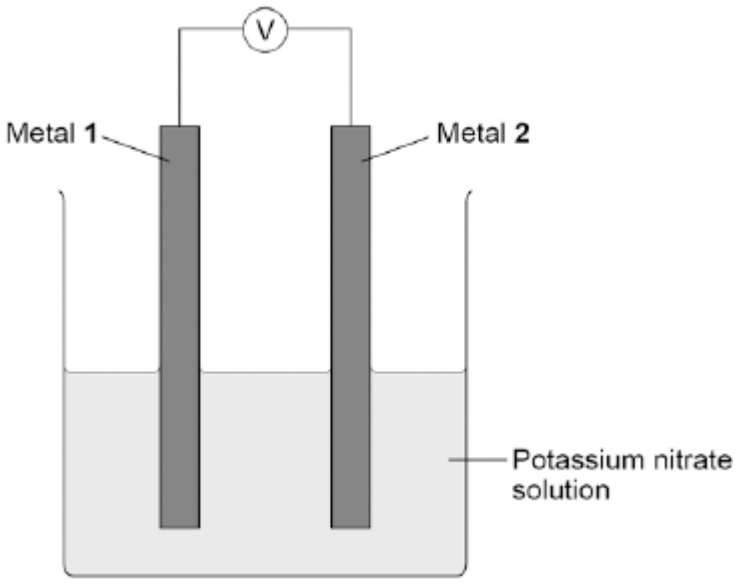
**Q1.**A student investigated simple cells using the apparatus shown in the figure below.




- If metal **2** is more reactive than metal **1** then the voltage measured is positive.
- If metal **1** is more reactive than metal **2** then the voltage measured is negative.
- The bigger the difference in reactivity of the two metals, the larger the voltage produced.

The student's results are shown in the table below.

| Metal 2 / Metal 1 | Chromium | Copper | Iron | Tin | Zinc |
|---|---|---|---|---|---|
| **Chromium** | 0.0 V | | | | |
| **Copper** | 1.2 V | 0.0 V | | | |
| **Iron** | 0.5 V | not measured | 0.0 V | | |
| **Tin** | 0.8 V | -0.4 V | 0.3 V | 0.0 V | |
| **Zinc** | 0.2 V | -1.0 V | -0.3 V | -0.6 V | 0.0 V |

(a) The ionic equation for the reaction occuring at the zinc electrode in the simple cell made using copper and zinc electrodes is:

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

Zinc is oxidised in this reaction.

Give a reason why this is oxidation.

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**(1)**

(b) Look at the table above.

Which **one** of the metals used was the least reactive?

Give a reason for your answer.

Metal .....

Reason .....

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**(2)**

(c) Predict the voltage that would be obtained for a simple cell that has iron as metal **1** and copper as metal **2**.

Explain your answer.

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**(3)**

(d) Hydrogen fuel cells have been developed for cars.

Write a word equation for the overall reaction that takes place in a hydrogen fuel cell.

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**(1)**

(e) Write the **two** half equations for the reactions that occur at the electrodes in a hydrogen fuel cell.

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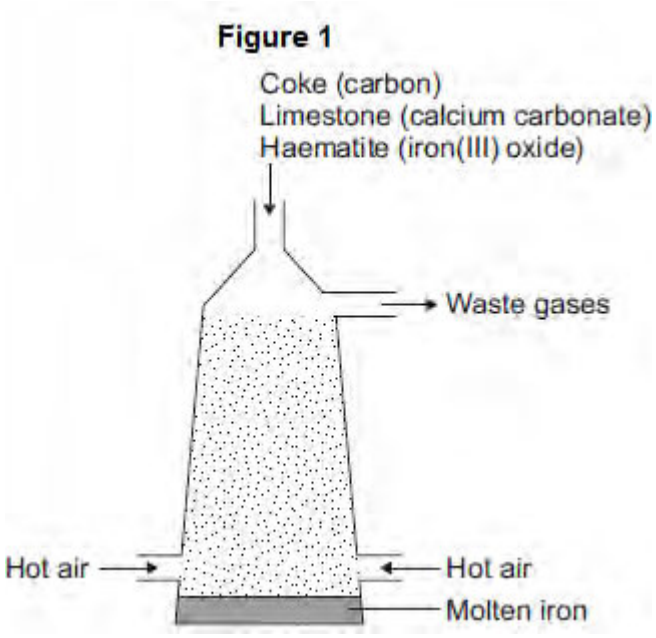
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**(2)**
**(Total 9 marks)**

**Q2.** This question is about iron and aluminium.

(a) Iron is extracted in a blast furnace. **Figure 1** is a diagram of a blast furnace.

**Figure 1**




(i) Calcium carbonate decomposes at high temperatures.

Complete the word equation for the decomposition of calcium carbonate.

calcium carbonate $\longrightarrow$ ..... +

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**(2)**

(ii) Carbon burns to produce carbon dioxide.

