NIOS Class 12 Chemistry Sample Paper-6

Duration: 180 Minutes **Maximum Marks: 80**

Instructions

- This paper contains **43** Questions. The paper is divided into two sections: **Section A – 40** marks, **Section B – 40** marks.
- **Section A** consists of
  - **Q.No. 1 to 16** – Multiple Choice type questions (MCQs) carrying 1 mark each. Select and write the most appropriate option out of the four options given in each of these questions. An internal choice has been provided in some of these questions. You have to attempt only one of the given choices in such questions.
  - **Q. No. 17 to 28** – Objective type questions. Q. No. 17 to 28 carry 02 marks each (with 2 sub- parts of 1 mark each). Attempt these questions as per the instructions given for each of the questions 17 –28.
- **Section B** consists of
  - **Q.No. 29 to 37** – Very Short questions carrying 02 marks each to be answered in the range of 30 to 50 words.
  - **Q.No. 38 to 41** – Short Answer type questions carrying 03 marks each to be answered in the range of 50 to 80 words.
  - **Q.No. 42 and 43** – Long Answer type questions carrying 05 marks each to be answered in the range of 80 to 120 words.
- There is **No Negative marking**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section: A

Q1. The number of oxygen atoms present in 0.50 mol of Al_2O_3 is: **(1)**

(A) 9.033×10^{23}

(B) 6.022×10^{23}

(C) 3.011×10^{23}

(D) 1.8066×10^{24}

Q2. Which of the following has the same empirical formula as ethanoic acid, $C_2H_4O_2$? **(1)**

(A) C_2H_6O

(B) CH_2O

(C) C_3H_6O

(D) CHO

Q3. The maximum number of electrons that can be accommodated in the shell with principal quantum number $n = 4$ is: **(1)**

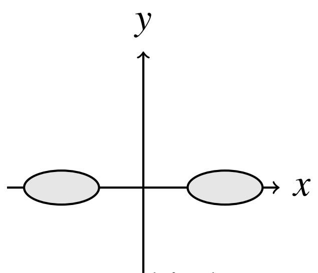
(A) 8

(B) 18

(C) 32

(D) 16

Q4. The orientation of atomic orbitals in space depends on the: **(1)**



p_x orbital

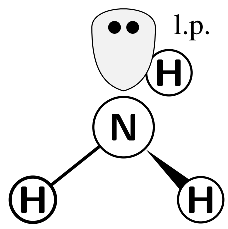
(A) Principal quantum number

(B) Azimuthal quantum number

(C) Spin quantum number

(D) Magnetic quantum number

Q5. The molecular shape of ammonia is: **(1)**



(A) Trigonal pyramidal

(B) Trigonal planar

(C) Tetrahedral

(D) Linear

Q6. A 1 molal solution means: **(1)**

(A) 1 mole of solute in 1 litre of solution

(B) 1 mole of solute in 1 kg of solvent

(C) 1 gram of solute in 1 kg of solvent

(D) 1 mole of solvent in 1 litre of solution

Q7. For an exothermic reaction carried out at constant pressure, the sign of enthalpy change is: **(1)**

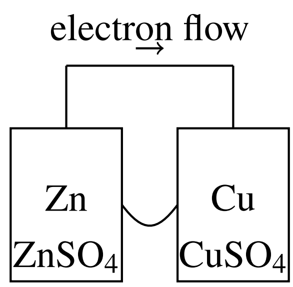
(A) Positive

(B) Zero

(C) Negative

(D) Infinite

Q8. In the Daniell cell shown below, the cathode is the: **(1)**



(A) Zinc electrode

(B) Salt bridge

(C) Porous partition

(D) Copper electrode

Q9. For a first-order reaction, the half-life is: **(1)**

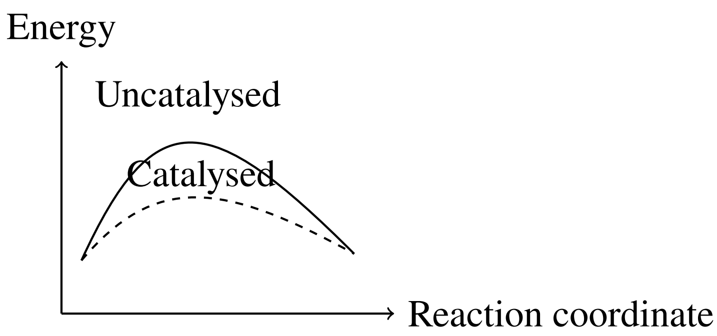
(A) Independent of the initial concentration

(B) Directly proportional to the initial concentration

(C) Inversely proportional to k^2

(D) Equal to zero

Q10. The energy profile shown below represents a reaction in which: **(1)**



(A) ΔH decreases and activation energy increases

(B) Activation energy decreases but ΔH remains unchanged

(C) Activation energy increases but ΔH remains unchanged

(D) Both activation energy and ΔH increase

Q11. Which of the following is a basic oxide? **(1)**

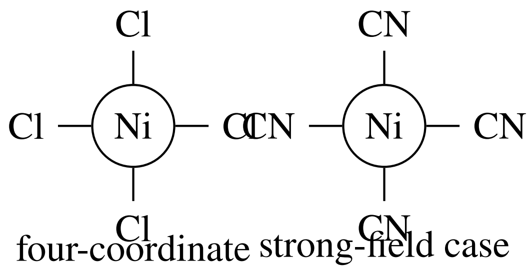
(A) CO_2

(B) SO_3

(C) MgO

(D) N_2O_5

Q12. Which of the following complexes is square planar? **(1)**



(A) $[NiCl_4]^{2-}$

(B) $[Ni(CO)_4]$

(C) $[ZnCl_4]^{2-}$

(D) $[Ni(CN)_4]^{2-}$

Q13. Ester is formed by a reaction between: **(1)**

(A) An acid and an alcohol

(B) An acid and a base

(C) An alkane and an alcohol

(D) A ketone and an alcohol

Q14. Which reagent is commonly used to distinguish an aldehyde from a ketone? **(1)**

(A) Bromine water

(B) Tollens' reagent

(C) Sodium chloride solution

(D) Dilute sodium hydroxide

Q15. Which of the following is an essential amino acid? **(1)**

(A) Glycine

(B) Alanine

(C) Valine

(D) Serine

Q16. Which of the following substances is commonly used as an antacid? **(1)**

(A) Aspirin

(B) Penicillin

(C) Chloramphenicol

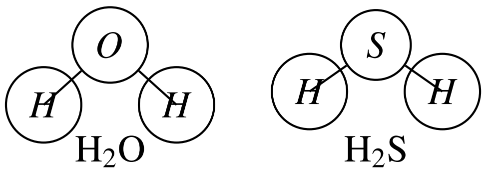
(D) Magnesium hydroxide

Note: Q. No. 17 to 28 are the objective type questions of 2 marks each.

