

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.

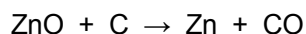
| Metal | Date of discovery | Main source | Main extraction method |
|--------|--------------------------------|----------------------------------|--|
| Gold | Known to ancient civilisations | In the Earth as the metal itself | Physically separating it from the rocks it is mixed with |
| Zinc | 1500 | 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.



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.

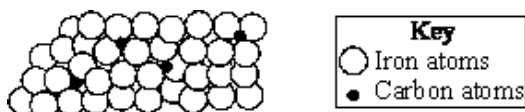
Explain, as fully as you can, why sodium was not extracted until 1807.

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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.

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(1)

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

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(1)

(d) Which elements are used to make brass?

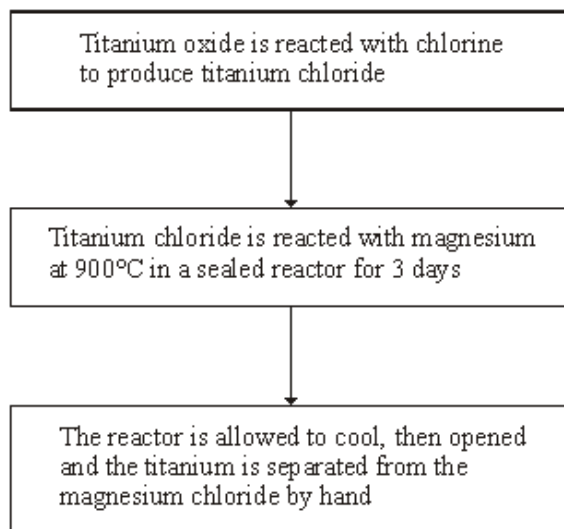
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(1)

(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)

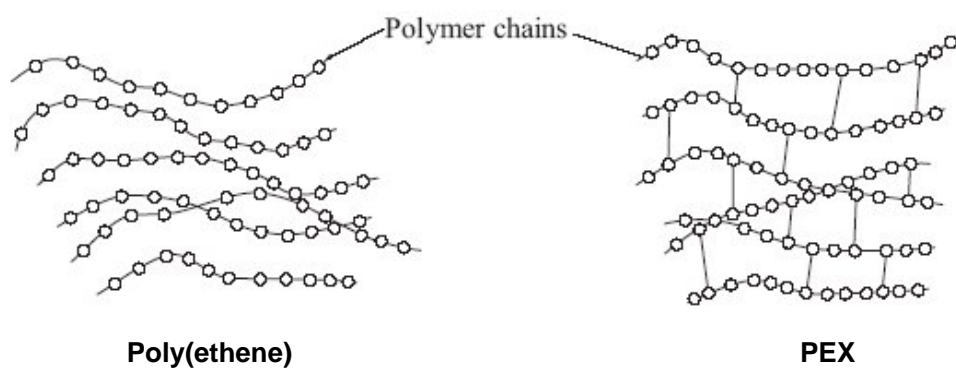
- (ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

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(1)

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



Poly(ethene) 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)

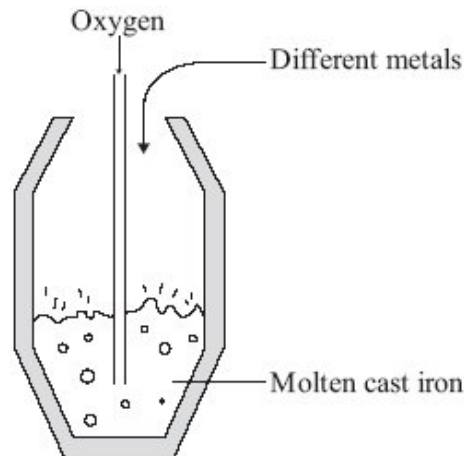
Q5. The demand for iron and steel is high.

- (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.

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- 2
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(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.

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(1)

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

Give **one** reason why.

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(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.

