Q1. Use the Reactivity Series of Metals on the Data Sheet to help you to answer this question.

The table gives information about the extraction of some metals.

Metal	Date of discovery	Main source	Main extraction method
Gold	Known to ancient civilisations	In the Earth as the metal itself	Physically separating it from the rocks it is mixed with
Zinc	1500	Zinc carbonate	Reduction by carbon
Sodium	1807	Sodium chloride	Electrolysis

(a) Explain why gold is found mainly as the metal itself in the Earth.

.....

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(1)

(b) One of the reactions involved in producing zinc is represented by this equation.

$ZnO + C \rightarrow Zn + CO$

Explain why carbon can be used to extract zinc.

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(1)

(c) Sodium is one of the most abundant metals on Earth.

Explain, as fully as you can, why sodium was not extracted until 1807.

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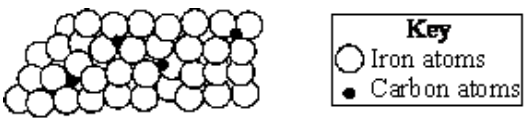
(2)

(Total 4 marks)

Q2. The diagram shows the arrangement of atoms in an *alloy.*



(a) What is meant by an *alloy?*

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(2)

(b) Name the alloy represented in the diagram.

.....

(1)

(c) Give **one** advantage of using this alloy instead of pure iron.

.....

.....

(1)

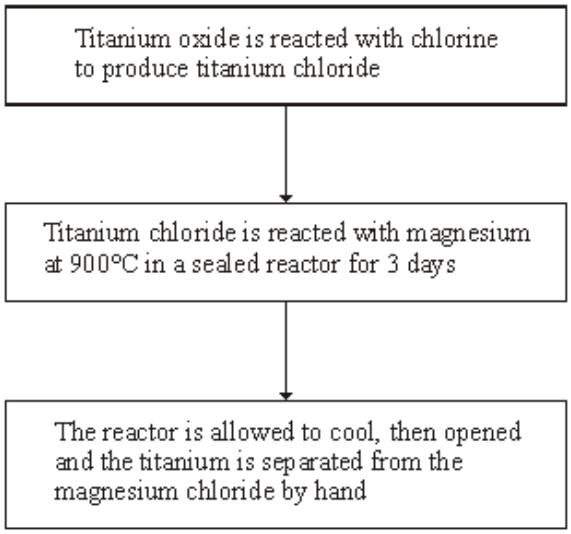
(d) Which elements are used to make brass?

.....

(1)
(Total 5 marks)

Q3. Titanium is used in aircraft, ships and hip replacement joints. Titanium is as strong as steel but 45% lighter, and is more resistant to acids and alkalis.

Most titanium is produced from its ore, rutile (titanium oxide), by a batch process that takes up to 17 days.



Titanium reactors produce about 1 tonne of the metal per day.
Iron blast furnaces produce about 20 000 tonnes of the metal per hour.

(a) Give **one** property of titanium that makes it more useful than steel for hip replacement joints.

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(1)

(b) In the reactor magnesium is used to produce titanium. If carbon were used instead of magnesium, no titanium would be produced.

What does this tell you about the relative reactivities of carbon, magnesium and titanium?

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(2)

(c) The use of titanium is limited because it is expensive.

Explain why titanium costs more than steel.

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(3)

(Total 6 marks)

Q4. (a) PEX is a material that is used as an alternative to copper for hot water pipes. PEX is made from poly(ethene).

(i) Describe how ethene forms poly(ethene).