Q17. Complete the following by using the options given below:
(Avogadro constant, molar mass, mole fraction, limiting reagent) **(2)**

1. One mole of any substance contains particles equal to the ....
2. The mass in grams of one mole of a substance is called its ....

Q18. Read the passage given below and answer the following questions:
Water and hydrogen sulphide are both hydrides of group 16 elements. In both molecules, the central atom is sp^3 hybridised. However, due to different electronegativity and different lone-pair repulsions, their bond angles and physical states are not the same. **(2)**



1. Write the hybridisation state of the central atom in H_2O and H_2S.
2. Which molecule has the larger bond angle and why?

Q19. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. Ionic bond involves transfer of electrons whereas covalent bond involves sharing of electrons.
2. A coordinate bond is formed by equal contribution of one electron each from the two bonded atoms.

Q20. Complete the following by using the options given below:
(atomic number, mass number, isotopes, isobars) **(2)**

1. The number of protons present in the nucleus of an atom is called its ....
2. The total number of protons and neutrons present in the nucleus is called its

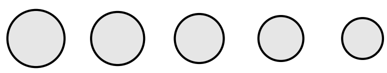
Q21. Complete the following by using the options given below:
(absence of d-orbitals, paramagnetic, diamagnetic, bent) **(2)**

1. Due to ...., nitrogen does not form pentahalides.
2. In the gaseous state nitric oxide is ..... but in the liquid state it is .....

Q22. Read the passage given below and answer the following questions:
At a sweet shop, a student requested the shopkeeper to put a warm sweet box inside a polythene bag. The shopkeeper refused and used a paper bag instead. The shopkeeper also explained that single-use plastic bags are discouraged because they create long-term environmental problems. **(2)**

1. Why is the use of polythene bags discouraged from an environmental point of view?
2. As a student of chemistry, why would you support paper bags over thin polythene bags in such situations?

Q23. Read the passage given below and answer the following questions:
Lanthanoids are the elements in which the differentiating electron enters the $4f$ subshell. Their most common oxidation state is +3, but some members can also show +2 and +4 due to extra stability associated with f^0, f^7 and f^{14} configurations. There is a gradual decrease in ionic size from La to Lu, which is known as lanthanoid contraction. **(2)**



decreasing size across the series

1. What is meant by lanthanoid contraction?
2. Name one lanthanoid that commonly shows the +2 oxidation state because of extra electronic stability.

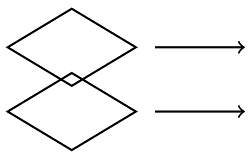
Q24. Match the items given in Column I with the most appropriate items in Column II: **(2)**

Column I	**Column II**
(a) Graphite	(i) Strong oxidising agent
(b) Bleaching powder	(ii) Conducts electricity due to delocalised electrons
(c) Tollens' reagent	(iii) Test for aldehydes
(d) Potassium permanganate	(iv) Disinfecting and bleaching agent

Q25. Complete the following reaction equations: **(2)**

1. $CH_3CH_2OH \xrightarrow[\text{acidified}]{[O]}$
2. $C_6H_5OH + 3Br_2(aq) \longrightarrow +3HBr$

Q26. Read the passage given below and answer the following questions:
Diamond and graphite are two allotropes of carbon. In diamond, each carbon atom is tetrahedrally bonded to four other carbon atoms, producing a rigid three-dimensional structure. In graphite, each carbon atom is bonded to three other carbon atoms in planar layers; one electron per carbon remains delocalised over the layer. **(2)**



graphite layers

1. Why does graphite conduct electricity whereas diamond does not?
2. Name the allotrope of carbon used in pencils.

Q27. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. An element is a pure substance that contains only one kind of atom.
2. Pure gold is a compound made up of three different kinds of atoms.

Q28. Read the passage given below and answer the questions given below:

Soaps are sodium or potassium salts of long-chain fatty acids. Detergents are synthetic cleansing agents that work well even in hard water because their calcium and magnesium salts remain soluble. Medicated soaps may contain antiseptic additives. Biodegradable detergents are preferred over branched-chain non-biodegradable detergents because they cause less long-term pollution. **(2)**

1. Why do detergents work well in hard water whereas soaps generally do not?
2. Name one antiseptic additive that may be used in medicated soap.

Section: B

Q29. (i) Explain the terms: (a) buffer capacity, (b) buffer index.

OR

(ii) Define freezing point and boiling point. **(2)**

Q30. Explain the relationship between enthalpy and spontaneity of a reaction. **(2)**

Q31. (i) Two litres of an ideal gas at a pressure of 8 atm expands isothermally into a vacuum until its total volume becomes 10 litres. How much heat is absorbed and how much work is done in the expansion?

OR

(ii) Which of the following will increase the internal energy of a system and why?

(a) Heat given to the system

(b) Work done by the system **(2)**

Q32. (i) Why do we usually study enthalpy change and not internal energy change for ordinary laboratory reactions?

OR

(ii) Comment on the bond energies of the four $C-H$ bonds in methane. **(2)**

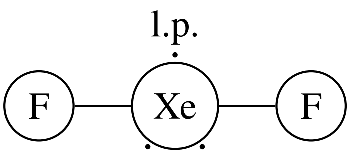
Q33. Explain the neutralization reaction according to Arrhenius theory. **(2)**

Q34. What is the effect of adding a catalyst on: (a) activation energy, and (b) Gibbs energy change of a reaction? **(2)**

Q35. (i) Why is Bi(V) a stronger oxidising agent than Sb(V)?