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(1)

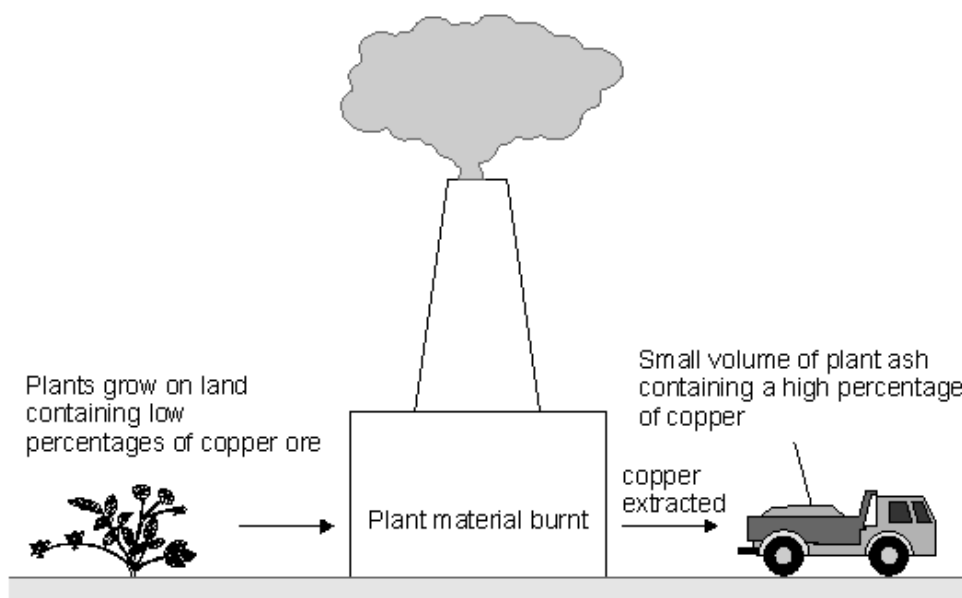
- (ii) Why can iron be used to get copper from copper sulfate solution?

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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**

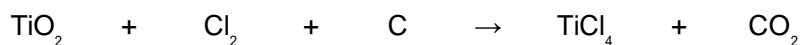
Titanium dioxide is converted into titanium chloride (TiCl_4) because the metal cannot be extracted from its oxide by *reduction* with carbon.

- (i) What does *reduction* mean?

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(1)

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



(1)

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

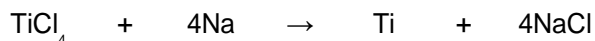
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(1)

(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.



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

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(1)

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

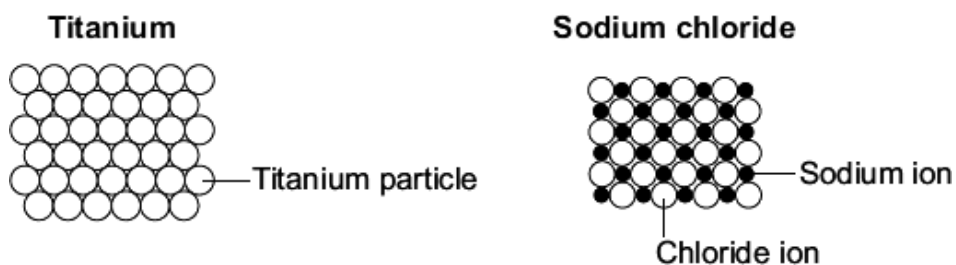
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(1)

(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

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(1)

- (ii) sodium chloride is a compound?

