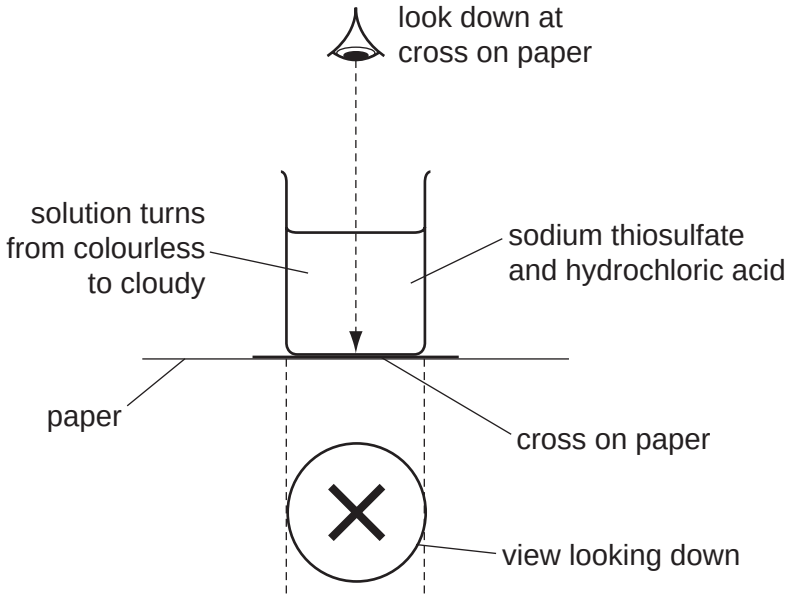
1 The equation for the reaction between sodium thiosulfate and hydrochloric acid is given below.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

The speed of this reaction was investigated using the following experiment. A beaker containing 50 cm^3 of 0.2 mol/dm^3 sodium thiosulfate was placed on a black cross. 5.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid was added and the clock was started.



Initially the cross was clearly visible. When the solution became cloudy and the cross could no longer be seen, the clock was stopped and the time recorded.

(a) The experiment was repeated with 25 cm^3 of 0.2 mol/dm^3 sodium thiosulfate and 25 cm^3 of water. Typical results for this experiment and a further two experiments are given in the table.

experiment	1	2		
volume of thiosulfate / cm^3	50	40	25	10
volume of water / cm^3	0	10	25	40
volume of acid / cm^3	5	5		5
total volume / cm^3	55	55	55	55
time / s	48	60	96	.....

(i) Explain why it is necessary to keep the total volume the same in all the experiments.

.....

.....

..... [2]

(ii) Complete the table. [1]

(iii) How and why does the speed of the reaction vary from experiment 1 to 4?

.....

.....

..... [3]

(b) The idea of collisions between reacting particles is used to explain changes in the speed of reactions. Use this idea to explain the following results.

volume of sodium thiosulfate / cm^3	25	25
volume of water / cm^3	25	25
volume of acid / cm^3	5	5
temperature / °C	20	42
time / s	96	40

.....

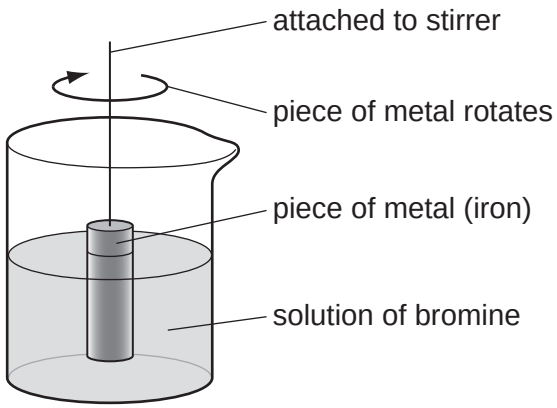
.....

.....

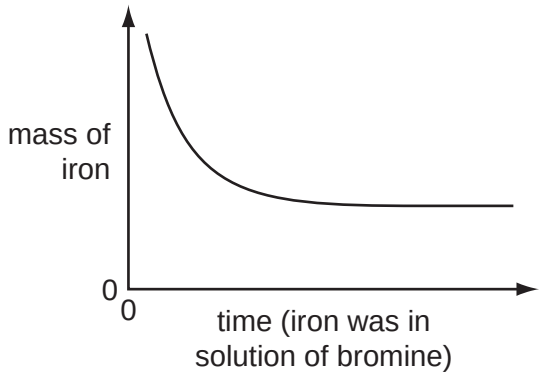
..... [4]

[Total: 10]

2 The rate of the reaction between iron and aqueous bromine can be investigated using the apparatus shown below.



(a) A piece of iron was weighed and placed in the apparatus. It was removed at regular intervals and the clock was paused. The piece of iron was washed, dried, weighed and replaced. The clock was restarted.
This was continued until the solution was colourless.
The mass of iron was plotted against time. The graph shows the results obtained.



