehydrogenase

Correct Answer: (B) Succinate dehydrogenase

Solution:

Succinate dehydrogenase is a unique enzyme that functions in both the Krebs' cycle and the mitochondrial electron transport chain. In the Krebs' cycle, it catalyzes the oxidation of succinate to fumarate. Simultaneously, it transfers electrons from FADH_2 to ubiquinone (Coenzyme Q) in the electron transport chain, contributing to ATP production.

Quick Tip

Succinate dehydrogenase is the only enzyme embedded in the inner mitochondrial membrane, linking two key energy-producing processes.

55. Sequential steps of Prophase of Meiosis I:

- (A) Zygotene
- (B) Pachytene
- (C) Leptotene
- (D) Diakinesis
- (E) Diplotene

Choose the correct answer from the options given below:

1. (A), (B), (C), (E), (D)
2. (C), (A), (B), (E), (D)
3. (B), (E), (D), (C), (A)
4. (C), (B), (D), (E), (A)

Correct Answer: (2) (C), (A), (B), (E), (D)

Solution:

Prophase I of meiosis is divided into five stages:

1. **Leptotene:** Chromosomes condense and become visible under a microscope.
2. **Zygotene:** Homologous chromosomes pair up and form synaptonemal complexes (synapsis).
3. **Pachytene:** Crossing-over occurs between homologous chromosomes, exchanging genetic material.
4. **Diplotene:** Synaptonemal complexes disassemble, and chiasmata (cross-over points) become visible.
5. **Diakinesis:** Chromosomes condense further, and chiasmata move to terminal positions, preparing for separation.

Quick Tip

Use the mnemonic "Lazy Zebras Paint Dotted Designs" to recall the sequence: Leptotene, Zygotene, Pachytene, Diplotene, Diakinesis.

56. The conditions for a reversible isothermal process are:

- (A) Infinitesimally slow process
- (B) Infinitely fast process
- (C) Constant Pressure
- (D) Constant Temperature

Choose the correct answer from the options given below:

1. (A) and (D) only.
2. (A), (C), and (D) only.

3. (B), (C), and (D) only.
4. (D) only.

Correct Answer: (1) (A) and (D) only.

Solution:

A reversible isothermal process occurs when the temperature remains constant throughout the process ($T = \text{constant}$), and the process is carried out infinitesimally slowly. This ensures that the system is in equilibrium with its surroundings at all times, allowing for maximum energy exchange without dissipation.

Quick Tip

For isothermal processes, heat exchange with surroundings maintains constant temperature, and infinitesimally slow execution ensures reversibility.

57. Crystalline materials possess:

- (A) Sharp melting point and boiling point
- (B) Anisotropic properties
- (C) Periodic arrangement of atoms
- (D) Isotropic properties

Choose the correct answer from the options given below:

1. (A), (C), and (D) only
2. (A) and (C) only
3. (A), (B), and (D) only
4. (C) and (D) only

Correct Answer: (2) (A) and (C) only.

Solution:

Crystalline materials exhibit a periodic arrangement of atoms in a lattice structure, leading to sharp melting and boiling points due to uniform bonding throughout the material. These materials are anisotropic, meaning their physical properties vary with direction. Isotropic

properties, where properties are identical in all directions, are characteristic of amorphous materials.

Quick Tip

Crystalline solids have a highly ordered atomic arrangement, resulting in distinct melting points and anisotropic properties.

58. Which of the following are the correct postulates of the quantum theory of light?

- (A) Each photon of frequency ν has the energy $h\nu$, the same as Planck's energy.
- (B) The higher ν , the greater the photon energy $h\nu$.
- (C) Blue color has lower energy than green color.
- (D) Changing the intensity of the incident light beam will change the frequency ν of the photon.

Choose the correct answer from the options given below:

1. (A), (B), and (C) only.
2. (A), (B), and (D) only.
3. (A) and (B) only.
4. (A) and (D) only.

Correct Answer: (3) (A) and (B) only.

Solution:

The quantum theory of light states that light consists of photons, each carrying energy $E = h\nu$, where h is Planck's constant and ν is the frequency. Photon energy increases with frequency. The statement that "blue color has lower energy than green color" is incorrect, as blue has a higher frequency and thus more energy. Changing the intensity of light affects the number of photons but does not alter their frequency.

