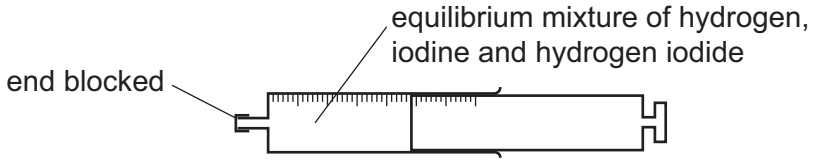
1 Hydrogen and iodine react together in a reversible reaction. Hydrogen iodide is formed.

$H_2(g)$	+	$I_2(g)$	$\rightleftharpoons$	$2HI(g)$
colourless gas		purple gas		colourless gas

The forward reaction is exothermic.

A gas syringe containing an equilibrium mixture of hydrogen, iodine and hydrogen iodide gases was sealed and heated to 250 °C. The equilibrium mixture was a pale purple colour.



The temperature of the gas syringe was increased to 300 °C.

(a) What happened to the **position** of the equilibrium when the temperature of the gas syringe was increased from 250 °C to 300 °C?

..... [1]

(b) What happened to the **rate** of the forward reaction and the **rate** of the backward reaction when the temperature of the gas syringe was increased from 250 °C to 300 °C?

rate of the forward reaction .....

rate of the backward reaction ..... [2]

[Total: 3]

2 Cobalt reacts with dilute hydrochloric acid to make the salt cobalt(II) chloride. Bubbles of hydrogen gas are produced.

(a) The rate of reaction of cobalt with dilute hydrochloric acid can be made faster by heating the acid or by increasing its concentration.

State **one** other way to make the rate of reaction faster.

..... [1]

(b) Use collision theory to explain how heating the dilute hydrochloric acid makes the rate of reaction faster.

.....

.....

.....

.....

..... [3]

[Total: 4]

3 Methanol is made by reacting carbon monoxide with hydrogen.

The reaction is exothermic and is a chemical equilibrium.

The equation for the reaction is shown.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Which changes in temperature and pressure increase the yield of methanol?

	temperature	pressure
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

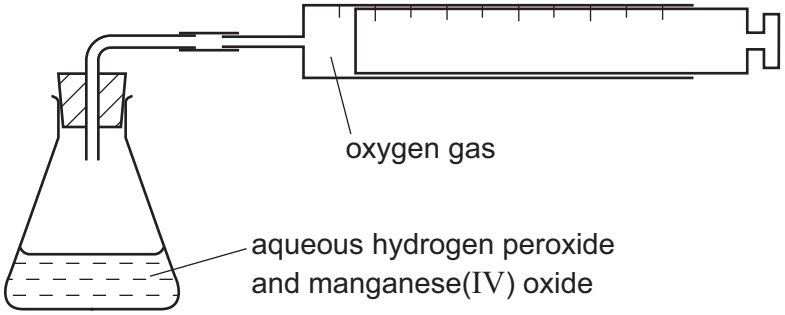
[1]

[Total: 1]

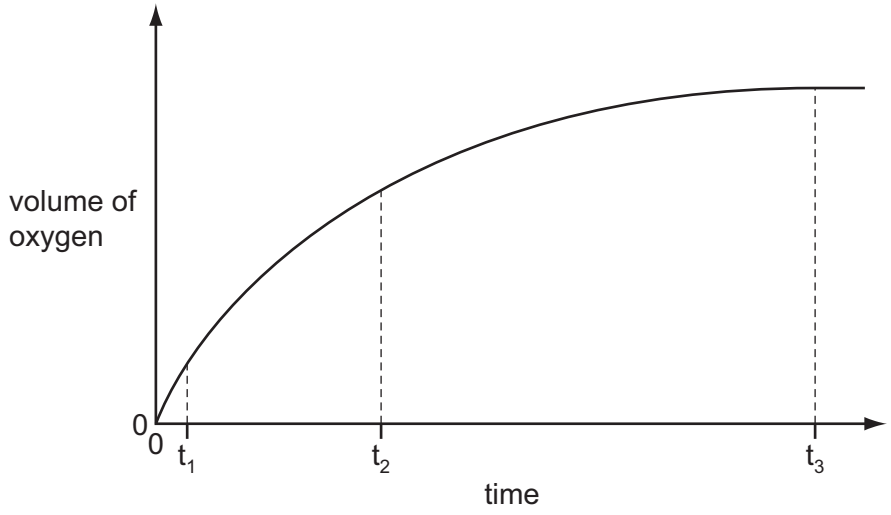
4 Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of this reaction can be investigated using the following apparatus.



40 cm^3 of aqueous hydrogen peroxide was put in the flask and 0.1 g of small lumps of manganese(IV) oxide was added.
The volume of oxygen collected was measured every 30 seconds. The results were plotted to give the graph shown below.



(a) **(i)** How do the rates at times t_1, t_2 and t_3 differ?

.....

..... [2]

(ii) Explain the trend in reaction rate that you described in **(a)(i)**.

.....

.....

..... [2]

(b) The experiment was repeated using 0.1 g of finely powdered manganese(IV) oxide. All the other variables were kept the same.

(i) On the axes, sketch the graph that would be expected.

[2]

(ii) Explain the shape of this graph.

.....

.....

.....

..... [2]

(c) Describe how you could show that the catalyst, manganese(IV) oxide, was not used up in the reaction. Manganese(IV) oxide is insoluble in water.

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..... [4]

(d) In the first experiment, the maximum volume of oxygen produced was 96 cm^3 measured at r.t.p. Calculate the concentration of the aqueous hydrogen peroxide in mol / dm^3.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(i) number of moles of O_2 formed = ... [1]

(ii) number of moles of H_2O_2 in 40 cm^3 of solution = ... [1]

(iii) concentration of the aqueous hydrogen peroxide in mol / dm^3 = ... [1]

[Total: 15]