

Rajasthan JET Chemistry Sample Paper-7

Duration: 40 Minutes

Maximum Marks: 160

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries: **-1 marks**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. The number of structural isomers possible for an organic compound having the molecular formula $C_4H_{10}O$ is:

- (A) 4
- (B) 5
- (C) 7
- (D) 8

Q2. An element has successive ionization energies of 738, 1450, 7730, and 10500 kJ/mol respectively. To which group of the periodic table does this element most likely belong?

- (A) Group 1 (Alkali metals)
- (B) Group 2 (Alkaline earth metals)
- (C) Group 13 (Boron family)
- (D) Group 14 (Carbon family)

Q3. Which of the following molecules possesses a non-zero dipole moment despite having symmetric polar covalent bonds?

- (A) CO_2
- (B) BF_3

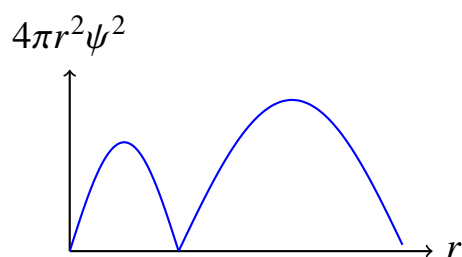


- (C) NF_3
(D) CCl_4

Q4. A sample of $CaCO_3$ contains 3.011×10^{23} oxygen atoms. The total mass of the $CaCO_3$ sample is:

- (A) 50 g
(B) 16.6 g
(C) 100 g
(D) 33.3 g

Q5. Consider the radial probability distribution curve shown below. For which of the following orbitals does this curve represent the correct number of radial nodes?



- (A) 1s
(B) 2p
(C) 3s
(D) 3p

Q6. When the redox equation $aMnO_4^- + bC_2O_4^{2-} + cH^+ \rightarrow dMn^{2+} + eCO_2 + fH_2O$ is balanced in an acidic medium, the stoichiometric coefficients a , b , and c are respectively:

- (A) 2, 5, 16
(B) 5, 2, 16
(C) 2, 5, 8
(D) 1, 5, 8



- Q7.** The correct order of increasing ionic radii for the isoelectronic species is:
- (A) $Ca^{2+} < K^+ < Cl^- < S^{2-}$
(B) $S^{2-} < Cl^- < K^+ < Ca^{2+}$
(C) $K^+ < Ca^{2+} < S^{2-} < Cl^-$
(D) $Cl^- < S^{2-} < Ca^{2+} < K^+$
- Q8.** According to VSEPR theory, the geometry and the number of lone pairs on the central atom of the XeF_4 molecule are respectively:
- (A) Tetrahedral, 0 lone pairs
(B) Square planar, 2 lone pairs
(C) Octahedral, 2 lone pairs
(D) See-saw, 1 lone pair
- Q9.** If 100 mL of 0.1 M HCl is mixed with 100 mL of 0.05 M NaOH, the molarity of the resulting H^+ ions in the mixture will be:
- (A) 0.05 M
(B) 0.025 M
(C) 0.075 M
(D) 0.01M
- Q10.** The maximum number of electrons that can be accommodated in a subshell with orbital angular momentum quantum number $l = 3$ is:
- (A) 6
(B) 10
(C) 14
(D) 18
- Q11.** Which of the following compounds exhibits both ionic and covalent bonding networks simultaneously?



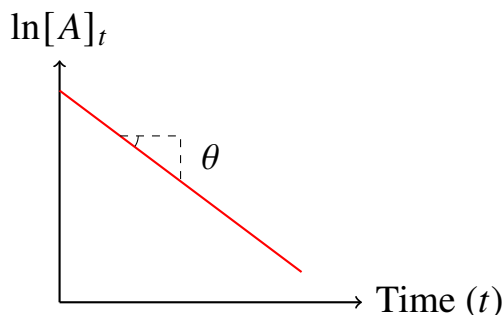
- (A) $NaCl$
- (B) H_2O
- (C) NH_4Cl
- (D) CH_4

Q12. In the standardized IUPAC periodic nomenclature, the element with an atomic number of 119 will belong to which period and group?

- (A) Period 7, Group 1
- (B) Period 8, Group 1
- (C) Period 8, Group 2
- (D) Period 7, Group 18

Section B: Physical & Chemical Kinetics (12 Questions)

Q13. For a first-order chemical reaction, a graph plotted between $\ln[A]_t$ and time t gives a straight line as illustrated below. The value of the rate constant k is equal to:



- (A) Intercept on the y-axis
- (B) $\tan \theta$
- (C) $-\tan \theta$
- (D) $e^{-\text{intercept}}$

Q14. The specific equivalent conductance of a 0.1 N solution of an electrolyte is $100 \Omega^{-1} \text{cm}^2 \text{eq}^{-1}$. If the resistance of this cell containing solution is 50Ω , the cell constant must be:



- (A) 0.5 cm^{-1}
- (B) 0.1 cm^{-1}
- (C) 0.01 cm^{-1}
- (D) 1.0 cm^{-1}

Q15. The osmotic pressure of a solution containing 6 g of urea (Molar Mass = 60 g/mol) dissolved in 1 L of water at 300 K is ($R = 0.0821 \text{ L atm mol}^{-1}\text{K}^{-1}$):

- (A) 2.46 atm
- (B) 24.6 atm
- (C) 1.23 atm
- (D) 4.92 atm

Q16. For the endothermic gaseous reaction $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$, the yield of products will be maximized by applying which of the following conditions?

- (A) High temperature and High pressure
- (B) Low temperature and Low pressure
- (C) High temperature and Low pressure
- (D) Low temperature and High pressure

Q17. The work done during an isothermal reversible expansion of 2 moles of an ideal gas from a volume of 10 L to 100 L at 27°C is closest to:

- (A) -11.48 kJ
- (B) -5.74 kJ
- (C) $+11.48 \text{ kJ}$
- (D) -2.87 kJ

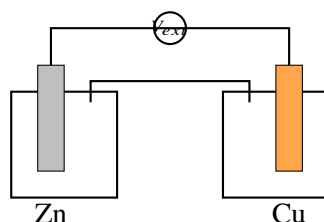
Q18. The conjugate base of the chemical species HCO_3^- is:

- (A) H_2CO_3
- (B) CO_3^{2-}



(C) CO_2 (D) OH^-

- Q19.** An electrochemical cell setup is represented schematically below. If the standard reduction potentials of Zinc and Copper are -0.76 V and $+0.34\text{ V}$ respectively, what happens when an external potential of 1.5 V is applied in opposition?