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(2)

(ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

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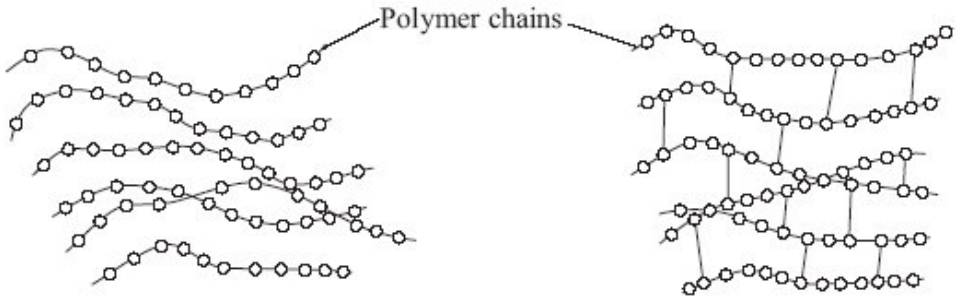
(1)

(iii) The simplified structures of poly(ethene) and PEX are shown.



Poly(ethene) **PEX**

Poly(ethene) is a thermoplastic that softens easily when heated.

Suggest and explain how the structure of PEX changes this property.

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(3)

(b) Copper was considered to be the most suitable material to use for hot water pipes.
PEX is now used as an alternative material for hot water pipes.

Copper is extracted from its ore by a series of processes.

1 The low-grade ore is powdered and concentrated.
2 Smelting is carried out in an oxygen flash furnace. This furnace is heated to 1100 °C using a hydrocarbon fuel. The copper ore is blown into the furnace with air, producing impure, molten copper.
3 Oxygen is blown into the impure, molten copper to remove any sulfur. The copper is cast into rectangular slabs.
4 The final purification of copper is done by electrolysis.

PEX is made from crude oil by a series of processes.

1 Fractional distillation
2 Cracking
3 Polymerisation
4 Conversion of poly(ethene) into PEX

Suggest the possible environmental advantages of using PEX instead of copper for hot water pipes.

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(4)
(Total 10 marks)

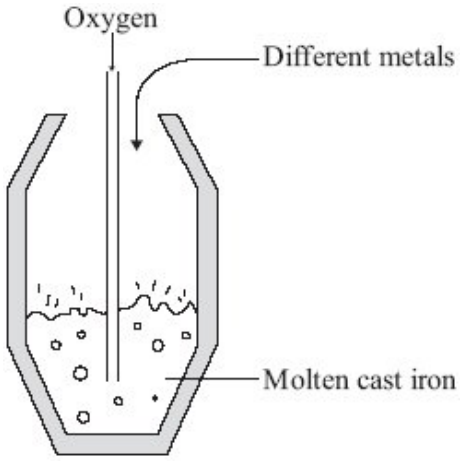
Q5. The demand for iron and steel is high.

(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.

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(2)

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

.....

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(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 .....

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2 .....

.....

(2)

(Total 5 marks)

Q6. Copper is found in the Earth's crust as an ore containing copper sulfide. Large areas of land, where this ore was once quarried, are contaminated with low percentages of copper sulfide. Copper would be too expensive to extract from this contaminated land using the traditional method of quarrying and then heating in a furnace.

(a) The percentage of copper ore in the contaminated land is low.

(i) It would be too expensive to extract from this land by the traditional method.

Explain why.

.....

.....

(1)

(ii) Extracting copper from this land by the traditional method would have a major environmental impact.

Give **one** reason why.

.....

.....

(1)

(b) One way to extract the copper from land that contains low percentages of copper sulfide is by bioleaching. Bioleaching uses bacteria. The bacteria produce a solution of copper sulfate.

It is possible to get copper from a solution of copper sulfate using scrap iron.

(i) It is economical to use scrap iron to get copper.

Give **one** reason why.

.....

.....

(1)

(ii) Why can iron be used to get copper from copper sulfate solution?

.....