(i) Suggest an explanation for the shape of the graph.

.....

.....

..... [3]

(ii) Predict the shape of the graph if a similar piece of iron with a much rougher surface had been used.
Explain your answer.

.....

..... [2]

(iii) Describe how you could find out if the rate of this reaction depended on the speed of stirring.

.....

.....

..... [2]

(b) Iron has two oxidation states +2 and +3. There are two possible equations for the redox reaction between iron and bromine.

$$Fe + Br_2 \rightarrow Fe^{2+} + 2Br^-$$

$$2Fe + 3Br_2 \rightarrow 2Fe^{3+} + 6Br^-$$

(i) Indicate, on the first equation, the change which is oxidation. Give a reason for your choice.

.....

..... [2]

(ii) Which substance in the first equation is the reductant (reducing agent)?

..... [1]

(c) Describe how you could test the solution to find out which ion, Fe^{2+} or Fe^{3+}, is present.

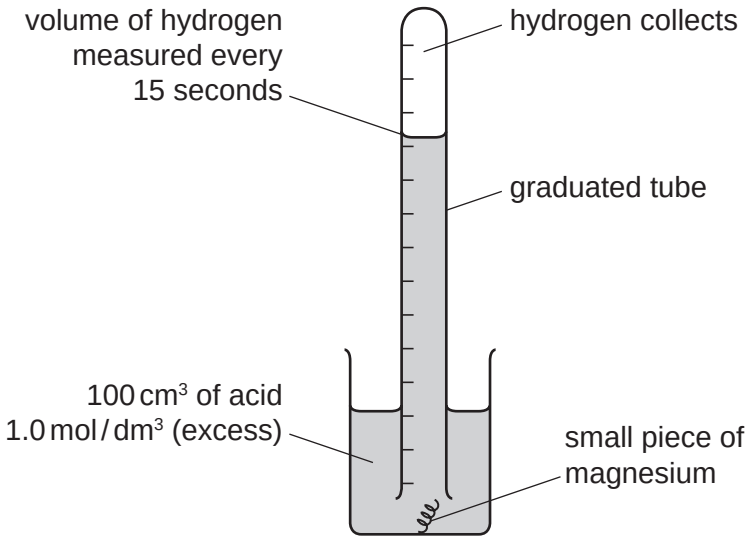
.....

.....

..... [3]

[Total: 13]

3 A diagram of the apparatus which could be used to investigate the rate of reaction between magnesium and an excess of an acid is drawn below.



(a) The magnesium kept rising to the surface. In one experiment, this was prevented by twisting the magnesium around a piece of copper. In a second experiment, the magnesium was held down by a plastic net fastened to the beaker.

(i) Suggest a reason why magnesium, which is denser than water, floated to the surface.

.....

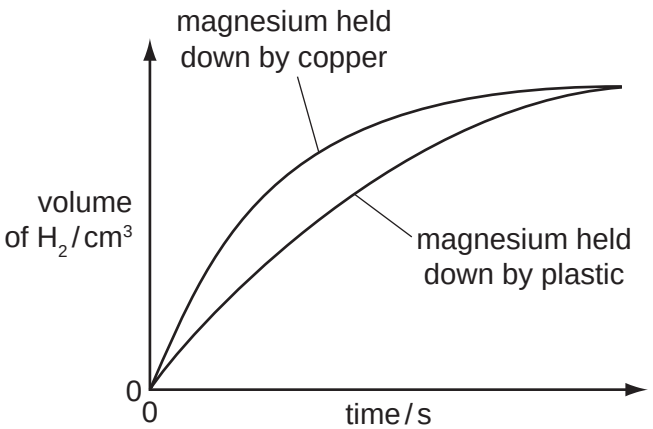
..... [1]

(ii) Iron, zinc and copper have similar densities. Why was copper a better choice than iron or zinc to weigh down the magnesium?

.....

..... [1]

(b) The only difference in the two experiments was the method used to hold down the magnesium. The results are shown below.



(i) In which experiment did the magnesium react faster?

..... [1]

(ii) Suggest a reason why the experiment chosen in **(i)** had the faster rate.

..... [1]

(c) The experiment was repeated using 1.0 mol / dm^3 propanoic acid instead of 1.0 mol / dm^3 hydrochloric acid. Propanoic acid is a weak acid.

(i) How would the graph for propanoic acid **differ** from the graph for hydrochloric acid?

..... [1]

(ii) How would the graph for propanoic acid be the **same** as the graph for hydrochloric acid?

..... [1]

(d) Give **two** factors which would alter the rate of this reaction.
For each factor explain why it alters the rate.

factor .....

explanation .....

.....

factor .....

explanation .....