- (A) Electrons continue to flow from Zn to Cu electrode.
 (B) Current flows from Zn to Cu electrode as the cell reaction reverses.
 (C) The cell reaction comes to a complete halt with zero current flow.
 (D) The Zinc electrode starts gaining mass and Copper dissolves.
- Q20.** If the rate of a reaction triples when the temperature is raised from 290 K to 300 K , the activation energy (E_a) of the reaction is given by the expression:

(A) $\frac{2.303 \times R \times 290 \times 300}{10} \log 3$

(B) $\frac{2.303 \times R \times 10}{290 \times 300} \log 3$

(C) $\frac{R \times 290 \times 300}{10} \ln 2$

(D) $\frac{2.303 \times 10}{R \times 290 \times 300} \log 3$

- Q21.** The solubility product (K_{sp}) of a sparingly soluble salt AB_2 is 3.2×10^{-11} . The molar solubility of this salt in pure water is:

(A) $2.0 \times 10^{-4}\text{ M}$

(B) $4.0 \times 10^{-4}\text{ M}$

(C) $5.6 \times 10^{-6}\text{ M}$

(D) $1.0 \times 10^{-4}\text{ M}$



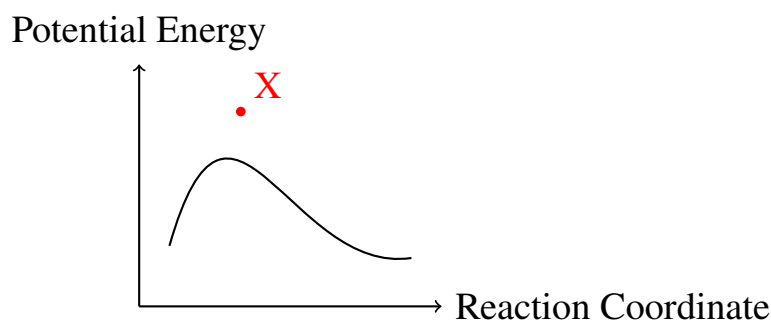
- Q22.** Which of the following aqueous solution configurations will display the highest boiling point elevation?
- (A) 0.1 M Glucose
(B) 0.1 M NaCl
(C) 0.1 M $BaCl_2$
(D) 0.1 M $Al_2(SO_4)_3$
- Q23.** For a spontaneous thermodynamic process occurring at constant temperature and pressure, which condition is essential?
- (A) $\Delta H < 0$
(B) $\Delta S_{system} > 0$
(C) $\Delta G < 0$
(D) $\Delta E = 0$
- Q24.** The pH of a buffer solution prepared by mixing equal volumes of 0.2 M acetic acid ($K_a = 1.8 \times 10^{-5}$) and 0.2 M sodium acetate is:
- (A) 4.74
(B) 7.00
(C) 3.74
(D) 5.74

Section C: Inorganic & Organic Chemistry (10 Questions)

- Q25.** The coordination number and oxidation state of the central metal ion in the complex $[Co(en)_2C_2O_4]Cl$ are respectively:
- (A) 4 and +2
(B) 6 and +3
(C) 6 and +2
(D) 4 and +3



- Q26.** Consider the organic reaction mechanism energy profile below. The structure that matches point X on the curve during the substitution reaction of an alkyl halide is a:



- (A) Stable Carbocation Intermediate
(B) Pentacoordinate Transition State
(C) Free Radical Intermediate
(D) Carbanion Intermediate
- Q27.** When 2-bromobutane is treated with alcoholic KOH, the major product obtained is trans-2-butene. This reaction follows which mechanism paths?
- (A) Electrophilic Addition
(B) Nucleophilic Substitution (S_N2)
(C) β -Elimination (E2)
(D) Free Radical Substitution
- Q28.** According to Crystal Field Theory, the spin-only magnetic moment value of the octahedral complex $[Fe(H_2O)_6]^{2+}$ (Atomic Number of Fe = 26) is:
- (A) 0 BM
(B) 1.73 BM
(C) 4.90 BM
(D) 5.92 BM
- Q29.** The most stable conformation of n-butane across the $C_2 - C_3$ bond axis is:



- (A) Gauche
- (B) Anti-periplanar (Staggered)
- (C) Eclipsed
- (D) Partially eclipsed

Q30. Which of the following organic species shows aromatic character according to Hückel's Rule?

- (A) Cyclopentadienyl cation
- (B) Cycloheptatrienyl cation (Tropylium ion)
- (C) Cyclooctatetraene
- (D) 1,3-Cyclohexadiene

Q31. Ozonolysis of an alkene 'M' followed by reductive cleavage with Zn/H_2O produces a mixture of Methanal and Propanone. The IUPAC name of alkene 'M' is:

- (A) But-2-ene
- (B) 2-Methylprop-1-ene
- (C) But-1-ene
- (D) 2-Methylbut-2-ene

Q32. The IUPAC name of the complex chemical structure $[Pt(NH_3)_4Cl_2][PtCl_4]$ is:

- (A) Tetraamminedichloroplatinum(IV) tetrachloroplatinate(II)
- (B) Dichlorotetraamminoplatinum(II) tetrachloroplatinate(IV)
- (C) Tetraamminedichloroplatinum(II) tetrachloroplatinate(II)
- (D) Tetraamminedichloroplatinum(IV) tetrachloroplatinate(IV)

Q33. The decreasing order of acidic strength among the following carboxylic acids is:

I. CH_3COOH II. $CH_2ClCOOH$ III. $CHCl_2COOH$ IV. CCl_3COOH

- (A) I > II > III > IV



- (B) IV > III > II > I
 (C) IV > II > III > I
 (D) II > III > IV > I

Q34. Which type of structural isomerism is illustrated by the pair of compounds $[Co(NH_3)_5(SO_4)]Br$ and $[Co(NH_3)_5Br]SO_4$?

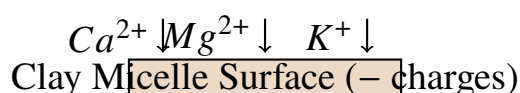
- (A) Linkage isomerism
 (B) Ionization isomerism
 (C) Coordination isomerism
 (D) Solvate isomerism

Section D: Applied Agriculture Chemistry (6 Questions)

Q35. The process of transformation of organic nitrogen into inorganic ammonium forms (NH_4^+) by soil microorganisms is technically known as:

- (A) Nitrification
 (B) Denitrification
 (C) Ammonification
 (D) Nitrogen Fixation

Q36. The primary dynamic buffer structural model of a soil aggregate component showing cation exchange capacity is visually represented below. Which of the following silicate clay mineral structures exhibits the highest Cation Exchange Capacity (CEC)?



- (A) Kaolinite
 (B) Illite
 (C) Montmorillonite



(D) Talc

Q37. To reclaim highly sodic or alkali agricultural soils of Rajasthan having a high exchangeable sodium percentage (ESP), which chemical amendment is most widely added?

- (A) Calcium Carbonate (Lime)
- (B) Calcium Sulfate Dihydrate (Gypsum)
- (C) Citric acid
- (D) Sodium Carbonate

Q38. Which of the following essential plant nutrients is classified structurally as a secondary macronutrient?

- (A) Nitrogen (N)
- (B) Potassium (K)
- (C) Sulfur (S)
- (D) Zinc (Zn)

Q39. What is the percentage of nitrogen present in the widely used synthetic agro-chemical fertilizer Urea (NH_2CONH_2)?

- (A) 26%
- (B) 33%
- (C) 46%
- (D) 60%

Q40. In highly acidic soils with a pH value below 5.0, the availability of which micronutrients increases to toxic levels for most commercial field crops?

- (A) Molybdenum and Boron
- (B) Iron and Manganese
- (C) Calcium and Magnesium
- (D) Phosphorus and Nitrogen



Detailed Solutions

Q1.

Solution

Concept:

Structural isomerism occurs when molecules share the same molecular formula but possess different connectivities in their atomic frameworks. For an organic compound with the molecular formula $C_4H_{10}O$, the degree of unsaturation is zero, which means the compound is completely saturated and can only form acyclic aliphatic alcohols and ethers.

