

UPCATET Agriculture Chemistry Sample Paper-5

Duration: 25 Minutes

Maximum Marks: 100

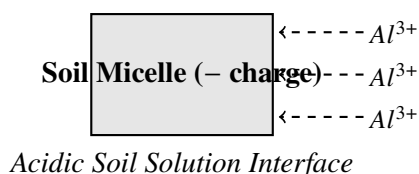
Instructions

- This paper contains **25** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **-1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. During a laboratory titration, 25 mL of an unknown strength H_2SO_4 solution isolated from an acidic soil extract requires exactly 20 mL of 0.1 N $NaOH$ to reach the phenolphthalein end-point. What is the normality of the soil acid extract?

- (A) 0.04 N
 (B) 0.08 N
 (C) 0.12 N
 (D) 0.16 N

Q2. A soil test reports a high concentration of dynamic trivalent aluminum (Al^{3+}) ions on the exchange complex, as illustrated in the schematic below. What is the most likely physiological consequence on plant roots growing in this environment?



- (A) Rapid increase in cellular elongation and secondary root branching
 (B) Inhibition of root elongation due to structural cell wall cross-linking



- (C) Enhanced uptake of rock phosphate minerals
- (D) Accelerated nodulation in leguminous crop varieties

Q3. A batch of commercial urea fertilizer $[CO(NH_2)_2]$ is evaluated in a laboratory. What is the precise theoretical percentage of elemental nitrogen content available to the plant upon complete mineralization?

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

Q4. An organic chemist performs the complete combustion of one mole of pure methane gas (CH_4) under standard laboratory conditions. Which option correctly identifies the stoichiometric moles of oxygen gas consumed and carbon dioxide produced?

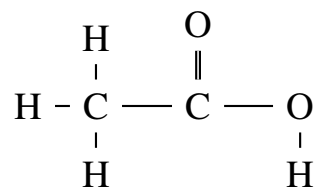
- (A) 1 mole O_2 , 1 mole CO_2
- (B) 2 moles O_2 , 1 mole CO_2
- (C) 2 moles O_2 , 2 moles CO_2
- (D) 1.5 moles O_2 , 1 mole CO_2

Q5. A specific chemical bond type is formed between a highly electropositive nutrient ion (such as K^+) and a highly electronegative element on a clay lattice surface. Which statement accurately describes the characteristics of this bond type?

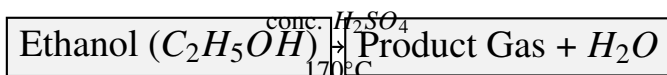
- (A) It involves rigid directional orbital hybridization with high melting points
- (B) It is formed by the mutual sharing of a pair of valence electrons between atoms
- (C) It is non-directional, relies on electrostatic attraction, and breaks down easily in aqueous solutions
- (D) It occurs due to the pooling of mobile delocalized electrons across a metal framework



- Q6.** The structural formula of an organic molecule isolated during plant fermentation is modeled below. Identify the correct systematic IUPAC name for this compound.



- (A) Methanoic acid
 (B) Ethanoic acid
 (C) Ethanol
 (D) Dimethyl ether
- Q7.** A sample of sodic soil is treated with agricultural gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) to lower its pH and displace exchangeable sodium. Which chemical reaction correctly represents this reclamation pathway on the soil colloid exchange complex?
- (A) $\text{Colloid}-\text{Na}_2 + \text{CaSO}_4 \rightarrow \text{Colloid}-\text{Ca} + \text{Na}_2\text{SO}_4$
 (B) $\text{Colloid}-\text{Ca} + 2\text{NaCl} \rightarrow \text{Colloid}-\text{Na}_2 + \text{CaCl}_2$
 (C) $\text{Colloid}-\text{H}_2 + \text{CaSO}_4 \rightarrow \text{Colloid}-\text{Ca} + \text{H}_2\text{SO}_4$
 (D) $\text{Colloid}-\text{Na}_2 + \text{H}_2\text{O} \rightarrow \text{Colloid}-\text{H}_2 + 2\text{NaOH}$
- Q8.** The phase change diagram below illustrates the industrial synthesis of an aliphatic hydrocarbon used as a fruit-ripening agent. What compound is produced when ethanol ($\text{C}_2\text{H}_5\text{OH}$) undergoes dehydration with concentrated sulfuric acid at an elevated temperature of 170°C ?



