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About O Level

(PURE) CHEMISTRY

(YEARLY)

About Thinking Process

When solving problems, we first analyse the questions and then gather relevant information until we are able to determine the answers. But for presentation reason, we need to organise, rearrange and then present ONLY the required workings and solutions.

Thinking process reveals the extra but relevant information which is not required as part of the solutions.

About MCQ with HELPs

Explanations are given so that students know exactly why the answer is the right one.

period	2014 to 2024
contents	June & November, Paper 1 & 2, Worked Solutions
form	Year By Year
compiled for	O Levels
special features	Thinking Process, MCQ with HELPs

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CONTENTS

Revised Syllabus

JUNE 2024 PAPER 1

MCQ Section

1. Which physical changes are both exothermic?

A condensation and evaporation
B evaporation and melting
C freezing and condensation
D melting and freezing

[Topic 10]

2. What is tap water?

A a compound
B a mixture of compounds and elements
C a mixture of elements
D an element

[Topic 3]

3. In which pair of particles is:

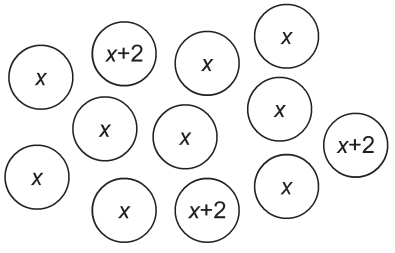
- the sum of their charges equal to zero
- the sum of their masses almost the same as $\frac{1}{12}$ of the mass of an atom of ^{12}C?

A one electron and one neutron
B one electron and one proton
C one neutron and one proton
D two neutrons

[Topic 3]

4. An element has two isotopes of relative isotopic masses x and $x + 2$.

The diagram shows the composition of atoms in a sample of the element.



What is the relative atomic mass of the sample of the element?

A $x + 0.5$ **B** $x + 1.0$
C $x + 1.5$ **D** $x + 2.0$

[Topic 4]

5. Which molecule has only four electrons involved in covalent bonds?

A Cl_2 **B** CO_2
C H_2S **D** N_2

[Topic 3]

6. The melting points and boiling points of four compounds, W, X, Y and Z, are given in the table.

	melting point / °C	boiling point / °C
W	63	354
X	–7	59
Y	1728	2230
Z	–183	–89

The four compounds are silicon (IV) oxide, ethane, bromine and a carboxylic acid of formula $C_{16}H_{32}O_2$.

Which row identifies W, X, Y and Z?

	silicon(IV) oxide	ethane	bromine	carboxylic acid $C_{16}H_{32}O_2$
A	W	X	Z	Y
B	W	Y	Z	X
C	Y	Z	W	X
D	Y	Z	X	W

[Topic 3]

7. What is the formula of zinc oxide?

A Zn_2O **B** ZnO
C Zn_2O_3 **D** ZnO_2

[Topic 4]

1. C During freezing, a substance transitions from a liquid to a solid, releasing heat energy in the process. Similarly, during condensation, gas molecules lose energy as they transition into a liquid state, also releasing heat. In contrast, evaporation and melting are endothermic processes, where heat is absorbed.

2. B Tap water primarily consists of water (H_2O), which is a compound, but it also contains various dissolved substances, such as minerals, salts, and sometimes trace elements or contaminants. Therefore, it is best described as a mixture of compounds and elements.

3. B Charges on:

Electron = –1, Proton = +1

Neutron = 0

Sum of charges of an electron and a proton = –1 + 1 = 0

The mass of a carbon-12 atom is 12 atomic mass units (amu). The combined mass of a proton and an electron is very close to 12 amu.

4. A

Relative atomic mass

$$= \frac{(9x + 3(x + 2))}{12}$$

$$= \frac{(12x + 6)}{12}$$

$$= x + 0.5$$

8. Which statement is correct?

A If the relative formula mass of hydrated sodium carbonate, $Na_2CO_3 \cdot xH_2O$, is 286, then x is 10.

B Phosphoric (V) acid, H_3PO_4, has a relative molecular mass of 50.

C The relative atomic mass of a sample of an element with isotopes of masses 20 and 22 can only be equal to 21.

D The relative atomic mass of an element is the average mass of atoms of isotopes of the element compared with the mass of a hydrogen atom.

[Topic 4]

9. In a volumetric experiment, 25.0 cm^3 of 0.100 mol / dm^3 sodium hydroxide reacts exactly with 20.0 cm^3 of dilute sulfuric acid.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

What is the concentration of the dilute sulfuric acid?

A 0.0625 mol / dm^3

B 0.0800 mol / dm^3

C 0.125 mol / dm^3

D 0.250 mol / dm^3

[Topic 4]

10. The equation for the reaction between ammonium chloride and calcium hydroxide is shown.

$$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$$

10.7 g of ammonium chloride and 14.8 g of calcium hydroxide are mixed and warmed.

10.0 g of calcium chloride is obtained from the reaction.

What is the percentage yield of calcium chloride?

