Metals & the Reactivity Series

IGCSE 0620 – Theory Questions

Question 1

(ii) Complete the equation for the decomposition of strontium carbonate.

$$SrCO_3 \rightarrow \text{.....} + \text{.....}$$

[1]

(c) Metal nitrates decompose when heated.

(i) Rubidium nitrate decomposes as follows:

$$2RbNO_3 \rightarrow 2RbNO_2 + O_2$$

What is the name of the compound $RbNO_2$?

..... [1]

(ii) The nitrates of most other metals decompose in a different way.
Complete the equation for the decomposition of strontium nitrate.

$$\text{.....}Sr(NO_3)_2 \rightarrow \text{.....} + 4NO_2 + \text{.....}$$

[2]

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Question 2

(c) When a mixture of sulfur and potassium nitrate is burned and the products are dissolved in water, sulfuric acid is formed.

(i) The sulfuric acid formed by this method is not pure. It contains another acid.
Deduce the identity of this acid.

..... [1]

(ii) The heat causes some of the potassium nitrate to decompose.
Write the equation for the action of heat on potassium nitrate.

..... [2]

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Question 3

4 Zinc is an important metal. Its uses include making alloys and the construction of dry cells (batteries).

(a) Name an alloy which contains zinc. What is the other metal in this alloy?

name of alloy .....

other metal in alloy .....

[2]

(b) The main ore of zinc is zinc blende, ZnS.

(i) The ore is heated in the presence of air to form zinc oxide and sulfur dioxide.
Write the equation for this reaction.

..... [2]

(ii) Give a major use of sulfur dioxide.

..... [1]

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Question 4

2 Aluminium is obtained by the reduction of aluminium ions to aluminium atoms.

(a) Write an ionic equation for the reduction of an aluminium ion to an aluminium atom.

..... [2]

(b) The original method of extracting aluminium involved the reduction of aluminium chloride using the reactive metal sodium. Aluminium obtained by this method was very expensive due to the high cost of extracting sodium from sodium chloride.

(i) Complete the equation for this reduction.

$AlCl_3$ + ...Na → ..... + ...

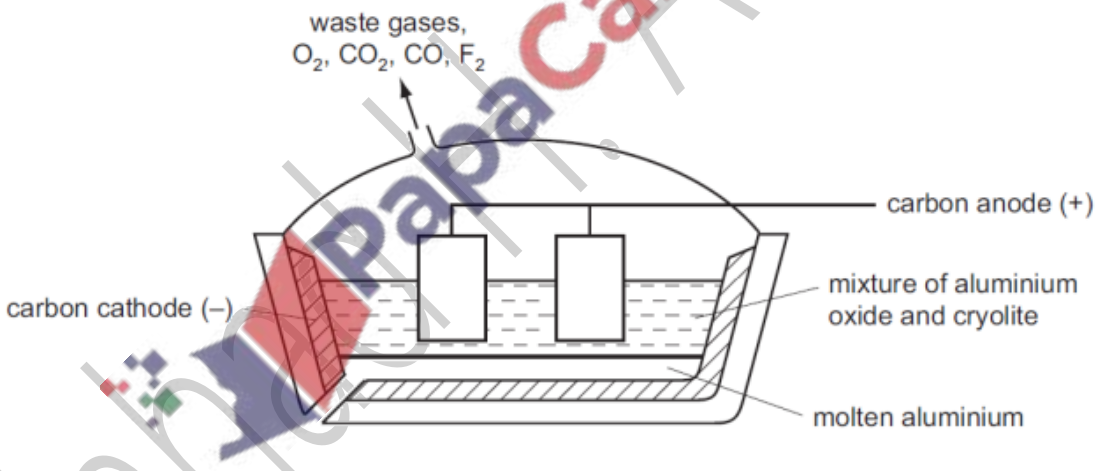
[2]

(ii) How can sodium metal be obtained from sodium chloride?

.....

..... [2]

(c) In the modern method, aluminium is obtained by the electrolysis of aluminium oxide (alumina) dissolved in molten cryolite, Na_3AlF_6.



(i) The major ore of aluminium is impure aluminium oxide.
What is the name of this ore?

..... [1]

(ii) This ore is a mixture of aluminium oxide, which is amphoteric, and iron(III) oxide which is basic.
Explain how these two oxides can be separated by the addition of aqueous sodium hydroxide.

.....

.....

..... [2]

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(iii) Give **two** reasons why the electrolyte contains cryolite.

.....

.....

..... [2]

(iv) The mixture of gases evolved at the positive electrode includes:

carbon dioxide
carbon monoxide
fluorine
oxygen

Explain the presence of these gases in the gaseous mixture formed at the positive electrode. Include at least **one** equation in your explanation.

.....

.....

.....

.....

..... [5]

(d) A major use of aluminium is the manufacture of pots and pans. One reason for this is its resistance to corrosion.

(i) Explain why aluminium, a reactive metal, is resistant to corrosion.

.....

..... [1]

(ii) Suggest **two** other reasons why aluminium is suitable for making pots and pans.

.....

..... [2]

[Total: 19]

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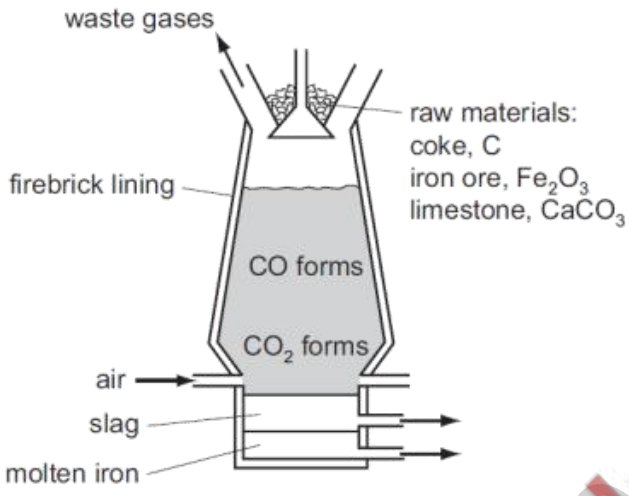
Question 5

4 Iron is extracted from the ore hematite in the Blast Furnace.



(a) The coke reacts with the oxygen in the air to form carbon dioxide.

$$C + O_2 \rightarrow CO_2$$

(i) Explain why carbon monoxide is formed higher in the Blast Furnace.

.....

..... [2]

(ii) Write an equation for the reduction of hematite, Fe_2O_3, by carbon monoxide.

..... [2]

(b) (i) Limestone decomposes to form two products, one of which is calcium oxide. Name the other product.

..... [1]

(ii) Calcium oxide reacts with silicon(IV) oxide, an acidic impurity in the iron ore, to form slag. Write an equation for this reaction.

..... [2]

(iii) Explain why the molten iron and the molten slag form two layers and why molten iron is the lower layer.

.....

..... [2]

(iv) Suggest why the molten iron does **not** react with the air.

..... [1]

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(c) Iron and steel rust. Iron is oxidised to hydrated iron(III) oxide, $Fe_2O_3.2H_2O$, which is rust.

(i) Name the **two** substances which cause iron to rust.

..... [1]

(ii) Explain why an aluminium article coated with aluminium oxide is protected from further corrosion but a steel article coated with rust continues to corrode.

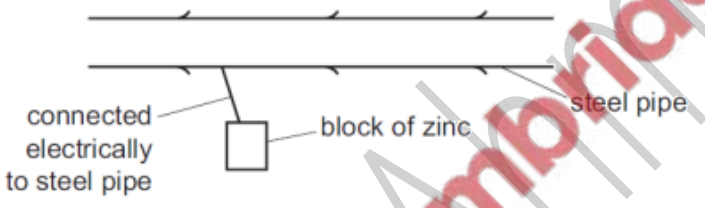
.....

..... [1]

(d) There are two electrochemical methods of rust prevention.

(i) The first method is sacrificial protection.

Explain why the steel article does not rust.



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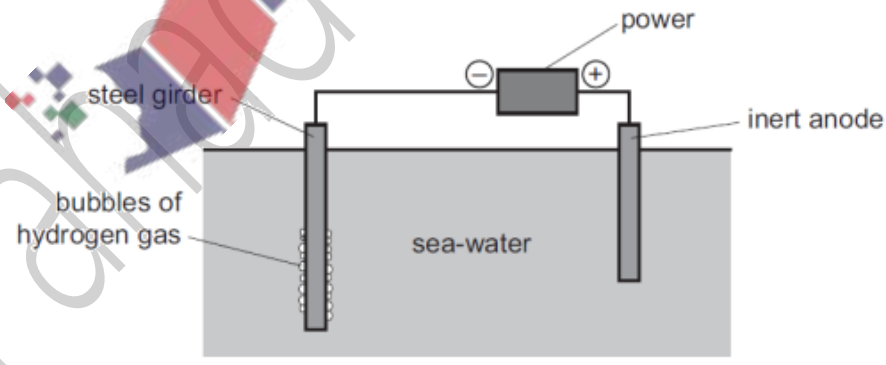
.....

.....

..... [4]

The second method is to make the steel article the cathode in a circuit for electrolysis.



(ii) Mark on the diagram the direction of the electron flow. [1]

(iii) The steel girder does not rust because it is the cathode. Reduction takes place at the cathode. Give the equation for the reduction of hydrogen ions.

..... [2]

[Total: 19]

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Question 6

5 Domestic rubbish is disposed of in landfill sites. Rubbish could include the following items.

item of rubbish	approximate time for item to break down
newspaper	one month
cotton rag	six months
woollen glove	one year
aluminium container	up to 500 years
styrofoam cup	1000 years

(a) Explain why aluminium, a reactive metal, takes so long to corrode.

..... [1]

Question 7

(d) **(i)** Brass is an alloy of copper and zinc. Suggest **two** reasons why brass is often used in preference to copper.

.....

..... [2]

(ii) Sacrificial protection is a method of rust prevention. Explain in terms of electron transfer why steel, which is in electrical contact with zinc, does not rust.

.....

.....

.....

..... [4]

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Question 8

3 The main uses of zinc are preventing steel from rusting and making alloys.

(a) The main ore of zinc is zinc blende. Zinc blende consists mainly of zinc sulfide, ZnS. There are two major methods of extracting zinc from its ore. They are the direct reduction of zinc oxide to zinc and by electrolysis. In both methods, zinc oxide is made from the zinc sulfide in the ore.

(i) How is zinc oxide made from zinc sulfide?

.....

..... [1]

(ii) Write an equation for the reaction used to reduce zinc oxide to zinc.

..... [1]

(b) In the electrolytic method, zinc oxide reacts with sulfuric acid to form impure aqueous zinc sulfate. This solution contains Ni^{2+}, Co^{2+} and Cu^{2+} ions as impurities.

(i) Write the equation for the reaction between zinc oxide and sulfuric acid.

..... [1]

(ii) Nickel, cobalt and copper are all less reactive than zinc. Explain why the addition of zinc powder removes these ions from the solution.

.....

