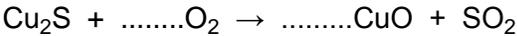


1

Copper is a widely used metal. The main ore of copper contains copper sulfide. Copper can be extracted from copper sulfide in a three stage process.

(a) In the first stage of extraction the copper sulfide is heated in air.

(i) Balance the symbol equation for the reaction.



(1)

(ii) Explain why there would be an environmental problem if the gas from this reaction were allowed to escape into the atmosphere.

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

(2)

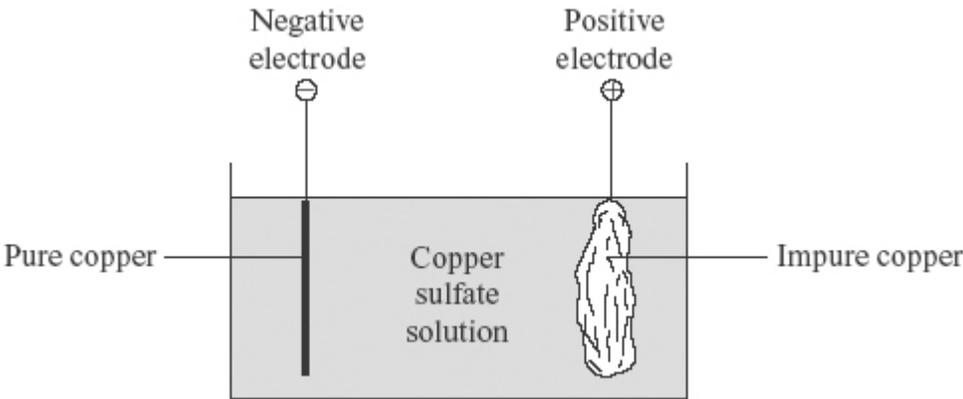
(b) In the second stage copper oxide, CuO, is reduced using carbon.

Describe and explain what happens during this reaction.

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

(2)

(c) During the third stage the copper can be purified as shown in the diagram.



(i) What is the name of the type of process used for this purification?

.....

(1)

(ii) Give **one** use of purified copper.

.....

(1)

(d) Copper-rich ores are running out.

New ways of extracting copper from low grade ores are being researched.

Recycling of copper may be better than extracting copper from its ores.

Explain why.

.....
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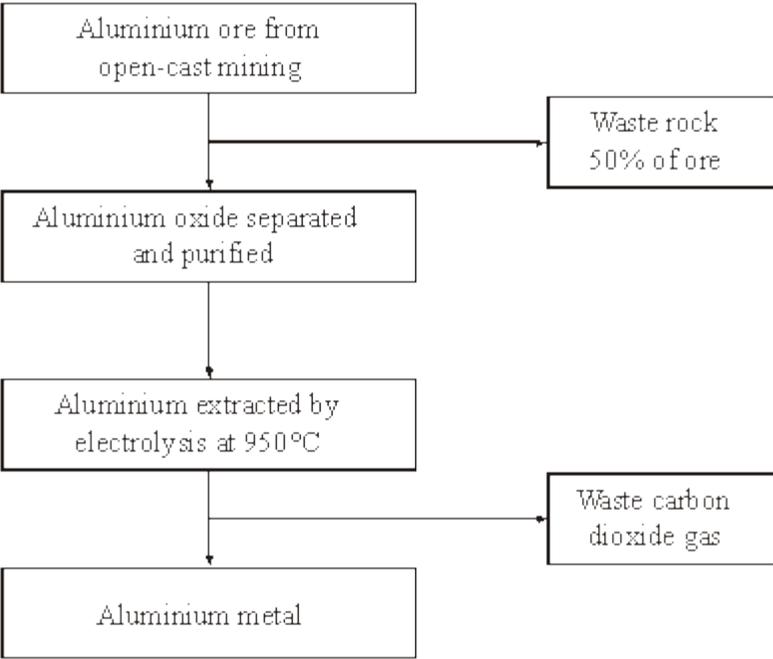
(3)

(Total 10 marks)

2

Aluminium has many uses because of its low density, good electrical conductivity, flexibility and resistance to corrosion.

The main steps in the extraction of aluminium are shown in the flow chart.



