

Metals

(Past Year Topical Questions 2010-2015)

Oct/Nov 2010 (31)

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

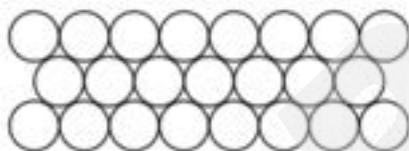
(a) (i) Suggest a reason why a bronze axe was better than a copper axe.

..... [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]

(c) The common ore of tin is tin(IV) oxide and an ore of copper is malachite, $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$.

(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]

Oct/Nov 2010 (32)

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]

Oct/Nov 2010 (33)

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.

$\text{NaOH} \rightarrow$

$\text{Mg(OH)}_2 \rightarrow$ [2]

May/June 2011 (31)

- 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 than 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]

(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]

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 = $908^{\circ}C$, cadmium bp = $765^{\circ}C$, lead bp = $1751^{\circ}C$

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

May/June 2011 (32)

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'.



[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]

Oct/Nov 2011 (31)

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]

May/June 2012 (31)

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

sodium	most reactive
calcium	↓
zinc	least reactive
copper	
silver	

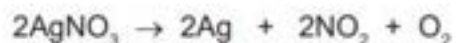
- (a) Sodium hydroxide and sodium carbonate do not decompose when heated. The corresponding calcium compounds do decompose when heated. Complete the following equations.



[2]

(b) All nitrates decompose when heated.

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



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

..... [1]

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



(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]

May/June 2012 (32)

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.

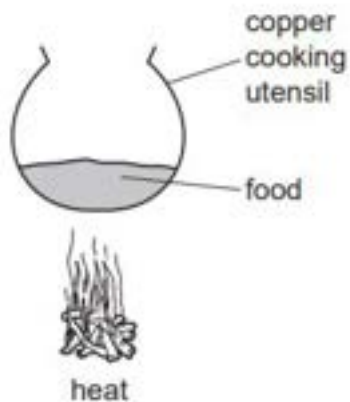
.....
..... [2]

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



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

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



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

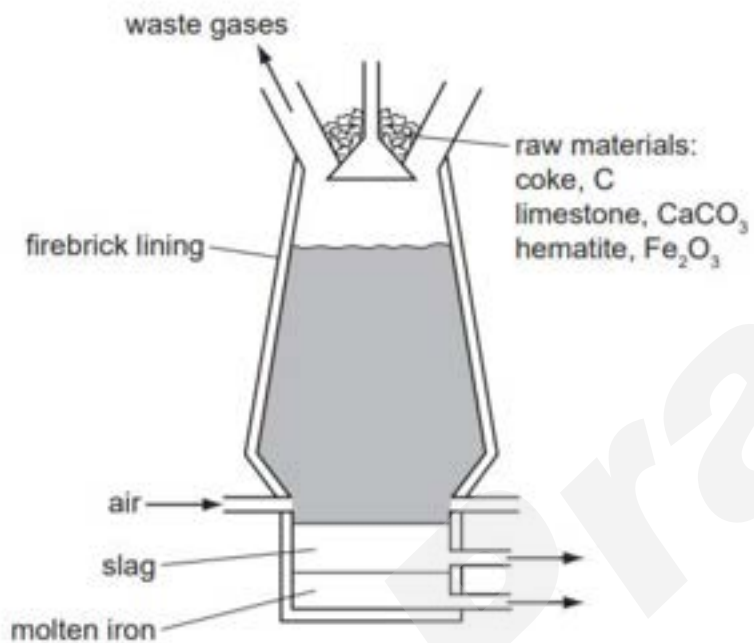
(e) Describe the bonding in a typical metal.

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

[Total: 10]

Oct/Nov 2012 (32)

- 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, Fe₂O₃, 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]
- (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]

Oct/Nov 2012 (33)

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]

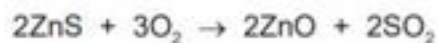
(iii) Describe the bonding in a typical metal, such as zinc, and then explain why it is malleable. You may use a diagram to illustrate your answer.

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



- (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]

- (iii) This impure solution of zinc sulfate contains zinc ions, silver(I) ions and lead ions. Explain why the addition of zinc powder produces pure zinc sulfate solution. Include at least one ionic equation in your explanation.

.....
.....
.....
.....
..... [4]

- (iv) Describe how zinc metal can be obtained from zinc sulfate solution by electrolysis. A labelled diagram is acceptable. Include all the products of this electrolysis. The electrolysis is similar to that of copper(II) sulfate solution with inert electrodes.

[4]

[Total: 18]

May/June 2013 (33)

- 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]

Oct/Nov 2013 (31)/Q2

(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]

(b) Each year, blast furnaces discharge millions of tonnes of carbon dioxide into the atmosphere. This will increase the percentage of atmospheric carbon dioxide.

