

Quantitative Chemistry 4

Name: _____

Class: _____

Date: _____

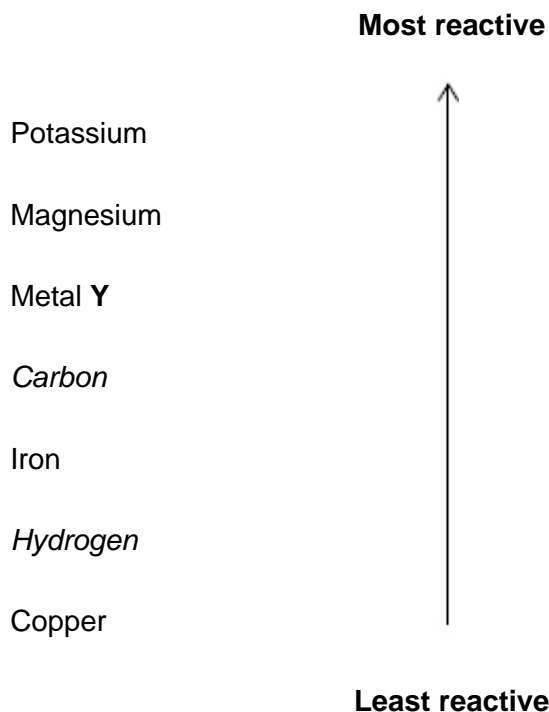
Time: **51 minutes**

Marks: **47 marks**

Comments:

1. This question is about elements and compounds.

(a) shows a reactivity series.



Give the method and conditions used to extract metal Y from a compound of metal Y.

(2)

Sodium reacts with titanium chloride (TiCl_4) to produce titanium.

(b) Complete the equation.

You should balance the equation.



(2)

(c) The reaction between sodium and titanium chloride is a redox reaction.

Write a half-equation to show that sodium is oxidised in this reaction.

(2)

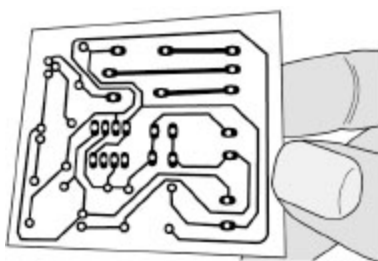
(f) Explain how sodium chloride can conduct electricity.

(3)
(Total 17 marks)

2.

Gold is used in the printed circuit boards found in smartphones.

The figure below shows a printed circuit board.



A type of smartphone contains 1.73×10^{-4} moles of gold.

(a) In one year, a manufacturer sold 2.48 million of this type of smartphone.

Calculate the total mass of gold contained in 2.48 million of these smartphones.

Give your answer in kilograms.

Relative atomic mass (A_r): Au = 197

Total mass of gold = _____ kg

(5)

(b) What is the total number of gold atoms in one of this type of smartphone?

The Avogadro constant = 6.02×10^{23} per mole

Tick (✓) **one** box.

2.87×10^{-28}

1.04×10^{20}

3.48×10^{27}

(1)

(c) The materials in printed circuit boards can be recycled.

Bioleaching is one method used to extract gold from printed circuit boards.

Describe how bioleaching is used to extract gold.

(3)

(d) Copper is also extracted using bioleaching.

Copper can also be extracted from low-grade ores using phytomining.

Phytomining has **not** been widely used to extract copper.

Suggest **two** reasons why.

1 _____

2 _____

(2)

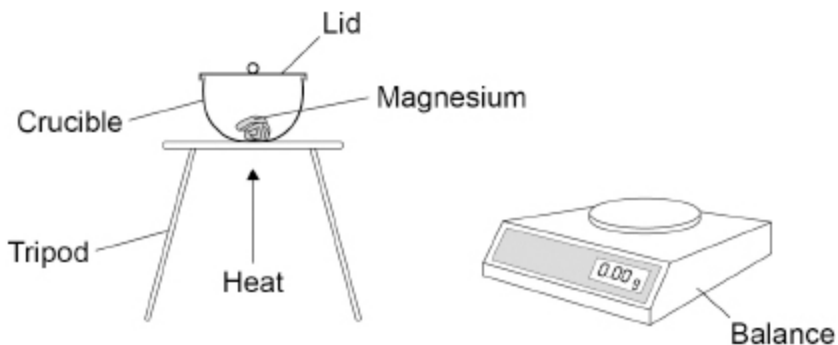
(Total 11 marks)

3.

Metal oxides are produced when metals are heated in air.

A student investigated the change in mass when 0.12 g of magnesium was heated in air.