[M_r: NH_4Cl, 53.5; $Ca(OH)_2$, 74; $CaCl_2$, 111]

A 39.2% **B** 45.0%

C 67.6% **D** 90.1%

[Topic 4]

MCQ Answers

5. C Cl_2 involves two electrons in a single bond while CO_2 has two double bonds between carbon and oxygen atoms which means that the total number of electrons involved in covalent bonding in CO_2 is eight.
H_2S involves four electrons (two pairs) in two single bonds while N_2 involves six electrons in a triple bond.

6. D Y has a very high melting and boiling point which corresponds to a giant molecular structure like silicon(IV) oxide. On the other hand, carboxylic acid has a long carbon chain which implies that it is a solid at room temperature and is represented by W. Bromine is a liquid at room temperature given by X. Therefore, Z represents ethane.

7. B In zinc oxide, one zinc atom combines with one oxygen atom to form the compound, hence the formula is ZnO.

8. A Let's evaluate each option to determine which one is correct:

A. M_r of $Na_2CO_3 \cdot xH_2O = 286$

$\Rightarrow (23\times2)+12+(16\times3)+18x = 286$

$\Rightarrow 106+18x = 286$

$\Rightarrow 18x = 286-106$

$\Rightarrow 18x = 180 \Rightarrow x = 10$

This statement is correct.

B. M_r of H_3PO_4 = 3 + 31 + (16 × 4) = 98
This statement is incorrect.

C. The relative atomic mass can be a weighted average of the isotopes based on their natural abundance. It can be any value between the masses of the isotopes (20 and 22), not just exactly equal to 21. This statement is incorrect.

D. The relative atomic mass is actually compared to the carbon-12 isotope (not hydrogen), which has a defined mass of exactly 12 units. This statement is incorrect.

9. A Moles of $NaOH = 0.1\times\frac{25}{1000} = 0.00250$ mol

Molar ratio, $NaOH : H_2SO_4 = 2:1$

Moles of $H_2SO_4 = \frac{0.00250}{2} = 0.00125$ mol

Concentration of $H_2SO_4 = \frac{0.00125}{\frac{20}{1000}}$

$= 0.0625$ mol / dm^3

10. D Moles of $NH_4Cl = \frac{10.7}{53.5} = 0.20$ mol

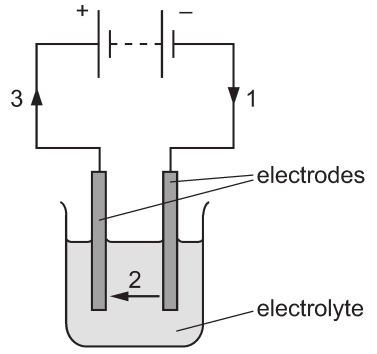
Moles of $Ca(OH)_2 = \frac{14.8}{74} = 0.2$ mol

0.1 mol of $Ca(OH)_2$ reacts with 0.2 mol of NH_4Cl to form 0.1 mol of $CaCl_2$

Maximum mass of $CaCl_2$ that can be produced $= 0.1\times111 = 11.1$ g

Percentage yield $= \frac{10}{11.1}\times100 = 90.1\%$

11. The diagram shows a simple electrolytic cell.



Which arrows show the movement of electrons?

A 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 only

[Topic 9]

12. Which changes are observed during the electrolysis of aqueous copper(II) sulfate using copper electrodes?

1 A pink solid is deposited on the negative electrode.
2 Bubbles form on the positive electrode.
3 The colour of the solution does not change.

A 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 and 3 only

[Topic 9]

13. Which row describes a hydrogen-oxygen fuel cell?

	chemical product	comparison of fuel cell with petrol engine
A	hydrogen and oxygen	hydrogen has a lower energy content by mass than petrol
B	hydrogen and oxygen	a renewable fuel may be used in a fuel cell, a petrol engine uses a non-renewable fuel
C	water only	hydrogen has a lower energy content by mass than petrol
D	water only	a renewable fuel may be used in a fuel cell, a petrol engine uses a non-renewable fuel

[Topic 9]

14. Which statements about endothermic reactions are correct?

1 Energy is absorbed from the surroundings.
2 Energy is released to the surroundings.
3 The temperature of the reaction mixture falls.
4 The temperature of the reaction mixture rises.

A 1 and 3 **B** 1 and 4
C 2 and 3 **D** 2 and 4

[Topic 10]

15. Hydrogen and chlorine react to form hydrogen chloride.

$$H_2 + Cl_2 \rightarrow 2HCl$$

Bond energy data is given in the table.

bond	bond energy in kJ/mol
H–H	436
Cl–Cl	242
H–Cl	431

What is the enthalpy change, ΔH, for this reaction?

A –247 kJ / mol
B –184 kJ / mol
C +184 kJ / mol
D +247 kJ / mol

[Topic 10]

MCQ Answers

11. C Electrons flow from the negative terminal to the positive terminal through the wires in the cell. Arrow 2 indicates the movement of ions, rather than electrons, present in the electrolyte.

12. C Copper ions in the solution gain electrons at the cathode and are reduced to form solid copper. This results in a pink deposit of copper metal on the cathode. When copper electrodes are used, no gas bubbles form at the anode. The concentration of copper ions in the solution remains constant because copper is deposited at the cathode at the same rate as it is dissolved from the anode. As a result, the blue color of the copper sulfate solution does not change significantly.