(a) Use the information in the flow chart to suggest the benefits of recycling aluminium.

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

(3)

(b) Pure aluminium is rarely used for the construction of large objects. Small amounts of other metals are usually mixed with aluminium.

Explain why.

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

(2)

(Total 5 marks)

3

Many everyday items are made from iron.

(a) Haematite is an *ore* of iron. Haematite contains iron oxide, Fe₂O₃.

(i) What is the meaning of the term *ore*?

.....
.....

(1)

(ii) Iron can be produced by reacting iron oxide with carbon in a blast furnace.

What type of reaction produces the iron?

.....
.....

(1)

(iii) The word equation for this reaction is:

iron oxide + carbon → iron + carbon dioxide

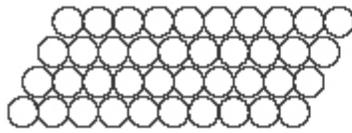
Complete and balance the symbol equation for this reaction.

.....Fe₂O₃ +C → +

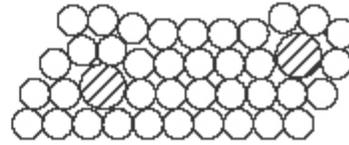
(2)

(b) Pure iron is relatively soft and not very strong.

The iron from the blast furnace is very hard and brittle. It contains about 4% carbon and is used as cast iron.



Pure iron



Cast iron

Explain the differences in the properties of pure iron and cast iron by referring to the diagrams.

.....

.....

.....

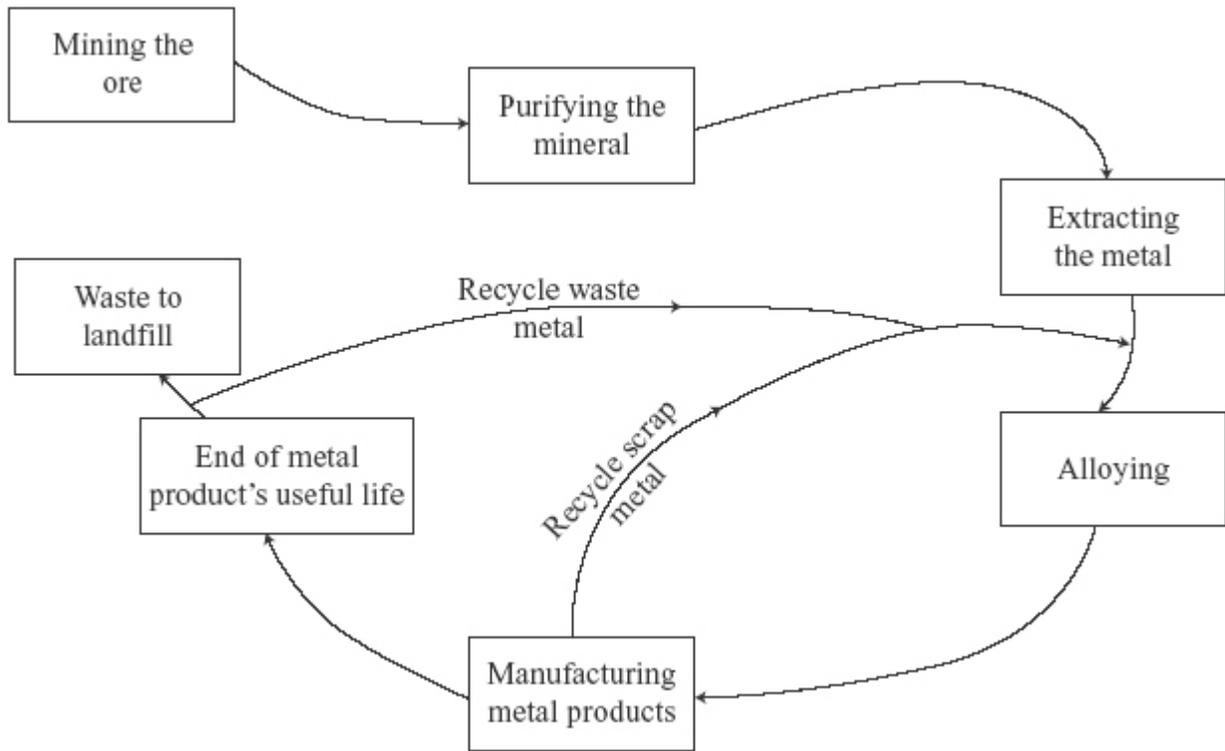
.....

