PEARSON EDEXCEL IGCSE CHEMISTRY · 4CH1

# CHEMISTRY



EXAM QUESTION PACK

## SECTION 2: INORGANIC CHEMISTRY (PACK 1)

| SCORE | PERCENTAGE |
| --- | --- |
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STEMUP

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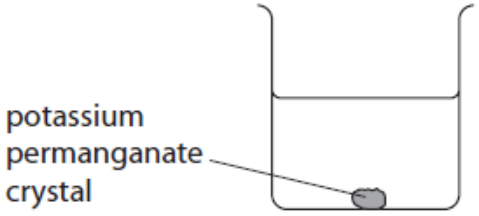
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Q1.

A potassium permanganate crystal is placed in a beaker of water.




After several days a coloured solution forms.

(a) Give the names of the two processes that cause the coloured solution to form.

**(2)**

1 .....

2 .....

(b) The formula of potassium permanganate is $KMnO_4$

(i) How many different types of atom are in $KMnO_4$?

**(1)**

☒ **A** 3

☒ **B** 4

☒ **C** 6

☒ **D** 7

(ii) Calculate the relative formula mass ($M_r$) of $KMnO_4$

**(1)**

$M_r$ = .....

(c) Potassium permanganate can be used as an oxidising agent.

State what is meant by the term **oxidising agent**.

**(1)**

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.....

**(Total for question = 5 marks)**

Q2.

This question is about some of the alkali metals and their compounds.

(a) When a teacher drops a small piece of sodium into a trough of cold water, she observes bubbles of gas.

Give two other observations that would be made when sodium reacts with cold water.

**(2)**

1 .....

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2 .....

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(b) Lithium reacts with fluorine to form the compound lithium fluoride.

(i) Give a chemical equation for this reaction.

**(1)**

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(ii) Give a test to show that lithium fluoride contains lithium ions.

**(2)**

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(iii) Draw diagrams to show the arrangement of the electrons in a lithium ion and in a fluoride ion.

Include the charge on each ion.

**(3)**

| lithium ion | fluoride ion |
|---|---|
| | |

(c) The table shows the electronic configurations of sodium and potassium.

| Element | Electronic configuration |
|---|---|
| sodium | 2.8.1 |
| potassium | 2.8.8.1 |

Explain, in terms of their electronic configurations, why potassium is more reactive than sodium.

**(3)**

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**(Total for question = 11 marks)**

Q3.

This question is about the metal aluminium.

(a) (i) Draw a labelled diagram to represent the structure and bonding in a metal.

**(2)**

(ii) Explain why a metal conducts electricity.

**(2)**

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(b) Aluminium is used to make cans for drinks.



Give two properties of aluminium that make it suitable for this use.

**(2)**

1 .....

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2 .....

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(c) Aluminium is extracted from aluminium oxide ($Al_2O_3$) by electrolysis.

The electrolyte is aluminium oxide dissolved in molten cryolite.

(i) State why aluminium cannot be extracted by heating aluminium oxide with carbon.

**(1)**

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(ii) Aluminium is produced at the negative electrode.

The ionic half-equation for the reaction is

$$Al^{3+} + 3e^- \rightarrow Al$$

State why this is a reduction reaction.

**(1)**

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(iii) Complete the ionic half-equation for the reaction at the positive electrode.

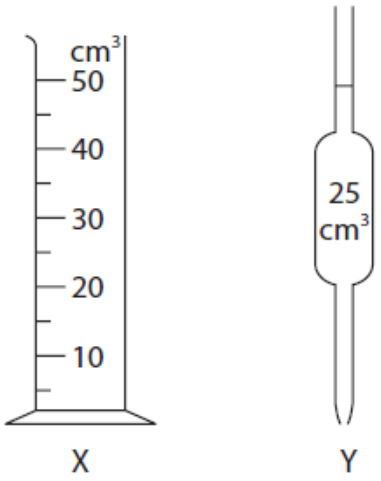
**(2)**

..... $O^{2-}$ → ..... +
.....

**(Total for question = 10 marks)**

Q4.

(a) The diagram shows two pieces of apparatus, X and Y.




(i) Give the name of each piece of apparatus.

**(2)**

X = .....

Y = .....

(ii) In a titration, a student adds 25.0 $cm^3$ of barium hydroxide solution to a conical flask.

Give a reason why it is better to use Y rather than X.

**(1)**

.....

.....

(b) The student uses methyl orange indicator in the titration.

(i) State the colour of methyl orange in barium hydroxide solution.

**(1)**

.....

(ii) Give a reason why universal indicator is **not** suitable for use in a titration.

**(1)**

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(c) The student adds some dilute nitric acid to a burette and does the titration.

The equation for the reaction is

$$Ba(OH)_2 + 2HNO_3 \rightarrow Ba(NO_3)_2 + 2H_2O$$

The student finds that 21.50 $cm^3$ of nitric acid of concentration 0.600 $mol/dm^3$ neutralises 25.0 $cm^3$ of barium hydroxide solution.

Calculate the concentration, in $mol/dm^3$, of the barium hydroxide solution.

**(3)**

concentration = ..... $mol/dm^3$

(d) State why sulfuric acid would not be a suitable acid to use in this titration.

**(1)**

.....

.....

**(Total for question = 9 marks)**

Q5.

Oxygen can be prepared from hydrogen peroxide using a catalyst.

(a) Which is a correct statement about oxygen?

**(1)**

☒ **A** it burns with a squeaky pop

☒ **B** it relights a glowing splint

☒ **C** it turns blue litmus red

☒ **D** it turns limewater milky

(b) Explain how a catalyst increases the rate of a reaction.

**(2)**

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(c) The equation for the preparation of oxygen from hydrogen peroxide is

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

This equation can also be written using displayed formulae to show all the covalent bonds in the molecules.

$$2H{-}O{-}O{-}H \rightarrow 2H{-}O{-}H + O{=}O$$

The table gives the bond energies for these bonds.

| **Bond** | H—O | O—O | O═O |
|---|---|---|---|
| **Bond energy in kJ/mol** | 463 | 143 | 498 |

(i) Use the values in the table to calculate the enthalpy change, $\Delta H$, for the reaction.

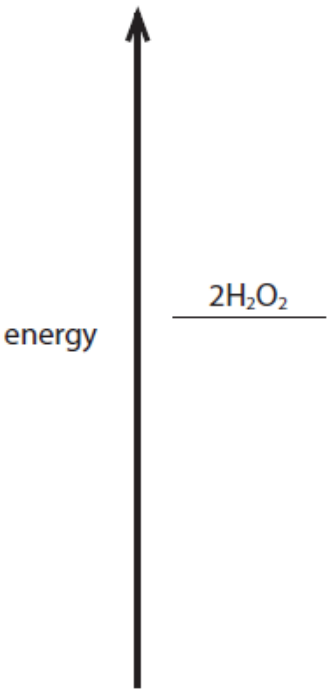
Include a sign in your answer.

**(3)**

$\Delta H$ = ..... kJ

(ii) Complete the energy level diagram to show the position of the products and the enthalpy change, $\Delta H$, for the reaction.