13. D The main product of a hydrogen-oxygen fuel cell is water, not hydrogen and oxygen. Additionally, hydrogen has a higher energy content per mass compared to petrol. Fuel cells can use renewable fuels while petrol engines typically use non-renewable fuels.

14. A In an endothermic reaction, energy is absorbed from the surroundings and the temperature of the reaction mixture falls. While in an exothermic reaction, energy is released to the surroundings, increasing the temperature of the reaction mixture.

16. Which statement is correct?

A Both physical changes and chemical changes produce new substances.

B Chemical changes are irreversible.

C During a chemical change, atoms rearrange themselves to form new chemical bonds.

D The only way to reverse a physical change is with a chemical reaction.

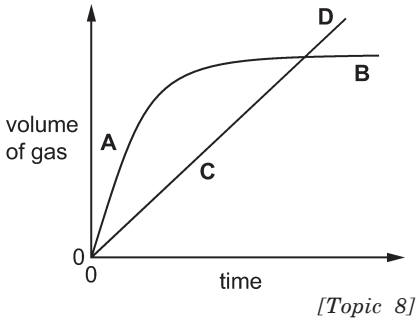
[Topic 10]

17. Two reactions each produce a gaseous product.

The reactions are performed separately using the same conditions of temperature and pressure.

The volume of gas formed in each experiment is measured over time and the results are plotted in the graph shown.

At which point is the rate of production of gas the greatest?



[Topic 8]

18. The reaction between calcium oxide and carbon dioxide is reversible and the forward reaction is exothermic.

$$CaO(s) + CO_2(g) \rightleftharpoons CaCO_3(s)$$

A mixture of calcium oxide and carbon dioxide is placed in a heated flask and the reaction reaches equilibrium.

Which statement about this equilibrium is correct?

A Less calcium carbonate is produced if the pressure in the flask increases.

B More calcium carbonate is produced when the temperature is increased.

C The flask must be sealed if equilibrium is to be reached.

D When equilibrium is reached, the reaction stops.

[Topic 8]

19. In the Haber process, hydrogen and nitrogen react to form ammonia in the presence of a catalyst.

Which reactant is obtained by fractional distillation and what is the catalyst used in the Haber process?

	obtained by fractional distillation	catalyst
A	hydrogen	nickel
B	hydrogen	iron
C	nitrogen	nickel
D	nitrogen	iron

[Topic 8]

15. B Energy absorbed in bond breaking = 436 + 242 = 678 kJ

Energy released in bond making = 2 × 431 = 862 kJ

Enthalpy change = 678 – 862 = –184 kJ / mol

16. C Physical changes do not produce new substances; they only change the state or appearance of a substance (e.g., melting ice to water). Physical changes can often be reversed without a chemical reaction (e.g., freezing and melting water).

Chemical changes, however, do produce new substances and can be reversed in some circumstances. Atoms in the reactants rearrange to form new substances with different properties by creating new chemical bonds.

17. A The rate of production of gas is represented by the slope of the curve on the graph. A steeper slope indicates a higher rate of production in this case at point **A**.

18. C Increasing pressure generally favors the side with fewer moles of gas. However, since there is only one mole of gas on the reactant side and no gas on the product side, increasing pressure would not significantly affect the amount of $CaCO_3$ produced. Since the forward reaction is exothermic, increasing the temperature will shift the equilibrium to favor the endothermic reverse reaction resulting in less $CaCO_3$ being produced. To establish equilibrium in a closed system, it is necessary to prevent the escape of gases. A sealed flask allows for the proper establishment of equilibrium between reactants and products.

At equilibrium, the forward and reverse reactions continue to occur at equal rates, so there is no net change in concentrations of reactants and products, but the reactions do not stop.

19. D In the Haber process, the reactant obtained by fractional distillation is nitrogen. Nitrogen gas is separated from the air. The catalyst used in the process is Iron.

NOVEMBER 2024 PAPER 1

MCQ Section

1. Helium gas and argon gas are mixed in a closed container at room temperature and pressure (r.t.p.).

What happens when the two gases are in the container?

A Argon and helium atoms become evenly mixed throughout the container even though they have different masses.

B Argon and helium atoms both move towards the bottom of the container. The argon atoms settle more quickly because they are larger and heavier.

C Argon and helium atoms both move towards the bottom of the container. The helium atoms settle more quickly because they are smaller and lighter.

D Argon atoms move to the bottom of the container because they are heavier. Helium atoms move to the top of the container because they are lighter.

[Topic 1]

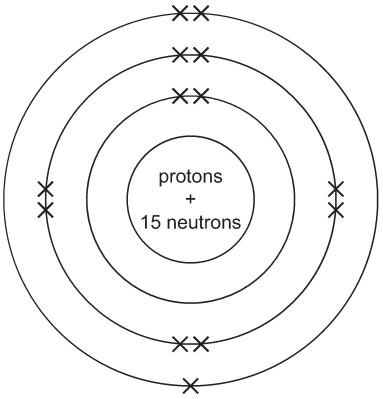
2. Substance X has a simple molecular structure and substance Y has a giant covalent structure.

Which row is correct?