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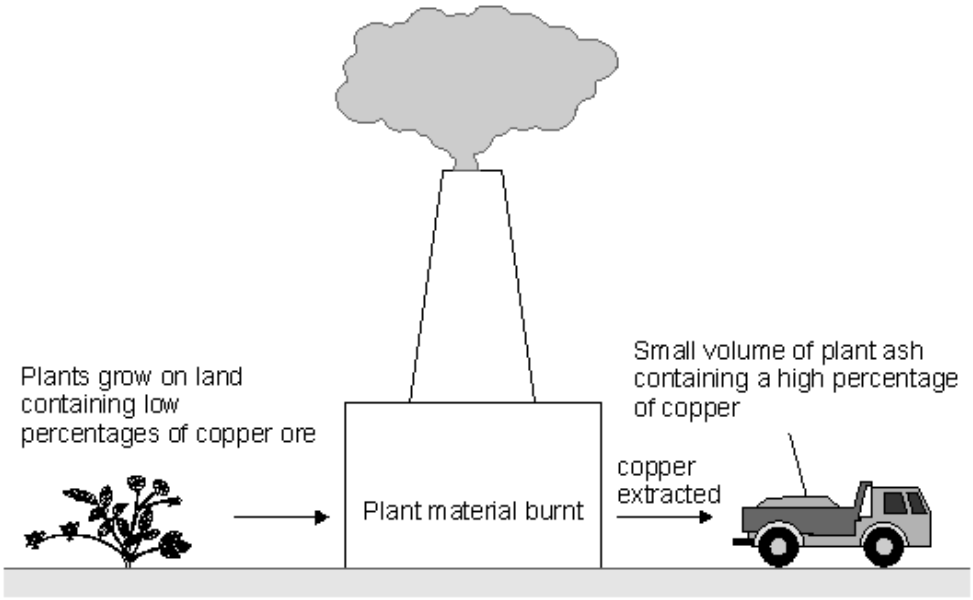
(1)

(c) A new way to extract the copper from land that contains low percentages of copper sulfide is phytomining.

Phytomining uses plants. Plants are grown on this land and absorb copper compounds through their roots.



(i) Use this information to give **two** advantages of phytomining compared to the traditional method.

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.....

(2)

(ii) Use this information to suggest **one** disadvantage of phytomining compared to the traditional method.

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(1)

(Total 7 marks)

Q7. Titanium is used for replacement hip joints because it has a low density, is strong and does not corrode.
Titanium is extracted from titanium dioxide (TiO_2) in three stages.

(a) **Stage 1**
Titanium dioxide is converted into titanium chloride ($TiCl_4$) because the metal cannot be extracted from its oxide by *reduction* with carbon.

(i) What does *reduction* mean?

.....

.....

(1)

(ii) Balance the chemical equation for the conversion of titanium dioxide to titanium chloride.

$$TiO_2 \quad + \quad Cl_2 \quad + \quad C \quad \rightarrow \quad TiCl_4 \quad + \quad CO_2$$

(1)

(iii) Chemical equations are always balanced. Explain why.

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.....

(1)

(b) **Stage 2**
Titanium is extracted from the titanium chloride by reacting it with sodium at 1000 °C in a reactor.
The only other substance in the reactor is argon gas.

$$TiCl_4 \quad + \quad 4Na \quad \rightarrow \quad Ti \quad + \quad 4NaCl$$

(i) What does this tell you about the reactivity of sodium compared with titanium?

.....

.....

(1)

(ii) Suggest why the reactor contains argon and **not** air.

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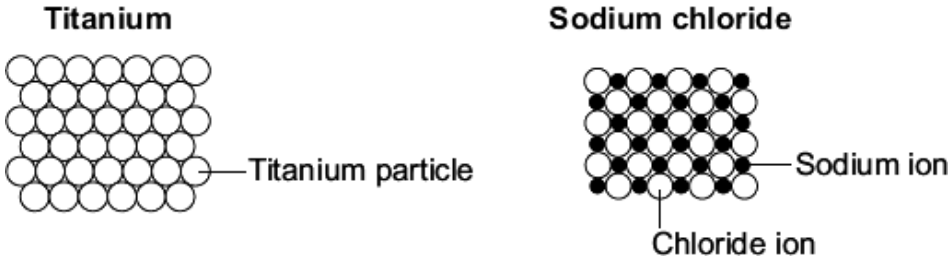
.....