**(2)**




**(Total for question = 8 marks)**

Q6.

A technician finds a white solid in an unlabelled beaker.

She knows that the solid is one of the following substances:

- potassium chloride
- potassium sulfate
- sodium chloride
- sodium sulfate.

Describe how the technician can use chemical tests to identify the solid in the beaker.

**(6)**

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**(Total for question = 6 marks)**

Q7.

The table gives some information about the halogens, chlorine, bromine and iodine.

| Halogen | Physical state at room temperature | Colour |
|---|---|---|
| chlorine | gas | pale green |
| bromine | | red-brown |
| iodine | solid | |

(a) Complete the table.

**(2)**

(b) Chlorine has two isotopes of mass numbers 35 and 37

The relative percentage of each isotope in a sample of chlorine is

chlorine-35 77.78% chlorine-37 22.22%

Calculate the relative atomic mass of this sample of chlorine.

Give your answer to one decimal place.

**(3)**

relative atomic mass = .....

(c) A student is given an aqueous solution of chlorine and an aqueous solution of potassium bromide.

Explain how he can use these two solutions to compare the reactivity of chlorine with the

reactivity of bromine.

**(4)**

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**(Total for question = 9 marks)**

Q8.

A student investigates the reaction between sodium hydroxide solution and dilute sulfuric acid.

He does a titration to find the concentration of the sulfuric acid.

This is his plan for the titration. There are some mistakes and omissions in his plan.

- rinse a conical flask with the sodium hydroxide solution
- use a measuring cylinder to measure out 25 $cm^3$ of the sodium hydroxide solution and add it to the conical flask
- add a few drops of methyl orange indicator to the conical flask
- rinse a burette with water and then fill it with the sulfuric acid
- add the acid from the burette to the conical flask until the indicator changes colour at the end-point of the titration
- record the final burette reading

(a) Give the colour change of the methyl orange indicator at the end-point.

**(2)**

from ..... to .....

(b) Describe four changes that the student could make to improve his plan.

**(4)**

1 .....

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2 .....

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3 .....

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4 .....

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(c) The student then does the titration correctly.

He finds that 16.70 $cm^3$ of the dilute sulfuric acid neutralises 25.0 $cm^3$ of sodium hydroxide solution of concentration 0.200 $mol/dm^3$

The equation for the reaction is

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

Calculate the concentration, in $mol/dm^3$, of the sulfuric acid.

**(3)**

concentration of sulfuric acid = ..... $mol/dm^3$

**(Total for question = 9 marks)**

Q9.

This question is about elements, compounds and mixtures.

(a) Name the element that burns with a lilac flame.

**(1)**

.....

(b) Name the technique used to separate the mixture of colours in black ink.

**(1)**

.....

(c) The box gives the names of some substances.

| air | bromine | magnesium | neon | sodium chloride | sulfur |
|---|---|---|---|---|---|

Choose substances from the box to answer these questions.

(i) Identify the compound.

**(1)**

.....

(ii) Identify the mixture.

**(1)**

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(iii) Identify the non-metal element that is a solid at room temperature.

**(1)**

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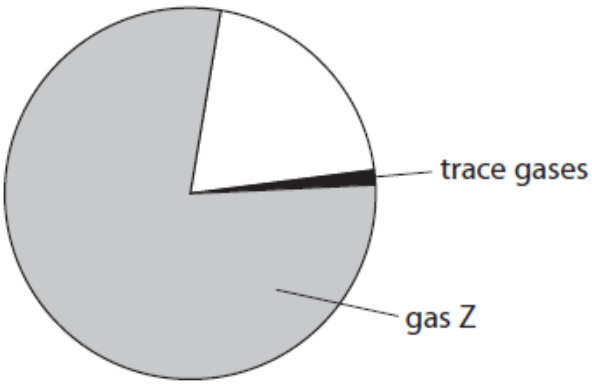
**(Total for question = 5 marks)**

Q10.

This question is about gases in the air.

The pie chart represents the percentages of gases in dry, unpolluted air.

Gases with percentages of less than 1% in air are called trace gases.




(a) (i) Which of these is gas Z?

**(1)**

☒ **A** hydrogen

☒ **B** methane

☒ **C** neon

☒ **D** nitrogen

(ii) Which of these is the approximate percentage of oxygen in dry, unpolluted air?

**(1)**

☒ **A** 0.04%

☒ **B** 0.9%

☒ **C** 21%

☒ **D** 35%

(b) One of the trace gases is carbon dioxide.

(i) Identify **two** reactions that produce carbon dioxide by placing a tick (✓) in two boxes.

**(2)**

| | |
|---|---|
| cracking an alkane | |
| complete combustion of an alkane | |
| reaction between magnesium and hydrochloric acid | |
| rusting of iron | |
| thermal decomposition of copper(II) carbonate | |

(ii) Name an environmental problem that is caused by the percentage of carbon dioxide increasing in the atmosphere.

**(1)**

.....

(iii) Name the trace gas with the highest percentage in dry, unpolluted air.

**(1)**

.....

(c) Rainwater is acidic because carbon dioxide dissolves in water to form carbonic acid.

Acid rain is more acidic than rainwater because acidic pollutant gases also dissolve in water.

(i) Give the name of the acid that forms when nitrogen dioxide dissolves in water.

**(1)**

.....

(ii) Name another pollutant gas that also forms acid rain.

**(1)**

.....

**(Total for question = 8 marks)**

Q11.

This question is about gases in the atmosphere.

The box gives the names of some gases.

| | | |
|---|---|---|
| argon | carbon dioxide | hydrogen |
| nitrogen | oxygen | water vapour |

(a) Choose gases from the box to answer these questions.

(i) Identify the least reactive gas in the atmosphere.

**(1)**

.....

(ii) Identify the most abundant gas in the atmosphere.

**(1)**

.....

(iii) Identify the gas that is not normally found in the atmosphere.

**(1)**

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(b) State an environmental problem caused by increasing amounts of carbon dioxide in the atmosphere.

**(1)**

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(c) Describe a test for carbon dioxide.

**(2)**

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**(Total for question = 6 marks)**

Q12.

This question is about gases.

(a) The box gives the names of some gases.

| argon | carbon dioxide | hydrogen | nitrogen | oxygen |
|---|---|---|---|---|

Use gases from the box to answer these questions.

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

(i) Name the most abundant gas in the Earth's atmosphere.

**(1)**

.....

(ii) Name the gas that is a compound.

**(1)**

.....

(iii) Name the least reactive of the gases.

**(1)**

.....

(iv) Name the gas formed by the complete combustion of hydrocarbons.

**(1)**

.....

(b) Describe the test for hydrogen gas.

**(1)**

.....

.....

**(Total for question = 5 marks)**

Q13.

This question is about some Group 2 elements and their compounds.

(a) Calcium reacts with water to produce calcium hydroxide and hydrogen gas.

(i) Give the word equation for this reaction.

**(1)**

.....

(ii) State two observations that would be made during this reaction.

**(2)**

1 .....

2 .....

(b) (i) Describe how a pure, dry sample of the insoluble salt, barium sulfate, could be made from the two solids sodium sulfate and barium chloride.

