

Name: \_\_\_\_\_

# Quantitative Chemistry part 1 AQA Triple Chemistry

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **85 minutes**

Marks: **80 marks**

Comments:

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1.

This question is about iron.

(a) Iron is a metal.

Describe how iron conducts thermal energy.

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(2)

(b) Pure iron is too soft for many uses.

Explain why mixing iron with other metals makes alloys which are harder than pure iron.

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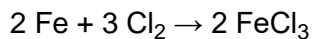
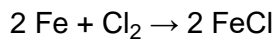
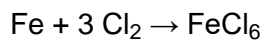
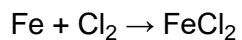
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(3)

(c) When iron reacts with chlorine, 0.12 mol of iron reacts with 0.18 mol of chlorine (Cl<sub>2</sub>).

Which is the correct equation for the reaction?

Tick (✓) **one** box.

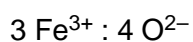
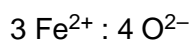


(1)

The most common oxides of iron are  $\text{Fe}_2\text{O}_3$  and  $\text{Fe}_3\text{O}_4$

(d) What is the ratio of the numbers of ions in  $\text{Fe}_3\text{O}_4$ ?

Tick (✓) **one** box.



(1)

(e) Calculate the percentage (%) by mass of iron in  $\text{Fe}_3\text{O}_4$

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

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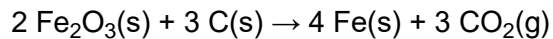
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Percentage by mass of iron = \_\_\_\_\_ %

(3)

(f)  $\text{Fe}_2\text{O}_3$  reacts with carbon to produce carbon dioxide.

The equation for the reaction is:



Calculate the volume of carbon dioxide gas at room temperature and pressure that is produced from 40.0 kg of  $\text{Fe}_2\text{O}_3$  using excess carbon.

Relative formula mass ( $M_r$ ):  $\text{Fe}_2\text{O}_3 = 160$

The volume of 1 mole of any gas at room temperature and pressure is  $24 \text{ dm}^3$ .

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Volume of carbon dioxide = \_\_\_\_\_  $\text{dm}^3$

**(5)**

**(Total 15 marks)**

2.

This question is about titanium dioxide ( $\text{TiO}_2$ ).

(a) Self-cleaning windows are coated with a layer of nanoparticles of titanium dioxide.

Titanium dioxide:

- helps sunlight break down dirt particles
- attracts water, so dirt is washed away by rain.

Nanoparticles of titanium dioxide are used instead of fine particles of titanium dioxide for coating self-cleaning windows.

Suggest **two** reasons why.

1 \_\_\_\_\_

\_\_\_\_\_

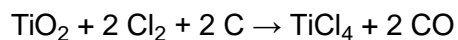
2 \_\_\_\_\_

\_\_\_\_\_

(2)

(b) Titanium is extracted from titanium dioxide in a two-stage process.

The equation for the first stage in the process is:



Calculate the volume of chlorine gas needed to react completely with 100 kg of titanium dioxide.

Relative atomic masses ( $A_r$ ): O = 16 Ti = 48

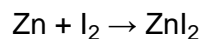




(b) A student used 6.35 g of iodine in the reaction.

6.29 g of zinc iodide was produced.

The equation for the reaction is:



Calculate the percentage yield of zinc iodide.

Give your answer to 3 significant figures.

Relative formula masses ( $M_r$ ):  $\text{I}_2 = 254$      $\text{ZnI}_2 = 319$

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Percentage yield (3 significant figures) = \_\_\_\_\_ %

**(5)**  
**(Total 11 marks)**

4.

A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

- (a) Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

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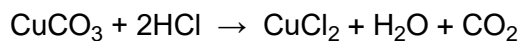
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(4)

- (b) A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:



Relative atomic masses,  $A_r$ : H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

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Mass of copper carbonate = \_\_\_\_\_ g

(4)

(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

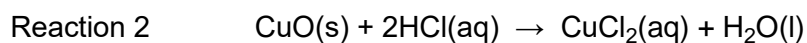
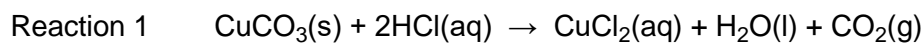
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Actual mass of copper chloride produced = \_\_\_\_\_ g

(2)

(d) Look at the equations for the two reactions:



Relative formula masses:  $\text{CuO} = 79.5$ ;  $\text{HCl} = 36.5$ ;  $\text{CuCl}_2 = 134.5$ ;  $\text{H}_2\text{O} = 18$

The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

Calculate the percentage atom economy for Reaction 2.