.....

.....

(3)

(c) The diagram shows the way in which iron is extracted, used and recycled.



Explain why the recycling of iron is necessary for sustainable development.

.....

.....

.....

.....

.....

.....

(3)
(Total 10 marks)

4

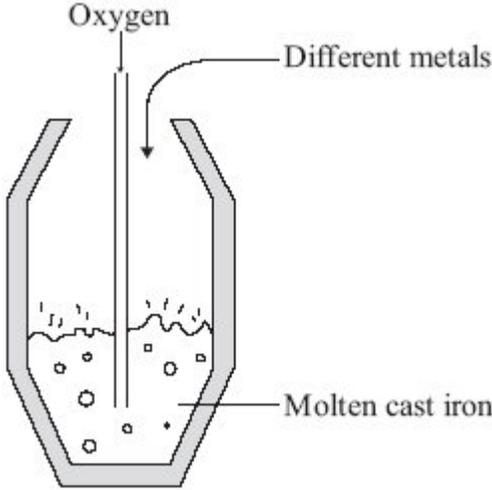
The demand for iron and steel is high.

- (a) Iron that is extracted from its oxide by carbon reduction in a blast furnace is called cast iron. Cast iron contains about 4% carbon. This carbon makes cast iron very brittle.

Carbon steels can be made by the following processes.

- Blowing oxygen into molten cast iron to remove most of the carbon.
- Adding a calculated amount of carbon.

Sometimes different metals may also be added to the molten carbon steels.



- (i) Suggest how blowing oxygen into molten cast iron removes most of the carbon.

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

(2)

- (ii) Why are different metals sometimes added to molten carbon steels?

.....
.....

(1)

(b) The percentage of iron and steel recycled in the UK has been increasing.

Year	%iron and steel recycled
1998	25
2000	35
2002	42
2004	46
2006	57

The UK government has set targets for the percentage of iron and steel to be recycled. In 2006 the target was exceeded.

Suggest **two** reasons why the UK government wants to encourage recycling of iron and steel.

1

.....

2

.....

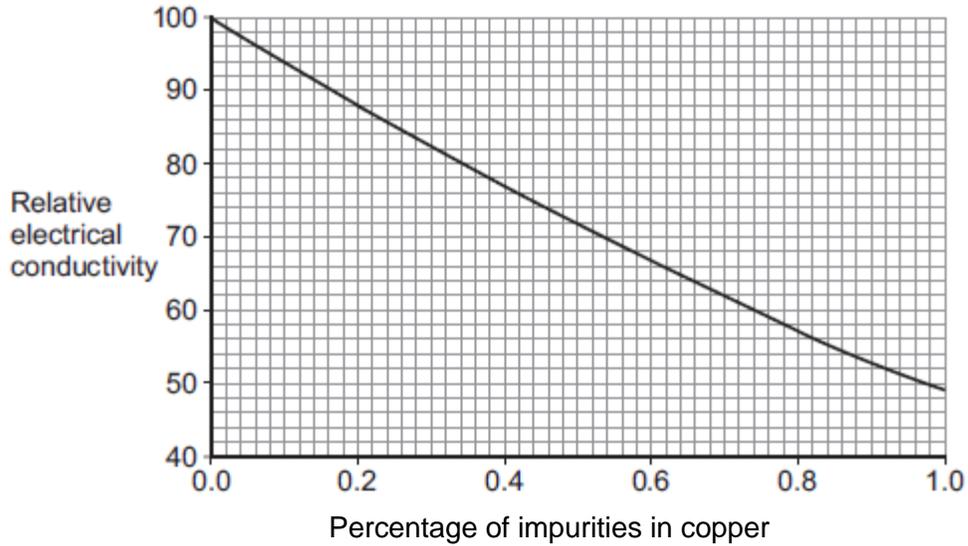
(2)
(Total 5 marks)

5

This question is about copper.

- (a) Most of the copper extracted is used in electric circuits.

