AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.1.2

The reactivity series

Past-paper questions

Tier	**Higher**
Question groups	**47**
Available paper years	**2008–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.4.1.2 The reactivity series

Question 01

June 2008 | CHY1AP | Original Q3 | Legacy

QUESTION THREE

- Iron is obtained by reducing its oxide ore with carbon.
- Aluminium **cannot** be obtained by reducing its oxide ore with carbon.
- Gold occurs as the metal itself.

3A From the information above, which row in the table shows the order of reactivity of the four elements?

	most reactive →			least reactive
1	aluminium	carbon	iron	gold
2	iron	aluminium	carbon	gold
3	iron	aluminium	gold	carbon
4	aluminium	iron	gold	carbon

3B Iron obtained directly from the blast furnace was used to build the Iron Bridge in Shropshire.

This bridge is unsuitable for use by modern lorries because . . .

1 it **cannot** be stopped from rusting.

2 it will easily bend out of shape.

3 it is too heavy to support its own weight.

4 it is too brittle and so it will break.

4.4.1.2 The reactivity series

Question 01 · continued

- Aluminium waste of high purity can be recycled.
- Any iron and other impurities are removed.
- The aluminium is then melted and processed in the same way as aluminium that has been extracted from its ore.
- Recycling aluminium in this way creates only 5% of the carbon dioxide produced by extracting aluminium from its ore.

3C Which of the following benefits an aluminium recycling company financially?

1 a fall in the price of aluminium

2 the high melting point of aluminium

3 the high purity of the aluminium waste arriving at the recycling plant

4 the metal can be purified by electrolysis

3D An environmental disadvantage of recycling aluminium is that . . .

1 the aluminium waste has to be transported for recycling.

2 land fill sites would **not** be filled so quickly.

3 the process creates only 5% of the carbon dioxide produced by extracting aluminium from its ore.

4 the price of aluminium will fall.

4.4.1.2 The reactivity series

Question 02

June 2008 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

Copper is found in the Earth's crust, both as the metal itself and as a variety of compounds.

7A This suggests that copper . . .

1 is a very reactive metal.

2 reacts with only a small number of other elements.

3 is **not** very reactive but more reactive than gold.

4 reacts rapidly with oxygen and sulfur at low temperatures.

A naturally occurring compound of copper is malachite, $CuCO_3.Cu(OH)_2$

7B Which row in the table shows the number of elements and the number of atoms of oxygen in the formula for malachite?

	Elements	Atoms of oxygen
1	4	5
2	4	4
3	5	3
4	6	2

Copper is extracted from high grade ores by first smelting the mined ore, then purification by electrolysis.

Copper salts can be extracted from some low grade ores by leaching. Sulfuric acid runs through the ore to produce a solution of copper sulfate. The copper can then be obtained from the solution by electrolysis.

7C An advantage of leaching over smelting is that . . .

1 leaching produces large amounts of copper sulfate.

2 there is no chance of environmental damage during leaching.

3 leaching does **not** require large quantities of energy.

4 there are no waste products left after leaching.

4.4.1.2 The reactivity series

Question 02 · continued June 2008 | CHY1AP | Original Q7 | Legacy

7D There is plenty of scrap copper and copper alloys that could be recycled.

One factor that could bring an increase in the amount that is recycled would be . . .

1 the opening of new large mines with high grade ores.

2 a reduction in the price of copper on the world markets.

3 that recycling became much more economic than extraction from the ore.

4 other metals being used instead of copper.

Turn over for the next question

4.4.1.2 The reactivity series

Question 03

June 2008 | CHY3H | Original Q4 | Legacy

4 The following article appeared recently in the *Manchester Gazette*.

> **Sodium Drum Blaze Scare**
>
> A 20 litre drum containing sodium burst into flames when it reacted violently with rainwater at a Manchester factory. It is believed that the sodium, which is normally stored under oil, had been accidentally left outside with the lid off.
>
> A factory worker put out the blaze before the fire services arrived, and a leading fire fighter said, "It was fortunate that potassium wasn't involved as it would have reacted more violently and exploded. These Group 1 *alkali metals* can be very dangerous".

4 (a) Group 1 metals are stored under oil.

Suggest why.

.....

(1 mark)

4 (b) Balance the equation which represents the reaction between sodium and water.

$$Na + H_2O \rightarrow NaOH + H_2$$

(1 mark)

4 (c) Explain why the Group 1 metals are called the *alkali metals*.

.....

.....

(1 mark)

4 (d) Explain, in terms of electrons, why potassium reacts more violently than sodium.

.....

.....

.....

.....

.....

.....

(3 marks)

6

4.4.1.2 The reactivity series

Question 04

November 2008 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

- Calcium reacts with water in this way:

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

- Magnesium reacts in a similar way.
- Neither calcium nor magnesium can be obtained from their oxides by carbon reduction.

7A Look at the equation for the reaction between calcium and water.

On each side of the equation, there is a total of . . .

1 2 compounds.

2 4 elements.

3 6 atoms.

4 7 atoms.

7B The information given suggests that calcium is . . .

1 more reactive than both hydrogen and carbon.

2 more reactive than hydrogen but less reactive than carbon.

3 less reactive than hydrogen but more reactive than carbon.

4 less reactive than either hydrogen or carbon.

7C Which of the following is a correctly balanced equation for the reaction between calcium and nitric acid?

1 $2Ca + 2HNO_3 \rightarrow 2Ca(NO_3)_2 + H_2$

2 $Ca + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2$

3 $2Ca + HNO_3 \rightarrow 2Ca(NO_3)_2 + H_2$

4 $Ca + 2HNO_3 \rightarrow 2Ca(NO_3)_2 + 2H_2$

4.4.1.2 The reactivity series

7D Calcium and magnesium are both in Group 2 of the periodic table.

This suggests that . . .

1 they are two of about 100 non-metallic elements.

2 their carbonates are likely to decompose differently on heating.

3 they are likely to be extracted from their ores by similar methods.

4 their carbonates will form the metal oxide and oxygen on heating.

Turn over for the next question

4.4.1.2 The reactivity series

Question 05

March 2009 | CHY1AP | Original Q2 | Legacy

QUESTION TWO

This question is about the production of metals.

Match words, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A decomposed

B acidified

C reduced

D extracted

Some metals are produced from their carbonate ores.

The ores are first . . . **1** . . . from the ground.

They are then heated until the metal carbonate is . . . **2** . . . .

When the ore is heated, sulfur impurities may react with air and eventually cause rainwater to be . . . **3** . . . .

Finally, the metal oxide can be reacted with carbon and so be . . . **4** . . . to the metal.

4.4.1.2 The reactivity series

Question 06

March 2009 | CHY1AP | Original Q9 | Legacy

QUESTION NINE

A scientist investigated the chemistry of four metals, **W**, **X**, **Y** and **Z**.

These are the results.

- The oxides of **W** and **Y** were reduced to the metal when mixed with carbon and heated.
- The oxide of **Z** could not be reduced by heating with carbon.
- The oxide of **X** decomposed to the metal on heating alone.
- **Y** gave off hydrogen gas with dilute acid but **W** and **X** did not.

9A Starting with the most reactive, what is the order of reactivity for the four metals?

1 **X**, **W**, **Y**, **Z**

2 **Z**, **Y**, **W**, **X**

3 **X**, **W**, **Z**, **Y**

4 **Z**, **W**, **Y**, **X**

9B Which metal is most likely to be found in the ground as the pure metal?

1 **W**

2 **X**

3 **Y**

4 **Z**

9C How would metal **Z** be produced?

1 by mixing the oxide of **Z** with carbon and heating

2 by mixing an oxide of **Z** with the metal **W** and heating

3 by electrolysis of a molten oxide of **Z**

4 by heating the oxide of **Z** in a stream of hydrogen gas

4.4.1.2 The reactivity series

Question 06 · continued

9D The equation for the reduction of the oxide of **W** to the metal **W** can be represented by the following equation:

$$2\mathbf{W}_2O_3 + \boldsymbol{q}C = 3CO_2 + \boldsymbol{r}\mathbf{W}$$

What values of ***q*** and ***r*** are needed to balance the equation?

1 ***q*** = 3 and ***r*** = 4

2 ***q*** = 2 and ***r*** = 2

3 ***q*** = 4 and ***r*** = 2

4 ***q*** = 3 and ***r*** = 2

END OF TEST

4.4.1.2 The reactivity series

Question 07

June 2009 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

This question is about three metals, copper, lead and zinc.

7A Copper is found in the Earth's crust as the metal itself.

Lead and zinc are also found in the Earth's crust, but only as compounds such as oxides and sulfides.

These facts suggest that . . .

1 copper is a very reactive metal.

2 lead and zinc are transition metals, but copper is not.

3 lead and zinc react rapidly with oxygen and sulfur, but copper does not.

4 lead and zinc are more reactive than copper.

7B A naturally occurring compound of zinc is hydrozincite, $2ZnCO_3.3Zn(OH)_2$

Which row in the table correctly shows the number of elements, and the number of atoms of oxygen in the formula for hydrozincite?

	Number of elements	Number of atoms of oxygen
1	4	12
2	4	8
3	5	5
4	6	4

Question 07 · continued

7C Zinc is also found as zincite, ZnO.

The metal can be extracted from zincite by mixing it with carbon and heating strongly.

Which row in the table correctly shows the name for this process and the products?

	Name of process	Products
1	electrolysis	zinc and carbon dioxide
2	leaching	zinc and oxygen
3	reduction	zinc and oxygen
4	reduction	zinc and carbon dioxide

Lead and zinc compounds are often found together in the same ore.

The metals can be extracted by mixing the ore with carbon and heating strongly in a furnace. They can then be separated.

The table shows the melting points and boiling points of lead and zinc.

	Lead	Zinc
Melting point in °C	328	420
Boiling point in °C	1740	907

The furnace operates at a temperature of 1200 °C.

7D How will the lead and zinc be separated?

1 Molten lead remains in the furnace and the zinc evaporates.

2 Molten lead and molten zinc form two separate layers in the furnace.

3 Molten zinc remains in the furnace and the lead evaporates.

4 Zinc and lead vapours leave the furnace and are separated in a condenser.

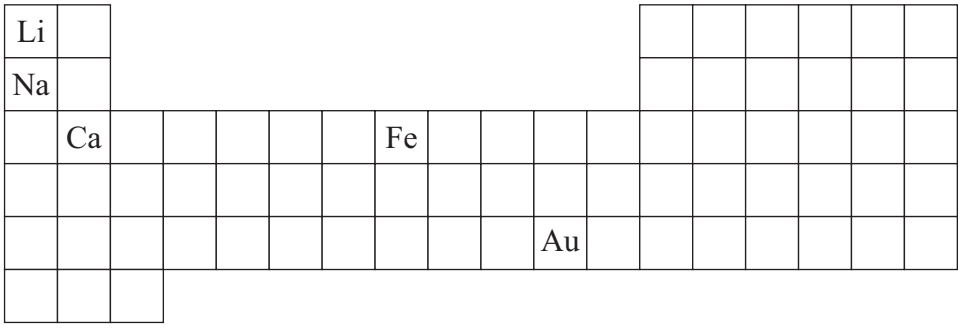
4.4.1.2 The reactivity series

Question 08

November 2009 | CHY1AP | Original Q1 | Legacy

QUESTION ONE

The diagram shows part of the periodic table.



Match elements, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table below.

A Calcium (Ca)

B Lithium (Li)

C Gold (Au)

D Iron (Fe)

1	It will not react with oxygen or water even at high temperatures.
2	It forms the oxide known as quicklime.
3	It has properties most similar to those of sodium (Na).
4	It is a transition element found in the Earth as an oxide.

4.4.1.2 The reactivity series

Question 09

November 2009 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

The equations show three reactions of the metal magnesium.

$$3Mg + Fe_2O_3 \rightarrow 3MgO + 2Fe$$

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

$$2Mg + O_2 \rightarrow 2MgO$$

8A Magnesium **cannot** be produced by heating magnesium oxide with carbon.

Which row in the table correctly shows the order of reactivity for iron, magnesium and carbon?

	Most reactive →		Least reactive
1	magnesium	carbon	iron
2	magnesium	iron	carbon
3	iron	carbon	magnesium
4	carbon	iron	magnesium

8B When magnesium reacts with hydrochloric acid, hydrogen is given off.
When excess magnesium is used and all the acid has reacted, hydrogen continues to be given off from the remaining magnesium.

The probable reason is that . . .

1 magnesium reacts with water to form hydrogen and magnesium hydroxide.

2 magnesium reacts with water to form hydrogen and oxygen.