..... [2]

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Question 9

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6 The following reactivity series shows both familiar and unfamiliar elements in order of decreasing reactivity. Each element is represented by a redox equation.

$$Rb \rightleftharpoons Rb^{+} + e^{-}$$
$$Mg \rightleftharpoons Mg^{2+} + 2e^{-}$$
$$Mn \rightleftharpoons Mn^{2+} + 2e^{-}$$
$$Zn \rightleftharpoons Zn^{2+} + 2e^{-}$$
$$H_2 \rightleftharpoons 2H^{+} + 2e^{-}$$
$$Cu \rightleftharpoons Cu^{2+} + 2e^{-}$$
$$Hg \rightleftharpoons Hg^{2+} + 2e^{-}$$

Two of the uses of the series are to predict the thermal stability of compounds of the metals and to explain their redox reactions.

(a) Most metal hydroxides decompose when heated.

(i) Complete the equation for the thermal decomposition of copper(II) hydroxide.

$Cu(OH)_2 \rightarrow$ ..... + ... [1]

(ii) Choose a metal from the above series whose hydroxide does not decompose when heated.

..... [1]

(b) (i) Define in terms of electron transfer the term *oxidation*.

..... [1]

(ii) Explain why the positive ions in the above equations are oxidising agents.

.....

..... [1]

(c) (i) Which metals in the series above do not react with dilute acids to form hydrogen?

..... [1]

(ii) Describe an experiment which would confirm the prediction made in **(c)(i)**.

.....

..... [1]

(d) (i) Which metal in the series above can form a negative ion which gives a pink / purple solution in water?

..... [1]

(ii) Describe what you would observe when zinc, a reducing agent, is added to this pink / purple solution.

..... [1]

[Total: 8]

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Question 10

4 For centuries, iron has been extracted from its ore in the blast furnace. The world production of pig iron is measured in hundreds of million tonnes annually.

(a) The following raw materials are supplied to a modern blast furnace.

iron ore which is hematite, Fe_2O_3
limestone which is calcium carbonate
carbon in the form of coke
air

Describe the essential reactions in the blast furnace. Each of the four raw materials must be mentioned at least once. Give the equation for the reduction of hematite.

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

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6 Lead is an excellent roofing material. It is malleable and resistant to corrosion. Lead rapidly becomes coated with basic lead carbonate which protects it from further corrosion.

(a) Lead has a typical metallic structure which is a lattice of lead ions surrounded by a 'sea' of mobile electrons. This structure is held together by attractive forces called a metallic bond.

(i) Explain why there are attractive forces in a metallic structure.

.....

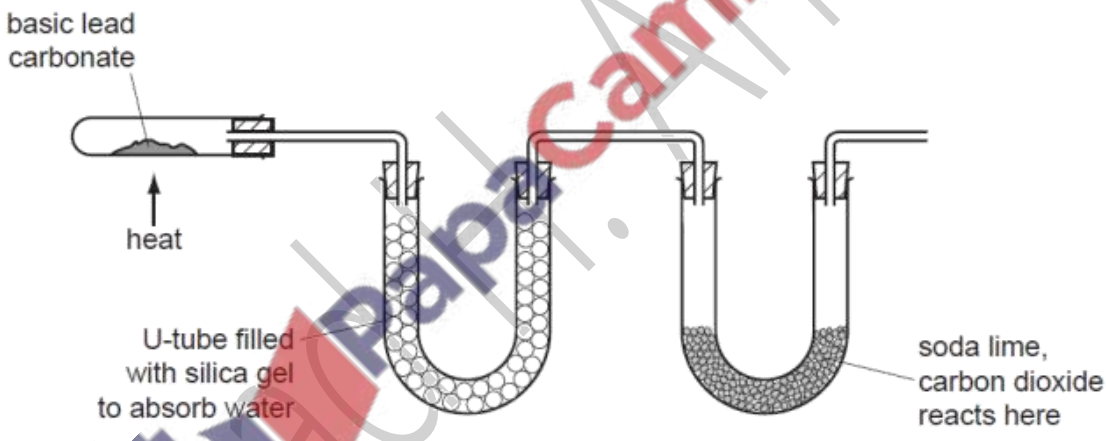
..... [2]

(ii) Explain why a metal, such as lead, is malleable.

.....

..... [2]

(b) Basic lead(II) carbonate is heated in the apparatus shown below. Water and carbon dioxide are produced.



(i) Silica gel absorbs water. Silica gel often contains anhydrous cobalt(II) chloride. When this absorbs water it changes from blue to pink.
Suggest a reason.

..... [1]

(ii) Soda lime is a mixture of sodium hydroxide and calcium oxide. Why do these two substances react with carbon dioxide?

.....

..... [2]

(iii) Name **two** substances formed when soda lime reacts with carbon dioxide.

..... [2]

Question 12

2 **(a)** Give **three** differences in physical properties between the Group I metal, potassium, and the transition element, iron.

1. .....

2. .....

3. ..... [3]

(b) The following metals are in order of reactivity.

potassium
zinc
copper

For those metals which react with water or steam, name the products of the reaction, otherwise write 'no reaction'.

potassium .....

.....

zinc .....

.....

copper .....

..... [5]

[Total: 8]

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4 Zinc alloys have been used for over 2500 years.

(a) (i) Explain the phrase *zinc alloy*.

.....

..... [1]

(ii) Making alloys is still a major use of zinc. State **one** other large scale use of zinc.

..... [1]

(iii) Describe the bonding in a typical metal, such as zinc, and then explain why it is malleable. You may use a diagram to illustrate your answer.

.....

.....

..... [3]

(iv) Suggest why the introduction of a different atom into the structure makes the alloy less malleable than the pure metal.

.....

..... [2]

(b) Zinc metal is made by the reduction of zinc oxide. The major ore of zinc is zinc blende, ZnS. Zinc blende contains silver and lead compounds as well as zinc sulfide.
Zinc blende is converted into impure zinc oxide by heating it in air.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

(i) Describe how zinc oxide is reduced to zinc.

..... [1]

(ii) Some of the zinc oxide is dissolved in sulfuric acid to make aqueous zinc sulfate. Write a balanced symbol equation for this reaction.

..... [2]

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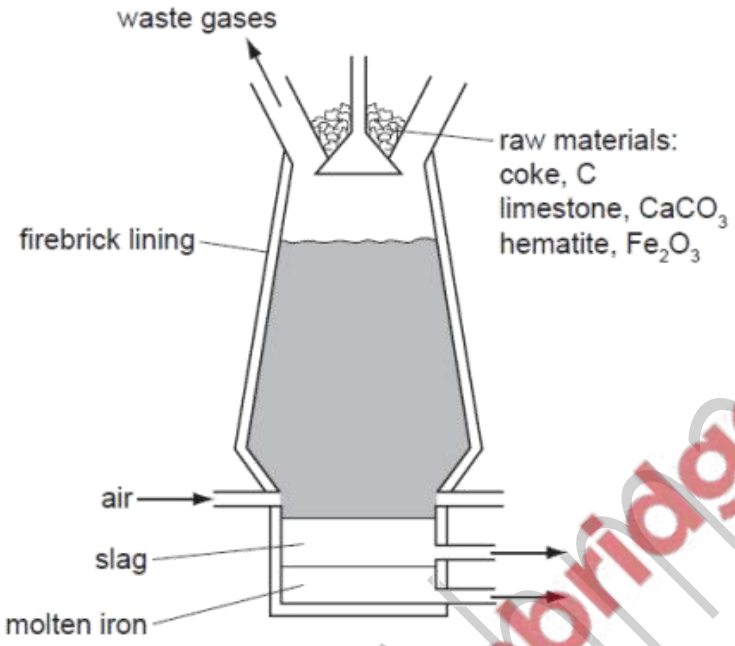
Question 14

4 Iron is extracted from its ore, hematite, in the blast furnace.



(a) The temperature inside the blast furnace can rise to 2000 °C.
Write an equation for the exothermic reaction which causes this high temperature.

..... [1]

(b) Carbon monoxide is formed in the blast furnace. This reduces the ore hematite, Fe_2O_3, to iron.

(i) Explain how carbon monoxide is formed in the blast furnace.

.....

..... [2]

(ii) Write an equation for the reduction of hematite by carbon monoxide.

..... [2]

(c) Explain why it is necessary to add limestone, calcium carbonate, to the blast furnace. Include an equation in your explanation.

.....

.....

..... [3]

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(d) Most of the iron from the blast furnace is converted into mild steel. A method of preventing the steel from rusting is coating it with zinc.

(i) What is the name of this method of rust prevention?

..... [1]

(ii) Explain, using the idea of electron transfer, why zinc-coated steel does not rust even when the coating is scratched and the steel is in contact with oxygen and water.

.....

.....

.....

..... [3]

[Total: 12]

Question 15

(b) Predict **two** differences in physical properties and **two** differences in chemical properties between rubidium and the transition metal niobium.

physical .....

.....

.....

chemical .....

.....

..... [4]

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Question 16

5 The reactivity series shows the metals in order of reactivity.

(a) The reactivity series can be established using displacement reactions. A piece of zinc is added to aqueous lead nitrate. The zinc becomes coated with a black deposit of lead.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

Zinc is more reactive than lead.

The reactivity series can be written as a list of ionic equations.

..... → ..... + ... most reactive metal : the best reductant (reducing agent)

$Zn \rightarrow Zn^{2+} + 2e^-$

$Fe \rightarrow Fe^{2+} + 2e^-$

$Pb \rightarrow Pb^{2+} + 2e^-$

$Cu \rightarrow Cu^{2+} + 2e^-$

$Ag \rightarrow Ag^{+} + e^-$

(i) In the space at the top of the list, write an ionic equation for a metal which is more reactive than zinc. [1]

(ii) Write an ionic equation for the reaction between aqueous silver(I) nitrate and zinc.

..... [2]

(iii) Explain why the positive ions are likely to be oxidants (oxidising agents).

..... [1]

(iv) Deduce which ion is the best oxidant (oxidising agent).

..... [1]

(v) Which ion(s) in the list can oxidise lead metal?

..... [1]

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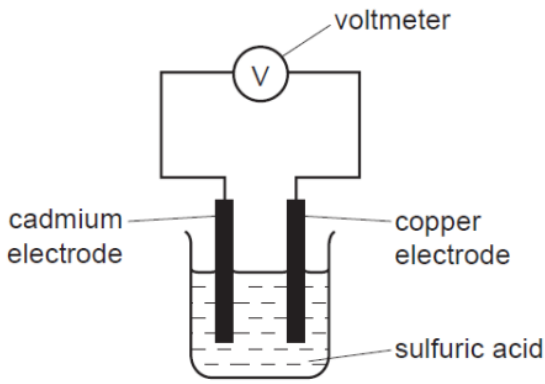
(b) A reactivity series can also be established by measuring the voltage of simple cells. The diagram shows a simple cell.