(1)

(c) **Stage 3**

After **Stage 2** the titanium is separated from the products by washing out the sodium chloride with water.

The diagrams show sections through the lattice of titanium metal and the lattice of sodium chloride.



How do the diagrams show that:

(i) titanium is an element

.....

.....

(1)

(ii) sodium chloride is a compound?

.....

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.....

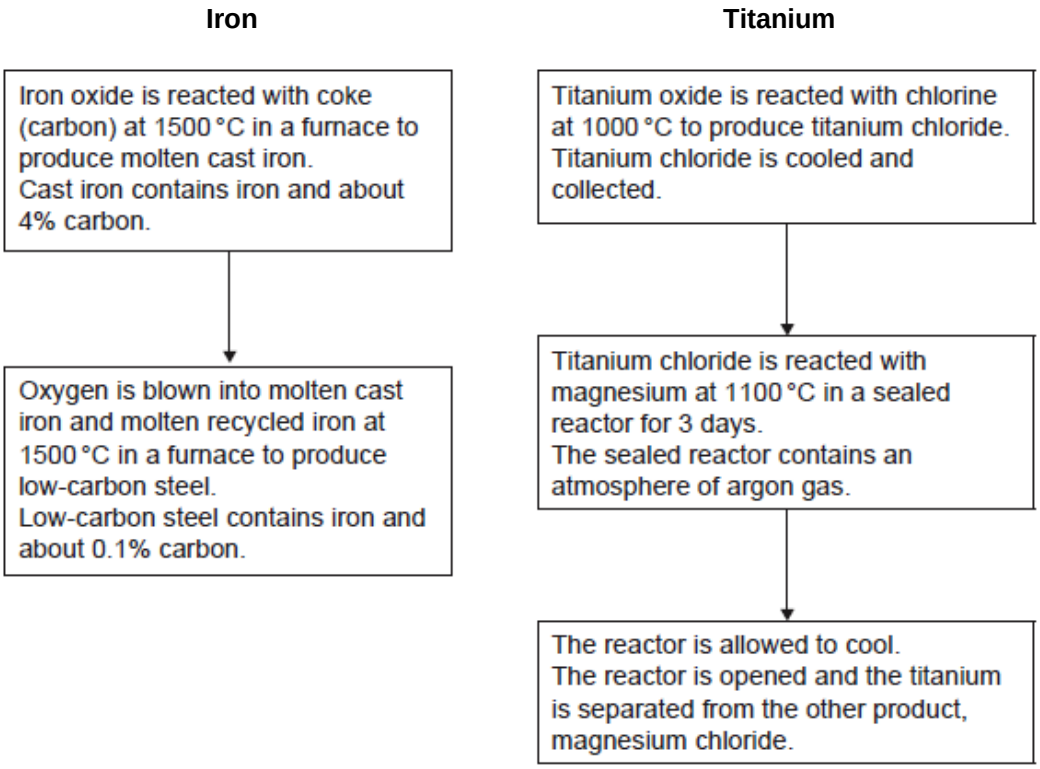
.....

(2)

(Total 8 marks)

Q8. Iron is produced from the ore haematite (iron oxide).

Titanium is produced from the ore rutile (titanium oxide).



(a) The production of low-carbon steel uses oxygen but the production of titanium uses argon.

Explain why.

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(3)

(b) There is less titanium than iron in the Earth's crust.

Apart from titanium's scarcity, explain why titanium costs much more than iron.

Use the two flow diagrams above to help you to answer this question.

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(3)

(c) Many chemical reactions take place in the production of both metals.

