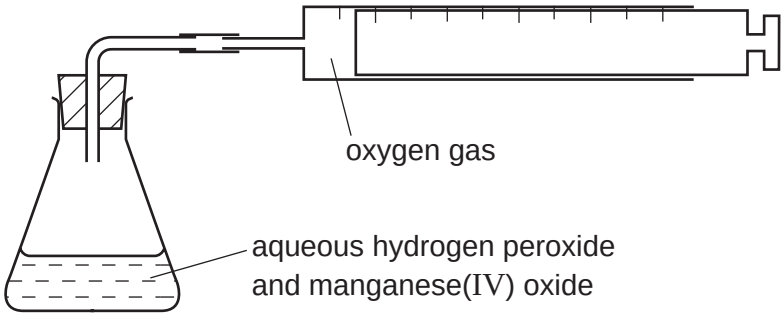
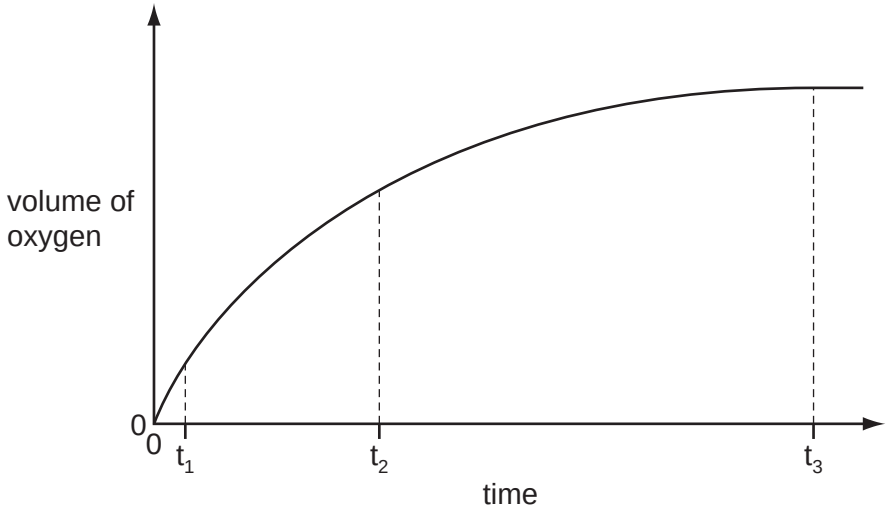
1 Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

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

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) 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 opposite, 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.

.....

.....

.....

.....

..... [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.

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

number of moles of O_2 formed = ... [1]

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

concentration of the aqueous hydrogen peroxide in mol / dm^3 = ...

..... [1]

[Total: 15]

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2 One of the factors which determine the reaction rate of solids is particle size.

(a) A mixture of finely powdered aluminium and air may explode when ignited.
An explosion is a very fast exothermic reaction. This causes a large and sudden increase in temperature.

Explain each of the following in terms of collisions between reacting particles.

(i) Why is the reaction between finely powdered aluminium and air very fast?

.....

..... [2]

(ii) Explain why for most reactions the rate of reaction decreases with time.

.....

..... [2]

(iii) Suggest an explanation why the rate of reaction in an explosion could increase rather than decrease with time.

.....

.....

..... [3]

(b) **(i)** Give another example of a substance other than a metal which, when finely powdered, might explode when ignited in air.

..... [1]

(ii) Describe a simple test-tube reaction which shows the effect of particle size on the rate at which a solid reacts with a solution.

.....

.....

..... [3]

[Total: 11]

3 The speed (rate) of a chemical reaction depends on a number of factors which include temperature and the presence of a catalyst.

(a) Reaction speed increases as the temperature increases.

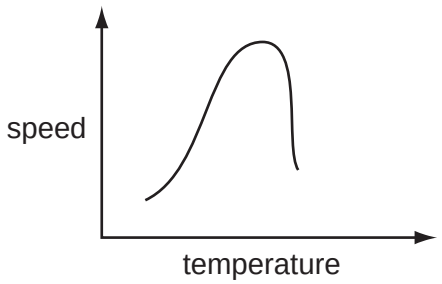
(i) Explain why reaction speed increases with temperature.