	X could be	Y could be
A	an element only	an element only
B	an element only	an element or a compound
C	an element or a compound	an element only
D	an element or a compound	an element or a compound

[Topic 3]

3. The diagram shows an atom of element Z.



Which symbol for element Z is correct?

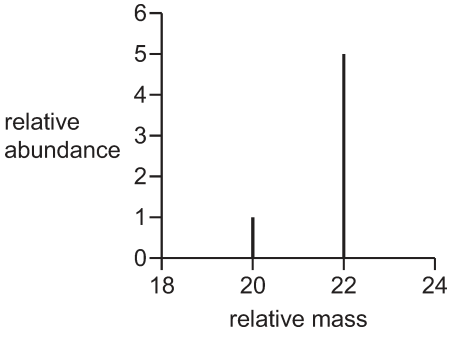
A $^{15}_{28}Z$ **B** $^{26}_{13}Z$

C $^{28}_{13}Z$ **D** $^{28}_{15}Z$

[Topic 3]

4. A sample of element Q contains two isotopes.

The diagram shows the relative abundances and relative masses of the two isotopes.



What is the relative atomic mass, A_r, of this sample of Q?

A 21.0 **B** 21.2

C 21.5 **D** 21.7

[Topic 3]

1. A In a closed container at room temperature and pressure, gases mix due to diffusion. This process involves the random movement of molecules until they are evenly distributed throughout the available space. Their molecules are free to move rapidly and randomly. This means that both argon (heavier) and helium (lighter) will mix uniformly without settling or separating based on their mass.

2. D Substance X can refer to either elements (like oxygen, O_2) or compounds (like CO_2) that consist of small molecules. For substance Y, giant covalent structures are typically associated with compounds like silicon dioxide (sand) and diamond. However, they can also include elements like graphite and diamond, which are both forms of carbon. Thus, giant covalent structures can be found in both elements and compounds.

3. C Number of electrons = 13

As the atom is neutral, the number of proton equals the number of protons = 13

Thus, the atomic number = 13.

Atomic mass = 13 + 15
= 28

4. D

$$A_r = \frac{(20\times1)+(22\times5)}{6}$$
$$= 21.66$$

5. Which statement about electrical conductivity is correct?

A Covalent compounds, such as glucose, conduct when molten or dissolved in water.

B Dilute acids, such as sulfuric acid, conduct because all the ions are free to move.

C Ionic compounds, such as sodium chloride, conduct due to movement of electrons.

D Metals, such as copper, conduct due to movement of positive ions.

[Topic 3]

6. Which substance is **not** malleable and conducts electricity by the movement of electrons through a lattice of atoms?

A aqueous sodium chloride

B gold

C graphite

D solid sodium chloride

[Topic 3]

7. What is the relative molecular mass, M_r, of ethene?

A the average mass of the isotopes of C and H compared to $\frac{1}{12}$ of the mass of an atom of ^{12}C

B the atomic numbers of the isotopes of C and H compared to $\frac{1}{12}$ of the mass of an atom of ^{12}C

C twice the A_r of C plus four times the A_r of H

D twice the A_r of C plus six times the A_r of H

[Topic 4]

8. What is the relative molecular mass, M_r, of N_2O?

A 22 **B** 30

C 44 **D** 46

[Topic 4]

9. Which contains the greatest mass of oxygen?

A 0.2 mol of aluminium nitrate, $Al(NO_3)_3$

B 0.3 mol of potassium sulfate, K_2SO_4

C 0.4 mol of sodium nitrate, $NaNO_3$

D 0.5 mol of magnesium carbonate, $MgCO_3$

[Topic 4]

10. Compound Z contains carbon, hydrogen and oxygen only.

Compound Z contains 48.65% carbon and 8.11% hydrogen by mass.

What is the empirical formula of Z?

A C_2H_4O **B** $C_3H_6O_2$

C $C_4H_8O_3$ **D** $C_8H_{16}O_5$

[Topic 4]

MCQ Answers

5. B Most covalent compounds do not conduct electricity even when molten or dissolved in water unless they dissociate into ions. When acids like sulfuric acid (H_2SO_4) are diluted in water, they dissociate into ions. These freely moving ions allow the solution to conduct electricity.
Ionic compounds like sodium chloride (NaCl) do not conduct electricity in their solid state due to fixed ion positions. Metals like copper conduct due to the movement of electrons (free electrons), not positive ions.

6. C Graphite is not malleable and conducts electricity through the movement of electrons. In graphite, carbon atoms are arranged in layers, and within these layers, electrons are delocalised and free to move, allowing for electrical conductivity. Gold is both malleable and conducts electricity by electron movement. Aqueous sodium chloride conducts electricity through the movement of ions while solid sodium chloride does not conduct electricity.