The figure below shows how impurities change the electrical conductivity of copper.



Copper extracted by smelting is about 99% pure.

The 99% pure copper produced by smelting is purified to 99.9999% pure copper by electrolysis.

Use values from the graph to explain why copper is purified to 99.9999%.

.....

.....

.....

.....

(2)

.....
Extra space
.....
.....
.....
.....
.....
.....
.....
.....
.....

(6)

- (c) Phytomining is used to obtain copper from land that contains very low percentages of copper compounds.

Describe how copper compounds are obtained by phytomining.

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

(3)

(Total 11 marks)

6

Cans for food and drinks are made from steel or aluminium.
The main metal in steel is iron.



By Sun Ladder (Own work) [CC-BY-SA-3.0 or GFDL],
via Wikimedia Commons

(a) Iron is extracted by heating a mixture of iron oxide and carbon in a blast furnace.

(i) Name this type of reaction.

.....

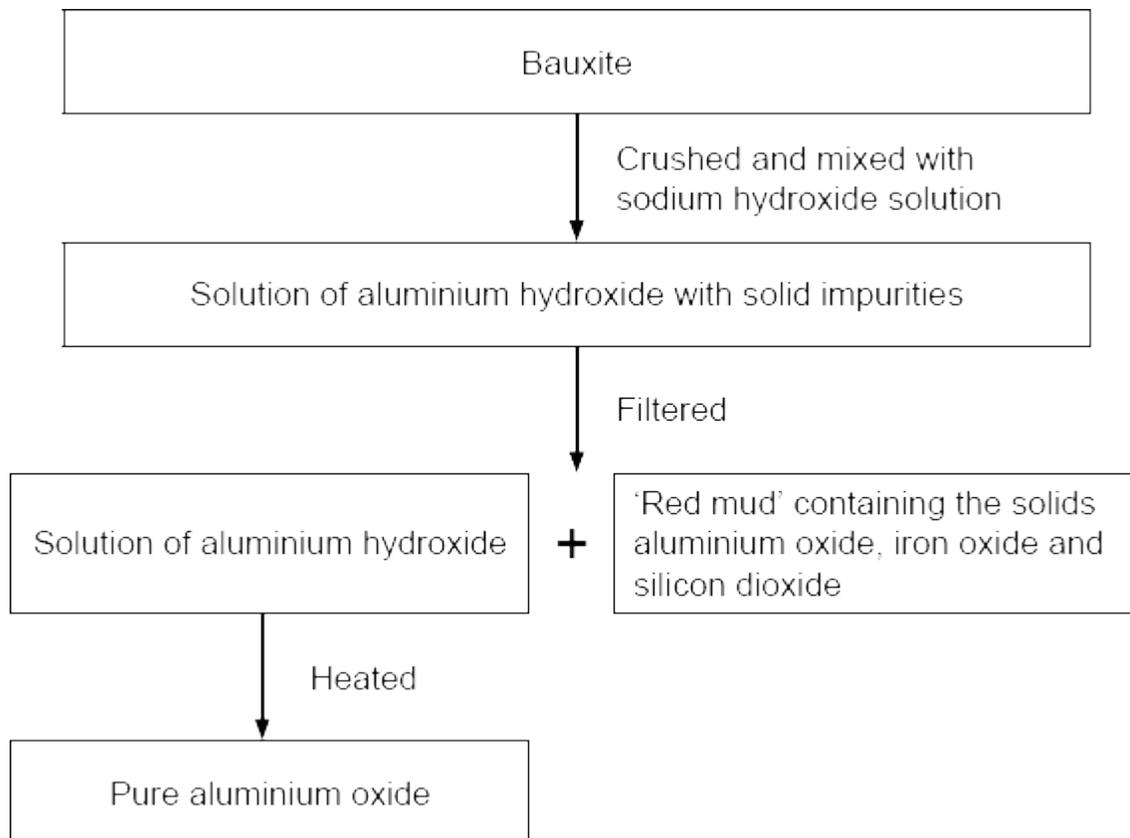
(1)

(ii) Balance the symbol equation for this reaction.



(1)

- (b) Aluminium ore, bauxite, contains aluminium oxide, iron oxide and silicon dioxide. Aluminium is extracted by electrolysis of aluminium oxide.



