1. The student reacts the magnesium carbonate they have made with hydrochloric acid.

i. Complete the **balanced equation.**

Include state symbols.

$MgCO_3(s) + 2HCl(aq) \rightarrow$ .....(.....) + $H_2O(l)$ + ...(.....)

[2]

ii. A student uses 0.2 mol of hydrochloric acid in the reaction. The hydrochloric acid is the **limiting reagent**.

At the end of the reaction, 0.82 g of magnesium carbonate is left unreacted.

Calculate the mass of magnesium carbonate that the student uses in the reaction.

Relative atomic mass (A_r): C = 12.0 Mg = 24.3 O = 16.0

Mass of magnesium carbonate = ... g **[4]**

2. Zinc reacts with iron chloride to form zinc chloride and iron.

$Zn + FeCl_2 \rightarrow ZnCl_2 + Fe$

What is the **balanced ionic equation** for this reaction?

A $Zn + Fe^{+} \rightarrow Zn^{+} + Fe$
B $Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$
C $Zn + 2Fe^{+} \rightarrow Zn^{2+} + 2Fe$
D $2Zn + Fe^{2+} \rightarrow 2Zn^{+} + Fe$

Your answer ☐ **[1]**

3. Molten aluminium oxide, Al_2O_3, is electrolysed.

Which row of the table shows the reactions at the electrodes?

	Cathode	Anode
A	$Al^{3+} + 3e^- \rightarrow Al$	$O^{2-} \rightarrow O_2 + 2e^-$
B	$Al^{3+} \rightarrow Al + 3e^-$	$O^{2-} + 2e^- \rightarrow O_2$
C	$Al^{3+} + 3e^- \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4e^-$
D	$Al^{3+} \rightarrow Al + 3e^-$	$2O^{2-} + 4e^- \rightarrow O_2$

Your answer ☐ **[1]**

4. Copper nitrate decomposes into copper oxide, nitrogen dioxide and oxygen.

$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$

How many moles of products are formed if 18 mol of copper nitrate decomposes?

	CuO (mol)	NO_2 (mol)	O_2 (mol)
A	18	18	18
B	18	36	9
C	36	18	9
D	36	36	18

Your answer ☐ **[1]**

5. What is the mass of one atom of beryllium, Be?

Relative atomic mass (A_r): Be = 9.0.

The Avogadro constant is 6.02×10^{23}.

A 6.64×10^{-24} g
B 1.50×10^{-23} g
C 2.41×10^{24} g
D 5.42×10^{24} g

Your answer ☐ **[1]**

6. A lithium ion is Li^+ and a phosphate ion is PO_4^{3-}.

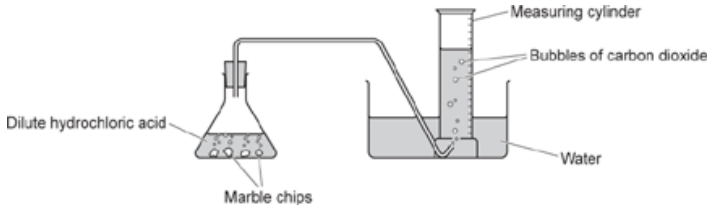
What is the formula of lithium phosphate?

A $Li(PO_4)_3$
B Li_2PO_4
C $Li_2(PO_4)_3$
D Li_3PO_4

Your answer ☐ **[1]**

7(a). A student investigates the reaction between marble chips and dilute hydrochloric acid.

The diagram shows their experiment.



The student measures the volume of carbon dioxide gas collected in the measuring cylinder every 30 seconds.

i. Suggest another piece of equipment that could be used to measure the volume of carbon dioxide gas.