OR

(ii) Draw the structure of XeF_2 molecule. **(2)**



Q36. How would you obtain ethane-1,2-diol from ethanol? **(2)**

Q37. Complete the following reaction equations: **(2)**

(a) $CH_3CHO + HCN \longrightarrow$

(b) $C_6H_5N_2^+Cl^- \xrightarrow[HCl]{CuCl} +N_2$

Q38. Define the following terms:

A. Mole fraction

B. Isotonic solutions

C. van't Hoff factor **(3)**

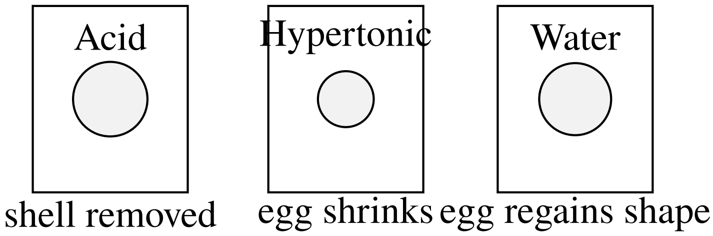
Q39. (i) How can you remove the hard calcium carbonate layer of an egg without damaging its semipermeable membrane? Can this egg be inserted into a bottle with a narrow neck without permanently distorting its shape? Explain the process involved.

OR

(ii) Calculate the molarity of each of the following solutions:

(a) 24.95 g of $CuSO_4 \cdot 5H_2O$ dissolved to make 1.00 L of solution.

(b) 20 mL of 1.5 M HCl diluted to 250 mL. **(3)**



Q40. Explain how the concentration of $[H^+]$ or $[OH^-]$ decides whether a solution is acidic, neutral, or alkaline. **(3)**

Q41. (i) What is the cause of anomalous behaviour of the top element in each group of the p-block elements?

OR

(ii) Comment on the ionic or covalent nature of the hydrides of the p-block elements. **(3)**

Q42. (i) Answer the following:

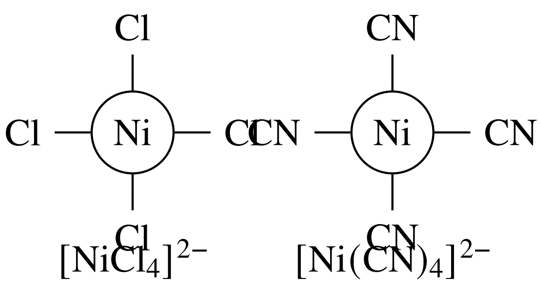
A. Write the IUPAC name of the complex $[Cr(NH_3)_4Cl_2]Cl$.

B. What type of isomerism is exhibited by the complex $[Co(en)_3]^{3+}$?

C. Why is $[NiCl_4]^{2-}$ paramagnetic but $[Ni(CN)_4]^{2-}$ diamagnetic?

OR

(ii) Explain the hybridisation, shape and magnetic behaviour of the complex $[Fe(CN)_6]^{4-}$ on the basis of valence bond theory. **(5)**



Q43. (i) What are the differences between α-glucose and β-glucose? What is meant by the pyranose structure of glucose?

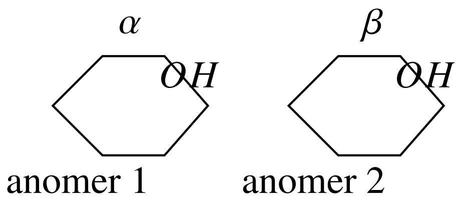
OR

(ii) (1) Why must water-soluble vitamins be supplied regularly in the diet? Give one example.

(2) Differentiate between the following:

(a) Essential and non-essential amino acids.

(b) Fibrous and globular proteins. **(5)**



Detailed Solutions

Q1.

Solution

Concept: Avogadro's number gives the number of particles in one mole. In Al_2O_3, each formula unit contains three oxygen atoms.

Step 1 — Number of formula units in 0.50 mol of Al_2O_3 is:

$$0.50 \times 6.022 \times 10^{23} = 3.011 \times 10^{23}$$

Step 2 — Each formula unit contains 3 oxygen atoms, so total oxygen atoms are:

$$3 \times 3.011 \times 10^{23} = 9.033 \times 10^{23}$$

Step 3 — Therefore the correct number of oxygen atoms is:

$$9.033 \times 10^{23}$$

This matches option A exactly.

Why other options are wrong:

- **Option B:** This counts only two oxygen atoms per formula unit.
- **Option C:** This is only the number of formula units, not the number of oxygen atoms.
- **Option D:** This is twice the required value.

Final Answer: $\boxed{9.033 \times 10^{23}}$ (Option A)

Answer: (A) Go Back to Question 1

Q2.

Solution

Concept: The empirical formula is the simplest whole-number ratio of atoms in a compound.

Step 1 — For ethanoic acid, the molecular formula is $C_2H_4O_2$.

Step 2 — Divide each subscript by 2:

$$C_2H_4O_2 \rightarrow CH_2O$$

Step 3 — Therefore the same empirical formula is CH_2O.

Why other options are wrong:

- **Option A:** C_2H_6O does not reduce to CH_2O.
- **Option C:** C_3H_6O reduces to C_3H_6O itself, not CH_2O.
- **Option D:** CHO is not the correct simplest ratio for ethanoic acid.

Final Answer: $\boxed{CH_2O}$ (Option B)

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept: The maximum number of electrons in a shell having principal quantum number n is given by $2n^2$.

Step 1 — For $n = 4$,

$$2n^2 = 2 \times 4^2$$

Step 2 — Therefore,

$$2n^2 = 2 \times 16 = 32$$

Step 3 — Hence the fourth shell can accommodate a maximum of 32 electrons.

Why other options are wrong:

- **Option A:** 8 corresponds to the second shell.
- **Option B:** 18 corresponds to the third shell.
- **Option D:** 16 is only n^2, not $2n^2$.

Final Answer: $\boxed{32}$ (Option C)

Answer: (C) Go Back to Question 3

Q4.

Solution

Concept: The magnetic quantum number m_l specifies the orientation of an orbital in space, while the azimuthal quantum number l specifies its shape.

Step 1 — The principal quantum number n decides the shell and approximate size of the orbital.

Step 2 — The azimuthal quantum number l decides whether an orbital is s, p, d, or f, that is, the general shape class.

Step 3 — The magnetic quantum number m_l tells how a given orbital is oriented relative to the coordinate axes.

Why other options are wrong:

- **Option A:** This gives shell number, not orientation.
- **Option B:** This gives subshell type and shape, not spatial orientation.
- **Option C:** Spin quantum number refers to electron spin only.

Final Answer: Magnetic quantum number (Option D)

Answer: (D) Go Back to Question 4

Q5.

Solution

Concept: In NH_3, nitrogen has three bond pairs and one lone pair. The electron pair geometry is tetrahedral but the molecular shape is trigonal pyramidal.