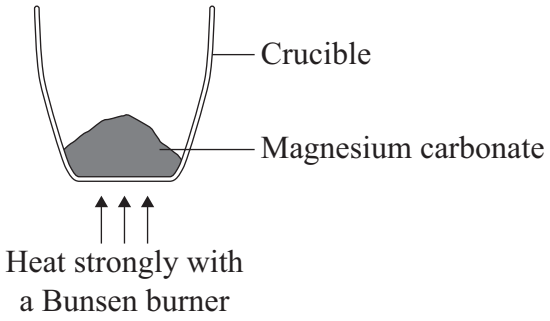
3 magnesium reacts with oxygen from the air to form hydrogen and magnesium oxide.

4 magnesium oxide decomposes to form magnesium, oxygen and hydrogen.

4.4.1.2 The reactivity series

Question 09 · continued November 2009 | CHY1AP | Original Q8 | Legacy

A student heated some magnesium carbonate in an open crucible.



The table shows the mass of the crucible and its contents at two-minute intervals.

Time in minutes	0	2	4	6	8
Mass of crucible and contents in grams	20.80	20.55	20.25	19.85	19.85

8C Which solid substances will the crucible contain after heating for two minutes?

1 magnesium carbonate only

2 magnesium oxide only

3 magnesium carbonate and magnesium oxide

4 magnesium and magnesium oxide

8D The student found that when the experiment was repeated using sodium carbonate instead of magnesium carbonate, there was no loss in mass.

The best conclusion that the student could make is that sodium carbonate . . .

1 does **not** decompose when heated.

2 only decomposes when heated gently.

3 only decomposes when heated to a very high temperature.

4 does **not** decompose at Bunsen burner temperatures.

4.4.1.2 The reactivity series

Question 10

March 2010 | CHY1AP | Original Q2 | Legacy

QUESTION TWO

This question is about types of reactions.

Match type of reaction, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table.

A reduction

B combustion

C thermal decomposition

D corrosion

	Example of the type of reaction
1	Copper carbonate forms copper oxide and carbon dioxide when heated.
2	Hydrogen reacts with oxygen to produce water.
3	Carbon steels react when exposed to air and water.
4	Zinc is obtained from zinc oxide by removal of the oxygen.

4.4.1.2 The reactivity series

Question 11

March 2010 | CHY1AP | Original Q6 | Legacy

QUESTION SIX

Titanium cannot be extracted by carbon reduction of its ore, which contains titanium dioxide, TiO_2

Titanium is obtained from titanium dioxide in two stages.

In **Stage 1**, the titanium dioxide is converted to titanium chloride ($TiCl_4$).

titanium dioxide + chlorine + carbon → titanium chloride + carbon dioxide

The possible escape of carbon dioxide and chlorine (a poisonous gas) can cause damage to the environment.

In **Stage 2**, the titanium chloride formed is reacted with sodium.

titanium chloride + sodium → titanium + sodium chloride

The sodium chloride formed is removed by washing the titanium with hydrochloric acid but the disposal of the acidic sodium chloride solution causes another environmental problem.

6A Which of the following is a correctly balanced equation for **Stage 2**?

1 $TiCl_4 + Na \rightarrow 4Ti + NaCl$

2 $TiCl_4 + Na \rightarrow Ti + 4NaCl$

3 $TiCl_4 + 4Na \rightarrow 4Ti + 4NaCl$

4 $TiC1_4 + 4Na \rightarrow Ti + 4NaCl$

6B Sodium, not carbon, is used to extract titanium from its compounds.

Which row in the table does this information suggest to be the order of reactivity for carbon, sodium and titanium?

	Most reactive →		**Least reactive**
1	Sodium	Titanium	Carbon
2	Sodium	Carbon	Titanium
3	Titanium	Sodium	Carbon
4	Carbon	Titanium	Sodium

4.4.1.2 The reactivity series

Question 11 · continued

6C In **Stage 1**, the gases carbon dioxide and chlorine should **not** be allowed to escape into the air because . . .

1 both add to global dimming.

2 both are poisonous gases.

3 carbon dioxide adds to global warming and chlorine is toxic.

4 carbon dioxide adds to global dimming and chlorine is expensive.

6D In **Stage 2**, the best way to dispose of the acidic sodium chloride solution is . . .

1 to pump it into the ocean.

2 to pump it into landfill sites.

3 to boil the solution until all the acid has evaporated.

4 to separate the acid from the salt so that both can be used in other chemical processes.

4.4.1.2 The reactivity series

Question 12

June 2010 | CHY1AP | Original Q9 | Legacy

QUESTION NINE

This question is about metals.

9A A scientist investigated some reactions of three metals, **K**, **L** and **M**.

- Metal **L** can be extracted by mixing its oxide with carbon and heating.
- Metal **M** cannot be extracted by mixing its oxide with carbon and heating.
- Hydrogen will displace metal **K** from its oxide but will not displace metal **L** from its oxide.
- The oxide of metal **K** is decomposed to the metal on heating alone.

The order of reactivity for the three metals, with the most reactive first, is . . .

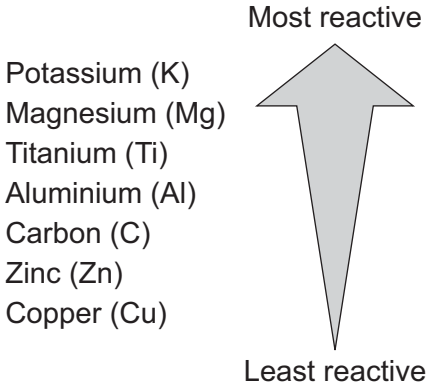
1 **K, L, M.**

2 **M, L, K.**

3 **L, K, M.**

4 **K, M, L.**

9B The order of reactivity for several metals and carbon is shown below.



Which of the following shows a correctly balanced equation for a possible reaction?

1 $ZnO + C \rightarrow Zn + CO_2$

2 $Cu + MgO \rightarrow CuO + Mg$

3 $2Mg + K_2O \rightarrow 2MgO + 2K$

4 $2Al + 3ZnO \rightarrow 3Zn + Al_2O_3$

4.4.1.2 The reactivity series

Question 12 · continued

Titanium is extracted from titanium chloride by mixing the titanium chloride with sodium and heating the mixture. The reaction is carried out in a furnace above 500 °C.

It is a batch process; this means that the furnace does not operate continuously but is cooled after each operation so that the titanium can be removed.

9C Which row in the table correctly describes the reaction for the extraction of titanium?

	Why the reaction occurs	Products of the reaction
1	Sodium is more reactive than titanium	Titanium, sodium and chlorine
2	Titanium is more reactive than sodium	Titanium and chlorine
3	Titanium is more reactive than sodium	Titanium and sodium chloride
4	Sodium is more reactive than titanium	Titanium and sodium chloride

9D The extraction of iron in a blast furnace is a continuous process.

Over a period of 12 months, the batch method for extraction of titanium requires much more energy per tonne of metal than the continuous method for the extraction of iron.

This is because . . .

1 the batch process is completed more quickly.

2 iron is less reactive than titanium.

3 the furnace is not maintained at a high temperature.

4 titanium chloride is not as pure as iron oxide.

END OF TEST

4.4.1.2 The reactivity series

Question 13

November 2010 | CHY1AP | Original Q1 | Legacy

QUESTION ONE

This question is about how we obtain some metals.

Match statements, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table.

A uses another metal

B does **not** use a chemical reaction

C could be done in a blast furnace

D is called electrolysis

1	Aluminium is made when an electric current passes through a molten aluminium compound.
2	Gold can be found at the bottom of some streams.
3	Titanium is made by reacting titanium chloride with magnesium.
4	Zinc is made when a mixture of zinc oxide and carbon is heated.

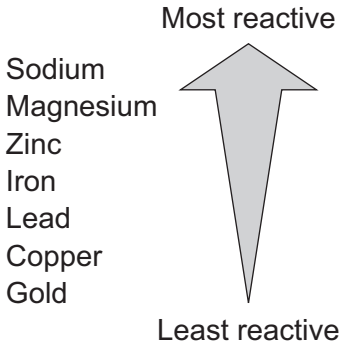
4.4.1.2 The reactivity series

Question 14

November 2010 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

A metal will displace a less reactive metal from its compounds.



If a reaction occurs, it releases heat. The reactivity of metals can be investigated by measuring the temperature rise if a fair test is carried out between metals and metal compounds.

Metal	Metal compound	Temperature rise in °C
Zinc	Lead nitrate	10
Iron	Lead nitrate	6
Zinc	Copper sulfate	19
Magnesium	Copper sulfate	48
Copper	Zinc sulfate	0

8A The results in the table suggest that the largest rise in temperature occurs when . . .

1 a metal reacts with a metal compound that is a sulfate.

2 a transition metal is used with a metal compound.

3 there is a large difference in reactivity between the metal used and the metal in the metal compound.

4 a Group 1 metal reacts with a transition metal compound.

4.4.1.2 The reactivity series

Question 14 · continued

8B Using copper and zinc sulfate does **not** cause a temperature rise.

This is because . . .

1 not enough copper is used.

2 zinc is more reactive than copper.

3 copper corrodes easily.

4 too much zinc sulfate is added.

8C Which of the following metals will cause the largest temperature rise when added to iron nitrate solution?

1 gold

2 sodium

3 lead

4 zinc

8D
- Carbon can reduce zinc oxide.
- Magnesium can react with carbon dioxide.
- Carbon can produce iron from iron oxide.

Where should carbon be placed in the reactivity series?

1 above magnesium but below sodium

2 above zinc but below magnesium

3 below iron but above lead

4 below lead but above copper

4.4.1.2 The reactivity series

Question 15

January 2011 | CHY1H | Original Q4 | Legacy

4 Titanium is used for replacement hip joints because it has a low density, is strong and does not corrode.
Titanium is extracted from titanium dioxide (TiO_2) in three stages.

4 (a) **Stage 1**
Titanium dioxide is converted into titanium chloride ($TiCl_4$) because the metal cannot be extracted from its oxide by *reduction* with carbon.

4 (a) (i) What does *reduction* mean?

.....

.....

(1 mark)

4 (a) (ii) Balance the chemical equation for the conversion of titanium dioxide to titanium chloride.

TiO_2 + Cl_2 + C → $TiCl_4$ + CO_2

(1 mark)

4 (a) (iii) Chemical equations are always balanced. Explain why.

.....

.....

.....

(1 mark)

4 (b) **Stage 2**
Titanium is extracted from the titanium chloride by reacting it with sodium at 1000 °C in a reactor.
The only other substance in the reactor is argon gas.

$TiCl_4$ + 4Na → Ti + 4NaCl

4 (b) (i) What does this tell you about the reactivity of sodium compared with titanium?

.....

.....

(1 mark)

4 (b) (ii) Suggest why the reactor contains argon and **not** air.

.....

.....

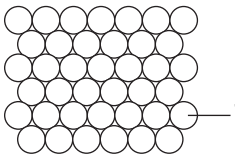
(1 mark)

4.4.1.2 The reactivity series

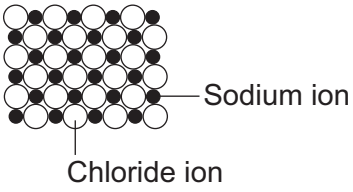
Question 15 · continued

4 (c) **Stage 3**
After **Stage 2** the titanium is separated from the products by washing out the sodium chloride with water.
The diagrams show sections through the lattice of titanium metal and the lattice of sodium chloride.

Titanium



Sodium chloride



How do the diagrams show that:

4 (c) (i) titanium is an element

.....

.....

(1 mark)

4 (c) (ii) sodium chloride is a compound?

.....

.....

.....

.....

(2 marks)

8

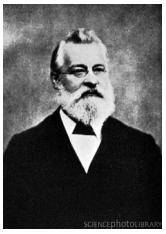
4.4.1.2 The reactivity series

Question 16

January 2011 | CHY3H | Original Q4 | Legacy

4 The periodic table on the Data Sheet may help you answer these questions.

4 (a) Many chemists have contributed to the development of the periodic table.



John Newlands was one of the first chemists who attempted to classify elements in a systematic way based on atomic weight. In 1866 he suggested that there was a repeating pattern of elements with similar properties every eighth element.
Part of Newlands' periodic table is shown below.

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co, Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce, La	Zr	Di, Mo	Ro, Ru

Many chemists in 1866 did not accept Newlands' periodic table.

4 (a) (i) Give **one** piece of evidence which supports Newlands' ideas.

.....

.....

(1 mark)

4 (a) (ii) Suggest **two** reasons why many chemists in 1866 did not accept Newlands' ideas.

1 .....

.....

.....

2 .....

.....

.....

(2 marks)

4.4.1.2 The reactivity series

Question 16 · continued

4 (b) Chlorine, bromine and iodine are Group 7 elements.

A student investigated the reactivity of these elements.
The student added:

- aqueous chlorine to potassium bromide and potassium iodide solutions
- aqueous bromine to potassium chloride and potassium iodide solutions
- aqueous iodine to potassium chloride and potassium bromide solutions.