.....

.....

..... [3]

(ii) Reactions involving enzymes do not follow the above pattern.
The following graph shows how the speed of such a reaction varies with temperature.



Suggest an explanation why initially the reaction speed increases then above a certain temperature the speed decreases.

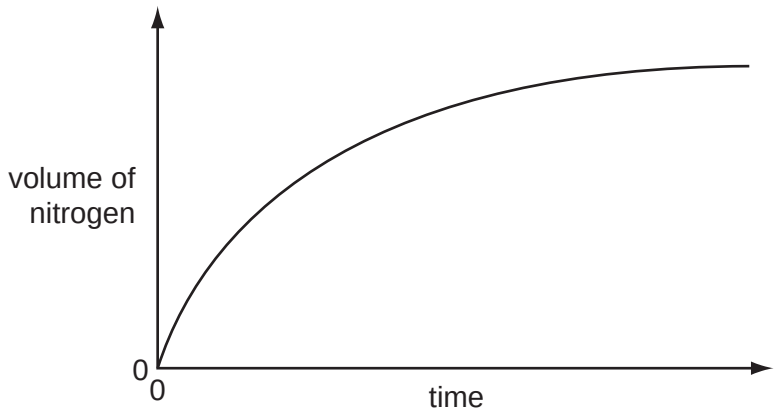
.....

..... [2]

(b) An organic compound decomposes to give off nitrogen.

$$C_6H_5N_2Cl(aq) \rightarrow C_6H_5Cl(l) + N_2(g)$$

The speed of this reaction can be determined by measuring the volume of nitrogen formed at regular intervals. Typical results are shown in the graph below.



(i) The reaction is catalysed by copper.
Sketch the graph for the catalysed reaction on the diagram above. [2]

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(ii) How does the speed of this reaction vary with time?

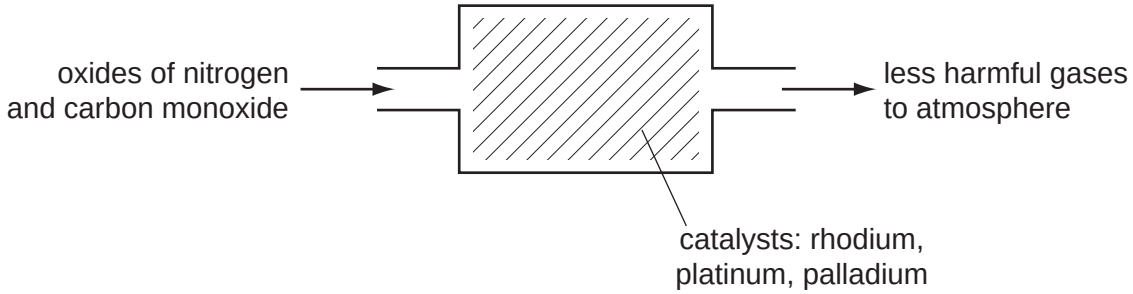
..... [1]

(iii) Why does the speed of reaction vary with time?

.....

..... [2]

(c) Catalytic converters reduce the pollution from motor vehicles.



(i) Describe how carbon monoxide and the oxides of nitrogen are formed in car engines.

.....

.....

.....

..... [4]

(ii) Describe the reaction(s) inside the catalytic converter which change these pollutants into less harmful gases. Include at least one equation in your description.

.....

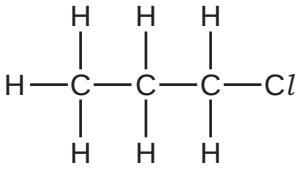
.....

..... [3]

[Total: 17]

4 Many organic compounds which contain a halogen have chloro, bromo or iodo in their name.

(a) The following diagram shows the structure of 1-chloropropane.



(i) Draw the structure of an isomer of this compound.

[1]

(ii) Describe how 1-chloropropane could be made from propane.