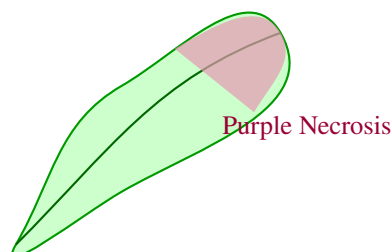
- (A) Methane
 (B) Ethane
 (C) Ethene
 (D) Ethyne



Q9. A research scholar prepares a standard solution by dissolving 5.3 grams of anhydrous sodium carbonate (Na_2CO_3 , molecular weight = 106) in water to make exactly 500 mL of volumetric solution. What is the precise molarity (M) of the prepared stock solution?

- (A) 0.05 M
- (B) 0.10 M
- (C) 0.20 M
- (D) 0.50 M

Q10. A visual crop survey reveals distinct dark purple and bronze discolorations along the older margins of maize leaves, as shown in the profile below. Which macronutrient deficiency is directly linked to this specific cellular stress symptom?



- (A) Nitrogen (N)
- (B) Phosphorus (P)
- (C) Potassium (K)
- (D) Zinc (Zn)

Q11. What is the total number of shared pairs of covalent electrons within a single molecule of ethane gas (C_2H_6)?

- (A) 4
- (B) 6
- (C) 7
- (D) 8



- Q12.** A farmer wants to prepare an accurate dilution of liquid agrochemical. If 10 mL of a concentrated 12 M liquid formulation is diluted with pure distilled water to a final volume of 250 mL, what is the resulting concentration of the solution?
- (A) 0.24 M
(B) 0.48 M
(C) 0.60 M
(D) 1.20 M
- Q13.** Which type of soil clay mineral is structurally classified as a 2:1 expanding crystalline silicate lattice, exhibiting an exceptionally high cation exchange capacity (CEC) and significant swelling properties?
- (A) Kaolinite
(B) Illite
(C) Montmorillonite
(D) Chlorite
- Q14.** What is the correct structural formula and chemical classification of the functional group found in a pure sample of glycerol extracted during agricultural lipid analysis?
- (A) Monohydric alcohol containing one –OH group
(B) Dihydric alcohol containing two –OH groups
(C) Trihydric alcohol containing three –OH groups
(D) Aliphatic aldehyde containing an –CHO group
- Q15.** According to Bohr's atomic model and wave mechanics, what occurs to the quantitative orbital radius and the total energy value of an electron as it transitions from a lower principal quantum energy level ($n = 1$) to a higher energy shell level ($n = 3$)?
- (A) Radius decreases; Energy decreases
(B) Radius increases; Energy increases

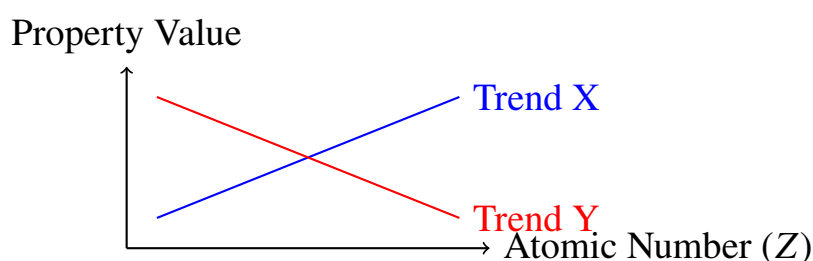


- (C) Radius increases; Energy decreases
- (D) Radius remains constant; Energy increases

Q16. An analytical chemist titrates a weak organic acid derived from compost against a strong alkaline solution (NaOH). Which chemical indicator would be most suitable for accurately pinpointing the equivalence point occurring at a pH range of 8.2 to 10.0?

- (A) Methyl orange
- (B) Bromothymol blue
- (C) Phenolphthalein
- (D) Methyl red

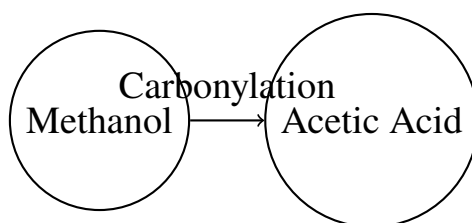
Q17. Consider the modern periodic trend diagram shown below. As an agricultural chemist analyzes elements in a horizontal sequence from left to right across Period 3 (Na to Cl), what is the correct trend for electronegativity and atomic radius?



- (A) Trend X represents Atomic Radius; Trend Y represents Electronegativity
- (B) Trend X represents Electronegativity; Trend Y represents Ionization Energy
- (C) Trend X represents Electronegativity; Trend Y represents Atomic Radius
- (D) Trend X represents Electron Affinity; Trend Y represents Non-metallic Character

Q18. The biochemical pathway below highlights the structural transformation of an organic acid found commonly in citrus fruits and plant vacuoles. What is the fundamental chemical formula of pure Acetic Acid?