Step 1 — Nitrogen in ammonia uses sp^3 hybridisation.

Step 2 — Out of the four hybrid orbitals, three form $N-H$ bonds and one contains a lone pair.

Step 3 — Because a lone pair occupies one corner of the tetrahedral electron geometry, the observed molecular shape becomes trigonal pyramidal.

Why other options are wrong:

- **Option B:** Trigonal planar requires no lone pair on the central atom.
- **Option C:** Tetrahedral is the electron-pair arrangement, not the molecular shape here.
- **Option D:** Linear geometry is not possible with four electron domains around nitrogen.

Final Answer: Trigonal pyramidal (Option A)

Answer: (A) Go Back to Question 5

Q6.

Solution

Concept: Molality is defined as the number of moles of solute present in one kilogram of solvent.

Step 1 — The word *molal* refers to a concentration term based on mass of solvent, not on volume of solution.

Step 2 — Therefore a 1 molal solution contains 1 mole of solute dissolved in 1 kg of solvent.

Step 3 — This definition is especially useful because molality does not change with temperature as volume-based units may change.

Why other options are wrong:

- **Option A:** This corresponds to molarity.
- **Option C:** This uses grams rather than moles.
- **Option D:** This reverses the role of solute and solvent.

Final Answer: 1 mole of solute in 1 kg of solvent (Option B)

Answer: (B) Go Back to Question 6

Q7.

Solution

Concept: In an exothermic reaction, heat is released by the system to the surroundings. At constant pressure, enthalpy change equals the heat exchanged.

Step 1 — At constant pressure,

$$\Delta H = q_p$$

Step 2 — For an exothermic process, the system loses heat. Therefore the heat term is negative.

Step 3 — Hence,

$$\Delta H < 0$$

Why other options are wrong:

- **Option A:** Positive enthalpy is for endothermic processes.
- **Option B:** Zero enthalpy change means no net heat effect.
- **Option D:** Enthalpy is not described as infinite here.

Final Answer: Negative (Option C)

Answer: (C) Go Back to Question 7

Q8.

Solution

Concept: In a Daniell cell, oxidation occurs at the zinc electrode and reduction occurs at the copper electrode. The cathode is the electrode where reduction takes place.

Step 1 — At the zinc electrode:

$$Zn \rightarrow Zn^{2+} + 2e^-$$

This is oxidation, so zinc is the anode.

Step 2 — At the copper electrode:

$$Cu^{2+} + 2e^- \rightarrow Cu$$

This is reduction, so copper is the cathode.

Step 3 — Therefore the cathode in the given cell is the copper electrode.

Why other options are wrong:

- **Option A:** Zinc is the anode, not the cathode.
- **Option B:** The salt bridge maintains electrical neutrality but is not an electrode.
- **Option C:** A porous partition is not the cathode.

Final Answer: Copper electrode (Option D)

Answer: (D) Go Back to Question 8

Q9.

Solution

Concept: For a first-order reaction, half-life is given by $t_{1/2} = 0.693/k$, so it depends only on the rate constant.

Step 1 — The half-life formula for a first-order reaction is:

$$t_{1/2} = \frac{0.693}{k}$$

Step 2 — The initial concentration does not appear in this expression.

Step 3 — Hence the half-life remains the same irrespective of the starting concentration for first-order kinetics.

Why other options are wrong:

- **Option B:** This is not true for first-order reactions.
- **Option C:** The dependence is on k, not k^2.
- **Option D:** Half-life is not zero.

Final Answer: Independent of the initial concentration (Option A)

Answer: (A) Go Back to Question 9

Q10.

Solution

Concept: A catalyst provides an alternative reaction pathway with lower activation energy, but it does not change the initial and final energy levels of reactants and products. Therefore ΔH remains unchanged.

Step 1 — In the graph, the catalysed path has a lower peak than the uncatalysed path, so the activation energy is reduced.

Step 2 — The reactants and products start and end at the same energy levels in both pathways. Therefore the enthalpy change remains the same.

Step 3 — So the correct interpretation is: activation energy decreases, but ΔH remains unchanged.

Why other options are wrong:

- **Option A:** A catalyst does not alter ΔH in this way.
- **Option C:** Catalysts do not increase activation energy.
- **Option D:** Neither activation energy nor ΔH both increase.

Final Answer: Activation energy decreases but ΔH remains unchanged (Option B)

Answer: (B) Go Back to Question 10

Q11.

Solution

Concept: Basic oxides are usually metal oxides, whereas acidic oxides are generally oxides of non-metals.

Step 1 — MgO is the oxide of a metal, magnesium.

Step 2 — It reacts with acids to form salt and water, showing basic character.

Step 3 — The other given oxides CO_2, SO_3 and N_2O_5 are acidic oxides of non-metals.

Why other options are wrong:

- **Option A:** CO_2 forms carbonic acid in water.
- **Option B:** SO_3 forms sulphuric acid.
- **Option D:** N_2O_5 is an acidic oxide.

Final Answer: $\boxed{\text{MgO}}$ (Option C)

Answer: (C) Go Back to Question 11

Q12.

Solution

Concept: Strong-field ligands such as CN^- cause electron pairing and often produce square planar complexes in d^8 systems like Ni^{2+}.

Step 1 — In $[NiCl_4]^{2-}$, chloride is a weak-field ligand, so the complex is tetrahedral and paramagnetic.

Step 2 — In $[Ni(CN)_4]^{2-}$, cyanide is a strong-field ligand. It causes pairing of electrons and leads to a square planar arrangement.

Step 3 — Therefore the square planar complex among the options is $[Ni(CN)_4]^{2-}$.

Why other options are wrong:

- **Option A:** Tetrahedral due to weak-field chloride ligands.
- **Option B:** $[Ni(CO)_4]$ is tetrahedral.
- **Option C:** Zinc complex is not the standard square-planar d^8 case here.

Final Answer: $\boxed{[Ni(CN)_4]^{2-}}$ (Option D)

Answer: (D) Go Back to Question 12

Q13.

Solution

Concept: Esterification is the reaction between a carboxylic acid and an alcohol to form an ester and water.

Step 1 — A carboxylic acid provides the acyl part of the ester.

Step 2 — An alcohol provides the alkoxy part.

Step 3 — Thus ester formation occurs between an acid and an alcohol.

