**(5070 METALS THEORY)**

1. The statements give some of the chemical properties of metal *X* and its compounds. 5070/21/M/J/16/QA5

• *X* does not react with cold water.

• *X* fizzes slowly with dilute hydrochloric acid.

• *X* does not react with aqueous sodium chloride.

• *X* reacts with aqueous lead (II) nitrate.

• *X* reacts with aqueous silver nitrate.

• *X*O reacts with magnesium to form *X*.

**(a)** Use the information to help arrange the following metals in order of reactivity.

lead, magnesium, silver, sodium and *X*

most reactive ...........................................................................

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least reactive ........................................................................... [2]

**(b)** Suggest a possible identity for *X*.

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**(c)** Construct the equation for the reaction between the oxide, *X*O, and magnesium.

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**(d)** Construct the ionic equation for the reaction between *X* and aqueous lead(II) nitrate,

Pb(NO3)2(aq).

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**(e)** Metal *X* is a good electrical conductor and has a high melting point.

Explain why *X*

• conducts electricity, ....................................................................................................

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• has a high melting point. ............................................................................................

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[Total: 8]

A5(a) sodium

magnesium

X

lead

silver

Sodium, magnesium, lead and silver in correct order (ignore X) (1)

X directly between magnesium and lead (1) [2]

A5(b)(ii) Zinc / iron / tin (1) [1]

A5(c) XO + Mg → MgO + X (1) [1]

A5(d) X + Pb2+ → X2+ + Pb (1) [1]

A5(e) Conducts electricity

Electrons can move (1)

High melting point

Attraction between sea of electrons and (positive) ions / forces between sea of

electrons and ions (1)

Attraction is very strong / force is very strong / it takes a lot of energy to

overcome these strong forces (1)

(this mark is dependent on attraction between (positive) ions and

electrons / forces between ions and electrons)[3]

[Total: 8]

2. Molybdenum is a transition element. It is used to make steel that is extremely hard. **5070/21/M/J/15/B7**

Molybdenum can be manufactured by heating together molybdenum(VI) oxide, MoO3, and aluminium.

**(a)** Construct the equation for this reaction.

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**(b)** Explain why this reaction involves both oxidation and reduction.

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**(c)** What mass of molybdenum can be made from 125 g of molybdenum (VI) oxide?

[*A* r: Mo, 96]

mass of molybdenum = ....................................................... g [3]

**(d)** Which metal is the less reactive, aluminium or molybdenum?

Explain your answer.

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**(e)** Molybdenum has a melting point of 2623 °C.

**(i)** Describe metallic bonding, with the aid of a labelled diagram.

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**(ii)** Suggest why molybdenum has a much higher melting point than aluminium.

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[Total: 10]

(a) MoO3 + 2Al→\_ Al2O3 + Mo (1) [1]

(b) Reduction since MoO3 loses oxygen AND

Oxidation since Al gains oxygen (1) [1]

(c) *M*r of MoO3 = 144 (1)

Moles of MoO3 is 0.868 (1)

Mass of Mo = 83.3 (g) (1) [3]

(d) Molybdenum because aluminium can displace it (1) [1]

(e) (i) Closely packed metal ions (1)

Delocalised electrons / free electrons / sea of electrons (1) [2]

(ii) ANY TWO FROM

(Much) strong(er) attraction between electrons and positive ions (1)

Needs more energy to break the attraction / needs more heat to overcome

the attraction (1)

Greater charge on cation (1)

More delocalised electrons (1) [2]

[Total: 10]

**5070/21/O/N/15/A4 part a and b**

3. Copper is a metal.

**(a)** Draw a labelled diagram to show the bonding in copper.

[2]

**(b)** Explain why metals are malleable.

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**5070/22/O/N/15/A4**

4. Iron is extracted in a blast furnace. The raw materials required are

**•** iron ore, which contains iron(III) oxide, Fe2O3 ,

**•** limestone,

**•** coke (carbon),

**•** air.

**(a)** The coke first burns in air to form carbon dioxide.

The carbon dioxide is then reduced by coke to produce carbon monoxide.

The carbon monoxide reduces the iron(III) oxide to iron.

Write equations for

**(i)** the reduction of carbon dioxide by coke,

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**(ii)** the reduction of iron(III) oxide to iron by carbon monoxide.

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**(b)** Why is limestone added to the blast furnace?

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**(c)** Another ore of iron contains an oxide with the formula Fe3O4.

Calculate the percentage by mass of iron in Fe3O4.

[2]

**(d)** Iron can be obtained by the electrolysis of an aqueous acidified solution of iron(II) sulfate.

The reactions at the electrodes are given.

at the anode (positive electrode): 4OH→O2 + 2H2O + 4e–

at the cathode (negative electrode): Fe2+ + 2e– → Fe

Which reaction is oxidation and which is reduction? Explain your answer.

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**(e)** Attaching magnesium strips to the iron hulls of ships can lower their rate of rusting.

Explain how the magnesium stops the iron from rusting.

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**(f)** Aqueous iron(II) chloride is one of the products formed when iron reacts with hydrochloric acid. Construct an equation for this reaction.

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[Total: 10]

(a) (i) CO2 + C → 2CO (1) [1]

(ii) Fe2O3 + 3CO → 2Fe + 3CO2 (1) [1]

(b) to form calcium oxide / to make calcium oxide (1) [1]



d) anode reaction is oxidation as loss of electrons (1) [2]

OR

anode reaction is oxidation as oxidation number of oxygen increases (1)

cathode reaction is reduction as gain of electrons (1)

OR

cathode reaction is reduction as oxidation number (of iron) decreases (1)

(e) 1 mark each for any two of: [2]

• magnesium more reactive than iron / magnesium higher in the reactivity

series

• magnesium reacts instead of iron / magnesium corrodes instead of iron /

magnesium corrodes preferentially

• magnesium loses electrons instead of iron

(f) Fe + 2HCl → FeCl2 + H2 (1) [1]

**5070/21/M/J/14/A3**

5. Zinc carbonate thermally decomposes to form zinc oxide and carbon dioxide.

ZnCO3(s) →ZnO(s) + CO2(g)

In an experiment, a sample of zinc carbonate is heated in a test-tube using a Bunsen burner.

The total volume of carbon dioxide formed is measured every 10 seconds.

The results are plotted on the graph below.



**(a)** Suggest why the volume of carbon dioxide does not increase by very much when the zinc

carbonate is first heated.

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**(b)** How is the graph used to find out when the decomposition has finished?

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**(c)** The same mass of zinc carbonate is heated using a **hotter** Bunsen flame.

On the axes above, draw the graph you would expect from the results of this experiment.

Explain your answer.

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**(d)** The experiment is repeated with different metal carbonates.

The Bunsen burner flame is not altered and the same number of moles of metal carbonate is used for each experiment.

The table shows the time taken for complete decomposition.



Predict and explain the time it would take magnesium carbonate and lead carbonate to

decompose.

magnesium carbonate ........................... s

lead carbonate ............................. s

explanation ............................................................................................................................

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[Total: 8]

(a) Initially zinc carbonate is cold so a low speed of reaction / at start zinc carbonate is not hot enough to decompose (1) [1]

(b) First time when the line is horizontal (1)

ALLOW explanation written on the graph [1]

(c) Graph starts at the origin and ends at the same volume (1)

Graph has same shape as original but always to the left and does not go above

the final volume (1)

Reaction is faster (1)

Particles have more energy / more successful collisions / more energetic

collisions / more fruitful collisions / more effective collisions / more particles have

energy above the activation energy (1) [4]

(d) MgCO3 any time greater than 70 and less than 360 and PbCO3 any time less

than 60 (1)

Idea that the time is linked to position of metal in the reactivity series e.g. the

more reactive the metal the longer the time (1) [2] [Total: 8]

**5070/21/M/J/14/A4**

6. Aluminium is manufactured by the electrolysis of aluminium oxide dissolved in molten cryolite.

**(a)** Give the equations for the reactions that occur at the electrodes during this electrolysis.

positive electrode .................................................................................................................

negative electrode ............................................................................................................ [2]

**(b)** Aluminium is a useful metal as it does not corrode in moist air.

Explain why aluminium does not corrode in moist air.

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**(c)** Underground iron pipes rust easily. This can be prevented by attaching a piece of magnesium to the pipe.

Explain this form of rust prevention.

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**(d)** Aluminium sulfate is a soluble salt.

Describe how a sample of aluminium sulfate crystals can be prepared from aluminium oxide.