(i) Explain why this increased percentage of carbon dioxide may cause problems in the future.

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

(ii) Until the early eighteenth century, charcoal, not coke, was used in the blast furnace. Charcoal is made from wood but coke is made from coal. Explain why the use of charcoal would have a smaller effect on the level of atmospheric carbon dioxide.

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

(iii) A method being developed to produce iron with lower emissions of carbon dioxide is by electrolysis. Hematite, Fe_2O_3 , is dissolved in molten lithium carbonate and electrolysed. The ore is split into its constituent elements.

Write an equation for the reaction at the negative electrode (cathode).

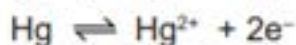
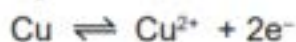
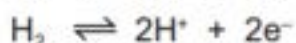
.....

Complete the equation for the reaction at the positive electrode (anode).

..... O^{2-} \rightarrow + [3]

[Total: 13]

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



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.



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

..... [1]

Oct/Nov 2013 (33)

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]

(c) The solution of zinc sulfate is electrolysed using inert electrodes.
This electrolysis is similar to that of copper(II) sulfate with inert electrodes.

(i) Write the equation for the reaction at the negative electrode (cathode).

..... [1]

(ii) Complete the equation for the reaction at the positive electrode (anode).



(iii) The electrolyte changes from zinc sulfate to

..... [1]

- (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]

[Total: 15]

May/June 2014 (31)

- 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]

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

X = does not react

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



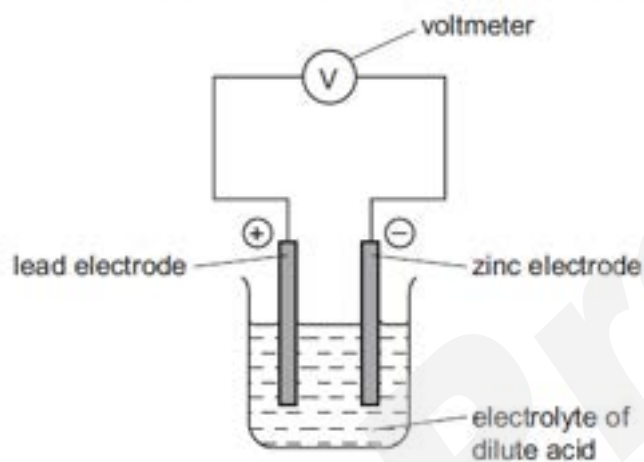
[2]

(iii) Complete the following ionic equation.



[1]

(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]

May/June 2014 (33)

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]

(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.

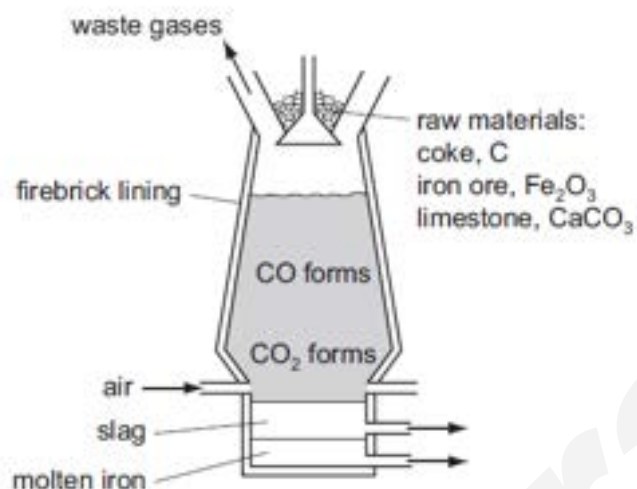
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.....

[2]

[Total: 14]

Oct/Nov 2014 (31)

- 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.



- (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]

- (c) Iron and steel rust. Iron is oxidised to hydrated iron(III) oxide, $\text{Fe}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$, 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.

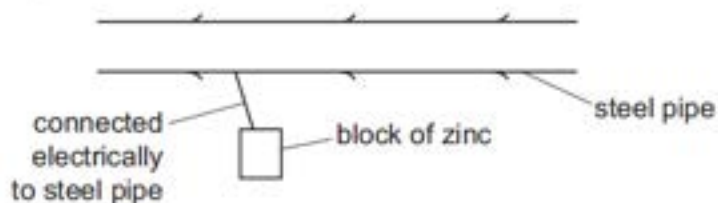
.....

..... [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.