The carbon dioxide produced reacts with more carbon to produce carbon monoxide.

Balance the equation.

$$C(s) + CO_2(g) \longrightarrow \text{.....} CO(g)$$

**(1)**

(iii) Carbon monoxide reduces iron(III) oxide:

$$Fe_2O_3(s) + 3\,CO(g) \longrightarrow 2\,Fe(s) + 3\,CO_2(g)$$

Calculate the maximum mass of iron that can be produced from 300 tonnes of iron(III) oxide.

Relative atomic masses ($A_r$): O = 16; Fe = 56

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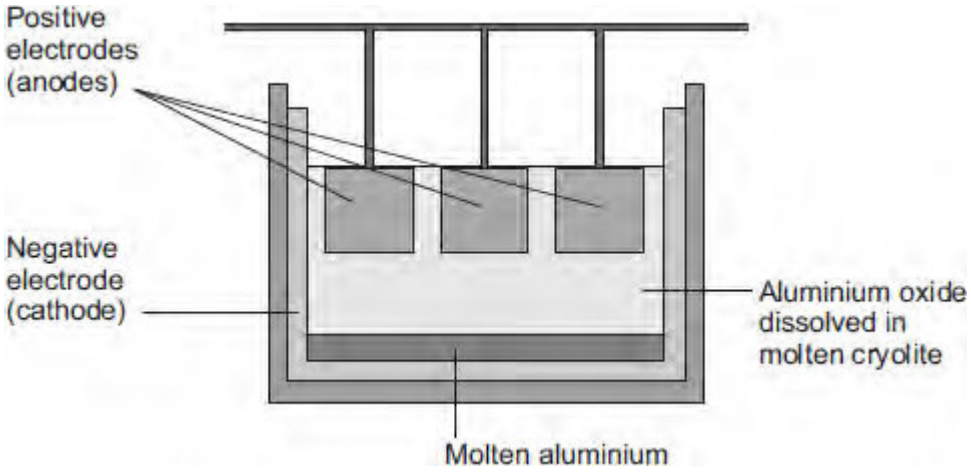
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Maximum mass = ..... tonnes

**(3)**

(b) Aluminium is extracted by electrolysis, as shown in **Figure 2**.

**Figure 2**




(i) Why can aluminium **not** be extracted by heating aluminium oxide with carbon?

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**(1)**

(ii) Explain why aluminium forms at the negative electrode during electrolysis.

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**(3)**

(iii) Explain how carbon dioxide forms at the positive electrodes during electrolysis.

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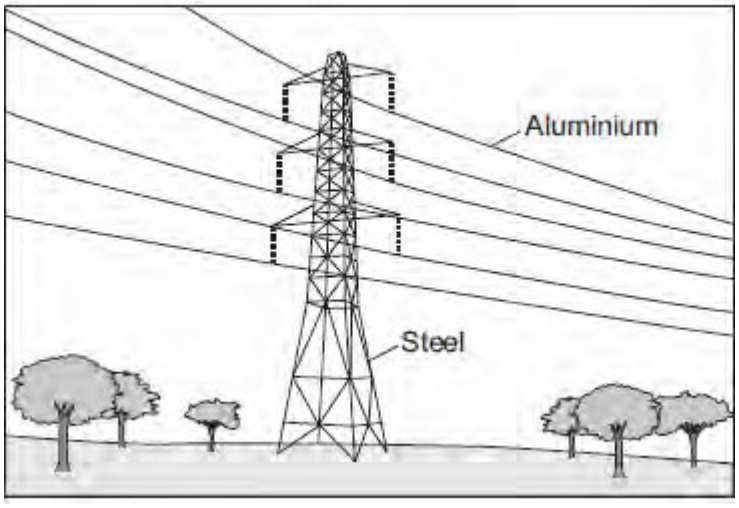
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**(3)**
**(Total 13 marks)**

**Q3.** This question is about metals.

**Figure 1** shows the metals used to make pylons and the wires of overhead cables.

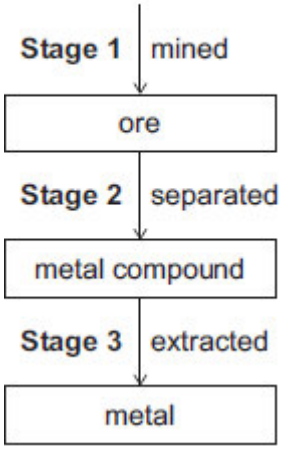
**Figure 1**




(a) An ore contains a metal compound.

A metal is extracted from its ore in three main stages, as shown in **Figure 2**.

**Figure 2**




Explain why **Stage 2** needs to be done.

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**(2)**

(b) Cast iron from a blast furnace contains 96% iron and 4% carbon.

(i) Cast iron is not suitable for the manufacture of pylons.