**(5)**

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(ii) Give an ionic equation for the reaction that occurs.

Include state symbols in your equation.

**(2)**

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(c) When magnesium nitrate is heated, magnesium oxide, nitrogen dioxide and oxygen form.

The equation for the reaction is

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

(i) What is the name for this type of reaction?

**(1)**

☒ **A** addition

☒ **B** combustion

☒ **C** decomposition

☒ **D** neutralisation

(ii) Calculate the **total** volume, in $dm^3$, of gas produced at rtp when 7.7 g of magnesium nitrate completely reacts.

[Assume that the molar volume of a gas at rtp is 24 $dm^3$]

[$M_r$ of $Mg(NO_3)_2$ = 148]

Give your answer to two significant figures.

**(4)**

total volume of gas = ..... $dm^3$

**(Total for question = 15 marks)**

Q14.

This question is about elements in Group 7 and their compounds.

The table gives information about some of these elements.

| Element | Symbol | Melting point in °C | Boiling point in °C | Colour at room temperature (20 °C) |
|---|---|---|---|---|
| fluorine | F | –220 | –188 | |
| chlorine | Cl | –101 | –35 | pale green |
| bromine | Br | –7 | 59 | red-brown |
| iodine | I | 114 | 184 | grey |

(a) (i) Predict the colour of fluorine at room temperature.

**(1)**

.....

(ii) How many of the elements in the table are liquids at room temperature (20°C)?

**(1)**

☒ **A** 0

☒ **B** 1

☒ **C** 2

☒ **D** 3

(iii) The element astatine is below iodine in Group 7.

Predict the formula of a molecule of astatine.

**(1)**

.....

(b) Sea water contains bromide ions.

Bromine can be obtained by bubbling chlorine through a sample of sea water.

The ionic equation for the reaction is

$$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$$

(i) Explain which species acts as an oxidising agent in this reaction.

**(2)**

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(ii) The reaction occurs because chlorine is more reactive than bromine.

Bromine is below chlorine in Group 7.

Explain the decrease in reactivity from chlorine to bromine.

**(3)**

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(c) Elements in Group 7 react with elements in Group 1 to form ionic compounds.

Which pair of ions both have the electronic configuration 2.8.8?

**(1)**

☒ **A** $Li^+$ and $Cl^-$

☒ **B** $K^+$ and $F^-$

☒ **C** $Li^+$ and $F^-$

☒ **D** $K^+$ and $Cl^-$

**(Total for question = 9 marks)**

Q15.

This question is about Group 7, the halogens.

(a) Which halogen has the palest colour?

**(1)**

☒ **A** astatine

☒ **B** bromine

☒ **C** fluorine

☒ **D** iodine

(b) Which halogen is a solid at room temperature?

**(1)**

☒ **A** astatine

☒ **B** bromine

☒ **C** chlorine

☒ **D** fluorine

(c) The table shows the electronic configurations of a fluorine atom and a chlorine atom.

| | Electronic configuration |
|---|---|
| fluorine | 2.7 |
| chlorine | 2.8.7 |

Explain the relative reactivities of fluorine and chlorine using the information in the table.

**(4)**

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(d) Lithium reacts with chlorine to form lithium chloride.

(i) Write a chemical equation for the reaction of lithium with chlorine.

**(1)**

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(ii) Describe tests to show that the product of the reaction is lithium chloride.

**(5)**

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**(Total for question = 12 marks)**

Q16.

Astatine, bromine, chlorine, fluorine and iodine are all halogens.

They are found in Group 7 of the Periodic Table.

(a) Predict which halogen has the lightest colour.

**(1)**

.....

(b) Name a halogen that is a solid at room temperature.

**(1)**

.....

(c) Bromine can be obtained from the bromide ions in sea water.

Chlorine is bubbled into sea water.
The chlorine oxidises the bromide ions to bromine atoms.
The bromine atoms then form bromine molecules.

(i) Complete the equation to show how bromine **atoms** are formed from bromide ions.

**(1)**

$$Cl_2 + \text{.....} Br^- \rightarrow 2Cl^- + \text{.....} Br$$

(ii) State why this reaction is described as the oxidation of bromide ions.

**(1)**

.....

.....

(iii) Write an equation to show how bromine atoms form bromine molecules.

**(1)**

.....

(d) Boron and fluorine form a covalent compound that has the molecular formula $BF_3$

Draw a dot-and-cross diagram to show the arrangement of the outer electrons in a molecule of $BF_3$

Use crosses (✕) to represent the outer electrons of boron. Use dots (•) to represent the outer electrons of fluorine.

**(2)**

**(Total for question = 7 marks)**

Q17.

This question is about the insoluble salt silver chloride (AgCl).

Silver chloride can be made by the reaction between copper(II) chloride and silver nitrate.

(a) Describe how a student could prepare a pure, dry sample of silver chloride starting with copper(II) chloride solution and silver nitrate solution.

**(4)**

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(b) A student investigates the quantity of silver chloride produced when different volumes of silver nitrate solution are added to copper(II) chloride solution.

This is the student's method.

- pour 5.0 $cm^3$ of copper(II) chloride solution into a test tube
- add 1.0 $cm^3$ of silver nitrate solution to the test tube
- allow the silver chloride precipitate to settle
- measure the height of the precipitate

The student repeats the method using different volumes of silver nitrate solution.

The table shows the student's results.

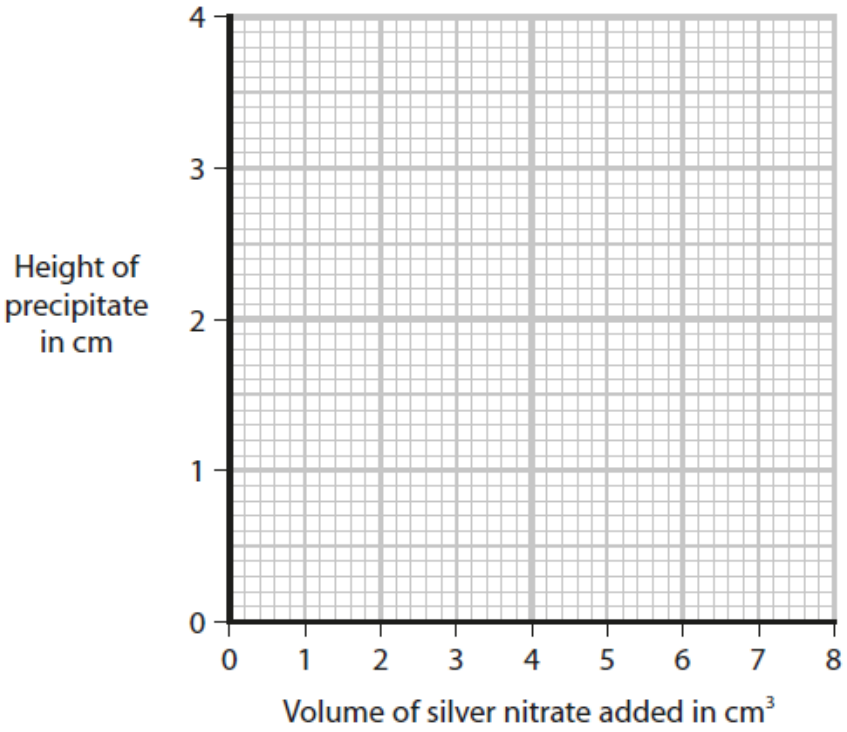
| Volume of silver nitrate added in $cm^3$ | Height of precipitate in cm |
|---|---|
| 0.0 | 0.0 |
| 1.0 | 0.5 |
| 2.0 | 1.0 |
| 3.0 | 1.2 |
| 4.0 | 2.0 |
| 5.0 | 2.5 |
| 6.0 | 3.0 |
| 7.0 | 3.0 |
| 8.0 | 3.0 |

(i) Plot the student's results.