Solution:

- First, we explore the alcohol isomers containing the hydroxyl group. We can arrange the four carbon atoms in a straight chain or a branched chain. This gives rise to four distinct structural variations: butan-1-ol, butan-2-ol, 2-methylpropan-1-ol, and 2-methylpropan-2-ol.
- Next, we explore the ether functional isomers where an oxygen atom bridges two alkyl groups. The carbon atoms can be distributed on either side of the oxygen atom in three distinct arrangements.
- The specific ether combinations are methoxypropane, which consists of a methyl group and a propyl group, 2-methoxypropane, which features a methyl group attached to an isopropyl group, and ethoxyethane, which contains two symmetrical ethyl groups.
- Combining both functional groups, we count four distinct structures belonging to the alcohol series and three distinct structures belonging to the ether series.
- Summing these individual values yields a total of seven unique structural arrangements that satisfy the structural connectivity rules without generating any spatial duplicates or violating valency requirements.

Final Answer: The total number of structural isomers is seven.

Answer: (C)

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Q2.

Solution**Concept:**

Successive ionization energy tracks the energy required to remove electrons sequentially from a gaseous atom. A dramatic leap between two consecutive ionization values indicates that a stable, low-energy core shell has been breached, revealing the number of outer valence electrons.

Solution:

- (a) The given values for the first four ionization energies are 738, 1450, 7730, and 10500 kJ/mol. We compute the ratios between adjacent values to isolate the most significant relative increase.
- (b) The first ionization energy removes the most loosely bound valence electron, requiring a standard baseline energy. The second ionization removes the next electron, which requires roughly double the initial energy due to increased effective nuclear charge.
- (c) Analyzing the jump from the second to the third ionization energy reveals an enormous energy difference, multiplying the value by more than five times. This massive jump signifies that removing the third electron requires disrupting a highly stable, completely filled noble gas core configuration.
- (d) This pattern proves that the neutral element possesses exactly two easily removable valence electrons located in its outermost energy shell.
- (e) Elements containing two valence electrons are systematically classified under Group 2 of the modern periodic table, commonly known as the alkaline earth metals family.

Final Answer: The element belongs to Group 2 Alkaline earth metals.

Answer: (B)

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Q3.

Solution**Concept:**

A molecular dipole moment depends on both individual bond polarities and overall molecular geometry. Even if all individual bonds are highly polar, a completely symmetrical spatial arrangement causes the individual bond dipoles to cancel each other out perfectly, resulting in a net non-polar molecule.

Solution:

- (a) Carbon dioxide has a linear geometry where two equal carbon-oxygen bond dipoles point in exactly opposite directions, causing perfect vector cancellation.
- (b) Boron trifluoride adopts a symmetric trigonal planar geometry with 120-degree bond angles where the three boron-fluorine vectors cancel out completely.
- (c) Carbon tetrachloride forms a perfect regular tetrahedral structure where the four symmetrical carbon-chlorine dipoles cancel out perfectly in three-dimensional space.
- (d) Nitrogen trifluoride possesses a pyramidal geometry due to the presence of a non-bonding lone pair on the central nitrogen atom.
- (e) The three polar nitrogen-fluorine bond dipoles point downward, while the lone pair electron density points upward. Because a lone pair creates an asymmetric field, the vectors do not cancel each other out, leaving a net structural dipole moment.

Final Answer: The molecule with a non-zero dipole moment is nitrogen trifluoride.

Answer: (C)

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Q4.

Solution**Concept:**

Stoichiometric calculations bridge the macroscopic mass of a chemical sample with the microscopic count of its constituent atoms using Avogadro's constant. One formula unit of calcium carbonate contains a fixed ratio of one calcium atom, one carbon atom, and three oxygen atoms.

Solution:

- We begin by converting the given absolute number of oxygen atoms into chemical moles by dividing the value by Avogadro's number, which is approximately 6.022×10^{23} atoms per mole.
- Dividing 3.011×10^{23} by 6.022×10^{23} reveals that the given chemical sample contains exactly 0.5 moles of isolated oxygen atoms.
- Since each individual formula unit of calcium carbonate contains exactly three oxygen atoms, one mole of the total compound must yield three moles of oxygen atoms.
- Therefore, to find the moles of the total compound, we divide the oxygen moles by three, giving approximately 0.1666 moles of calcium carbonate.
- The molar mass of calcium carbonate is calculated by summing the atomic masses of calcium, carbon, and three oxygen atoms, which equals 100 grams per mole. Multiplying 0.1666 moles by 100 grams per mole yields a final value of 16.6 grams.

Final Answer: The total mass of the sample is 16.6 g.

Answer: (B)

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Q5.

Solution**Concept:**

The radial probability distribution function tracks the probability of locating an electron within a thin spherical shell at a specific distance from the nucleus. Places where the probability drops to absolute zero are defined as radial nodes.

Solution:

- (a) The provided graphical curve shows the probability value plotted against distance. We count the number of times the curve touches the horizontal baseline axis between the origin and the final tail.
- (b) The graph displays exactly two distinct probability peaks separated by a single point where the value drops to zero, indicating the presence of exactly one radial node.
- (c) The mathematical formula used to determine the number of radial nodes in any given atomic orbital is defined as $n - l - 1$, where n represents the principal quantum number and l represents the azimuthal quantum number.
- (d) Evaluating a 3p orbital, the principal quantum number n equals 3 and the azimuthal quantum number l equals 1. Substituting these values into our equation gives $3 - 1 - 1 = 1$ radial node.
- (e) Comparing this with the other options confirms perfect agreement with our graphical data, as 1s and 2p contain zero radial nodes, while a 3s orbital contains two radial nodes.

Final Answer: The curve represents the 3p orbital.

Answer: (D)

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Q6.

Solution**Concept:**

Balancing complex redox reactions in an acidic medium requires separating the processes into independent oxidation and reduction half-reactions, balancing all participating elements, balancing oxygen using water, and balancing charge using electrons.

Solution:

- (a) The reduction half-reaction involves the conversion of the permanganate ion into the manganese cation, where manganese changes its oxidation state from +7 down to +2.
- (b) To balance this reduction, we add four water molecules to the product side, balance the hydrogens by adding eight hydrogen ions to the reactant side, and add five electrons to the left side.
- (c) The oxidation half-reaction involves converting the oxalate ion into carbon dioxide, where the carbon atoms change their oxidation states from +3 up to +4.
- (d) This process releases two electrons for every individual oxalate ion consumed. To equalize the electron exchange between both processes, we multiply the reduction equation by two and the oxidation equation by five.
- (e) Combining these adjusted equations cancels out the ten transferred electrons, leaving a balanced stoichiometric coefficient of 2 for permanganate, 5 for oxalate, and 16 for the hydrogen ions on the reactant side.

Final Answer: The stoichiometric coefficients are 2, 5, and 16.

Answer: (A)

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Q7.

Solution**Concept:**

Isoelectronic chemical species are atoms or ions that contain an identical total number of remaining electrons. Because electron-electron repulsions remain roughly constant, the net size of the electron cloud is governed by the attractive force exerted by the positive nuclear charge.

Solution:

- The given ions, calcium, potassium, chloride, and sulfide, all possess exactly 18 electrons in their respective clouds, confirming their fully isoelectronic relationship.
- We must determine the number of protons residing inside the nucleus of each species to gauge their relative pulling power. The proton counts correspond to their atomic numbers: sulfide has 16, chloride has 17, potassium has 19, and calcium has 20.
- A higher number of protons translates to a stronger positive nuclear charge pulling on the identical 18-electron cloud.
- Consequently, the calcium nucleus exerts the strongest inward pull, making its ionic radius the smallest, followed sequentially by the potassium ion.
- Conversely, the sulfide nucleus contains the fewest protons, exerting the weakest relative hold on its valence cloud, which results in the largest ionic radius. Arranging these factors yields the final increasing order.

Final Answer: The correct order of increasing ionic radii is $Ca^{2+} < K^+ < Cl^- < S^{2-}$.