7. C The chemical formula for ethene is C_2H_4.

$$M_r = 2\times A_r(C) + 4\times A_r(H)$$
$$M_r = (2\times 12) + (4\times 1)$$
$$= 24 + 4 = 28$$

8. C M_r of N_2O
= 14 + 14 + 16 = 44

9. A For each compound the mass of oxygen is:

A. M_r of $Al(NO_3)_3 = 27 + (14\times 3) + (16\times 9) = 213$
0.2 mol of $Al(NO_3)_3 = 0.2\times 213 = 42.6$g
Mass of oxygen $= \frac{16\times 9}{213}\times 42.6 = 28.8$ g

B. M_r of $K_2SO_4 = (39\times 2) + 32 + (16\times 4) = 174$
Mass of $K_2SO_4 = 0.3\times 174 = 52.2$g
Mass of Oxygen $= \frac{16\times 4}{174}\times 52.2 = 19.2$g

C. M_r of $NaNO_3 = 23 + 14 + (16\times 3) = 85$
Mass of $NaNO_3 = 0.4\times 85 = 34$ g
Mass of Oxygen $= \frac{16\times 3}{85}\times 34 = 19.2$ g

D. M_r of $MgCO_3 = 24 + 12 + (16\times 3) = 84$
Mass of $MgCO_3 = 0.5\times 84 = 42$ g
Mass of Oxygen $= \frac{16\times 3}{84}\times 42 = 24$ g

11. Which fertiliser contains the highest percentage by mass of nitrogen?

[M_r : NH_4NO_3, 80; $(NH_4)_3PO_4$, 149; $(NH_4)_2SO_4$, 132; $(NH_2)_2CO$, 60]

A NH_4NO_3

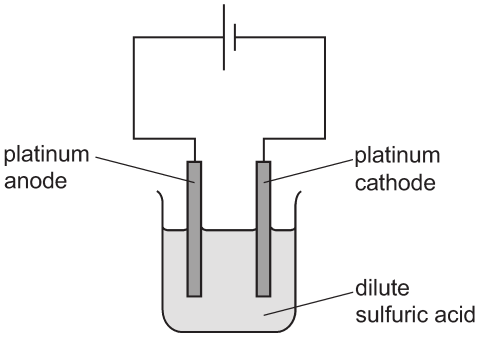
B $(NH_4)_3PO_4$

C $(NH_4)_2SO_4$

D $(NH_2)_2CO$

[Topic 4]

12. An electrolytic cell is shown.



Which statement is correct?

A Electrons move from the cathode to the anode in the external circuit.

B Hydrogen ions gain electrons at the anode.

C In the electrolyte, positive ions move to the cathode and negative ions move to the anode.

D The hydroxide ions in the electrolyte move to the cathode.

[Topic 9]

13. An aqueous mixture of copper(II) nitrate and silver nitrate is electrolysed with pure copper electrodes.

Which ionic half-equation describes the change occurring at the anode?

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

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

C $Ag \rightarrow Ag^+ + e^-$

D $Ag^+ + e^- \rightarrow Ag$

[Topic 9]

14. What is a disadvantage of using a hydrogen-oxygen fuel cell to power a car?

A Gasoline / petrol is a non-renewable resource.

B The hydrogen tank may split in an accident, leading to an explosion.

C The product of the reaction between oxygen and hydrogen is toxic.

D The oxygen is obtained from air.

[Topic 9]

MCQ Answers

10. B Oxygen percentage in Z = 100 – 48.65 – 8.11 = 43.24

Element	C	H	O
%	48.65	8.11	43.24
Ar	12	1	16
Moles	$\frac{48.65}{12}$	$\frac{8.11}{1}$	$\frac{43.24}{16}$
=	4.05	8.11	2.7
Ratio	$\frac{4.05}{2.7}$	$\frac{8.11}{2.7}$	$\frac{2.7}{2.7}$
=	1.5	3	1
=	3	6	2

Empirical formula = $C_3H_6O_2$

11. D Percentage by mass of Nitrogen in:

$\mathbf{A} = \frac{(14\times2)}{80}\times100 = 35\%$, $\mathbf{B} = \frac{(14\times3)}{149}\times100 = 28\%$

$\mathbf{C} = \frac{(14\times2)}{132}\times100 = 21\%$, $\mathbf{D} = \frac{(14\times2)}{60}\times100 = 47\%$

12. C During electrolysis in a cell with dilute sulfuric acid (H_2SO_4), hydrogen ions are positive ions that move towards the cathode. Sulfate ions are negative and would typically be expected to move towards the anode. Electrons flow from the anode to the cathode through an external circuit during electrolysis. Hydrogen ions gain electrons at the cathode, not at the anode. Hydroxide ions are negatively charged and thus might be expected to move to the anode.

13. A When an aqueous mixture of copper(II) nitrate and silver nitrate is electrolysed using pure copper electrodes, the anode (where oxidation occurs) will involve in the dissolution of copper metal into Cu^{2+} ions.

14. B Hydrogen is highly flammable and can ignite easily if it escapes containment. While safety measures are implemented to prevent such incidents, the risk remains a concern.

15. D In an exothermic reaction, thermal energy is given out. This occurs when more energy is released during bond formation than was required to break existing bonds. The net result is a release of excess energy into the surroundings as heat.

MCQ Answers

15. When chemical reaction X takes place, thermal energy is given out.

Which row is correct for this reaction?

	type of reaction	explanation
A	endothermic	More energy is required to break the bonds than the energy released when the bonds are formed.
B	endothermic	Less energy is required to break the bonds than the energy released when the bonds are formed.
C	exothermic	More energy is required to break the bonds than the energy released when the bonds are formed.
D	exothermic	Less energy is required to break the bonds than the energy released when the bonds are formed.