The student's results are shown below.

Solution	Potassium chloride	Potassium bromide	Potassium iodide
Chlorine		Solution turned orange-brown	Solution turned brown
Bromine	No reaction		Solution turned brown
Iodine	No reaction	No reaction	

4 (b) (i) Use these results to state **and** explain the trend in reactivity of these Group 7 elements.

.....

.....

.....

.....

(2 marks)

4 (b) (ii) Complete the equation below, which represents the reaction between chlorine and potassium bromide.

Cl_2 + 2KBr ⟶ ..... + 2KCl

(1 mark)

4 (b) (iii) In terms of electronic structure, state why chlorine, bromine and iodine are in Group 7.

.....

.....

(1 mark)

4.4.1.2 The reactivity series

Question 16 · continued

4 (c) Lithium, sodium and potassium are Group 1 elements.

Group 1 elements become **more** reactive down the group.

Explain why in terms of electronic structure.

.....

.....

.....

.....

.....

.....

(3 marks)

10

Turn over for the next question

4.4.1.2 The reactivity series

Question 17

March 2011 | CHY1AP | Original Q2 | Legacy

QUESTION TWO

This question is about the positions of four metals in the reactivity series.

- Only metal **C** can be extracted by heating the metal oxide in hydrogen.
- Only metals **B** and **C** can be extracted by mixing their oxides with carbon and heating strongly.
- When the oxide of metal **A** is mixed with metal **D** and heated, metal **A** is produced.

Match metals, **A**, **B**, **C** and **D**, with the numbers **1–4** in the reactivity series.

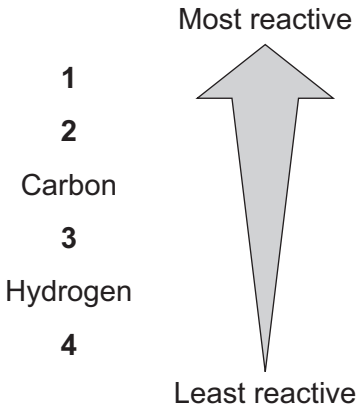
A Metal **A**

B Metal **B**

C Metal **C**

D Metal **D**

Reactivity series



4.4.1.2 The reactivity series

Question 18

March 2011 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

Zinc is a reactive metal that will react with oxygen at high temperatures. Its two main ores are zinc sulfide (ZnS) and zinc carbonate ($ZnCO_3$). The relative abundance of each ore is about the same throughout the world.

To extract zinc, the ores are first heated to produce zinc oxide:

$$2ZnS + 3O_2 \xrightarrow{\text{heat}} 2ZnO + 2SO_2$$

$$ZnCO_3 \xrightarrow{\text{heat}} ZnO + CO_2$$

The zinc oxide is mixed with carbon (C) and heated in a furnace.

In the furnace, these reactions occur:

$$C + O_2(air) \xrightarrow{\text{heat}} CO_2$$

$$CO_2 + C \longrightarrow 2CO$$

Zinc is extracted by the following reaction:

$$ZnO + CO \longrightarrow Zn + CO_2$$

8A An advantage of using zinc carbonate instead of zinc sulfide is that. . .

1 zinc carbonate is more common and therefore cheaper.

2 only one waste product is formed.

3 less zinc is lost during the reaction.

4 zinc is formed directly without another chemical being used.

8B The atmosphere inside the furnace is kept rich in carbon monoxide (CO).

This is to . . .

1 prevent zinc oxide from reacting with carbon (C).

2 stop the zinc from re-forming zinc oxide.

3 remove carbon (C) from the furnace.

4 make carbon dioxide (CO_2).

4.4.1.2 The reactivity series

Question 18 · continued

8C Zinc ores also contain lead compounds. Lead is produced with the zinc in the furnace. The temperature inside the furnace is about 1500 °C.

	Boiling point in °C	Density in g per cm^3	Reactivity
Lead	1749	11.3	Low
Zinc	907	7.1	High

Pure zinc is obtained from the furnace because . . .

1 zinc leaves the furnace as vapour, and liquid lead remains in the furnace.

2 liquid zinc floats on liquid lead in the furnace.

3 lead leaves the furnace as vapour, and liquid zinc remains in the furnace.

4 lead is more reactive than zinc and reacts with oxygen to form lead oxide.

8D Limestone is added to the furnace because . . .

1 it provides energy for the reaction.

2 it removes any acidic impurities.

3 it is the only source of the carbon dioxide in the furnace.

4 it is thermally stable.

4.4.1.2 The reactivity series

Question 19

June 2011 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

Iron and copper can be extracted from their oxides by reduction with carbon.
Aluminium cannot be extracted from its oxide in this way.

Copper can be found in the Earth's crust as the metal itself.
Iron and aluminium are found only as compounds in the Earth's crust.

5A Which row in the table shows the order of reactivity of the four elements in the passage above?

	Most reactive ⟶ Least reactive			
1	copper	iron	aluminium	carbon
2	aluminium	carbon	iron	copper
3	carbon	copper	iron	aluminium
4	iron	aluminium	copper	carbon

5B Iron can be extracted from iron oxide, Fe_2O_3, by mixing the oxide with carbon and heating strongly in air.

Which row in the table below shows the name of the process and the products of the reaction?

	Name of the process	**Products of the reaction**
1	electrolysis	Fe, O_2 and CO_2
2	reduction	Fe and CO_2
3	electrolysis	Fe and CO_2
4	reduction	Fe, O_2 and CO_2

4.4.1.2 The reactivity series

Question 19 · continued

5C Copper is extracted from high grade ores by first heating them strongly in a furnace to obtain impure copper. This is called smelting. Pure copper is then obtained by electrolysis.

Copper is extracted from low grade ores by leaching. A solution of sulfuric acid is run through the ores to produce a solution of copper sulfate. Electrolysis of this solution gives pure copper.

An advantage of leaching over smelting is that . . .

1 leaching uses less energy.

2 leaching causes no environmental damage.

3 leaching leaves no waste.

4 leaching produces purer copper.

5D Extraction of aluminium from its ores requires a lot of energy. Aluminium obtained by recycling scrap aluminium saves about 95% of this energy.

Another advantage of recycling scrap aluminium is that . . .

1 large, new aluminium ore mines will be developed.

2 alternative metals will replace aluminium in making drinks cans.

3 deposits of aluminium ore will last longer.

4 recycled aluminium contains other metals.

4.4.1.2 The reactivity series

Question 20

June 2011 | CHY1AP | Original Q9 | Legacy

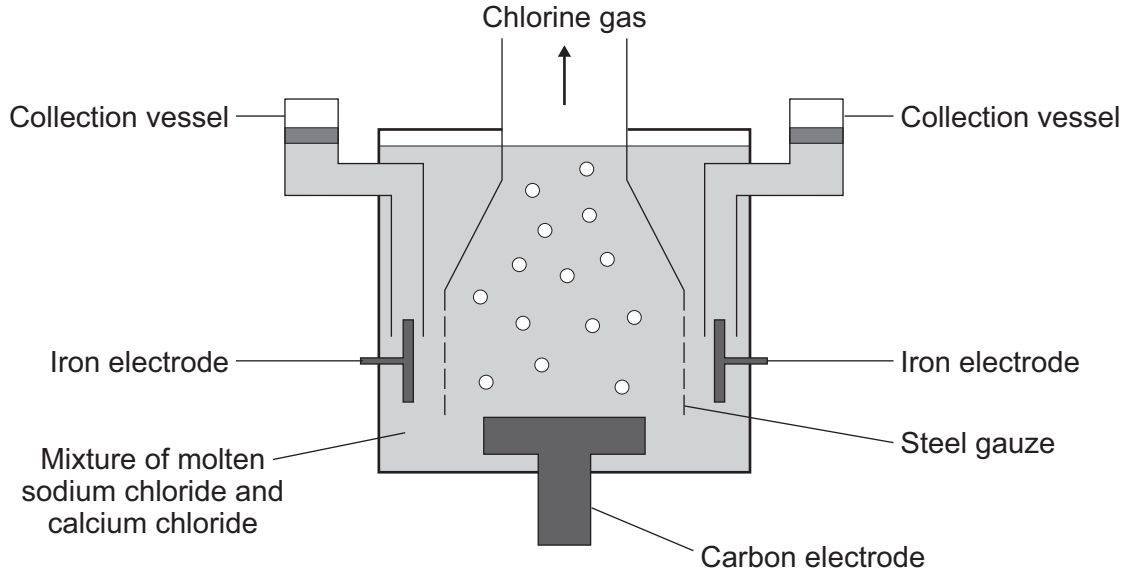
QUESTION NINE

Sodium cannot be extracted from its oxide by reduction with carbon.

Sodium metal is extracted by electrolysis of molten sodium chloride. The melting point of sodium chloride is very high (800°C), so calcium chloride is added to reduce the melting point of the mixture to about 550°C.

During electrolysis, both sodium and calcium are obtained at the iron electrodes, and chlorine at the carbon electrode.

The diagram shows the electrolysis cell used for the extraction of sodium.



The table shows some properties of sodium and calcium.

	Melting point in °C	Density in g per cm^3	Reactivity
Sodium	97	0.97	Very reactive
Calcium	839	1.55	Reactive

9A In the extraction of sodium, a mixture of sodium chloride and calcium chloride is used to . . .

1 reduce the amount of energy required to melt the mixture.

2 obtain a pure sample of sodium.

3 absorb the chlorine gas.

4 increase the temperature of the mixture.

4.4.1.2 The reactivity series

Question 20 · continued

9B The purpose of the steel gauze is to prevent the reaction of . . .

1 sodium with calcium.

2 sodium with chlorine.

3 iron electrodes with sodium chloride.

4 sodium chloride with calcium chloride.

9C In the collection vessel there is . . .

1 solid sodium below a layer of liquid calcium.

2 solid calcium below a layer of liquid sodium.

3 a mixture of liquid sodium and liquid calcium.

4 a mixture of solid calcium and solid sodium.

9D The information in the diagram suggests that the element carbon . . .

1 has a melting point lower than 550 °C.

2 reacts rapidly with chlorine gas.

3 is an electrical conductor.

4 is more reactive than iron.

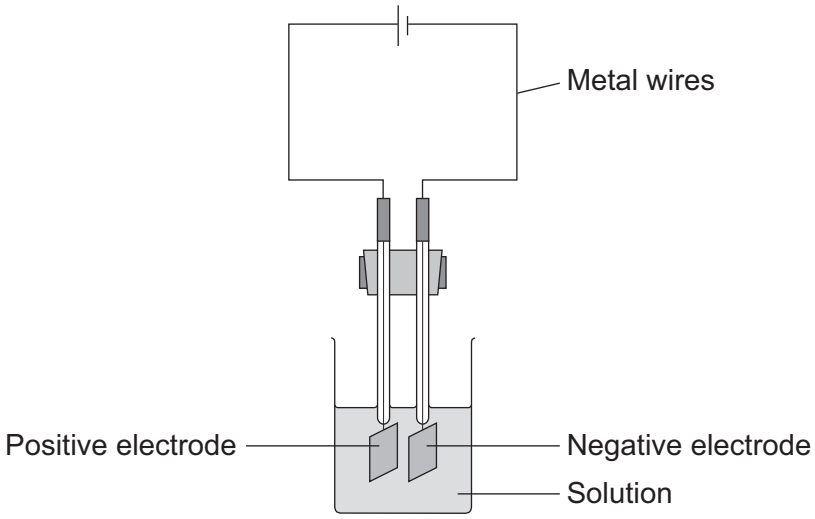
END OF TEST

4.4.1.2 The reactivity series

Question 21

June 2011 | CHY2H | Original Q5 | Legacy

5 The diagram shows apparatus used by a student to investigate electrolysis.



The student was given a solution by the teacher. The solution contained a mixture of ionic compounds.

5 (a) Name the particles which carry the electric current through:

5 (a) (i) the metal wires.....

(1 mark)

5 (a) (ii) the solution. .....

(1 mark)

5 (b) The table shows the ions in the solution.

Positive ions in the solution	Negative ions in the solution
Zinc ion (Zn^{2+})	Chloride ion (Cl^-)
Iron(III) ion (Fe^{3+})	Hydroxide ion (OH^-)
Hydrogen ion (H^+)	Nitrate ion (NO_3^-)
Copper(II) ion (Cu^{2+})	Sulfate ion (SO_4^{2-})

The reactivity series on the Data Sheet may help you to answer this question.

5 (b) (i) Which element is most likely to be formed at the negative electrode?

.....

(1 mark)

4.4.1.2 The reactivity series

Question 21 · continued

5 (b) (ii) Explain, as fully as you can, why you have chosen this element.

.....

.....

.....

.....

(2 marks)

5 (c) The electrolysis of sodium chloride solution is an industrial process.