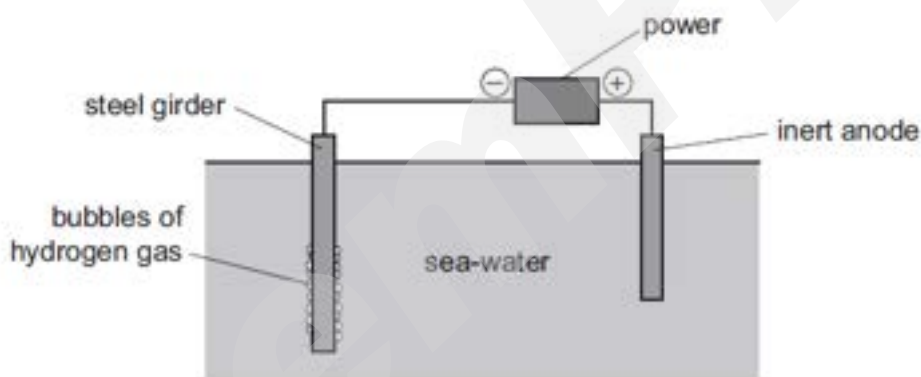
.....

.....

.....

..... [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]

May/June 2015 (31)

2 Iron from the Blast Furnace is impure. It contains about 5% of impurities, mainly carbon, sulfur, silicon and phosphorus, which have to be removed when this iron is converted into steel.

(a) Explain how the addition of oxygen and calcium oxide removes these impurities. Include an equation for a reaction of oxygen and a word equation for a reaction of calcium oxide in this process.

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

[5]

(b) Mild steel is the most common form of steel. Mild steel contains a maximum of 0.3% of carbon.

High carbon steel contains 2% of carbon. It is less malleable and much harder than mild steel.

(i) Give a use of mild steel.

..... [1]

(ii) Suggest a use of high carbon steel.

..... [1]

(iii) Explain why metals are malleable.

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

- (iv) Suggest an explanation why high carbon steel is less malleable and harder than mild steel.

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

[Total: 12]

May/June 2015 (32) /Q6

- (b) All nitrates decompose when heated. The extent to which a nitrate decomposes is determined by the metal in the salt.

- (i) Sodium nitrate decomposes to form sodium nitrite, NaNO_2 .

Write the equation for decomposition of sodium nitrate.

..... [2]

- (ii) Sodium nitrite is a reducing agent.

What would be observed if an excess of sodium nitrite solution was added to a solution of acidified potassium manganate(VII)?

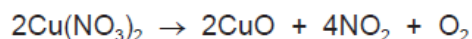
..... [2]

- (iii) Copper(II) nitrate decomposes to form copper(II) oxide, nitrogen dioxide and oxygen.

What is the relationship between the extent of decomposition and the reactivity of the metal in the nitrate?

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

(c) The equation for the decomposition of copper(II) nitrate is given below.



(i) Predict what you would observe when copper(II) nitrate is heated.

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

Oct/Nov 2015 (32)

3 Two of the main uses of zinc are for galvanising and for making alloys.

One of the main ores of zinc is zinc blende, ZnS. There are two stages in the extraction of zinc from this ore.

(a) **Stage 1** Zinc oxide is made from zinc blende.

Describe how this is done and write a word equation for the reaction.

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

(b) **Stage 2** Zinc oxide is reduced to zinc.

Write a word equation for the reduction of zinc oxide by coke.

..... [1]

- (c) The zinc produced by this process is impure. It can be purified by electrolysis using a method which is similar to the purification of copper. Under the conditions used in the process, zinc is the product at the negative electrode (cathode).

Complete the following description of this purification.

The electrolyte is aqueous [1]

The negative electrode (cathode) is made of [1]

The positive electrode (anode) is impure zinc.

The equation for the reaction at the cathode is [1]

The equation for the reaction at the anode is [1]

Explain why the concentration of the electrolyte does not change.

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

- (d) Brass is an alloy which contains zinc.

(i) Name the other metal in brass.

..... [1]

(ii) Suggest **two** reasons why an alloy such as brass is preferred to either of its constituent metals.

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

5 Iron is extracted from its ore, hematite, in a blast furnace.

Substances added to the furnace are:

- iron ore, hematite, containing impurities such as silica, SiO_2
- air
- coke, C
- limestone, CaCO_3

Substances formed in the blast furnace are:

- molten iron
- molten slag
- waste gases such as carbon dioxide

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

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

(b) Write an equation for the conversion of hematite, Fe_2O_3 , to iron.

..... [2]

(c) Explain how the silica impurity is removed and separated from the molten iron.

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

(d) The molten iron from the furnace is impure.
It contains impurities which include the element carbon.

Explain how the carbon is removed. Include an equation in your answer.

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

[Total: 10]

Oct/Nov 2015 (33)

6 A reactivity series of metals is given below.

	metal name	symbol
most reactive ↓ least reactive	sodium	Na
	lithium	Li
	magnesium	Mg
	zinc	Zn
	manganese	Mn
	iron	Fe
	copper	Cu
	rhodium	Rh

(a) Which two metals will react most vigorously with cold water?

..... [1]

(b) Which two metals will not react with dilute hydrochloric acid?

..... [1]

(c) Deduce the formula of iron(III) sulfate.

..... [1]