- (A) HCHO
- (B) CH₃OH
- (C) CH₃COOH
- (D) HCOOH

Q19. A biological process called nitrification converts ammonium into nitrate ions in aerated agricultural soils. What is the exact oxidation state of the nitrogen atom in the chemical structures of ammonium (NH₄⁺) and nitrate (NO₃⁻) respectively?

- (A) -3 and +5
- (B) +3 and -5
- (C) -3 and +3
- (D) 0 and +5

Q20. Which specific soil condition significantly increases the chemical fixation and absolute unavailability of applied orthophosphate fertilizers (H₂PO₄⁻) due to the formation of highly insoluble hydroxy-phosphate precipitates?

- (A) Neutral soil environments with a pH between 6.5 and 7.0
- (B) Highly acidic soil environments with a pH below 5.0 rich in active iron and aluminum
- (C) Well-aerated sandy loam soils rich in organic humus fractions
- (D) Submerged or anaerobic wetland paddy soils

Q21. An organic chemist processes natural gas from an agricultural biodigester. What primary chemical product is obtained when a molecule of ethane (C₂H₆) undergoes free radical monosubstitution with chlorine gas (Cl₂) under the direct influence of ultraviolet light?

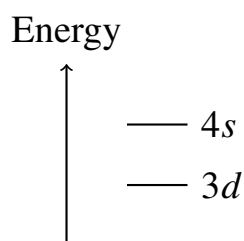


- (A) Chloromethane
- (B) Chloroethane
- (C) 1,2-dichloroethane
- (D) Vinyl chloride

Q22. Which fundamental quantum number dictates the precise directional spatial orientation of an electron orbital in a central atomic coordinate space?

- (A) Principal quantum number (n)
- (B) Azimuthal quantum number (l)
- (C) Magnetic quantum number (m_l)
- (D) Spin quantum number (s)

Q23. The energy level configurations of a critical transition metal micronutrient are shown below. If the atom loses three electrons to form a trivalent cation (M^{3+}), from which subshells are the electrons sequentially removed according to the Aufbau and Hund rules?



- (A) All three electrons are extracted exclusively from the $3d$ subshell
- (B) Two electrons from $4s$ and one electron from $3d$ subshell
- (C) One electron from $4s$ and two electrons from $3d$ subshell
- (D) Two electrons from $4s$ and one electron from $3p$ subshell

Q24. A series of soil chemistry flasks are measured for exact hydrogen ion concentrations. If a soil solution sample registers a measured hydronium concentration $[H^+]$ of 1.0×10^{-4} moles per liter, what is its corresponding soil pH and classification?

- (A) pH = 4; Strongly Acidic



- (B) pH = 10; Strongly Alkaline
- (C) pH = 7; Completely Neutral
- (D) pH = 6; Slightly Acidic

Q25. Which nitrogenous fertilizer compound leaves behind a highly toxic and undesirable residual effect when applied sequentially across intensive tea orchard plantations or tobacco fields due to its high chloride index?

- (A) Ammonium sulfate
- (B) Ammonium chloride
- (C) Calcium ammonium nitrate
- (D) Urea



Detailed Solutions

Q1.

Solution

Concept:

Volumetric analysis of acid-base mixtures relies on the principle of equivalence, which states that at the neutralization endpoint, the total gram equivalents of acid must equal the total gram equivalents of base. Normality is the measure of concentration expressed in gram equivalents per liter of solution.

Solution:

- Identify the volumetric variables given for the neutralisation reaction: the volume of the acidic soil extract (V_1) is 25 mL, the volume of the standard sodium hydroxide solution (V_2) used is 20 mL, and the normality of the sodium hydroxide base (N_2) is 0.1 N.
- Apply the law of chemical equivalence formula: $N_1 \times V_1 = N_2 \times V_2$, where N_1 represents the unknown normality of the H_2SO_4 soil extract.
- Substitute the known parameters into the mathematical equation: $N_1 \times 25 = 0.1 \times 20$.
- Simplify the expression to calculate the value of N_1 : $N_1 = \frac{2}{25}$.
- Complete the final division: $N_1 = 0.08$ N.

Final Answer: 0.08 N**Answer:** (B)

Q2.

Solution**Concept:**

Soil acidity and aluminum toxicity strongly govern root architecture and plant physiology. In highly acidic soil solutions, trivalent aluminum ions become solubilized and toxic, chemically interacting with root cellular structures.

Solution:

- (a) Trivalent aluminum ions dissolve into the soil solution from clay surfaces when the soil pH drops below 5.0.
- (b) Once active in the rhizosphere, these ions bind tightly to the negatively charged pectins located within the root apoplast.
- (c) This strong ionic binding causes extensive cross-linking of the cell wall matrix, making the cell walls rigid and unable to expand.
- (d) Consequently, cellular elongation at the root tip is immediately blocked, hindering the development of healthy roots.
- (e) The visual result is a stunted, highly restricted root system with brittle, thickened tips that fail to take up water and nutrients.