.....

..... [2]

(iii) Suggest an explanation why the method you have described in **(ii)** does not produce a pure sample of 1-chloropropane.

.....

..... [2]

(b) Organic halides react with water to form an alcohol and a halide ion.

$$CH_3–CH_2–I + H_2O \rightarrow CH_3–CH_2–OH + I^-$$

(i) Describe how you could show that the reaction mixture contained an iodide ion.

.....

..... [2]

(ii) Name the alcohol formed when 1-chloropropane reacts with water.

..... [1]

(c) The speed (rate) of reaction between an organic halide and water can be measured by the following method.

A mixture of 10 cm^3 of aqueous silver nitrate and 10 cm^3 of ethanol is warmed to 60 °C. Drops of the organic halide are added and the time taken for a precipitate to form is measured.

Silver ions react with the halide ions to form a precipitate of the silver halide.

$$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$$

Typical results for four experiments, **A**, **B**, **C** and **D**, are given in the table.

experiment	organic halide	number of drops	time / min
A	bromobutane	4	6
B	bromobutane	8	3
C	chlorobutane	4	80
D	iodobutane	4	0.1

(i) Explain why it takes longer to produce a precipitate in experiment **A** than in **B**.

.....

..... [2]

(ii) How does the order of reactivity of the organic halides compare with the order of reactivity of the halogens?

.....

..... [2]

(iii) Explain why the time taken to produce a precipitate would increase if the experiments were repeated at 50 °C.

.....

.....

..... [3]

[Total: 15]

5 Hydriodic acid, HI(aq), is a strong acid. Its salts are iodides.

(a) It has the reactions of a typical strong acid. Complete the following equations.

(i) .....Li + ...HI $\rightarrow$ ..... + ... [1]

(ii) zinc carbonate + hydriodic acid $\rightarrow$ ..... + ... + ...
....
[1]

(iii) MgO + ...HI $\rightarrow$ ..... + ... [1]

(b) Two of the reactions in **(a)** are acid / base and one is redox. Which one is redox? Explain your choice.

.....

.....

..... [2]

(c) Describe how you could distinguish between hydriodic, HI(aq), and hydrobromic, HBr(aq) acids, by bubbling chlorine through these two acids.

result with hydriodic acid .....

result with hydrobromic acid ..... [2]

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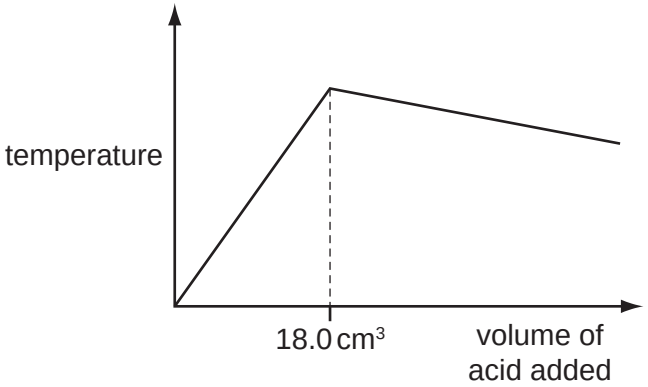
(d) 20.0 cm^3 of aqueous sodium hydroxide, 2.00 mol / dm^3, was placed in a beaker. The temperature of the alkali was measured and 1.0 cm^3 portions of hydriodic acid were added. After each addition, the temperature of the mixture was measured. Typical results are shown on the graph.



$$NaOH(aq) + HI(aq) \rightarrow NaI(aq) + H_2O(l)$$

(i) Explain why the temperature increases rapidly at first then stops increasing.

.....

..... [2]

(ii) Suggest why the temperature drops after the addition of 18.0 cm^3 of acid.

..... [1]

(iii) In another experiment, it was shown that 15.0 cm^3 of the acid neutralised 20.0 cm^3 of aqueous sodium hydroxide, 1.00 mol / dm^3. Calculate the concentration of the acid.

.....

..... [2]

[Total: 12]