..... [4]

[Total: 10]

4 The following are examples of redox reactions.

(a) Bromine water was added to aqueous sodium sulfide.

$$Br_2(aq) + S^{2-}(aq) \rightarrow 2Br^-(aq) + S(s)$$

(i) Describe what you would observe when this reaction occurs.

.....

..... [2]

(ii) Write a symbol equation for this reaction.

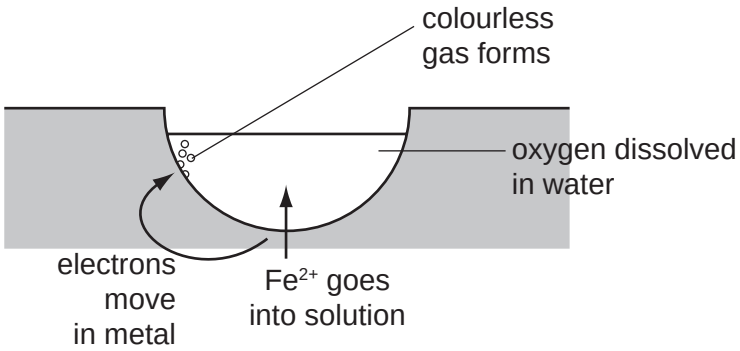
..... [1]

(iii) Explain, in terms of electron transfer, why bromine is the oxidant (oxidising agent) in this reaction.

.....

..... [2]

(b) Iron and steel in the presence of water and oxygen form rust.



The reactions involved are:

reaction 1

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

The electrons move through the iron on to the surface where a colourless gas forms.

reaction 2

$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

from water

reaction 3

$.....Fe(OH)_2 + O_2 + ...H_2O \rightarrow .....Fe(OH)_3$

The water evaporates to leave rust.

(i) What type of reaction is **reaction 1**? ..... [1]

(ii) Deduce the name of the colourless gas mentioned in **reaction 1**.

..... [1]

(iii) What is the name of the iron compound formed in **reaction 2**?

..... [1]

(iv) Balance the equation for **reaction 3**.

.....$Fe(OH)_2$ + O_2 + ...H_2O $\rightarrow$ .....$Fe(OH)_3$

[1]

(v) Explain why the change $Fe(OH)_2$ to $Fe(OH)_3$ is oxidation.

.....

..... [1]

(vi) Explain why iron in electrical contact with a piece of zinc does not rust.

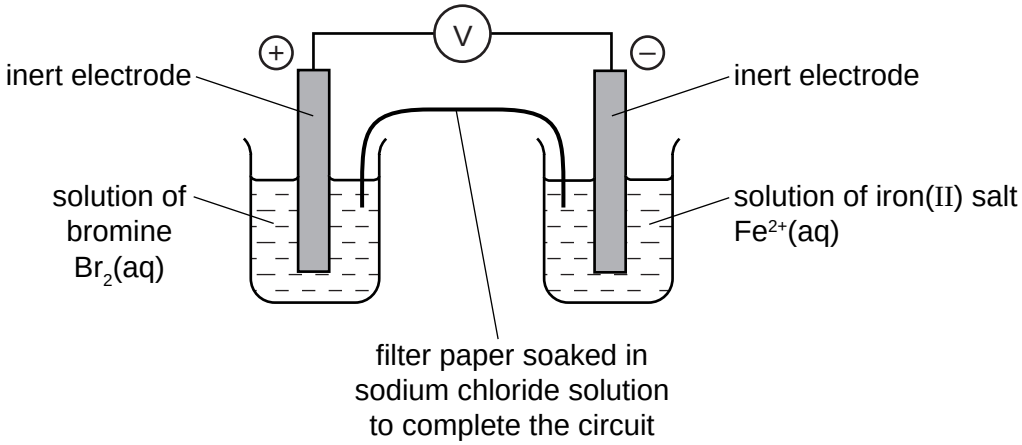
.....

.....

..... [3]

[Total: 13]

5 The diagram shows a cell. This is a device which produces electrical energy. The reaction in a cell is a redox reaction and involves electron transfer.



(i) Complete the sentence.

A cell will change ..... energy into electrical energy. [1]

(ii) Draw an arrow on the diagram to show the direction of the electron flow. [1]

(iii) In the left hand beaker, the colour changes from brown to colourless.
Complete the equation for the reaction.

$$Br_2 + \text{.....} \rightarrow \text{.....}$$

[2]

(iv) Is the change in **(iii)** oxidation or reduction? Give a reason for your choice.

.....

..... [1]

(v) Complete the following description of the reaction in the right hand beaker.

Fe^{2+} changes into ..... . [1]

(vi) When a solution of bromine is replaced by a solution of chlorine, the voltage increases. When a solution of bromine is replaced by a solution of iodine, the voltage decreases.
Suggest an explanation for this difference.

.....

..... [1]

[Total: 7]