Final Answer: Inhibition of root elongation due to structural cell wall cross-linking

Answer: (B)



Q3.

Solution**Concept:**

The chemical composition and nutrient density of synthetic fertilizers are determined using the molar mass percentages of their elemental constituents based on their specific chemical formulas.

Solution:

- Write out the complete molecular formula of commercial urea, which is $CO(NH_2)_2$, or CH_4N_2O .
- Determine the individual atomic masses for each element in the compound: Carbon is 12, Hydrogen is 1, Nitrogen is 14, and Oxygen is 16.
- Calculate the total molar mass of urea: $12 + (4 \times 1) + (2 \times 14) + 16 = 12 + 4 + 28 + 16 = 60$ grams per mole.
- Find the total mass contributed by the elemental nitrogen atoms within the formula: $2 \times 14 = 28$ grams per mole.
- Calculate the nitrogen percentage: $\frac{28}{60} \times 100 = 0.4666 \times 100 = 46.66$ percent, which rounds down closely to 46 percent.

Final Answer: 46 percent

Answer: (C)



Q4.

Solution**Concept:**

Hydrocarbon combustion involves the exothermic chemical reaction of an aliphatic alkane with elemental oxygen gas to yield oxidized carbon dioxide gas and gaseous water molecules.

Solution:

- (a) Write out the unbalanced chemical equation representing the complete combustion of methane gas: $CH_4 + O_2 \rightarrow CO_2 + H_2O$.
- (b) Balance the carbon atoms on both sides of the reaction: one mole of methane yields exactly one mole of carbon dioxide.
- (c) Balance the hydrogen atoms: the four hydrogen atoms present in one mole of methane require the formation of two moles of water.
- (d) Count the total oxygen atoms present on the product side: two from carbon dioxide and two from water, giving four total atoms.
- (e) Balance the reactant oxygen molecules by assigning two moles of O_2 gas, completing the balanced equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$.

Final Answer: 2 moles O_2 , 1 mole CO_2

Answer: (B)



Q5.

Solution**Concept:**

Chemical bonding at the clay-water interface is dictated by the electronegativity differences between the structural components of the clay lattice and exchangeable nutrient cations.

Solution:

- (a) Potassium carries a low electronegativity and easily loses its single valence electron to form a highly electropositive cation (K^+).
- (b) The surface oxygen atoms of the silicate clay mineral lattice present a high concentrated negative charge density.
- (c) The massive electronegativity difference between these two entities results in a complete transfer of electrons, generating an ionic bond.
- (d) Ionic bonds are completely non-directional and are held together by omnidirectional electrostatic forces of attraction.
- (e) Because of this electrostatic nature, water molecules easily hydrate these ions, allowing the bonds to break down and dissociate in aqueous soil solutions.

Final Answer: It is non-directional, relies on electrostatic attraction, and breaks down easily in aqueous solutions

Answer: (C)



Q6.

Solution**Concept:**

The systematic nomenclature of organic compounds follows specific rules established by the International Union of Pure and Applied Chemistry (IUPAC) to identify carbon chain lengths and principal functional groups.

Solution:

- (a) Analyze the provided chemical structure diagram to identify the total number of carbon atoms linked in the continuous chain.
- (b) The chain contains exactly two carbon atoms, which establishes the core parent alkane root prefix as "eth".
- (c) Examine the terminal functional group present in the structure: a carbon double-bonded to an oxygen and single-bonded to a hydroxyl group, written as $-COOH$.
- (d) Identify this group as a carboxylic acid, which dictates that the systematic suffix of the molecule must end in "oic acid".
- (e) Combine the parent root and functional suffix together to arrive at the proper systematic name: ethanoic acid.

Final Answer: Ethanoic acid

Answer: (B)



Q7.

Solution**Concept:**

Sodic soil reclamation involves a chemical cation displacement reaction where divalent calcium ions replace monovalent sodium ions on the negatively charged exchange complex of the soil.

Solution:

- (a) Sodic soils possess high levels of exchangeable sodium ions on their colloid surfaces, which leads to soil particle dispersion.
- (b) Agricultural gypsum, chemically known as calcium sulfate dihydrate, dissolves in the soil moisture to liberate free divalent calcium ions (Ca^{2+}).
- (c) Divalent calcium ions possess a higher charge density and greater affinity for the negative exchange site than monovalent sodium ions (Na^+).
- (d) The calcium ions physically displace the sodium ions from the clay complex, forcing them into the surrounding soil solution.
- (e) The displaced sodium combines with sulfate ions to form soluble sodium sulfate (Na_2SO_4), which is then leached out of the root zone by irrigation water.