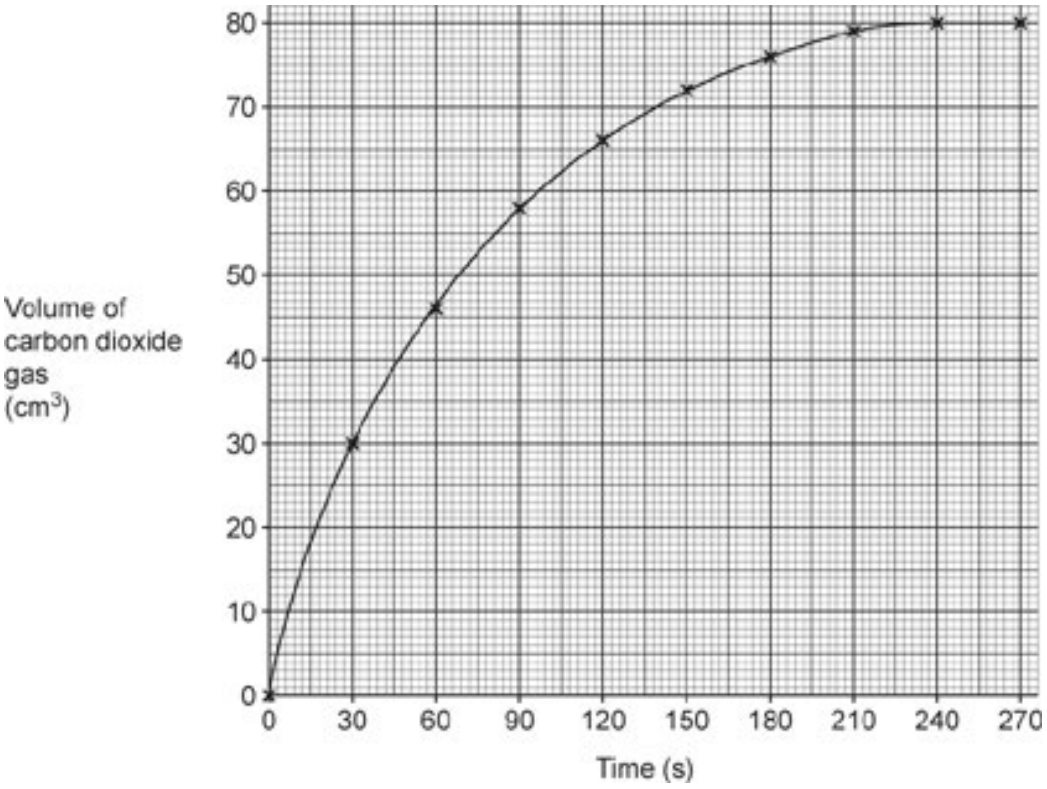
_____ **[1]**

ii. Explain how the student could tell that the dilute hydrochloric acid is the limiting reactant in this reaction.

_____

_____ **[1]**

(b). The student plots their results on a graph.



Use the graph and a tangent line to calculate the rate of the reaction at 60 seconds.

Rate of reaction at 60 seconds = ... cm^3 / s **[3]**

(c). The rate of the reaction can be changed by adding a catalyst.

i. What happens to the final volume of carbon dioxide when a catalyst is added?

---

[1]

ii. How does the mass of the catalyst change during the experiment?

---

[1]

8. Copper is extracted by heating copper oxide with carbon.

$2CuO + C \rightarrow 2Cu + CO_2$

i. Explain why this is an example of a **redox** reaction.

---

[2]

ii. Calculate the mass of copper that can be made from 15 tonnes of copper oxide.

$2CuO + C \rightarrow 2Cu + CO_2$

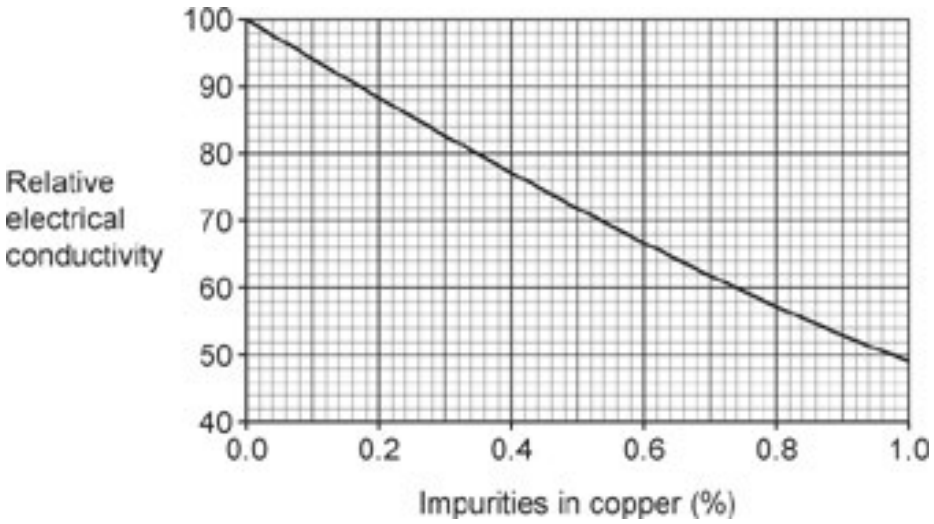
Give your answer to **2** significant figures.