[Topic 10]

16. Which statement about a physical change is correct?

A A physical change is impossible to reverse.

B In a physical change, the appearance of a substance may change.

C New substances are formed in a physical change.

D There is no energy released or taken in during a physical change.

[Topic 10]

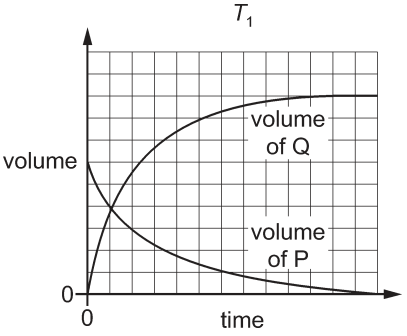
17. Gas P decomposes to form gas Q.

$$xP \rightarrow yQ$$

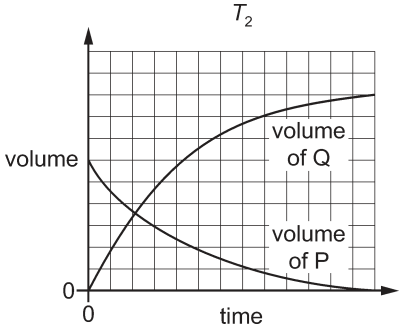
Two experiments are done to investigate the rate of reaction. The conditions are the same except that two different temperatures, T_1 and T_2, are used.

The results are plotted on graphs, drawn to the same scale.

T_1



T_2



Which row is correct?

	x	y	temperature
A	2	3	T_1 is higher than T_2
B	2	3	T_2 is higher than T_1
C	3	2	T_1 is higher than T_2
D	3	2	T_2 is higher than T_1

[Topic 8]

18. Samples of nitrogen and hydrogen are reacted and allowed to reach equilibrium. The equation is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad \Delta H = -92\ kJ/mol$$

The temperature is increased and a new equilibrium is established.

Which statement about the new equilibrium is correct?

A The amount of product increases.

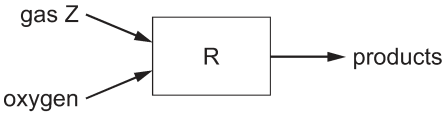
B The amount of product decreases.

C The rate of the forward reaction is greater than the rate of the reverse reaction.

D The rate of the forward reaction is less than the rate of the reverse reaction.

[Topic 8]

19. In the diagram, R represents one of the reactions in the Contact process.



Which statement is correct?

A Gas Z is SO_2.

B In R, an iron catalyst speeds up the reaction.

C In R, the pressure is approximately 200 atm.

D In R, the temperature is approximately 45°C.

[Topic 8]

16. B Physical changes are generally reversible; for example, freezing water vapor back into ice. However, during these processes, the appearance or state of matter can indeed change without altering the chemical composition. No new substances are formed during a physical change. Energy is often involved in physical changes — either absorbed (e.g. melting) or released (e.g. freezing).

17. A When reading the graph, assume 1 unit for each small box.

Starting volume of P = 6

Ending volume of Q = 9; we can deduce that x = 2 and y = 3;

The fact that the volume of Q is achieved in less time during the first experiment suggests that T_1 is higher than T_2.

18. B When the temperature is increased in an exothermic reaction (as indicated by ΔH = –92 kJ/mol), the equilibrium shifts to favor the reactants. This means that some of the ammonia (NH_3) will decompose back into nitrogen and hydrogen to counteract the increase in temperature.

19. A In contact process, sulfur dioxide reacts with oxygen to produce sulfur trioxide in presence of Vanadium (V) oxide as a catalyst at 1–2 atm pressure and 400 – 450 °C temperature.

NOVEMBER 2024 PAPER 2

THEORY Section

Answer **all** the questions

Question 1

(a) Fig. 1.1 shows the electronic configurations of five atoms, **A**, **B**, **C**, **D** and **E**.

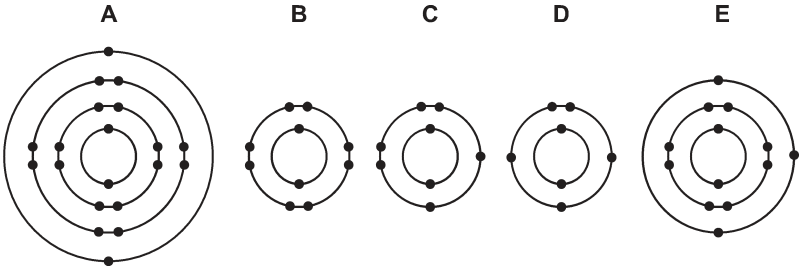


Fig. 1.1

Answer the questions about these electronic configurations.

Each electronic configuration may be used once, more than once or not at all.

State which electronic configuration, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom of a noble gas [1]

(ii) an atom of an element that is used in food containers because of its resistance to corrosion [1]

(iii) an atom of an element in Group V of the Periodic Table [1]

(iv) an atom of an element in Period 3 of the Periodic Table [1]

(v) an atom that forms a stable ion with a charge of 2–. [1]

(b) Deduce the number of protons and neutrons in the vanadium atom shown.