Final Answer: $Colloid-Na_2 + CaSO_4 \rightarrow Colloid-Ca + Na_2SO_4$

Answer: (A)



Q8.

Solution**Concept:**

The dehydration of primary aliphatic alcohols using strong mineral acid catalysts proceeds through a temperature-dependent elimination pathway to form unsaturated gaseous hydrocarbons.

Solution:

- (a) Ethanol mixed with concentrated sulfuric acid undergoes an initial protonation reaction to form an oxonium ion intermediate.
- (b) At an elevated temperature of 170°C , an intramolecular elimination reaction occurs, causing a water molecule to break away.
- (c) The elimination of the water molecule generates a highly reactive carbocation intermediate within the carbon chain.
- (d) A adjacent proton is then pulled away, causing the single bond between the carbon atoms to transition into a stable double bond.
- (e) This specific structural transition converts the molecule into ethene gas (C_2H_4), which functions naturally as a commercial fruit-ripening agent.

Final Answer: Ethene

Answer: (C)



Q9.

Solution**Concept:**

Molarity measures the chemical concentration of a solute within a volumetric solution, defined as the total number of moles of solute dissolved per liter of solution.

Solution:

- (a) Note the initial analytical values: mass of sodium carbonate solute is 5.3 grams, and the molecular weight is given as 106.
- (b) Calculate the total moles of solute present using the mass formula: $\text{Moles} = \frac{5.3}{106} = 0.05$ moles of solute.
- (c) Convert the total volume of the solution from milliliters to liters: $\frac{500 \text{ mL}}{1000 \text{ mL/L}} = 0.5$ liters of solution.
- (d) State the standard mathematical definition for molarity: $\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Volume of Solution in Liters}}$.
- (e) Substitute the values to find the final concentration: $\text{Molarity} = \frac{0.05}{0.5} = 0.10 \text{ M}$.

Final Answer: 0.10 M**Answer: (B)**

Q10.

Solution**Concept:**

Essential macronutrients act as vital structural and metabolic components within plant tissues. When a specific nutrient becomes deficient, crops show unique visual symptoms depending on how mobile that nutrient is within their vascular system.

Solution:

- (a) Phosphorus is highly mobile within plant vascular networks, meaning it can be easily redistributed from older tissues to active young growth zones.
- (b) When a soil environment suffers from a severe phosphorus shortage, the plant pulls the nutrient out of its older, lower leaves to sustain new growth.
- (c) This depletion disrupts normal carbohydrate metabolism, leading to an abnormal accumulation of sugars within the older leaf cells.
- (d) The high sugar concentrations trigger the overproduction of purple anthocyanin pigments within the cells.
- (e) This biochemical shift produces a distinct dark purple and bronze coloration along the outer margins of the older leaves.

Final Answer: Phosphorus (P)

Answer: (B)



Q11.

Solution**Concept:**

Covalent chemical bonds are characterized by the regional sharing of localized valence electron pairs between highly electronegative non-metallic atoms to achieve a stable electronic configuration matching adjacent noble gases.

Solution:

- (a) Draw or visualize the structural formula of an ethane molecule, which belongs to the saturated aliphatic alkane hydrocarbon series and contains two central carbon atoms bonded with six terminal hydrogen atoms.
- (b) Analyze the chemical bonding localized between the two central carbon atoms, which share a single pair of valence electrons to establish one strong directional carbon-to-carbon single covalent bond.
- (c) Examine the peripheral chemical bonding between the carbon core and the surrounding hydrogen atoms, where each individual carbon atom shares one electron pair with three distinct hydrogen atoms.
- (d) Calculate the total count of carbon-to-hydrogen single covalent bonds across the entire structural arrangement, which yields exactly six individual peripheral covalent linkages.
- (e) Sum all the localized shared electron pairs together by adding the single central carbon-carbon bond to the six peripheral carbon-hydrogen bonds, arriving at a total of seven shared pairs.

Final Answer: 7**Answer:** (C)

Q12.

Solution**Concept:**

The chemical dilution of standard laboratory solutions follows the fundamental principle of mass conservation, which states that the total number of millimoles or equivalents of solute remains constant during fluid modification.

Solution:

- Identify the initial volumetric and concentration variables provided for the concentrated stock agrochemical liquid formulation: the starting volume (V_1) is 10 mL and the starting concentration (M_1) is 12 M.
- Identify the terminal volumetric parameter given for the final diluted mixture: the target volume (V_2) achieved after adding pure distilled water is exactly 250 mL.
- State the standard linear volumetric dilution equation derived from chemical conservation laws: $M_1 \times V_1 = M_2 \times V_2$, where M_2 represents the unknown terminal molarity of the solution.
- Substitute the known experimental values into the linear mathematical expression: $12 \times 10 = M_2 \times 250$.
- Isolate the variable to solve for the final concentration value: $M_2 = \frac{120}{250} = \frac{12}{25} = 0.48$ M.