**(2)**

(ii) Draw two straight lines of best fit, ignoring the anomalous result.

**(1)**




(iii) Suggest a mistake the student made to cause the anomalous result.

**(1)**

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.....

(iv) Give a reason why the last three heights are the same.

**(1)**

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(c) The equation for the reaction between copper(II) chloride and silver nitrate is

$$CuCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Cu(NO_3)_2(aq)$$

A student measures 25.0 $cm^3$ of 0.500 $mol/dm^3$ copper(II) chloride solution and reacts it with silver nitrate solution.

(i) Name a piece of apparatus suitable for measuring 25.0 $cm^3$ of copper(II) chloride solution.

**(1)**

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(ii) Calculate the maximum mass, in grams, of silver chloride that could be produced.

[$M_r$ of AgCl = 143.5]

**(3)**

maximum mass = ..... g

(iii) In an experiment using different solutions, the mass of silver chloride produced is 0.744 g.

The maximum mass of silver chloride that could be produced is 0.850 g.

Calculate the percentage yield.

**(2)**

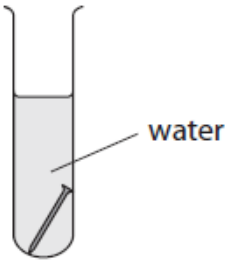
percentage yield = ..... %

**(Total for question = 15 marks)**

Q18.

A student investigates the rusting of iron.

(a) She places an iron nail in a test tube of water and leaves it for several days.




(i) Predict the appearance of the iron nail after several days.

**(1)**

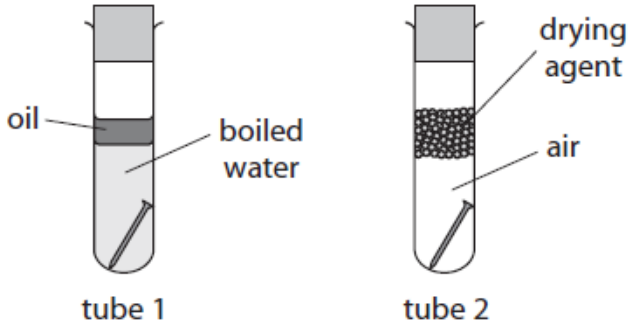
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(ii) Name the main compound in rust

**(1)**

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(b) The student then sets up two more test tubes containing iron nails.




Explain why the iron nail in tube 1 and the iron nail in tube 2 do not rust.

**(4)**

tube 1

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tube 2

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**(Total for question = 6 marks)**

Q19.

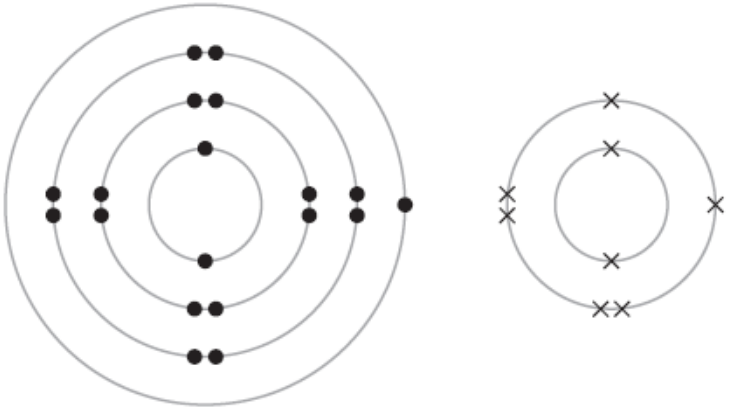
This question is about ionic compounds.

(a) State the formula of the cation and the anion in magnesium sulfate.

**(2)**

cation . . . . . anion . . . . . .

(b) The diagram shows the electronic configuration of a potassium atom and an oxygen atom.

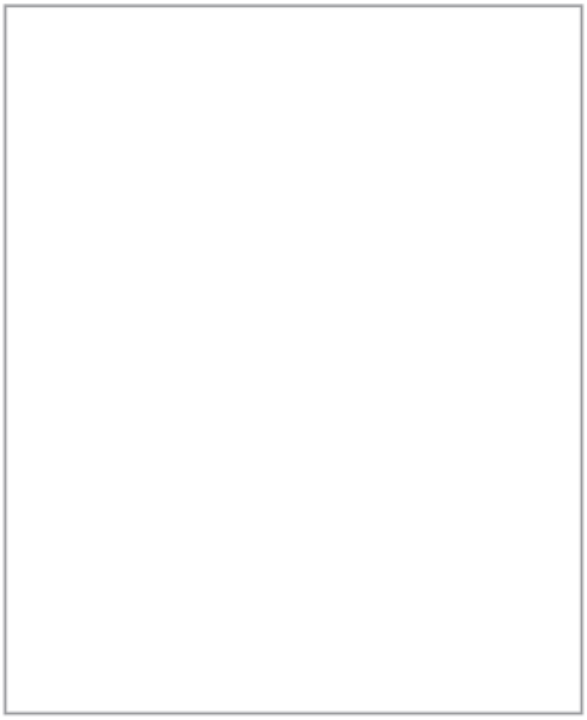



Potassium oxide ($K_2O$) is an ionic compound.

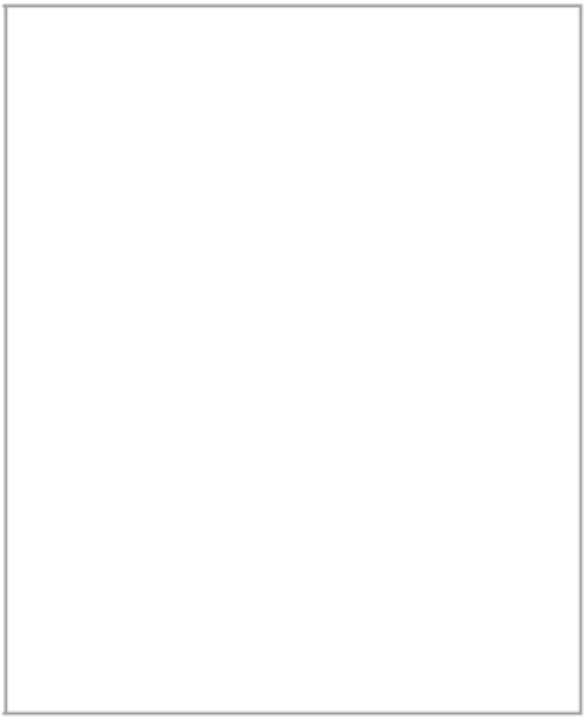
Draw the electronic configuration of a potassium ion and an oxide ion.