A chemical reaction in the production of iron is:

$$2\ Fe_2O_3 + 3\ C \rightarrow 4\ Fe + 3\ CO_2$$

A chemical reaction in the production of titanium is:

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

Titanium can be used to produce iron from iron oxide. The chemical reaction is:

$$2\ Fe_2O_3 + 3\ Ti \rightarrow 4\ Fe + 3\ TiO_2$$

Use these three reactions and the Chemistry Data Sheet to answer this question.

Suggest the position of titanium in the Reactivity Series of Metals.

Explain your answer.

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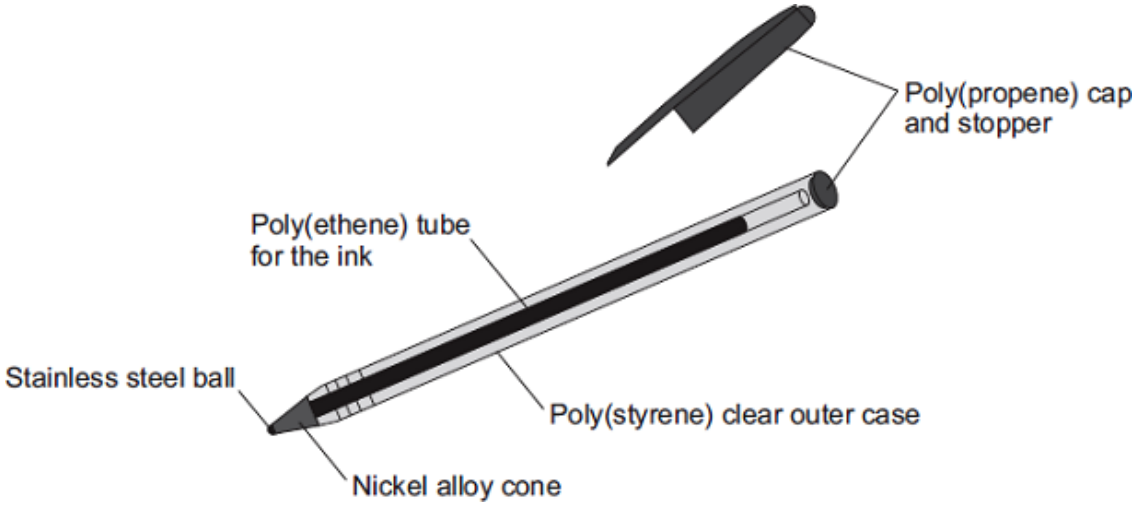
(2)
(Total 8 marks)

Q9. The diagram shows a ballpoint pen.



(a) Give **one** advantage and **one** disadvantage of recycling the materials from this type of ballpoint pen.

.....

.....

.....

.....

(2)

(b) Alloys are used to make the ballpoint pen.

Give **two** reasons why alloys are used in the ballpoint pen.

.....

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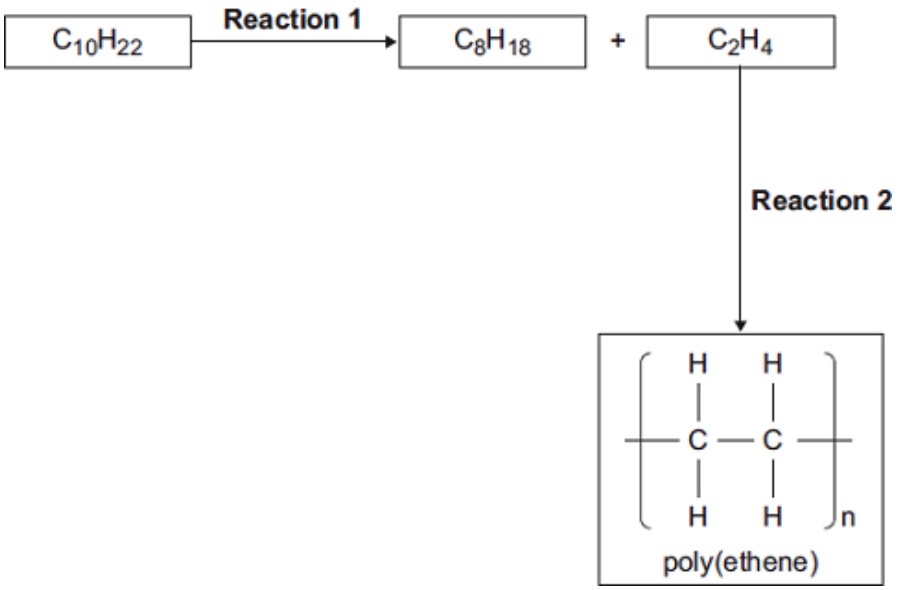
.....

