Cambridge IGCSE
Topical Past Papers

CHEMISTRY 9-1

0971 P4

2020 — 2025

1 - (0971/42_Summer_2020_Q1)

(a) Give the name of the process that:

(i) occurs when a gas turns into a liquid

..... [1]

(ii) occurs when a solid turns into a gas without first forming a liquid

..... [1]

(iii) is used to separate a mixture of liquids with different boiling points

..... [1]

(iv) is used to extract aluminium from aluminium oxide

..... [1]

(v) is used to separate a mixture of amino acids.

..... [1]

(b) The symbols of the elements in Period 2 of the Periodic Table are shown.

Li Be B C N O F Ne

For each of the following, give the symbol of an element from Period 2 which matches the description.

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

Which element:

(i) combines with hydrogen to produce ammonia

..... [1]

(ii) makes up approximately 21% of clean, dry air

..... [1]

(iii) has atoms with only two electrons in the outer shell

..... [1]

(iv) has atoms with only seven protons

..... [1]

(v) is a monoatomic gas

..... [1]

(vi) is a soft metal stored in oil?

..... [1]

[Total: 11]

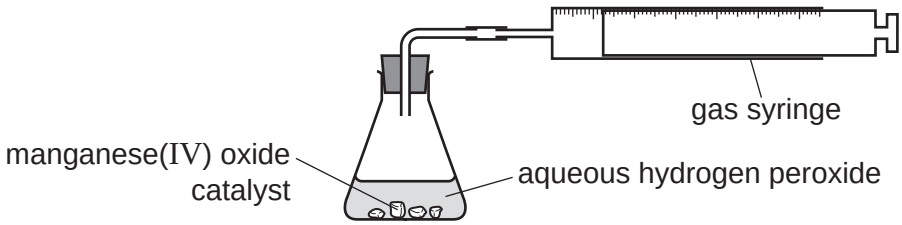
2 - (0971/42_Summer_2020_Q4)

Oxygen is produced by the decomposition of hydrogen peroxide. Manganese(IV) oxide is the catalyst for this reaction.

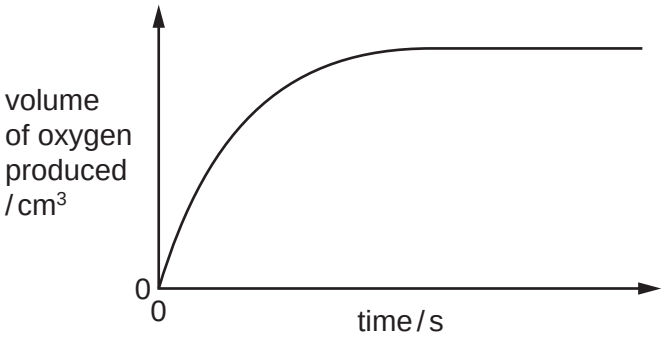
(a) What is meant by the term *catalyst*?

..... [2]

(b) A student measures the volume of oxygen produced at regular time intervals using the apparatus shown. Large lumps of manganese(IV) oxide are used.



A graph of the results is shown.



What happens to the **rate** of this reaction as time increases?
In your answer, explain why the rate changes in this way.

..... [4]

(c) The experiment is repeated using the same mass of manganese(IV) oxide. Powdered manganese(IV) oxide is used instead of large lumps. All other conditions stay the same.

Sketch a graph on the axes in **(b)** to show how the volume of oxygen changes with time. [2]

(d) In terms of particles, explain what happens to the rate of this reaction when the temperature is increased.

..... [3]

(e) The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

25.0 cm^3 of aqueous hydrogen peroxide forms 48.0 cm^3 of oxygen at room temperature and pressure (r.t.p.).

Calculate the concentration of aqueous hydrogen peroxide at the start of the experiment using the following steps.

- Calculate the number of moles of oxygen formed.

..... mol

- Deduce the number of moles of hydrogen peroxide that decomposed.

..... mol

- Calculate the concentration of hydrogen peroxide in mol / dm^3.

..... mol / dm^3
[3]

(f) Oxygen can also be produced by the decomposition of potassium chlorate(V), $KClO_3$.

The only products of this decomposition are potassium chloride and oxygen.

Write a chemical equation for this decomposition.

..... [2]

[Total: 16]

3 - (0971/42_Winter_2021_Q1)

This question is about states of matter.