Why other options are wrong:

- **Option B:** Acid and base undergo neutralisation, not esterification.
- **Option C:** An alkane does not undergo esterification in this way.
- **Option D:** A ketone and an alcohol do not directly form esters under standard esterification conditions.

Final Answer: An acid and an alcohol (Option A)

Answer: (A) Go Back to Question 13

Q14.

Solution

Concept: Aldehydes are more readily oxidised than ketones. Tollens' reagent oxidises aldehydes and produces a silver mirror, while most ketones do not respond.

Step 1 — When an aldehyde is treated with Tollens' reagent, silver ions are reduced to metallic silver.

Step 2 — Ketones usually do not undergo this oxidation under the same conditions.

Step 3 — Hence Tollens' reagent is a standard test used to distinguish aldehydes from ketones.

Why other options are wrong:

- **Option A:** Bromine water is not the standard distinguishing test here.
- **Option C:** Sodium chloride does not help in this differentiation.
- **Option D:** Dilute sodium hydroxide alone does not provide a specific aldehyde-ketone distinction.

Final Answer: Tollens' reagent (Option B)

Answer: (B) Go Back to Question 14

Q15.

Solution

Concept: Essential amino acids are those that the human body cannot synthesise in adequate amounts and therefore must be obtained from food.

Step 1 — Glycine, alanine and serine are non-essential because the body can synthesise them.

Step 2 — Valine is one of the essential amino acids.

Step 3 — Therefore the correct choice is valine.

Why other options are wrong:

- **Option A:** Glycine is non-essential.
- **Option B:** Alanine is non-essential.
- **Option D:** Serine is non-essential.

Final Answer: Valine (Option C)

Answer: (C) Go Back to Question 15

Q16.

Solution

Concept: Antacids are mild basic substances used to neutralise excess hydrochloric acid in the stomach.

Step 1 — Magnesium hydroxide is a weak base and can neutralise excess stomach acid safely.

Step 2 — Aspirin is an analgesic, penicillin is an antibiotic, and chloramphenicol is also an antibiotic.

Step 3 — Hence the commonly used antacid among the options is magnesium hydroxide.

Why other options are wrong:

- **Option A:** Aspirin is not an antacid.
- **Option B:** Penicillin is not an antacid.
- **Option C:** Chloramphenicol is not an antacid.

Final Answer: $Mg(OH)_2$ (Option D)

Answer: (D) Go Back to Question 16

Q17.

Solution

Concept: Avogadro constant gives the number of particles in one mole, while molar mass gives the mass of one mole of a substance in grams.

Step 1 — One mole contains 6.022×10^{23} particles. This constant is called the Avogadro constant.

Step 2 — The mass of one mole of a substance expressed in grams is called its molar mass.

Step 3 — Therefore the blanks are filled by *Avogadro constant* and *molar mass*.

Why other options are wrong:

- **Mole fraction:** It is a concentration term, not a particle count or one-mole mass term.
- **Limiting reagent:** It refers to reactant exhaustion in stoichiometry, not a definition of mole or mass.

Final Answer: Avogadro constant; molar mass

Answer: (See above) Go Back to Question 17

Q18.

Solution

Concept: Both H_2O and H_2S have four electron domains around the central atom and hence are sp^3 hybridised. Bond angle depends on electron-pair repulsions and the tendency of the central atom to use hybrid orbitals effectively.

Step 1 — In water, oxygen has two bond pairs and two lone pairs; in hydrogen sulphide, sulphur also has two bond pairs and two lone pairs. Therefore both central atoms are described as sp^3 hybridised.

Step 2 — However, oxygen is smaller and more electronegative than sulphur. Bond pair–lone pair and lone pair–lone pair repulsions are more effective in H_2O, leading to a larger angle than in H_2S.

Step 3 — Thus H_2O has the larger bond angle. Water has a bond angle of about 104.5°, while hydrogen sulphide has a smaller angle close to 92°.

Why other options are wrong:

- **If one says different hybridisation:** That is incorrect because both are treated as sp^3 in elementary bonding theory.
- **If one says H_2S has larger angle:** This ignores the weaker hybridisation and larger size of sulphur.

Final Answer: sp^3 in both; H_2O has the larger bond angle

Answer: (See above) Go Back to Question 18

Q19.

Solution

Concept: Ionic bonding involves transfer of electrons, covalent bonding involves sharing of electrons, and a coordinate bond involves donation of both bonding electrons by one atom.

Step 1 — Statement 1 is correct because ionic bonds arise from electron transfer and covalent bonds arise from electron sharing.

Step 2 — Statement 2 is incorrect because in a coordinate bond, both bonding electrons are donated by one atom, not one electron by each atom.

Step 3 — Hence the answers are True and False.

Final Answer: T; F

Answer: (See above) **Go Back to Question 19**

Q20.

Solution

Concept: Atomic number counts protons; mass number counts total nucleons, that is protons plus neutrons.

Step 1 — The number of protons in the nucleus defines the element and is called the atomic number.

Step 2 — The total number of protons and neutrons is called the mass number.

Step 3 — Therefore the blanks are *atomic number* and *mass number*.

Final Answer: atomic number; mass number

Answer: (See above) **Go Back to Question 20**

Q21.

Solution

Concept: Nitrogen cannot expand its octet because vacant d-orbitals are absent in the valence shell. Nitric oxide is paramagnetic in the gaseous state due to an odd electron; association in the liquid state leads to diamagnetic behaviour.

Step 1 — Nitrogen belongs to the second period, so it has no vacant d-orbitals available in its valence shell. Hence it cannot form pentahalides.

Step 2 — Nitric oxide, NO, contains an odd electron and is paramagnetic as a gas.

Step 3 — In the liquid state, association reduces the effect of the unpaired electron, so it behaves diamagnetically.

Final Answer: absence of d-orbitals; paramagnetic; diamagnetic

Answer: (See above) **Go Back to Question 21**

Q22.

Solution

Concept: Thin polythene bags are non-biodegradable and persist in the environment for a long time. Paper bags decompose more readily and are generally less harmful in day-to-day disposal.

Step 1 — Polythene bags are discouraged because they do not decompose easily. They accumulate in soil and water, obstruct drainage, harm animals and contribute to long-term pollution.

Step 2 — Paper bags, though not impact-free, are more biodegradable and are less likely to remain in the environment for many years.

Step 3 — Therefore, from a chemistry and environmental perspective, supporting paper bags over thin polythene bags is reasonable in such ordinary use cases.