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Percentage atom economy = \_\_\_\_\_ %

(3)

(e) The atom economy for Reaction 1 is 68.45 %.

Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference.

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(1)

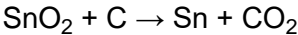
(Total 14 marks)

5.

This question is about metals and metal oxides.

Tin (Sn) is extracted from tin oxide using carbon.

The equation for the reaction is:



(a) Which substance is reduced in this reaction?

Give **one** reason for your answer.

Answer in terms of oxygen.

Substance reduced \_\_\_\_\_

Reason \_\_\_\_\_

\_\_\_\_\_

(2)

(b) Why can carbon be used to extract tin from tin oxide?

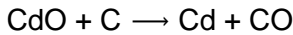
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(1)

(c) Cadmium (Cd) can be extracted by the reaction of cadmium oxide with carbon.

The equation for the reaction is:



Calculate the percentage atom economy for the production of cadmium in this reaction.

Relative atomic masses (*Ar*): C = 12 Cd = 112

Relative formula mass (*Mr*): CdO = 128

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Percentage atom economy = \_\_\_\_\_ %

(3)

(d) Tungsten is a transition metal.

Potassium is a Group 1 metal.

Give **two** differences between the properties of tungsten and the properties of potassium.

1 \_\_\_\_\_

\_\_\_\_\_

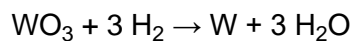
2 \_\_\_\_\_

\_\_\_\_\_

**(2)**

Tungsten oxide reacts with hydrogen to give tungsten (W) and water.

(e) The equation for the reaction is:



The law of conservation of mass states:

‘The mass of the products equals the mass of the reactants during a chemical reaction.’

Show that the equation obeys the law of conservation of mass.

Relative atomic mass ( $A_r$ ):    W = 184

Relative formula masses ( $M_r$ ):    H<sub>2</sub> = 2    WO<sub>3</sub> = 232    H<sub>2</sub>O = 18

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**(2)**

(f) The reaction producing tungsten has a high atom economy.

Why is it important to use reactions with a high atom economy in industry?

\_\_\_\_\_

\_\_\_\_\_

**(1)**

**(Total 11 marks)**

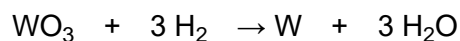
**6.** This question is about the extraction of metals.

(a) Tungsten is a metal.

The symbol of tungsten is W

Tungsten is produced from tungsten oxide by reaction with hydrogen.

The equation for the reaction is:



Calculate the percentage atom economy when tungsten is produced in this reaction.

Use the equation:

$$\text{percentage atom economy} = \frac{184}{(M_r \text{ WO}_3) + (3 \times M_r \text{ H}_2)} \times 100$$

Relative formula masses ( $M_r$ ):  $\text{WO}_3 = 232$      $\text{H}_2 = 2$

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Percentage atom economy = \_\_\_\_\_%

**(2)**

Aluminium is extracted from aluminium oxide.

(b) 38% of a rock sample is aluminium oxide.

Calculate the mass of aluminium oxide in 40 kg of the rock sample.

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Mass of aluminium oxide = \_\_\_\_\_ kg

**(2)**

(c) The formula of aluminium oxide is  $\text{Al}_2\text{O}_3$

Calculate the relative formula mass ( $M_r$ ) of aluminium oxide.

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

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Relative formula mass ( $M_r$ ) = \_\_\_\_\_

**(2)**

(d) 60.0 kg of aluminium oxide produces a maximum of 31.8 kg of aluminium.

In an extraction process only 28.4 kg of aluminium is produced from 60.0 kg of aluminium oxide.

Calculate the percentage yield.

Give your answer to 3 significant figures.

Use the equation:

$$\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100$$

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Percentage yield = \_\_\_\_\_%

**(3)**

(e) Extracting metals by electrolysis is a very expensive process.

Explain why aluminium is extracted using electrolysis and not by reduction with carbon.

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(2)

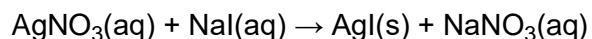
(Total 11 marks)

7.

This question is about silver iodide.

Silver iodide is produced in the reaction between silver nitrate solution and sodium iodide solution.

The equation for the reaction is:



(a) A student investigated the law of conservation of mass.

This is the method used.

1. Pour silver nitrate solution into a beaker labelled **A**.
2. Pour sodium iodide solution into a beaker labelled **B**.
3. Measure the masses of both beakers and their contents.
4. Pour the solution from beaker **B** into beaker **A**.
5. Measure the masses of both beakers and their contents again.