(a) Complete the table, using ticks (✓) and crosses (✗), to describe the properties of gases, liquids and solids.

state of matter	particles are touching	particles have random movement	particles are regularly arranged
gas			
liquid			
solid			

[3]

(b) Substances can change state.

(i) Boiling and evaporation are two ways in which a liquid changes into a gas.

Describe **two** differences between boiling and evaporation.

1 .....

2 .....

[2]

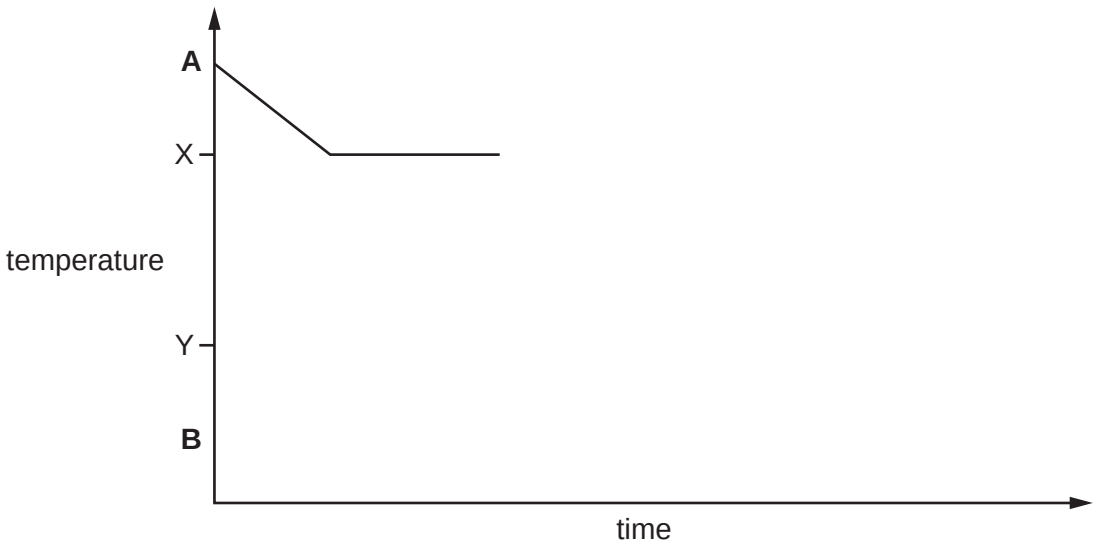
(ii) Name the change of state when:

- a gas becomes a liquid .....
- a solid becomes a gas. .....

[2]

(c) A substance boils at temperature X and melts at temperature Y.

Complete the graph to show the change in temperature over time as the substance cools from temperature **A** to temperature **B**.



[2]

(d) A solution is a mixture of a solute and a solvent.

(i) Name the process when a solid substance mixes with a solvent to form a solution.

..... [1]

(ii) Name the type of reaction when two solutions react to form an insoluble substance.

..... [1]

[Total: 11]

4 - (0971/41_Summer_2022_Q6)

This question is about zinc and its compounds.

(a) Zinc is extracted from its ore which is mainly zinc sulfide, ZnS.

The steps for this extraction are shown.

step 1 Zinc sulfide is converted into zinc oxide.

step 2 The zinc oxide is then reduced to zinc in a furnace. The zinc formed becomes a gas.

step 3 The zinc gas is cooled to form molten zinc.

(i) Name the ore of zinc, which is mainly zinc sulfide.

..... [1]

(ii) Describe how zinc sulfide is converted into zinc oxide in **step 1**.

.....

..... [1]

(iii) Name the reducing agent used in **step 2**.

..... [1]

(iv) Explain why the zinc forms a gas in **step 2** inside the furnace.

..... [1]

(v) State the name of the physical change occurring when zinc gas is converted into molten zinc.

..... [1]

(b) Zinc sulfate crystals, $ZnSO_4 \cdot 7H_2O$, are hydrated.

Zinc sulfate crystals are made by reacting zinc carbonate with dilute sulfuric acid.

The equation for the overall process is shown.

$$ZnCO_3 + H_2SO_4 + 6H_2O \rightarrow ZnSO_4 \cdot 7H_2O + CO_2$$

step 1 Large pieces of solid zinc carbonate are added to dilute sulfuric acid until the zinc carbonate is in excess. This forms aqueous zinc sulfate.

step 2 The excess zinc carbonate is separated from the aqueous zinc sulfate.

step 3 The aqueous zinc sulfate is heated until a saturated solution is formed.

step 4 The saturated solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(i) In **step 1**, zinc carbonate is in excess when no more zinc carbonate dissolves.