5 (c) (i) The reaction at one of the electrodes can be represented by the equation shown below.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

The chloride ions (Cl^-) are oxidised.

Explain why.

.....

.....

(1 mark)

5 (c) (ii) The reaction at the other electrode can be represented by an equation.

Complete and balance the equation for the reaction at the other electrode.

$$H^+ \rightarrow H_2$$

(1 mark)

7

4.4.1.2 The reactivity series

Question 22

November 2011 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

Titanium (Ti) is extracted from the ore called rutile. Rutile is mainly made up of titanium oxide (TiO_2). Titanium is not very reactive so it should be possible to displace titanium from its oxide with carbon. But carbon reacts with titanium, making it very brittle.

Therefore, titanium is extracted by reacting titanium chloride ($TiCl_4$) with sodium. Titanium chloride is produced by reacting titanium oxide with chlorine. The sodium used for the reaction is obtained by electrolysis.

The titanium chloride is added to a reactor in which sodium has been heated to about 550 °C in an inert argon atmosphere. During the reaction, the temperature increases to about 1000 °C.
After the reaction is complete, and everything has cooled, which can take several days, the mixture is crushed and washed with water to remove the sodium chloride (NaCl).

7A Which row in the table is the correct order of reactivity for carbon, sodium and titanium?

	Most reactive ⟶		**Least reactive**
1	sodium	carbon	titanium
2	carbon	titanium	sodium
3	titanium	carbon	sodium
4	sodium	titanium	carbon

7B The equation for the reaction of titanium chloride with sodium is shown below.

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$

When 190 g of titanium chloride were reacted with sodium, 48 g of titanium and 234 g of sodium chloride were produced.

How much sodium is required to produce 48 g of titanium?

1 23 g

2 92 g

3 190 g

4 234 g

4.4.1.2 The reactivity series

Question 22 · continued

7C A student suggested that there are four possible reasons why titanium is expensive.

J the cost of the process used to remove the sodium chloride
K large amounts of energy are needed to produce the sodium
L it takes several days to complete the process of separating the mixture
M the reacting mixture needs to be cooled to a low temperature

Which two of these reasons are correct?

1 **J** and **M**

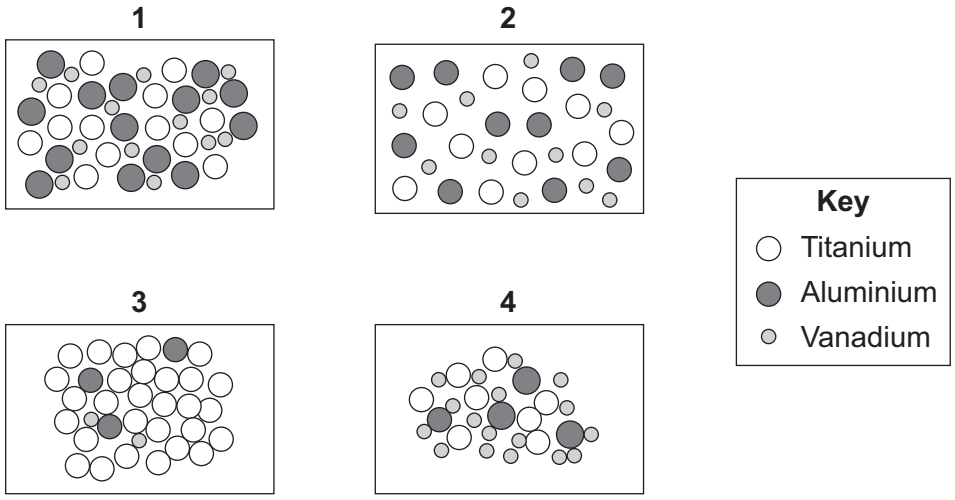
2 **K** and **L**

3 **J** and **K**

4 **L** and **M**

7D Titanium is often alloyed with small amounts of vanadium (4 %) and aluminium (6 %). This makes the titanium harder and stronger.

Which of the diagrams below shows the atoms in a sample of this titanium alloy?



4.4.1.2 The reactivity series

Question 23

November 2011 | CHY1BP | Original Q1 | Legacy

QUESTION ONE

The table shows the abundance in the Earth's atmosphere of each of four noble gases.

Noble gas	Abundance (percentage in the atmosphere by volume)
Argon	0.9300
Neon	0.0018
Helium	0.0005
Krypton	0.0001

Match properties, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences.

A abundance

B colour

C density

D reactivity

Argon is used in filament lamps because of its low chemical . . . **1** . . . .

Neon is used in electric discharge tubes for advertising signs because it produces a bright . . . **2** . . . .

Helium is used in balloons because it has a low . . . **3** . . . .

Krypton is the noble gas in the table with the lowest . . . **4** . . . .

4.4.1.2 The reactivity series

Question 24

January 2013 | CH1HP | Original Q7 | Legacy

7 Iron is produced from the ore haematite (iron oxide).

Titanium is produced from the ore rutile (titanium oxide).

Iron	Titanium
Iron oxide is reacted with coke (carbon) at 1500 °C in a furnace to produce molten cast iron. Cast iron contains iron and about 4% carbon.	Titanium oxide is reacted with chlorine at 1000 °C to produce titanium chloride. Titanium chloride is cooled and collected.
↓	↓
Oxygen is blown into molten cast iron and molten recycled iron at 1500 °C in a furnace to produce low-carbon steel. Low-carbon steel contains iron and about 0.1% carbon.	Titanium chloride is reacted with magnesium at 1100 °C in a sealed reactor for 3 days. The sealed reactor contains an atmosphere of argon gas.
	↓
	The reactor is allowed to cool. The reactor is opened and the titanium is separated from the other product, magnesium chloride.

7 (a) The production of low-carbon steel uses oxygen but the production of titanium uses argon.

Explain why.

.....

.....

.....

.....

.....

.....

.....

.....

(3 marks)

4.4.1.2 The reactivity series

Question 24 · continued

7 (b) There is less titanium than iron in the Earth's crust.

Apart from titanium's scarcity, explain why titanium costs much more than iron.

Use the two flow diagrams on page 16 to help you to answer this question.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(3 marks)

7 (c) Many chemical reactions take place in the production of both metals.

A chemical reaction in the production of iron is:

$$2\,Fe_2O_3 + 3\,C \rightarrow 4\,Fe + 3\,CO_2$$

A chemical reaction in the production of titanium is:

$$TiCl_4 + 2\,Mg \rightarrow Ti + 2\,MgCl_2$$

Titanium can be used to produce iron from iron oxide. The chemical reaction is:

$$2\,Fe_2O_3 + 3\,Ti \rightarrow 4\,Fe + 3\,TiO_2$$

Use these three reactions and the Chemistry Data Sheet to answer this question.

Suggest the position of titanium in the Reactivity Series of Metals.

Explain your answer.

.....

.....

.....

.....

.....

(2 marks)

8

4.4.1.2 The reactivity series

Question 25

June 2013 | CH2HP | Original Q4 | Legacy

4 This question is about potassium.

4 (a) Humphrey Davy was a professor of chemistry.

In 1807 Davy did an electrolysis experiment to produce potassium.

4 (a) (i) Davy first tried to electrolyse a solid potassium salt to produce potassium.

Explain why this electrolysis did **not** work.

.....

.....

.....

.....

(2 marks)

4 (a) (ii) Humphrey Davy was the first person to produce potassium.

Humphrey Davy's experiment to produce this new element was quickly accepted by other scientists.

Suggest why.

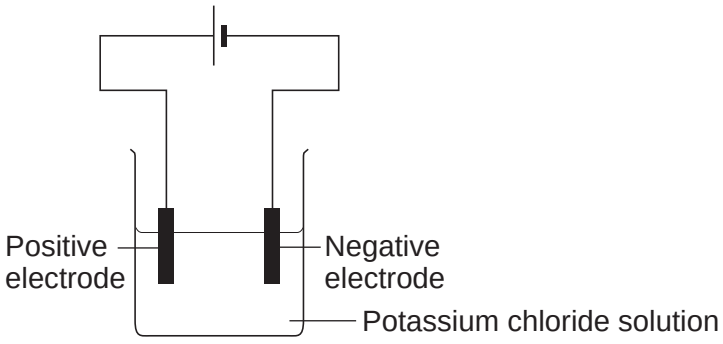
.....

.....

(1 mark)

4 (b) A student dissolved some potassium chloride in water.
The student tried to electrolyse the potassium chloride solution to produce potassium.

The apparatus the student used is shown in the diagram.



4.4.1.2 The reactivity series

Question 25 · continued

The student expected to see potassium metal at the negative electrode, but instead saw bubbles of a gas.

- Name the gas produced at the negative electrode.
- Explain why this gas was produced at the negative electrode **and** why potassium was not produced.

The reactivity series of metals on the Chemistry Data Sheet may help you to answer this question.

.....

.....

.....

.....

.....

.....

(3 marks)

4 (c) The student tried to electrolyse molten potassium chloride to produce potassium.

4 (c) (i) Potassium metal was produced at the negative electrode.

Describe how potassium atoms are formed from potassium ions.

.....

.....

.....

.....

(2 marks)

Question 4 continues on the next page

4.4.1.2 The reactivity series

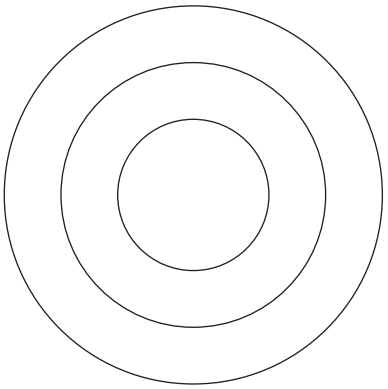
Question 25 · continued

4 (c) (ii) Complete and balance the equation for the reaction at the positive electrode.

.....Cl^- $\longrightarrow$ Cl_2 + ...

(1 mark)

4 (c) (iii) Complete the diagram to show the electronic structure of a chloride ion (Cl^-).



(1 mark)

10

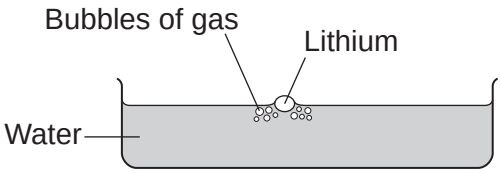
4.4.1.2 The reactivity series

Question 26

June 2013 | CH3HP | Original Q1 | Legacy

1 Lithium is in Group 1 of the periodic table.

Lithium reacts with water to produce a gas and an alkaline solution.



1 (a) (i) Name the gas produced.

.....

(1 mark)

1 (a) (ii) Which ion causes the solution to be alkaline?

.....

(1 mark)

1 (b) Potassium is also in Group 1 of the periodic table.
Potassium reacts with water in a similar way to lithium.

Write down **two** differences you would see between the reactions of potassium and lithium with water.

1 .....

.....

2 .....

.....

(2 marks)

4

4.4.1.2 The reactivity series

Question 27

June 2014 | CH1HP | Original Q4 | Legacy

4 Where copper ore has been mined there are areas of land that contain very low percentages of copper compounds.

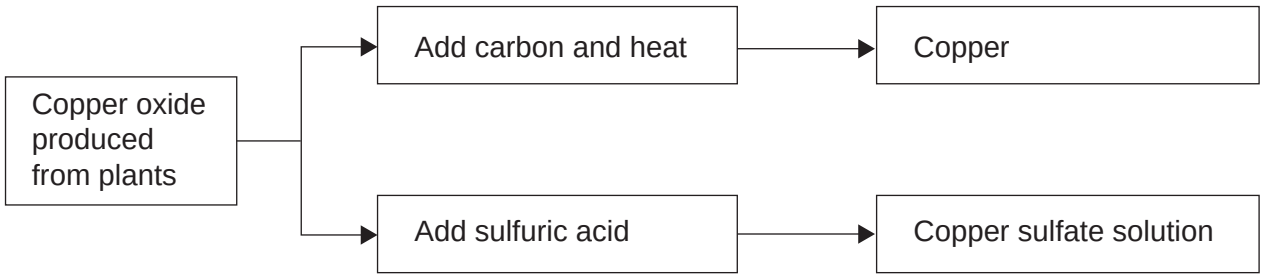
One way to extract the copper is to grow plants on the land.

The plants absorb copper compounds through their roots.

The plants are burned to produce copper oxide.

The copper oxide produced from plants can be reacted to produce copper or copper sulfate solution, as shown in **Figure 3**.

Figure 3



4 (a) (i) Complete the sentence.

[1 mark]

Using plants to extract metals is called ..... .

4 (a) (ii) Suggest **two** reasons why copper from these areas of land is **not** extracted by smelting.

[2 marks]

.....

.....

.....

.....

.....

4 (a) (iii) Complete and balance the chemical equation for the reaction of copper oxide with carbon.