Final Answer: 0.48 M**Answer:** (B)

Q13.

Solution**Concept:**

The structural classification of crystalline aluminosilicate clay minerals determines their physico-chemical surface properties, including expansion behavior, internal surface area availability, and structural cation exchange capacity.

Solution:

- (a) Crystalline silicate clays are classified based on the ratio of tetrahedral silica sheets to octahedral alumina sheets arranged within their basic structural unit cells.
- (b) The 2:1 mineral group consists of a single octahedral sheet sandwiched securely between two opposing outer tetrahedral sheets, creating an accessible interlayer space.
- (c) In montmorillonite clay minerals, isomorphic substitution of magnesium ions for aluminum ions in the octahedral sheet generates a high net negative layer charge.
- (d) The structural layers are held together loosely by weak van der Waals forces, allowing water molecules to easily enter and expand the internal crystal lattice.
- (e) This expanding nature unlocks vast internal surface areas, which gives montmorillonite an exceptionally high cation exchange capacity compared to non-expanding minerals like kaolinite or illite.

Final Answer: Montmorillonite

Answer: (C)



Q14.

Solution**Concept:**

Aliphatic alcohols are structurally categorized into distinct chemical sub-classes based on the absolute number of hydrophilic neutral hydroxyl functional groups attached along the primary carbon skeleton.

Solution:

- (a) Isolate the organic compound glycerol from agricultural lipid fractions during analytical characterization and determine its complete structural configuration, which is systematically named propane-1,2,3-triol.
- (b) Examine the underlying carbon backbone of the molecule, which consists of three contiguous saturated carbon atoms bonded to one another via single covalent linkages.
- (c) Observe that each individual carbon atom within this chain holds exactly one separate, functional hydroxyl group, yielding three reactive groups per molecule.
- (d) Apply the classification rules for aliphatic alcohols: molecules containing one hydroxyl group are monohydric, two are dihydric, and three are classified as trihydric.
- (e) Conclude that since glycerol features three distinct functional hydroxyl groups attached across its three-carbon framework, it is properly categorized as a trihydric alcohol.

Final Answer: Trihydric alcohol containing three –OH groups

Answer: (C)



Q15.

Solution**Concept:**

Bohr atomic theory explains electron transitions between discrete stationary energy orbits using quantized orbital radius equations and negative potential-kinetic energy summation balances.

Solution:

- (a) State the relationship for the radius of an electron orbit in a hydrogen-like atom: radius is directly proportional to the square of the principal quantum number (n^2).
- (b) Calculate the radius shift as an electron transitions from the ground energy state ($n = 1$) up to the excited state ($n = 3$), which results in a nine-fold increase in distance.
- (c) State the relationship for the total energy of an electron inside an atomic orbit: energy is inversely proportional to the square of the principal quantum number, expressed as a negative value.
- (d) Analyze the energy value change using the mathematical relationship: energy increases from a more negative value at $n = 1$ to a less negative value at $n = 3$.
- (e) Conclude that moving an electron farther away from the positive pull of the nucleus increases both its physical orbital radius and its total mechanical energy.

Final Answer: Radius increases; Energy increases

Answer: (B)



Q16.

Solution**Concept:**

Acid-base indicators are weak organic acids or bases that change color within specific pH ranges based on their structural ionization balance at the titration equivalence point.

Solution:

- (a) Analyze the chemical reaction between a weak compost-derived organic acid and a strong alkaline titrant like sodium hydroxide, which yields a basic conjugate salt solution at the equivalence point.
- (b) Note that due to the hydrolysis of the resulting basic salt in an aqueous environment, the true neutral stoichiometric equivalence point shifts into an alkaline pH range above 7.0.
- (c) Identify the specific transition interval of the pH curve for this weak acid-strong base combination, which typically spans a range between 8.2 and 10.0.
- (d) Evaluate the working pH ranges of standard indicators: methyl orange changes color at low pH values, while bromothymol blue operates near a neutral pH value of 7.0.
- (e) Select phenolphthalein as the ideal indicator because its clear-to-pink color change perfectly aligns with the basic equivalence point range of 8.2 to 10.0.

Final Answer: Phenolphthalein

Answer: (C)



Q17.

Solution**Concept:**

Periodic table trends across a horizontal period are governed by a progressive increase in the nuclear charge without an increase in the number of electron shielding shells.