Quick Tip

Photon energy depends on frequency, not intensity. Higher frequency light, like blue, carries more energy than lower frequency light.

59. The following species have an equal number of electrons. Arrange them in increasing order of their size:

- (A) Ne
- (B) Na^+
- (C) O^{2-}
- (D) F^-

Choose the correct answer from the options given below:

- 1. (A), (B), (C), (D)
- 2. (B), (C), (A), (D)
- 3. (B), (A), (D), (C)
- 4. (D), (C), (A), (B)

Correct Answer: (3) (B), (A), (D), (C)

Solution:

The size of isoelectronic species depends on the nuclear charge. Higher nuclear charge pulls electrons closer, resulting in a smaller size. Na^+ , with the highest nuclear charge, is the smallest. Ne follows, as it is neutral. F^- is larger than Ne due to added electron repulsion, and O^{2-} is the largest due to even greater repulsion among electrons.

Quick Tip

For isoelectronic species, the size decreases as the nuclear charge increases. Cations are smaller, while anions are larger.

60. Identify the correct statements with reference to VSEPR theory:

- (A) Lone pairs cause more repulsion than double bonds.
- (B) Double bonds cause more repulsion than a single bond.
- (C) Triple bonds cause more repulsion than a double bond.
- (D) Single bonds cause more repulsion than a lone pair.

Choose the correct answer from the options given below:

1. (A), (B), and (C) only.
2. (B) and (C) only.
3. (A) and (B) only.
4. (B), (C), and (D) only.

Correct Answer: (2) (B) and (C) only.

Solution:

According to the VSEPR theory, electron pairs repel each other to minimize repulsion and determine molecular geometry. Lone pairs exert the strongest repulsion, followed by triple bonds, double bonds, and single bonds. Thus, double bonds cause more repulsion than single bonds, and triple bonds cause more repulsion than double bonds.

Quick Tip

Electron repulsion order: Lone pair > Triple bond > Double bond > Single bond. This determines bond angles in molecules.

61. Which of the following arrangements does not represent the correct order of properties stated against it?

- (A) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: Paramagnetic behavior
(B) $Zn^{2+} < Ni^{2+} < Cr^{2+} < Fe^{2+}$: Number of unpaired electrons
(C) $Sc^{3+} < Ti^{3+} < V^{3+} < Cr^{3+} < Mn^{3+}$: Number of oxidation states
(D) $Co^{2+} < Cr^{2+} < Mn^{2+} < Ni^{2+}$: Stability in aqueous solution

Choose the correct answer from the options given below:

1. (A), (B) and (C) only.
2. (A) and (C) only.
3. (A), (B) and (D).
4. (B), (C) and (D) only.

Correct Answer: (3) (A), (B) and (D).

Solution:

The paramagnetic behavior in option (A) does not follow the expected order because Fe^{2+} should have fewer unpaired electrons than Mn^{2+} . In option (B), Cr^{2+} has more unpaired electrons than Ni^{2+} , contradicting the stated sequence. Finally, the stability order in aqueous solution for option (D) does not correctly align with experimental observations.

Quick Tip

Properties such as paramagnetic behavior and stability depend on electronic configuration, ligand field stabilization, and experimental conditions.

62. The process of vulcanization makes rubber:

- (A) Soluble in water
- (B) Elastic
- (C) Hard
- (D) Soft

Choose the correct answer from the options given below:

1. (A), (B) and (D) only.
2. (B) and (C) only.
3. (B) and (D).
4. (B) only.

Correct Answer: (2) (B) and (C) only.

Solution:

Vulcanization introduces sulfur cross-links between the polymer chains of rubber. This enhances the material's elasticity and hardness, making it suitable for industrial applications such as tires and seals.

Quick Tip

Vulcanization improves the durability, elasticity, and resistance of rubber to temperature changes.

63. Which of the following will give benzoic acid on acidic hydrolysis?

- (A) Phenyl cyanide
- (B) Benzimidazole
- (C) Benzoic anhydride
- (D) Methyl benzoate

Choose the correct answer from the options given below:

1. (A) and (D) only.
2. (A), (C) and (D) only.
3. (A), (B), (C) and (D).
4. (C) and (D) only.