Relative atomic mass (A_r): Cu = 63.5
Relative molecular mass (M_r): CuO = 79.5

Mass of copper = ...tonnes **[3]**

iii. Copper is used in electrical wires.

The graph shows how impurities in copper affect the relative electrical conductivity of copper.



Copper extracted from copper oxide is about 99% pure.

Explain why copper extracted from copper oxide is purified to almost 100% pure using electrolysis.

Use data from the graph in your answer.

[2]

9. The first member of the alkane homologous series is methane, CH_4.

Write the **balanced symbol** equation for the **complete** combustion of methane.

[2]

10. Nitrogen and oxygen react together at high temperatures in car engines.

Nitrogen monoxide is made.

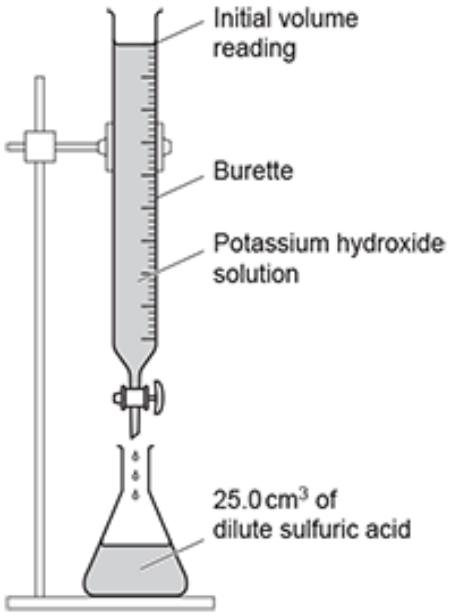
What is the **balanced** equation for the reaction?

A $N + O \rightarrow NO$
B $N + O_2 \rightarrow NO_2$
C $N_2 + O_2 \rightarrow 2NO$
D $2N_2 + O_2 \rightarrow 2N_2O$

Your answer ☐ **[1]**

11(a). A student plans a titration experiment.

The diagram shows some of the apparatus they use.



At the end of the titration, the student reads the final volume reading from the top of the meniscus instead of from the bottom of the meniscus.

How does the measured volume of potassium hydroxide compare to the actual volume?

Tick (✓) **one** box.

The measured volume will be greater than the actual volume. ☐
The measured volume will be smaller than the actual volume. ☐
The measured volume will be the same as the actual volume. ☐

[1]

(b). The student uses a potassium hydroxide solution with a concentration of 0.100 mol / dm^3 to neutralise the 25.0 cm^3 of dilute sulfuric acid.

The table shows the student's results.

Titration number	**1**	**2**	**3**	**4**
Final burette reading (cm^3)	24.1	26.6	26.0	26.8
Initial burette reading (cm^3)	0.0	1.5	2.1	2.8
Titre (volume of potassium hydroxide solution used) (cm^3)	24.1	25.1	23.9	24.0

i. Calculate the average titre using the student's concordant results.

Average titre = ... cm^3 **[1]**

ii. This is the equation for the reaction in this experiment.

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

Calculate the concentration of sulfuric acid in **g / dm^3** .

Relative atomic mass (A_r): H = 1.0 O = 16.0 S = 32.0

Concentration of sulfuric acid = ... g / dm^3 **[5]**

12. Group 7 elements (halogens) react with halides in solution.

Chlorine reacts with potassium bromide to form potassium chloride and bromine.

$Cl_2(g) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(aq)$

This is the half equation that shows what happens to chlorine.

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

i. Explain why this half equation shows reduction.

---

[1]

ii. Write the **balanced half** equation for the reaction of the bromide ions.

---

[2]

13. Cracking breaks down large molecules produced in fractional distillation into more useful molecules.

The equation shows the cracking of octacosane to make dodecane and **one** other product.