Show the charge on each ion.

**(3)**



potassium ion



oxide ion

(c) A sample of solid potassium oxide is added to water.

A reaction occurs and a colourless solution forms.

When a few drops of phenolphthalein indicator are added to the solution it turns pink.

(i) Identify the ion responsible for the colour change.

**(1)**

.....

(ii) Give a chemical equation for the reaction between potassium oxide and water.

**(1)**

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(d) Explain why ionic compounds conduct electricity when molten or in aqueous solution, but not when in the solid state.

**(2)**

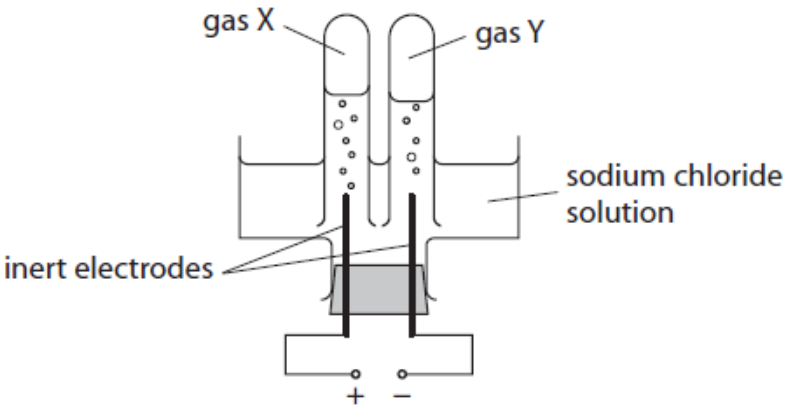
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(e) The diagram shows the apparatus a teacher uses to demonstrate the electrolysis of a concentrated aqueous solution of sodium chloride.




During the electrolysis two gases, X and Y, are formed. One of the gases produces a squeaky pop when tested with a lighted splint.

Use ionic half-equations to identify X and Y.

**(4)**

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**(Total for question = 13 marks)**

Q20.

This question is about magnesium and magnesium compounds.

(a) Magnesium burns in oxygen to form magnesium oxide.

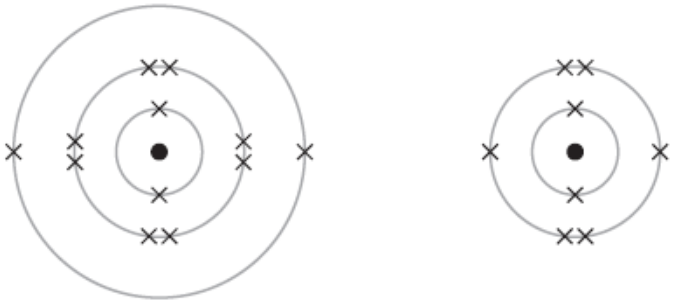
State two observations that would be seen during the reaction.

**(2)**

1 .....

2 .....

(b) The diagram shows the electron configurations of a magnesium atom and an oxygen atom.



magnesium atom oxygen atom

Describe the changes in the electronic configurations when magnesium reacts with oxygen to form the ionic compound magnesium oxide, MgO

**(2)**

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(c) Magnesium can be produced by the electrolysis of molten magnesium chloride.

(i) State why magnesium cannot be produced by heating magnesium oxide with carbon.

**(1)**

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(ii) Explain the different ways that magnesium and magnesium chloride conduct electricity.

**(4)**

magnesium

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magnesium chloride

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(d) During the electrolysis of molten magnesium chloride, magnesium is formed at the negative electrode.

The ionic half-equation for the reaction is

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

(i) State why this is a reduction reaction.

**(1)**

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(ii) Write an ionic half-equation for the formation of chlorine at the positive electrode.

**(1)**

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**(Total for question = 11 marks)**

Q21.

This question is about metals.

(a) Which statement describes metallic bonding?

**(1)**

☒ **A** electrostatic attraction between oppositely charged ions

☒ **B** electrostatic attraction between the nuclei of two atoms and a pair of electrons shared between them

☒ **C** electrostatic attraction between positively charged particles and delocalised electrons

☒ **D** electrostatic attraction between atoms

(b) Aluminium is malleable and can be easily shaped to make saucepans used for cooking food.

State two other properties of aluminium that make it suitable for saucepans used for cooking food.

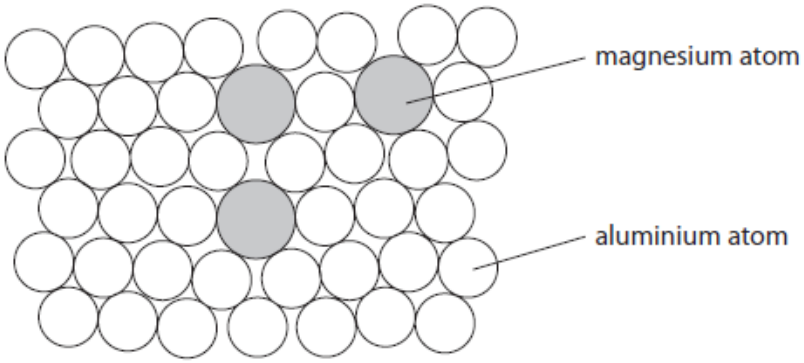
**(2)**

1 .....

2 .....

(c) Magnalium is an alloy of aluminium and magnesium.

The diagram shows how the atoms are arranged in this alloy.




(i) State what is meant by the term **alloy**.

**(1)**

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(ii) Explain why magnalium is harder than aluminium.

**(3)**

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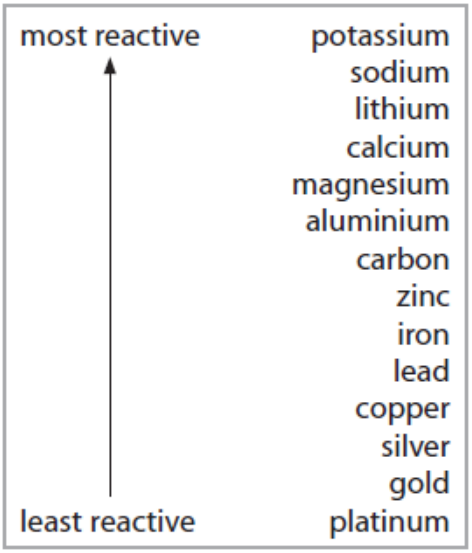
**(Total for question = 7 marks)**

Q22.

Metals are found in the Earth's crust either as uncombined elements or in metal compounds in rocks.

The method of extraction of a metal is related to its position in the reactivity series.

The table shows the positions of some metals and carbon in the reactivity series.




(a) (i) State the name given to rocks that contain metal compounds used in the extraction of metals.

**(1)**

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(ii) Name a metal that is found as an uncombined element in the Earth's crust.

**(1)**

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(b) Carbon extraction and electrolysis are two methods of obtaining a metal from a compound.