Results from cells using the metals tin, cadmium, zinc and copper are given in the table below.

cell	electrode 1 positive electrode	electrode 2 negative electrode	voltage / volts
1	copper	cadmium	0.74
2	copper	tin	0.48
3	copper	zinc	1.10

Write the four metals in order of increasing reactivity and explain how you used the data in the table to determine this order.

.....

.....

..... [3]

[Total: 9]

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Question 17

4 The ore of aluminium is bauxite which is impure aluminium oxide. Alumina, pure aluminium oxide, is obtained from bauxite.
Aluminium is formed at the cathode when a molten mixture of alumina and cryolite, Na_3AlF_6, is electrolysed.

(a) (i) Name **two** products formed at the anode in this electrolysis.

..... [2]

(ii) All the aluminium formed comes from the alumina not the cryolite.
Suggest **two** reasons why the electrolyte must contain cryolite.

.....

..... [2]

(iii) The major impurity in bauxite is iron(III) oxide. Iron(III) oxide is basic, aluminium oxide is amphoteric. Explain how aqueous sodium hydroxide can be used to separate them.

.....

.....

..... [2]

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Question 18

3 The uses of a substance are determined by its properties.

(a) Plastics are poor conductors of electricity. They are used as insulation for electric cables. Which other **two** properties of plastics make them suitable for this purpose?

.....

..... [2]

(b) Chromium is a hard, shiny metal. Suggest **two** reasons why chromium is used to electroplate steel.

.....

..... [2]

(c) Why is aluminium used extensively in the manufacture of aeroplanes?

.....

..... [2]

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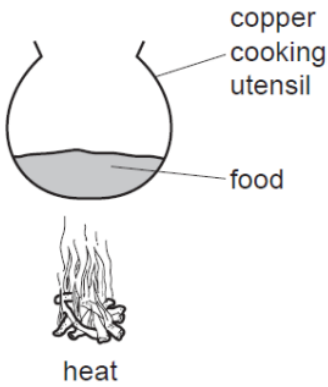
(d) Why is copper a suitable material from which to make cooking utensils?



.....

..... [2]

(e) Describe the bonding in a typical metal.

.....

.....

..... [2]

[Total: 10]

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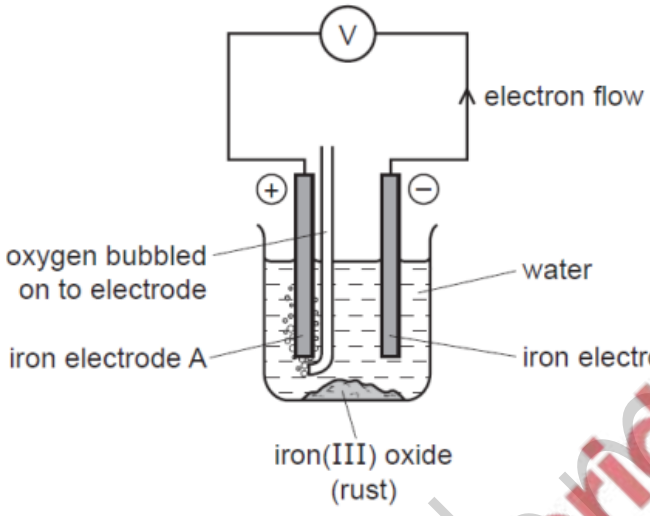
Question 19

8 Iron and steel rust when exposed to water and oxygen. Rust is hydrated iron(III) oxide.

(a) The following cell can be used to investigate rusting.



(i) What is a cell?

.....

..... [2]

(ii) Which electrode will be oxidised and become smaller? Explain your choice.

.....

.....

..... [3]

(iii) What measurements would you need make to find the rate of rusting of the electrode you have chosen in **(ii)**?

.....

..... [2]

(iv) Suggest an explanation why the addition of salt to the water increases the rate of rusting.

..... [1]

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Question 20

5 Reactive metals tend to have unreactive compounds. The following is part of the reactivity series.

sodium	most reactive
calcium	↓
zinc	
copper	↓
silver	least reactive

(a) Sodium hydroxide and sodium carbonate do not decompose when heated.
The corresponding calcium compounds do decompose when heated.
Complete the following equations.

calcium carbonate → ..... + ...
....

$Ca(OH)_2$ → ..... + ... [2]

(b) All nitrates decompose when heated.

(i) The equation for the thermal decomposition of silver(I) nitrate is given below.

$$2AgNO_3 \rightarrow 2Ag + 2NO_2 + O_2$$

What are the products formed when copper(II) nitrate is heated?

..... [1]

(ii) Complete the equation for the action of heat on sodium nitrate.

.....$NaNO_3$ → ..... + ...

[2]

(c) Which of the metals in the list on page 5 have oxides which are not reduced by carbon?

..... [1]

(d) Choose from the list on page 5, metals whose ions would react with zinc.

..... [2]

[Total: 8]

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Question 21

4 Vanadium is a transition element. It has more than one oxidation state.
The element and its compounds are often used as catalysts.

(a) Complete the electron distribution of vanadium by inserting one number.

2 + 8 + ... + 2

[1]

(b) Predict **three** physical properties of vanadium which are typical of transition elements.

1. .....

2. .....

3. ..... [2]

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Question 22

3 The Group I metals show trends in both their physical and chemical properties.

(a) (i) How do their melting points vary down the Group?

..... [1]

(ii) Which element in the Group has the highest density?

..... [1]

(iii) All Group I metals react with cold water. Complete the following equation.

.....Rb + ...H_2O → ..... + ...

[2]

(b) Lithium reacts with nitrogen to form the ionic compound, lithium nitride.

(i) State the formula of the lithium ion. ..... [1]

(ii) Deduce the formula of the nitride ion. ..... [1]

(iii) In all solid ionic compounds, the ions are held together in a lattice.
Explain the term *lattice*.

.....

..... [1]

(iv) What is the ratio of lithium ions to nitride ions in the lattice of lithium nitride?
Give a reason for your answer.

..... lithium ions : ..... nitride ions

.....

..... [2]

[Total: 9]

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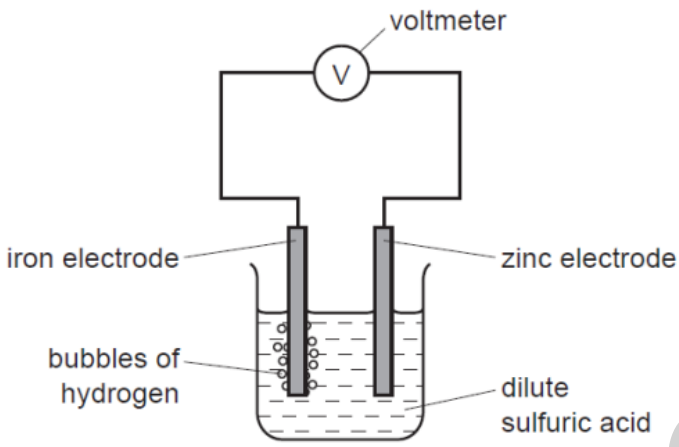
Question 23

5 The diagram shows a simple cell.



(a) Write an equation for the overall reaction occurring in the cell.

..... [2]

(b) Explain why all cell reactions are exothermic and redox.

.....

.....

..... [3]

(c) Which electrode, zinc or iron, is the negative electrode? Give a reason for your choice.

.....

..... [2]

(d) Suggest **two** ways of increasing the voltage of this cell.

.....

..... [2]

[Total: 9]

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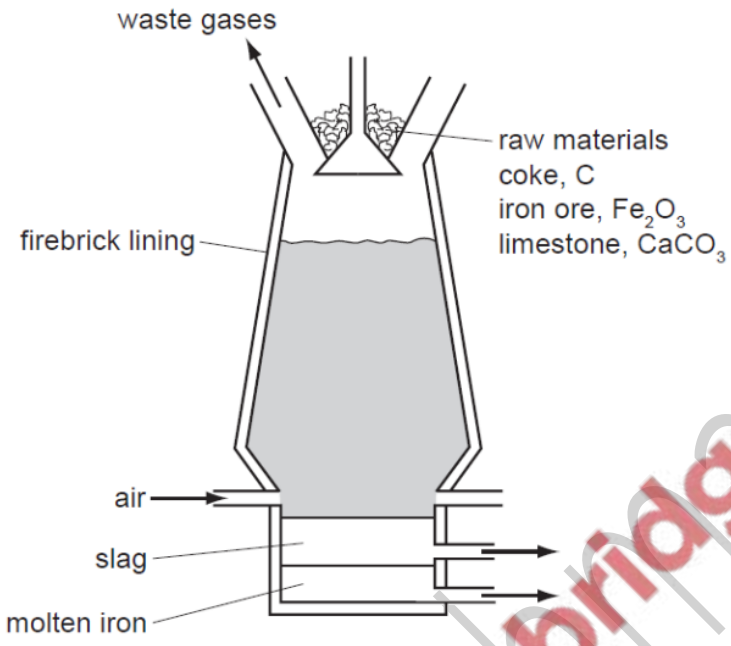
Question 24

4 Iron is extracted from its ore, hematite, in the blast furnace.



Describe the reactions involved in this extraction. Include in your description an equation for a redox reaction and one for an acid / base reaction.

.....

.....

.....

.....

..... [5]

[Total: 5]

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Question 25

2 Tin is an element in Group IV.

(a) The position of tin in the reactivity series is:

zinc
iron
tin
copper

(i) For each of the following, decide if a reaction would occur. If there is a reaction, complete the equation, otherwise write 'no reaction'.

$Cu + Sn^{2+} \rightarrow$ .....

$Fe + Sn^{2+} \rightarrow$ .....

$Sn + Zn^{2+} \rightarrow$ ..... [4]

(ii) Name the **three** products formed when tin(II) nitrate is heated.

.....

..... [2]

(c) Steel articles can be plated with tin or zinc to prevent rusting.
When the zinc layer is damaged exposing the underlying steel, it does not rust, but when the tin layer is broken the steel rusts. Explain.

.....

.....

..... [4]

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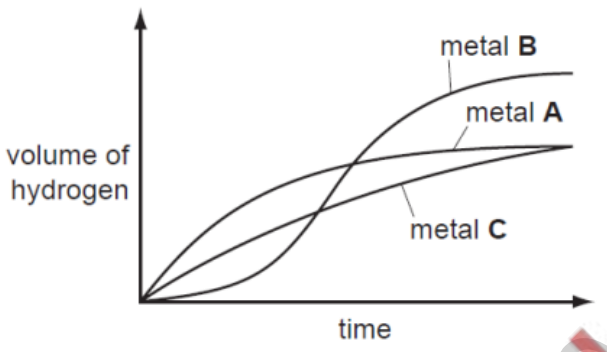
Question 26

7 Excess hydrochloric acid was added to powdered zinc. The hydrogen evolved was collected and its volume measured every 20 seconds.

The experiments were repeated at the same temperature using the same number of moles of powdered magnesium and aluminium.



(a) Identify metals **A**, **B** and **C** by choosing from zinc, magnesium and aluminium. Give a reason for each choice.

metal **A** .....