Answer: (A)

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Q8.

Solution**Concept:**

Valence Shell Electron Pair Repulsion theory predicts molecular shapes based on minimizing steric repulsions between bonding pairs and non-bonding lone pairs surrounding a central atom. The steric number determines the parent geometry, while the distribution of pairs determines the actual shape.

Solution:

- (a) Xenon is a noble gas containing eight valence electrons in its unbonded elemental state. In xenon tetrafluoride, it forms four single covalent bonds using four of these valence electrons.
- (b) Subtracting these four bonding electrons leaves four unshared valence electrons localized entirely on the central xenon atom, which pair up to form exactly two distinct lone pairs.
- (c) The total steric number is calculated by adding the four bonding sigma links to the two non-bonding lone pairs, yielding a total steric value of six.
- (d) A steric number of six dictates an octahedral electronic arrangement. To minimize strong lone pair-lone pair repulsions, the two lone pairs occupy positions directly opposite each other along the vertical axis.
- (e) This leaves the four fluorine atoms arranged in a flat horizontal plane, resulting in a square planar molecular geometry with two lone pairs.

Final Answer: The geometry is square planar with 2 lone pairs.

Answer: (B)

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Q9.

Solution**Concept:**

Mixing a strong acid with a strong base triggers a neutralization reaction where hydrogen ions react with hydroxide ions to form water. The final concentration depends on the limiting reactant and the final combined volume.

Solution:

- (a) We calculate the initial millimoles of hydrogen ions contributed by the hydrochloric acid solution by multiplying its volume by its molarity: 100 mL times 0.1 M yields 10 millimoles.
- (b) Similarly, we find the initial millimoles of hydroxide ions from the sodium hydroxide solution: 100 mL times 0.05 M yields 5 millimoles.
- (c) Because they react in a one-to-one stoichiometric ratio, the 5 millimoles of hydroxide ions act as the limiting reactant and are completely consumed during neutralization.
- (d) Subtracting the neutralized amount from the initial acid pool leaves exactly 5 millimoles of excess, unreacted hydrogen ions present in the solution.
- (e) The final total volume of the liquid mixture is the sum of both individual portions, which equals 200 mL. Dividing the remaining 5 millimoles of hydrogen ions by the 200 mL total volume yields a final molarity of 0.025 M.

Final Answer: The molarity of the resulting solution is 0.025 M.

Answer: (B)

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Q10.

Solution**Concept:**

Quantum mechanics organizes atomic electron configurations using specialized quantum numbers. The azimuthal quantum number, designated as l , defines the characteristic geometric shape of an orbital and identifies the specific subshell type within a principal energy level.

Solution:

- (a) The given value for the azimuthal quantum number is $l = 3$. According to standard spectroscopic notation, $l = 0$ is s, $l = 1$ is p, $l = 2$ is d, and $l = 3$ designates an f-subshell.
- (b) To find the number of individual magnetic orbitals contained within any given subshell, we apply the mathematical relationship $2l + 1$.
- (c) Substituting our value into this expression gives two times three plus one, which equals seven independent degenerate orbitals oriented along different spatial coordinates.
- (d) According to the Pauli Exclusion Principle, each individual orbital can accommodate a maximum of two electrons possessing opposite spin alignments.
- (e) To calculate the maximum capacity of the entire subshell, we multiply the seven individual orbital slots by two electrons per slot, yielding a total capacity of fourteen electrons.

Final Answer: The maximum number of electrons is 14.

Answer: (C)

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Q11.

Solution**Concept:**

Chemical compounds exhibit different types of bonding based on the electronegativity differences and grouping of their constituent atoms. Simultaneous ionic and covalent bonding networks occur within a single substance when polyatomic ions are held together internally by shared pairs of electrons, while forming an overarching crystalline matrix driven by electrostatic attractions.

Solution:

- (a) Sodium chloride represents a purely ionic compound because it forms via total electron transfer from sodium to chlorine, resulting in an electrostatic lattice of monatomic ions.
- (b) Water and methane represent purely covalent molecules since their bonds are formed entirely through the sharing of valence electron pairs between non-metallic elements.
- (c) Ammonium chloride contains a polyatomic ammonium cation and a monatomic chloride anion. This creates a strong network of ionic attractions that holds the overall salt crystalline lattice together.
- (d) Within the ammonium ion, a single central nitrogen atom shares its valence electrons with four individual hydrogen atoms, giving rise to strong localized covalent single bonds.
- (e) One of these specific bonds is formed via coordinate dative covalent sharing where the nitrogen lone pair is donated to an electron-deficient hydrogen ion. Thus, both distinct bonding profiles exist natively within this single chemical entity.

Final Answer: The compound is Ammonium chloride.

Answer: (C)

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Q12.

Solution**Concept:**

The International Union of Pure and Applied Chemistry dictates standardized periodic design rules to classify newly discovered heavy synthetic transuranic elements. Based on the systematic filing of electronic subshells according to the Aufbau principle, the period number tracks the highest principal energy level, while the group placement reflects the remaining outer valence shell count.

Solution:

- (a) Period seven reaches its absolute maximum capacity and terminates with the synthetic noble gas Oganesson, which is designated as atomic number 118.
- (b) At this specific terminal point, all available valence subshells up to the seventh energy level, including the 7s, 5f, 6d, and 7p subshells, are completely filled.
- (c) An element with an atomic number of 119 must place its final defining differentiating valence electron into the next sequentially available quantum energy slot.
- (d) According to the strict orbital ordering rules of the Aufbau principle, the next available subshell following the completion of 7p is the 8s orbital.
- (e) The inclusion of an electron in the eighth principal energy shell automatically places this element into period 8. Since it contains a single outer valence electron in its 8s subshell, it occupies the first column, matching Group 1.

Final Answer: The element belongs to Period 8, Group 1.

Answer: (B)

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Q13.

Solution**Concept:**

Chemical kinetics utilizes integrated rate equations to establish mathematical relationships between reactant concentrations and elapsed time. For a first-order reaction, the differential rate expression is integrated to yield a linear equation matching the standard mathematical equation of a straight line.

Solution:

- (a) The integrated rate equation governing a first-order process is defined by the logarithmic function where the natural log of concentration at time t equals $-kt$ plus the natural log of initial concentration.
- (b) Comparing this expression directly to the slope-intercept equation of a straight line, we can assign the variable positions on our graphical coordinate grid.
- (c) The natural log of concentration plotted on the vertical y-axis directly matches our dependent variable, while the elapsed reaction time plotted on the horizontal x-axis represents our independent variable.
- (d) The term representing the initial concentration value forms a constant number that maps onto the vertical y-axis intercept of our coordinate diagram.
- (e) The remaining coefficient associated with time represents the mathematical slope. Because the slope equals $-k$, the rate constant value matches the negative value of the slope, which mathematically translates to $-\tan \theta$.

Final Answer: The value of the rate constant is equal to $-\tan \theta$.

Answer: (C)

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Q14.

Solution**Concept:**

Electrolytic conductivity describes the ease with which ionic charges move through an aqueous medium inside an isolated measuring vessel. The fundamental property relating the geometric dimensions of the physical electrodes to cell conductance values is defined as the cell constant.