Give **one** reason why.

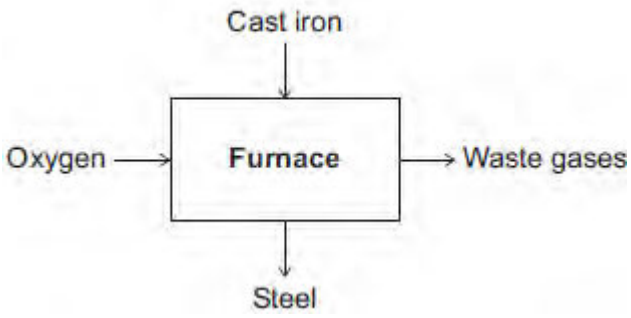
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**(1)**

(ii) Most cast iron is converted into steel, as shown in **Figure 3**.

**Figure 3**




Describe how cast iron is converted into steel.

Use **Figure 3** to help you to answer this question.

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**(2)**

(c) Aluminium and copper are good conductors of electricity.

(i) State **one** property that makes aluminium more suitable than copper for overhead cables.

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**(1)**

(ii) How can you tell that copper is a transition metal and aluminium is **not** a transition metal from the position of each metal in the periodic table?

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**(2)**

(iii) Copper can be extracted from solutions of copper salts by adding iron.

Explain why.

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**(2)**
**(Total 10 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)**

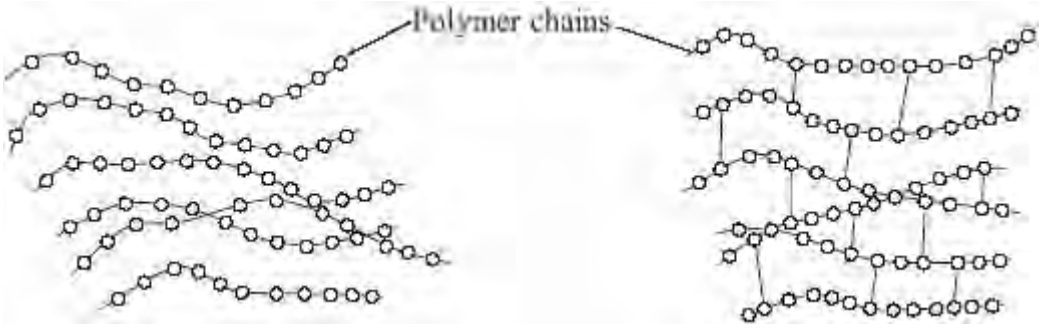
(ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

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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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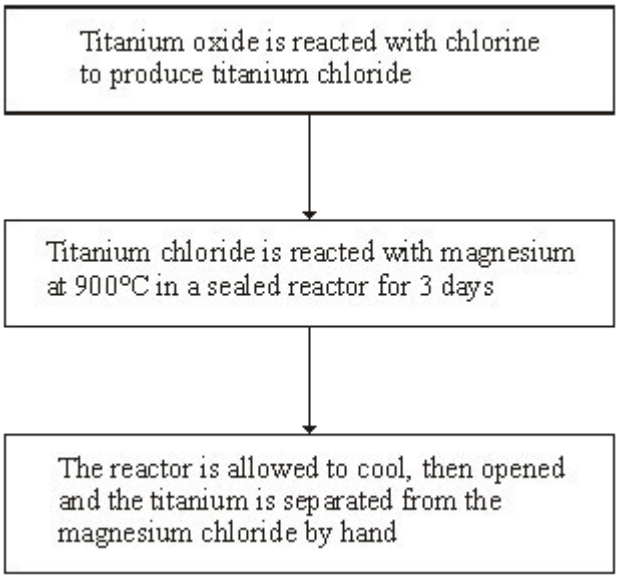
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**(4)**
**(Total 10 marks)**

**Q5.** 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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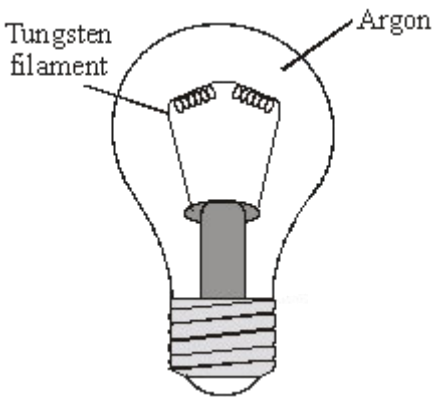
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**(3)**
**(Total 6 marks)**

**Q6.** The diagram shows an electric light bulb.




When electricity is passed through the tungsten filament it gets very hot and gives out light.

(a) What reaction would take place if the hot tungsten was surrounded by air?

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**(1)**

(b) State why argon is used in the light bulb. Explain your answer in terms of the electronic structure of an argon atom.

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**(3)**
**(Total 4 marks)**

**Q7.** 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)**