State one **other** observation that indicates the zinc carbonate is in excess in **step 1**.

..... [1]

(ii) Name a different substance, other than zinc carbonate, that can be added to dilute sulfuric acid to produce aqueous zinc sulfate in **step 1**.

..... [1]

(iii) **Step 1** is repeated using powdered zinc carbonate instead of large pieces.

All other conditions are kept the same.

The rate of reaction increases.

Give a reason why the rate of reaction increases. Explain your answer in terms of particles.

..... [2]

(iv) Suggest what is observed when the solution is saturated in **step 3**.

..... [1]

(v) The formula of zinc sulfate crystals is $ZnSO_4 \cdot 7H_2O$.

Give the formula of the solid formed if the crystals are heated to dryness in **step 3**.

..... [1]

[Total: 11]

5 - (0971/41_Summer_2023_Q3)

This question is about ionic and covalent compounds.

(a) **(i)** Sodium reacts with oxygen to form the ionic compound sodium oxide.
The electronic configurations of an atom of sodium and an atom of oxygen are shown in Fig. 3.1.

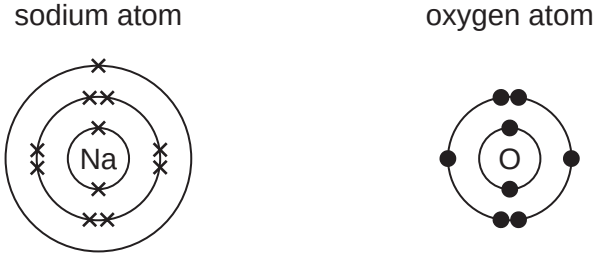


Fig. 3.1

Ions are formed by the transfer of electrons from sodium atoms to oxygen atoms.

Complete the dot-and-cross diagrams in Fig. 3.2 to show the electronic configuration of **one** sodium ion and **one** oxide ion. Show the charges on the ions.

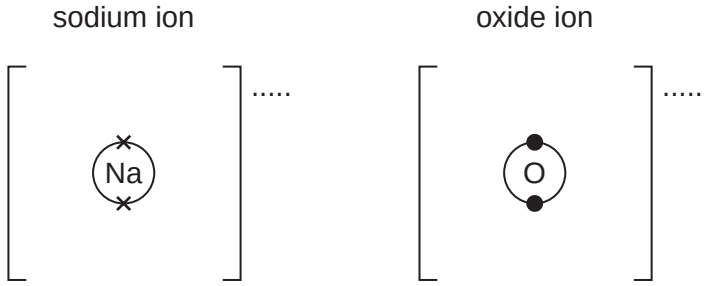


Fig. 3.2

[3]

(ii) Write the formula of sodium oxide.

..... [1]

(b) Carbon dioxide, CO_2, is a covalent compound.

Complete the dot-and-cross diagram in Fig. 3.3 to show the electronic configuration in a molecule of carbon dioxide. Show outer shell electrons only.

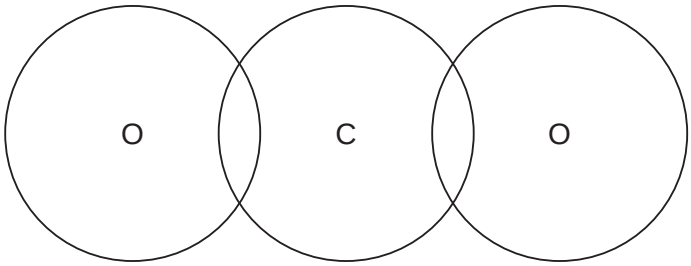


Fig. 3.3

[2]

(c) The melting points of sodium oxide and carbon dioxide are shown in Table 3.1.

Table 3.1

	melting point/°C
sodium oxide	1275
carbon dioxide	–78

(i) Explain, in terms of bonding, why sodium oxide has a high melting point.

..... [2]

(ii) Carbon dioxide has a low melting point.

State the general term for the weak forces that cause carbon dioxide to have a low melting point.