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[Total: 10]

(a) Positive electrode: 2O2– → O2 + 4e– (1)

Negative electrode: Al3+ + 3e– → Al (1) [2]

(b) Has a layer of aluminium oxide on the surface (1)

The layer stops water getting to the surface / layer will not let oxygen reach the

surface / the layer will not flake off / layer is non-porous / layer is impermeable (1) [2]

(c) Magnesium is more reactive (than iron) / magnesium is oxidised more

easily / magnesium is above iron in the reactivity series (1)

Magnesium reacts instead of iron (1) [2]

(d) Use of excess aluminium oxide (1)

Use of sulfuric acid (1)

Filter mixture (to get filtrate) (1)

Evaporate some of solution and allow to crystallise / leave in warm place to

crystallise (1) [4]

[Total: 10]

**5070/22/M/J/14/A5**

7. Haematite, limestone and coke are heated together in a blast furnace in the manufacture of iron.

**(a)** State why each of the following compounds are needed in a blast furnace.

haematite ..............................................................................................................................

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limestone ...............................................................................................................................

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coke ......................................................................................................................................

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**(b)** Iron has a high melting point because it has strong metallic bonding.

Describe, using a labelled diagram, metallic bonding.

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**(c)** When iron is made into the alloy steel, the properties of iron are changed.

High carbon steels are stronger than iron but are brittle.

State a property of low carbon steels.

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**(d)** When magnesium powder is added to aqueous iron(II) sulfate, the following reaction occurs.

Mg(s) + Fe2+(aq)→ Mg2+(aq) + Fe(s)

1. Explain, using electron transfer, why iron(II) ions are reduced in this reaction.

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**(ii)** What would you observe in this reaction?

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[Total: 8]

(a) Haematite – is iron ore / contains the iron / is reduced to form iron (1)

Limestone – (decomposes to) form calcium oxide which removes impurities (1)

ALLOW: lime (in place of calcium oxide)

Coke – forms carbon monoxide / reduces the iron ore (1) [3]

(b) Positive ions in regular layers (1)

NOTE: 2 layers of ions is the minimum required in a diagram.

Electrons shown interspersed between the particles drawn (1)

NOTE: Marks can be scored from correct description in writing or from a labelled

diagram. [2]

(c) Softer / more malleable / more ductile (1) [1]

(d) (i) Iron(II) ions gain electrons / iron ions gain electrons / it gains electrons (1) [1]

(ii) Green solution becomes paler / green solution fades / green solution

becomes colourless / magnesium becomes coated with a dark solid (1) [1]

[Total: 8]

**5070/22/O/N/14/A5**

8. The table below shows the reactivity of five metals with either cold water or steam or with both.



**(a)** Deduce the order of reactivity of these metals using the information in the table.

most reactive .....................................................................

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least reactive ..................................................................... [1]

**(b)** A simple electrochemical cell contains two electrodes in an electrolyte.

**(i)** Complete the diagram below to show how you could measure the voltage between the

two different metal electrodes **X** and **Y**.



**(ii)** The order of reactivity of some metals is shown below.



Which combination of metals from this list would produce the highest voltage when used

as electrodes in an electrochemical cell?

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**(c)** Strips of zinc can be attached to the hull of a ship to stop the steel from rusting.

Explain how these strips of zinc stop the steel from rusting.

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[Total: 5]

(a) sodium

barium

magnesium

nickel

copper (1) [1]

(b) (i) voltmeter and two wires either side of voltmeter across the electrodes (1) [1]

(ii) iron and silver (1) [1]

(c) ANY TWO FROM

• the zinc corrodes instead of the iron / zinc reacts instead of the iron (1)

• zinc is more reactive (than iron) / zinc is more reactive (than steel) / zinc higher in the

reactivity series (than steel / iron) OR reverse argument (1)

• the zinc loses electrons in preference to the iron (1)

IGNORE: sacrificial protection without qualification [2]

[Total: 5]

**5070/21/O/N/14/A1 part c**

9. Aluminium is higher than zinc in the reactivity series.

Explain why aluminium foil does not react with an aqueous solution of zinc ions.

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aluminium forms an oxide layer (1)

layer is unreactive / layer cannot be easily removed from the surface / layer

adheres to (metal) surface / layer is impermeable to water (1) [2]

**5070/21/O/N/14/A4**

10. The diagram shows a simple electrochemical cell.



The voltages produced by different combinations of metal electrodes are shown in the table below. The more reactive metal is always the negative electrode.



**(a) (i)** Write an equation showing the conversion of zinc to zinc ions.

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**(ii)** How does the table above show that copper is above silver in the reactivity series?

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**(iii)** Which combination of metals in the table above will give the highest voltage?

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**(iv)** Use the information in the table to deduce the order of reactivity of the metals copper,

iron, magnesium, tin and zinc. Explain your answer.



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**(b)** Refer to the structure of metals to explain

**(i)** why metals are malleable,

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**(ii)** why metals conduct electricity.

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**(c)** Explain why plating iron with tin prevents the iron from rusting.

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[Total: 9]

(a) (i) Zn → Zn2+ + 2e– / Zn – 2e– → Zn2+ (1) [1]

(ii) in the copper / silver cell the copper is the negative electrode (1) [1]

(iii) silver and magnesium (1) [1]

(iv) magnesium

zinc

iron

tin

copper (1)

the higher the voltage (difference between copper and the metal) the more

reactive the metal / voltage (difference) gets smaller, the less reactive the

metal (1) [2]

(b) (i) metal layers (1)

slide over each other when force applied (1) [2]

(ii) electrons (originating from valency shell) can move / sea of

electrons / some of the electrons are mobile / there are free electrons (1) [1]

(c) tin prevents oxygen and/or water from reaching the iron (1) [1] [Total: 9]

**5070/22/M/J/13/A3 part e**

11. Aluminium is used to make alloys for the aircraft industry. One reason for this is that

aluminium does not corrode very easily.

**(i)** State one other reason why aluminium is used in the manufacture of aircraft.

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**(ii)** Explain why aluminium does not corrode very easily.

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(i) Low density [1]

(ii) It has an oxide layer / aluminium oxide is on the surface (1)

Layer is impermeable to water / layer is impermeable to air / layer is (fairly) resistant to

acids / layer is (fairly) resistant to alkalis / layer is unreactive / layer does not flake off /

layer adheres to the surface / layer is non-porous (1) [2]

**5070/21/M/J/13/B7**

12. Malachite is an ore of copper. The formula of malachite is CuCO3.Cu(OH)2.

Malachite reacts as though it is a mixture of copper(II) carbonate and copper(II) hydroxide.A small sample of malachite is added to excess dilute hydrochloric acid, HC*l*(aq).

The carbon dioxide formed is collected and has a volume of 96 cm3 at room temperature and pressure.

**(a)** What would you observe when malachite reacts with HC*l*(aq)?

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**(b)** Construct the equation for the reaction between malachite and HC*l*(aq).

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**(c)** Calculate the mass of carbonate ion, CO32−, in the sample of malachite.

mass of CO32− = .............................................. g [3]

**(d)** Copper is extracted from malachite by heating with carbon.

**(i)** Construct an equation for the reduction of malachite by carbon.

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**(ii)** Malachite is a finite resource. Give one **other** reason why copper should be recycled.

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[Total: 10]

(a) ANY TWO FROM

Dissolves (1)

Blue / green solution (1)

Fizzes / bubbles / effervescence (1) [2]

(b) CuCO3.Cu(OH)2 + 4HCl → 2CuCl2 + CO2 + 3H2O (1)

Correct formulae (1)

Balancing (1) [2]

(c) Moles of CO2 / moles of CO32– = 0.004 (1)

Mr of CO32– = 60 (1)

Mass of CO32– = 0.24 g (1) [3]

(d) (i) CuCO3.Cu(OH)2 + C → 2Cu + 2CO2 + H2O

Correct formulae (1)

Balancing (1) [2]

(ii) ANY ONE FROM:

less energy used (in recycling than in extracting from the ore) (1)

reduces pollution / reduces waste / reduces trash / less of an eyesore / not an

eyesore / less landfill / no landfill (1)

(less mining) saves more land for other uses / (less mining) saves land for more

agriculture (1) [1]

[Total: 10]

**5070/21/O/N/13/B6**

13. Iron is extracted from its ore (haematite, Fe2O3) in a blast furnace.

Coke (carbon) and limestone (calcium carbonate) are also added to the furnace.

