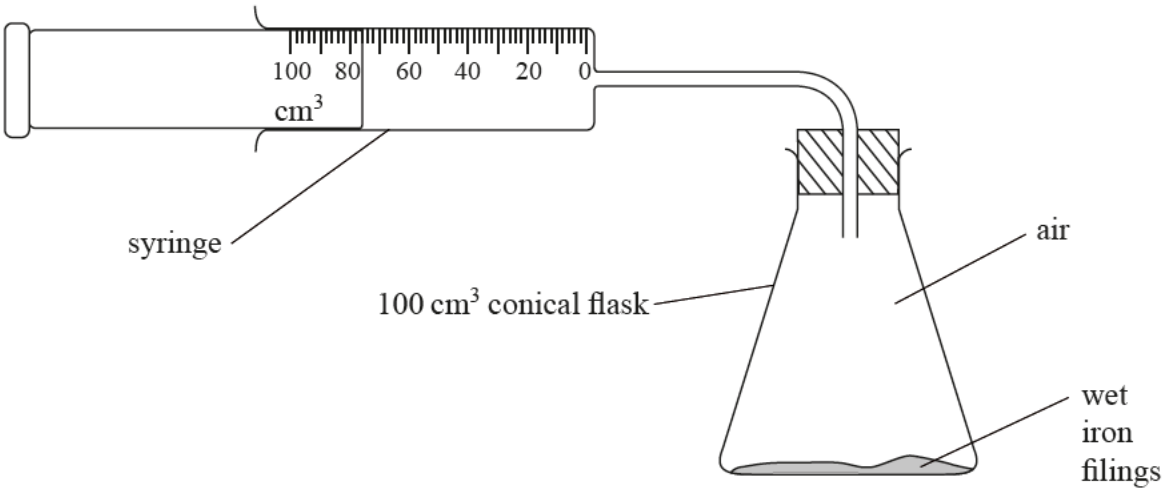
1 Rusting occurs when iron is exposed to air and water. During rusting, iron reacts with oxygen from the air to form an oxide.

Some students set up this apparatus to measure the volume of oxygen in a sample of air.

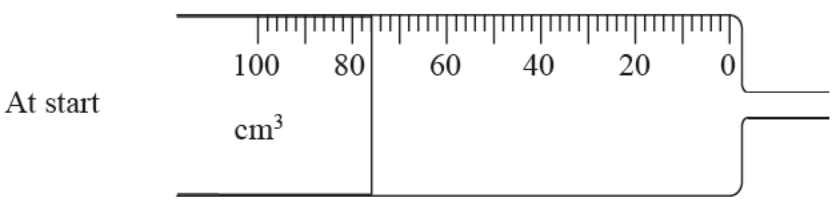


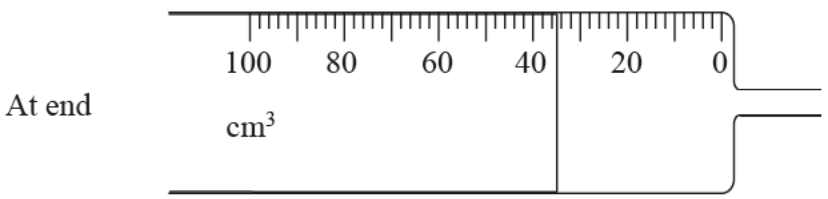
Each student used an excess of wet iron filings.

At the start of the experiment the reading on the syringe was recorded and the apparatus was then left for a week until the reaction was completed.

At the end of the experiment the reading on the syringe was recorded again.

(a) The syringes used in one student's experiment are shown below.





Record the syringe readings at the start and at the end of the experiment in the table below, and calculate the volume of oxygen used up.

Syringe reading at start in cm^3	
Syringe reading at end in cm^3	
Volume of oxygen used up in cm^3	