.....

metal **B** .....

.....

metal **C** .....

..... [5]

(b) Using 'moles', explain why two of the metals form the same volume of hydrogen but the third metal forms a larger volume.

.....

.....

..... [3]

[Total: 8]

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Question 27

4 A major ore of zinc is zinc blende, ZnS. A by-product of the extraction of zinc from this ore is sulfur dioxide which is used to make sulfuric acid.

(a) (i) Zinc blende is heated in air. Zinc oxide and sulfur dioxide are formed. Write the balanced equation for this reaction.

..... [2]

(ii) Zinc oxide is reduced to zinc by heating with carbon. Name **two** other reagents which could reduce zinc oxide.

..... [2]

(iii) The zinc obtained is impure. It is a mixture of metals. Explain **how** fractional distillation could separate this mixture.
zinc bp = 908 °C, cadmium bp = 765 °C, lead bp = 1751 °C

.....

..... [2]

0620/s11/qp31

Question 28

3 Iron from the blast furnace is impure. It contains about 4 % carbon and 0.5 % silicon. Most of this impure iron is used to make mild steel, an alloy of iron containing less then 0.25 % carbon.

(a) A jet of oxygen is blown through the molten iron in the presence of a base, usually calcium oxide. Explain how the percentage of carbon is reduced and how the silicon is removed.

.....

.....

.....

..... [4]

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(b) (i) Why are steel alloys used in preference to iron?

..... [1]

(ii) State a use of the following alloys.

mild steel .....

stainless steel ..... [2]

(c) Both iron and steel have typical metallic structures - a lattice of positive ions and a sea of electrons.

(i) Suggest an explanation for why they have high melting points.

.....

.....

..... [2]

(ii) Explain why, when a force is applied to a piece of steel, it does not break but just changes its shape.

.....

..... [2]

[Total: 11]

0620/s11/qp31

Question 29

8 Nitrogen dioxide is a brown gas. It can be made by heating certain metal nitrates.

$$2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$$

(a) (i) Name another metal whose nitrate decomposes to give the metal oxide, nitrogen dioxide and oxygen.

..... [1]

(ii) Complete the word equation for a metal whose nitrate does not give nitrogen dioxide on decomposition.

metal nitrate → ..... + oxygen

[1]

0620/s10/qp32

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7 Aluminium was first isolated in 1827 using sodium.

$$AlCl_3 + 3Na \rightarrow Al + 3NaCl$$

Aluminium, obtained by this method, was more expensive than gold.

(a) Suggest an explanation why aluminium was so expensive.

.....

..... [1]

(b) The modern method for extracting aluminium is the electrolysis of a molten electrolyte, aluminium oxide dissolved in cryolite. The aluminium oxide decomposes.

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Both electrodes are made of carbon.

(i) Give **two** reasons why the oxide is dissolved in cryolite.

.....

.....

..... [2]

(ii) Complete the ionic equation for the reaction at the anode.

..... $O^{2-} \rightarrow O_2$ + ... e^-

[2]

(iii) Why do the carbon anodes need to be replaced frequently?

.....

..... [1]

(c) The electrolysis of a molten electrolyte is one method of extracting a metal from its ore. Other methods are the electrolysis of an aqueous solution and the reduction of the oxide by carbon. Explain why these last two methods cannot be used to extract aluminium.

electrolysis of an aqueous solution .....

.....

using carbon .....

..... [2]

[Total: 8]

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Question 31

4 The reactivity series of metals given below contains both familiar and unfamiliar elements. For most of the unfamiliar elements, which are marked *, their common oxidation states are given.

* barium	Ba
* lanthanum	La (+3)
magnesium	
zinc	
* chromium	Cr (+2), (+3), (+6)
iron	
copper	
* palladium	(+2)

Choose metal(s) from the above list to answer the following questions.

(i) Which **two** metals would not react with dilute hydrochloric acid?

.....

[2]

(ii) Which **two** unfamiliar metals (*) would react with cold water?

.....

[2]

(iii) What is the oxidation state of barium?

.....

[1]

(iv) Name an unfamiliar metal (*) whose oxide cannot be reduced by carbon.

.....

[1]

(v) Why should you be able to predict that metals such as iron and chromium have more than one oxidation state?

.....

.....

[1]

[Total: 7]

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Question 32

(c) **(i)** Give **two** reasons why copper is used,

in electric wiring, ...

..... [2]

in cooking utensils. .....

..... [2]

(ii) Give another use of copper.

..... [1]

0620/s08/qp31

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Question 33

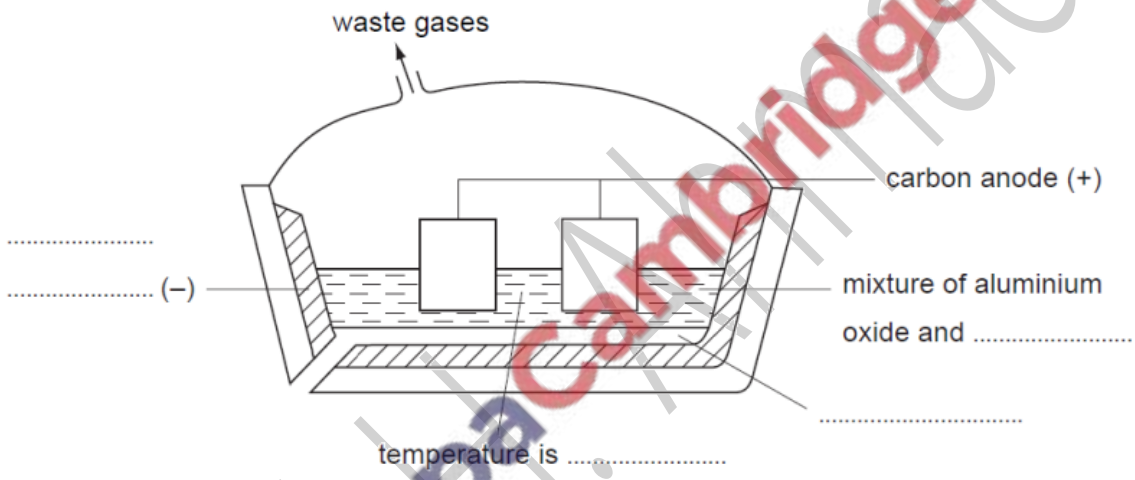
6 Aluminium is extracted by the electrolysis of a molten mixture that contains alumina, which is aluminium oxide, Al_2O_3.

(a) The ore of aluminium is bauxite. This contains alumina, which is amphoteric, and iron(III) oxide, which is basic. The ore is heated with aqueous sodium hydroxide. Complete the following sentences.

The ..... dissolves to give a solution of .....

The ..... does not dissolve and can be removed by ..... [4]

(b) Complete the labelling of the diagram.



[4]

(c) The ions that are involved in the electrolysis are Al^{3+} and O^{2-}.

(i) Write an equation for the reaction at the cathode.

..... [2]

(ii) Explain how carbon dioxide is formed at the anode.

.....

..... [2]

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(d) Give an explanation for each of the following.

(i) Aluminium is used extensively in the manufacture of aircraft.

..... [1]

(ii) Aluminium is used to make food containers.

..... [2]

(iii) Aluminium electricity cables have a steel core.

..... [1]

[Total: 16]

0620/s07/qp3

Question 34

5 **(a)** Titanium is produced by the reduction of its chloride. This is heated with magnesium in an inert atmosphere of argon.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

(i) Explain why it is necessary to use argon rather than air.

..... [1]

(ii) Name another metal that would reduce titanium chloride to titanium.

..... [1]

(iii) Suggest how you could separate the metal, titanium, from the soluble salt magnesium chloride.

.....

..... [2]

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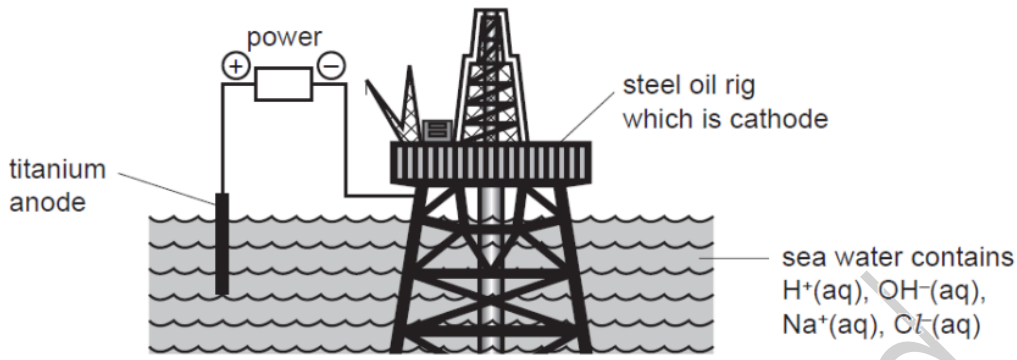
(b) Titanium is very resistant to corrosion. One of its uses is as an electrode in the cathodic protection of large steel structures from rusting.



(i) Define oxidation in terms of electron transfer.

.....

.....

[1]

(ii) The steel oil rig is the cathode. Name the gas formed at this electrode.

.....

[1]

(iii) Name the **two** gases formed at the titanium anode.

..... and .....

[2]

(iv) Explain why the oil rig does not rust.

.....

.....

.....

[2]

(v) Another way of protecting steel from corrosion is sacrificial protection.
Give **two** differences between sacrificial protection and cathodic protection.

.....

.....

.....

[2]

[Total: 12]

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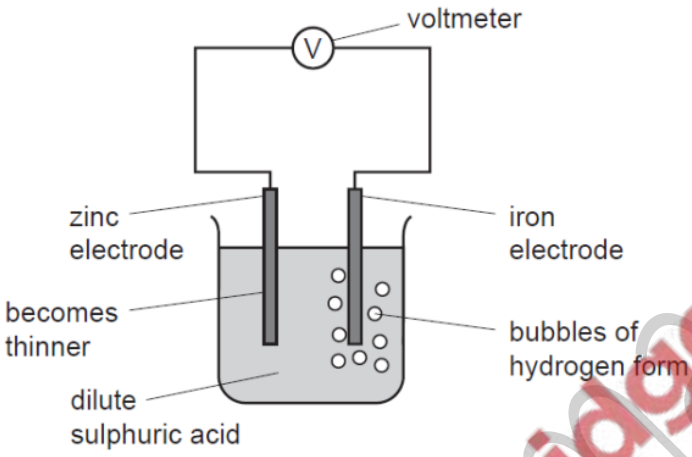
Question 35

(c) Cell reactions are both exothermic and redox. They produce electrical energy as well as heat energy.

(i) The diagram shows a simple cell.



Which substance in this cell is the reductant and which ion is the oxidant?

reductant .....

oxidant ..... [2]

(ii) How could the voltage of this cell be increased?

..... [1]

(iii) What is the important large scale use, relating to iron and steel, of this type of cell reaction?