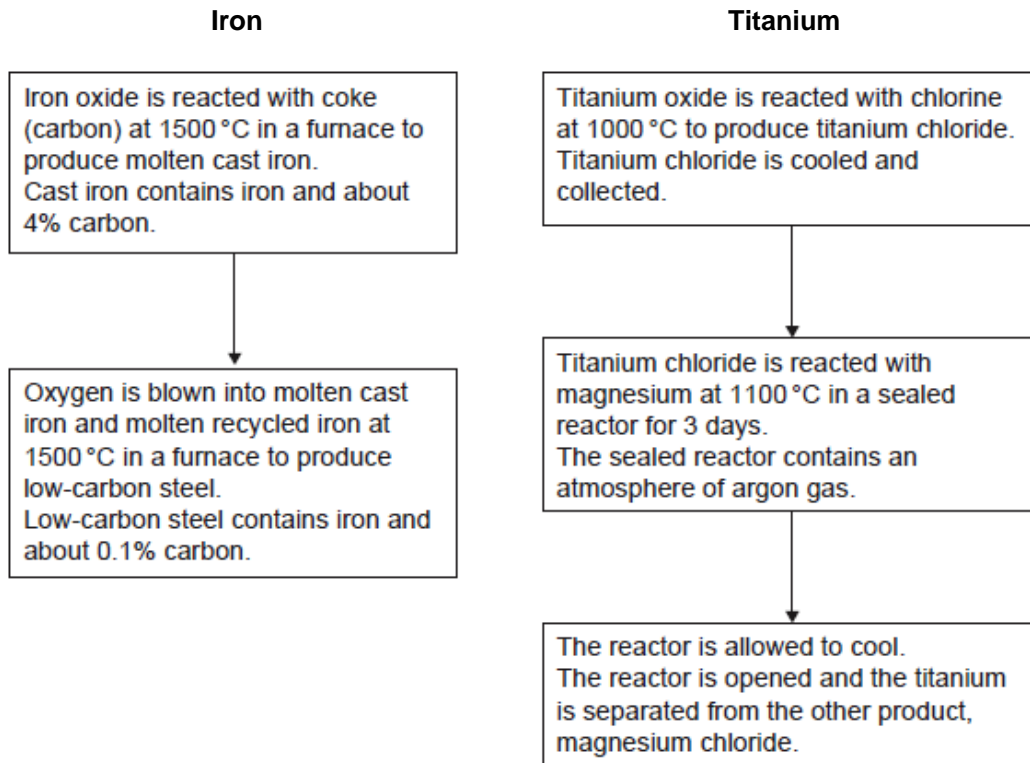
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(2)

(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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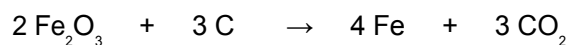
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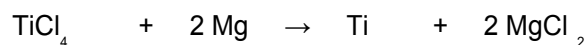
(3)

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

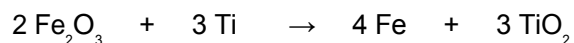
A chemical reaction in the production of iron is:



A chemical reaction in the production of titanium is:



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



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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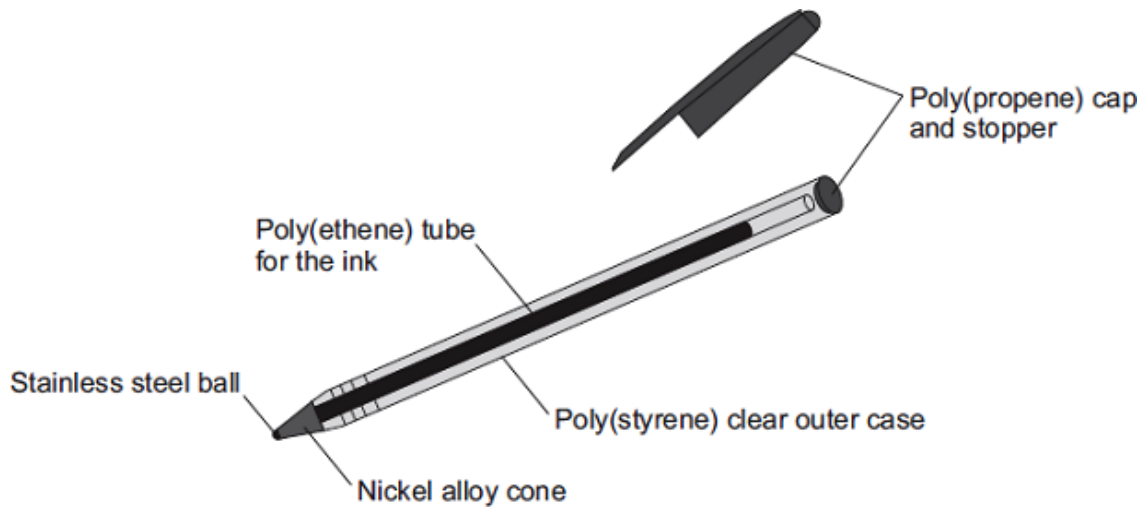
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(2)

(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.