Solution:

- (a) Trace the elements horizontally from left to right across Period 3, starting at electropositive sodium ($Z = 11$) and ending at highly electronegative chlorine ($Z = 17$).
- (b) Note that as the atomic number increases sequentially across the period, protons are added to the nucleus while electrons fill the same outer valence shell.
- (c) This systematic addition increases the effective nuclear charge, which pulls the outer electrons closer and causes the atomic radius to contract from left to right.
- (d) Observe that this stronger nuclear pull also increases the atom's ability to attract shared electrons within a chemical bond, causing electronegativity to rise.
- (e) Match these observations with the provided trend lines: Trend X, which rises, represents increasing electronegativity, while Trend Y, which falls, represents a decreasing atomic radius.

Final Answer: Trend X represents Electronegativity; Trend Y represents Atomic Radius

Answer: (C)



Q18.

Solution**Concept:**

The structural representation of aliphatic carboxylic acids uses empirical molecular configurations to identify the presence of both a hydrophobic alkyl radical and a hydrophilic carboxyl group.

Solution:

- (a) Review the provided biochemical transformation pathway, which shows the chemical carbonylation of a single-carbon methanol molecule into a two-carbon organic acid.
- (b) Identify the common name of the compound produced by this industrial pathway as acetic acid, which belongs to the saturated monocarboxylic acid family.
- (c) Recall the systematic IUPAC designation for this two-carbon organic acid, which is ethanoic acid, indicating it contains a total of two carbon atoms.
- (d) Break down the structural parts of the molecule: a single methyl radical groups with a terminal, highly oxidized carboxyl functional group.
- (e) Combine these structural components into the standard chemical formula for pure acetic acid, which is written as CH_3COOH .

Final Answer: CH_3COOH

Answer: (C)



Q19.

Solution**Concept:**

Oxidation states represent the hypothetical charge an atom would carry if all its chemical bonds to different elements were completely ionic. This metric tracks electron distribution during biological transformations.

Solution:

- State the standard rules for assigning oxidation numbers: hydrogen is generally assigned a value of +1 and oxygen is assigned a value of -2.
- Set up an algebraic equation for the nitrogen atom (X) inside the cationic ammonium polyatomic molecule: $X + (4 \times 1) = +1$.
- Solve the linear equation to find the oxidation state of the nitrogen atom within the ammonium ion: $X = +1 - 4 = -3$.
- Set up a separate algebraic equation for the nitrogen atom (Y) inside the anionic nitrate polyatomic molecule: $Y + (3 \times -2) = -1$.
- Solve this equation to find the oxidation state of the nitrogen atom within the nitrate ion: $Y = -1 + 6 = +5$.

Final Answer: -3 and +5**Answer:** (A)

Q20.

Solution**Concept:**

The chemical fixative behavior of applied orthophosphate fertilizers depends on soil solution pH, which regulates the solubility of competing metal cations like iron, aluminum, and calcium.

Solution:

- (a) Applied orthophosphate fertilizers dissolve into the soil solution primarily as available monovalent dihydrogen phosphate anions (H_2PO_4^-).
- (b) When soil pH drops below 5.0, the soil environment becomes highly acidic, causing iron and aluminum oxyhydroxide minerals to dissolve and release active trivalent cations.
- (c) These active trivalent iron (Fe^{3+}) and aluminum (Al^{3+}) ions react with the soluble dihydrogen phosphate anions in the soil solution.
- (d) This chemical interaction forms highly insoluble precipitates, such as variscite and strengite, through a process known as phosphate fixation.
- (e) These stable mineral precipitates lock away the phosphorus, making it permanently unavailable for uptake by crop root systems.

Final Answer: Highly acidic soil environments with a pH below 5.0 rich in active iron and aluminum

Answer: (B)



Q21.

Solution**Concept:**

Saturated aliphatic hydrocarbons such as alkanes undergo chemical substitution reactions rather than additions because they lack reactive multiple bonds. Under light catalysis, a halogen atom displaces a hydrogen atom via a radical chain mechanism.

Solution:

- (a) Identify the saturated nature of the starting material, ethane, which possesses two carbon atoms and six hydrogen atoms bound entirely by stable covalent single bonds.
- (b) When chlorine gas mixes with the hydrocarbon in the presence of intense ultraviolet light, the electromagnetic radiation breaks the chlorine molecular bond homolytically.
- (c) This homolytic cleavage generates highly reactive chlorine free radicals that immediately attack the saturated carbon framework of the ethane molecule.
- (d) A chlorine radical abstracts a hydrogen atom to form hydrogen chloride gas while converting the alkane skeleton into an ethyl radical intermediate.
- (e) The unstable ethyl radical reacts quickly with another elemental chlorine molecule to yield a stable monosubstituted haloalkane along with another propagating radical.
- (f) This specific photochemical sequence replaces exactly one hydrogen atom with one chlorine atom, producing chloroethane as the primary organic end product.