**(a)** Describe the essential reactions taking place in the blast furnace.

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**(b)** Steel is an alloy made by the addition of carbon or metals to iron.

Use the diagrams below to explain why an alloy of iron and manganese is less malleable

than pure iron.



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**(c)** Iron reacts with dilute hydrochloric acid to form iron(II) chloride.

Fe(s) + 2HC*l* (aq) FeC*l*2(aq) + H2(g)

A student added 2.1 g of iron to 50 cm3 of 0.10 mol / dm3 hydrochloric acid.

**(i)** Calculate the amount, in moles, of iron present.

........................................... mol [1]

**(ii)** Calculate the amount, in moles, of hydrochloric acid present.

........................................... mol [1]

**(iii)** Calculate the volume of hydrogen formed in this reaction, measured at room

temperature and pressure.

...........................................cm3 [2]

[Total: 10]

(a) (i) ANY FOUR FROM:

carbon converted to carbon dioxide (from air blast) (1)

carbon monoxide formed from reaction of carbon with carbon dioxide (1)

carbon monoxide converts iron oxide, iron ore or haematite to iron (1)

(in hotter parts of furnace) carbon converts iron oxide, iron ore or haematite to iron (1)

idea of reduction of iron oxide (1)

calcium carbonate/limestone decomposes to calcium oxide (1)

calcium oxide reacts with silicon dioxide/sand to form slag (1)

balanced equation for iron oxide reduction (1) [4]

(b) in ‘pure’ iron the layers can slide (when force applied) (1)

in alloy the (larger) Mn atoms stop the layers from sliding (1) [2]

(c) (i) 0.0375 / 0.038 mol (1) [1]

(ii) 0.005 / 5 *×* 10–3 mol (1) [1]

(iii) mol H2 = 5 x 10–3/2 = 2.5 x 10–3 mol (1)

60 (cm3) / 0.06 dm3 (1) [2]

[Total: 10]

**5070/22/O/N/13/B6**

14. Aluminium is extracted from purified bauxite by electrolysis.

**(a)** Describe how this electrolysis is carried out and construct equations for the reactions

occurring at both the anode and cathode.

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**(b)** What properties of aluminium make it useful for

**(i)** making aircraft, .........................................................................................................

**(ii)** making electricity cables. ...................................................................................... [2]

**(c)** Aluminium is high in the reactivity series.

**(i)** Explain why aluminium does not react with aqueous copper(II) sulfate.

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.............................................................................................................................. [2]

**(ii)** When a few drops of aqueous sodium chloride are added to a mixture of aluminium

and aqueous copper(II) sulfate, a vigorous reaction occurs.

copper(II) sulfate + aluminium aluminium sulfate + copper

What type of reaction is this?

.............................................................................................................................. [1]

**(iii)** State the formula of aluminium sulfate.

.............................................................................................................................. [1]

[Total: 10]

(a) 2 marks for the reactions at the anode and cathode:

anode reaction: 2O2– → O2 + 4e– / 2O2– – 4e– → O2 (1)

cathode reaction: Al3+ + 3e– → Al / Al3+ → Al – 3e‑ (1)

2 marks for the description:

mention of molten aluminium oxide + cryolite in correct context (1)

AND

Any one of:

● cryolite increases conductivity of aluminium oxide / cryolite helps in dissolving

electrolyte mixture (1)

● graphite electrode(s) / carbon electrode(s) (1)

● any temperature between and including 900–1200 °C quoted (1)

● at anode carbon + oxygen → carbon dioxide (in words or equation) (1) [4]

(b) (i) low density (1) [1]

(ii) (good) electrical conductor (1)

ACCEPT: has mobile electrons [1]

(c) (i) has an oxide layer (1)

oxide (layer) is unreactive / oxide (layer) ‘sticks’ strongly to the surface

(of the aluminium) / oxide is non-porous (1) [2]

(ii) displacement / redox (1) [1]

(iii) Al2(SO4)3 (1) [1]

[Total: 10]

**5070/21/M/J/12/A5**

15. Displacement reactions occur when a metal reacts with a metal compound.

The table shows the results of some displacement reactions.

In each case a sample of powdered metal is added to an aqueous metal sulfate.



**(a)** Place the four metals in order of increasing reactivity.

least reactive …………………………….

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…………………………….

most reactive ……………………………. [1]

**(b)** Iron powder is added to aqueous copper(II) sulfate.

What you would observe in this reaction?

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..................................................................................................................................... [2]

**(c)** Aluminium foil is added to aqueous copper(II) chloride. A displacement reaction takes

place. The temperature of the reaction mixture increases.

**(i)** Name the type of reaction in which the temperature of the reaction mixture

increases.

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**(ii)** Construct the ionic equation for this displacement reaction.

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**(d)** Explain why, even though it is high up in the reactivity series, aluminium does not react

with cold water.

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**(e)** Molybdenum, atomic number 42, is manufactured by the displacement reaction between

molybdenum(VI) oxide and aluminium.

MoO3 + 2Al→ Mo + Al2O3

Calculate the mass of aluminium needed to make 1 tonne of molybdenum.

[1 tonne is one million grams.]

mass of aluminium = ................................................. [2]

[Total: 9]

(a) Copper, nickel, iron and magnesium (1) [1]

(b) Any two from:

Pink solid (1)

(Blue solution) becomes colourless / becomes pale green (1)

Allow the blue colour becomes paler

temperature increases (1) [2]

(c) (i) Exothermic (1) [1]

(ii) 3Cu2+ + 2Al → 2Al3+ + 3Cu

Ignore state symbols [1]

(d) (Surface) layer of aluminium oxide (1)

Which does not flake off / acts as a protective barrier / which is impermeable to water / does not allow water or air to reach surface of aluminium (1) [2]

(e) Moles of Mo = 10417 (1)

Mass of Al = 562500 g / 0.5625 tonnes (1)

Allow answer to 2 sig figs up to calculator value [2]

[Total: 9]

**5070/22/M/J/12/B7**

16. Many carbonates thermally decompose to form carbon dioxide and an oxide.

Copper carbonate forms carbon dioxide and copper oxide.

CuCO3 →CuO + CO2

Six 2.00 g samples of carbonates are heated strongly until there is no further change in

mass. The table shows the mass of solid remaining at the end of the heating.



**(a)** What is the mass of carbon dioxide formed when 2.00 g of copper(II) carbonate is

heated?

mass of carbon dioxide = ............................................. g [1]

**(b)** The thermal stability of the carbonates is related to the reactivity of the metal.

Which carbonate is the **least** thermally stable?

..................................................................................................................................... [1]

**(c)** For each carbonate, a 2.00 g sample was heated.

Explain why the mass of carbon dioxide formed is different for each carbonate.

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**(ii)** Explain why calcium oxide is used in a blast furnace.

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**(e)** Copper(II) chloride can be prepared by the reaction between copper(II) carbonate and

hydrochloric acid.

**(i)** Construct the ionic equation for this reaction.

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............................................................................................................................. [1]

**(ii)** Describe the essential practical details for the preparation of a crystalline sample of

copper(II) chloride.

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............................................................................................................................. [3]

[Total: 10]

(a) 0.71 g

Allow: 0.709 / 0.704 g [1]

(b) Copper (carbonate) [1]

(c) Used different amounts in moles [1]

Allow: different atomic masses of the metal / different molecular masses of compound / % of carbon in each compound is different

(d) (i) calcium ions with Ca2+ and 2.8.8 as drawn or as numbers (1)

oxide ion with O2– and 2.8 as drawn or as numbers (1) [2]

(ii) Reacts with sand to make slag / reacts with silicon dioxide to make calcium silicate /

removes silicon dioxide as slag (1) [1]



(ii) Add excess copper(II) carbonate to hydrochloric acid (1)

Filter (1)

Evaporate the filtrate partially / evaporate to crystallisation point (1)

Allow: leave to crystallise [3]

[Total: 10]

**5070/21/O/N/12/A2**

17. Steel is more resistant to corrosion than iron.

**(a)** What are the essential conditions for the corrosion of iron?

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..................................................................................................................................... [1]

**(b)** Ships’ hulls can be prevented from corroding by attaching pieces of magnesium to them.

Explain why this prevents the hulls from corroding.

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**(c)** Steel is an alloy.

Explain the meaning of the term *alloy*.

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..................................................................................................................................... [1]

**(d)** Samples of iron were placed in aqueous solutions having different pH values.

The table shows how the speed of corrosion of iron varies with the pH of the solution.