The 'red mud' which is dumped in very large ponds contains:

Name of solid	Percentage (%)
Aluminium oxide	10
Iron oxide	65
Silicon dioxide	25

- (i) 100 tonnes of bauxite produced 50 tonnes of pure aluminium oxide and 50 tonnes of 'red mud'.

What percentage of aluminium oxide did the bauxite contain?

.....

Answer = %

(1)

- (ii) Apart from the solids shown in the table, name **one** other substance that would be in the 'red mud'.

.....

(1)

(iii) The purification of the aluminium oxide is usually done near to the bauxite quarries.

Suggest **one** reason why.

.....

(1)

(c) Aluminium is used to make many things including cans.

During one year in the USA:

- 100 billion aluminium cans were sold
- 55 billion aluminium cans were recycled.

Give **one** environmental impact of recycling aluminium cans and **one** ethical or social impact of recycling aluminium cans.

Environmental

.....

Ethical or social

.....

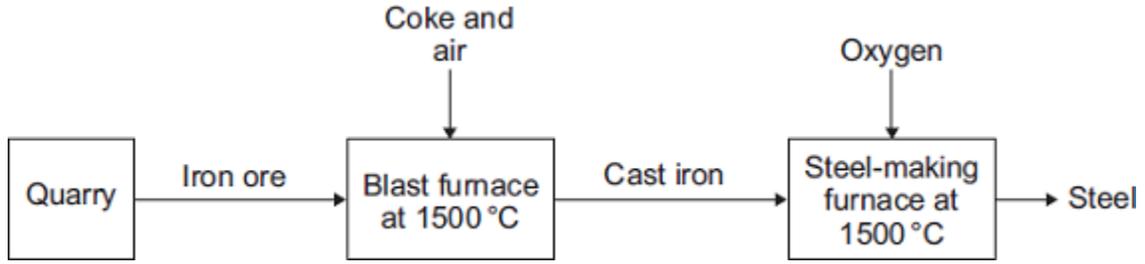
(2)

(Total 7 marks)

7

The iron produced from iron ore in a blast furnace is called cast iron.

Cast iron is converted into steel in a furnace.



Iron ore contains iron oxide.

Coke contains carbon.

(a) Quarrying iron ore will have an impact on everything near to the quarry.

(i) Describe **one** positive impact and **one** negative impact of quarrying iron ore.

positive impact

.....

negative impact

.....

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

Ores contain enough metal to make extraction of the metal

- carbon neutral.
- economical.
- reversible.

(1)

(b) Many chemical reactions take place in a blast furnace.

Use the flow diagram to help you to answer this question.

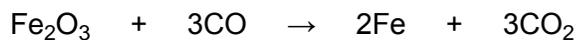
Suggest how the blast furnace is heated.

.....

.....

(1)

(c) A chemical reaction for the extraction of iron is:



(i) Complete the word equation for this chemical reaction.

..... + carbon monoxide → iron +

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

Iron is extracted from its ore by

- decomposition.
- oxidation.
- reduction.

(1)

(d) Cast iron contains about 4% carbon.
Cast iron is converted into low-carbon steels.

(i) Low-carbon steel is produced by blowing oxygen into molten cast iron.

Suggest how oxygen removes most of the carbon.

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

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

Metals, such as nickel, are added to low-carbon steels to make the steel

- corrode easily.
- easy to shape.
- much harder.

(1)

(e) Recycling steel uses less energy than producing steel from iron ore.

Tick (✓) **one** advantage and Tick (✓) **one** disadvantage of recycling steel.

Statement	Advantage Tick (✓)	Disadvantage Tick (✓)
Iron is the second most common metal in the Earth's crust.		
Less carbon dioxide is produced.		
More iron ore needs to be mined.		
There are different types of steel which must be sorted.		