Final Answer: Chloroethane

Answer: (B)



Q22.

Solution**Concept:**

Quantum mechanics describes the wave behavior of atomic electrons using four separate quantum numbers that define the energy, shape, spatial distribution, and intrinsic spin vectors of individual atomic subshells.

Solution:

- (a) Review the structural functions assigned to each of the four fundamental parameters within a three-dimensional mathematical coordinate space.
- (b) The principal quantum number determines the primary distance of the electron from the nucleus, effectively setting the shell volume and energy level.
- (c) The azimuthal quantum number describes the underlying geometric form of the region, defining whether the orbital looks like a sphere or a dumbbell.
- (d) The magnetic quantum number specifies the exact orientation of that specific geometric shape relative to an external three-dimensional coordinate system.
- (e) For any given subshell value, this parameter ranges from negative value to positive value, determining the total number of independent space orientations.
- (f) Therefore, while the azimuthal index controls the general shape of an orbital, the magnetic index specifically governs its directional path in space.

Final Answer: Magnetic quantum number (m_l)

Answer: (C)



Q23.

Solution**Concept:**

Cation formation in transition elements requires the sequential removal of valence electrons from outermost subshells following precise energy rules, where structural shielding factors shift ionization priorities.

Solution:

- (a) Write the complete ground-state atomic configuration for a transition metal element using the standard rules of orbital energy ordering.
- (b) Note that during orbital filling, the four-s subshell completes before the three-d subshell because it possesses a slightly lower initial energy level.
- (c) Once electrons reside inside these orbitals, the three-d subshell drops lower in energy than the four-s subshell due to nuclear configuration changes.
- (d) When an atom experiences ionization to produce a trivalent cation, electrons must leave the outermost principal quantum level first.
- (e) Remove the first two valence electrons from the four-s orbital because it occupies the highest shell number farthest from the nucleus.
- (f) Extract the third required electron from the highest energy electron remaining within the adjacent three-d subshell to yield the stable cation configuration.

Final Answer: Two electrons from 4s and one electron from 3d subshell

Answer: (B)



Q24.

Solution**Concept:**

Soil pH values are determined by measuring the negative base-ten logarithm of the active hydronium ion concentration present within an equilibrium aqueous soil solution extract.

Solution:

- (a) Note the quantitative analytical data obtained from the laboratory flask: the active hydronium concentration equals exactly one point zero times ten to the power of minus four moles per liter.
- (b) State the core logarithmic formula utilized to evaluate standard pH values: pH is equal to the negative base-ten logarithm of the hydronium concentration.
- (c) Substitute the experimental measurement directly into the equation: pH is equal to the negative base-ten logarithm of ten to the power of minus four.
- (d) Simplify the expression using standard rules of exponents: the log operation yields a value of negative four, which becomes positive four.
- (e) Evaluate the classification of the soil sample using standard agronomic reference indices based on the calculated numeric value.
- (f) Conclude that any agricultural soil showing a value of four falls far below the neutral index and is classified as strongly acidic.

Final Answer: pH = 4; Strongly Acidic

Answer: (A)



Q25.

Solution**Concept:**

The selection of synthetic nitrogen sources for intensive crop management requires balancing absolute nutrient content against toxic salt indices and long-term residual chemical alterations in the rhizosphere.

Solution:

- (a) Analyze the chemical properties of ammonium chloride, which releases both soluble ammonium ions and free chloride anions upon dissolving into soil moisture.
- (b) Note that certain premium cash crops, including tobacco plants and orchard tea bushes, are highly sensitive to high concentrations of chloride ions.
- (c) Continuous applications of this fertilizer cause chloride anions to accumulate in the root zone, creating toxic osmotic stress conditions.
- (d) The excessive salt load prevents the crop roots from absorbing moisture, leading to leaf scorch, poor quality, and cellular necrosis.
- (e) Other nitrogen fertilizers like urea or ammonium sulfate supply the necessary macronutrients without introducing these toxic levels of halogen companion anions.
- (f) Therefore, ammonium chloride remains poorly suited for chloride-sensitive crops due to its high salt index and hazardous chemical residue.

Final Answer: Ammonium chloride

Answer: (B)



Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	C	4	B	5	C
6	B	7	A	8	C	9	B	10	B
11	C	12	B	13	C	14	C	15	B
16	C	17	C	18	C	19	A	20	B
21	B	22	C	23	B	24	A	25	B