[2 marks]

.....CuO + C ⟶ ..... + CO_2

4.4.1.2 The reactivity series

Question 27 · continued

4 (b) Copper is produced from copper sulfate solution by displacement using scrap iron or by electrolysis.

4 (b) (i) Use the Chemistry Data Sheet to help you to answer this question.

Give **two** reasons why scrap iron is used to displace copper.

[2 marks]

.....

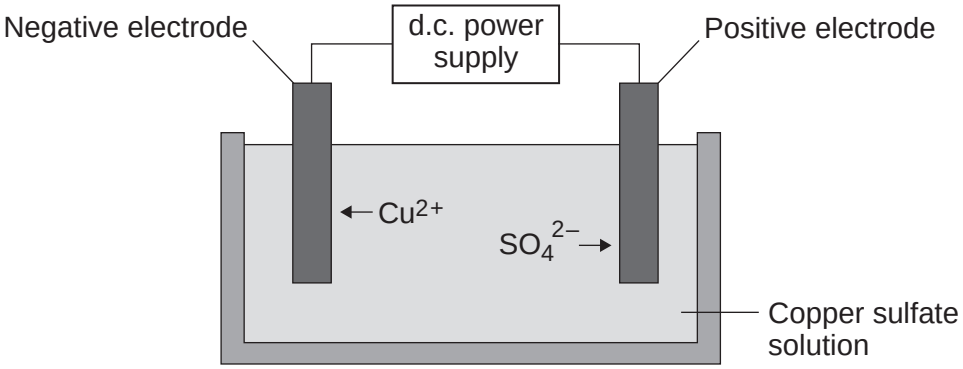
.....

.....

.....

4 (b) (ii) **Figure 4** shows the electrolysis of copper sulfate solution.

Figure 4



Describe what happens to the copper ions during electrolysis.

[2 marks]

.....

.....

.....

.....

9

4.4.1.2 The reactivity series

Question 28

June 2014 | CH3HP | Original Q3 | Legacy

3 In 1869, Dmitri Mendeleev produced his periodic table of the elements.

Mendeleev placed the alkali metals in the same group.

3 (a) What evidence did Mendeleev use to decide that the alkali metals should be in the same group?

[1 mark]

.....

.....

3 (b) Describe how the elements in the modern periodic table are arranged:

3 (b) (i) in terms of protons

[1 mark]

.....

.....

3 (b) (ii) in terms of electrons.

[1 mark]

.....

.....

3 (c) State **two** properties of transition elements that make them more useful than alkali metals for making water pipes.

[2 marks]

.....

.....

.....

.....

.....

4.4.1.2 The reactivity series

Question 28 · continued

3 (d) Describe and explain the trend in reactivity of the alkali metals (Group 1).

[4 marks]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

9

4.4.1.2 The reactivity series

Question 29

June 2015 | CH3HP | Original Q3 | Legacy

3 This question is about the halogens (Group 7).

3 (a) How do the boiling points of the halogens change down the group from fluorine to iodine?

[1 mark]

.....

.....

3 (b) Sodium bromide is produced by reacting sodium with bromine.

Sodium bromide is an ionic compound.

3 (b) (i) Write down the symbols of the **two** ions in sodium bromide.

[1 mark]

.....

3 (b) (ii) Chlorine reacts with sodium bromide solution to produce bromine and one other product.

Complete the word equation for the reaction.

[1 mark]

chlorine + sodium bromide ⟶ bromine + ...

3 (b) (iii) Why does chlorine displace bromine from sodium bromide?

[1 mark]

.....

.....

3 (b) (iv) Use the Chemistry Data Sheet to help you to answer this question.

Suggest which halogen could react with sodium chloride solution to produce chlorine.

[1 mark]

.....

5

4.4.1.2 The reactivity series

Question 30

June 2016 | CH1HP | Original Q3 | Legacy

3 Metals are extracted from ores in the Earth's crust.

Some ores contain metal carbonates and some ores contain metal oxides.

3 (a) (i) Name the type of reaction that happens when a metal carbonate is heated.

[1 mark]

_____

3 (a) (ii) Which solid product is formed when copper carbonate is heated?

[1 mark]

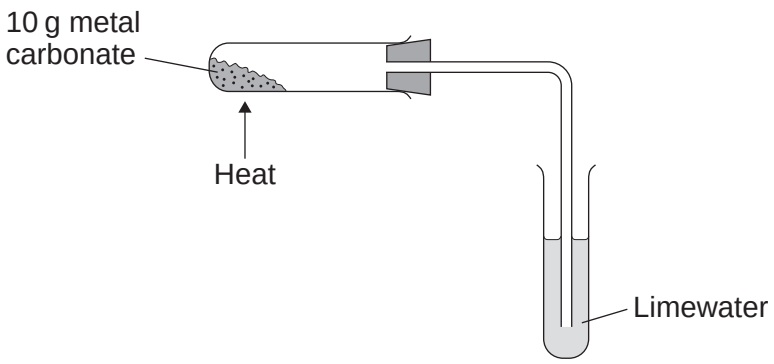
Tick (✓) **one** box.

- copper ☐
- copper nitrate ☐
- copper oxide ☐
- copper sulfide ☐

3 (b) A student investigated heating four metal carbonates.

Figure 4 shows the apparatus used.

Figure 4



4.4.1.2 The reactivity series

Question 30 · continued

The student heated each metal carbonate for five minutes.

Table 3 shows the results.

Table 3

Metal carbonate	Mass of metal carbonate at start in g	Mass of solid after heating for 5 minutes in g	Observations
Copper carbonate	10.0	6.9	Limewater turns cloudy
Magnesium carbonate	10.0	9.1	Limewater turns cloudy
Potassium carbonate	10.0	10.0	Limewater does not turn cloudy
Zinc carbonate	10.0	8.3	Limewater turns cloudy

3 (b) (i) Explain the results for potassium carbonate.

[3 marks]

3 (b) (ii) Suggest how the reactivity series can be used to predict which metal carbonate reacts most easily when heated.

[2 marks]

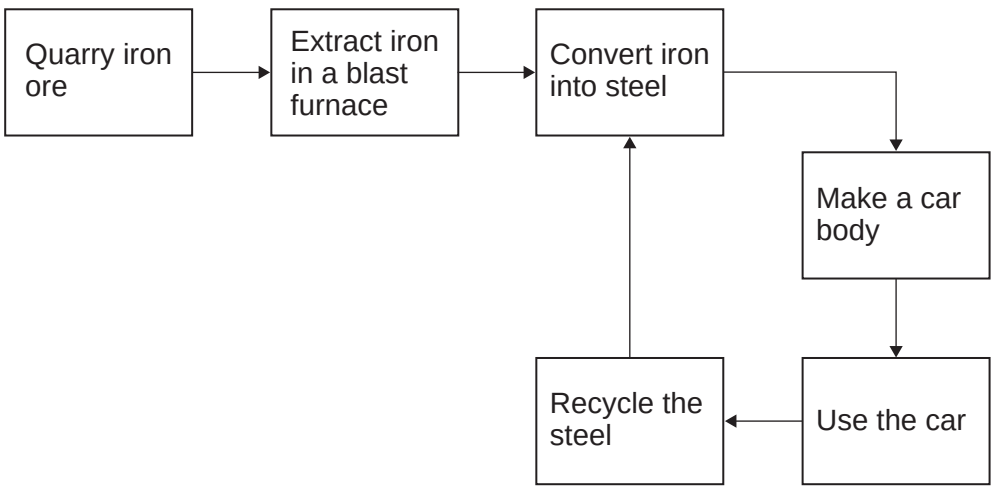
Question 3 continues on the next page

4.4.1.2 The reactivity series

Question 30 · continued

3 (c) **Figure 5** shows a simple life cycle of a car body.

Figure 5



3 (c) (i) Complete the sentence.

[1 mark]

Iron ores must contain enough iron to _____

_____

3 (c) (ii) Some iron ores contain iron oxide (Fe_2O_3).

Complete and balance the equation for a reaction to produce iron from iron oxide.

[2 marks]

_____ Fe_2O_3 + _____ C ⟶ _____ + _____ CO_2

3 (c) (iii) Give **two** reasons why iron produced in a blast furnace is converted into steel.

[2 marks]

_____

_____

_____

_____

4.4.1.2 The reactivity series

Question 30 · continued

3 (c) (iv) When a car reaches the end of its useful life, the car body can be:

- recycled
- reused
- sent to landfill.

Give **three** reasons why a steel car body should be recycled and **not** reused or sent to landfill.

[3 marks]

15

4.4.1.2 The reactivity series

Question 31

June 2016 | CH3HP | Original Q3 | Legacy

3 This question is about elements and the periodic table.

3 (a) Newlands and Mendeleev both produced early versions of the periodic table.

3 (a) (i) Complete the sentence.

[1 mark]

In their periodic tables, Newlands and Mendeleev arranged the elements in order of

_____ .

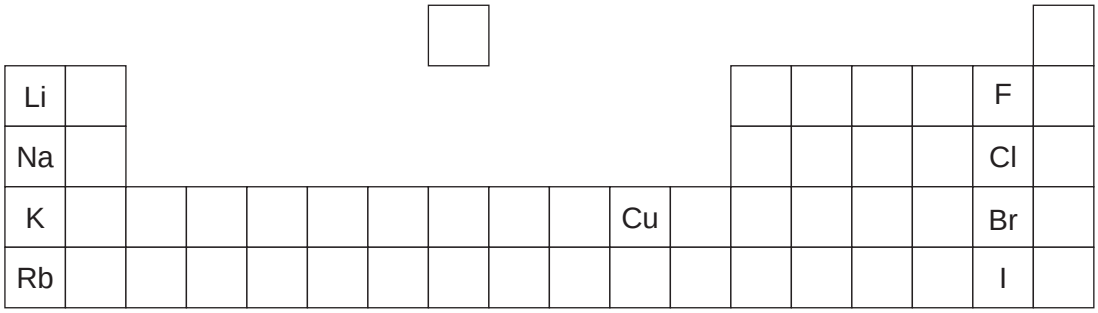
3 (a) (ii) Name the particle that allowed the elements to be arranged in order of their atomic number in the modern periodic table.

[1 mark]

_____

3 (b) **Figure 4** shows the position of nine elements in the modern periodic table.

Figure 4



3 (b) (i) Which **one** of the nine elements shown in **Figure 4** has the lowest boiling point?

[1 mark]

_____

3 (b) (ii) Copper and potassium have different melting points and boiling points.
Give **one other** difference between the properties of copper and potassium.

[1 mark]

_____

_____

4.4.1.2 The reactivity series

Question 31 · continued

3 (b) (iii) Explain why the reactivity of the elements increases going down Group 1 from lithium to rubidium but decreases going down Group 7 from fluorine to iodine.

[4 marks]

8

4.4.1.2 The reactivity series

Question 32

June 2018 | 8462/1H | Original Q5

0 5 A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

Table 2 shows the student's results.

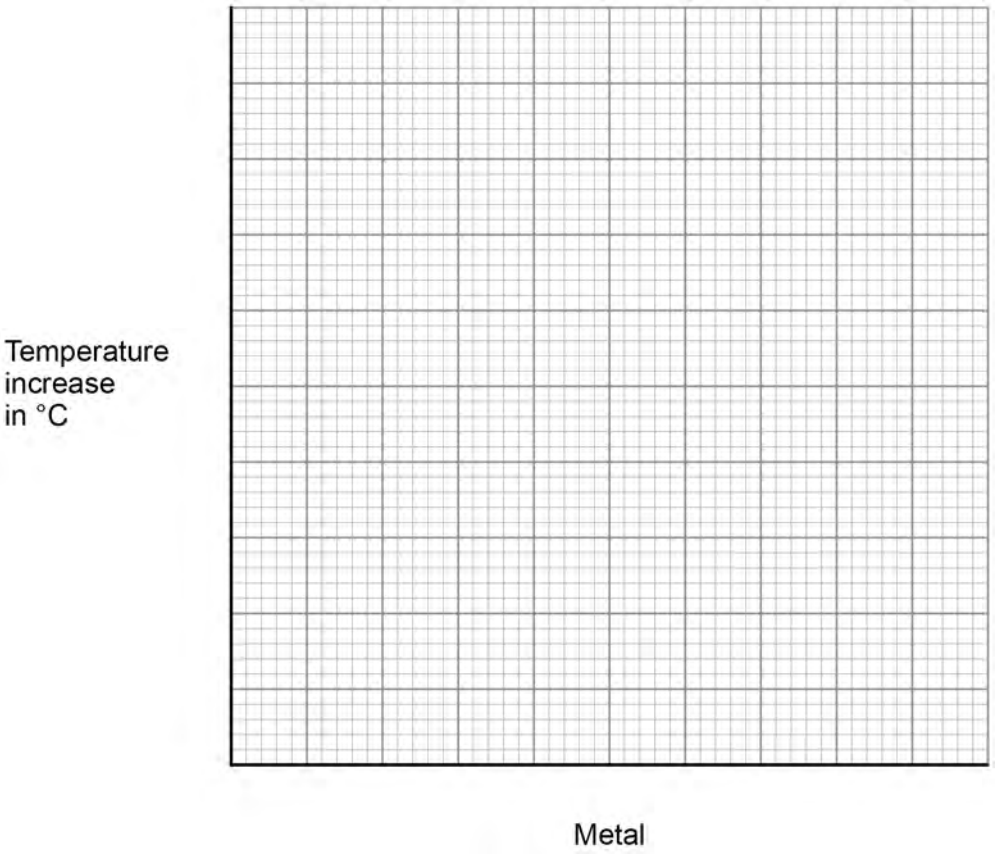
Table 2

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

0 5 . 1 Plot the data from **Table 2** on **Figure 4** as a bar chart.