Correct Answer: (2) (A), (C) and (D) only.

Solution:

Phenyl cyanide undergoes hydrolysis in acidic conditions to produce benzoic acid. Similarly, benzoic anhydride and methyl benzoate yield benzoic acid upon hydrolysis. Benzimidazole does not produce benzoic acid.

Quick Tip

Compounds containing functional groups such as nitriles, esters, and anhydrides can be hydrolyzed to form carboxylic acids.

64. Match List-I with List-II:

List-I	List-II
(A) CCl_4	(i) Refrigerant
(B) $\text{C}_6\text{F}_6\text{Cl}_6$	(ii) Insecticide
(C) CHCl_3	(iii) Propellant for aerosols
(D) CH_2Cl_2	(iv) Antiseptic for wounds

Choose the correct answer from the options given below:

1. (A) - (iii), (B) - (i), (C) - (ii), (D) - (iv).
2. (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii).

3. (A) - (i), (B) - (ii), (C) - (iv), (D) - (iii).

4. (A) - (iii), (B) - (iv), (C) - (i), (D) - (ii).

Correct Answer: (2) (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii).

Solution:

Each compound in List-I is matched with its respective application in List-II based on its chemical properties and usage:

- **(A) CCl_4 :** Carbon tetrachloride is primarily used as an insecticide due to its chemical properties.
- **(B) $\text{C}_6\text{F}_6\text{Cl}_6$:** Hexachlorofluorobenzene is commonly used as a refrigerant due to its stable and non-flammable nature.
- **(C) CHCl_3 :** Chloroform is widely used as an antiseptic for cleaning wounds.
- **(D) CH_2Cl_2 :** Dichloromethane (methylene chloride) is used as a propellant for aerosols due to its volatility and low toxicity in small amounts.

Thus, the correct match is (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii).

Quick Tip

Relate the chemical properties of compounds to their specific industrial applications.

65. Two metals are completely miscible with each other to form a continuous range of solid solutions only if:

- (A) Two metals must be similar in size—their metallic radii must not differ by more than 15%.
- (B) Both metals must have the same crystal structure.
- (C) The chemical properties must be similar—particularly the same electronegativity.
- (D) Both metals must have the same electrical conductivity.

Choose the correct answer from the options given below:

1. (A) and (D) only.

2. (A), (B) and (C) only.
3. (A), (B), (C) and (D).
4. (B) and (C) only.

Correct Answer: (2) (A), (B) and (C) only.

Solution:

According to Hume-Rothery rules, the metals must have similar atomic radii (within 15%), the same crystal structure, and comparable electronegativity to form a continuous solid solution.

Quick Tip

Hume-Rothery rules help in predicting the miscibility of metals based on size, structure, and electronegativity.

66. Arrange the following structures in terms of increasing order of confinement:

- (A) Quantum Well
- (B) Bulk Material
- (C) Quantum Dot
- (D) Carbon Nanotube

Choose the correct answer from the options given below:

1. (A), (B), (C), (D)
2. (B), (A), (D), (C)
3. (C), (B), (A), (D)
4. (D), (B), (C), (A)

Correct Answer: (2) (B), (A), (D), (C).

Solution:

Confinement refers to the restriction of particle movement. Bulk materials have no confinement (free movement in all dimensions), quantum wells restrict motion in one dimension, carbon nanotubes restrict motion in two dimensions, and quantum dots restrict motion in all three dimensions (highest confinement).

Quick Tip

The degree of confinement increases with reduced dimensions of freedom for particle movement.

67. Match List-I with List-II:

List-I (System)	List-II (Axial lengths and angles)
(A) Cubic	(I) $a = b = c, \alpha = \beta = \gamma = 90^\circ, \gamma = 120^\circ$
(B) Tetragonal	(II) $a \neq b = c, \alpha = \beta = \gamma = 90^\circ$
(C) Orthorhombic	(III) $a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$
(D) Hexagonal	(IV) $a = b \neq c, \alpha = \beta = 90^\circ, \gamma = 120^\circ$

Choose the correct answer from the options given below:

1. (A) - (IV), (B) - (II), (C) - (III), (D) - (I)
2. (A) - (I), (B) - (III), (C) - (II), (D) - (IV)
3. (A) - (IV), (B) - (II), (C) - (I), (D) - (III)
4. (A) - (IV), (B) - (III), (C) - (II), (D) - (I)

Correct Answer: 2. (A) - (I), (B) - (III), (C) - (II), (D) - (IV).