Final Answer: Polythene is non-biodegradable; paper is more eco-friendly and biodegradable

Answer: (See above) Go Back to Question 22

Q23.

Solution

Concept: Lanthanoid contraction is the steady decrease in ionic size across the lanthanoid series due to poor shielding by $4f$ electrons. Some lanthanoids show +2 state because of especially stable half-filled or fully filled $4f$ configurations.

Step 1 — As we move from La to Lu, nuclear charge increases, but the added $4f$ electrons shield poorly.

Step 2 — Therefore the outer electrons experience stronger effective nuclear charge and the size decreases gradually. This is lanthanoid contraction.

Step 3 — Europium commonly shows the +2 oxidation state because the Eu^{2+} ion has a stable $4f^7$ configuration. Ytterbium may also show +2 due to $4f^{14}$.

Final Answer: Gradual decrease in size from La to Lu; e.g. Eu

Answer: (See above) Go Back to Question 23

Q24.

Solution

Concept: Matching questions are solved by identifying the defining property or common use of each substance.

Step 1 — Graphite conducts electricity because of delocalised electrons in its layers, so (a) matches (ii).

Step 2 — Bleaching powder is used as a disinfecting and bleaching agent, so (b) matches (iv). Tollens' reagent is used for aldehyde testing, so (c) matches (iii).

Step 3 — Potassium permanganate is a strong oxidising agent, so (d) matches (i).

Final Answer: $\boxed{a\text{-}ii,\ b\text{-}iv,\ c\text{-}iii,\ d\text{-}i}$

Answer: (See above) Go Back to Question 24

Q25.

Solution

Concept: Primary alcohols on oxidation give aldehydes and then carboxylic acids. Phenol undergoes electrophilic substitution with bromine water to form tribromophenol.

Step 1 — Ethanol on oxidation under strong oxidising conditions gives ethanoic acid:

$$CH_3CH_2OH \xrightarrow[\text{acidified}]{[O]} CH_3COOH$$

Step 2 — Phenol reacts with excess bromine water to give 2, 4, 6-tribromophenol:

$$C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$$

Step 3 — Hence the completed products are ethanoic acid and 2, 4, 6-tribromophenol.

Final Answer: $\boxed{CH_3COOH;\ 2,4,6\text{-tribromophenol}}$

Answer: (See above) Go Back to Question 25

Q26.

Solution

Concept: Graphite contains delocalised electrons that can move along the layers, whereas diamond has all four valence electrons involved in localised sigma bonds.

Step 1 — In graphite, each carbon atom is bonded to three others and one electron remains delocalised over the layer. These mobile electrons conduct electricity.

Step 2 — In diamond, each carbon is tetrahedrally bonded to four other carbons. All valence electrons are used in sigma bonding, so no free electrons are available for conduction.

Step 3 — The allotrope used in pencils is graphite.

Final Answer: Graphite conducts due to delocalised electrons; pencil allotrope is graphite

Answer: (See above) Go Back to Question 26

Q27.

Solution

Concept: An element contains only one kind of atom. Gold is an element, not a compound of several atoms of different elements.

Step 1 — Statement 1 is true because that is the definition of an element.

Step 2 — Statement 2 is false because pure gold consists of only gold atoms.

Final Answer: T; F

Answer: (See above) Go Back to Question 27

Q28.

Solution

Concept: Detergents work in hard water because their calcium and magnesium salts remain soluble, unlike the insoluble scum formed by soaps.

Step 1 — Hard water contains Ca^{2+} and Mg^{2+} ions. Soap reacts with these ions to form insoluble salts called scum.

Step 2 — Detergents do not form insoluble precipitates so readily, so they continue to clean effectively even in hard water.

Step 3 — One antiseptic additive used in medicated soap is bithionol. Other acceptable examples include some antiseptic formulations used in medicated products.

Final Answer: Detergents form soluble salts in hard water; one additive is bithionol

Answer: (See above) Go Back to Question 28

Q29.

Solution

Concept: Buffer-related terms measure resistance to pH change, while freezing point and boiling point are characteristic temperatures associated with phase change.

Step 1 — Alternative (i): Buffer capacity is the amount of acid or base a buffer can absorb without a large change in pH. Buffer index is the quantitative measure of that resistance, that is, how much strong acid or base must be added to change the pH by one unit.

Step 2 — Alternative (ii): Freezing point is the temperature at which a liquid changes into a solid under a given pressure. Boiling point is the temperature at which the vapour pressure of a liquid becomes equal to the external pressure and the liquid boils.

Step 3 — Both alternatives are correct internal-choice responses and either may be attempted in the examination.

Final Answer: Buffer terms or freezing/boiling definitions as explained above

Answer: (See above) Go Back to Question 29

Q30.

Solution

Concept: Spontaneity is determined by Gibbs free energy, not by enthalpy alone. Enthalpy contributes to spontaneity, but entropy also matters.

Step 1 — For a process at constant temperature and pressure,

$$\Delta G = \Delta H - T\Delta S$$

This equation shows that both enthalpy change and entropy change control spontaneity.

Step 2 — If $\Delta G < 0$, the process is spontaneous. Many exothermic reactions are spontaneous because negative ΔH helps make ΔG negative.

Step 3 — However, a reaction is not spontaneous merely because it is exothermic. A process with positive ΔH may still be spontaneous if the increase in entropy is sufficiently large.

Final Answer: Spontaneity depends on $\Delta G = \Delta H - T\Delta S$, not on ΔH alone

Answer: (See above) Go Back to Question 30

Q31.

Solution

Concept: In free expansion of an ideal gas into vacuum, external pressure is zero, so no work is done. For an ideal gas in isothermal expansion, internal energy depends only on temperature and remains unchanged, so heat absorbed is also zero.

Step 1 — Alternative (i): Work done is

$$w = -P_{\text{ext}}\Delta V$$

Since the gas expands into vacuum, $P_{\text{ext}} = 0$. Therefore,

$$w = 0$$

Step 2 — For an ideal gas under isothermal conditions, $\Delta U = 0$. From the first law,

$$\Delta U = q + w$$

Therefore,

$$0 = q + 0 \Rightarrow q = 0$$

So neither heat is absorbed nor work is done.

Step 3 — Alternative (ii): Heat given to the system increases its internal energy because energy enters the system. Work done by the system tends to reduce the internal energy if not compensated by heat input.