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(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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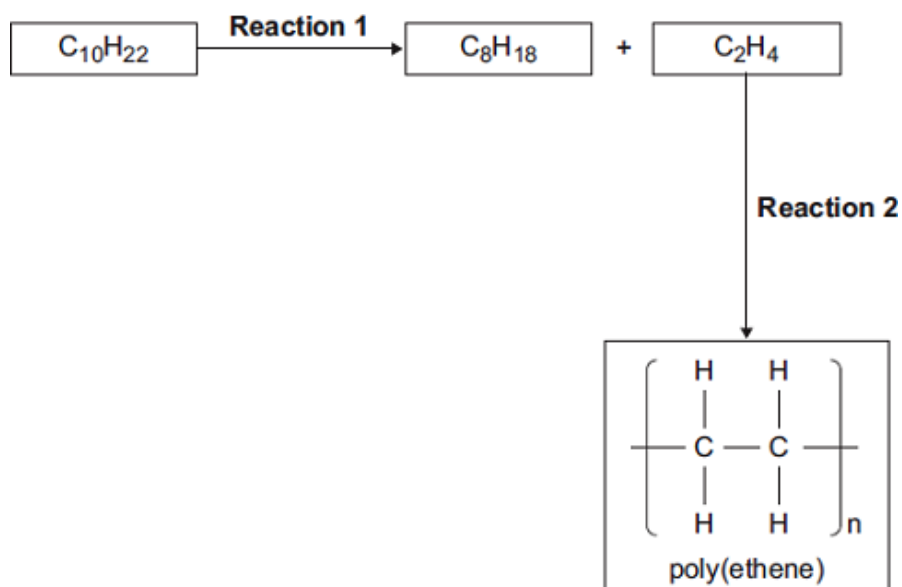
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(2)

- (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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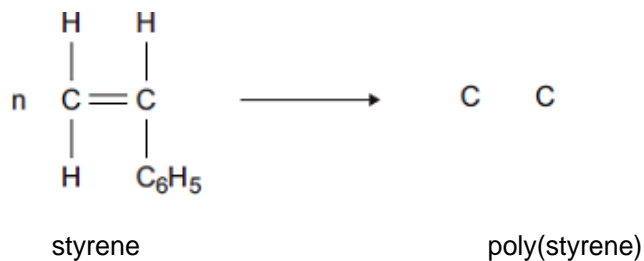
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(2)

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



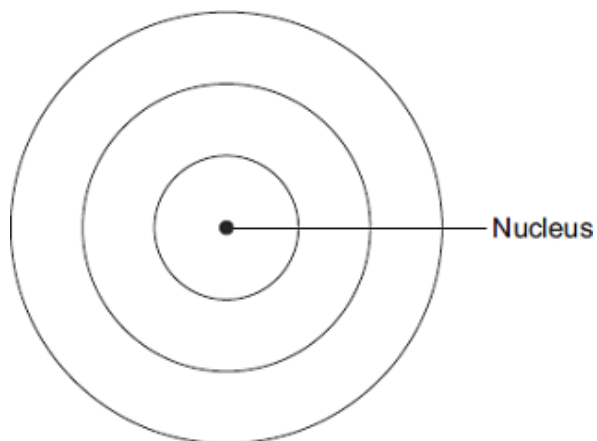
(2)

(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.

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(1)

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

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(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.



(1)

(ii) Why does aluminium react with iron oxide?

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(1)

(Total 5 marks)