..... [1]

[Total: 9]

6 - (0971/41_Summer_2024_Q4)

Hydrogen iodide thermally decomposes into iodine and hydrogen. The reaction is reversible.

$$\underset{\text{colourless gas}}{2HI(g)} \rightleftharpoons \underset{\text{purple gas}}{I_2(g)} + \underset{\text{colourless gas}}{H_2(g)}$$

Fig. 4.1 shows a gas syringe containing a mixture of hydrogen iodide, iodine and hydrogen gases. The gas syringe is sealed and the mixture is heated to 300 °C. The mixture of gases reaches equilibrium and is purple.

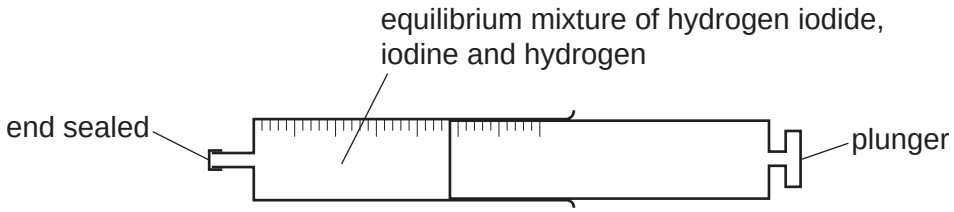


Fig. 4.1

(a) State what is meant by the term equilibrium.

..... [2]

(b) The pressure of the mixture is increased. All other conditions stay the same. The position of equilibrium does **not** change.

The colour of the gaseous mixture turns darker purple.

The temperature remains constant.

$$\underset{\text{colourless gas}}{2HI(g)} \rightleftharpoons \underset{\text{purple gas}}{I_2(g)} + \underset{\text{colourless gas}}{H_2(g)}$$

(i) Explain why the position of equilibrium does **not** change.

..... [1]

(ii) Suggest why the colour of the mixture of gases turns darker purple.

..... [1]

(c) The temperature of the mixture of gases is decreased. All other conditions stay the same.

The mixture of gases turns lighter purple.

State what can be deduced about the forward reaction from this information.

..... [1]

(d) Deduce the oxidation number of iodine, I, in:

HI .....

I_2. .....
[2]

(e) Methanol is manufactured by reacting carbon monoxide with hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The rate of formation of methanol increases when a catalyst is used.

(i) Choose from the list the element that is most likely to be used as the catalyst.

Draw a circle around your chosen answer.

calcium carbon copper sodium sulfur [1]

(ii) State the effect on the position of equilibrium when a catalyst is used.

..... [1]

(iii) State the effect that a catalyst has on the activation energy, E_a, of a reaction.

..... [1]

[Total: 10]

7 - (0971/41_Summer_2024_Q6)

This question is about metals.

(a) Fig. 6.1 shows a blast furnace used to extract iron from its ore.

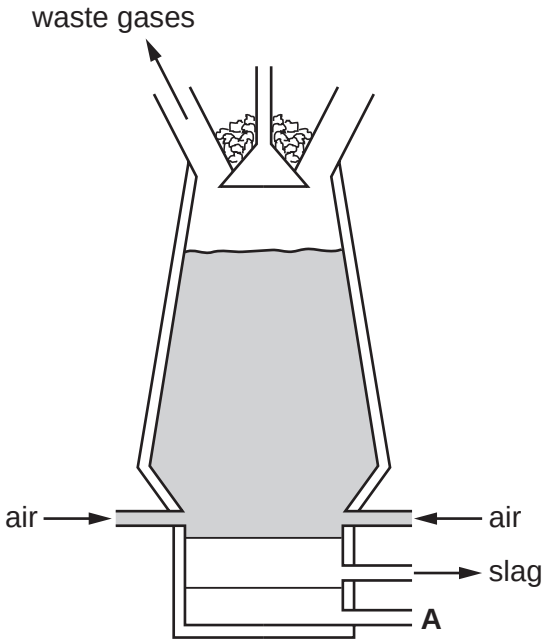


Fig. 6.1

(i) Coke and iron ore are added at the top of the blast furnace.

Name one **other** substance that is added at the top of the blast furnace.

..... [1]

(ii) Name the substance that leaves the blast furnace at **A**.

..... [1]

(iii) Slag is produced from an impurity in iron ore.

Name the impurity in iron ore that is converted into slag.

..... [1]

(iv) Name **two** substances that react together to produce the high temperature in the blast furnace.

..... and ..... [1]

(v) Name **two** waste gases that leave the blast furnace.

1 .....

2 .....
[2]

(b) Zinc is produced from zinc oxide in a furnace.

The zinc is produced as a gas. It then forms molten zinc.