Describe how pH affects the speed of corrosion of iron.

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..................................................................................................................................... [2]

[Total: 6]

(a) oxygen/air and water

ALLOW moist air/damp oxygen [1]

(b) magnesium is more reactive than iron (1)

magnesium loses electrons rather than iron/magnesium corrodes instead of iron (1) [2]

(c) mixture of metals / mixture of metal and non metal [1]

(d) the higher the pH the less the corrosion/the lower the pH the higher the corrosion (1)

between pH 5 and 8 there is no difference in corrosion rate (1)

Note: answer must make specific reference to pH rather than acid, acidic, alkali or

alkaline [2]

[Total: 6]

**5070/21/O/N/12/B7**

18. Tin is a metal in Group IV of the Periodic Table.

**(a)** Draw a labelled diagram to show the structure of a metal.

[2]

**(b)** Explain why metals

**(i)** conduct electricity, ....................................................................................................

**(ii)** are malleable. ...........................................................................................................

............................................................................................................................. [2]

**(c)** At high temperatures, tin reacts with steam to form tin(II) oxide, SnO, and one other

product.

This reaction is reversible.

The other product is a gas which gives a ‘pop’ with a lighted splint.

**(i)** Construct an equation for this reaction.

[1]

**(ii)** Tin(II) oxide is an amphoteric oxide.

Explain the meaning of the term *amphoteric oxide*.

............................................................................................................................. [1]

**(d) (i)** Concentrated nitric acid reacts with tin to form tin(IV) oxide, SnO2, nitrogen dioxide

and water. Construct an equation for this reaction.

[1]

**(ii)** Nitric acid contains nitrate ions.

Describe a test for nitrate ions.

Give the result of a positive test.

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............................................................................................................................. [3]

[Total: 10]

(a) positive ions close to each other in a regular arrangement (1)

electrons between the positive ions randomly arranged (1) [2]

(b) (i) electrons are delocalised/electrons free to move (1)

(ii) layers slide over each other (when a force is applied) (1) [2]

(c) (i) Sn + H2O  SnO + H2

the equilibrium sign must be present to gain the mark [1]

(ii) oxide which reacts with acids as bases [1]

(d) (i) Sn + 4HNO3 → SnO2 + 4NO2 + 2H2O [1]

(ii) add (concentrated aqueous) sodium hydroxide and aluminium foil (1)

ALLOW add sodium hydroxide and Devarda’s alloy

warm and test gas with red litmus paper (1)

(red) litmus turns blue/ammonia produced (1)

ALLOW the brown-ring test [3]

[Total: 10]

**5070/21/O/N/12/B10**

19. Limestone consists mainly of the compound calcium carbonate.

**(a)** Explain why limestone is used in the blast furnace for the extraction of iron.

Include any relevant equations in your answer.

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**(b)** Group II carbonates decompose on heating.

The temperatures at which some Group II carbonates decompose are given in the table

below.



**(i)** Which one of these carbonates is least likely to decompose on heating?

............................................................................................................................. [1]

**(ii)** Describe how the thermal stability of these carbonates changes with the reactivity

of the metal.

............................................................................................................................. [1]

**(c)** The speed of reaction of calcium carbonate with hydrochloric acid can be calculated by

measuring the volume of gas given off at various time intervals.

**(i)** Draw a labelled diagram of the apparatus you could use to follow the course of this

reaction.

[2]

**(ii)** State and explain the effect of the following on the volume of a fixed mass of gas

• increasing the pressure,

• increasing the temperature.

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[Total: 10]

(a) any three from

to remove impurities in the ore as slag (1)

calcium carbonate decomposes to calcium oxide/CaCO3 → CaO + CO2 (1)

calcium oxide reacts with silicon dioxide/CaO + SiO2 → CaSiO3 (1)

slag is calcium silicate/slag is CaSiO3 (1) [3]

(b) (i) barium carbonate [1]

(ii) the more reactive the metal the more stable the carbonate [1]

(c) (i) suitable apparatus e.g. gas syringe/upturned measuring cylinder (1)

closed system – essentially does the method work (1) [2]

(ii) increasing pressure decreases the volume and increasing temperature increases

the volume (1)

(increasing pressure) pushes molecules closer together so more collisions with walls

of container (1)

(increasing temperature) makes molecules move faster/molecules have more

energy (1) [3]

[Total: 10]

**. 5070/22/O/N/12/A2**

20. A student heated different mixtures of metals and metal oxides

The table shows his results.



**(a) (i)** Predict the order of reactivity of the metals iron, lead, magnesium and zinc.



.............................................................................................................................. [1]

**(ii)** Construct the equation for the reaction of iron(III) oxide, Fe2O3, with zinc. The

products are zinc oxide, ZnO, and iron.

[1]

**(b)** Aluminium is high in the reactivity series but does not appear to react with either water

or acids.

**(i)** Explain why aluminium appears to be unreactive.

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.............................................................................................................................. [2]

**(ii)** Explain why aluminium is used in the manufacture of aircraft.

.............................................................................................................................. [1]

**(iii)** Only one naturally-occurring isotope of aluminium is known.

State the number of protons and neutrons in this isotope of aluminium.

number of protons .....................................................................................................

number of neutrons .............................................................................................. [1]

[Total:6]

(a) (i) lead < iron < zinc < magnesium [1]

(ii) Fe2O3 + 3Zn → 3ZnO + 2Fe [1]

(b) (i) (forms an) oxide layer / has a coat of oxide; (1)

which is strongly fixed to the surface / which is not easily removed / which is

unreactive; (1) [2]

(ii) low density [1]

(iii) protons = 13 and neutrons = 14 [1] [Total: 6]

 **5070/22/M/J/11/B9**

21. Copper is a transition metal. It is used both in its pure form and in alloys.

**(a)** The physical properties of copper can be explained in terms of metallic bonding.

Describe, with the aid of a labelled diagram, the metallic bonding in copper.

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**(b)** Pure copper is used to make electrical wires because it is a good electrical conductor.

**(i)** Explain why copper is a good electrical conductor.

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..............................................................................................................................[1]

**(ii)** Describe how impure copper can be purified.

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**(c)** Name an alloy that contains copper.

......................................................................................................................................[1]

**(d)** Many millions of tonnes of copper are recycled every year.

Describe some of the advantages and disadvantages of recycling copper.

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......................................................................................................................................[3]

[Total: 10]

(a) closely packed positive ions regularly arranged; [1]

REJECT: closely packed atoms

sea of electrons / delocalised electrons / free electrons; [1]

NOTE: electrons can be shown in diagram as e– / e or – or dots labelled electron

attraction between electrons and positive ions [1]

IGNORE: attraction between electrons and protons

NOTE: marks can be obtained from either written description or a diagram but take account

of any contradictory statements

(b) (i) electrons can move / has delocalised electrons / electrons are free / has sea of electrons

/ has mobile electrons [1]

(ii) impure copper anode and pure copper cathode ; [1]

electrolysis of (aqueous) copper(II) sulfate / copper(II) nitrate [1]

ALLOW: electrolysis of copper sulfate / copper nitrate

NOT: electrolysis of copper chloride

ALLOW: description of electrolysis e.g. cells connected to electrodes dipping in

electrolyte / pass electric current through solution of copper sulfate

ALLOW: relevant information from a diagram

IGNORE: copper being deposited at the wrong electrode

(c) brass / bronze / gilding metal / Muntz metal / yellow metal / bell metal / cupro-nickel /

gunmetal / speculum metal / (cupro) nickel-silver / duralumin [1]

ALLOW: smart alloy / gold alloy

IGNORE: steel alloys

(d) Any three of: [3]

• copper ores are in limited supply / are becoming worked out / are finite (resource) /

saves resources / less copper extracted from the soil

IGNORE: no waste of copper

• less energy used (in recycling than in extracting from the ore)

• reduces pollution / reduces waste / reduces trash / less eyesore / not an eyesore / less

landfill / no landfill

IGNORE: does not cause pollution

• (need to) sort out recycled metals / (need to) collect scrap / collecting scrap (costs

money) / collecting scrap requires energy

• need to purify the recycled copper

• (less mining) saves more land for other uses / (less mining) saves land for more

agriculture

IGNORE: costs / time consuming

[Total: 10]

 **5070/21/O/N/11/A5 part A**

22. Three types of bonding are covalent, ionic and metallic.

**(a) (i)** Draw a labelled diagram to illustrate metallic bonding.

[2]

**(ii)** Use ideas about the structure of metals to explain why metals are

malleable, .................................................................................................................