..... [1]

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Question 36

2 Some reactions of metals **W**, **X**, **Y** and **Z** are given below.

metal	reaction with water	reaction with dilute hydrochloric acid
W	A few bubbles form slowly in cold water.	Vigorous reaction. Gas given off.
X	Vigorous reaction. Metal melts. Gas given off.	Explosive reaction. Should not be attempted.
Y	No reaction.	No reaction.
Z	Does not react with cold water. Hot metal reacts with steam.	Steady fizzing.

(a) Arrange these metals in order of reactivity.

most reactive .....

.....

.....

least reactive ..... [2]

(b) Which of these metals could be

(i) magnesium,

..... [1]

(ii) copper?

..... [1]

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(c) The equation for the reaction of **X** with cold water is given below.

$$2\mathbf{X}(s) + 2H_2O(l) \longrightarrow 2\mathbf{X}OH(aq) + H_2(g)$$

(i) Describe the test you would use to show that the gas evolved is hydrogen.

.....

..... [1]

(ii) How could you show that the water contained a compound of the type **X**OH?

.....

..... [2]

(iii) In which group of the Periodic Table does metal **X** belong?

..... [1]

(iv) The ore of **X** is its chloride. Suggest how metal **X** could be extracted from its chloride.

..... [2]

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Question 37

1 Iron is a transition element.

(a) Which of the following statements about transition elements are correct?

Tick **three** boxes.

The metals are highly coloured e.g. yellow, green, blue. ☐

The metals have low melting points. ☐

Their compounds are highly coloured. ☐

Their compounds are colourless. ☐

The elements and their compounds are often used as catalysts. ☐

They have more than one oxidation state. ☐

[3]

(b) **(i)** In which Period in the Periodic Table is iron to be found?

..... [1]

(ii) Use the Periodic Table to work out the number of protons and the number of neutrons in one atom of iron.

number of protons = ... number of neutrons = ... [1]

(c) Iron is extracted in a blast furnace. The list below gives some of the substances used or formed in the extraction.

carbon monoxide **coke** **iron ore** **limestone** **slag**

(i) Which substance is a mineral containing largely calcium carbonate?

..... [1]

(ii) Which substance is formed when impurities in the ore react with calcium oxide?

..... [1]

(iii) Which substance is also called hematite?

..... [1]

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(d) State **two** functions of the coke used in the blast furnace.

.....

..... [2]

(e) Most of the iron is converted into mild steel or stainless steel. Give **one** use for each.

mild steel .....

stainless steel ..... [2]

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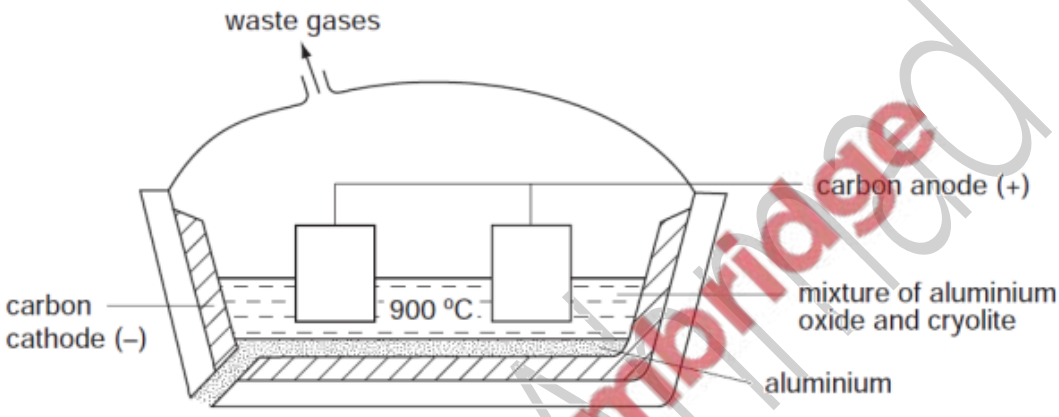
Question 38

6 The position of aluminium in the reactivity series of metals is shown below.

magnesium
aluminium
zinc
copper

(a) Aluminium is extracted by the electrolysis of its molten oxide.



(i) Name the main ore of aluminium.

..... [1]

(ii) Why does the molten electrolyte contain cryolite?

..... [1]

(iii) Oxygen is produced at the positive electrode (anode). Name another gas which is given off at this electrode.

..... [1]

(b) Aluminium reacts very slowly with aqueous copper(II) sulphate.

$$2Al(s) + 3CuSO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3Cu(s)$$

(i) Which of the two metals has the greater tendency to form ions?

..... [1]

(ii) Describe what you would see when this reaction occurs.

..... [1]

(iii) Explain why aluminium reacts so slowly.

..... [1]

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(c) Complete the following table by writing "reaction" or "no reaction" in the spaces provided.

oxide	type of oxide	reaction with acid	reaction with alkali
magnesium	basic	.....	.....
aluminium	amphoteric	.....	.....

[2]

(d) Predict the equations for the decomposition of the following aluminium compounds.

(i) ..... $Al(OH)_3$ → ..... + ... [2]

(ii) aluminium nitrate → ..... + ... + ...

.... [2]

0620/s05/qp3

Question 39

(c) All three metals react with cold water. Complete the word equation for these reactions.

metal + water → ..... + ... [2]

0620/s03/qp3

Question 40

4 Nitrogen dioxide, NO_2, is a dark brown gas.

(a) Most metal nitrates decompose when heated to form the metal oxide, nitrogen dioxide and oxygen.

(i) Write a symbol equation for the decomposition of lead(II) nitrate.

$Pb(NO_3)_2$ → ..... + ... + ... [2]

(ii) Potassium nitrate does not form nitrogen dioxide on heating. Write the word equation for its decomposition.

.....[1]

0620/s03/qp3

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Question 41

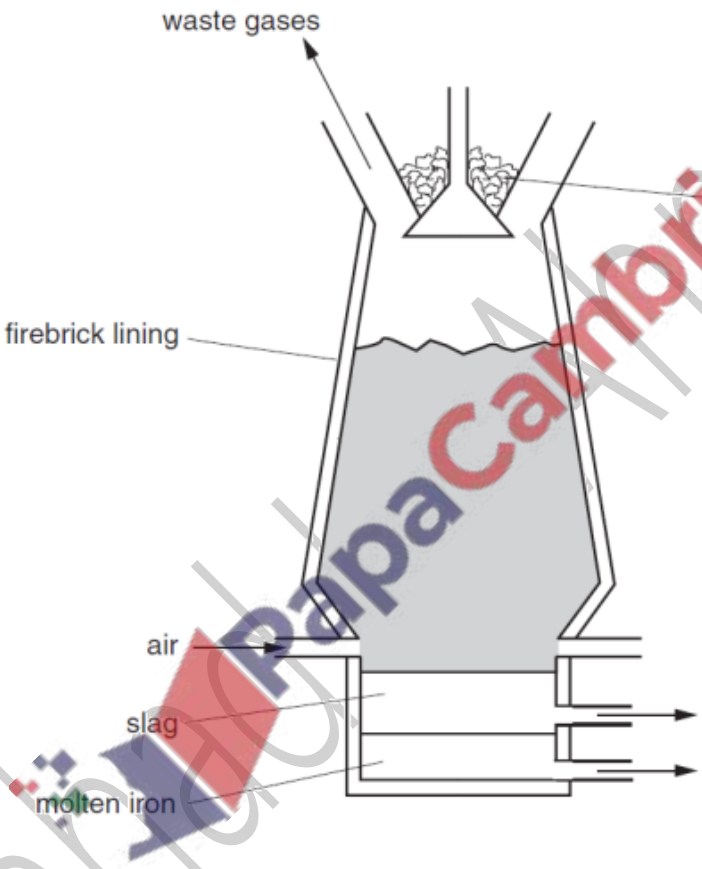
1 No one knows where iron was first isolated. It appeared in China, the Middle East and in Africa. It was obtained by reducing iron ore with charcoal.

(a) Complete the following equation.

$$\underset{\text{iron ore}}{Fe_2O_3} + \underset{\text{charcoal}}{C} \rightarrow \text{.....} + \text{.....}$$

[2]

(b) In 1705 Abraham Darby showed that iron ore could be reduced using coke in a blast furnace.



(i) The temperature in the furnace rises to 2000 °C. Write an equation for the exothermic reaction that causes this high temperature.

.....

(ii) In the furnace, the ore is reduced by carbon monoxide. Explain how this is formed.

.....

.....[3]

(c) The formation of slag removes an impurity in the ore. Write a word equation for the formation of the slag.

.....[2]

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(d) Stainless steel is an alloy of iron. It contains iron, other metals and about 0.5% of carbon.

(i) State a use of stainless steel.

.....

(ii) Name a metal, other than iron, in stainless steel.

.....

(iii) The iron from the blast furnace is impure. It contains about 5% of carbon and other impurities, such as silicon and phosphorus. Describe how the percentage of carbon is reduced and the other impurities are removed.

.....

.....

.....[6]

(e) One of the methods used to prevent iron or steel from rusting is to electroplate it with another metal, such as tin. Complete the following.

The anode is made of ..... .

The cathode is made of ..... .

The electrolyte is a solution of ..... .

[3]

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Question 42

4 Zinc is extracted from zinc blende, ZnS.

(a) Zinc blende is heated in air to give zinc oxide and sulphur dioxide. Most of the sulphur dioxide is used to make sulphur trioxide. This is used to manufacture sulphuric acid. Some of the acid is used in the plant, but most of it is used to make fertilisers.

(i) Give another use of sulphur dioxide.

.....

[1]

(ii) Describe how sulphur dioxide is converted into sulphur trioxide.

.....

.....

.....

[3]

(iii) Name a fertiliser made from sulphuric acid.

.....

[1]

(b) Some of the zinc oxide was mixed with an excess of carbon and heated to 1000 °C. Zinc distils out of the furnace.

$$2ZnO + C \rightleftharpoons 2Zn + CO_2$$
$$C + CO_2 \rightarrow 2CO$$

(i) Name the **two** changes of state involved in the process of distillation.

.....

[2]

(ii) Why is it necessary to use an excess of carbon?

.....

.....

[2]

(d) Give two uses of zinc.

1. .....

2. .....

[2]

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(b) The major ore of zinc is zinc blende, ZnS.

(i) Describe how zinc is extracted from zinc blende.

.....

.....

..... [2]

(ii) Give a use of zinc.

..... [1]

(c) The major ore of strontium is its carbonate, $SrCO_3$. Strontium is extracted by the electrolysis of its molten chloride.

(i) Name the reagent that will react with the carbonate to form the chloride.

..... [1]

(ii) The electrolysis of molten strontium chloride produces strontium metal and chlorine. Write ionic equations for the reactions at the electrodes.

negative electrode (cathode) .....

positive electrode (anode) ..... [2]

(iii) One of the products of the electrolysis of concentrated aqueous strontium chloride is chlorine. Name the other two.

..... [2]

(d) Both metals react with water.