$^{51}_{23}V$

[2]

[Total: 7] [Topic: 5]

Solution

(a) (i) B **(ii) E** **(iii) D**

(iv) E **(v) C**

(b) Number of protons: 23

Number of neutrons: 51 – 23 = 28

Question 2

Iron is extracted in the blast furnace by the reduction of iron(III) oxide, Fe_2O_3.

This process is made up of three steps.

(a) (i) In step 1, carbon burns in air to produce carbon dioxide.

Give one **other** reason why carbon is burned in air in the blast furnace. [1]

(ii) In step 2, carbon monoxide is produced by the reaction of carbon dioxide with carbon.

State **one** adverse effect of carbon monoxide on health. [1]

(iii) In step 3, iron(III) oxide is reduced by carbon monoxide.

Write the symbol equation for this reaction. [1]

(b) Explain why calcium carbonate is added to the blast furnace.

Include any relevant reactions or equations in your answer. [2]

(c) Iron is a transition element.

Transition elements have high melting and boiling points.

State two **other** properties that are typical of transition elements but **not** of Group I metals. [2]

(d) Iron is prevented from rusting by galvanising with zinc.

Explain **two** different ways in which zinc prevents rusting. [3]

(e) The equation shows the reaction of iron with steam in a closed container.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

Predict and explain what happens to the position of equilibrium when the pressure is increased. The temperature remains the same. [2]

(f) Fe_3O_4 reacts with concentrated hydrochloric acid.

The products are iron(II) chloride, iron(III) chloride and a liquid that turns blue cobalt(II) chloride paper pink.

Construct the symbol equation for this reaction. [2]

[Total: 14] [Topic: 6]

Solution

(a) **(i)** Carbon is burned in air to produce heat.

(ii) Carbon monoxide is a poisonous gas.

(iii) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(b) The main role of calcium carbonate in the blast furnace is to react with acidic impurities, such as silicon dioxide, to form a molten slag. When heated in the blast furnace, calcium carbonate decomposes into calcium oxide and carbon dioxide: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Calcium oxide then reacts with Silicon dioxide to form slag:
$CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l)$

(c) 1. Transition metals can exist in multiple oxidation states.
2. Transition metals often form compounds that are vividly colored.

(d) The zinc coating serves as a physical barrier that prevents moisture and oxygen from reaching the iron surface. By forming a dense layer of zinc oxide when it reacts with air, this barrier significantly reduces the rate of corrosion. Additionally, zinc is more reactive than iron, which means it will corrode preferentially when both metals are exposed to moisture and oxygen.

(e) Prediction: No effect on the position of the equilibrium.

Explanation: Increasing the pressure shifts the equilibrium with lesser number of gas molecules. Therefore, when the pressure is increased, there will be no significant shift in the position of equilibrium because both sides have the same number of gaseous moles.

(f) $Fe_3O_4 + 8HCl \rightarrow FeCl_2 + 2FeCl_3 + 4H_2O$

COMMENT on **ANSWER**

"**(a)** **(i)** In the blast furnace, carbon is burned in air not only to produce carbon dioxide but also to generate the necessary heat for the extraction process. The combustion of carbon (coke) is exothermic, releasing significant amounts of heat that raise the temperature within the furnace to around 1800 °C.

(ii) One adverse effect of carbon monoxide on health is that it can lead to impaired oxygen transport in the body.

(c) Transition elements are widely used as catalysts."

Question 3

Fig. 3.1 shows the apparatus used for the electrolysis of dilute sulfuric acid using graphite electrodes.

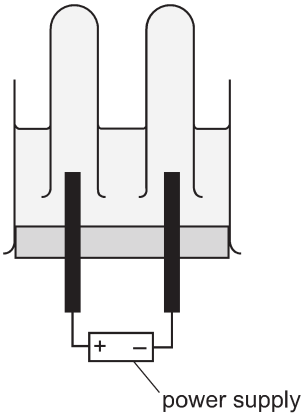


Fig. 3.1

(a) Define the term electrolysis. [2]

(b) Label the anode on Fig. 3.1. [1]

(c) **(i)** Name the product at the cathode. [1]

(ii) Oxygen is formed at the anode.

Construct the ionic half-equation for the reaction at the anode. [1]

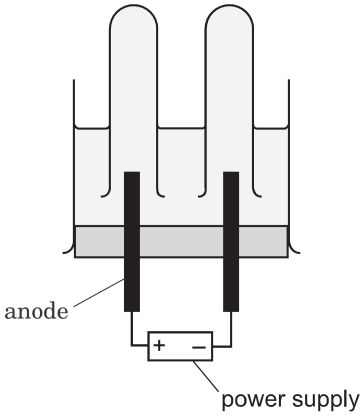
(d) Name a suitable element other than graphite that is used for the electrodes in this electrolysis. [1]

[Total: 6] [Topic: 9]

Solution

(a) Electrolysis is the decomposition of an ionic / aqueous compound by passing electricity through it.

(b)



(c) **(i)** Hydrogen

(ii) $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

(d) Platinum

Question 4

This question is about alkanes and alkenes.