............................................................................................................................. [1]

good conductors of electricity. ..................................................................................

............................................................................................................................. [1]

(a) (i) Positive ions in regular layers (1) positive ions can be shown as circles with + or

labelled as ions NOT atoms

electrons shown interspersed between the ions (1) electrons can be shown in

diagram as e–/e or – or dots labelled electron [2]



(ii) malleable: idea of layers sliding when force applied (1)

conducts: electrons can move/the sea of electrons/the delocalised electrons/free

electrons (1) [2]

(b) no free electrons/no mobile electrons/all electrons involved in bonding/no delocalised

electrons/no sea of electrons (1)

strong bonding throughout the whole structure/covalent bonding throughout the whole

structure/idea of many strong bonds (1)

NOT ionic bonds

23. Aluminium is extracted from bauxite ore. 5070/21/O/N/11/B8

**(a)** One stage in purifying bauxite to obtain pure aluminium oxide involves mixing the

crushed ore with concentrated aqueous sodium hydroxide. The products of the reaction

are aqueous sodium aluminate, NaAlO2, and water.

**(i)** What type of oxide is aluminium oxide? Give a reason for your answer.

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**(ii)** Write an equation for the reaction of aluminium oxide with aqueous sodium

hydroxide.

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**(iii)** The impurities in the ore are insoluble in water.

Suggest how the impurities are separated from the aqueous sodium aluminate.

............................................................................................................................. [1]

**(b)** Pure aluminium oxide is electrolysed in the presence of cryolite to produce aluminium.

**(i)** Aluminium forms at the cathode and oxygen at the anode.

Write ionic equations for the reaction at

the cathode ......................................................................................................... [1]

the anode. ............................................................................................................ [2]

**(ii)** Explain why cryolite is added to the aluminium oxide.

............................................................................................................................. [1]

**(c) (i)** Aluminium is higher in the metal reactivity series than iron.

Apart from differences in malleability, explain why fizzy drinks cans are made from

aluminium rather than iron.

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............................................................................................................................. [2]

**(ii)** Aluminium is often used in the form of alloys.

What do you understand by the term *alloy*?

..................................................................................................................................

............................................................................................................................. [1]

[Total: 10]

(a) (i) amphoteric oxide because it react both with acids and bases/amphoteric because it

reacts as both an acid and a base (1) [1]

(ii) Al2O3 + 2NaOH → 2NaAlO2 + H2O (1)

ALLOW other equations making NaAl(OH)4 or NaAl(OH)6 [1]

(iii) Filtration (1) [1]

(b) (i) cathode: Al 3+ + 3e– → Al (1)

anode: 2O2– → O2 + 4e–

correct symbols and formulae including electron (1)

balancing (1) [3]

(ii) to dissolve the aluminium oxide/to lower the melting point of the mixture (1) [1]

(c) (i) Any two from:

aluminium (apparently) unreactive/does not corrode (1)

IGNORE aluminium does not rust

because of oxide layer (1)

acid in drink could react with iron/acid in drink doesn’t react with aluminium (1) [2]

(ii) mixture of metals or a metal with a non-metal (1) [1]

[Total: 10]

**5070/21/M/J/10/A5**

24. Mobile phones are made from a large number of different substances.

The table shows the composition of a typical mobile phone.



**(a)** One of the plastics used in a mobile phone is poly(ethene).

**(i)** What type of polymerisation occurs when poly(ethene) is made?

............................................................................................................................ [1]

**(ii)** Draw the structure of the monomer needed to make poly(ethene).

[1]

**(b)** There is a growing awareness that mobile phones should be recycled.

**(i)** State **two** advantages of recycling the substances used to make mobile phones.

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............................................................................................................................ [2]

**(ii)** Suggest **one** disadvantage of recycling the substances used to make a mobile

phone.

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............................................................................................................................ [1]

**(c)** The copper used in mobile phones is purified using electrolysis.

For this electrolysis name

the electrolyte used, .........................................................................................................

the material used for the anode, ......................................................................................

the material used for the cathode. ............................................................................. [3]

**(d)** One of the reasons why copper is used in mobile phones is because it is a good

conductor of electricity.

**(i)** Draw a labelled diagram to show the metallic bonding in copper.

[2]

**(ii)** Explain how copper conducts electricity.

..................................................................................................................................

............................................................................................................................ [1]

**(e)** The iron used in a mobile phone must not rust.

**(i)** Suggest **one** way to stop the iron used from rusting.

............................................................................................................................ [1]

**(ii)** Explain how this method for rust prevention works.

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............................................................................................................................ [1]

**(iii)** Explain why aluminium does not corrode very easily.

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............................................................................................................................ [1]

[Total: 14]

(a) (i) Addition (1) ALLOW additional



(b) (i) Any two from

reduces litter / reduces need for land fill sites (1)

reduces need for incineration / produce less toxic gases when burnt (1)

saves a finite resource / metal ores are a finite resource / crude oil is a finite

resource (1)

saves energy (1)

Less environmental damage due to mining activities / AW (1)

NOT less pollution unless qualified / NOT costs less unless qualified (2)

(ii) Any one from

difficult to sort substances (1)

difficult to collect all the mobile phones (1) (1) [3]

(c) electrolyte – copper sulfate / CuSO4 (1)

anode – impure copper (1)

cathode – (pure) copper (1) [3]

ALLOW one mark if impure and pure copper are reversed

(d) (i) Close packed positive ions (attracted to) (1)

Positive ions are touching or almost touching each other. Can be labelled with

just a positive sign

(Delocalised) electrons (1)

(ii) Electrons move / delocalised electrons / free electrons / sea of electrons (1) [3]

(e) (i) Alloy it to make steel / galvanised / tin plate / use of a sacrificial metal / paint (1)

ALLOW coat with oil

(ii) Any one from

Sacrificial protection – Metal in sacrificial metal loses electrons more easily than

iron / sacrificial metal oxidised in preference to iron / sacrificial metal more

reactive than iron (1)

Paint / oil / tin / zinc – stops oxygen and/or water reaching surface of iron (1)

Alloy – iron surrounded by layer of chromium oxide (1)

(iii) Has a (protective) layer of (aluminium) oxide (1) [3]

[Total: 14]

**5070/22/O/N/10/B8**

25. Magnesium is a reactive metal.

**(a) (i)** Name the products formed when magnesium reacts with steam.

.............................................................................................................................. [1]

**(ii)** Write the equation for the reaction of magnesium with ethanoic acid, CH3COOH.

[2]

**(b)** Magnesium chloride is a soluble salt.

Describe how you can make pure dry crystals of magnesium chloride from magnesium

carbonate.

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...................................................................................................................................... [3]

**(c)** The equation shows the reaction which occurs when magnesium carbonate is heated.

MgCO3 →MgO + CO2

State the name given to this type of chemical reaction.

...................................................................................................................................... [

**(d)** A student compared the action of heat on three solid metal carbonates.

She heated each carbonate using the apparatus shown below. In each case, she

recorded the length of time taken for the limewater to turn milky.



1. State one factor that must be kept constant if the speeds of reaction are to be

compared in a fair way.

.............................................................................................................................. [1]

**(ii)** The time taken for the limewater to turn milky for each metal carbonate is shown in

the table.



Describe and explain these results in terms of the reactivity of the metals.

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.............................................................................................................................. [2]

[Total: 10]

(a) (i) magnesium oxide and hydrogen (both required) [1]

ALLOW: correct formula of products

IGNORE: incorrect equation

(ii) 2CH3COOH + Mg → (CH3COO)2Mg + H2 [2]

1 mark for correct reactants and products

1 mark for balance (dependent on correct reactant and products)

(b) any three from: [3]

• add hydrochloric acid to (excess) magnesium carbonate;

REJECT: this first mark if titration suggested

• filter (off excess carbonate);

• heat filtrate or solution to crystallisation point / evaporate off (some of) the water

from the filtrate / leave in a warm place / leave to crystallise;

NOT: heat / dry it / put it in the oven / let all water evaporate

• pick out crystals / filter off crystals / dry crystals on filter paper

(c) (thermal) decomposition [1]

ALLOW: endothermic

(d) (i) height or strength of Bunsen flame /

ALLOW: temperature of Bunsen / temperature / amount of energy (applied) /

distance of Bunsen flame from tube / amount of carbonate in the tube /

ALLOW: volume of carbonate in tube / mass of carbonate / same amount of

limewater in tube [1]

ALLOW: same size of (carbonate) particles

IGNORE: pressure

(ii) order of decomposition is copper (carbonate) > zinc (carbonate) > magnesium

(carbonate); (1)

ALLOW: copper carbonate takes shortest time and magnesium carbonate takes

longest time / copper carbonate the fastest and magnesium carbonate the slowest

the less reactive (the metal), the faster the rate (of decomposition) /

the more reactive (the metal) the slower the rate (of decomposition) /

the more reactive (the metal) the longer it takes (to decompose) / (1) [2]

ALLOW: the most reactive takes the most time ORA

[Total: 10]

26. Aluminium and iron are both metals. 5070/02/M/J/09/B11

Iron rusts in the presence of oxygen and water. Rusting involves a series of reactions.