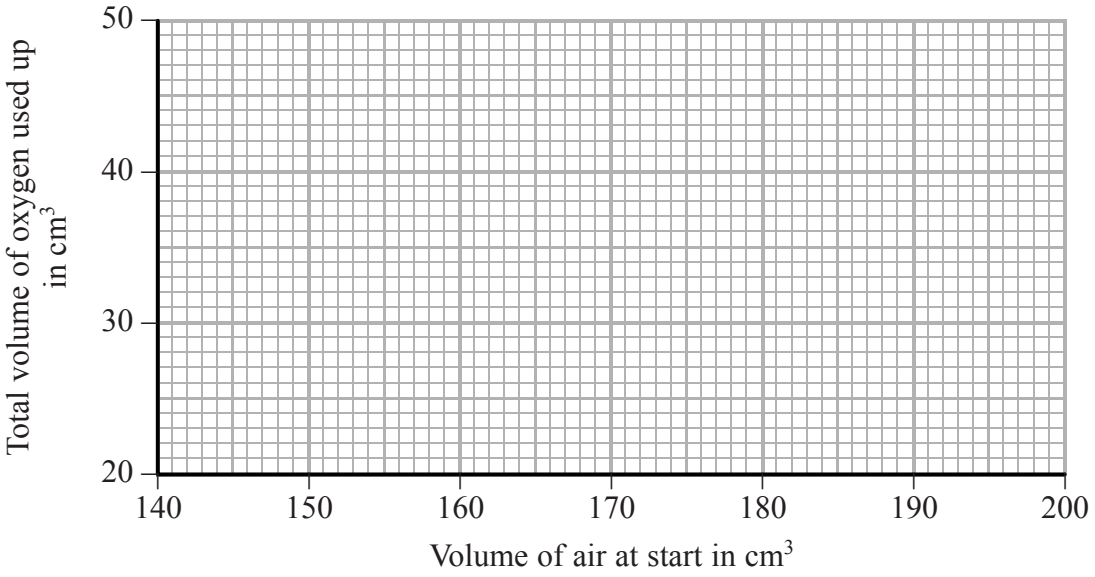
(3)

(b) The results of the other students are shown in the table.

Total volume of air at start in cm^3	Total volume of gas at end in cm^3	Volume of oxygen used up in cm^3
200	160	40
180	144	36
165	140	25
150	120	30
185	148	37

(i) Use the results in the table to plot a graph of volume of oxygen used up against volume of air at start. Draw a straight line of best fit.

(3)



(ii) One of the results is anomalous. Identify this result by circling it on the graph.

(1)

(c) Another group of students did experiments that gave several anomalous results.
The teacher discussed possible errors that could have caused these anomalous results.

Complete the table by choosing words from the following list to show what effect each error would have on the volume of oxygen used up.

decreased

increased

no change

Possible error causing anomalous result	Effect on volume of oxygen used up
iron filings not in excess	
experiment left for 1 day instead of 1 week	
apparatus left in warmer place for 1 week	

(3)

(d) Use the following results to calculate the percentage of oxygen in air.

Give your answer to one decimal place.

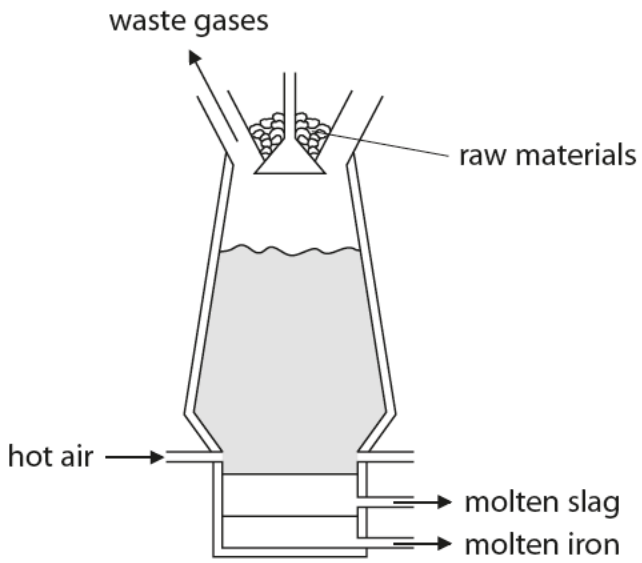
Total volume of air at start in cm^3	140
Volume of gas at end in cm^3	111

(2)

%

(Total for Question 1 = 12 marks)

2 Iron is extracted from its ore using a blast furnace.



(a) The iron ore is mixed with two other raw materials and put into the top of the furnace.

Give the names of the two other raw materials.

(2)

1 .....

2 .....

(b) The most common ore used is haematite, which contains iron(III) oxide, Fe_2O_3

The oxide is converted into iron by reaction with carbon monoxide, CO

(i) Write a chemical equation for the reaction between iron(III) oxide and carbon monoxide.

(2)

.....

(ii) Explain which element is reduced in this reaction.

(2)

.....

.....

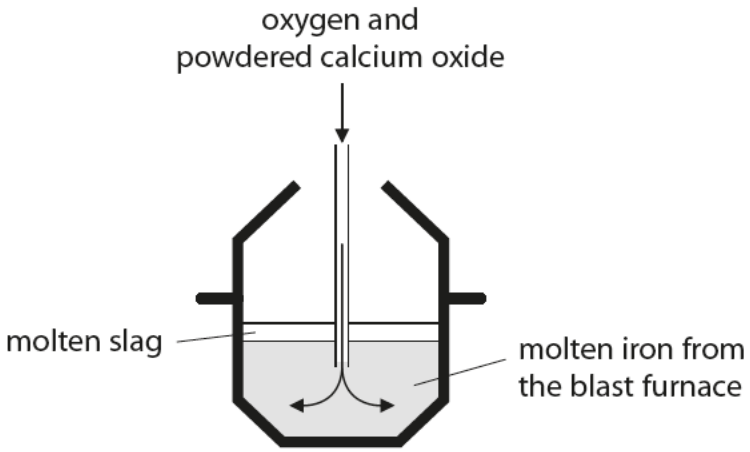
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(c) The iron from the blast furnace contains about 10% by mass of impurities.