(2)

(Total 12 marks)

Mark schemes

1

- (a) (i) $\text{Cu}_2\text{S} + 2\text{O}_2 \rightarrow 2\text{CuO} + \text{SO}_2$
accept fractions and multiple

1

- (ii) any **two** from:

- sulfur dioxide
accept sulphur dioxide / sulphur oxide / SO_2
- causes acid rain
ignore other comments eg global warming / ozone / global dimming / greenhouse effect
- consequence of acid rain eg kills fish / plants

2

- (b) any **two** from:

- heat (copper oxide with carbon)
- oxygen is removed by carbon
accept copper (oxide) loses oxygen

or

carbon gains oxygen
accept carbon oxide

or

carbon monoxide / carbon dioxide is produced

or

carbon displaces copper
accept a correct word or balanced symbol equation

- because carbon is more reactive than copper
allow a correct comparison of reactivity

2

- (c) (i) electrolysis
accept electroplating 1
- (ii) (electrical) wiring / appliances / coins / pipes / cladding for buildings / jewellery / making alloys 1
- or**
named alloys
- (d) any **three** explanations from:
for recycling
- less acid rain (pollution)
 - copper reserves last longer / conserved
- or**
do not run out
- energy for extraction (saved)
- or**
less energy required
- less mining / quarrying
 - less waste (copper) / electrical appliances dumped
- or**
less landfill
- against recycling
- collection problems
 - transport problems
 - difficult to separate copper from appliances
 - energy used to melt the collected copper
- ignore electrolysis / pollution*
ignore ideas about less machinery / plant
ignore idea of cost

3

[10]

2

(a) any **three** from:

- resources / aluminium / ores are conserved
accept converse argument
- less / no mining **or** less associated environmental problems
eg quarrying / eyesore / dust / traffic / noise / loss of land / habitat
ignore just pollution
- less / no waste (rock) / landfill
*do **not** accept 'wastes 50% of the ore'*
- no purification / separation (of aluminium oxide)
- (aluminium extraction / production) has high energy / electricity / heat / temperature requirements
- less carbon dioxide produced
accept no carbon dioxide produced
ignore references to cost

3

(b) statement

ignore density

1

linked reason

eg

(pure) Al / it is weak / soft (1)

as layers / rows can slide (over each other) (1)

or

alloy / other metals / they make it stronger / harder (1)

stops layers / rows sliding over each other (1)

accept disrupts the structure owtte if no other mark awarded

*accept to form an alloy **or** to change properties for 1 mark*

1

[5]

3

(a) (i) contain enough metal to make it economical / worth while to extract 1

(ii) reduction
accept displacement
accept redox 1

(iii) Fe + CO₂
do not accept Fe₂ / Fe₄ 1

correct balancing
accept multiples and halves
$$2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$$

allow Fe₂ / Fe₄ as ecf 1

(b) **Pure Iron**

(in pure metal all the atoms are the same size and) able to slip / slide over each other – (property soft)

OWTTE
ignore references to molecules / particles
*if they say 'move' both times, allow **one** mark but 'crack' or 'split' is wrong..* 1

Cast iron

(in cast iron) different sized atoms / larger atoms **or** structure is distorted / disrupted

OWTTE 1

so it is difficult for layers of atoms to slip / slide over each other

OWTTE 1

(c) any **three** from:

- conserves / saves resources / metal ores
- saves energy resources (used for extraction / processing)
accept cheaper / saves money
- decreases waste materials
- decreases a named pollution
*do **not** accept acid rain*

3

[10]

4

- (a) (i) reacts with carbon / C
accept burns / oxidises carbon

1

carbon dioxide / CO₂ / gas is formed / given off
accept carbon monoxide / CO
accept correctly balanced equation for 2 marks
ignore state symbols

1

- (ii) change / improve properties
accept any specific property
accept to make alloys / special steels
ignore brittle

1

(b) any **two** from:

- to conserve ores / iron
accept ores / iron are non-renewable / non-sustainable
allow less quarrying / mining
- to prevent the use of landfills
allow reduce waste
- to conserve energy / fuel
accept fossil fuels are non-renewable
- to reduce carbon / carbon dioxide emissions
- to meet EU / International targets
ignore costs / demand

2

[5]

5

(a) pure copper is twice as good a conductor as 99% pure copper

accept reverse argument

accept answers quoting 2 correct values from the graph scores 2

qualitative answer (e.g. pure copper is a better conductor than impure copper) scores 1

or

answers quoting a conductivity value from the graph scores 1

2

- (b) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response.