(2)

(c) Decane ($C_{10}H_{22}$) can be used to produce poly(ethene).



(i) Describe the conditions needed for **Reaction 1**.

.....

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.....

.....

(2)

(ii) Describe, in terms of molecules, how poly(ethene) is produced in **Reaction 2**.

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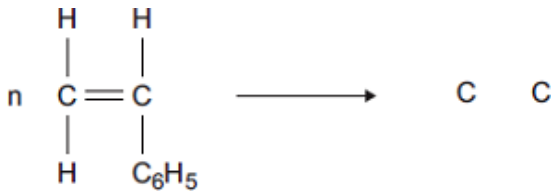
(2)

(d) Complete the displayed structure of the product in the equation.



styrene poly(styrene)

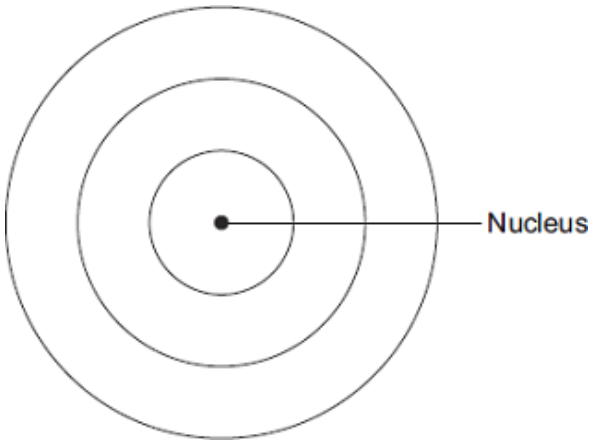
(2)

(Total 10 marks)

Q10. Aluminium has many uses.

(a) An aluminium atom has 13 electrons.

(i) Draw the electronic structure of an aluminium atom.



(1)

(ii) Name the **two** sub-atomic particles in the nucleus of an aluminium atom.

..... and .....

(1)

(iii) Why is there no overall electrical charge on an aluminium atom?

.....

.....

(1)

(b) Rail tracks are made from steel.

Molten iron is used to weld rail tracks.

The reaction of aluminium with iron oxide is used to produce molten iron.

(i) Balance the chemical equation for the reaction.

$$\text{.....Al} + Fe_2O_3 \longrightarrow \text{.....Fe} + Al_2O_3$$

(1)

(ii) Why does aluminium react with iron oxide?

.....

.....

(1)

(Total 5 marks)

M1. (a) unreactive / near bottom of reactivity series

1

(b) carbon more reactive / higher up reactivity series

1

(c) very reactive / near top of reactivity series

1

cannot use displacement methods / can only be extracted by electrolysis / had to wait discovery of electricity

1

[4]

M2. (a) mixture

not *compound*

1

of a metal with other element(s) / metals

not *of elements*
not *of a metal with other substances*

1

(b) steel

allow stainless steel

1

(c) stronger / increased strength / harder / less malleable / less brittle

not *corrosion / rusting*

1

(d) copper and zinc

1

[5]

M3. (a) any **one** from:

- light(er) / less dense
  ignore stronger
- resistant to acids / alkalis / chemical
  accept resistant to corrosion

1

(b) any **two** from:

it must be clear
list principle applies
allow reverse argument
ignore reference to temperature

