Chemical Measurements

Total mark – 19

Q1.

A student investigated the reactivity of metals with hydrochloric acid.

This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a polystyrene cup.
2. Measure the temperature of the hydrochloric acid.
3. Add one spatula of metal powder to the hydrochloric acid and stir.
4. Measure the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1 to 5 three more times.
7. Repeat steps 1 to 6 with different metals.

The table below shows the student's results.

Metal	Temperature increase in °C				Mean temperature increase in °C
	Trial 1	Trial 2	Trial 3	Trial 4	
Cobalt	6	7	5	9	7
Magnesium	54	50	37	55	**X**
Zinc	18	16	18	20	18

(a) Calculate the mean temperature increase **X** for magnesium in the table above.

Do **not** include the anomalous result in your calculation.

X = _____ °C

(2)

(b) Determine the order of reactivity for the metals cobalt, magnesium and zinc.

Use the table above.

Most reactive _____

_____

Least reactive _____

(1)

(c) The range of measurements either side of the mean shows the uncertainty in the mean temperature increase.

Complete the sentence.

Use the table above.

The mean temperature increase for zinc is 18 ± _____ °C

(1)

(d) What type of variable is the volume of hydrochloric acid in this investigation?

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

(1)

(e) Suggest **one** way of improving **step 3** in the method to give results which are more repeatable.

_____

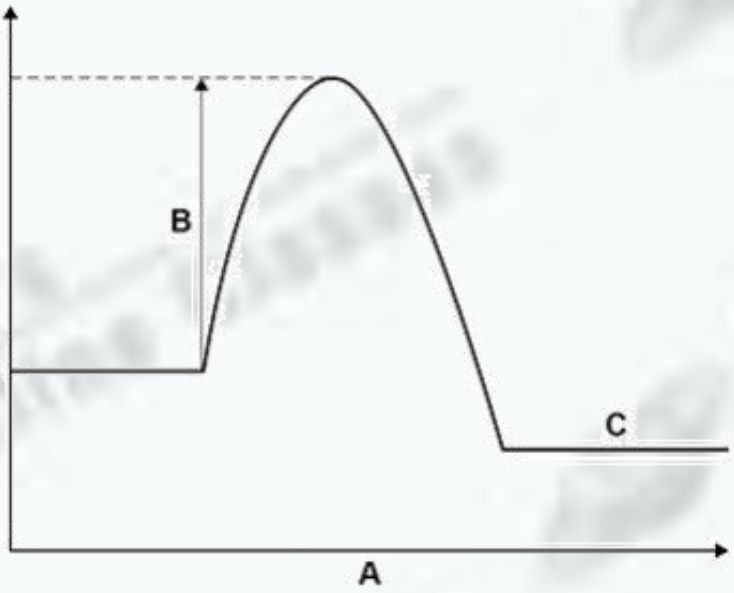
_____

_____

_____

(1)

(f) The figure below shows a reaction profile for the reaction of magnesium with hydrochloric acid.



What do labels **A**, **B** and **C** represent on the figure above?

Choose answers from the box.

activation energy	**energy**	**overall energy change**
products	**progress of reaction**	**reactants**

A _____

B _____

C _____

(3)

Mark Scheme

Q1.

(a) $\frac{54 + 50 + 55}{3}$ 1

= 53 (°C)

*if no other mark awarded allow **1** mark for*

$\frac{54 + 50 + 37 + 55}{4}$ = *49 (°C)* 1

(b) (most reactive) magnesium zinc
(least reactive) cobalt

*allow ecf from question **(a)*** 1

(c) (18 ±) 2 (°C) 1

(d) control 1

(e) use the same mass of metal / powder 1

(f) (A) progress of reaction 1

(B) activation energy 1

(C) products 1

Q2.

This question is about the extraction of metals.

Element **R** is extracted from its oxide by reduction with hydrogen.

The equation for the reaction is:

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

(a) The sum of the relative formula masses (M_r) of the reactants ($3\ H_2 + \mathbf{R}O_3$) is 150

Calculate the relative atomic mass (A_r) of **R**.

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

Relative atomic mass (A_r) of **R** = _____

(2)

(b) Identify element **R**.

You should use:

- your answer to part (a)
- the periodic table.

Identity of **R** = _____

(1)

(c) Carbon is used to extract tin (Sn) from tin oxide (SnO_2).

The equation for the reaction is:

$$SnO_2 + C \rightarrow Sn + CO_2$$

Calculate the percentage atom economy for extracting tin in this reaction.

Relative atomic masses (A_r): C = 12 O = 16 Sn = 119

Percentage atom economy = _____ %

(3)

(d) Tungsten (W) is a metal.

Tungsten is extracted from tungsten oxide (WO_3).

All other solid products from the extraction method must be separated from the tungsten.

The table below shows information about three possible methods to extract tungsten from tungsten oxide.

Method	Reactant	Relative cost of reactant	Products
1	Carbon	Low	Tungsten solid Carbon dioxide gas Tungsten carbide solid
2	Hydrogen	High	Tungsten solid Water vapour
3	Iron	Low	Tungsten solid Iron oxide solid

Evaluate the three possible methods for extracting tungsten from tungsten oxide.

(4)

Mark Scheme

Q2.

(a) ($3 \times M_r$ H_2O = 3 × (2 + 16) =) 54

(A_r **R** = 150 – 54 =) 96

ignore units

1

alternative approach:
(M_r **R**O_3 = 150 – 6 =) 144 (1)

(A_r **R** = 144 – (3 × 16) =) 96 (1)

ignore units

1

(b) **(R =)** molybdenum / Mo

allow ecf from question ***(a)***

1

(c) (total M_r of reactants) = 163

1

(% atom economy =) $\frac{119}{163}$ (×100)

allow correct use of an incorrectly calculated value of total M_r

1

= 73 (%)

allow 73.00613 (%) correctly rounded to at least 2 significant figures

1

(d) **Level 2:** Some logically linked reasons are given. There may also be a simple judgement.

3–4

Level 1: Relevant points are made. They are not logically linked.

1–2

No relevant content

0

Indicative content

- carbon and iron are the cheapest reactants
- hydrogen is the most expensive reactant

- separating solid products is expensive
- separating solid products is time consuming

- in method 1, tungsten needs to be separated from tungsten carbide
- in method 1, some tungsten is lost as tungsten carbide
- in method 1, the carbon dioxide produced will escape

- in method 2, the water vapour produced will escape
- in method 2, no separation of solids is needed

- in method 3, tungsten needs to be separated from iron oxide