The table below shows the student's results.

	Mass before mixing in g	Mass after mixing in g
Beaker <b>A</b> and contents	78.26	108.22
Beaker <b>B</b> and contents	78.50	48.54

Explain how the results demonstrate the law of conservation of mass.

You should use data from table above in your answer.

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(2)

- (b) Suggest how the student could separate the insoluble silver iodide from the mixture at the end of the reaction.

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(1)

The student purified the separated silver iodide.

This is the method used.

1. Rinse the silver iodide with distilled water.
2. Warm the silver iodide.

- (c) Suggest **one** impurity that was removed by rinsing with water.

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(1)

- (d) Suggest why the student warmed the silver iodide.

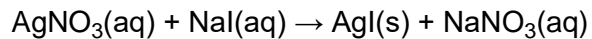
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(1)

- (e) Calculate the percentage atom economy for the production of silver iodide in this reaction.

The equation for the reaction is:



Give your answer to 3 significant figures.

Relative formula masses:

$$(M_r): \quad \text{AgNO}_3 = 170 \quad \text{NaI} = 150 \quad \text{AgI} = 235 \quad \text{NaNO}_3 = 85$$

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Percentage atom economy (3 significant figures) = \_\_\_\_\_ %

(4)

- (f) Give **one** reason why reactions with a high atom economy are used in industry.

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(1)

(Total 10 marks)

## Mark schemes

1.

- (a) (thermal) energy is transferred  
*allow heat is transferred*

1

by delocalised electrons

1

- (b) (the alloy / mixture has) different sized atoms

1

(so the) layers are distorted

1

(so the) layers cannot easily slide

*allow (positive / metal) ions for atoms throughout*

*allow (so the) atoms cannot slide over each other*

1

- (c)  $2 \text{Fe} + 3 \text{Cl}_2 \rightarrow 2 \text{FeCl}_3$

1

- (d)  $1 \text{Fe}^{2+} : 2 \text{Fe}^{3+} : 4 \text{O}^{2-}$

1

- (e) ( $M_r \text{Fe}_3\text{O}_4 =$ ) 232

1

$$(\% \text{Fe} =) \frac{3 \times 56}{232} \times 100$$

*allow*  $\frac{168}{232} \times 100$

*allow correct use of an incorrectly determined  $M_r$  using the values of  $A_r$  given in the question*

1

$$= 72.4 (\%)$$

*allow 72.41379 correctly rounded to at least 2 significant figures*

1

(f) (40.0 kg  $\Rightarrow$ ) 40 000 (g)

*a maximum of 4 marks can be awarded for a method which determines and uses the volume of iron oxide as a gas*

1

$$\text{(moles Fe}_2\text{O}_3 = \frac{40\,000}{160} \Rightarrow) 250$$

*allow correct use of an incorrectly converted or unconverted mass*

1

$$\text{(moles CO}_2 = 250 \times \frac{3}{2} \Rightarrow) 375$$

*allow correct use of an incorrectly determined number of moles of Fe}\_2\text{O}\_3*

1

$$\text{(volume of CO}_2 \Rightarrow) 375 \times 24$$

*allow correct use of an incorrectly determined number of moles of CO}\_2*

1

$$= 9000 \text{ (dm}^3\text{)}$$

1

[15]

2.

(a) (nanoparticles)

any **two** from:

- have a higher surface area to volume ratio
- less (material) needed (for the same effect)  
*allow a thinner coating is needed*
- more light gets through

2

*allow converse arguments for fine particles*

(b) ( $M_r$  TiO<sub>2</sub>  $\Rightarrow$ ) 80

1

(conversion 100 kg  $\Rightarrow$ ) 100 000 (g)

1

$$\left( \text{moles TiO}_2 = \frac{100\,000}{80} \Rightarrow \right)$$

1250

*allow correct use of an incorrectly determined  $M_r$   
allow correct use of an incorrect / no conversion of mass*

1

$$\text{(moles Cl}_2 = 1250 \times 2 \Rightarrow) 2500$$

*allow correct use of an incorrectly determined number of moles of TiO}\_2*

1

(volume  $\text{Cl}_2$  ⇒)  $2500 \times 24$

*allow correct use of an incorrectly determined number of moles of  $\text{Cl}_2$*

1

= 60 000 ( $\text{dm}^3$ )

1

[8]

3.