The figure below shows the apparatus.



The student measured the mass of magnesium oxide produced.

- (a) 0.12 g of magnesium reacted to produce 0.20 g of magnesium oxide.

Calculate the number of moles of oxygen gas (O_2) that reacted.

Relative atomic mass (A_r): O = 16

Moles of oxygen gas = _____

(3)

- (b) The student repeated the experiment **without** a lid on the crucible.

Suggest why the mass of magnesium oxide produced would be different without a lid on the crucible.

(2)

(c) Copper reacts with oxygen to produce copper oxide.

63.5 g of copper produces 79.5 g of copper oxide.

Calculate the mass of copper oxide produced when 0.50 g of copper reacts with oxygen.

Give your answer to 3 significant figures.

Mass (3 significant figures) = _____ g

(3)

(d) Iron reacts with oxygen to produce an oxide of iron.

0.015 moles of iron reacts with 0.010 moles of oxygen gas (O₂).

Determine:

- the formula of the iron oxide produced
- the balanced symbol equation for the reaction.

Formula of iron oxide = _____

Balanced symbol equation

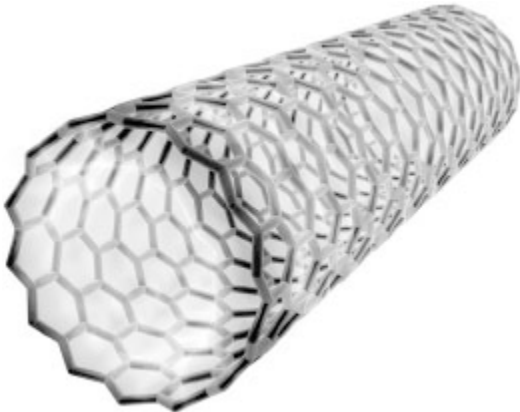
(4)

(Total 12 marks)

4.

Carbon nanotubes are cylindrical fullerenes.

The figure below represents the structure of a carbon nanotube.



(a) Describe the arrangement of carbon atoms in the nanotube shown in above figure.

(1)

(b) Nanotubes are used in electronics.

Give **one** other use of nanotubes.

(1)

(c) A nanotube contains 2380 carbon atoms.

Calculate the number of moles of carbon in this nanotube.

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

Number of moles of carbon = _____ mols

(2)

(d) Explain why carbon nanotubes can conduct electricity.

Refer to bonding between carbon atoms in your answer.

(3)
(Total 7 marks)

Mark schemes

1.

(a) electrolysis

1

of molten compound (of metal **Y**)

allow liquid for molten

1

OR

displacement (1)

by heating with a more reactive metal

or

by heating with potassium / magnesium (1)

(b) $4 \text{Na} + \text{TiCl}_4 \rightarrow 4 \text{NaCl} + \text{Ti}$

allow multiples

*allow 1 mark for NaCl **and** Ti with incorrect / no balancing*

2

(c) $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$

allow multiples

allow 1 mark for $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$ with incorrect balancing

2

ignore state symbols

(d) **method 1:**

$$\text{(moles of Al} = \frac{108}{27} \text{)} = 4$$

1

$$\text{(moles CuCl}_2 = \frac{1210}{134.5} \text{)} =$$

8.996

allow 9

1

(identifying limiting reagent)

4 moles Al gives 6 moles Cu

8.996 moles CuCl₂ gives

8.996 moles Cu

allow correct use of an incorrectly calculated value(s) for moles of Al and / or CuCl₂

1

therefore aluminium is the limiting reagent

must follow on from MP3

1

$$\text{(mass of Cu} = 2 \times 3 \times 63.5)$$

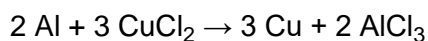
$$= 6 \times 63.5$$

1

$$= 381 \text{ (g)}$$

1

method 2:



$$(2 \times 27) \quad (3 \times 134.5) \quad (3 \times 63.5)$$

$$54 \text{ (g)} \quad 403.5 \text{ (g)} \quad 190.5 \text{ (g)}$$

$$(1) \quad (1) \quad (1)$$

(so)

108 g Al (reacts with 807 g CuCl₂) to produce 381 g Cu (1)

allow correct use of an incorrect calculation of mass for Al / CuCl₂ / Cu

(so) there is excess CuCl₂

or

807 g CuCl₂ is less than 1210 g CuCl₂(1)

therefore aluminium is limiting reactant (1)

must follow on from MP4 / MP5

method 3:

134.5 g CuCl₂ produces 63.5 g Cu (1)

(mass conversion 1.21 kg CuCl₂ =) 1210 (g) (1)

1210 g CuCl₂ produces ($\frac{63.5}{134.5} \times 1210 =$) 571 g Cu (1)

allow correct use of an incorrect / no conversion of mass of CuCl₂

54 g Al produces 190.5 g Cu (1)

108 g Al produces ($\frac{190.5}{54} \times 108 =$) 381 (g) (1)

(therefore) aluminium is the limiting reactant (1)

must follow on from MP3 and MP5

(e) delocalised electrons

allow free electrons

1

carry (electrical) charge through the metal / sodium

ignore throughout for through

ignore current / electricity

MP2 is dependent upon MP1

1

(f) (conducts electricity) when liquid / molten

or

(conducts electricity) in (aqueous) solution

allow (conducts electricity) when dissolved in water

1

(because) ions

1

(ions) are free to move

or

(ions) allow charge to flow

1

[17]

2.

(a) (mass in one phone =)

$$1.73 \times 10^{-4} \times 197$$

1

$$= 0.034081 \text{ (g)}$$

1

(total mass =)

$$0.034081 \times 2.48 \times 10^6$$

allow (total mass =) $0.034081 \times 2\,480\,000$

allow correct use of an incorrectly determined mass in one phone

1

$$= 84520.88 \text{ (g)}$$

1

(conversion $84520.88 \text{ g} =$) 84.5 (kg)

allow 84.52088 (kg) correctly rounded to at least 2 significant figures

allow conversion at MP2, MP3

allow correct conversion of an incorrectly determined mass using all numbers from the question

alternative approach

(total moles =)

$$1.73 \times 10^{-4} \times 2.48 \times 10^6 \text{ (1)}$$

allow (total moles =)

$$1.73 \times 10^{-4} \times 2\,480\,000$$

$$= 429.04 \text{ (1)}$$

(total mass =) $429.04 \times 197 \text{ (1)}$

allow correct use of an incorrectly determined total moles

$$= 84520.88 \text{ (g) (1)}$$

(conversion $84520.88 \text{ g} =$) 84.5 (kg) (1)

allow 84.52088 (kg) correctly rounded to at least 2 significant figures

allow correct conversion of an incorrectly determined mass using all numbers from the question

1

(b) 1.04×10^{20}

1

- (c) uses bacteria 1
- to produce leachate / solutions containing gold compounds 1
- from which gold is obtained by displacement / electrolysis 1
- (d) any **two** from:
- high-grade ores still available
 - land not available
 - phytomining takes a long time
 - very small yields produced
 - new technology

2

[11]

3.

- (a) (mass of oxygen = 0.20 – 0.12) = 0.08 (g) 1

$$(\text{moles of oxygen}) = \frac{0.08}{32}$$

1

$$= 0.0025$$

allow 1 mark for 0.005

if derived from $\frac{0.08}{16}$

1

- (b) (without a lid the) mass of magnesium oxide was less 1

(because) products escaped allow magnesium oxide escaped 1

- (c) (mass of copper oxide =) 1

$$\frac{79.5}{63.5} \times 0.5$$

1

$$= 0.62598 \text{ (g)}$$

1

$$= 0.626 \text{ (g)}$$

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

1

(d) 3:2 ratio Fe : O₂ (molecules)
or
3:4 ratio Fe : O (atoms) 1

(formula) Fe₃O₄
allow 1 mark for Fe₃O₂ from 3:2 ratio Fe : O (atoms)
(MP2 but not MP1) 1

3 Fe + 2 O₂ → Fe₃O₄
allow multiples
allow correct use of incorrectly determined formula
allow 1 mark for Fe, O₂ and Fe₃O₄
or
allow 1 mark for Fe, O₂ and incorrectly determined formula 2

[12]

4. (a) hexagonal (rings of carbon atoms) 1

(b) any **one** from:

- nanotechnology
- materials

ignore references to electronic use
allow suitable use such as:

- sporting equipment
- body armour

allow drug delivery 1

(c) (number of moles =) $\frac{2380}{6.02 \times 10^{23}}$ 1

= 3.95 × 10⁻²¹ (mols)
allow 3.953488 × 10⁻²¹ (mols) correctly rounded to at least 2 significant figures 1

(d) each (carbon) atom forms three covalent bonds

1

(so) one electron from each (carbon) atom is delocalised

1

(so these) delocalised electrons carry (electrical) charge through the structure /
nanotube

ignore throughout for through

ignore current / electricity

1

[7]