- magnesium is <u>more</u> reactive than titanium
  magnesium is above titanium in the reactivity series
- titanium is <u>more</u> reactive than carbon
- magnesium is <u>more</u> reactive than carbon
- magnesium is <u>most</u> reactive
- carbon is <u>least</u> reactive

2

(c) any **three** from:

it = titanium
*ignore references to cost / easier / usefulness alone **or** references to incorrect processes*

- takes a long time to process
- low abundance (of ore)
- small amount produced
- batch process used **or** blast furnace is continuous
- more stages used to manufacture titanium
  allow ≥ 3 / many / several
- more energy used (per tonne of titanium)
  allow high energy requirement
  ignore references to temperature
- magnesium / chlorine is expensive
- labour intensive

3

[6]

M4. (a) (i) many ethene / molecules / monomers

accept double bonds open / break

1

join to form a long hydrocarbon / chain / large molecule

accept addition polymerisation
ignore references to ethane
*correct equation gains **2** marks*

1

(ii) (can be deformed but) return to their original shape (when heated or cooled)

ignore 'it remembers its shape'

1

(iii) cross links / extra bonds in PEX

accept inter-molecular bonds
ignore inter-molecular forces

1

molecules / chains in PEX are held in position

accept rigid structure

1

molecules / chains in PEX unable to slide past each other / move

it = PEX throughout

1

(b) any **four** from:

- less (hydrocarbon) fuels used
  allow less energy
- less / no electrical energy used
  allow no electrolysis
- reduce carbon / carbon dioxide emissions
  allow less global warming
- reduce / no pollution by sulfur dioxide / acid rain
- continuous process
  allow less / no transportation
- conserve copper which is running out or only low-grade ores available
- reduce the amount of solid waste rock that needs to be disposed
  allow less waste
- reduce the need to dig large holes (to extract copper ores)
  allow less mining
  ignore costs / sustainability / non-renewable

4

[10]

M5. (a) (i) reacts with carbon / C

accept burns / oxidises carbon

1

carbon dioxide / CO_2 / 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]

M6. (a) (i) because large amounts of energy would be needed to extract the copper

accept because it is labour-intensive to extract copper from this land

accept because copper would have to be extracted from a large area of land (owtte)

1

(ii) any **one** from:

- produces large amounts of solid waste
- atmospheric pollution from carbon dioxide / sulfur dioxide
- more lorries / traffic

1

(b) (i) iron is cheap

accept iron is much more abundant than copper

1

(ii) iron displaces copper from solutions of its salts

accept iron is more reactive than copper

1

(c) (i) any **two** from:

- less expensive / energy to extract the small amounts of copper
- plants will remove carbon dioxide from the atmosphere as they grow
- can release energy when plants are burned

2

(ii) not continuous as it takes a long time for plants to grow

accept supply not continuous as plants only harvested once / twice a year

1

[7]

M7. (a) (i) removal of oxygen

*accept definition in terms of electrons **or** oxidation numbers*

ignore oxides

1

(ii) 2 (Cl_2)

allow correct multiples

1

(iii) no atoms are lost / made (during a chemical reaction)

or

the atoms are rearranged (during a chemical reaction)

accept because of (the law of) conservation of mass / matter

1

(b) (i) sodium is more reactive (than titanium)

*accept sodium is very reactive **or** titanium is less reactive*

*do **not** accept sodium is more reactive than argon*

1

(ii) any **one** from:

- sodium / titanium would react with oxygen / air

accept air / oxygen is reactive

- sodium / titanium does not react with argon

accept argon is unreactive / inert / a noble gas / in group O

1

(c) (i) all atoms are the same / it only contains one type of atom

accept all ions are the same

*do **not** accept only got one atom*

*do **not** accept all atoms are the same size*

ignore particles

1

(ii) two <u>different</u> / <u>types</u> atoms / elements / ions

accept more than one type of atom / ion / element

*do **not** accept different size*

1

bonded / joined together

accept definite proportions

*do **not** accept mixture*

1

[8]