Complete and balance the equation.

$$\underset{\text{octacosane}}{C_{28}H_{58}} \longrightarrow \underset{\text{dodecane}}{C_{12}H_{26}} + \text{.....}$$

[2]

14. 0.1 g of magnesium reacts with hydrochloric acid to make 0.008 g of hydrogen gas.

Calculate the volume occupied by 0.008 g of hydrogen gas in **cm^3** .

Relative atomic mass (A_r): H = 1.0

Volume of hydrogen gas = ... cm^3 **[4]**

15. Butane, C_4H_{10}, is an alkane.

Butane undergoes complete combustion in oxygen.

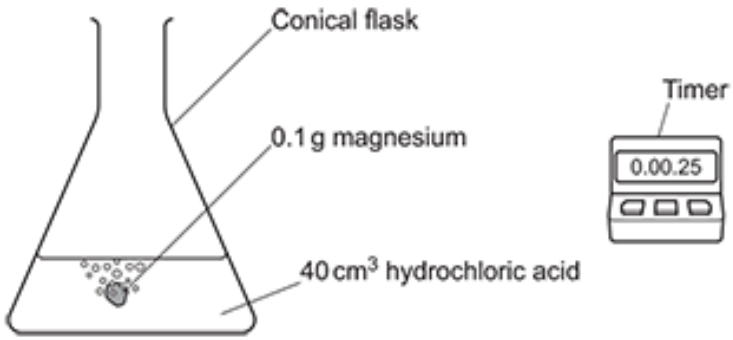
Write the **balanced symbol** equation for the complete combustion of butane.

---

[2]

16. A teacher investigates the reaction between hydrochloric acid and magnesium.

The diagram shows the teacher's experiment.



The teacher uses five different concentrations of hydrochloric acid. Each time they react the hydrochloric acid with 0.1 g of magnesium powder.

The table shows the teacher's results.

Concentration of hydrochloric acid (mol / dm^3)	**Time for magnesium powder to react(s)**
0.5	117
1.0	82
1.5	48
2.0	24
2.5	16

Write the **balanced symbol** equation for the reaction between hydrochloric acid, HC*l*, and magnesium.

_____ **[2]**

17. Magnesium nitrate is an ionic compound.

i. Explain why magnesium forms Mg^{2+} ions.

_____

_____ **[1]**

ii. A solution containing magnesium ions reacts with a solution containing hydroxide ions.

Solid magnesium hydroxide is made.

Write the **balanced ionic** equation for this reaction.

_____ **[2]**

18. Seawater can contain isotopes of sulfur.

i. Draw **three** lines to connect each **isotope** with its correct **description**.

Isotope	Description
$^{16}_{32}S$	This isotope contains 17 neutrons.
$^{16}_{33}S$	This isotope has a full outer shell of electrons.
$^{16}_{34}S$	This isotope has more protons than neutrons.
	This isotope has the highest mass number.
	This isotope has the same number of neutrons and protons.

[2]

ii. Some of this sulfur in seawater is in the form of magnesium sulfate, $MgSO_4$.

What is the relative formula mass of a sample of magnesium sulfate, $MgSO_4$, where all of the sulfur atoms are the isotope sulfur-33?

Sulfur-33 is $^{16}_{33}S$

Relative atomic mass (A_r): O = 16.0 Mg = 24.3

Relative formula mass = ... **[2]**

iii. A scientist wants to separate magnesium sulfate from other compounds using thin layer chromatography.

The spot does **not** move from the start line on the chromatogram.

State what the scientist should change so that magnesium sulfate is separated from the other compounds.

---

[1]

iv. Explain why magnesium sulfate has a high melting point.

---**[2]**

19. Magnesium nitrate decomposes when heated to form magnesium oxide.

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

i. Calculate the **mass** of oxygen made when 0.45 moles of magnesium nitrate decomposes.

Relative atomic mass (A_r): O = 16.0.

Mass of oxygen = ... g **[3]**

ii. Calculate how many **molecules** of nitrogen dioxide, NO_2, are produced from 0.45 moles of magnesium nitrate.

The Avogadro constant is 6.02×10^{23}.

Give your answer to **3** significant figures.