Initially iron atoms lose electrons to form iron(II) ions.

Fe(s) →Fe2+(aq) + 2e–

At the same time oxygen, O2, and water molecules react to form hydroxide ions.

O2(g) + 2H2O(l) + 4e– →4OH–(aq)

Aqueous iron(II) ions then react with aqueous hydroxide ions to form solid iron(II)

hydroxide.

Finally the iron(II) hydroxide is oxidised to give hydrated iron(III) oxide (rust).

**(a) (i)** Explain why the formation of iron(II) ions from iron atoms is an example of

oxidation.

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.............................................................................................................................. [1]

**(ii)** Write the ionic equation, including state symbols, for the reaction between iron(II)

ions and hydroxide ions.

.............................................................................................................................. [2]

**(b)** The table shows part of the reactivity series of metals.



An iron object plated with either zinc or tin will **not** rust.

**(i)** Suggest how tin stops iron from rusting.

.............................................................................................................................. [1]

**(ii)** An iron object plated with tin will start to rust if the layer of tin is scratched.

An iron object plated with zinc will not rust if the layer of zinc is scratched.

Use the information in the table to explain these two observations.

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**(c)** Explain why aluminium will **not** corrode in the presence of oxygen and water.

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...................................................................................................................................... [1]

**(d)** State a use of aluminium and explain why this metal is particularly suited for the stated

use.

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...................................................................................................................................... [2]

[Total: 10]

(a) (i) Electrons lost/ oxidation number (of iron) increases / oxidation number goes from 0

to +2 ; [1]

NOT: incorrect oxidation numbers

(ii) Fe2+(aq) + 2OH–(aq) → Fe(OH)2(s) [2]

correct balanced equation = 1 mark

correct state symbols = 1 mark

(mark for state symbols dependent on correct formulae)

(b) (i) stops water from getting to the surface (of the iron) / [1]

stops oxygen getting to surface (of the iron) /

stops oxygen / water getting to the iron /

stops air getting to the iron /

ALLOW: acts as a protective barrier / layer

NOT: ideas about sacrificial protection

NOT: tin does not react with water / air / tin less reactive than iron

(ii) with tin: oxygen / water can react with the iron (where it is scratched) ; [1]

NOT: iron more reactive than tin

with zinc any two of: [2]

• zinc more reactive than iron

NOT: zinc oxide protective layer

• zinc is sacrificial metal / idea of sacrificial protection i.e. zinc corrodes more

readily than iron / zinc reacts first

NOT: zinc rusts more readily than iron

• zinc loses electrons more readily than iron

NOT: zinc displaces iron

(c) has layer of (aluminium) oxide that will not flake off / [1]

layer of insoluble / unreactive (aluminium) oxide /

layer of impermeable (aluminium) oxide / protective oxide layer /

NOT: oxide coating without further qualification

NOT: forms a protective layer with oxygen

(d) correct use ; [1]

e.g. drink cans / car bodies / aircraft bodies / high voltage electricity cables /

cooking foil / window frames / ladders /

ALLOW: cooking utensils / mirrors (as does not corrode)

NOT: for cutlery

correct explanation related to specific use stated ; [1]

e.g. drinks cans → will not react with water / acids

car bodies → will not corrode

aircraft bodies → lightweight / low density

electricity cables → lightweight / good conductor of electricity

[Total: 10]

. **5070/02/O/N/09/B10**

27. Iron is extracted by reducing iron ore in a blast furnace. The raw materials used are iron ore, coke, air and limestone

**(a)** Name an ore of iron.

...................................................................................................................................... [1]

**(b)** Explain, by reference to the chemical reactions involved, why limestone is used in the

blast furnace.

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...................................................................................................................................... [3]

**(c)** Coke burns in oxygen to form carbon dioxide.

Explain, in terms of bond breaking and bond making, why this reaction is exothermic.

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...................................................................................................................................... [3]

**(d)** In the centre of the blast furnace iron(III) oxide, Fe2O3, is reduced by carbon monoxide

to form iron and carbon dioxide. Near the bottom of the blast furnace the remaining

iron(III) oxide is reduced by carbon to form iron and carbon monoxide.

Write equations for both of these reactions.

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...................................................................................................................................... [2]

**(e)** When cold, the iron obtained from the blast furnace is brittle.

How can this iron from the blast furnace be converted to mild steel?

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...................................................................................................................................... [1]

[Total: 10]

(a) haematite / limonite / magnetite / siderite [1]

(b) Any 3 of:

• calcium carbonate / limestone decomposes to calcium oxide;

• calcium oxide reacts with silica / silicon dioxide / sand (in the ore);

• calcium oxide is basic so reacts with acidic impurities;

• to form a slag / calcium silicate (this mark consequential on either of the two above);

• silicates / impurities would clog up the blast furnace if not removed [3]

(c) energy needed to break the bonds (in carbon and oxygen) / bond breaking is endothermic; [1]

energy released on forming bonds in CO2 / bond forming is exothermic; [1]

more energy involved in bond making than bond breaking / more energy released than

absorbed [1]

(d) Fe2O3+ 3CO → 2Fe + 3CO2 [1]

Fe2O3 + 3C → 2Fe + 3CO [1]

IGNORE: state symbols

IGNORE: word equation

(e) remove (some) carbon / blow oxygen through (the molten iron) / react it with oxygen / use a basic oxygen converter [1]

NOT: use a furnace / use a converter

NOT: adding other metals to form stainless steel / alloys

[Total: 10]

28. In the production of aluminium, sodium hydroxide is used to separate aluminium oxide

from the impurities in the bauxite ore. The main impurity in the ore is iron(III) oxide.

Aluminium oxide is an amphoteric oxide whilst iron(III) oxide is a basic oxide.

Suggest how these two oxides can be separated by the addition of aqueous sodium

hydroxide.

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...................................................................................................................................... [2]

**(d)** Aluminium is extracted by the electrolysis of a mixture of molten aluminium oxide and

cryolite. What is the function of the cryolite? 5070/02/O/N/08/A6 part c, d and e

...................................................................................................................................... [1]

**(e)** Acidic foods can be safely packed in aluminium containers.

Explain why the acid in the food does not attack the aluminium, despite the fact that

aluminium is a reactive metal.

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...................................................................................................................................... [2]

(c) any two of:

• aluminium oxide dissolves (in sodium hydroxide)/aluminium oxide forms a solution (in

sodium hydroxide)/aluminium oxide is soluble (in excess sodium hydroxide)/

• iron(III) oxide does not dissolve (in excess sodium hydroxide)/iron(III) oxide is insoluble

(in excess sodium hydroxide)

NOT: iron(III) forms a precipitate

• separate by filtration/allowing iron oxide to settle and drawing off solution/decanting

ALLOW: separate by centrifugation/use a centrifuge [2]

FOR ALL 3 points IGNORE: names of solids/solutions formed

(d) dissolves the aluminium oxide/alumina or

lowers melting point of the melt/aluminium oxide mixture OWTTE [1]

ALLOW: lowers the melting point of aluminium oxide

ALLOW: lowers the temperature at which electrolysis takes place

NOT: lowers the temperature (unqualified)

(e) (aluminium) covered with (aluminium) oxide layer/there is (aluminium) oxide on the surface

ALLOW: protective layer formed by reaction with oxygen

NOT: wrong layer e.g. oxygen layer/layer of nitrogen

layer/aluminium oxide is unreactive/layer stops (chemical) reaction/protective layer formed

NOT: aluminium is unreactive [2]

**5070/02/M/J/07/A7**

29. The carbonates of many metallic elements decompose when heated.

**(a)** Name the gas produced during the decomposition of a metal carbonate and describe a

chemical test for this gas.

gas produced ...................................................................................................................

chemical test ....................................................................................................................