0 marks

No relevant content

Level 1 (1–2 marks)

Simple list of a limited number of points given, with no linking between ideas

Level 2 (3–4 marks)

A broader set of points made. There will probably not be links between ideas

Level 3 (5–6 marks)

Answer includes linking between ideas, showing the consequence of either not recycling or the advantage of recycling. Answers such as less fossil fuel needed so less carbon dioxide produced **or** less carbon dioxide produced so less global warming

examples of the points made in the response

resources

(recycling) conserves supplies of ores
copper available for longer

as (at present rate of use) copper ores will run out in about 35 years

(recycling) conserves supplies of fossil fuels **or** energy
less fuel used at a lower cost

land pollution

mining scars landscape **or** produces noise pollution
mining destroys wildlife habitats

(recycling) less need to mine ores / fossil fuels
so less habitat destroyed or less scarring of landscape

(recycling) less need to use landfill for waste

atmospheric pollution

burning fossil fuels produces carbon dioxide / greenhouse gas
which (may) cause global warming **or** climate change

extraction produces sulfur dioxide
which causes acid rain
which can kill trees / fish

6

- (c) grow plants

accept plants absorb copper (through roots)

1

then plants are burned

1

ash (from burning) contains copper compounds

1

[11]

6

(a) (i) reduction
accept redox / smelting

1

(ii) 3 4 3

1

(b) (i) 55

ignore other units

(ii) Water

accept sodium hydroxide

accept correct formulae H_2O or $NaOH$

1

(iii) any **one** from:

- save energy / fuel for transporting the ore
accept less (cost of) transport allow transported quickly
- (old) quarries nearby for waste/red mud

1

(c) **Environmental**

any **one** from:

- less mining / quarrying (of bauxite)
allow loss of habitat / less qualified noise pollution
- less landfill space needed / used
allow less red mud / waste
- less use of fossil fuels / energy
- less carbon dioxide produced

1

Ethical or social

any **one** from:

- saves resources
allow using resources more than once
- creates (local) employment
if answers reversed and both correct award 1 mark
- more people aware of the need for recycling
allow less qualified noise pollution if not given in environmental

1

7

(a) (i) Positive impact

any **one** from:

- provides employment **or**
- improves local economy
- improved transport - new roads are built, new rail links
- after use the quarry could provide recreation facilities

1

Negative impact

any **one** from:

- destruction of animal habitats
- fewer plants and trees to absorb carbon dioxide
- visual pollution **or** noise pollution **or** atmospheric / air pollution
allow dust pollution
- more traffic
- uses non-renewable resources
allow pollutants from burning diesel

1

(ii) economical

1

(b) carbon / coke burns (in oxygen / air)

accept carbon / coke reacts with oxygen / air

1

(c) (i) iron oxide (reactant)

must be words

1

carbon dioxide (product)

1

(ii) reduction

1

(d) (i) oxygen reacts with carbon

1

or

oxygen and carbon produce carbon dioxide / carbon monoxide

carbon dioxide / carbon monoxide is a gas

or

the carbon is removed as a gas

1

(ii) much harder

1

(e) Advantage:

less carbon dioxide is produced

1

Disadvantage:

there are different types of steel which must be sorted

1

[12]

Examiner reports

1 The majority of these candidates could not balance symbol equations for chemical reactions but a few achieved good marks in part (a)(ii), usually by realising that acid rain could be produced and by stating that the gas was sulfur dioxide or by giving an environmental problem caused by acid rain. The better candidates appreciated that the reactants, copper oxide and carbon, would need to be heated for the carbon to 'take away' the oxygen from the copper. There were some correct descriptions of displacement, although the majority of these candidates did not realise that this is caused by the relative reactivities of copper and carbon. The process of electrolysis was unfamiliar to most candidates but the majority gave a correct use for purified copper. Surprisingly few candidates gave good explanations of why they were in favour of recycling. Most marks were awarded for the idea of copper ores 'running out' or for recognising that there are problems with waste as landfill space is limited. Only the more able candidates mentioned that less energy would be required for the extraction processes and/or that there would be less mining/quarrying needed hence reducing the associated environmental problems.