(i) Write a word equation for the reaction of zinc and water and state the reaction conditions.

word equation ..... [1]

conditions ..... [2]

(ii) Write an equation for the reaction of strontium with water and give the reaction condition.

equation ..... [2]

condition ..... [1]

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Question 44

7 **(a)** **(i)** Write a symbol equation for the action of heat on zinc hydroxide.

[2]

(ii) Describe what happens when solid **sodium** hydroxide is heated strongly.

[1]

(b) What would be **observed** when copper(II) nitrate is heated?

[3]

0620/w04/qp3

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Question 45

4 In the following list of ionic equations, the metals are in order of reactivity.

$\square \rightarrow \square + \square$

$Zn \rightarrow Zn^{2+} + 2e^-$

$Sn \rightarrow Sn^{2+} + 2e^-$

$Hg \rightarrow Hg^{2+} + 2e^-$

$Ag \rightarrow Ag^{+} + e^-$

↑ reactivity of metals increases

(a) (i) In the space at the top of the series, write an ionic equation that includes a more reactive metal. [1]

(ii) Define *oxidation* in terms of electron transfer.

.....

[1]

(iii) Explain why the positive ions are likely to be oxidising agents.

[1]

(iv) Which positive ion(s) can oxidise mercury metal (Hg)?

[1]

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Question 46

3 Zinc blende is the common ore of zinc. It is usually found mixed with an ore of lead and traces of silver.

(a) (i) Describe how zinc blende is changed into zinc oxide.

.....

.....[2]

(ii) Write an equation for the reduction of zinc oxide by carbon.

.....[2]

(iii) The boiling point of lead is 1740 °C and that of zinc is 907 °C. Explain why, when both oxides are reduced by heating with carbon at 1400 °C, only lead remains in the furnace.

.....

.....[2]

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(b) A major use of zinc is to make diecasting alloys. These contain about 4% of aluminium and they are stronger and less malleable than pure zinc.

(i) Give one other large scale use of zinc.

.....[1]

(ii) Describe the structure of a typical metal, such as zinc, and explain why it is malleable.

.....

.....

.....[3]

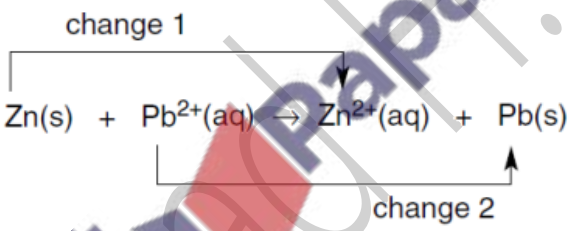
(iii) Suggest why the introduction of a different metallic atom into the structure makes the alloy stronger than the pure metal.

.....

.....[2]

(c) A solution of an impure zinc ore contained zinc, lead and silver(I) ions. The addition of zinc dust will displace both lead and silver.

(i) The ionic equation for the displacement of lead is as follows.



Which change is reduction? Explain your answer.

.....

.....[2]

(ii) Write an ionic equation for the reaction between zinc atoms and silver(I) ions.

.....[2]

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Question 47

4 For over 5000 years copper has been obtained by the reduction of its ores. More recently the metal has been purified by electrolysis.

(a) Copper is used to make alloys.

(i) Give **two** other uses of copper.

.....[2]

(ii) Alloys have similar structures to pure metals. Give a labelled diagram that shows the structure of a typical alloy, such as brass.

[3]

(d) Copper is an unreactive metal. Its compounds are easily reduced to the metal or decomposed to simpler compounds. Complete the following equations.

(i) ...CuO + ... → ...Cu + ...

(ii) Copper(II) hydroxide $\xrightarrow[\text{(heat)}]{}$ ..... + ...
.....

(iii) $Cu(NO_3)_2 \xrightarrow[\text{(heat)}]{}$ ..... + ... + ...

[4]

Question 48

2 Manganese is a transition element. It has more than one valency and the metal and its compounds are catalysts.

(a) **(i)** Predict **three** other properties of manganese that are typical of transition elements.

.....

.....[3]

(ii) Complete the electron distribution of manganese by inserting one number.

2 + 8 + ... + 2 [1]

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Question 49

(iii) Aluminium is also above hydrogen in the reactivity series.
Why does methanoic acid not react with an aluminium kettle?

.....

..... [1]

0620/s10/qp31

Question 50

(d) Complete the table which shows some of the properties of titanium and its uses.
The first line has been completed as an example.

property	related use
soluble in molten steel	making steel titanium alloys
.....	making aircraft and space vehicles
resistant to corrosion, especially in sea water	.....

[2]

0620/s10/qp31

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Question 51

7 Aluminium is obtained from purified alumina, Al_2O_3, by electrolysis.

(a) Alumina is obtained from the main ore of aluminium.
State the name of this ore.

..... [1]

(b) Describe the extraction of aluminium from alumina. Include the electrolyte, the electrodes and the reactions at the electrodes.

.....

.....

.....

.....

.....

.....

..... [6]

(c) Aluminium is resistant to corrosion. It is protected by an oxide layer on its surface.
The thickness of this oxide layer can be increased by anodising.

(i) State a use of aluminium due to its resistance to corrosion.

..... [1]

(ii) Anodising is an electrolytic process. Dilute sulfuric acid is electrolysed with an aluminium object as the anode. The thickness of the oxide layer is increased. Complete the equations for the reactions at the aluminium anode.

.....OH^- → O_2 + $2H_2O$ + ...e^-

....Al + ... → .....Al_2O_3 [4]

[Total: 12]

0620/s14/qp33

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Question 52

4 Iron from a blast furnace contains about 5% of the impurities – carbon, silicon, phosphorus and sulfur. Most of this impure iron is used to make steels, such as mild steel, and a very small percentage is used to make pure iron.

(a) Calcium oxide and oxygen are used to remove the impurities from the iron produced in the blast furnace.

(i) State how these chemicals are manufactured.

calcium oxide .....

.....

oxygen .....

..... [3]

(ii) Describe how these two chemicals remove the four impurities. Include at least one equation in your answer.

.....

.....

.....

.....

.....

.....

..... [5]

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(b) (i) Describe the structure of a typical metal such as iron. You may include a diagram.

.....

.....

[2]

(ii) Explain why pure iron is malleable.

.....

..... [2]

(iii) Mild steel is an alloy of iron and carbon.
Suggest why mild steel is harder than pure iron.

.....

.....

..... [2]

[Total: 14]

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Question 53

7 One way of establishing a reactivity series is by displacement reactions.

(a) A series of experiments was carried out using the metals lead, magnesium, zinc and silver. Each metal was added in turn to aqueous solutions of the metal nitrates.

The order of reactivity was found to be:

magnesium	most reactive
zinc	↓
lead	
silver	least reactive

(i) Complete the table.

✓ = reacts
✗ = does not react

	metal			
aqueous solution	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead(II) nitrate		✓	✓	✗
magnesium nitrate				
zinc nitrate				
silver nitrate				

[3]

(ii) Displacement reactions are redox reactions.
On the following equation, draw a **ring** around the reducing agent and an **arrow** to show the change which is oxidation.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

[2]

(iii) Complete the following ionic equation.

$$Zn + 2Ag^{+} \rightarrow \text{.....} + \text{.....}$$

[1]

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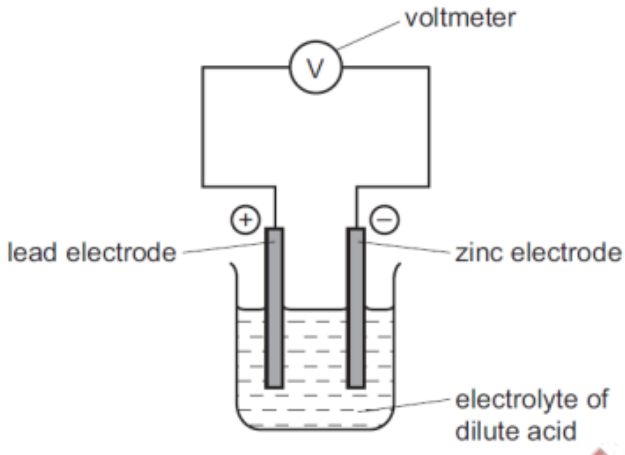
(b) Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.



(i) Mark on the above diagram the direction of the electron flow. [1]

(ii) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

.....

.....

..... [2]

(iii) The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

cell	electrode 1	polarity	electrode 2	polarity
A	zinc	–	lead	+
B	manganese	–	lead	+
C	copper	+	lead	–

What information about the order of reactivity of these four metals can be deduced from the table?

.....

.....

..... [2]

(iv) What additional information is needed to establish the order of reactivity of these four metals using cells?

..... [1]

[Total: 12]

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Question 54

5 Zinc is obtained from the ore, zinc blende, ZnS.

(a) Describe the extraction of zinc from its ore, zinc blende. Include at least one balanced equation in your description.

.....

.....

.....

.....

..... [5]

(b) State **two** major uses of zinc.

.....

..... [2]

[Total: 7]

0620/s14/qp31

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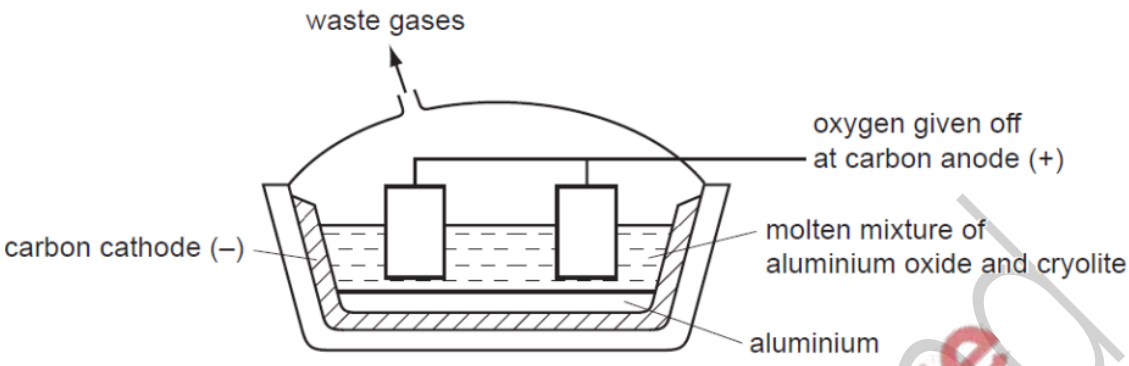
Question 55

6 Aluminium is an important metal with a wide range of uses.

(a) Aluminium is obtained by the electrolysis of aluminium oxide dissolved in molten cryolite.



(i) Solid aluminium oxide is a poor conductor of electricity. It conducts either when molten or when dissolved in molten cryolite. Explain why.

.....

.....

..... [2]

(ii) Why is a solution of aluminium oxide in molten cryolite used rather than molten aluminium oxide?

..... [1]

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(iii) Explain why the carbon anodes need to be replaced periodically.

..... [1]

(iv) One reason why graphite is used for the electrodes is that it is a good conductor of electricity. Give another reason.