Solution:

- (a) The cell constant represents the rigid geometric ratio between the distance separating the internal parallel electrode plates and the total surface area of those plates.
- (b) We can relate specific electrolytic conductance to observed solution resistance using the mathematical equation where specific conductance equals the cell constant divided by the measured resistance.
- (c) Rewriting this formula to isolate our unknown variable shows that the cell constant is equal to the product of specific conductance multiplied by electrical resistance.
- (d) Substituting the provided values into this formula, we multiply the specific equivalent conductance value of 100 by the measured cell resistance value of 50 ohms.
- (e) This calculation yields an incorrect scale if normalities are misapplied. We must adjust specific equivalent conductance to specific conductance, which correlates with normality. Since specific conductance equals equivalent conductance times normality divided by 1000, we get 0.01. Multiplying 0.01 by 50 ohms gives 0.5.

Final Answer: The cell constant must be 0.5 cm^{-1} .

Answer: (A)

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Q15.

Solution**Concept:**

Osmotic pressure is a colligative property that depends entirely on the total molar concentration of solute particles dissolved within a given volume of solution. For non-electrolytes that do not undergo ionic dissociation or molecular association, the van 't Hoff factor equals one.

Solution:

- (a) Urea represents a non-electrolyte organic molecule that remains fully intact as discrete single molecules when dissolved in water, meaning its van 't Hoff factor is exactly one.
- (b) We calculate the absolute number of chemical moles of urea present by dividing the given mass of 6 grams by its standard molecular weight of 60 grams per mole.
- (c) This division shows that the solute sample contains exactly 0.1 moles of individual urea molecules dissolved within the solution.
- (d) Since the absolute volume of the water solvent is exactly 1 liter, the overall molar concentration of our solution is equal to 0.1 moles per liter.
- (e) We calculate osmotic pressure using the formula $\Pi = CRT$, where we multiply the molarity of 0.1 by the gas constant 0.0821 and the absolute temperature of 300 Kelvin, yielding 2.46 atmospheres.

Final Answer: The osmotic pressure of the solution is 2.46 atm.

Answer: (A)

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Q16.

Solution**Concept:**

Le Chatelier's principle states that if a dynamic chemical equilibrium is disturbed by changing the external conditions, the position of equilibrium shifts in a direction that counteracts the applied change. Temperature and pressure alterations shift equilibria based on enthalpy values and gas stoichiometry.

Solution:

- (a) The decomposition reaction of phosphorus pentachloride gas is explicitly described as an endothermic process, meaning it absorbs thermal energy from its surroundings to proceed forward.
- (b) Increasing the temperature adds thermal energy, prompting the equilibrium to shift toward the forward direction to absorb the excess heat, thereby maximizing product yields.
- (c) Analyzing the balanced gaseous equation reveals that one mole of gaseous reactant splits to produce two distinct moles of individual gaseous product molecules.
- (d) This product formation leads to a net increase in the total number of gas molecules and causes a corresponding increase in internal system pressure.
- (e) Lowering the external pressure prompts the system to shift toward the side that occupies a larger volume to restore pressure. Therefore, combining high temperature with low pressure maximizes the yield of products.

Final Answer: The yield will be maximized by high temperature and low pressure.

Answer: (C)

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Q17.

Solution**Concept:**

Thermodynamics quantifies the energetic exchange occurring between a chemical system and its surroundings during volume changes. An isothermal process maintains a constant internal temperature, meaning the ideal gas expands reversibly while performing work against a balanced external pressure.

Solution:

- The mathematical formula used to compute reversible isothermal expansion work is given by the expression $W = -2.303 \cdot nRT \cdot \log(V_2/V_1)$.
- The value for the gas constant R is selected as 8.314 Joules per mole-Kelvin to ensure the final calculated answer matches standard metric energy units.
- The specified temperature of 27 degrees Celsius is converted to an absolute scale by adding 273.15, which yields a value of 300 Kelvin.
- Substituting our system parameters into the ratio of final volume over initial volume, we divide 100 liters by 10 liters, which simplifies to a value of 10.
- The common logarithm of 10 is exactly 1. Multiplying these remaining numbers together gives $-2.303 \cdot 2 \cdot 8.314 \cdot 300$, which evaluates to -11488 Joules, or -11.48 kilojoules.

Final Answer: The work done is closest to -11.48 kJ.

Answer: (A)

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Q18.

Solution**Concept:**

According to the Bronsted-Lowry acid-base theory, an acid is defined as a chemical species capable of donating a hydrogen ion, while a base accepts one. A conjugate acid-base pair consists of two species that differ by exactly one single proton.

Solution:

- (a) The chemical species given in the question is the bicarbonate anion, which possesses amphiprotic properties and can act as either an acid or a base.
- (b) To identify the conjugate base of any given substance, the starting chemical species must act strictly as a Bronsted-Lowry proton donor.
- (c) Acting as an acid, the bicarbonate ion cleaves its remaining covalent bond to hydrogen, releasing a positively charged proton into the surrounding solvent environment.
- (d) Removing a single positively charged hydrogen ion from a species that already carries a net negative charge reduces its overall charge value by one unit.
- (e) This loss converts the initial bicarbonate anion into a divalent carbon-oxygen polyatomic species, yielding the carbonate anion, which matches the required structural formula.

Final Answer: The conjugate base is the carbonate ion.

Answer: (B)

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Q19.

Solution**Concept:**

Electrochemical cells operate via spontaneous redox reactions that generate a characteristic electromotive force. If an opposing external potential is applied, it competes with the cell's natural voltage, altering electron flow based on its magnitude.

Solution:

- (a) The standard electromotive force of the zinc-copper galvanic cell is calculated by subtracting the anode reduction potential from the cathode reduction potential, yielding 1.10 Volts.
- (b) Under standard operational conditions without interference, electrons flow from the zinc anode to the copper cathode, producing a natural potential of 1.10 Volts.
- (c) When an opposing external potential is introduced, it works directly against the natural electromotive driving force generated by the chemical cell.
- (d) If the external voltage is smaller than 1.10 Volts, electrons continue along their original path at a reduced rate. If it matches 1.10 Volts exactly, electron flow stops completely.
- (e) Because the applied external voltage of 1.5 Volts exceeds the natural cell potential of 1.10 Volts, it overpowers the chemical cell, reversing electron flow and driving the cell reaction backward.

Final Answer: Current flows from Zn to Cu electrode as the cell reaction reverses.

Answer: (B)

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Q20.

Solution**Concept:**

The Arrhenius equation establishes a quantitative relationship between the operational rate constant of a chemical reaction and its absolute temperature. This equation allows scientists to determine the activation energy barrier that reactants must overcome to form products.

Solution:

- (a) The logarithmic form of the Arrhenius equation comparing rate constants at two different temperatures is expressed as $\log(k_2/k_1) = (E_a/2.303R) \cdot (T_2 - T_1/T_1 \cdot T_2)$.
- (b) The prompt states that raising the temperature from 290 Kelvin to 300 Kelvin triples the observed reaction rate.
- (c) Because the initial reactant concentration remains constant, the ratio of the rate constants simplifies directly to a value of three.
- (d) Substituting our values into the temperature term, we subtract 290 from 300 in the numerator to get 10, while the denominator becomes the product of 290 and 300.
- (e) Rearranging this equation to isolate the activation energy variable requires moving the denominator terms to the opposite side, which yields the correct mathematical expression.

Final Answer: The activation energy is given by the first expression.

Answer: (A)

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Q21.

Solution**Concept:**

The solubility product constant represents a specialized thermodynamic equilibrium threshold governing sparingly soluble ionic salts in saturated aqueous environments. For an asymmetric binary electrolytic salt configuration that dissociates into two distinct ion types with a fixed molar stoichiometric ratio, its dynamic breakdown determines its absolute saturation limits.