2 In part (a) most candidates were able to use the flow chart to suggest the benefits of recycling aluminium.

Part (b) produced good answers although many candidates provided no explanation and therefore only scored one mark.

3 Surprisingly, candidates found part (a) difficult. Few could explain what an ore was. Acceptance of reduction, displacement and redox in part(a)(ii) meant that many candidates got the mark, but a disappointing number gave oxidation and even chemical reaction as the answer. A lot of candidates could not balance the equation, with a large number writing iron as Fe_2 .

Part (b) was less of a problem as most candidates answered this well.

There were a variety of possible correct responses to part (c). Few candidates picked up all three marks although there were a lot of good, if not complete, explanations. A minority blamed unrecycled iron for global warming, global dimming, destroying the ozone layer and acid rain.

- 4**
- (a) (i) This part was well answered with most candidates gaining at least one mark. The reaction of carbon with oxygen to form carbon dioxide is well known. Incorrect answers often suggested that the oxygen would displace either the carbon or the iron.
 - (ii) The second part was also well answered. Stronger was by far the most common correct response followed closely by to make alloys.

- (b) The suggestions that recycling was to be encouraged to conserve iron ores and conserve energy were the most popular correct ideas. Candidates seemed very familiar with the subject matter of this question.

5

- (a) Despite the instruction to use values from the graph, some students ignored this and gave a simple qualitative description. A common error was to read a value from the graph for 99.9% pure copper (0.1% impurities) and state it was the value for 99% pure copper.
- (b) There were many excellent answers, with students using the information in the question as well as their own knowledge. Many students filled all the available space and went onto continuation sheets. More planning before starting to write will ensure that a concise answer can be given as there is no additional credit for lengthy answers.
- (c) Most students were aware that plants are grown, absorb copper ions and are then burned. However, fewer realised that the ashes contain copper compounds, many answers stating or implying that the element copper can be collected from the ash.

6

- (a) (i) Surprisingly only about a third of students realised that the extraction of iron was a reduction process.
- (ii) About half of the students could correctly balance the equation.
- (b) (i) Very few students calculated that there was 55% aluminium oxide in the bauxite.
- (ii) Few students realised that there would also be water or sodium hydroxide in the red mud.
- (iii) A slight majority of students correctly suggested that the advantage of the bauxite quarry and extraction plant being close was related to transport.
- (c) In this last part, students struggled to appreciate the difference between environmental impacts and ethical or social impacts. Many students confuse recycling with re-using.

7

- (a) (i) Most students gained at least one mark. The most common correct answers were 'provides jobs' and a 'specified type of pollution'. There were a number of vague answers that did not describe the impacts and just stated 'pollution' or 'carbon dioxide produced' or 'non-renewable'. A number of students also referred to the process of producing iron or steel instead of the quarrying of iron ore.
- (ii) Few students knew that ores contain enough metal to make extraction of the metal economic.

- (b) Surprisingly poorly answered because most students thought that 'by coke' or by 'coke and air' were sufficient for the answer. There were a range of interesting responses that did not gain credit such as, the blast furnace is heated by 'the Sun', 'a bunsen burner', 'hot air', 'a flame', 'fire' and 'electrolysis'. Although many students mentioned coke and air, they did not state they react just that they are added. Several students did not mention coke but suggested other fuels such as coal or natural gas as being used to heat the blast furnace.
- (c) (i) Many correct answers were given but it is surprising that a significant number of students still could not name iron oxide calling it iron ore and carbon dioxide was often called 'carbonate', 'cobalt' or 'carbon monoxide'.
- (ii) Few students understood that iron is extracted from its ore by reduction.
- (d) (i) Very few students gained any marks. The most common incorrect idea was that oxygen is stronger so it pushes or blows the carbon out. Most students who got one mark did so for knowing that carbon dioxide is produced. Other incorrect suggestions were that oxygen is more reactive than carbon so removes it by decomposition or by neutralisation or by reduction.
- (ii) Most students knew that metals, such as nickel, are added to low-carbon steels to make the steel much harder.
- (e) Most students gained at least one mark. The most common correct answer was the advantage that less carbon dioxide is produced. Several students thought that four ticks were needed, that is, one in each row. Many incorrectly thought that the disadvantage was more iron needs to be mined.