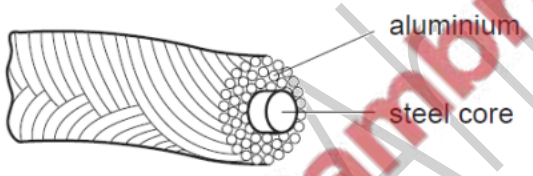
..... [1]

(b) Aluminium is used to make food containers because it resists corrosion.
Explain why it is not attacked by the acids in food.

.....

..... [2]

(c) Aluminium is used for overhead power (electricity) cables which usually have a steel core.



(i) Give **two** properties of aluminium which make it suitable for this use.

.....

..... [2]

(ii) Explain why the cables have a steel core.

.....

..... [1]

[Total: 10]

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Question 56

5 All metal nitrates decompose when heated. A few form a nitrite and oxygen. Most form the metal oxide, oxygen and a brown gas called nitrogen dioxide.

(a) (i) Name a metal whose nitrate decomposes to form the metal nitrite and oxygen.

..... [1]

(ii) Complete the equation for the action of heat on lead(II) nitrate.

.....$Pb(NO_3)_2$ → ..... + ...NO_2 + O_2 [2]

(iii) Suggest why the nitrate of the metal, named in **(a)(i)**, decomposes less readily than lead(II) nitrate.

.....

..... [2]

0620/s13/qp33

Question 57

3 Iron from the blast furnace is impure. It contains 5% of impurities, mainly carbon, sulfur, silicon and phosphorus. Almost all of this impure iron is converted into the alloy, mild steel.

(a) (i) State a use of mild steel.

..... [1]

(ii) Name and give a use of another iron-containing alloy.

name .....

use ..... [2]

(b) The oxides of carbon and sulfur are gases. The oxides of silicon and phosphorus are not. Explain how these impurities are removed from the impure iron when it is converted into mild steel.

.....

.....

.....

.....

..... [5]

[Total: 8]

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Question 58

6 Nickel is a transition element.

(a) Predict **three** differences in the chemical properties of nickel and barium.

.....

.....

..... [3]

0620/w11/qp33

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Question 59

4 **(a)** Steel rusting is an example of an oxidation reaction.

(i) Define the term *steel*.

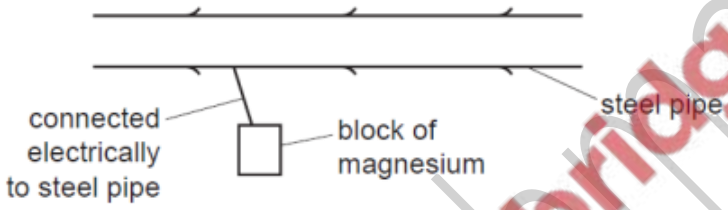
.....

..... [2]

(ii) Define oxidation in terms of electron transfer.

..... [1]

(b) A method of preventing steel rusting is sacrificial protection.

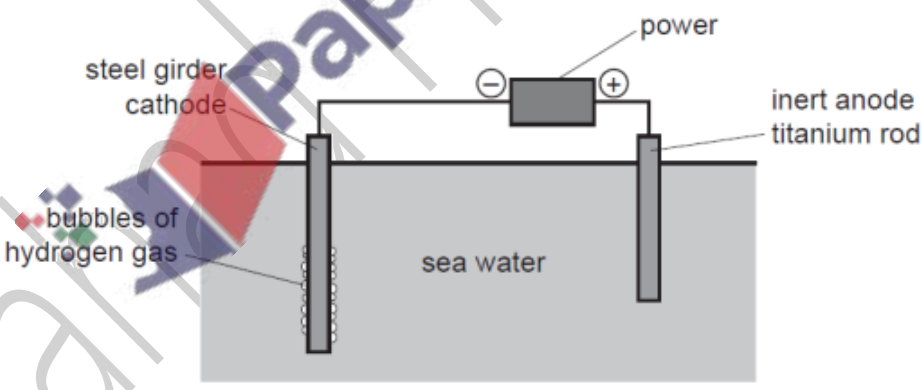


Give an explanation, in terms of electron transfer, why the steel does not rust.

.....

..... [2]

(c) Another method of preventing steel rusting is cathodic protection.



(i) Write an equation for the formation of the gas given off at the steel cathode during cathodic protection.

..... [2]

(ii) Give **one** difference between the two methods.

.....

..... [2]

[Total: 9]

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Question 60

3 Antimony, Sb, is an element in Group V.

(a) The main ore of antimony is its sulfide. The extraction of antimony is similar to that of zinc.
Describe how each of these changes in the extraction of antimony is carried out.

(i) antimony sulfide to antimony oxide

..... [1]

(ii) antimony oxide to antimony

..... [1]

Question 61

7 Some hydroxides, nitrates and carbonates decompose when heated.

(a) (i) Name a metal hydroxide which does not decompose when heated.

..... [1]

(ii) Write the equation for the thermal decomposition of copper(II) hydroxide.

..... [2]

(iii) Suggest why these two hydroxides behave differently.

..... [1]

(b) (i) Metal nitrates, except those of the Group 1 metals, form three products when heated.
Name the products formed when zinc nitrate is heated.

.....

..... [2]

(ii) Write the equation for the thermal decomposition of potassium nitrate.

..... [2]

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Question 62

(c) Describe how you could test the solution to find out which ion, Fe^{2+} or Fe^{3+}, is present.

.....

.....

..... [3]

0620/w11/qp31

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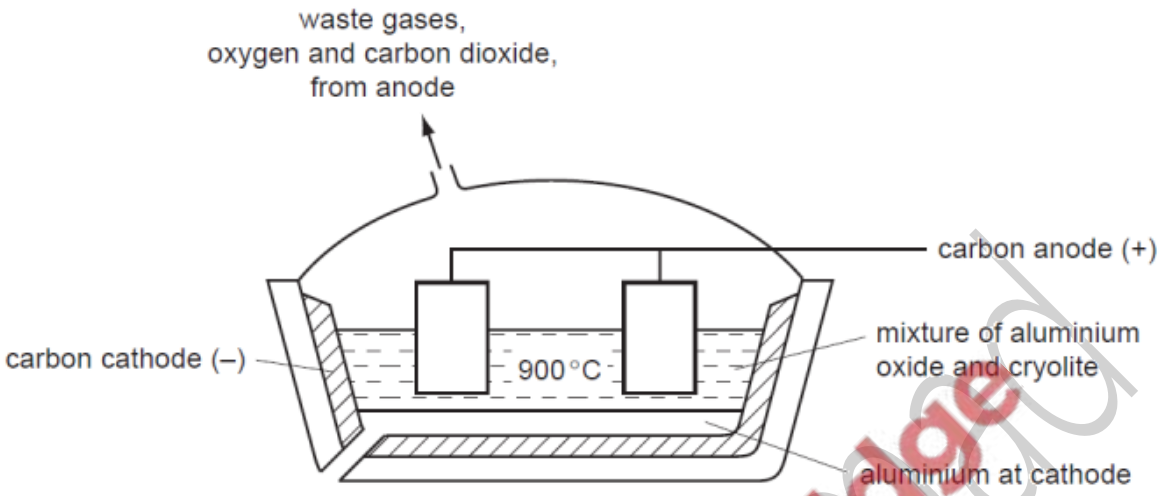
Question 63

3 Aluminium is extracted by the electrolysis of a molten mixture of alumina, which is aluminium oxide, and cryolite.



(a) (i) Alumina is obtained from the main ore of aluminium.
Name this ore.

.....[1]

(ii) Explain why it is necessary to use a mixture, alumina and cryolite, rather than just alumina.

.....

.....[2]

(iii) Copper can be extracted by the electrolysis of an aqueous solution.
Suggest why the electrolysis of an aqueous solution cannot be used to extract aluminium.

.....

.....

.....[2]

(b) The ions which are involved in the electrolysis are Al^{3+} and O^{2-}. The products of this electrolysis are given on the diagram.
Explain how they are formed. Use equations where appropriate.

.....

.....

.....

.....[4]

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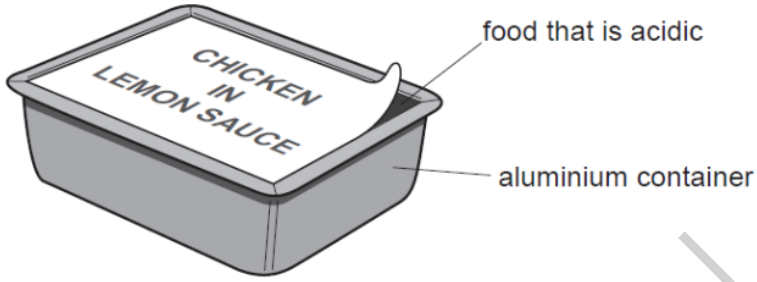
(c) The uses of a metal are determined by its properties.

(i) Foods which are acidic can be supplied in aluminium containers.

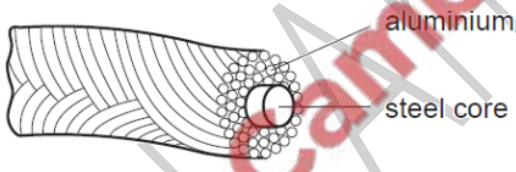


Explain why the acid in the food does not react with the aluminium.

.....

..... [1]

(ii) Explain why overhead electrical power cables are made from aluminium with a steel core.



.....

.....

..... [3]

[Total: 13]

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Question 64

2 About 4000 years ago the Bronze Age started in Britain. Bronze is an alloy of copper and tin.

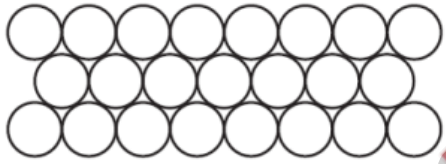
(a) (i) Suggest a reason why a bronze axe was better than a copper axe.

..... [1]

(ii) Brass is another copper alloy. Name the other metal in brass.

..... [1]

(b) The diagram below shows the arrangement of particles in a pure metal.



(i) What is the name given to a regular arrangement of particles in a crystalline solid?

..... [1]

(ii) Draw a diagram which shows the arrangement of particles in an alloy.

[2]

(iii) Explain the term *malleable*.

..... [1]

(iv) Why are metals malleable?

.....

..... [2]

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(c) The common ore of tin is tin(IV) oxide and an ore of copper is malachite, $CuCO_3.Cu(OH)_2$.

(i) Write a word equation for the reduction of tin(IV) oxide by carbon.

..... [1]

(ii) Malachite is heated to form copper oxide and two other chemicals.
Name these chemicals.

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

0620/w10/qp31

Question 65

4 Chromium is a transition element.

(a) (i) Predict **two** differences in the physical properties of chromium and sodium.

.....

..... [2]

(ii) Predict **two** differences in the chemical properties of chromium and sodium.

.....

.....