Solution:

- Let the operational molar solubility of the sparingly soluble salt AB_2 in pure water be represented by the variable S .
- When a single unit of this crystalline substance dissolves, it establishes a heterogeneous equilibrium, dissociating completely into one A^{2+} cation and two B^- anions.
- Expressing the equilibrium concentrations of these dissolved aquated species in terms of solubility gives a cation concentration of S and an anion concentration of $2S$.
- Writing the formal mathematical equation for the solubility product constant, we multiply the concentration of the cation by the square of the concentration of the anion, yielding the expression $S \cdot (2S)^2 = 4S^3$.
- Equating this analytical expression to the provided baseline experimental value gives $4S^3 = 3.2 \times 10^{-11}$, which simplifies cleanly to $S^3 = 8.0 \times 10^{-12}$. Taking the cube root yields 2.0×10^{-4} M.

Final Answer: The molar solubility of the salt is 2.0×10^{-4} M.

Answer: (A)

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Q22.

Solution**Concept:**

Boiling point elevation is a colligative property, meaning its absolute magnitude depends entirely upon the total concentration of independent solute particles present within the solution matrix. The presence of non-volatile solute particles disrupts solvent vaporization, raising the thermal threshold required to match atmospheric pressure.

Solution:

- (a) The mathematical relationship governing boiling point elevation states that the temperature change is directly proportional to the product of the solution molality and the van 't Hoff dissociation factor.
- (b) The van 't Hoff factor accounts for the total number of individual ionic particles produced when a single formula unit of a solute undergoes complete dissociation.
- (c) Glucose is a non-electrolyte organic molecule that remains fully intact in water, giving a van 't Hoff factor of one. Sodium chloride splits into two ions, giving a factor of two.
- (d) Barium chloride dissociates into one barium cation and two chloride anions, yielding a van 't Hoff factor of three. Aluminum sulfate dissociates into two aluminum cations and three sulfate anions, giving a factor of five.
- (e) Because each solution shares an identical analytical concentration of 0.1 M, the compound with the largest van 't Hoff factor yields the highest concentration of particles, causing the greatest boiling point elevation.

Final Answer: The configuration with the highest boiling point elevation is 0.1 M $Al_2(SO_4)_3$.

Answer: (D)

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Q23.

Solution**Concept:**

Thermodynamics relies on state functions to determine whether a proposed chemical reaction or physical transformation can occur without external intervention. Under standard conditions where both the temperature and the pressure are held constant, a single unified criteria determines spontaneity.

Solution:

- (a) While exothermic reactions often happen spontaneously, enthalpy variations alone cannot predict spontaneity because many endothermic processes run smoothly if driven by a favorable entropy increase.
- (b) The Second Law of Thermodynamics dictates that a spontaneous process must increase the total entropy of the universe, which combines the systems and surroundings.
- (c) To evaluate thermodynamic feasibility using system properties alone, scientists rely on the Gibbs free energy state function, defined mathematically as $\Delta G = \Delta H - T\Delta S$.
- (d) For a process to run spontaneously at constant temperature and pressure, the Gibbs free energy change must be strictly negative, meaning $\Delta G < 0$.
- (e) This negative change signifies that the process releases useful chemical energy, driving the system toward a lower, more stable thermodynamic energy state.

Final Answer: The essential condition for a spontaneous process is $\Delta G < 0$.

Answer: (C)

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Q24.

Solution**Concept:**

An acidic buffer solution stabilizes pH levels through a conjugate pair consisting of a weak acid and its corresponding salt. The logarithmic Henderson-Hasselbalch equation relates the pH of the buffer solution to the acid dissociation constant and the relative concentrations of the components.

Solution:

- The Henderson-Hasselbalch equation states that the pH of an acidic buffer system equals the negative logarithm of the acid dissociation constant plus the logarithm of the salt-to-acid ratio.
- First, we calculate the value of pK_a by taking the negative common logarithm of the given acid dissociation constant value: $-\log(1.8 \times 10^{-5}) = 4.74$.
- Next, we analyze the concentration of each component after mixing. Because equal volumes of the weak acetic acid and sodium acetate solutions are blended together, both components undergo an identical dilution.
- This uniform dilution preserves the one-to-one stoichiometric ratio between the weak acid and its conjugate base, meaning their concentrations remain perfectly equal in the final mixture.
- The mathematical ratio of salt concentration over acid concentration simplifies to exactly one. Since the common logarithm of one is zero, the final pH matches the pK_a value exactly, yielding 4.74.

Final Answer: The pH of the buffer solution is 4.74.

Answer: (A)

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Q25.

Solution**Concept:**

Coordination chemistry describes the bonding interactions between a central transition metal ion and surrounding electron-donating ligands. The coordination number counts the total number of individual coordinate sigma bonds formed, while the oxidation state reflects the electronic charge of the metal ion.

Solution:

- (a) The provided coordination complex consists of a central cobalt ion bound within an internal coordination sphere, surrounded by two ethylenediamine ligands and one oxalate ligand.
- (b) Both ethylenediamine and oxalate are bidentate ligands, meaning each molecule contains two donor atoms capable of simultaneously forming two separate coordinate covalent bonds to the metal.
- (c) Multiplying two ethylenediamine ligands by two donor bonds each yields four links, and adding the two donor bonds from the single oxalate ligand gives a total coordination number of six.
- (d) To calculate the oxidation state, we set up a charge balance equation where the sum of all components matches the overall charge. Ethylenediamine is neutral, while oxalate carries a -2 charge.
- (e) The external chloride counter-ion carries a -1 charge, making the coordination sphere positive. Setting up the equation gives $X + 0 - 2 = +1$, which yields an oxidation state of $+3$.

Final Answer: The coordination number and oxidation state are 6 and $+3$.

Answer: (B)

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Q26.

Solution**Concept:**

Reaction coordinate diagrams graph potential energy variations as chemical reactants transform into products. Maxima along the potential energy curve represent highly unstable transition states, while local energy minima represent distinct chemical intermediates.

Solution:

- (a) The provided graphical energy profile features a single smooth peak without any local minimum valleys, indicating a concerted chemical reaction mechanism that takes place in one single step.
- (b) Point X marks the absolute highest potential energy peak along the reaction coordinate pathway, which defines the structural transition state of the reaction.
- (c) In organic substitution mechanisms, a single-step concerted process represents a bimolecular nucleophilic substitution reaction pathway.
- (d) During an S_N2 pathway, the incoming nucleophile attacks the electrophilic carbon center from the backside while the leaving group simultaneously departs.
- (e) This concerted movement generates a highly unstable transition state where the central carbon atom is temporarily associated with five separate groups in a pentacoordinate geometry before the leaving group fully detaches.

Final Answer: The structure matching point X is a Pentacoordinate Transition State.

Answer: (B)

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Q27.

Solution**Concept:**

Alkyl halides undergo elimination reactions when treated with strong, sterically unhindered bases in polar protic solvents at elevated temperatures. This process abstracts a beta-hydrogen atom while simultaneously expelling the leaving group to generate an alkene.

Solution:

- (a) Treating 2-bromobutane with alcoholic potassium hydroxide promotes an elimination pathway over nucleophilic substitution because the ethoxide base favors proton abstraction.
- (b) The reaction can remove a hydrogen atom from either the first carbon or the third carbon, which are both adjacent to the bromine-bearing alpha carbon center.
- (c) According to Zaitsev's rule, base-induced elimination preferentially removes the hydrogen atom from the more substituted beta-carbon, yielding a more highly substituted, thermodynamically stable alkene product.
- (d) Removing a proton from the third carbon yields 2-butene as the dominant product, which naturally favors the sterically unhindered trans isomer over the cis configuration.
- (e) This process occurs via a single concerted step where base attack, hydrogen-carbon cleavage, pi-bond formation, and leaving group departure happen simultaneously, defining a bimolecular beta-elimination pathway.