......................................................................................................................................[2]

**(b)** Calcium oxide is manufactured by the decomposition of calcium carbonate.

Write the equation for this decomposition.

......................................................................................................................................[1]

**(c)** A student investigates the decomposition of five different metal carbonates.

The diagram shows the apparatus the student uses.



The student heats a 0.010 mol sample of each carbonate using the blue flame of the

same Bunsen burner. She measures the time it takes for 100 cm3 of gas to be collected

in the gas syringe.

The table shows her results.



The student used calcium carbonate, copper(II) carbonate, magnesium carbonate,

sodium carbonate and zinc carbonate.

Complete the table to show the identity of each metal **U**, **V**, **X**, **Y** and **Z**.



Explain how you used the student’s results to identify each metal.

..........................................................................................................................................

..........................................................................................................................................

.....................................................................................................................................[3]

**(d)** The nitrates of metallic elements also decompose when heated.

Calcium nitrate decomposes to form calcium oxide, nitrogen dioxide and oxygen.

2Ca(NO3)2(s) →2CaO(s) + 4NO2(g) + O2(g)

A 0.010 mol sample of calcium nitrate is heated. Calculate the number of moles of gas

produced when this sample is completely decomposed.

................................ moles [1]

[Total: 7]

(a) carbon dioxide/CO2: [1]

limewater goes cloudy/white/milky/white precipitate [1]

(both limewater and result needed for one mark)

IF: another gas e.g. hydrogen then no marks

(b) CaCO3 → CaO + CO2 [1]

IGNORE: state symbols

REJECT: balanced equation with other species on left or right

(c) U – copper

V – magnesium

X – calcium

Y – sodium

Z – zinc correct order = 2 marks

U – sodium

V – magnesium

X – zinc

Y – copper

Z – calcium order reversed = 1 mark [2]

reason e.g.

the more reactive the metal, the longer the time taken to decompose ORA/

the more reactive the metal, the slower the rate (of decomposition) ORA/

ALLOW: more reactive metal (carbonates) take longer to decompose

ALLOW: the more reactive the metal (carbonate) the more stable it is to heat(ing) [1]

NOT: the metals are in order of the reactivity series

(d) 0.01 × 5/2 = 0.025 [1] [Total: 7]

**5070/02/O/N/06/A2 part a**

30. The table shows the decomposition temperatures of some metal carbonates.



**(a) (i)** Describe how the decomposition temperature depends on the position of the metal

in the reactivity series.

...................................................................................................................................

...............................................................................................................................[1]

**(ii)** Write an equation for the thermal decomposition of magnesium carbonate.

...............................................................................................................................[1]

(i) the more reactive the metal the higher the (decomposition)

temperature/the less readily the carbonate is decomposed (or reverse

argument) [1]

NOTE: comparison essential

NOT: the smaller the cation, the lower the decomposition temperature

(ii) MgCO3 → MgO + CO2 (ignore state symbols) [1]

31. Brass is an alloy containing zinc and copper. 5070/02/M/J/06/B10

**(a)** Explain why the physical properties of brass are different from those of zinc and copper. [1]

**(b)** A sample of powdered brass is added to excess dilute nitric acid.

The mixture is heated gently until all the brass reacts.

The resulting solution, **A**, contains aqueous copper(II) ions and aqueous zinc ions.

**(i)** Suggest the colour of solution **A**. [1]

**(ii)** Describe and explain, with the aid of equations, what happens when aqueous sodium

hydroxide is slowly added to solution **A**. [5]

**(c)** Another sample of powdered brass is added to excess dilute hydrochloric acid.

The mixture is heated and an aqueous solution of a compound **B** together with a solid **C** are formed.

**(i)** Name both **B** and **C**. [2]

**(ii)** Write an ionic equation for this reaction. [1]

(a) atoms in brass do not slide as easily [1]

(b) (i) colour is blue (1)

(ii) any 5 of:

• blue precipitate;

• Cu2+ + 2OH- → Cu(OH)2

ALLOW: full equation

• white precipitate masked by blue one/ ppt lighter blue in colour than with copper

hydroxide alone

• Zn2+ + 2OH- → Zn(OH)2

ALLOW: full equation

• precipitates are copper hydroxide and zinc hydroxide or correct

formulae (can be from the equations)

• part of the precipitate redissolves in excess (sodium hydroxide)/ ppt of zinc hydroxide

redissolves in excess (sodium hydroxide)

[6]

(c) (i) names: B is zinc chloride (1)

C is copper (1)

(ii) ionic equation (1)

Zn + 2 H+ → Zn2+ + H2 [3]

[Total: 10]

 **5070/02/M/J/05/A2**

32. Iron is one of the most important metals. It is a transition element.

Most iron is used in the alloy steel.

**(a)** Explain, in terms of metallic bonding, why iron is a good electrical conductor.

..........................................................................................................................................

..........................................................................................................................................

......................................................................................................................................[2]

**(b)** Describe how different proportions of carbon can modify the physical properties of steel.

..........................................................................................................................................

..........................................................................................................................................

......................................................................................................................................[2]

**(c)** When underwater, iron pipes will rust relatively rapidly.

**(i)** State the essential conditions needed for the rusting of iron.

...................................................................................................................................

**(ii)** Pieces of magnesium are often attached to underwater iron pipes. Explain how the

magnesium protects the iron pipes against rusting.

...................................................................................................................................

...................................................................................................................................

…............................................................................................................................[3]

**(d)** Write **two** typical properties that are generally common **only** to transition elements.

1. ......................................................................................................................................

2. ..................................................................................................................................[2]

**(e)** A sample of a compound of iron is analysed. The sample contains 0.547 g of potassium,

0.195 g of iron, 0.252 g of carbon and 0.294 g of nitrogen.

Calculate the empirical formula of this compound.

Answer .........................................................................................................................[3]

(a) iron has positive ions and delocalised electrons (1)

the electrons are free to move (1)

moving electrons is an electric current (1) [3]

(b) high carbon steels are strong or are brittle (allow harder) (1)

low carbon steels are soft or are more easily shaped

(allow more malleable) (1) [2]

(c) (i) conditions are air (oxygen) and water or moist air (1)

(ii) magnesium is above iron in the reactivity series

(or is more reactive) (1)

hence it corrodes before the iron (1) [3]

(d) any two from:

coloured compounds/variable oxidation states/can act as

catalysts/valency/form complex ions [2]

(e) calculation

for idea of dividing by correct Ar (1)

dividing by the smallest (1)

for final formula only if first 2 fully correct (1)



33. The diagram below shows an experiment in which steam was passed over hot iron filings. The products of the reaction are iron oxide, Fe3O4, and a gas which burns with a blue flame. 5070/02/O/N/05/B10

****

**(a)** Write an equation, including state symbols, for the reaction and describe what you would see as the iron reacts with the steam. [3]

**(b)** Describe how the observations would be different if the experiment was repeated using each of the following two metals in place of the iron filings.

**(i)** magnesium

**(ii)** copper [3]

**(c) (i)** Both copper and aluminium are good conductors of electricity. Explain why overhead

cables are usually made from aluminium and not copper.

**(ii)** Draw a diagram to show the structure and bonding of aluminium metal. Use your

diagram to explain why aluminium conducts electricity so well.

[4]

[Total: 10 marks]

a. apparatus with battery and graphite electrodes;

test tubes to collect gases

no labels max 1

2

b i) H+, OH-, SO42-; 1

ii) 

oxygen relights a glowing splint;

hydrogen pops when lit; 4

Iii) Acid becomes more concentrated 1

c) React with more reactive metal e.g. Mg or Zn;

M + H2SO4→ H2 + MSO4; 2

[Total= 10]

34. The table below shows some of the ores of iron. 5070/02/M/J/04/B10

****

**(a)** Which ore in the table contains the greatest percentage by mass of iron? Explain your

answer. [2]

**(b)** Give the equations for the **redox** reactions taking place in the extraction of iron from

haematite.