Final Answer: For free expansion: $w = 0$, $q = 0$; heat supplied increases internal energy

Answer: (See above) Go Back to Question 31

Q32.

Solution

Concept: At constant pressure, enthalpy is more convenient to measure than internal energy. In methane, the successive bond dissociation energies are not strictly identical because each step refers to a different species after one bond has already been broken.

Step 1 — Alternative (i): Most laboratory reactions are performed in open vessels under nearly constant atmospheric pressure. Under such conditions, the heat exchanged is equal to enthalpy change, so ΔH is directly useful and measurable.

Step 2 — Alternative (ii): In CH_4, although the four C – H bonds are equivalent in the intact molecule, the four bond dissociation energies measured successively are not exactly the same. After each bond cleavage, the species changes, so the next bond is removed from a different chemical environment.

Step 3 — Therefore chemistry often uses an average bond enthalpy for the C – H bonds in methane.

Final Answer:

Enthalpy is practical at constant pressure; successive C–H bond energies are not exactly equal

Answer: (See above) Go Back to Question 32

Q33.

Solution

Concept: According to Arrhenius theory, an acid furnishes H^+ ions in aqueous solution and a base furnishes OH^- ions. Neutralization is the reaction between these ions to form water.

Step 1 — Suppose hydrochloric acid and sodium hydroxide are mixed. In water,

$$HCl \rightarrow H^+ + Cl^-$$

$$NaOH \rightarrow Na^+ + OH^-$$

Step 2 — The essential chemical change is:

$$H^+ + OH^- \rightarrow H_2O$$

The remaining ions form the salt.

Step 3 — Hence Arrhenius neutralization is the reaction of an Arrhenius acid with an Arrhenius base to give salt and water.

Final Answer: Acid + base $\rightarrow$ salt + water; net $H^+ + OH^- \rightarrow H_2O$

Answer: (See above) Go Back to Question 33

Q34.

Solution

Concept: A catalyst lowers activation energy by providing an alternative pathway, but it does not change the thermodynamic state functions of the reaction such as Gibbs energy change.

Step 1 — Activation energy E_a decreases in the presence of a catalyst. As a result, a larger fraction of molecules can react per unit time.

Step 2 — The Gibbs energy change ΔG depends on the free energies of reactants and products. Since the catalyst does not alter these states, ΔG remains unchanged.

Step 3 — Thus the catalyst changes the rate of reaction but not the thermodynamic feasibility.

Final Answer: $\boxed{E_a \text{ decreases; } \Delta G \text{ remains unchanged}}$

Answer: (See above) **Go Back to Question 34**

Q35.

Solution

Concept: The inert pair effect becomes stronger down group 15, making the +3 oxidation state more stable relative to +5 in heavier elements such as bismuth. Also, XeF_2 is linear according to VSEPR theory.

Step 1 — Alternative (i): In bismuth, the $6s^2$ electron pair is relatively inert. Therefore the +3 oxidation state is more stable than +5. As a result, Bi(V) tends to accept electrons and get reduced to Bi(III), making Bi(V) a stronger oxidising agent than Sb(V).

Step 2 — Alternative (ii): In XeF_2, xenon has five electron pairs around it: two bond pairs and three lone pairs. The electron pair geometry is trigonal bipyramidal.

Step 3 — The three lone pairs occupy equatorial positions to minimise repulsion, leaving the two fluorine atoms in opposite axial positions. Hence the molecule is linear.

Final Answer: $\boxed{\text{Bi(V) is reduced easily to Bi(III); } XeF_2 \text{ is linear}}$

Answer: (See above) **Go Back to Question 35**

Q36.

Solution

Concept: Ethane-1,2-diol can be prepared from ethanol by first converting ethanol into ethene and then converting ethene into the glycol by hydroxylation.

Step 1 — Dehydrate ethanol to form ethene:

$$CH_3CH_2OH \xrightarrow[443\,K]{\text{conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$$

Step 2 — Add two hydroxyl groups across the double bond using cold dilute alkaline $KMnO_4$ or another suitable hydroxylating reagent:

$$CH_2{=}CH_2 \xrightarrow[\text{cold}]{\text{alkaline } KMnO_4} HOCH_2CH_2OH$$

Step 3 — Thus ethanol is converted to ethene, and ethene is converted to ethane-1,2-diol.

Final Answer: $\boxed{CH_3CH_2OH \rightarrow CH_2{=}CH_2 \rightarrow HOCH_2CH_2OH}$

Answer: (See above) Go Back to Question 36

Q37.

Solution

Concept: Hydrogen cyanide adds to aldehydes to form cyanohydrins. Benzene diazonium chloride undergoes Sandmeyer reaction with cuprous chloride to give chlorobenzene.

Step 1 — For ethanal:

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$$

The product is acetaldehyde cyanohydrin.

Step 2 — For benzene diazonium chloride:

$$C_6H_5N_2^+Cl^- \xrightarrow[HCl]{CuCl} C_6H_5Cl + N_2$$

Step 3 — Therefore the products are the cyanohydrin and chlorobenzene.

Final Answer: $\boxed{CH_3CH(OH)CN;\ C_6H_5Cl}$

Answer: (See above) Go Back to Question 37

Q38.

Solution

Concept: Mole fraction, isotonicity and van't Hoff factor are all important terms in the chemistry of solutions and colligative properties.

Step 1 — Mole fraction: Mole fraction of a component is the ratio of the number of moles of that component to the total number of moles present in the mixture:

$$X_i = \frac{n_i}{\sum n_i}$$

Step 2 — Isotonic solutions: Two solutions having the same osmotic pressure at a given temperature are called isotonic solutions.

Step 3 — van't Hoff factor: It is the ratio of the actual number of particles present in solution after dissociation or association to the number expected if the solute behaved ideally. It is also expressed as the ratio of normal molar mass to abnormal molar mass in colligative property calculations.

Final Answer: Definitions of mole fraction, isotonic solution and van't Hoff factor as given above

Answer: (See above) **Go Back to Question 38**

Q39.

Solution

Concept: Osmosis depends on the concentration difference across a semipermeable membrane. Molarity is calculated as moles of solute per litre of solution.

Step 1 — Alternative (i): To remove the hard calcium carbonate shell of an egg without damaging the semipermeable membrane, place the egg in a dilute mineral acid such as dilute hydrochloric acid or vinegar-like acidic medium. The shell dissolves due to reaction of calcium carbonate with acid, while the membrane remains intact.