Number of molecules of NO_2 = ... **[3]**

20. Complete the **balanced half** equation for the production of bromine from bromide ions.

$$2Br^- - \text{.....} \rightarrow \text{.....}$$

[2]

21. What is the correct balanced equation for the combustion of hexane, C_6H_{14}?

A $C_6H_{14} + 13O_2 \rightarrow 6CO_2 + 7H_2O$
B $C_6H_{14} + 6O_2 \rightarrow 6CO_2 + 7H_2O$
C $2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$
D $2C_6H_{14} + 26O_2 \rightarrow 12CO_2 + 14H_2O$

Your answer ☐ **[1]**

22. How many moles are in 30 g of nitrogen, N_2?

Relative atomic mass (A_r): N = 14.0

A 0.47 mol
B 0.93 mol
C 1.07 mol
D 2.14 mol

Your answer ☐ **[1]**

23. Calcium phosphate contains the ions Ca^{2+} and PO_4^{3-}.

What is the formula for calcium phosphate?

A $CaPO_4$
B Ca_2PO_4
C $Ca_2(PO_4)_3$
D $Ca_3(PO_4)_2$

Your answer ☐ **[1]**

24(a). Most cars have catalytic converters which catalyse the reaction between nitrogen monoxide and carbon monoxide to make nitrogen and carbon dioxide gases.

i. Explain how the use of a catalyst in the catalytic converter increases this rate of reaction.

_____

_____

[2]

ii. The equation shows the reaction that takes place in a catalytic converter.

$2CO + 2NO \rightarrow N_2 + 2CO_2$

During a car journey, 187 g of carbon dioxide is made by the catalytic converter.

Calculate the **volume of carbon monoxide**, in dm^3, removed from the exhaust gases.

Relative atomic mass (A_r): C = 12.0 O = 16.0

Volume of carbon monoxide = ... dm^3 **[4]**

(b). C_2H_4 burns in oxygen.

Write the **balanced symbol** equation for the **incomplete** combustion of C_2H_4.

_____ **[2]**

25. Sodium, in Group 1, reacts with fluorine in Group 7.

Sodium fluoride is made.

What is the **balanced symbol** equation for the reaction?

A $Na + F \rightarrow NaF$
B $2Na + F_2 \rightarrow 2NaF$
C $Na + F_2 \rightarrow NaF_2$
D $2Na + F \rightarrow Na_2F$

Your answer ☐ **[1]**

26. Phosphorus can exist as P_4 molecules.

Phosphorus trichloride, PCl_3, is made in the reaction of phosphorus, P_4, and chlorine as shown in the equation.

$P_4 + 6Cl_2 \rightarrow 4PCl_3$

i. A scientist starts the reaction with 2.0 mol of phosphorus, P_4.

Calculate the mass of 2.0 mol of phosphorus.

Mass of phosphorus = ... g **[2]**

ii. Calculate the maximum mass of phosphorus trichloride, PCl_3, that could be made from 2.0 mol of phosphorus, P_4.

Maximum mass of phosphorus trichloride = ... g **[3]**

iii. The scientist reacts the 2.0 mol of phosphorus, P_4, with 866.2 g of chlorine, Cl_2.

Which is the **limiting reactant**? Explain your answer.

Limiting reactant _____

Explanation _____

_____

_____

_____

[4]

27(a).

Compounds that contain the element zinc, Zn, have many uses.

Calculate the mass of one atom of zinc.

The Avogadro constant is 6.02×10^{23}.

Give your answer to **3** significant figures.

Mass of one atom of zinc = ... g **[3]**

(b). Zinc bromide is an ionic compound made from zinc ions, Zn^{2+}, and bromide ions, Br^-.

i. Construct a **balanced ionic** equation for the formation of zinc bromide.

_____ **[2]**

ii. Zinc bromide can conduct electricity when aqueous or molten, but not when solid.

Zinc metal can conduct electricity when solid.

Explain why.

Zinc bromide _____

_____

Zinc metal _____

_____

[3]

28. Write the **ionic symbol** equation for a neutralisation reaction.

Include state symbols.

_____ **[2]**

29. One mole of hydrogen gas, H_2, fills a volume of 24 dm^3.

How much volume does 2.0 g of hydrogen gas fill?

A 12 dm^3
B 24 dm^3
C 36 dm^3
D 48 dm^3

Your answer ☐ **[1]**

END OF QUESTION PAPER