(a) Butane belongs to the alkane homologous series.

Members of the same homologous series have the same functional group and the same general formula.

State two **other** characteristics of a homologous series. [2]

(b) Fig. 4.1 shows the displayed formula of butane.

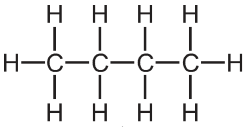


Fig. 4.1

(i) Explain how Fig. 4.1 shows that butane is a saturated compound. [1]

(ii) Give the structural formula of butane. [1]

(c) Nonane, C_9H_{20}, is present in the naphtha fraction from the distillation of petroleum.

(i) State **one** use of the naphtha fraction. [1]

(ii) When nonane is cracked, shorter hydrocarbon molecules are formed.

Construct the symbol equation for a reaction in which nonane is cracked and the only products are propane and ethene. [2]

(d) Propane reacts with chlorine in the presence of ultraviolet light.

Fig. 4.2 shows the displayed formulae of the reactants and products.

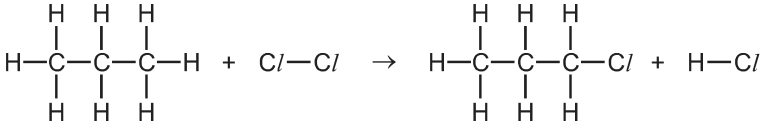


Fig. 4.2

(i) Name the type of chemical reaction that takes place. [1]

(ii) State the purpose of the ultraviolet light in this reaction. [1]

(iii) Calculate the enthalpy change of this reaction in kJ / mol.

Use the bond energies in Table 4.1.

Table 4.1

type of bond	C–C	C–H	C*l*–C*l*	C–C*l*	H–C*l*
bond energy in kJ / mol	347	413	243	346	432

[3]

(e) The equation shows the reaction of ethene with chlorine.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

Explain how this equation shows that this reaction is an addition reaction. [1]

[Total: 13] [Topic: 12 & 10]

Solution

(a) 1. The physical properties of the members of a homologous series, such as boiling points and melting points, generally show a gradual change with increasing molecular mass.

2. The members of a homologous series differ from one member to the next by a $-CH_2-$ unit.

(b) (i) Butane consists of carbon-carbon single bonds only.

(ii) $CH_3CH_2CH_2CH_3$

(c) (i) Naphtha is used as a chemical feedstock.

(ii) $C_9H_{20} \rightarrow C_3H_8 + 3C_2H_4$

(d) (i) Substitution reaction.

(ii) Ultravoilet light provides the activation energy for the reaction.

(iii) Energy associated with bond breaking = C–H + C*l*–C*l*

= 413 + 243 = 656 kJ

Energy associated with bond forming = C–C*l* + H–C*l*

= 346 + 432 = 778 kJ

Enthalpy change = 656 – 778 = –122 kJ / mol

(e) In this reaction, two reactants combine to form a single product. This characteristic of forming one larger molecule from two smaller reactants is a defining feature of addition reactions.

COMMENT on **ANSWER**

"**(d) (i)** As the hydrogen in propane is substituted by Chlorine, the reaction is termed substitution reaction."

Question 5

A student adds large pieces of zinc to dilute hydrochloric acid. The zinc is in excess.

(a) Complete the equation by adding state symbols for the products.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(.....) + H_2(.....)$$ [1]

(b) Fig. 5.1 shows how the volume of hydrogen changes with time as the reaction proceeds.

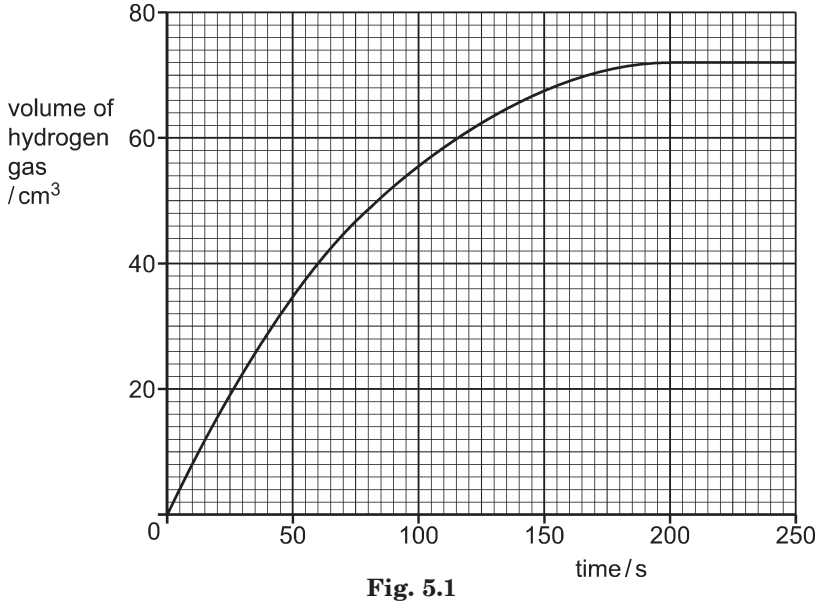


Fig. 5.1