(i) Suggest why the zinc produced inside the furnace is a gas.

..... [1]

(ii) State the name of the physical change that occurs when gaseous zinc is converted into molten zinc.

..... [1]

(c) Zinc is used to coat iron to prevent rusting.

(i) Name the process used to coat iron with zinc as a method of rust prevention.

..... [1]

(ii) When the zinc coating is scratched, the iron underneath does not rust.

Explain why the iron underneath the zinc does **not** rust.

.....

..... [2]

(d) Zinc oxide neutralises both acids and bases.

(i) State the general name given to oxides that neutralise both acids and bases.

..... [1]

(ii) When zinc oxide neutralises aqueous sodium hydroxide, sodium zincate is formed.

The formula of the zincate ion is ZnO_2^{2-}.

Deduce the formula of sodium zincate.

..... [1]

(iii) Name the zinc compound that forms when zinc oxide neutralises dilute sulfuric acid.

..... [1]

[Total: 14]

8 - (0971/41_Summer_2025_Q2)

Atoms are made of electrons, neutrons and protons.

(a) Complete Table 2.1.

Table 2.1

particle	relative charge	relative mass
electron		$\frac{1}{1840}$
neutron	0	
proton		

[2]

(b) Atoms of the same element are known as isotopes.

$^{39}_{19}K$ and $^{41}_{19}K$ are isotopes of potassium.

(i) Complete Table 2.2 to show the number of electrons, neutrons and protons in one atom or ion of these isotopes.

Table 2.2

isotope	electrons	neutrons	protons
$^{39}_{19}K$			
$^{41}_{19}K^{+}$			

[3]

(ii) Table 2.3 shows the relative masses and the percentage abundances of the two isotopes in a sample of potassium.

Table 2.3

relative mass of isotope	percentage abundance of isotope
39	90
41	10

Calculate the relative atomic mass of this sample of potassium to **one** decimal place.

relative atomic mass = ... [2]

(iii) An isotope of aluminium has a nucleon number of 27.

Aluminium has a relative atomic mass of 27.

State what conclusion can be made from this information.

..... [1]

(c) A calcium atom has the electronic configuration of 2,8,8,2.

Give the formula of one atom and one negative ion that has the same electronic configuration as Ca^{2+}.

- atom .....
- negative ion .....

[2]

[Total: 10]

9 - (0971/41_Summer_2025_Q4)

This question is about nitrogen and its compounds.

Nitrogen contains molecules with the formula N_2.

(a) Complete the dot-and-cross diagram in Fig. 4.1 to show the electronic configuration in a nitrogen molecule. Show outer-shell electrons only.

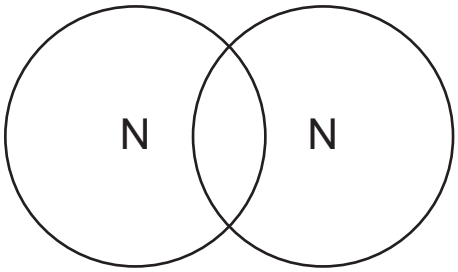


Fig. 4.1

[2]

(b) Ammonia, NH_3, is manufactured by reacting nitrogen with hydrogen, H_2, in the Haber process.

(i) State **three** typical conditions for the reaction between nitrogen and hydrogen in the Haber process.

1 .....

2 .....

3 .....

[3]

(ii) Write the symbol equation for the chemical reaction in the Haber process.

..... [1]

(c) Ammonia is converted into nitric acid in a two-step process.

In step 1, ammonia and oxygen are passed over a catalyst.

(i) Balance the symbol equation for this reaction.

$$4NH_3 + ...O_2 \rightleftharpoons .....NO + ...H_2O$$

[1]

(ii) Give the oxidation number of nitrogen in:

- NH_3 .....
- NO. .....

[2]

(iii) Define oxidation in terms of oxidation number.

..... [1]

(iv) In step 2, oxygen and water react with NO to produce nitric acid as the only product.

Write a symbol equation for this chemical reaction.

..... [2]

(d) Ammonia is converted into ammonium sulfate, $(NH_4)_2SO_4$.

$$2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(s)$$

360 dm^3 of ammonia gas, measured at r.t.p., reacts with excess sulfuric acid.

Calculate the mass of ammonium sulfate produced, using the following steps.

- Calculate the number of moles of $NH_3(g)$ in 360 dm^3.