(a) **Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

5-6

**Level 2:** The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3-4

**Level 1:** The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1-2

**No relevant content**

0

**Indicative content**

**dissolve iodine in ethanol**

- in a beaker

**add zinc to iodine solution**

- stir

**continue adding until zinc is in excess**

- shown by solid remaining

**filter (the reaction mixture)**

- to remove the excess zinc

**heat the solution**

- using a water bath
- **or**
- using an electric heater
- to evaporate off some of the ethanol
- cool / leave remaining solution to crystallise

(b)

$$\left(\text{moles I}_2 = \frac{6.35}{254} =\right) 0.025$$

1

(moles  $\text{ZnI}_2 = 0.025$  theoretical mass  $\text{ZnI}_2 = 0.025 \times 319 =$ )  
7.975 (g)

*allow (moles Zn = 0.025 mass of Zn = 0.025 × 65 = 1.625 g  
theoretical mass  $\text{ZnI}_2 = 1.625 + 6.35 =$ ) 7.975 (g)*

*allow correct use of an incorrectly determined number of moles of  $\text{I}_2$*

1

$$(\% \text{ yield} =) \frac{6.29}{7.975} \times 100$$

*allow correct use of an incorrectly determined theoretical mass of  
 $\text{ZnI}_2$*

1

$$= 78.871 (\%)$$

1

$$= 78.9 (\%)$$

*allow an answer correctly rounded to 3 significant figures from an  
incorrect calculation which uses both mass values in the question*

**alternative approach 1:**

$$\left(\text{moles I}_2 = \frac{6.35}{254} =\right) 0.025 \quad (1)$$

$$\left(\text{moles ZnI}_2 = \frac{6.29}{319} =\right) 0.019717868 \quad (1)$$

$$\frac{(\% \text{ yield} =) 0.019717868}{0.025} \times 100 \quad (1)$$

*allow correct use of an incorrectly determined number of moles of  $\text{I}_2$   
and/or  $\text{ZnI}_2$*

$$= 78.871 (\%) (1)$$

$$= 78.9 (\%) (1)$$

*allow an answer correctly rounded to 3 significant figures from an  
incorrect calculation which uses both mass values in the question*

**alternative approach 2:**

$$\left( \begin{array}{l} \text{moles ZnI}_2 = \\ \frac{6.29}{319} = \end{array} \right) 0.019717868 \quad (1)$$

(moles I<sub>2</sub> reacted = 0.019717868  
mass I<sub>2</sub> reacted = 0.019717868 × 254 =)  
5.0083(g) (1)

$$(\% \text{ yield} =) \frac{5.0083}{6.35} \times 100 \quad (1)$$

*allow correct use of an incorrectly determined number of moles of ZnI<sub>2</sub>*

$$= 78.871 (\%) (1)$$

$$= 78.9 (\%) (1)$$

*allow correct use of an incorrectly determined mass of I<sub>2</sub> reacted  
allow an answer correctly rounded to 3 significant figures from an  
incorrect calculation which uses both mass values in the question*

1

[11]

4.

- (a) add excess copper carbonate (to dilute hydrochloric acid)  
*accept alternatives to excess, such as 'until no more reacts'*

1

filter (to remove excess copper carbonate)  
*reject heat until dry*

1

heat filtrate to evaporate some water **or** heat to point of crystallisation  
*accept leave to evaporate or leave in evaporating basin*

1

leave to cool (so crystals form)  
*until crystals form*

1

*must be in correct order to gain 4 marks*

- (b)  $M_r \text{ CuCl}_2 = 134.5$   
*correct answer scores 4 marks*

1

moles copper chloride = (mass /  $M_r$  = 11 / 134.5) = 0.0817843866

1

$M_r \text{ CuCO}_3 = 123.5$

1

Mass CuCO<sub>3</sub> (=moles ×  $M_2$  = 0.08178 × 123.5) = 10.1(00)

1

accept 10.1 with no working shown for 4 marks

(c)  $\frac{79.1}{100} \times 11.0$

or

$11.0 \times 0.791$

1

8.70 (g)

1

accept 8.70(g) with no working shown for 2 marks

(d) Total mass of reactants = 152.5

1

134.5

152.5

allow ecf from step 1

1

88.20 (%)

1

allow 88.20 with no working shown for 3 marks

(e) atom economy using carbonate lower because an additional product is made or carbon dioxide is made as well

allow ecf

1

[14]

5.