(i) Explain, without giving practical details, which method is most suitable to obtain calcium from calcium chloride.

**(2)**

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(ii) Explain, without giving practical details, which method is most suitable to obtain lead from lead oxide.

**(2)**

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(c) Explain, using a labelled diagram, why lead metal is malleable.

**(3)**

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(d) Aluminium is extracted from aluminium oxide.

The overall equation for the process is

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Calculate the maximum mass, in grams, of aluminium that could be obtained from 1.275 kg of aluminium oxide.

**(3)**

mass = ..... g

**(Total for question = 12 marks)**

Q23.

A teacher prepares the insoluble salt lead(II) bromide ($PbBr_2$) by mixing solutions of lead(II) nitrate and sodium bromide.

(a) Describe what the teacher should do next to obtain a pure, dry sample of lead(II) bromide.

**(3)**

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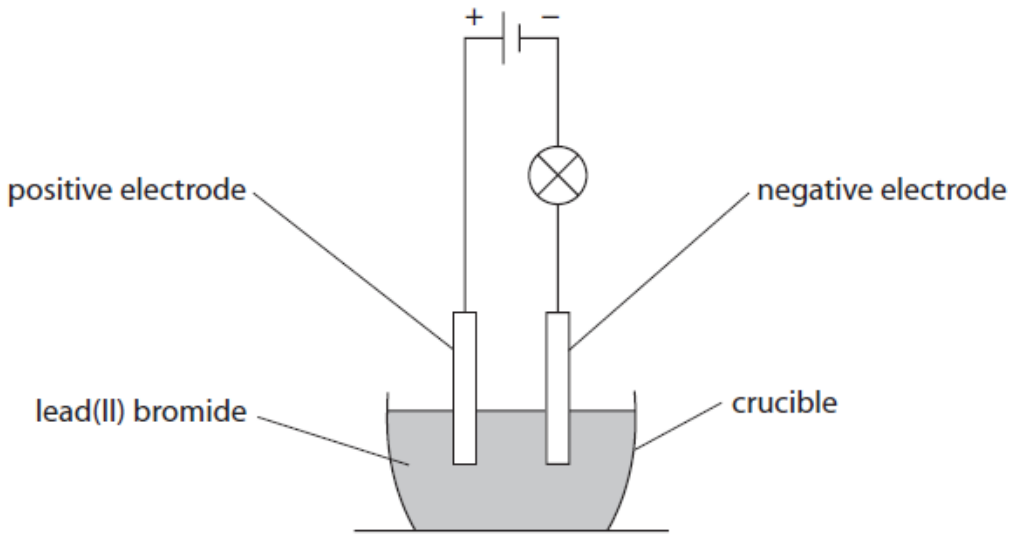
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(b) The teacher then sets up a circuit in a fume cupboard using the pure, dry sample of lead(II) bromide.




Explain why the lamp does not light when the lead(II) bromide is solid.

**(2)**

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(c) The teacher heats the lead(II) bromide.

When the lead(II) bromide is molten, the lamp lights and bromine forms at the positive electrode.

(i) State what observation would be made at the positive electrode.

**(1)**

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(ii) Explain how bromide ions in the molten lead(II) bromide become bromine molecules at the positive electrode.

**(4)**

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(d) Write an ionic half-equation for the reaction that occurs at the negative electrode.

Include state symbols in your equation.

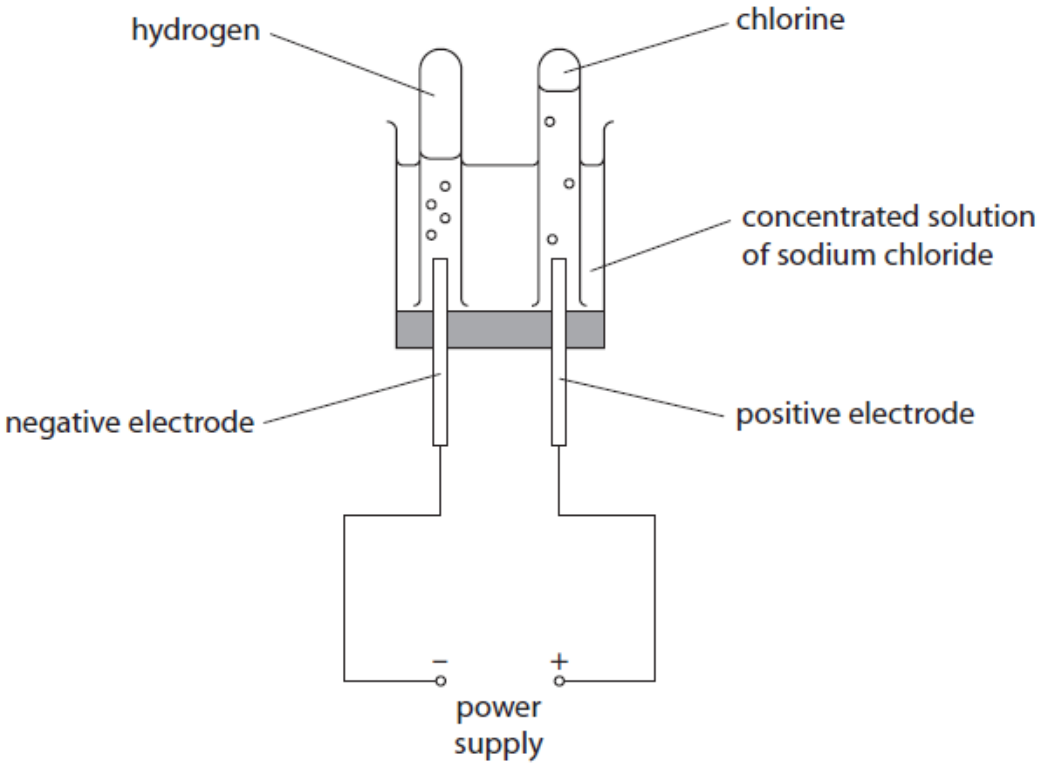
**(2)**

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**(Total for question = 12 marks)**

Q24.

The diagram shows how hydrogen gas and chlorine gas can be prepared in the laboratory by electrolysis of a concentrated solution of sodium chloride.




(a) (i) Give a test for hydrogen gas.

**(1)**

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(ii) Give a test for chlorine gas.

**(2)**

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(b) The ionic half-equation for the formation of chlorine at the positive electrode is

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

(i) State why this reaction is an oxidation reaction.

**(1)**

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(ii) Give the ionic half-equation for the formation of hydrogen at the negative electrode.

**(1)**

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(iii) State why it is safer to do this electrolysis in a fume cupboard.

**(1)**

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(iv) Suggest why the volume of chlorine collected during this electrolysis is less than the volume of hydrogen collected.

**(1)**

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(c) In the chemical industry, chlorine can be produced by the electrolysis of molten sodium chloride.

The overall equation for this reaction is

$$2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$$

(i) Explain why sodium chloride needs to be molten rather than solid for electrolysis to occur.

**(2)**

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(ii) Calculate the maximum volume, in $dm^3$, of chlorine gas at rtp that can be obtained from 23.4 tonnes of molten sodium chloride.