In each case state which substance is oxidised and which is reduced. [4]

**(c)** Iron is malleable. Describe how this property can be explained in terms of its structure.

[2]

**(d)** State and explain how the properties of iron can be changed by the addition of carbon.

[2]

(a) no mark for Fe3O4 alone

% Fe’s are Fe2O3 122/160 = 70.0 {1}

Fe3O4 168/232 = 74.4 {1}

FeCO3 56/126 = 48.2 {1}

{3}

…………………………………………………………………………………………

(b) four equations plus four statements at {1} each

allow statements using oxidation states

C + O2 → CO2

C oxidised and O2 reduced

C + CO2 → 2 CO

C oxidised and CO2 reduced

Fe2O3 + 3 CO → 2 Fe + 3 CO2

Fe2O3 reduced and CO oxidised

Fe2O3 + 3 C → 2 Fe + 3 CO

Fe2O3 reduced and C oxidised

{4}

…………………………………………………………………………………………

(c) metals have +ve ions in sea of electrons {1}

ions can slide around {1}

{2}

…………………………………………………………………………………………

(d) low carbon gives softer/more malleable steel {1}

carbon disrupts the packing {1}

{2}

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**5070/02/O/N/04/B9**

35. Iron from the Blast Furnace contains carbon as an impurity. To remove the carbon, oxygen is blown on the molten iron in a large vessel known as a converter. The carbon is oxidised to carbondioxide.



**(a)** The temperature of the molten iron increases as the oxygen is blown onto it. Explain why. [1]

**(b)** During the oxygen blow, some of the molten iron is oxidised to iron(III) oxide. Write an

equation for this reaction. State symbols are not required. [2]

**(c)** Scrap steel is recycled by being added, as a solid, to the molten iron, before the oxygen blow.

The graph below shows how the temperature of the molten iron changes during the oxygen blow.



**(i)** Describe how the temperature of the molten iron changes during the oxygen blow.

Explain why the solid scrap steel affects the temperature change during the oxygen blow.

**(ii)** Give a reason why it is important to recycle steel. [3]

**(d)** The diagram shows the arrangement of atoms in pure iron.



Draw similar diagrams to show the arrangement of atoms in

**(i)** low carbon steel alloy,

**(ii)** high carbon steel alloy.

**(iii)** How do the properties of the two types of steel differ? Use your diagrams to explain why

the properties are different. [4]

[Total: 10 marks]

(a) reaction is exothermic/gives out heat/gives out energy[1]

(b) 4Fe + 3O2 → 2Fe2O3

(1) for Fe2O3;

CONSEQUENTIAL (1) for rest of equation correct[2]

(c) (i) rises slowly then faster;

melting the scrap is endothermic/uses energy

/temperature of molten iron changes less when scrap is

melting.[2]

(ii) aving metal ores/saving energy for extraction/saves

need to dispose of scrap iron.[1]

(d) (i) and(ii)

(mark together)

more carbon in high carbon steel;

both alloys contain more iron than carbon;[2]

(iii) Property:

low C steel softer/weaker/more easily shaped/less brittle

than high carbon steel; ORA

Structure:

properties change because carbon atoms are smaller

than iron atoms (may come from reference to

diagram)/metallic bonding is disrupted/lattice is

disrupted/alloy structure is less regular/layers need to slip

when steel changes shape[2]

10 marks

**5070/02/M/J/04/B8**

36. Nickel is a transition element. It is manufactured in a four-stage process from nickel(II)

sulphide, NiS.

• Stage 1 – nickel(II) sulphide is heated in air to form nickel(II) oxide and sulphur dioxide.

• Stage 2 – nickel(II) oxide is heated with carbon to give impure nickel.

• Stage 3 – impure nickel is reacted with carbon monoxide to make nickel tetracarbonyl, Ni(CO)4.

• Stage 4 – nickel tetracarbonyl is decomposed to give pure nickel.

**(a) (i)** Construct the balanced equation for the reaction in stage 1.

**(ii)** Calculate the mass of sulphur dioxide that is formed when 182 kg of nickel sulphide

is heated in air. [3]

**(b)** Nickel tetracarbonyl is a liquid with a boiling point of 43 °C.

Suggest, with a reason, the type of bonding in nickel tetracarbonyl. [2]

**(c)** Suggest **one** possible environmental consequence of the manufacture of nickel. [1]

**(d)** Give an example of the use of nickel as a catalyst. [1]

**(e)** In an experiment, small amounts of three metals were added to three aqueous metal

nitrate solutions.

The results are shown in the table.



Predict the observations when nickel is added to separate solutions of zinc nitrate and

copper(II) nitrate.

Write an ionic equation for **one** of the reactions that takes place. [3]

(a)

(i) equation {1}

2 NiS + 3 O2 → 2 NiO + 2 SO2

(ii) (59 + 32) kg NiS forms (32 + 32) kg SO2 {1}

182 kg NiS forms 182x64/91 = 128 kg SO2 {1}

{3}

…………………………………………………………………………………………..

(b) it is covalent {1}

because low b.p. {1}

shows small forces present {1}

{3}

…………………………………………………………………………………………..

(c) compound and problem both needed {1}

e.g.

SO2 causes acid rain or an effect of acid rain

CO2 causes greenhouse effect or an effect of warming

CO is toxic

{1}

…………………………………………………………………………………………

(d) used in hydrogenation of alkenes {1}

{1}

………………………………………………………………………………………….

(e) Ni + Zn(NO3)2 no reaction {1}

Ni + Cu(NO3)2 soln changes blue to green

and/or pink solid {1}

an equation {1}

Zn + Ni2+ → Zn2+ + Ni

Zn + Cu2+ → Zn2+ + Cu

Ni + Cu2+ → Ni2+ + Cu {3}

……………………………………………………………………………………….

**5070/2/O/N/03/B9**

37. This diagram shows an electrolysis tank used industrially to produce aluminium from

aluminium oxide. 

One reason that this process is expensive is that the graphite anodes need replacing

regularly.

**(a)** Explain, with the help of an equation, why the graphite anodes need replacing regularly.

[2]

**(b)** Adding molten cryolite reduces the cost of the process by lowering energy demand.

Explain how adding molten cryolite reduces the energy demand of the process. [2]

**(c)** State two uses of aluminium. State the property of aluminium which makes it suitable for

each use. [2]

**(d)** Aluminium is above hydrogen in the reactivity series.

The following experiments were set up.



A reaction occurred in Experiment 2, but not in Experiment 1.

**(i)** Explain what observations you would see in each experiment. Explain why the two

strips behave differently.

**(ii)** State the change in oxidation state of aluminium during the reaction in

Experiment 2. [4]

38. Zinc can be extracted from calamine, ZnCO3, in a two-stage process. 5070/2/O/N/02/B7

Stage 1 ZnCO3→ ZnO + CO2

Stage 2 ZnO + C→ Zn + CO

**(a)** Explain why the gases from stage 2 must be removed for the safety of the workers. [1]

**(b)** Explain why the same two-stage process cannot be used to extract sodium from sodium

carbonate, Na2CO3. [2]

**(c)** Industrial processes release large amounts of carbon dioxide. This contributes to global

warming.

Describe **two** environmental consequences of an increase in global warming. [2]

**(d)** In the laboratory, two experiments were set up using zinc metal.



For each experiment, describe what you would observe and how you would test any gases evolved. Write an equation for the reaction in each beaker. [5]

[Total : 10]

**5070/2 Nov01/B10**

39.**(a)** You are provided with the following substances.

magnesium metal

copper metal

aqueous chlorine

aqueous iodine

aqueous copper(II) sulphate

aqueous magnesium nitrate

aqueous potassium chloride

aqueous potassium iodide.

Use substances from the list to show that,

**(i)** iodine is less reactive than chlorine,

**(ii)** copper is less reactive than magnesium.

Your answer should include details of your observations and the equations for the reactions which occur. [7]

**(b)** The table shows information about three metals, **X**, **Y** and **Z**.



**(i)** Place the three metals in order of increasing reactivity.

**(ii)** Suggest the identity of the three metals **X**, **Y** and **Z**. [3]

[10 marks]

(a)(i) Reagents: Chlorine soln. mixed with potassium iodide soln. 1

Observation: Colourless to brown / orange 1

Eqn: Cl2 + 2KI → I2 + 2KCl or ionic 1

(ii) Reagents: magnesium and copper sulphate solution 1

Observation: brown / red-brown / pink / black (allow orange or coppercoloured)

metal / deposit / solid formed / blue colour fades 1

Eqn: Mg + CuSO4 → Cu + MgSO4 or ionic 1

Negative result to confirm outcome in either case 1

(b)(i) X Z Y 1

(ii) X = Ag / Au / Pt

Z = Zn / Cu / Fe / Sn

Y = Al

3 correct (2)

2/1 correct only (1) 3