  One mole of any gas occupies 24 dm^3 at r.t.p.

  ..... mol

- Calculate the number of moles of $(NH_4)_2SO_4$ produced.

  ..... mol

- Calculate the mass of $(NH_4)_2SO_4$ produced.

  The M_r of $(NH_4)_2SO_4$ is 132.

  ..... g

[3]

[Total: 15]

1 - (0971/42_Summer_2020_Q1)

(a)(i)	condensation	**1**
(a)(ii)	sublimation	**1**
(a)(iii)	fractional distillation	**1**
(a)(iv)	electrolysis	**1**
(a)(v)	chromatography	**1**
(b)(i)	N	**1**
(b)(ii)	O	**1**
(b)(iii)	Be	**1**
(b)(iv)	N	**1**
(b)(v)	Ne	**1**
(b)(vi)	Li	**1**

2 - (0971/42_Summer_2020_Q4)

(a)	substance that speeds up a reaction / increases rate (1) unchanged (chemically) at the end **OR** not used up **OR** lowers activation energy **OR** provides alternative pathway (1)	**2**
(b)	rate decreases (1) particles further apart / less particles per unit volume (1) fewer collisions per unit time / lower collision frequency (1) reaction stops because all hydrogen peroxide is used up	**4**
(c)	steeper gradient (1) reaches same volume of oxygen (1)	**2**
(d)	particles gain kinetic energy / particles move faster (1) greater number of collisions with activation energy (or more) / greater number of particles with activation energy (or more) / greater number of particles with energy required for reaction (1) more collisions are successful / more collisions are fruitful / more collisions lead to reaction (1)	**3**
(e)	**M1** moles of oxygen $= \frac{48.0}{24000}$ or moles of oxygen = 0.002 (1) **M2** moles of hydrogen peroxide = **M1** $\times 2$ or moles of hydrogen peroxide = 0.004 (1) **M3** concentration = **M2** $\times 40 = 0.16$ mol / dm^3 (1) allow ECF	**3**
(f)	$2KClO_3 \rightarrow 2KCl + 3O_2$ **ALL** formulae correct (1) balancing (1)	**2**

3 - (0971/42_Winter_2021_Q1)

<table>
<tr><td>(a)</td><td>1 mark for each correct row
<table><tr><td>State</td><td>touching</td><td>random movement</td><td>regularly arranged</td></tr><tr><td>Gas</td><td></td><td>✔</td><td></td></tr><tr><td>Liquid</td><td>✔</td><td>✔</td><td></td></tr><tr><td>Solid</td><td>✔</td><td></td><td>✔</td></tr></table></td><td>3</td></tr>
<tr><td>(b)(i)</td><td>boiling happens at a specific temperature (1)
boiling has bubbles (1)</td><td>2</td></tr>
<tr><td>(b)(ii)</td><td>condensation (1)
sublimation (1)</td><td>2</td></tr>
<tr><td>(c)</td><td>one horizontal line level with Y (1)
two separate decreases before and after horizontal line (1)</td><td>2</td></tr>
<tr><td>(d)(i)</td><td>dissolving</td><td>1</td></tr>
<tr><td>(d)(ii)</td><td>precipitation</td><td>1</td></tr>
</table>

4 - (0971/41_Summer_2022_Q6)

(a)(i)	zinc blende	**1**
(a)(ii)	heat(zinc sulfide) strongly in air / roast in air	**1**
(a)(iii)	carbon **or** carbon monoxide	**1**
(a)(iv)	the temperature in the furnace is above **or** higher than the boiling point of zinc **OR** the boiling point of zinc is below **or** less than the temperature of the furnace	**1**
(a)(v)	condensation / condensing / condense	**1**
(b)(i)	no bubbles **or** no fizzing **or** no effervescence	**1**
(b)(ii)	zinc / zinc oxide / zinc hydroxide	**1**
(b)(iii)	(powder has) larg**er** surface area **OR** lumps have small**er** surface area (1) (powder has) more collisions per unit time / more collision frequency **OR** **lumps** have fewer collisions per unit time / less collision frequency (1)	**2**
(b)(iv)	crystals (form on glass rod or microscope slide)	**1**
(b)(v)	$ZnSO_4$	**1**

5 - (0971/41_Summer_2023_Q3)