[2 marks]

Figure 4



4.4.1.2 The reactivity series

Question 32 · continued

0 5 . 2 The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

[1 mark]

0 5 . 3 The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

[4 marks]

Question 5 continues on the next page

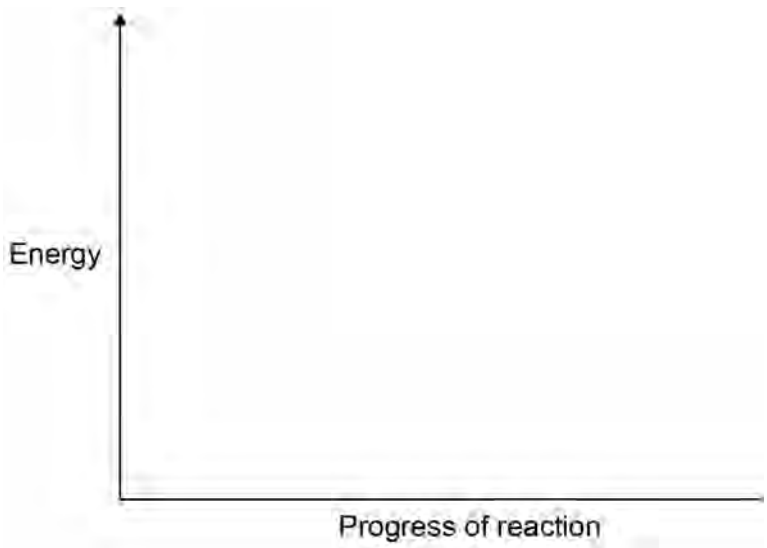
4.4.1.2 The reactivity series

Question 32 · continued

0 5 . 4 Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 5**.

[3 marks]

Figure 5



10

4.4.1.2 The reactivity series

Question 33

June 2018 | 8462/1H | Original Q8

0 8 Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two stage industrial process.

Stage 1 $TiO_2 + 2\,C + 2\,Cl_2 \rightarrow TiCl_4 + 2\,CO$

Stage 2 $TiCl_4 + 4\,Na \rightarrow Ti + 4\,NaCl$

0 8 . 1 Suggest **one** hazard associated with **Stage 1**.

[1 mark]

0 8 . 2 Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

[1 mark]

0 8 . 3 Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

[2 marks]

4.4.1.2 The reactivity series

Question 33 · continued

0 8 . 4 Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

[3 marks]

In **Stage 2**, sodium displaces titanium from titanium chloride.

0 8 . 5 Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

[1 mark]

0 8 . 6 Complete the half equation for the oxidation reaction.

[1 mark]

Na → _____ + _____

Question 33 · continued

0 8 . 7 In **Stage 2**, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

$$TiCl_4 + 4\,Na \rightarrow Ti + 4\,NaCl$$

Relative atomic masses (A_r): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

[4 marks]

0 8 . 8 For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

[2 marks]

Mass of titanium = _____ kg

15

4.4.1.2 The reactivity series

Question 34

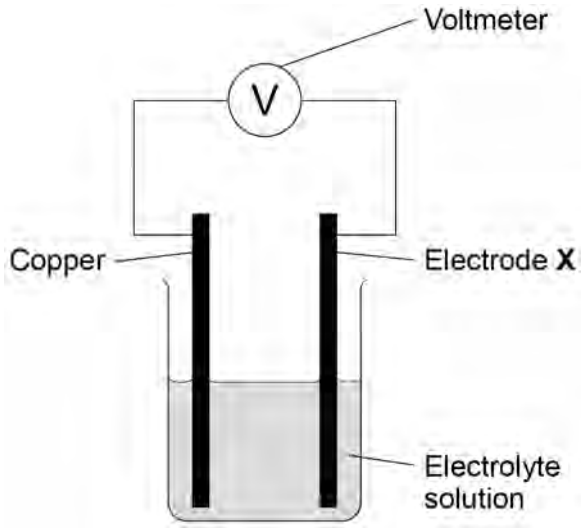
June 2019 | 8462/1H | Original Q6

0 6 This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 9 shows the apparatus.

Figure 9



This is the method used.

1. Use cobalt as electrode **X**.

2. Record the cell voltage.

3. Repeat steps 1 and 2 using different metals as electrode **X**.

0 6 . 1 Suggest **two** control variables used in this investigation.

[2 marks]

1 _____

_____

2 _____

_____

4.4.1.2 The reactivity series

Question 34 · continued

Table 4 shows the student's results.

Table 4

Electrode X	Voltage of cell in volts
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	–0.46
tin	+0.48

0 6 . 2 Write the six metals used for electrode **X** in order of reactivity.

Use **Table 4**.

Justify your order of reactivity.

[4 marks]

Most reactive _____

_____

_____

_____

_____

Least reactive _____

Justification _____

_____

_____

_____

_____

4.4.1.2 The reactivity series

Question 34 · continued

0 6 . 3 Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

- Magnesium and cobalt ☐
- Magnesium and tin ☐
- Nickel and cobalt ☐
- Nickel and tin ☐

0 6 . 4 Hydrogen fuel cells can be used to power different forms of transport.

Some diesel trains are being converted to run on hydrogen fuel cells.

A newspaper article referred to the converted trains as the new 'steam trains'.

Suggest why.

[2 marks]

9

4.4.1.2 The reactivity series

Question 35

November 2020 | 8462/1H | Original Q2

0 2 This question is about metals and the reactivity series.

0 2 . 1 Which **two** statements are properties of most transition metals?

[2 marks]

Tick (✓) **two** boxes.

- They are soft metals. ☐
- They form colourless compounds. ☐
- They form ions with different charges. ☐
- They have high melting points. ☐
- They have low densities. ☐

0 2 . 2 A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

[3 marks]

4.4.1.2 The reactivity series

Question 35 · continued

0 2 . 3 A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

[4 marks]

Question 2 continues on the next page

4.4.1.2 The reactivity series

Question 35 · continued

0 2 . 4 Metal **M** has two isotopes.

Table 2 shows the mass numbers and percentage abundances of the isotopes.

Table 2

Mass number	Percentage abundance (%)
203	30
205	70

Calculate the relative atomic mass (A_r) of metal **M**.

Give your answer to 1 decimal place.

[2 marks]

Relative atomic mass (1 decimal place) = _____

11

4.4.1.2 The reactivity series

Question 36

November 2020 | 8462/1H | Original Q6

0 6 This question is about displacement reactions.

0 6 . 1 The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

[1 mark]

0 6 . 2 A mixture contains 1.00 kg of aluminium and 3.00 kg of iron oxide.

The equation for the reaction is:

$$2\,Al + Fe_2O_3 \rightarrow 2\,Fe + Al_2O_3$$

Show that aluminium is the limiting reactant.

Relative atomic masses (A_r): O = 16 Al = 27 Fe = 56

[4 marks]

4.4.1.2 The reactivity series

Question 36 · continued

Magnesium displaces zinc from zinc sulfate solution.

0 6 . 3 Complete the ionic equation for the reaction.

You should include state symbols.

[2 marks]

$$Mg(s) + Zn^{2+}(aq) \rightarrow _____ + _____$$

0 6 . 4 Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

[2 marks]

9

4.4.1.2 The reactivity series

Question 37

November 2020 | 8462/1H | Original Q8

0 8 This question is about the halogens.

Table 5 shows the melting points and boiling points of some halogens.

Table 5

Element	Melting point in °C	Boiling point in °C
Fluorine	–220	–188
Chlorine	–101	–35
Bromine	–7	59

0 8 . 1 What is the state of bromine at 0 °C **and** at 100 °C?

[1 mark]

Tick (✓) **one** box.

State at 0 °C	State at 100 °C	
Gas	Gas	☐
Gas	Liquid	☐
Liquid	Gas	☐
Liquid	Liquid	☐
Solid	Gas	☐
Solid	Liquid	☐

4.4.1.2 The reactivity series

Question 37 · continued

0 8 . 2 Explain the trend in boiling points of the halogens shown in **Table 5**.

[4 marks]

0 8 . 3 Why is it **not** correct to say that the boiling point of a single bromine molecule is 59 °C?

[1 mark]

Question 8 continues on the next page

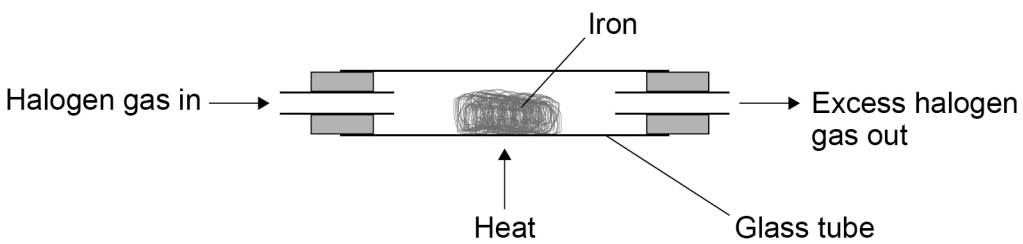
4.4.1.2 The reactivity series

Question 37 · continued

Iron reacts with each of the halogens in their gaseous form.

Figure 5 shows the apparatus used.

Figure 5



0 8 . 4 Give **one** reason why this experiment should be done in a fume cupboard.

[1 mark]

0 8 . 5 Explain why the reactivity of the halogens decreases going down the group.

[3 marks]

4.4.1.2 The reactivity series

Question 37 · continued

0 8 . 6 A teacher investigated the reaction of iron with chlorine using the apparatus in **Figure 5**.

The word equation for the reaction is:

iron + chlorine → iron chloride

The teacher weighed:

- the glass tube
- the glass tube and iron before the reaction
- the glass tube and iron chloride after the reaction.

Table 6 shows the teacher's results.

Table 6

	Mass in g
Glass tube	51.56
Glass tube and iron	56.04
Glass tube and iron chloride	64.56

Calculate the simplest whole number ratio of:

moles of iron atoms : moles of chlorine atoms

Determine the balanced equation for the reaction.

Relative atomic masses (A_r): Cl = 35.5 Fe = 56

[6 marks]

Moles of iron atoms : moles of chlorine atoms = _____ : _____

Equation for the reaction _____

16

4.4.1.2 The reactivity series

Question 38

November 2021 | 8462/1H | Original Q4

0 4 This question is about Group 1 elements.

0 4 . 1 Give **two** observations you could make when a small piece of potassium is added to water.

[2 marks]

1 _____

_____

2 _____

_____

0 4 . 2 Complete the equation for the reaction of potassium with water.

You should balance the equation.

[2 marks]

$$K + \qquad H_2O \rightarrow \qquad +$$

0 4 . 3 Explain why the reactivity of elements changes going down Group 1.

[4 marks]

_____

_____

_____

_____

_____

_____

_____

_____

_____

4.4.1.2 The reactivity series

Question 38 · continued

Sodium reacts with oxygen to produce the ionic compound sodium oxide.

Oxygen is a Group 6 element.

0 4 . 4 Draw a dot and cross diagram to show what happens when atoms of sodium and oxygen react to produce sodium oxide.

[4 marks]

Diagram

4.4.1.2 The reactivity series

Question 38 · continued

0 4 . 5 Why is oxygen described as being reduced in the reaction between sodium and oxygen?

[1 mark]

0 4 . 6 Explain why sodium oxide has a high melting point.

[3 marks]

16

4.4.1.2 The reactivity series

Question 39

November 2021 | 8462/1H | Original Q6

0 6 This question is about metals.

0 6 . 1 **Table 3** shows information about four substances.

Table 3

Substance	Melting point in °C	Boiling point in °C	Does it conduct electricity in the solid state?	Does it conduct electricity in the liquid state?
A	–117	79	No	No
B	801	1413	No	Yes
C	1535	2750	Yes	Yes
D	1610	2230	No	No

Which substance could be a metal?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 6 . 2 Explain why alloys are harder than pure metals.

[3 marks]

4.4.1.2 The reactivity series

Question 39 · continued

0 6 . 3 A student wants to compare the reactivity of an unknown metal, **Q**, with that of zinc.