Solution:

The classification of crystal systems is based on axial lengths and interaxial angles:

- **(A) Cubic:** All sides are equal ($a = b = c$), and all angles are 90° . This corresponds to (I).
- **(B) Tetragonal:** Two sides are equal, and one is different ($a \neq b = c$), with all angles being 90° . This matches (III).
- **(C) Orthorhombic:** All sides are unequal ($a \neq b \neq c$), but all angles remain 90° . This corresponds to (II).
- **(D) Hexagonal:** Two sides are equal ($a = b$), one is different (c), and the angles are $\alpha = \beta = 90^\circ, \gamma = 120^\circ$. This matches (IV).

Thus, the correct match is (A) - (I), (B) - (III), (C) - (II), (D) - (IV).

Quick Tip

Understanding symmetry and axial relationships is key to identifying crystal systems.

68. Match List-I with List-II:

List-I (Type of Crystalline Solid)	List-II (Example)
(A) Ionic	(I) Methane, CH ₄
(B) Covalent	(II) Copper, Cu
(C) Molecular	(III) Sodium Chloride, NaCl
(D) Metallic	(IV) Diamond, C

Choose the correct answer from the options given below:

1. (A) - (III), (B) - (II), (C) - (I), (D) - (IV).
2. (A) - (III), (B) - (I), (C) - (II), (D) - (IV).
3. (A) - (II), (B) - (I), (C) - (IV), (D) - (III).
4. (A) - (III), (B) - (IV), (C) - (I), (D) - (II).

Correct Answer: 4. (A) - (III), (B) - (IV), (C) - (I), (D) - (II).

Solution:

Different crystalline solids are categorized based on their bonding and structural characteristics:

- **(A) Ionic:** Sodium Chloride (NaCl) is an ionic solid, where strong electrostatic forces exist between oppositely charged ions.
- **(B) Covalent:** Diamond (C) is a covalent solid, characterized by a network of covalent bonds giving it exceptional hardness.
- **(C) Molecular:** Methane (CH₄) is a molecular solid where weak van der Waals forces hold the molecules together.
- **(D) Metallic:** Copper (Cu) is a metallic solid, where a sea of delocalized electrons provides conductivity and malleability.

Thus, the correct match is (A) - (III), (B) - (IV), (C) - (I), (D) - (II).

Quick Tip

Ionic solids involve electrostatic forces, covalent solids have strong covalent bonds, molecular solids rely on weak intermolecular forces, and metallic solids exhibit delocalized electron bonding.

69. Match List-I with List-II:

List-I	List-II
(A) Principal Quantum Number (n)	(i) $-1/2, +1/2$
(B) Azimuthal Quantum Number (l)	(ii) 1, 2, 3,...
(C) Magnetic Quantum Number (m_l)	(iii) 0, ∓ 1 , ∓ 2 , ∓ 3 , ..., $\mp l$
(D) Spin Quantum Number (s)	(iv) 0, 1, 2,... $n - 1$

Choose the correct answer from the options given below:

1. (A) - (ii), (B) - (iv), (C) - (iii), (D) - (i).
2. (A) - (ii), (B) - (iii), (C) - (iv), (D) - (i).
3. (A) - (iv), (B) - (ii), (C) - (iii), (D) - (i).
4. (A) - (iv), (B) - (ii), (C) - (i), (D) - (iii).

Correct Answer: 1. (A) - (ii), (B) - (iv), (C) - (iii), (D) - (i).

Solution:

Solution:

Quantum numbers describe the unique quantum state of an electron in an atom:

- **Principal Quantum Number (n):** Represents the main energy level (1, 2, 3, ...).
- **Azimuthal Quantum Number (l):** Determines the subshell and ranges from 0 to $n - 1$ (0, 1, 2, ..., $n-1$).
- **Magnetic Quantum Number (m_l):** Represents the orientation of orbitals and ranges from $-l$ to $+l$ (0, ± 1 , ± 2 , ± 3 , ..., $\pm l$).