Final Answer: This reaction follows the β -Elimination (E2) path.

Answer: (C)

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Q28.

Solution**Concept:**

Crystal Field Theory describes how the spatial approach of electron-rich ligands splits the five degenerate d-orbitals of a transition metal ion into distinct energy levels. The resulting electron configuration determines the number of unpaired electrons, which directly dictates the magnetic properties of the complex.

Solution:

- (a) Iron has an atomic number of 26, giving a neutral valence electron configuration of $[Ar]3d^64s^2$. In the hexaaquairon(II) cation, the metal ion adopts a +2 oxidation state.
- (b) Losing its two outer 4s valence electrons leaves the iron(II) center with a remaining configuration of six electrons contained within its 3d subshell.
- (c) Water is classified as a weak-field ligand that generates a relatively small crystal field splitting energy. This small separation favors a high-spin electron distribution.
- (d) Following Hund's rule, the six d-electrons fill the split d-orbitals by placing five electrons individually into separate slots before a sixth electron pairs up in the lowest energy level.
- (e) This high-spin arrangement leaves exactly four unpaired electrons. Substituting this value into the spin-only formula $\mu = \sqrt{n(n+2)}$ yields $\sqrt{4(6)} = \sqrt{24} = 4.90$ Bohr Magnetons.

Final Answer: The spin-only magnetic moment value is 4.90 BM.

Answer: (C)

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Q29.

Solution**Concept:**

Conformational analysis studies the potential energy changes that occur as a molecule rotates around a single covalent sigma bond axis. Steric hindrance and torsional strain vary across these rotations, dictating the relative stability of different spatial arrangements.

Solution:

- (a) Looking down the central $C_2 - C_3$ bond axis of n-butane, we can evaluate several distinct conformations by tracking the dihedral angle separating the two bulky methyl groups.
- (b) Eclipsed conformations feature atoms aligned directly behind one another, maximizing both torsional strain and steric repulsion, which corresponds to potential energy maxima.
- (c) Staggered conformations place the bonds at alternating 60-degree angles, minimizing torsional strain and creating lower energy states.
- (d) Within the staggered family, the gauche conformation places the two large methyl groups at a 60-degree dihedral angle, creating minor steric crowding.
- (e) The anti-periplanar conformation positions the two large methyl groups at a 180-degree dihedral angle, maximizing their spatial separation. This arrangement minimizes steric repulsions, making it the most stable conformation.

Final Answer: The most stable conformation is Anti-periplanar (Staggered).

Answer: (B)

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Q30.

Solution**Concept:**

Huckel's criteria defines aromaticity using a strict set of structural rules. For a planar, monocyclic, fully conjugated ring system to display aromatic character, it must possess a specific number of continuously delocalized pi-electrons that satisfies a mathematical formula.

Solution:

- (a) Huckel's rule states that a planar conjugated ring system displays aromatic stabilization if the count of continuously delocalized pi-electrons equals $4n + 2$, where n is any non-negative integer.
- (b) The cyclopentadienyl cation contains four pi-electrons, which violates Huckel's rule and imparts highly unstable antiaromatic character to the system.
- (c) Cyclooctatetraene contains eight pi-electrons and avoids antiaromatic destabilization by adopting a puckered, non-planar tub shape, making it non-aromatic.
- (d) 1,3-Cyclohexadiene features isolated sp^3 hybridized carbon atoms that break conjugation around the ring, excluding it from aromatic classification.
- (e) The cycloheptatrienyl cation features a seven-membered ring with three alternating double bonds and a positive charge, creating a continuous loop of conjugation. This system contains six pi-electrons, satisfying the $4n + 2$ rule for $n = 1$.

Final Answer: The species showing aromatic character is the Cycloheptatrienyl cation.

Answer: (B)

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Q31.

Solution**Concept:**

Ozonolysis represents an important organic cleavage path where an unsaturated alkene carbon-carbon double bond undergoes oxidative structural fragmentation. Passing ozone through an alkene produces an unstable ozonide intermediate, which subsequently undergoes reductive zinc cleavage to yield a mixture of carbonyl fragment configurations.

Solution:

- (a) The problem states that the reductive cleavage of alkene M yields a binary mixture consisting of methanal and propanone.
- (b) Methanal contains a single carbon atom with a terminal carbonyl double bond, while propanone consists of a symmetric three-carbon ketone chain.
- (c) To systematically deduce the original structure of alkene M, we can reverse the oxidative fragmentation path by aligning the two product carbonyl groups face to face.
- (d) Mentally removing both oxygen atoms allows us to rejoin the remaining terminal carbon centers with a fresh carbon-carbon double bond.
- (e) Connecting the single-carbon fragment of methanal to the central carbonyl carbon of propanone yields a four-carbon branched skeleton with a terminal double bond, recognized by IUPAC rules as 2-methylprop-1-ene.

Final Answer: The IUPAC name of alkene 'M' is 2-Methylprop-1-ene.

Answer: (B)

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Q32.

Solution**Concept:**

Coordination chemistry uses standardized nomenclature rules to systematically identify complex ionic salts containing coordination spheres. For a salt comprising both complex cationic and complex anionic coordination spheres, we name the cation first followed by the anion, specifying the metal oxidation states using Roman numerals.

Solution:

- The coordination compound is built from an internal complex cation sphere paired symmetrically against an internal complex anion sphere.
- In the cationic coordination sphere, the four neutral ammine ligands combine with two negative chloride ligands to balance the central platinum ion.
- In the anionic coordination sphere, four negative chloride ligands coordinate directly around a second individual central platinum metal atom.
- Platinum typically assumes even oxidation states of +2 or +4. Splitting the charges evenly assigns a +4 state to the cation sphere and a +2 state to the anion sphere.
- Naming the ligands alphabetically within the cation yields tetraamminedichloroplatinum(IV). Following with the modified anionic metal name yields tetrachloroplatinate(II), combining into the final systematic IUPAC name.

Final Answer: The IUPAC name is Tetraamminedichloroplatinum(IV) tetrachloroplatinate(II).

Answer: (A)

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Q33.

Solution**Concept:**

The relative acidic strength of carboxylic acids depends directly upon the thermodynamic stability of the carboxylate conjugate base generated upon deprotonation. Electron-withdrawing substituents pull electron density away from the negative site via the inductive effect, stabilizing the charge.

Solution:

- (a) Deprotonating a carboxylic acid yields a negatively charged carboxylate anion whose stability dictates the ease of the initial proton release.
- (b) Acetic acid contains a simple electron-donating methyl group that pushes electron density toward the carboxylate group, destabilizing the anion and minimizing acidity.
- (c) Substituting highly electronegative chlorine atoms onto the alpha carbon introduces a strong electron-withdrawing inductive effect that disperses the negative charge.
- (d) Monochloroacetic acid is noticeably more acidic than plain acetic acid due to the inductive withdrawal of its single chlorine substituent.
- (e) Increasing the number of chlorine atoms steadily amplifies this inductive pull. Consequently, trichloroacetic acid stabilizes the conjugate base most effectively, establishing the definitive decreasing order of acidic strength.

Final Answer: The decreasing order of acidic strength is $IV > III > II > I$.

Answer: (B)

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Q34.