Both metals are more reactive than silver.

The student is provided with:

- silver nitrate solution
- metal **Q** powder
- zinc powder
- a thermometer
- normal laboratory equipment.

No other chemicals are available.

Describe a method the student could use to compare the reactivity of metal **Q** with that of zinc.

Your method should give valid results.

[4 marks]

8

4.4.1.2 The reactivity series

Question 40

November 2021 | 8462/2H | Original Q9

0 9 A student investigated how a change in concentration affects the rate of the reaction between zinc powder and sulfuric acid.

The equation for the reaction is:

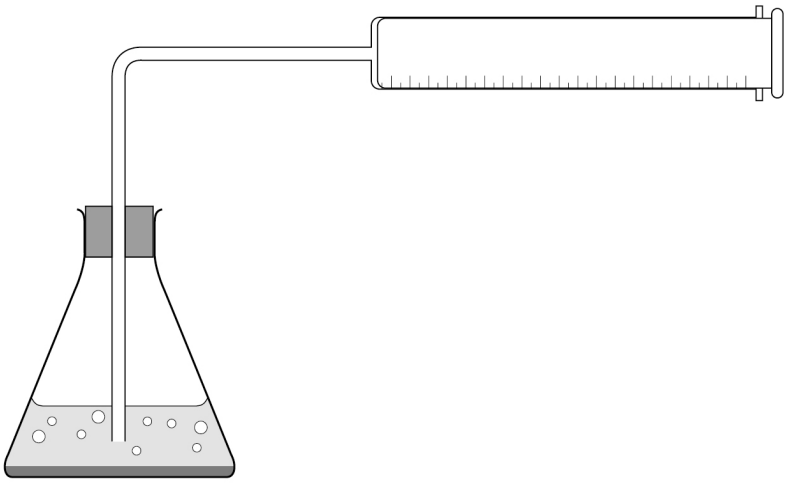
$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

This is the method used.

1. Pour 50 cm^3 of sulfuric acid of concentration 0.05 mol/dm^3 into a conical flask.
2. Add 0.2 g of zinc powder to the conical flask.
3. Put the stopper in the conical flask.
4. Measure the volume of gas collected every 30 seconds for 5 minutes.
5. Repeat steps 1 to 4 with sulfuric acid of concentration 0.10 mol/dm^3

Figure 8 shows the apparatus used.

Figure 8



0 9 . 1 The student made an error in setting up the apparatus in **Figure 8**.

What error did the student make?

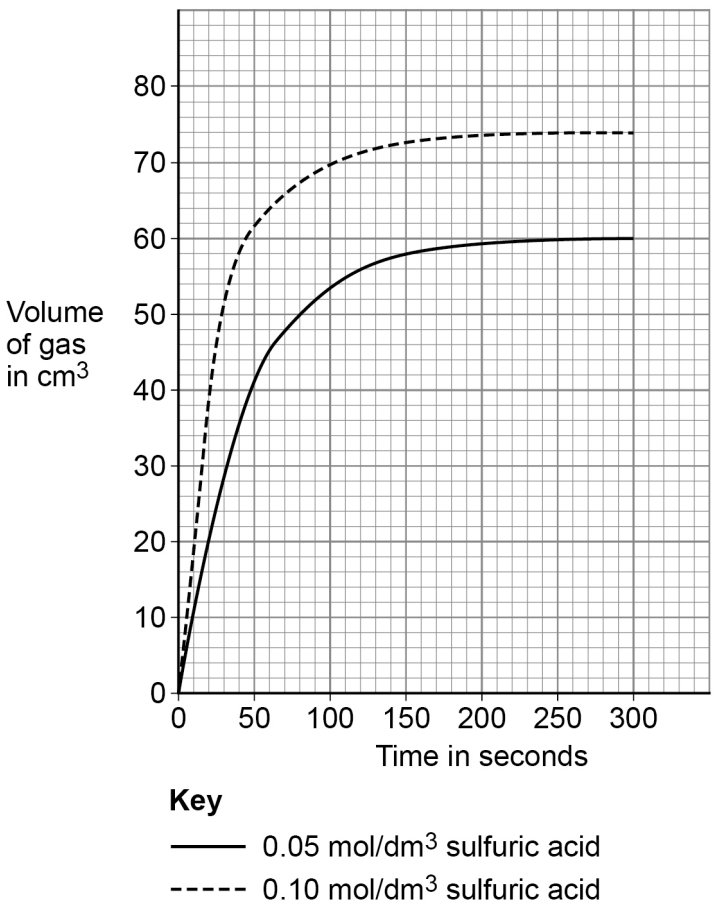
[1 mark]

Question 40 · continued

The student corrected the error.

Figure 9 shows the student's results.

Figure 9



0 9 . 2 Explain why the lines of best fit on **Figure 9** become horizontal.

[2 marks]

0 9 . 3 How does **Figure 9** show that zinc powder reacts more slowly with 0.05 mol/dm^3 sulfuric acid than with 0.10 mol/dm^3 sulfuric acid?

[1 mark]

4.4.1.2 The reactivity series

Question 40 · continued

0 9 . 4 Determine the rate of the reaction for 0.05 mol/dm^3 sulfuric acid at 80 seconds.

Show your working on **Figure 9**.

Give your answer to 2 significant figures.

[5 marks]

Rate of reaction (2 significant figures) = _____ cm^3/s

0 9 . 5 The activation energy for the reaction between zinc and sulfuric acid is lowered if a solution containing metal ions is added.

What is the most likely formula of the metal ions added?

[1 mark]

Tick (✓) **one** box.

Al^{3+} ☐

Ca^{2+} ☐

Cu^{2+} ☐

Na^{+} ☐

10

4.4.1.2 The reactivity series

Question 41

June 2022 | 8462/1H | Original Q4

0 4 This question is about zinc and compounds of zinc.

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2\,HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

0 4 . 1 The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

[1 mark]

0 4 . 2 Why is excess zinc oxide used rather than excess hydrochloric acid?

[1 mark]

0 4 . 3 Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

[1 mark]

0 4 . 4 Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

[2 marks]

4.4.1.2 The reactivity series

Question 41 · continued

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

0 4 . 5 Complete the ionic equation for this reaction.

[1 mark]

$$Zn + _____ \rightarrow Zn^{2+} + _____$$

0 4 . 6 Why is zinc described as being oxidised in this reaction?

[1 mark]

4.4.1.2 The reactivity series

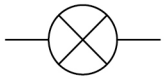
Question 41 · continued

0 4 . 7 Zinc and copper can be used with another substance to produce electricity.

Complete **Figure 7** to show how zinc, copper and another substance can be used to light a lamp.

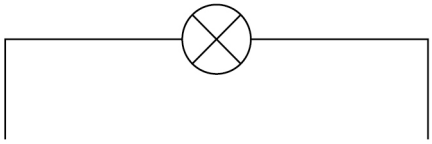
Label:

- zinc
- copper
- the other substance used.

The symbol  represents the lamp.

[3 marks]

Figure 7



4.4.1.2 The reactivity series

Question 42

June 2022 | 8462/1H | Original Q5

0 5 This question is about groups in the periodic table.

The elements in Group 1 become more reactive going down the group.

Rubidium is below potassium in Group 1.

0 5 . 1 Rubidium and potassium are added to water.

Predict **one** observation you would see that shows that rubidium is more reactive than potassium.

[1 mark]

0 5 . 2 Explain why rubidium is more reactive than potassium.

[3 marks]

0 5 . 3 Complete the equation for the reaction of rubidium with water.

You should balance the equation.

[3 marks]

$$Rb + H_2O \rightarrow \quad +$$

4.4.1.2 The reactivity series

Question 42 · continued

The noble gases are in Group 0.

0 5 . 4 Which is a correct statement about the noble gases?

[1 mark]

Tick (✓) **one** box.

- The noble gases all have atoms with eight electrons in the outer shell. ☐
- The noble gases have boiling points that increase going down the group. ☐
- The noble gases have molecules with two atoms. ☐
- The noble gases react with metals to form ionic compounds. ☐

0 5 . 5 **Table 1** shows information about the three isotopes of neon.

Table 1

Mass number	Percentage abundance (%)
20	90.48
21	0.27
22	9.25

Calculate the relative atomic mass (A_r) of neon.

Give your answer to 3 significant figures.

[3 marks]

Relative atomic mass (3 significant figures) = _____

11

4.4.1.2 The reactivity series

Question 43

June 2022 | 8462/1H | Original Q7

0 7 This question is about silicon and compounds of silicon.

0 7 . 1 The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\,C(s) + SiO_2(s) \rightarrow Si(s) + 2\,CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

[2 marks]

0 7 . 2 Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

[2 marks]

4.4.1.2 The reactivity series

Question 43 · continued

Magnesium also reduces silicon dioxide.

The equation for the reaction is:

$$2\,Mg(s) + SiO_2(s) \rightarrow Si(s) + 2\,MgO(s)$$

0 7 . 3 Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

[1 mark]

0 7 . 4 Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide.

Relative atomic masses (A_r): O = 16 Mg = 24 Si = 28

[5 marks]

Minimum mass of magnesium = _____ g

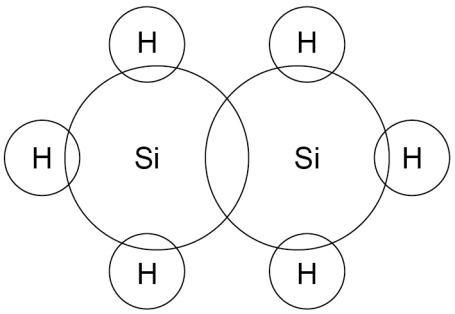
Question 43 · continued

Si_2H_6 is a covalent compound of silicon and hydrogen.

0 7 . 5 Complete **Figure 9** to show the outer shell electrons in a molecule of Si_2H_6

[1 mark]

Figure 9



0 7 . 6 Si_2H_6 reacts with oxygen.

The equation for the reaction is:

$$2\,Si_2H_6(g) + 7\,O_2(g) \rightarrow 4\,SiO_2(s) + 6\,H_2O(g)$$

30 cm^3 of Si_2H_6 is reacted with 150 cm^3 (an excess) of oxygen.

Calculate the total volume of gases present after the reaction.

All volumes of gases are measured at the same temperature and pressure.

[4 marks]

Volume of gases = _____ cm^3

15

4.4.1.2 The reactivity series

Question 44

June 2023 | 8462/1H | Original Q9

0 9 This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

0 9 . 1 Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

[2 marks]

Substance reduced _____

Reason _____

_____

0 9 . 2 Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide?

Relative atomic mass (A_r): C = 12

[1 mark]

Tick (✓) **one** box.

$\frac{1}{3} \times 12$ g ☐

$\frac{3}{2} \times 12$ g ☐

1×12 g ☐

3×12 g ☐

Question 9 continues on the next page

Question 44 · continued

A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

A, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

Table 6 shows information about three of the reaction mixtures.

Table 6

Reaction	Metal	Metal nitrate solution	Equation
1	**A**	**B**NO_3	**A** + 2**B**NO_3 → 2**B** + **A**$(NO_3)_2$
2	**C**	**A**$(NO_3)_2$	2**C** + 3**A**$(NO_3)_2$ → 3**A** + 2**C**$(NO_3)_3$
3	**C**	**D**$(NO_3)_2$	no reaction

0 9 . 3 The ionic equation for **Reaction 1** is:

$$\mathbf{A} + 2\mathbf{B}^{+} \rightarrow 2\mathbf{B} + \mathbf{A}^{2+}$$

Why is this a redox reaction?

[1 mark]

Tick (✓) **one** box.

A gains electrons and $\mathbf{B}^{+}$ loses electrons. ☐

A loses electrons and $\mathbf{B}^{+}$ gains electrons. ☐

Both **A** and $\mathbf{B}^{+}$ gain electrons. ☐

Both **A** and $\mathbf{B}^{+}$ lose electrons. ☐

4.4.1.2 The reactivity series

Question 44 · continued

0 9 . 4 Which of the four metals has the greatest tendency to form positive ions?

Use **Table 6**.

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 9 . 5 The nitrate ion has the formula NO_3^-

Which of the four metals could be aluminium?

Explain your answer.

Use **Table 6**.

[3 marks]

Metal _____

Explanation _____

_____

_____

_____

Question 9 continues on the next page

4.4.1.2 The reactivity series

Question 44 · continued

0 9 . 6 Metal **X** is extracted from an oxide of metal **X** by reaction with hydrogen.

The equation for the reaction is:

$$\mathbf{X}O_3 + 3H_2 \rightarrow \mathbf{X} + 3H_2O$$

The percentage atom economy for obtaining metal **X** by this method is 77.3%.

Calculate the relative atomic mass (A_r) of metal **X**.