- **Spin Quantum Number (s):** Represents the spin of the electron and can have values of $+1/2$ or $-1/2$.

Quick Tip

Remember the ranges for each quantum number:

- n : Main shell (1, 2, 3, ...)
- l : Subshell (0 to $n - 1$)
- m_l : Orbital orientation ($-l$ to $+l$)
- s : Spin ($+1/2$ or $-1/2$)

70. Match List-I with List-II:

List-I	List-II
(A) XeF ₂	(i) Trigonal Planar
(B) BF ₃	(ii) Distorted Octahedral
(C) XeF ₄	(iii) Linear
(D) SF ₆	(iv) Regular Octahedral

Choose the correct answer from the options given below:

1. (A) - (i), (B) - (iii), (C) - (ii), (D) - (iv).
2. (A) - (iii), (B) - (i), (C) - (ii), (D) - (iv).
3. (A) - (iv), (B) - (iii), (C) - (ii), (D) - (i).
4. (A) - (iii), (B) - (iv), (C) - (i), (D) - (ii).

Correct Answer: 2. (A) - (iii), (B) - (i), (C) - (ii), (D) - (iv).

Solution:

The molecular geometries are determined by VSEPR theory:

- **(A) XeF₂:** Linear geometry, as it has three lone pairs and two bond pairs.
- **(B) BF₃:** Trigonal planar geometry, with three bonding pairs and no lone pairs around the central atom.

- (C) XeF_4 : Distorted octahedral geometry, with four bonding pairs and two lone pairs.
- (D) SF_6 : Regular octahedral geometry, with six bonding pairs and no lone pairs.

Quick Tip

Use the VSEPR theory to determine the geometry:

- Lone pairs create repulsion, distorting the geometry.
- Symmetry in bonding pairs results in regular geometries (e.g., octahedral for SF_6).

71. Match List-I with List-II:

List-I	List-II
(A) Linus Pauling	(i) Alpha particle scattering experiment
(B) Albert Einstein	(ii) Photoelectric effect
(C) Ernest Rutherford	(iii) Electronegativity
(D) Max Planck	(iv) Black body radiations

Choose the correct answer from the options given below:

- (1) (A) - (III), (B) - (II), (C) - (I), (D) - (IV)
- (2) (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
- (3) (A) - (IV), (B) - (III), (C) - (I), (D) - (II)
- (4) (A) - (III), (B) - (II), (C) - (IV), (D) - (I)

Correct Answer: (1) (A) (iii), (B) (ii), (C) (i), (D) (iv).

Solution:

Linus Pauling introduced the concept of electronegativity, a measure of an atom's ability to attract shared electrons. Albert Einstein explained the photoelectric effect, showing that light behaves as particles (photons). Ernest Rutherford conducted the alpha particle scattering experiment, leading to the discovery of the atomic nucleus. Max Planck developed the quantum theory of black body radiation, introducing the idea of quantized energy levels.

Quick Tip

Link the scientific achievements with the corresponding scientist's name to understand the historical development of scientific concepts.

72. Match List-I with List-II:

List-I	List-II
(A) Alkaline phosphatase	(i) Cleaves DNA
(B) DNA Polymerase	(ii) Cleaves ssDNA
(C) SI Nuclease	(iii) Nick translation
(D) DNase I	(iv) Removes phosphate group present at 5' end of DNA

Choose the correct answer from the options given below:

- (1) (A) - (IV), (B) - (III), (C) - (II), (D) - (I)
- (2) (A) - (I), (B) - (III), (C) - (II), (D) - (IV)
- (3) (A) - (I), (B) - (II), (C) - (IV), (D) - (III)
- (4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer:(1) (A) - (IV), (B) - (III), (C) - (II), (D) - (I).

Solution:

Alkaline phosphatase is used to remove phosphate groups from DNA's 5' end, preventing self-ligation during cloning. DNA polymerase is involved in nick translation, replacing damaged DNA regions. SI nuclease specifically cleaves single-stranded DNA, and DNase I cleaves DNA randomly, aiding in digestion.