..... [2]

0620/w10/qp32

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Question 66

2 An ore of the important metal zinc is zinc blende, ZnS. This is changed into zinc oxide which is reduced to the impure metal by carbon reduction.

(a) **(i)** How is zinc oxide obtained from zinc sulfide?

.....

..... [2]

(ii) Write a balanced equation for the reduction of zinc oxide by carbon.

..... [1]

(iii) The major impurity in the zinc is cadmium. The boiling point of zinc is 907 °C and that of cadmium is 767 °C.
Name a technique which could be used to separate these two metals.

..... [2]

(b) In common with most metals, zinc is a good conductor of electricity. It is used as an electrode in cells.

(i) Give **two** other uses of zinc.

.....

..... [2]

(ii) Describe the metallic bonding in zinc and then explain why it is a good conductor of electricity.

.....

.....

.....

..... [4]

[Total: 11]

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Question 67

3 The reactions of a metal and the thermal stability of some of its compounds are determined by the position of the metal in the reactivity series.

(a) To find the order of reactivity of the metals, cobalt, magnesium, silver and tin, the following experiments were carried out.

experiment	result
tin plus silver(I) nitrate solution	silvery layer on tin
magnesium plus tin(II) nitrate solution	grey deposit on magnesium
tin plus cobalt nitrate solution	no reaction

(i) Give as far as possible the order of reactivity of these metals.
Write the least reactive first.

..... [2]

(ii) What additional experiment needs to be done to put all four metals in order of reactivity?

..... [1]

(iii) Write an ionic equation for the reaction between tin atoms and silver(I) ions. Indicate on the equation the change which is oxidation.

.....

..... [3]

(b) Sodium is a more reactive metal than magnesium. Sodium compounds are more stable than magnesium compounds.

In an experiment, their hydroxides were heated. If the hydroxide did not decompose write 'no reaction' otherwise complete the equation.

$NaOH \rightarrow$ .....

$Mg(OH)_2 \rightarrow$ ..... [2]

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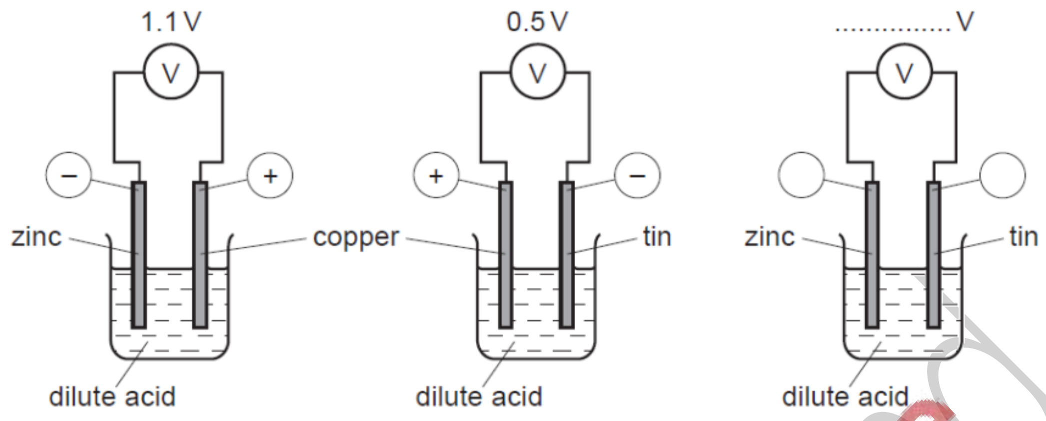
(c) A cell consists of two different metal electrodes in an electrolyte.
Three possible cells are shown below.



(i) Why is the more reactive metal the negative electrode?

....

.... [2]

(ii) How can you deduce that zinc is more reactive than tin?

.... [1]

(iii) How could you change the zinc/copper cell to have a voltage greater than 1.1 V?

.... [1]

(iv) Complete the labelling of the zinc/tin cell. [2]

[Total: 14]

0620/w10/qp33

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Question 68

2 Vanadium is a transition element.

(a) An atom of the most common isotope of vanadium can be represented as $^{51}_{23}V$.

Complete the following table to show the number of protons, electrons and neutrons in each particle.

particle	number of protons	number of electrons	number of neutrons
$^{51}_{23}V$			
$^{51}_{23}V^{3+}$			
$^{50}_{23}V$			

[3]

(b) The major use of vanadium is to make vanadium steel alloys.

(i) Explain the phrase *steel alloys*.

.....

..... [2]

(ii) State the name and use of another steel alloy.

name .....

use ..... [2]

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Question 69

3 **(a)** An important ore of zinc is zinc blende, ZnS.

(i) How is zinc blende changed into zinc oxide?

.....

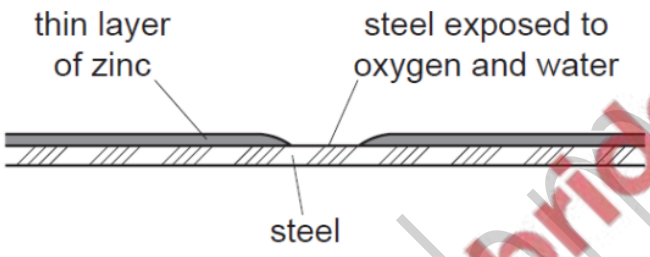
[1]

(ii) Write a balanced equation for the reduction of zinc oxide to zinc by carbon.

.....

[2]

(b) A major use of zinc is galvanizing; steel objects are coated with a thin layer of zinc. This protects the steel from rusting even when the layer of zinc is broken.



Explain, by mentioning ions and electrons, why the exposed steel does not rust.

.....

.....

.....

.....

.....

.....

[3]

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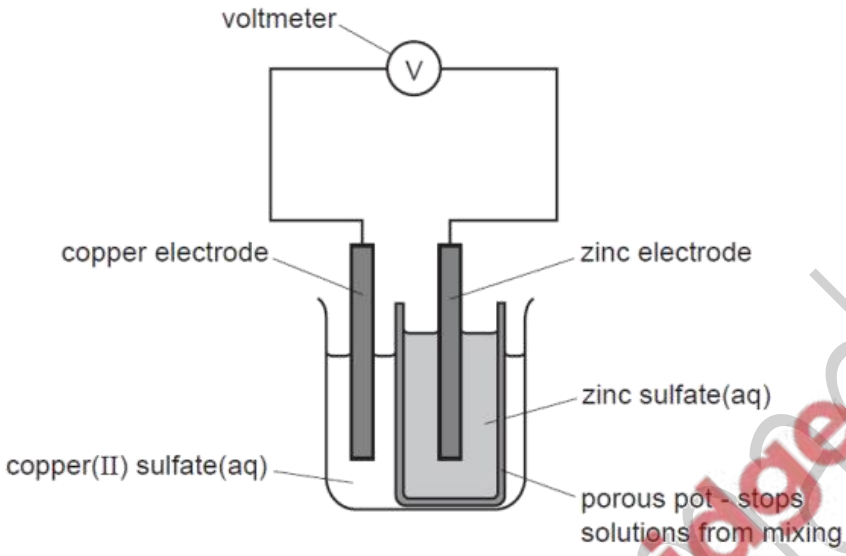
(c) Zinc electrodes have been used in cells for many years, one of the first was the Daniel cell in 1831.



(i) Give an explanation for the following in terms of atoms and ions.

observation at zinc electrode – *the electrode becomes smaller*

explanation .....

..... [1]

observation at copper electrode – *the electrode becomes bigger*

explanation .....

..... [1]

(ii) When a current flows, charged particles move around the circuit.

What type of particle moves through the electrolytes?

..... [1]

Which particle moves through the wires and the voltmeter?

..... [1]

[Total: 10]

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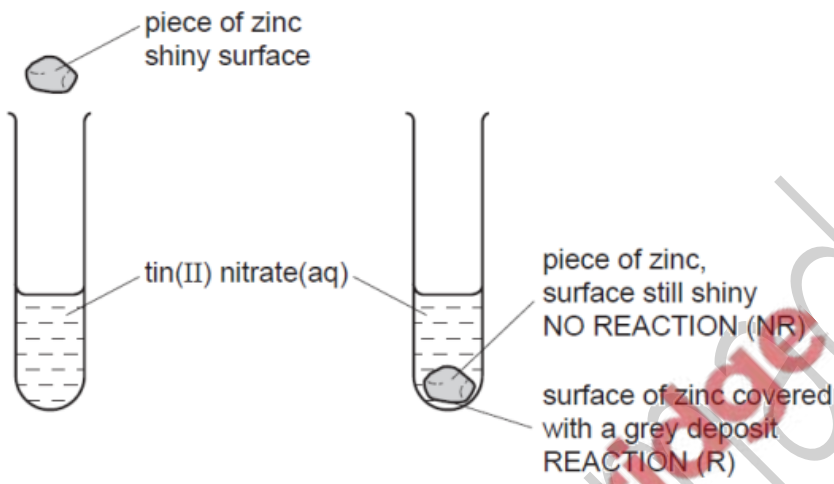
Question 70

6 The reactivity series lists metals in order of reactivity.

(a) To find out which is the more reactive metal, zinc or tin, the following experiment could be carried out.



This experiment could be carried out with other metals and the results recorded in a table. Then the order of reactivity can be deduced.

(i) The order was found to be:

manganese	most reactive
zinc	
tin	
silver	least reactive

Complete the table of results from which this order was determined.

aqueous solution	**tin Sn**	**manganese Mn**	**silver Ag**	**zinc Zn**
tin(II) nitrate		R	NR	R
manganese(II) nitrate				
silver(I) nitrate				
zinc nitrate				

[3]

(ii) Write the ionic equation for the reaction between tin atoms and silver(I) ions.

.....

[2]

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(iii) The following is a redox reaction.

$$Mn + Sn^{2+} \longrightarrow Mn^{2+} + Sn$$

Indicate on the equation the change which is oxidation.
Give a reason for your choice.

.... [2]

(iv) Explain why experiments of this type cannot be used to find the position of aluminium in the reactivity series.

....

.... [2]

(b) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges, K^+ and Ca^{2+}, their compounds behave differently when heated.

(i) Explain why the ions have different charges.

....

.... [2]

(ii) Their hydroxides are heated.
If the compound decomposes, complete the word equation.
If it does not decompose, write "no reaction".

Potassium hydroxide $\rightarrow$ ....

Calcium hydroxide $\rightarrow$ .... [2]

(iii) Complete the equations for the decomposition of their nitrates.

$2KNO_3 \rightarrow$ .... + ...

$2Ca(NO_3)_2 \rightarrow$ .... + ... + ... [4]

[Total: 17]

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Question 71

3 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is $Fe_2O_3.2H_2O$.
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

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

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

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

(b) **(i)** Name a reagent that can reduce iron(III) oxide to iron.

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

(ii) Write a symbol equation for the reduction of iron(III) oxide, Fe_2O_3, to iron.

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

(c) **(i)** Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

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

(ii) Use your answer to **(i)** to calculate the percentage of iron in rust.

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

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

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

(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

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

[Total: 13]

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