[1 tonne = $10^6$ g]

[$M_r$ of NaCl = 58.5]

[molar volume of chlorine at rtp = 24 $dm^3$]

Give your answer in standard form.

**(4)**

volume = ..... $dm^3$

**(Total for question = 13 marks)**

Q25.

This question is about ammonia gas, $NH_3$

(a) Ammonia can be prepared in a laboratory from the reaction between ammonium chloride, $NH_4Cl$, and sodium hydroxide. The other products of the reaction are sodium chloride and water.

(i) Give a chemical equation for this reaction.

**(1)**

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(ii) Give a test for ammonia gas.

**(2)**

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(b) In industry, ammonia is produced from nitrogen and hydrogen.

The equation for this reaction is

$$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$$

In a sealed container, the reaction can reach a position of dynamic equilibrium.

Explain the meaning of the term **dynamic equilibrium**.

**(2)**

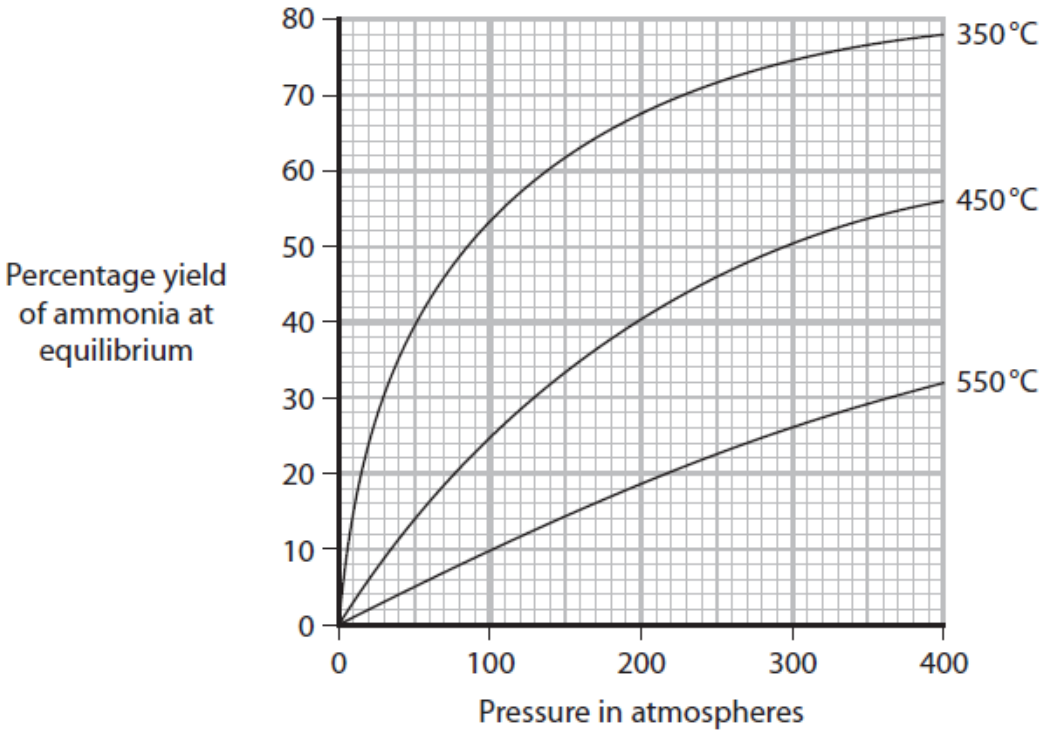
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(c) The graph shows the percentage yield of ammonia at equilibrium for different temperatures and pressures.




Using the graph, explain if the forward reaction is exothermic or endothermic.

**(2)**

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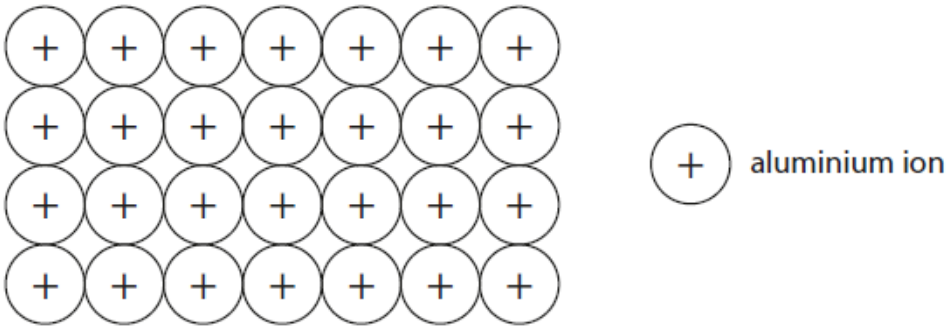
**(Total for question = 7 marks)**

Q26.

This question is about the metal aluminium.

(a) Aluminium is malleable and conducts electricity.

The diagram shows the arrangement of the ions in aluminium metal.




(i) Explain why aluminium is malleable.

**(2)**

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(ii) Explain why aluminium conducts electricity.

**(2)**

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(b) Aluminium cannot be extracted by heating a mixture of carbon and aluminium oxide.

Give a reason why heating a mixture of aluminium oxide and carbon does not produce aluminium.

**(1)**

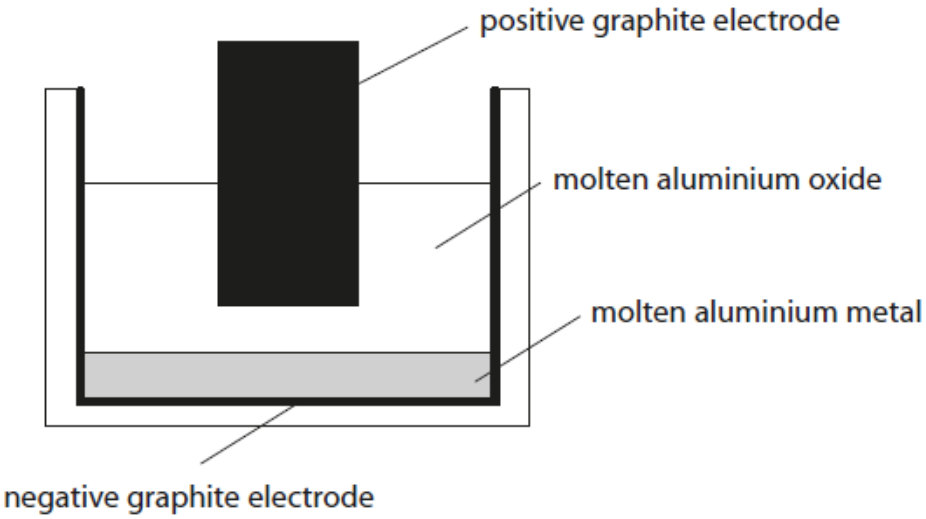
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(c) Aluminium is extracted industrially by the electrolysis of molten aluminium oxide $Al_2O_3$ at a temperature of about 950 °C.

Aluminium metal forms at the negative electrode and oxygen gas forms at the positive electrode. The positive and negative electrodes are made of graphite.