Quick Tip

Understanding enzyme-specific actions is fundamental in genetic engineering and molecular biology.

73. Match List-I with List-II:

List-I	List-II
(A) IgA	(i) Basophils
(B) IgE	(ii) Secretory components
(C) IgG	(iii) Pentamer
(D) IgM	(iv) Crosses Placenta

Choose the correct answer from the options given below:

- (1) (A) - (II), (B) - (I), (C) - (IV), (D) - (III)
- (2) (A) - (I), (B) - (III), (C) - (II), (D) - (IV)
- (3) (A) - (I), (B) - (II), (C) - (IV), (D) - (III)
- (4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (3) (A) (i), (B) (ii), (C) (iii), (D) (iv).

Solution:

Immunoglobulins (antibodies) have specific roles in the immune system:

- **(A) IgA:** Found in mucosal areas and secretions, such as saliva and tears, and is associated with secretory components for mucosal immunity.
- **(B) IgE:** Plays a key role in allergic reactions by activating basophils and mast cells.
- **(C) IgG:** The most abundant antibody in the bloodstream, capable of crossing the placenta to provide passive immunity to the fetus.
- **(D) IgM:** The first antibody produced during an immune response and exists as a pentamer, allowing efficient antigen agglutination.

Quick Tip

Familiarize yourself with the roles and structures of different immunoglobulin classes to understand their immune functions.

74. Match List-I with List-II:

List-I	List-II
(A) Thiamine (B1)	(i) Riboflavin adenine nucleotide
(B) Riboflavin (B2)	(ii) Tetrahydrofolic acid
(C) Niacin	(iii) Nicotinamide adenine dinucleotide
(D) Folic acid	(iv) Co-carboxylase

Choose the correct answer from the options given below:

- (1) (A) - (IV), (B) - (I), (C) - (III), (D) - (II)
- (2) (A) - (I), (B) - (III), (C) - (II), (D) - (IV)
- (3) (A) - (I), (B) - (II), (C) - (IV), (D) - (III)
- (4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (1) (A) - (IV), (B) - (I), (C) - (III), (D) - (II)

Solution:

Thiamine (Vitamin B1) is a precursor for co-carboxylase, essential in carbohydrate metabolism. Riboflavin forms coenzymes like flavin adenine dinucleotide (FAD) and riboflavin adenine nucleotide. Niacin is converted into NAD/NADP, critical for redox reactions. Folic acid is metabolized to tetrahydrofolic acid, aiding nucleotide synthesis.

Quick Tip

Link each vitamin to its metabolic coenzyme function for efficient learning.

75. Match List-I with List-II:

List-I	List-II
(A) Lyman	(i) $n = 2, 3, 4, \dots$
(B) Balmer	(ii) $n = 3, 4, 5, \dots$
(C) Paschen	(iii) $n = 4, 5, 6, \dots$
(D) Bracket	(iv) $n = 5, 6, 7, \dots$

Choose the correct answer from the options given below:

- (1) (A) - (I), (B) - (II), (C) - (III), (D) - (IV)
- (2) (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

(3) (A) - (I), (B) - (II), (C) - (IV), (D) - (III)

(4) (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Correct Answer: (1) (A) (i), (B) (ii), (C) (iii), (D) (iv).

Solution:

The spectral series in hydrogen are characterized by electronic transitions between energy levels:

- **(A) Lyman series:** Transitions ending at $n = 1$ involve energy levels $n = 2, 3, 4, \dots$ and correspond to ultraviolet radiation.
- **(B) Balmer series:** Transitions ending at $n = 2$ involve energy levels $n = 3, 4, 5, \dots$ and correspond to visible radiation.
- **(C) Paschen series:** Transitions ending at $n = 3$ involve energy levels $n = 4, 5, 6, \dots$ and correspond to infrared radiation.
- **(D) Bracket series:** Transitions ending at $n = 4$ involve energy levels $n = 5, 6, 7, \dots$ and correspond to far-infrared radiation.

Quick Tip

Memorize spectral series with their final energy levels and spectral regions (UV, visible, IR).