(a) (substance reduced)  
 $\text{SnO}_2$

allow tin oxide

1

(reason)

$(\text{SnO}_2)$  loses oxygen

allow (tin oxide) loses oxygen

MP2 is dependent upon MP1 being awarded

1

(b) carbon is more reactive than tin

allow tin is less reactive than carbon

1

(c) (total  $M_r = 128 + 12 =$ ) 140

allow (total  $M_r = 112 + 12 + 16 =$ ) 140

1

(% atom economy =)

$$\frac{112}{140} \times 100$$

*allow correct use of an incorrectly determined total  $M_r$*

1

= 80 (%)

1

*allow the converse for potassium*

*allow the transition metal for tungsten*

*allow the Group 1 metal for potassium*

*ignore references to atomic structure*

(d) any **two** from:

tungsten

- has a higher melting / boiling point

- is denser

- is harder

*allow is less malleable / ductile*

- is stronger

- is less reactive

*allow specific reactions showing difference in reactivity*

- has ions with different charges

- forms coloured compounds

- can be a catalyst

2

(e) (sum of relative formula masses on left hand side =)

$$232 + (3 \times 2) = 238$$

*allow (sum of relative formula masses on left hand side =)*

$$232 + 6 = 238$$

1

(is equal to sum of relative formula masses on right hand side =)

$$184 + (3 \times 18) = 238$$

*allow (is equal to sum of relative formula masses on right hand side  
=)  $184 + 54 = 238$*

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

$$232 + 6 = 184 + 54$$

**or**

*allow 1 mark for both sides = 238*

1

- (f) for sustainable development  
*allow to minimise use of limited resources*  
*allow to minimise use of energy*  
*allow to minimise waste*

**or**  
 for economic reasons  
*ignore references to yield*

1  
 [11]

**6.**

- (a)  
*an answer of 77 (%) scores 2 marks*  
*an answer of 78.63247863 (%) correctly rounded to at least 2 significant figures scores 1 mark*

$$\frac{184}{(232 + 6)} \times 100$$

$$= 77 (\%)$$

*allow 77.31092437 (%) correctly rounded to at least 2 significant figures*

1  
  
1

- (b)  
*an answer of 15 (kg) scores 2 marks*

$$\frac{38}{100} \times 40$$

$$= 15 (\text{kg})$$

*allow 15.2 (kg)*

1  
  
1

- (c)  
*an answer of 102 scores 2 marks*

$$(2 \times 27) + (3 \times 16)$$

$$= 102$$

*ignore units*

1  
  
1

(d)

*an answer of 89.3 (%) scores 3 marks*

$$\frac{28.4}{31.8} \times 100$$

1

$$= 89.3081761 (\%)$$

*allow 89.3081761(%) correctly rounded to at least 2 significant figures*

1

$$= 89.3 (\%)$$

*allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses the masses in the question*

1

(e) aluminium is more reactive than carbon

*allow aluminium is above carbon in the reactivity series*

1

(so) carbon cannot displace aluminium

*allow (so) carbon cannot replace aluminium*

**or**

(so) carbon cannot reduce aluminium oxide

*allow (so) carbon cannot remove oxygen from aluminium oxide*

*allow (so) carbon will not react with aluminium oxide*

1

[11]

7.

(total) mass before = 156.76 (g)

**and**

(total) mass after = 156.76 (g)

*allow*  $78.26 + 78.50 = 156.76$

**and**

$108.22 + 48.54 = 156.76$

**or**

increase in mass of beaker **A** and contents = 29.96 (g)

**and**

decrease in mass of beaker **B** and contents = 29.96 (g)

*allow*  $108.22 - 78.26 = 29.96$

**and**

$48.54 - 78.50 = -29.96$

1

(so) the mass of products equals the mass of the reactants

**or**

(so) there is no change in mass during the reaction

*allow (so) no atoms were lost or made during the reaction*

1

(b) filter / filtration

*allow a description of filtration*

1

(c) sodium nitrate (solution)

**or**

silver nitrate (solution)

**or**

sodium iodide (solution)

*allow correct formulae*

*allow sodium / nitrate / silver / iodide ions*

1

(d) to remove / evaporate the water

*allow to dry (the solid)*

1

(e) (total  $M_r = 170 + 150 = 320$   
*allow*  $(235 + 85) = 320$

1

(% atom economy =) 235

$$\frac{235}{320} \times 100$$

*allow correct use of incorrectly calculated total  $M_r$*

1

= 73.4375 (%)

1

= 73.4 (%)

*allow an answer correctly calculated to 3 significant figures from an incorrect percentage calculation which uses the values in the question*

1

(f) any **one** from:

- for sustainable development
- for economic reasons
- to produce a high(er) percentage of useful product

*allow to reduce waste*

1

[10]