

Name: _____

Quantitative Chemistry part 3 AQA Triple Chemistry

Class: _____

Date: _____

Time: **48 minutes**

Marks: **47 marks**

Comments:

1.

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

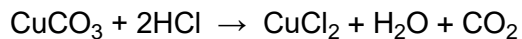
In both reactions one of the products is copper chloride.

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

(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.

Mass of copper carbonate = _____ g

(4)

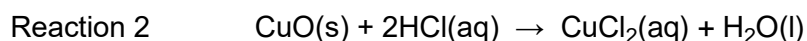
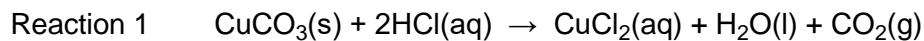
(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

Actual mass of copper chloride produced = _____ g

(2)

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



Relative formula masses: CuO = 79.5; HCl = 36.5; CuCl₂ = 134.5; H₂O = 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.

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.

(1)

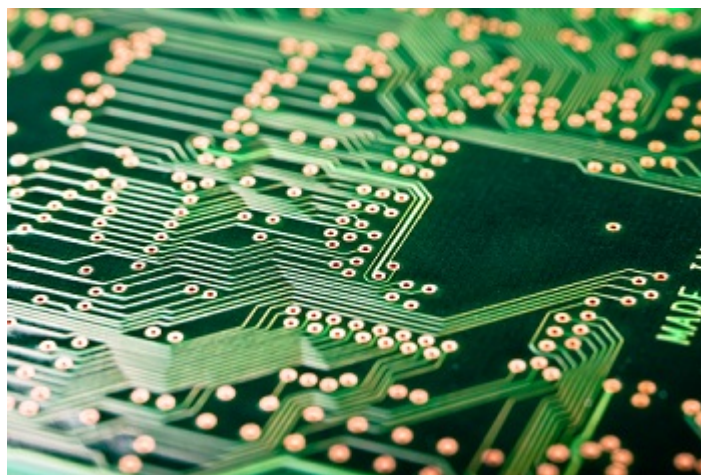
(Total 14 marks)

(d) Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

(2)
(Total 9 marks)

3.

Etching is a way of making printed circuit boards for computers.



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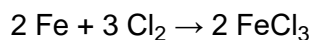
Printed circuit boards are made when copper sheets are etched using iron(III) chloride solution. Where the copper has been etched, only plastic remains.

(a) Copper is a good conductor of electricity.

Explain why.

(2)

(b) Iron(III) chloride can be produced by the reaction shown in the equation:



(i) Calculate the maximum mass of iron(III) chloride (FeCl_3) that can be produced from 11.20 g of iron.

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

Maximum mass of iron(III) chloride = _____ g

(3)

(ii) The actual mass of iron(III) chloride (FeCl_3) produced was 24.3 g.

Calculate the percentage yield.

(If you did not answer part (b)(i) assume that the maximum theoretical mass of iron(III) chloride (FeCl_3) is 28.0 g. This is **not** the correct answer to part (b)(i).)

Percentage yield = _____ %

(1)

(Total 6 marks)

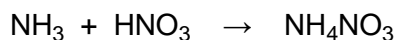
4.

Ammonium nitrate is an important fertiliser. It is made by reacting nitric acid with the alkali ammonia.

(i) State the type of reaction taking place.

(1)

(ii) The equation for this reaction is:



Calculate the number of tonnes of ammonium nitrate that can be made from 68 tonnes of ammonia.

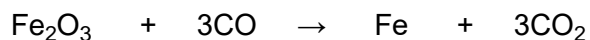
(Relative atomic masses: H = 1, N = 14, O = 16)

(3)

(Total 4 marks)

5.

Iron is the most commonly used metal. Iron is extracted in a blast furnace from iron oxide using carbon monoxide.



(a) A sample of the ore haematite contains 70% iron oxide.

Calculate the amount of iron oxide in 2000 tonnes of haematite.