(a)(i)	**M1** Na with 2,8 **all crosses**(1) **M2** O with 2,8 outer shell **with 6 dots and 2 crosses**(1) **M3** + **AND** 2−(1)	**3**
(a)(ii)	Na_2O	**1**
(b)	**M1** both bonds with 2 dots and 2 crosses(1) **M2** 2 lone pairs (all dots or all crosses) on both oxygen atoms completing all 3 octets(1)	**2**
(c)(i)	**M1** positive ions and negative ions (1) **M2** strong attraction / strong bonds (1)	**2**
(c)(ii)	intermolecular forces	**1**

6 - (0971/41_Summer_2024_Q4)

(a)	**M1** The **rate** of forward reaction equals the rate of the reverse reaction(1) **M2 concentrations** of reactants and products are no longer changing(1)	**2**
(b)(i)	same number of gas moles on both sides of the equilibrium **OR** same number of gas molecules on both sides of the equilibrium	**1**

(b)(ii)	iodine **particles** or **molecules** (forced) closer together **OR** same number of iodine **particles** or **molecules** in a smaller volume	**1**
(c)	endothermic	**1**
(d)	**M1** –1 (1) **M2** zero (1)	**2**
(e)(i)	copper	**1**
(e)(ii)	no effect	**1**
(e)(iii)	(activation energy is) low**er**	**1**

7 - (0971/41_Summer_2024_Q6)

(a)(i)	limestone **OR** calcium carbonate	**1**
(a)(ii)	(molten) iron	**1**
(a)(iii)	silicon(IV) oxide **OR** silicon dioxide	**1**
(a)(iv)	coke or carbon **and** oxygen	**1**

(a)(v)	**Any two from:** • nitrogen • carbon dioxide • argon	**2**
(b)(i)	the temperature in the furnace is above **or** higher than the boiling point of zinc **ORA** **OR** the boiling point of zinc is below **or** less than the temperature of the furnace **ORA**	**1**
(b)(ii)	condensation / condensing	**1**
(c)(i)	galvanising	**1**
(c)(ii)	**M1** zinc is more reactive than iron (1) **M2** zinc is oxidised / zinc loses electrons / zinc forms positive ions / zinc forms zinc ions (1)	**2**
(d)(i)	amphoteric	**1**
(d)(ii)	Na_2ZnO_2	**1**
(d)(iii)	zinc sulfate	**1**

8 - (0971/41_Summer_2025_Q2)

<table>
<tr><td>(a)</td><td>
<table>
<tr><th>M1 charge (1)</th><th>M2 mass(1)</th></tr>
<tr><td>–1</td><td></td></tr>
<tr><td></td><td>1</td></tr>
<tr><td>+1</td><td>1</td></tr>
</table>
1 mark for each correct column</td><td>2</td></tr>
<tr><td>(b)(i)</td><td>
<table>
<tr><th>electron</th><th>neutron</th><th>proton</th></tr>
<tr><td>19</td><td>20</td><td>19</td></tr>
<tr><td>18</td><td>22</td><td>19</td></tr>
</table>
1 mark for each correct column</td><td>3</td></tr>
<tr><td>(b)(ii)</td><td>M1 (41 × 10) + (39 × 90) = 3920 (1)
M2 (3920 ÷ 100) = 39.2(1)</td><td>2</td></tr>
<tr><td>(b)(iii)</td><td>aluminium has only 1 isotope which has nucleon number 27</td><td>1</td></tr>
<tr><td>(c)</td><td>M1 Ar (1)
M2 P^{3-} or S^{2-} or Cl^{-} (1)</td><td>2</td></tr>
</table>

9 - (0971/41_Summer_2025_Q4)

(a)	**M1** 3 dots and 3 crosses shared **M2** one non-bonding pair of 2 dots on one N atom and 2 crosses on the other N atom to complete the octet on both	**2**
(b)(i)	**Conditions can be in any order** **M1** (temperature) 450 **and** °C **M2**(pressure) 200 **and** atmospheres / 20 000 **and** kPa **M3** iron **and** catalyst	**3**
(b)(ii)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$	**1**
(c)(i)	$\mathbf{5}O_2 \rightarrow \mathbf{4}NO + \mathbf{6}H_2O$	**1**
(c)(ii)	**M1** –3 **M2** +2	**2**
(c)(iii)	increase in oxidation number	**1**
(c)(iv)	$4NO + 3O_2 + 2H_2O \rightarrow 4HNO_3$ **M1** HNO_3(1) **M2** equation completely correct	**2**
(d)	**M1** 15 **M2** 7.5 **M3** 990	**3**