Two of the impurities are carbon and silicon.

The diagram shows a method of decreasing the amounts of carbon and silicon in the iron.



The oxygen converts carbon and silicon into their oxides.

The carbon dioxide escapes as a gas. Silicon dioxide reacts with the calcium oxide to form molten slag.

(i) Write a chemical equation for the reaction between carbon and oxygen to form carbon dioxide.

(1)

.....

(ii) The equation for the reaction between silicon dioxide and calcium oxide to form slag is

$$SiO_2(s) + CaO(s) \rightarrow CaSiO_3(l)$$

What type of reaction is this?

(1)

☒ **A** combustion

☒ **B** decomposition

☒ **C** neutralisation

☒ **D** redox

(d) One problem with using iron is rusting.

(i) Name the two substances that must be present for iron to rust.

(2)

1 .....

2 .....

(ii) One method of preventing iron from rusting is to paint it.

State how this method of rust prevention works.

(1)

.....

.....

(e) Iron can also be protected from rusting by coating it with zinc.

(i) Give the name of this type of protection.

(1)

.....

(ii) Explain how this method of protection works, even when the surface of the zinc is scratched to expose the iron underneath.

(2)

.....

.....

.....

.....

(f) Aluminium is extracted from its oxide using electrolysis.

(i) Why is aluminium **not** extracted by heating its oxide with carbon monoxide?

(1)

.....

.....

(ii) Why is iron **not** extracted from its oxide using electrolysis?

(1)

.....

.....

(Total for Question 2 = 16 marks)

3 Titanium is extracted from its main ore, rutile, in a three-stage process.

Stage 1 Rutile is heated with chlorine and coke (carbon) at a temperature of about 900 °C.

$$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$$

Stage 2 $TiCl_4$ is then added to liquid magnesium at a temperature of about 800 °C in an atmosphere of argon.

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

During the reaction the temperature rises to about 1100 °C.

Stage 3 The magnesium chloride is removed by distillation from the mixture formed in stage 2, leaving behind pure titanium.

(a) In stage 1, is the carbon oxidised or reduced?

Give a reason for your answer.

(1)

.....

.....

(b) What does the reaction in stage 2 indicate about the reactivity of magnesium compared to the reactivity of titanium?

Explain your answer.

(2)

.....

.....

.....

.....

(c) In stage 3, suggest why distillation can be used to remove magnesium chloride from titanium.

(1)

.....

.....

(d) Titanium has these properties.

- it is corrosion resistant
- it has a high melting point
- it has a very high strength-to-weight ratio
- it is non-toxic

Complete the table to suggest an important property of titanium for each use.

Choose from the four properties listed.

You must choose a different property for each use.

(3)

Use	roperty
aircraft engines	
replacement hip joints	
propellers for boats	

(Total for Question 3 = 7 marks)

4 Iron is a useful metal. One problem with using iron is that it can rust.

(a) (i) Name the iron compound present in rust.

(1)

.....

(ii) Name the **two** substances that iron reacts with when it rusts.

(2)

1 .....

2 .....

(b) What type of reaction occurs in the rusting of iron?

Place a cross (☒) in **one** box.

(1)

- ☐ combustion
- ☐ decomposition
- ☐ displacement
- ☐ oxidation

(c) Galvanising can prevent iron from rusting. In this process, the iron is coated with another metal.

(i) Identify the other metal.

(1)

.....

(ii) Identify one object suitable for galvanising.

Place a cross (☒) in **one** box.

(1)

- ☐ bicycle chain
- ☐ bucket
- ☐ car engine
- ☐ drink can

(d) State **two** other methods used to prevent iron from rusting.

(2)

1 .....

.....

2 .....

.....

(Total for Question 4 8 marks)

5 Like other metals, iron is malleable and is a good conductor of electricity.

(a) (i) Explain why iron is malleable.

(2)

.....

.....

.....

.....

(ii) Explain why iron is a good conductor of electricity.

(2)

.....

.....

.....

.....

(b) Iron forms two sulfates.
One has the formula $FeSO_4$ and the other has the formula $Fe_2(SO_4)_3$

The addition of sodium hydroxide solution can be used to distinguish between solutions of these sulfates.

(i) State what would be observed in each case.

(2)

$FeSO_4$ .....

.....

$Fe_2(SO_4)_3$ .....

.....

(ii) Write a chemical equation for the reaction of iron(II) sulfate ($FeSO_4$) with sodium hydroxide solution.

(2)

.....

.....

(Total for Question 5 8 marks)