Amount of iron oxide = _____ tonnes

(1)

(b) Calculate the amount of iron that can be extracted from 2000 tonnes of haematite.
(Relative atomic masses: O = 16; Fe = 56)

Amount of iron = _____ tonnes

(4)

(Total 5 marks)

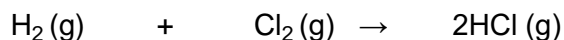
6. Calculate the percentage of iron in iron sulphate (FeSO₄).

(Relative atomic masses: Fe = 56, O = 16, S = 32)

Percentage of iron in iron sulphate = _____%

(Total 3 marks)

7. The balanced symbol equation for the reaction is



Starting with 2 g of hydrogen, what mass of hydrogen chloride would be produced?
(Relative atomic masses: H = 1; Cl = 35.5)

Mass of hydrogen chloride = _____ g

(Total 3 marks)

8. Ammonium chloride, NH₄Cl, is made up of nitrogen, hydrogen and chlorine atoms.

(i) Complete the table to show the number of atoms of each element present in NH₄Cl.

Element	Number of atoms in NH ₄ Cl
nitrogen	1
hydrogen	
chlorine	

(1)

(ii) Calculate the relative formula mass of ammonium chloride, NH_4Cl .

(Relative atomic masses: H = 1, N = 14, Cl = 35.5)

Relative formula mass = _____

(2)
(Total 3 marks)

Mark schemes

1.

- (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_3 (=moles $\times M_2 = 0.08178 \times 123.5$) = 10.1(00)

1

accept 10.1 with no working shown for 4 marks

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

or

11.0×0.791

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]

2.

- (a) the (minimum) energy needed for particles to react
or

the (minimum) energy needed for a reaction to occur

allow the (minimum) energy needed to start a reaction

1

- (b) (M_r of Fe_2O_3 =) 160

1

$$\text{(moles Fe}_2\text{O}_3 = \frac{3000}{160} =)$$

18.75 (mol)

allow correct use of incorrectly calculated M_r

1

$$\text{(moles Al} = \frac{1000}{27} =) 37.0 \text{ (mol)}$$

allow 37.037037 (mol) correctly rounded to at least 2 significant figures

*if both MP2 and MP3 are not awarded allow 1 mark for 0.01875 mol Fe_2O_3 **and** 0.037 mol Al*

1

(aluminium is limiting because)

37.0 mol is less than the ($2 \times 18.75 =$) 37.5 mol (aluminium needed)

or

iron oxide is in excess because 18.75 mol is more than the ($\frac{37.0}{2} =$) 18.5 mol (iron oxide needed)

allow correct use of incorrect number of moles from steps 2 and/or 3

alternative approaches:

approach 1:

(finding required mass of aluminium by moles method)

$$(M_r \text{ of } \text{Fe}_2\text{O}_3 =) 160 \text{ (1)}$$

$$(\text{moles } \text{Fe}_2\text{O}_3 = \frac{3000}{160} =)$$

$$18.75 \text{ (mol) (1)}$$

allow correct use of incorrectly calculated M_r

$$(\text{moles Al needed} = 18.75 \times 2 =) 37.5 \text{ (mol)}$$

and

$$(\text{mass Al needed} = 37.5 \times 27 =) 1012.5 \text{ (g) or } 1.0125 \text{ kg (1)}$$

allow correct use of incorrectly calculated moles of iron oxide

allow correct use of incorrectly calculated moles of aluminium needed

(so) 1.00 kg of aluminium is not enough (1)

dependent on calculated mass of aluminium needed being greater than 1.00 (kg)

approach 2:

(finding required mass of aluminium by proportion method)

$$(M_r \text{ of } \text{Fe}_2\text{O}_3 =) 160 \text{ (1)}$$

(3.00 kg Fe_2O_3 needs)

$$\frac{3.00}{160} \times 2 \times 27 \text{ (kg Al) (1)}$$

allow correct use of incorrectly calculated M_r

$$(\Rightarrow) 1.0125 \text{ (kg) (1)}$$

(so) 1.00 kg of aluminium is not enough (1)

dependent on calculated mass of aluminium needed being greater than 1.00 (kg)

alternative approaches:

approach 3:
(finding required mass of iron oxide by moles method)