Step 2 — The shell-free egg can be shrunk by placing it in a hypertonic solution, such as concentrated sodium chloride solution, so water moves out by osmosis. The shrunken egg can then be inserted into a bottle with a narrow neck. On adding water, the outside becomes hypotonic relative to the egg contents, water moves in again and the egg regains its shape.

Step 3 — Alternative (ii): For $CuSO_4 \cdot 5H_2O$, molar mass is about 249.5 g mol^{-1}.

$$\text{Moles} = \frac{24.95}{249.5} = 0.10 \text{ mol}$$

Since the solution volume is 1.00 L,

$$M = \frac{0.10}{1.00} = 0.10 \text{ M}$$

For dilution of HCl:

$$M_1V_1 = M_2V_2$$

$$1.5 \times 20 = M_2 \times 250$$

$$M_2 = \frac{30}{250} = 0.12 \text{ M}$$

Final Answer:

Osmosis-based shrinking and re-expansion of the egg; molarities 0.10 M and 0.12 M

Answer: (See above) Go Back to Question 39

Q40.

Solution

Concept: Acidity and alkalinity depend on the relative concentrations of hydrogen ions and hydroxide ions in water.

Step 1 — In pure water at 25°C,

$$[H^+] = [OH^-] = 1.0 \times 10^{-7}\ M$$

Such a solution is neutral.

Step 2 — If $[H^+] > [OH^-]$, the solution is acidic. This corresponds to a pH less than 7.

Step 3 — If $[OH^-] > [H^+]$, the solution is alkaline or basic. This corresponds to a pH greater than 7.

Final Answer: $\boxed{\text{Acidic if } [H^+] > [OH^-],\ \text{neutral if equal, alkaline if } [OH^-] > [H^+]}$

Answer: (See above) **Go Back to Question 40**

Q41.

Solution

Concept: The first member of each p-block group behaves differently because of small size, high ionisation enthalpy, high electronegativity and absence of vacant *d*-orbitals. Hydrides of p-block elements are mostly covalent because bonding occurs with elements of comparable electronegativity.

Step 1 — Alternative (i): The top element in each p-block group has very small atomic size and high charge density. It also has higher ionisation enthalpy and higher electronegativity than the heavier members. Most importantly, it has no vacant *d*-orbitals in its valence shell. These factors together produce anomalous behaviour.

Step 2 — Alternative (ii): Hydrides of p-block elements are usually covalent because hydrogen forms bonds mainly by electron sharing with these non-metals or metalloids. In contrast, s-block hydrides are more ionic.

Step 3 — Therefore the first-member anomaly and the predominantly covalent nature of p-block hydrides can both be explained by electronic structure and bonding considerations.

Final Answer:

Top-member anomaly arises from small size, high electronegativity and no *d*-orbitals; *p*-block hydrides are mainly covalent

Answer: (See above) **Go Back to Question 41**

Q42.

Solution

Concept: Coordination compounds are described by ligand names, oxidation state, isomerism and ligand-field effects. Magnetic behaviour depends on electron pairing caused by weak-field or strong-field ligands.

Step 1 — Alternative (iA): In $[Cr(NH_3)_4Cl_2]Cl$, the complex cation is $[Cr(NH_3)_4Cl_2]^+$ and chromium is in the +3 oxidation state. The correct IUPAC name is tetraamminedichloridochromium(III) chloride.

Step 2 — Alternative (iB): The tris-chelate complex $[Co(en)_3]^{3+}$ exhibits optical isomerism because the chelate arrangement can produce non-superimposable mirror images.

Step 3 — Alternative (iC): In $[NiCl_4]^{2-}$, chloride is a weak-field ligand. Nickel is in the +2 oxidation state with $3d^8$ configuration. Pairing is not forced, so the complex is tetrahedral, sp^3 hybridised and paramagnetic with two unpaired electrons. In $[Ni(CN)_4]^{2-}$, cyanide is a strong-field ligand and causes pairing. The complex becomes square planar, dsp^2 hybridised and diamagnetic.

Step 4 — Alternative (ii): In $[Fe(CN)_6]^{4-}$, iron is in the +2 oxidation state, that is $3d^6$. Since CN^- is a strong-field ligand, electron pairing occurs. Two inner $3d$ orbitals, one $4s$ and three $4p$ orbitals hybridise to give d^2sp^3 hybridisation. Hence the complex is octahedral and diamagnetic.

Final Answer:

Tetraamminedichloridochromium(III) chloride; optical isomerism; weak-field versus strong-field pairing explains the magnetic behaviour

Answer: (See above) Go Back to Question 42

Q43.

Solution

Concept: α- and β-glucose are anomers that differ in configuration at the anomeric carbon. Water-soluble vitamins are not stored efficiently in the body and therefore need regular dietary supply. Amino acids and proteins are classified on the basis of biosynthetic necessity and structure.

Step 1 — Alternative (i): In cyclic glucose, the difference between α-D-glucose and β-D-glucose lies in the orientation of the $-$OH group at the anomeric carbon (C-1). If the $-$OH group at C-1 is on the side opposite to the terminal CH_2OH group in the Haworth representation, the form is α; if it is on the same side, it is β. Such isomers are called anomers.

Step 2 — The pyranose structure of glucose means that glucose can exist in a six-membered ring form resembling pyran, with five carbon atoms and one oxygen atom in the ring.

Step 3 — Alternative (ii1): Water-soluble vitamins must be supplied regularly because they are not stored in large amounts and are readily excreted in urine. One example is vitamin C; members of the vitamin B complex are also water-soluble.

Step 4 — Alternative (ii2a): Essential amino acids cannot be synthesised adequately by the body and must be taken in food; valine is an example. Non-essential amino acids can be synthesised by the body; glycine is an example.

Step 5 — Alternative (ii2b): Fibrous proteins are elongated, generally insoluble and structural in function, for example keratin. Globular proteins are compact, usually soluble and often biologically active, for example enzymes and haemoglobin.

Final Answer:

α- and β-glucose differ at C-1; glucose can form a six-membered pyranose ring; water-soluble vitamins need regular intake; essential/non-essential amino acids and fibrous/globular proteins differ as explained

Answer: (See above) **Go Back to Question 43**

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	B	3	C	4	D	5	A
6	B	7	C	8	D	9	A	10	B
11	C	12	D	13	A	14	B	15	C
16	D								