M8. (a) (because to produce low-carbon steel) oxygen is needed to react with / oxidise carbon

accept (to produce low-carbon steel) oxygen removes carbon as carbon dioxide

1

(to produce titanium) an atmosphere of argon is used because it is unreactive

1

any oxygen / air would react with / oxidise magnesium or titanium

ignore magnesium chloride / titanium chloride reacts with oxygen

1

(b) for titanium:

it = titanium

ignore references to abundance / usefulness / temperature / amounts / relative reactivity / equipment

allow converse arguments for iron

- there are more stages in its manufacture

  *accept slower rate of production **or** is more labour intensive **or** a batch process is used or the process used is not continuous*

  1

- larger amounts of energy are needed

  accept the titanium chloride is cooled and reheated which is not energy efficient

  1

- magnesium / chlorine / argon have to be produced **or** are expensive **or** are used

  1

(c) titanium is below magnesium and above iron (in the reactivity series of metals)

*allow similar position to aluminium **or** carbon **or** zinc*

1

because magnesium removes chlorine from titanium chloride **and** titanium removes oxygen from iron oxide

*allow magnesium displaces titanium **and** titanium displaces iron*

1

OR

magnesium more reactive than titanium because it removes chlorine from titanium chloride (1)

accept magnesium more reactive than titanium because it displaces titanium

titanium more reactive than iron because it removes oxygen from iron oxide (1)

accept titanium more reactive than iron because it displaces iron

[8]

M9. (a) any **one** advantage from:

- conserves resources (of crude oil / metal ores)
  ignore can be made into other items
  allow the materials (in the pen) are non-renewable
  allow less expensive than producing from the raw material
- reduces use of landfill
  ignore less waste
- less use of fuels/energy
- less carbon dioxide produced
  ignore global warming unqualified

1

any **one** disadvantage from:

- made of different polymers / alloys / materials
- difficulty / cost of separating the different materials
  allow not all the materials can be recycled

1

(b) hard / strong / durable

1

resistant to corrosion **or** unreactive

allow do not rust
*do **not** allow corrosive*

1

(c) (i) vapours (of decane)

ignore pressure / hot / heat
allow high temperature (≥150 °C)

1

passed over a catalyst **or** porous pot **or** aluminium oxide

allow catalyst even if incorrectly named

1

or
mixed with steam (1)
at a (very) high temperature (1)
if temperature quoted, must be ≥ 500 °C

(ii) many monomers **or** many ethene molecules

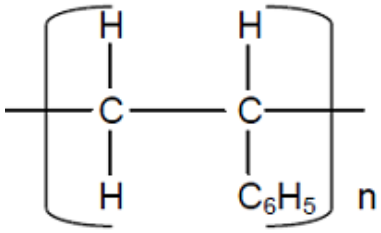
1

join / bond
allow addition polymerisation for second mark

1

OR
monomers / ethene molecules (1)
form chains **or** very large molecules (1)
*if no other mark awarded allow double bond breaks / opens up **or** double bond forms a single bond for **1** mark*

(d)



allow bonds that do not extend through brackets
7 single bonds are used and are in the correct places with no additional atoms (1)
the brackets and the n are in the correct place (1)

2

[10]

M10. (a) (i) 2.8.3
any sensible symbol can be used to represent an electron

1

(ii) proton(s) **and** neutron(s)
both needed for the mark

1

(iii) number of protons is equal to number of electrons
allow positive and negative charges cancel out
allow same amount of protons and electrons

1

(b) (i) **2** Al + Fe_2O_3 → **2** Fe + Al_2O_3
equation must be balanced

1

(ii) aluminium is more reactive (than iron)

it = aluminium

accept converse

accept aluminium displaces iron

accept aluminium is higher in the reactivity series (than iron)

1

[5]