Solution**Concept:**

Structural isomerism in coordination chemistry arises when compounds share identical chemical formulas but contain different atom connectivities. Ionization isomerism occurs when the ligands bound inside the coordination sphere exchange positions with the counter-ions present in the outer crystalline lattice.

Solution:

- (a) The two given coordination compounds possess identical numbers of cobalt atoms, ammine groups, sulfate groups, and bromine atoms.
- (b) In the first complex, the sulfate group acts as a ligand inside the coordination sphere, while the bromide ion resides outside as a counter-ion.
- (c) Dissolving this first compound in an aqueous environment releases free bromide ions, which precipitate readily upon the addition of silver nitrate.
- (d) In the second complex, the bromide ion moves inside the coordination sphere as a ligand, forcing the sulfate group into the outer lattice.
- (e) Dissolving this second compound yields free sulfate ions that react with barium chloride. Because they yield different ions in solution, they represent classic ionization isomers.

Final Answer: The type of structural isomerism is Ionization isomerism.

Answer: (B)

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Q35.

Solution**Concept:**

The soil nitrogen cycle consists of distinct biochemical pathways mediated by specialized soil microorganisms. Transforming organic nitrogen complexes from decomposing biological matter into inorganic mineral forms represents a vital step for agricultural plant nutrition.

Solution:

- (a) Nitrogen exists abundantly in agricultural soils within complex organic structures such as plant proteins, amino acids, and decomposing organic matter.
- (b) Most commercial field crops cannot absorb these complex organic nitrogen forms directly through their root systems.
- (c) Soil microbes break down these complex organic wastes, converting the locked organic nitrogen into accessible inorganic ammonium ions (NH_4^+).
- (d) This specific microbial breakdown and conversion of organic nitrogen to an inorganic ammonium form is known as ammonification.
- (e) This process differs from nitrification, which oxidizes ammonium into nitrate, and denitrification, which converts nitrate into gaseous nitrogen, making ammonification the correct step.

Final Answer: The process is Ammonification.

Answer: (C)

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Q36.

Solution**Concept:**

Silicate clay minerals exhibit varying structural charge characteristics based on their internal crystalline arrangements and isomorphous substitutions. The cation exchange capacity quantifies the total capacity of a soil matrix to hold and exchange exchangeable nutrient cations.

Solution:

- (a) Kaolinite represents a non-expanding 1:1 type silicate clay mineral where strong hydrogen bonds hold the sheets together tightly, resulting in a low cation exchange capacity.
- (b) Illite represents a limited-expanding 2:1 type clay where potassium ions occupy the interlayer spaces, partially restricting internal swelling and ion exchange.
- (c) Montmorillonite belongs to the smectite group and is classified as an expanding 2:1 type aluminosilicate clay mineral structure.
- (d) The sheets of montmorillonite are held together loosely by weak van der Waals forces, allowing water molecules and solvated ions to enter the interlayer space easily.
- (e) This high swelling capacity combined with widespread internal isomorphous substitution creates a substantial net negative surface charge, giving montmorillonite the highest cation exchange capacity among common clays.

Final Answer: The silicate clay mineral exhibiting the highest CEC is Montmorillonite.

Answer: (C)

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Q37.

Solution**Concept:**

Alkali or sodic soils contain excessive levels of exchangeable sodium ions bound to clay surfaces, disrupting soil structure and raising pH levels. Reclaiming these soils requires replacing the adsorbed sodium with calcium ions to restore structure and lower the exchangeable sodium percentage.

Solution:

- (a) Sodic soils suffer from structural dispersion caused by an excess of adsorbed sodium ions, which limits water infiltration and impedes plant growth.
- (b) Adding calcium carbonate is ineffective because lime is highly insoluble in alkaline conditions and cannot supply the required concentration of calcium ions.
- (c) Calcium sulfate dihydrate, commonly known as gypsum, is a moderately soluble salt that provides a rich source of divalent calcium ions in alkaline conditions.
- (d) When applied to sodic soils, the calcium ions displace the harmful adsorbed sodium ions from the clay micelle surfaces via cation exchange.
- (e) The displaced sodium ions react with the remaining sulfate ions to form highly soluble sodium sulfate, which can then be leached deep below the root zone.

Final Answer: The chemical amendment added is Calcium Sulfate Dihydrate (Gypsum).

Answer: (B)

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Q38.

Solution**Concept:**

Essential plant nutrients are classified into distinct structural groups based on the relative quantities required for healthy plant development. Macronutrients are needed in large amounts, whereas micronutrients are required in trace quantities.

Solution:

- (a) Nitrogen, phosphorus, and potassium are classified as primary macronutrients because crops consume them in large quantities, often requiring supplemental fertilizer applications.
- (b) Micronutrients like zinc, iron, and boron are equally essential for plant metabolism but are needed only in trace amounts.
- (c) Calcium, magnesium, and sulfur are classified as secondary macronutrients because plants require them in moderate amounts.
- (d) Sulfur plays an indispensable role in plant biology, serving as a core constituent of essential amino acids like cysteine and methionine.
- (e) Because sulfur is required in macro quantities but ranks below the primary trio in typical fertilizer demand, it is classified as a secondary macronutrient.

Final Answer: The plant nutrient classified as a secondary macronutrient is Sulfur (S).

Answer: (C)

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Q39.

Solution**Concept:**

The mass percentage of an element within a chemical compound is determined using stoichiometric principles. Dividing the total mass of the target element by the overall molar mass of the compound yields its precise mass fraction.

Solution:

- (a) The standard chemical formula for the synthetic agrochemical fertilizer urea is written as NH_2CONH_2 .
- (b) To calculate its molar mass, we sum the atomic weights of all constituent atoms: two nitrogen atoms, four hydrogen atoms, one carbon atom, and one oxygen atom.
- (c) Substituting the atomic masses gives a total molar mass of $(2 \times 14) + (4 \times 1) + 12 + 16 = 60$ grams per mole.
- (d) Next, we isolate the total mass contributed solely by the nitrogen atoms within a single mole of urea, which equals 28 grams.
- (e) Dividing the mass of nitrogen by the total molar mass of urea ($28/60$) and multiplying by 100 yields approximately 46.6

Final Answer: The percentage of nitrogen present in Urea is 46

Answer: (C)

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Q40.

Solution**Concept:**

Soil pH heavily influences the chemical solubility and bioavailability of essential mineral nutrients. Strongly acidic soil environments alter the chemical speciation of metallic elements, increasing their solubility to levels that can become phytotoxic.

Solution:

- (a) When soil pH drops below 5.0, the concentration of hydrogen ions increases, accelerating the weathering of insoluble oxide and hydroxide minerals.
- (b) Elements like calcium, magnesium, and potassium leach out of acidic soils easily, leading to widespread nutrient deficiencies.
- (c) Conversely, heavy metallic micronutrients bound within mineral matrices dissolve rapidly as the surrounding environment acidifies.
- (d) In strongly acidic soils, iron and manganese minerals dissolve into highly bioavailable ionic forms.
- (e) This drastic increase in solubility raises their concentrations in the soil solution, leading to excessive absorption that can reach toxic levels for most commercial crops.

Final Answer: The micronutrients that increase to toxic levels are Iron and Manganese.

Answer: (B)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	C	4	B	5	D
6	A	7	A	8	B	9	B	10	C
11	C	12	B	13	C	14	A	15	A
16	C	17	A	18	B	19	B	20	A
21	A	22	D	23	C	24	A	25	B
26	B	27	C	28	C	29	B	30	B
31	B	32	A	33	B	34	B	35	C
36	C	37	B	38	C	39	C	40	B