Relative atomic masses (A_r): H = 1 O = 16

[4 marks]

Relative atomic mass (A_r) = _____

12

4.4.1.2 The reactivity series

Question 45

June 2024 | 8462/1H | Original Q2

0 2 This question is about the periodic table.

Sodium and potassium are in Group 1 of the periodic table.

0 2 . 1 Give **one** similarity and **one** difference between the electronic structures of sodium and potassium.

[2 marks]

Similarity _____

_____

Difference _____

_____

Group 1 elements react with water.

0 2 . 2 Give **two** observations made when potassium reacts with water.

[2 marks]

1 _____

_____

2 _____

_____

0 2 . 3 Potassium hydroxide solution is produced when potassium reacts with water.

What is the colour of universal indicator when added to potassium hydroxide solution?

Give **one** reason for your answer.

[2 marks]

Colour of universal indicator _____

Reason _____

_____

4.4.1.2 The reactivity series

Question 45 · continued

Table 1 shows the densities of some of the elements in Group 0 of the periodic table.

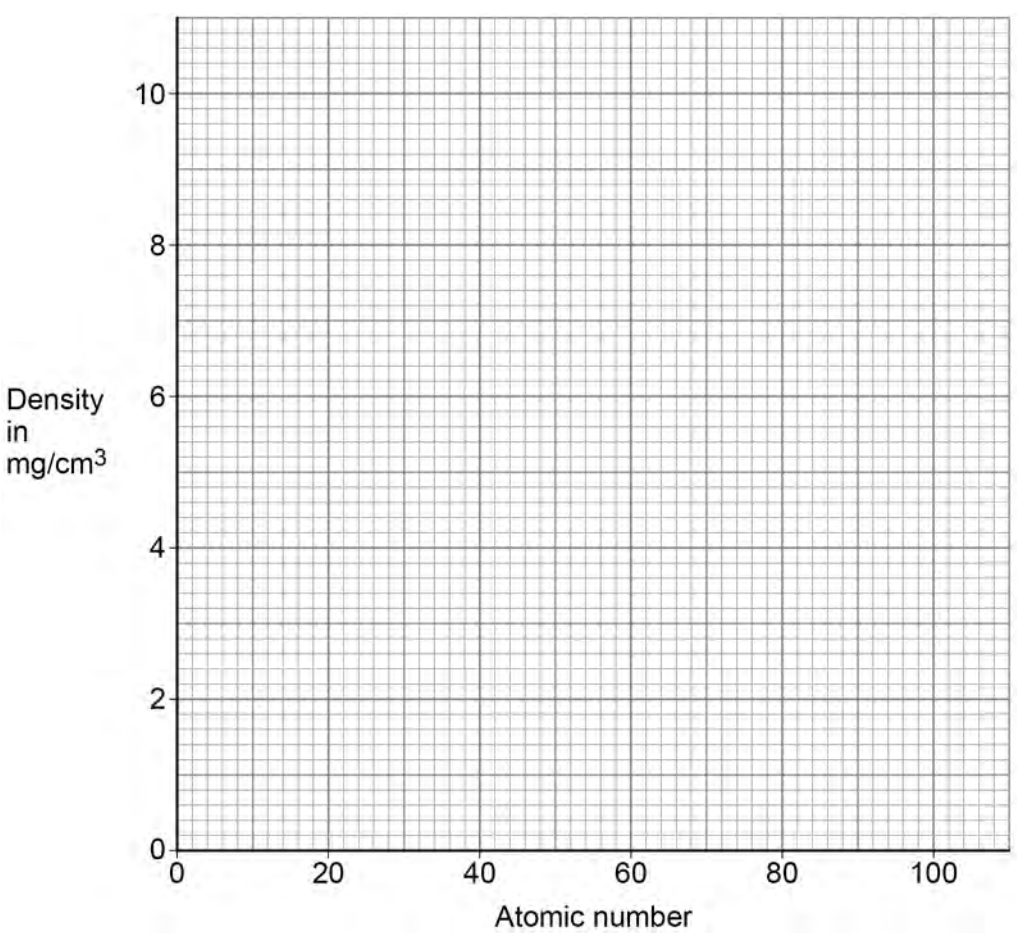
Table 1

Element	Atomic number	Density in mg/cm^3
Helium	2	0.2
Neon	10	0.8
Argon	18	1.6
Krypton	36	**X**
Xenon	54	5.4
Radon	86	9.1

0 2 . 4 Plot the data from **Table 1** on **Figure 1**.

[2 marks]

Figure 1



4.4.1.2 The reactivity series

Question 45 · continued

0 2 . 5 Estimate the density (**X**) of krypton.

Use **Figure 1** and **Table 1**.

[1 mark]

Density = _____ mg/cm^3

0 2 . 6 The elements in Group 7 are called the halogens.

A more reactive halogen can displace a less reactive halogen from a solution of its salt.

Which combination of solutions will produce a reaction when mixed?

[1 mark]

Tick (✓) **one** box.

Chlorine and potassium fluoride ☐

Chlorine and potassium bromide ☐

Bromine and potassium fluoride ☐

Bromine and potassium chloride ☐

0 2 . 7 Which of the following describes the trends going down Group 7?

[1 mark]

Tick (✓) **one** box.

Relative molecular mass decreases and boiling point decreases. ☐

Relative molecular mass decreases and boiling point increases. ☐

Relative molecular mass increases and boiling point decreases. ☐

Relative molecular mass increases and boiling point increases. ☐

11

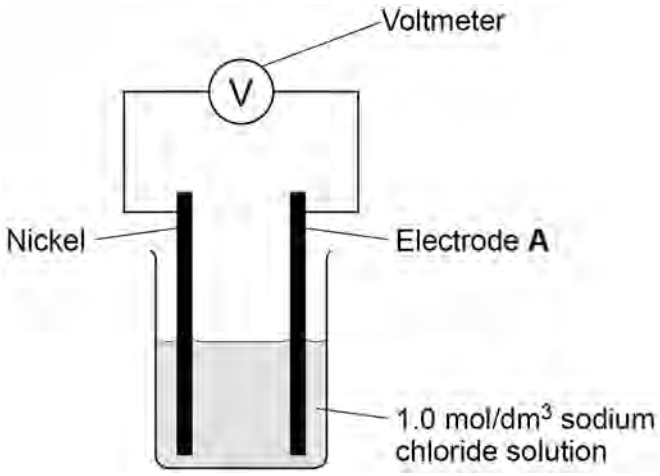
4.4.1.2 The reactivity series

Question 46

0 6 A student investigated the voltage produced by different pairs of metal electrodes in a chemical cell.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Place a nickel electrode and an electrode made from a different metal (electrode **A**) in 1.0 mol/dm^3 sodium chloride solution.
2. Measure the voltage produced.
3. Repeat using different metals for electrode **A**.

Table 3 shows the results.

Table 3

Electrode A	Symbol of metal	Voltage in volts
Copper	Cu	–0.59
Magnesium	Mg	2.12
Nickel	Ni	0.00
Silver	Ag	–1.05
Zinc	Zn	0.51

4.4.1.2 The reactivity series

Question 46 · continued

0 6 . 1 Write the symbols of the five metals in **Table 3** in order of reactivity.

Justify your answer.

[3 marks]

Most reactive _____ _____ _____ _____ _____ Least reactive

Justification _____

_____

0 6 . 2 The voltage produced by a chemical cell depends on the concentration of the electrolyte solution.

Plan an experiment to investigate how the voltage produced by a chemical cell varies with the **concentration** of the electrolyte solution.

The following substances are available:

- the metal electrodes in **Table 3**
- 1.0 mol/dm^3 sodium chloride solution
- pure water.

[6 marks]

4.4.1.2 The reactivity series

Question 46 · continued

0 6 . 3 Describe how a hydrogen fuel cell produces a potential difference.

[2 marks]

11

4.4.1.2 The reactivity series

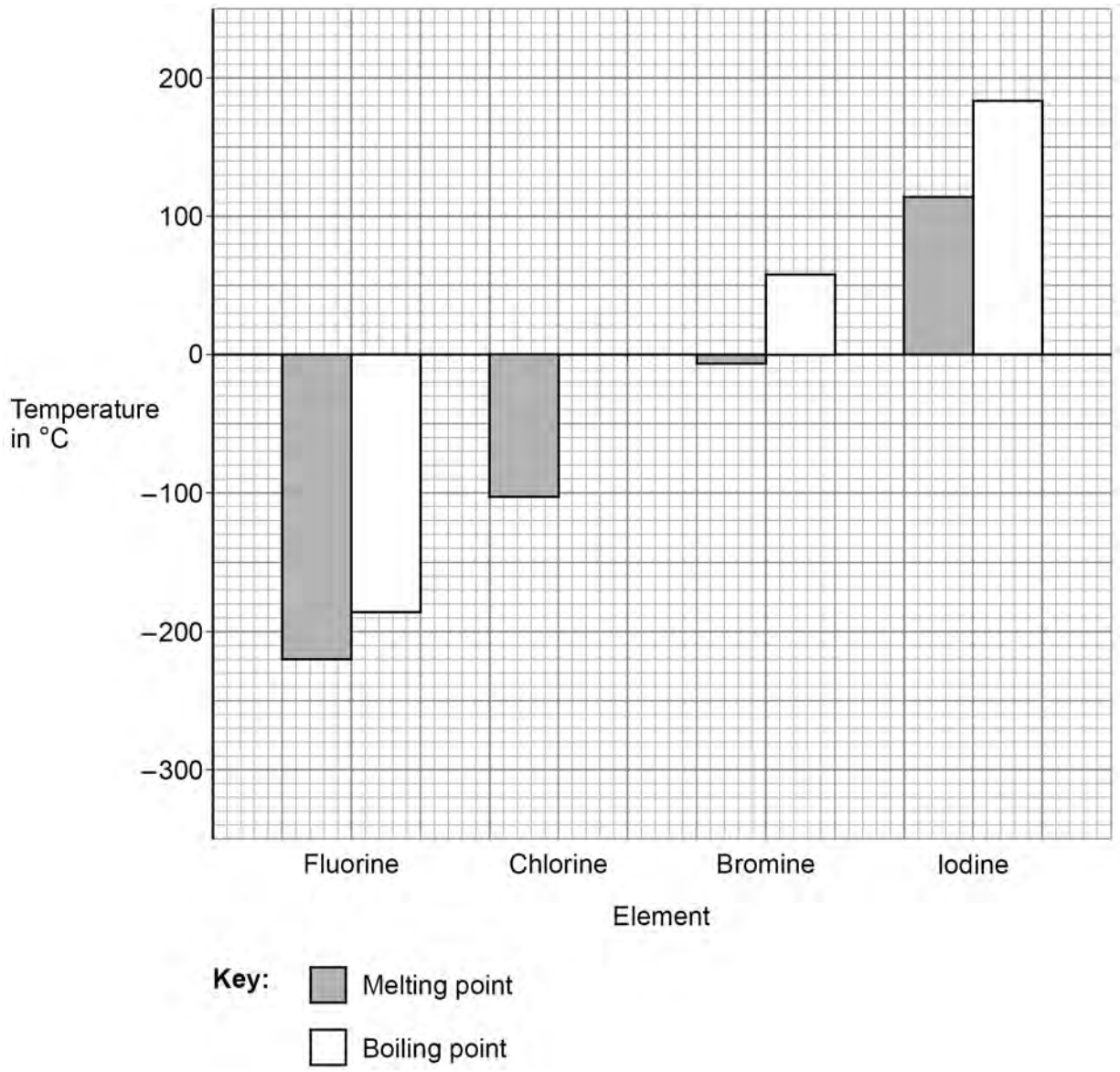
Question 47

June 2025 | 8462/1H | Original Q4

0 4 The elements in Group 7 of the periodic table are known as the halogens.

Figure 4 shows information about some of the elements in Group 7.

Figure 4



4.4.1.2 The reactivity series

Question 47 · continued

0 4 . 1 Predict the boiling point of chlorine.

Use **Figure 4**.

[1 mark]

_____ °C

0 4 . 2 What is the state of fluorine at –250 °C?

Use **Figure 4**.

[1 mark]

_____

Astatine (At) is an element in Group 7.

0 4 . 3 What is the number of electrons in the outer shell of an astatine atom?

[1 mark]

_____

0 4 . 4 Hydrogen reacts with astatine to produce hydrogen astatide.

Predict the formula of hydrogen astatide.

[1 mark]

_____

Question 4 continues on the next page

4.4.1.2 The reactivity series

Question 47 · continued

0 4 . 5 Explain the trend in reactivity of the elements going down Group 7.

[4 marks]

Extra space

0 4 . 6 A more reactive halogen can displace a less reactive halogen from a solution of its salt.

Write a balanced equation for the reaction between bromine and potassium iodide.

[3 marks]

_____ + _____ ⟶ _____ + _____

11