The diagram shows the apparatus used.




(i) Explain how aluminium metal forms at the negative electrode.

**(2)**

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(ii) Write an ionic half-equation for the formation of oxygen gas at the positive electrode.

**(1)**

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(iii) Suggest why carbon dioxide gas is also produced at the positive electrode.

**(2)**

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(d) Aluminium reacts with iron(III) oxide. The reaction is exothermic.

The equation for the reaction is

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

(i) State how the equation shows that iron(III) oxide is reduced.

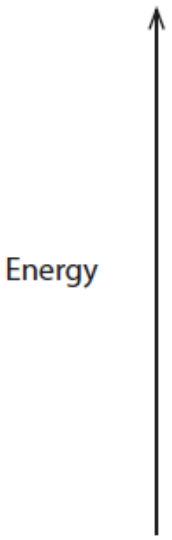
**(1)**

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(ii) Draw an energy level diagram for the reaction between aluminium and iron(III) oxide.

**(3)**




**(Total for question = 14 marks)**

Q27.

(a) The box gives the names of some metals.

| calcium | copper | iron | magnesium | silver | zinc |
|---|---|---|---|---|---|

(i) Identify the metal from the box that burns with a bright white flame.

**(1)**

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(ii) In the Earth, metals are found either in ores or as uncombined elements.

Explain which metal from the box is most likely to be found as an uncombined element.

**(2)**

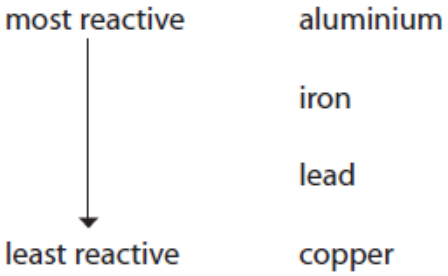
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(b) This is the order of reactivity of four metals.




The method used to obtain a metal from its oxide depends on the reactivity of the metal.

Two possible methods are

Method 1 heating the metal oxide with carbon

Method 2 electrolysis

Explain which method should be used to obtain lead from lead(II) oxide, PbO

Include an equation for the formation of lead in your answer.

**(3)**

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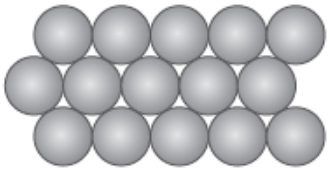
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(c) The diagram shows the arrangement of the particles in a pure metal.



Metals are often made into alloys to make them harder.

Explain why alloys are harder than pure metals.

Draw a diagram to support your answer.

**(4)**

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**(Total for question = 10 marks)**

Q28.

This question is about sodium and potassium.

A trough is filled with water and a few drops of phenolphthalein indicator are added.

(a) A small piece of sodium is dropped into the water. One of the products of the reaction is an alkali.

(i) Complete the chemical equation for the reaction of sodium with water.

**(2)**

_____Na(.....) + _____$H_2O(l)$ → _____NaOH(.....) + $H_2(g)$

(ii) Identify the ion that causes the solution to become alkaline.

**(1)**

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(iii) Give three observations that would be made when sodium reacts with water.

**(3)**

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2 .....

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3 .....

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(b) Explain why potassium is more reactive than sodium.

Refer to the electronic configurations of the atoms in your answer.

**(3)**

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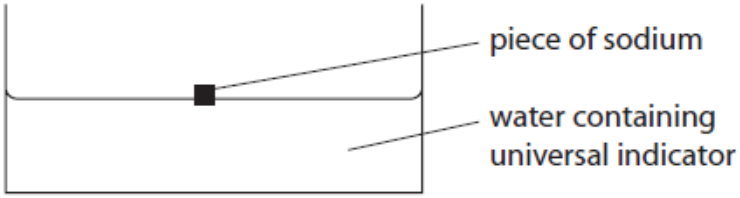
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**(Total for question = 9 marks)**

Q29.

This question is about the reactions of Group 1 metals with water.

(a) A teacher adds a piece of sodium to some water containing universal indicator.




The equation for this reaction is

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

The sodium floats on the surface of the water and the universal indicator changes colour because an alkaline solution is formed.

(i) Give two other observations.

**(2)**

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2 .....

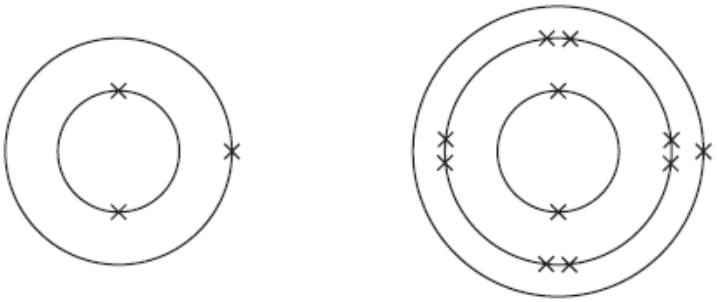
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(ii) Give the final colour of the universal indicator.

**(1)**

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(b) The diagram represents an atom of lithium and an atom of sodium.



lithium sodium

(i) Give a reason why lithium and sodium have similar reactions with water.

**(1)**

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(ii) Explain why lithium is less reactive than sodium.

**(3)**

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(c) The teacher adds 0.150 g of lithium to an excess of water and collects the hydrogen gas produced.

The equation for the reaction is

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

The teacher collects 254 $cm^3$ of hydrogen gas at room temperature and pressure (rtp).

Show by calculation that 1 mol of hydrogen gas has a volume of approximately 24 000 $cm^3$ at rtp.

**(4)**

**(Total for question = 11 marks)**

Q30.

Zinc metal is obtained from sulfide ores.

The most common ore of zinc is sphalerite, which contains zinc sulfide (ZnS) and a small amount of cadmium sulfide (CdS).

The stages involved in the extraction of zinc from sphalerite are:

Stage 1 Sphalerite is strongly heated in air.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

$$2CdS(s) + 3O_2(g) \rightarrow 2CdO(s) + 2SO_2(g)$$

Stage 2 The mixture of oxides is reacted with sulfuric acid.

$$ZnO(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2O(l)$$

$$CdO(s) + H_2SO_4(aq) \rightarrow CdSO_4(aq) + H_2O(l)$$

Stage 3 Zinc dust is added to the solution containing zinc sulfate and cadmium sulfate to remove the cadmium ions.

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

Stage 4 The solid cadmium is filtered off and the pure zinc sulfate solution is electrolysed.

(a) State how the reaction in stage 3 shows that zinc is more reactive than cadmium.

**(1)**

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(b) (i) During the electrolysis in stage 4, zinc is deposited on the cathode.

Write an ionic half-equation for the reaction that occurs.

**(1)**

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(ii) Complete the ionic half-equation for the reaction occurring at the anode.

..... $H_2O$ → .....$H^+$ + $O_2$ + ..... $e^-$

**(1)**

(iii) Explain how the pH of the solution surrounding the anode changes during the electrolysis.

**(2)**

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(c) Zinc is mixed with copper to make the alloy brass.

Explain why brass is harder than pure copper.

**(3)**

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**(Total for question = 8 marks)**