$$M_r \text{ of Fe}_2\text{O}_3 = 160 \text{ (1)}$$

$$\text{(moles Al} = \frac{1000}{27} =) 37.0 \text{ (mol) (1)}$$

allow 37.037037 (mol) correctly rounded to at least 2 significant figures

$$\text{(moles Fe}_2\text{O}_3 \text{ needed)} = \frac{37.0}{2} = 18.5 \text{ (mol)}$$

and

$$\text{(mass Fe}_2\text{O}_3 \text{ needed} = 18.5 \times 160 =) 2960 \text{ (g) or } 2.96 \text{ (kg) (1)}$$

allow correct use of incorrectly calculated moles of aluminium

allow correct use of incorrectly calculated moles of iron oxide needed

allow correct use of incorrectly calculated M_r

(so) 3.00 kg of iron oxide is an excess (1)

dependent on calculated mass of iron oxide needed being less than 3.00 (kg)

approach 4:
(finding required mass of iron oxide by proportion method)

$$(M_r \text{ of Fe}_2\text{O}_3 =) 160 \text{ (1)}$$

$$\text{(1.00 kg Al needs)} \frac{1.00}{2 \times 27} \text{ (kg Fe}_2\text{O}_3) \text{ (1)}$$

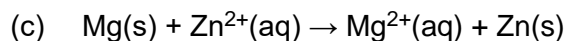
allow correct use of incorrectly calculated M_r

$$=) 2.96 \text{ (kg) (1)}$$

(so) 3.00 kg of iron oxide is an excess (1)

dependent on calculated mass of iron oxide needed being less than 3.00 (kg)

1



allow multiples

allow 1 mark for $\text{Mg}^{2+} + \text{Zn}$ with missing or incorrect state symbols

2

(d) magnesium (atoms) are oxidised because they lose electrons

1

(and) zinc (ions) are reduced because they gain electrons

if no other marks awarded allow 1 mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons 1

1

[9]

3.

(a) copper has delocalised electrons

*accept copper has free electrons
ignore sea of electrons or mobile electrons*

1

(electrons) which can move through the metal / structure

allow (electrons) which can carry a charge through the metal / structure

1

(b) (i) ($M_r \text{FeCl}_3 =$) 162.5

*correct answer with or without working gains 3 marks
can be credited from correct substitution in step 2*

1

or

2 (moles of) $\text{FeCl}_3 = 325$

or

112 \rightarrow 325

$$\frac{11.20}{56} \times 162.5$$

allow ecf from step 1

accept $\frac{325}{112} \times 11.2$

1

= 32.5

accept 32.48

1

(ii) 74.8

*accept 74.77 – 75
accept ecf from (b)(i)
if there is no answer to part(i)*

or

if candidate chooses not to use their answer then accept 86.79 – 87

1

[6]

- 4.** (i) neutralisation/acid base reaction
for 1 mark 1
- (ii) 17 (tonnes)
give 80 (tonnes) (even if only in working)
for 1 mark each
- 320 (tonnes) or alternative method)
3 marks for correct answer
- (if 17 and 80 not given allow 1 mark for correct answer using their figures) 3
- [4]**
- 5.** (a) 1400 1
- (b) 980
correct answer gains full credit
- 160 tonnes Fe₂O₃ produces 112 tonnes Fe
*if incorrect allow one mark for relative formula mass iron oxide = 160
allow e.c.f.*
- 1400 tonnes Fe₂O₃ will produce 1400 / 160 × 112 tonnes Fe
use of 2000 tonnes Fe₂O₃ – deduct one mark only if working out is correct 4
- [5]**
- 6.** 36.8 / 37
*correct answer, no workings = 3 if incorrect, allow 1 mark for rfm FeSO₄ = 152
or if incorrect rfm, allow 1 mark for 56/Y × 100 where Y is incorrect formula mass*
- allow 2 marks for $\frac{56}{152} \times 100$* [3]
- 7.** 73 (seventy three)
*if answer is incorrect allow 1 mark for the correct proportion that H₂:HCl is 1:2
and 1 mark for 36.5* [3]

8.

(i) 4 and 1

both answers must be correct

1

(ii) 53.5

*if incorrect relative formula mass
allow 1 mark for correct working
accept e.c.f. from c(i) for 2 marks*

2

[3]