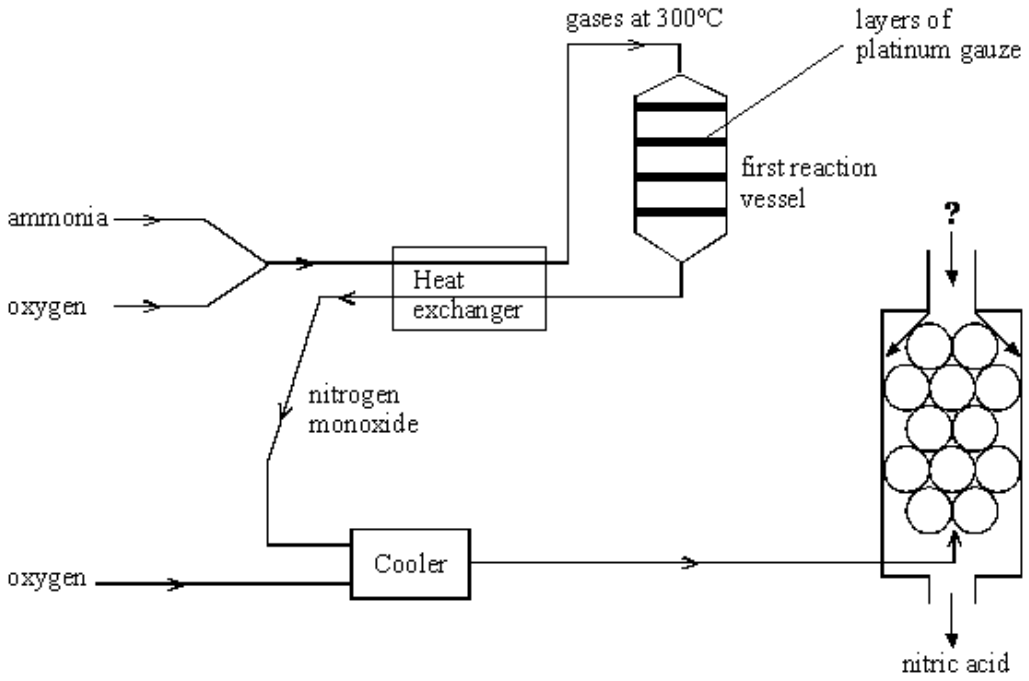
Q1. The chart shows the processes involved in the manufacture of nitric acid from ammonia.



(a) Complete the word equation for the reaction that takes place in the first reaction vessel.

ammonia + ... ⟶ nitrogen monoxide + water

(1)

(b) (i) What is the use of the platinum gauze in the reaction vessel?

.....

(1)

(ii) At first, the platinum gauze is electrically heated. However, as the reaction continues, no further heating is necessary.
Explain why.

.....

(1)

(c) Explain why the heat exchanger is used.

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(2)

(d) To convert nitrogen monoxide into nitric acid, **two** further reactants are needed.
What are they?

..... and .....

(1)

(e) In an old method, nitrogen monoxide was produced from nitrogen instead of ammonia.

$N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$ 184 kJ of energy is taken in from the surroundings for each formula mass (mole) of reactants.

The reaction was carried out at a high temperature (3000°C).
Suggest **two** reasons for this.

1 .....

2 .....

(2)

(f) Complete the word equation below, to show how to make the fertiliser, ammonium nitrate.

..... + ... ⟶ ammonium nitrate + water

(2)

(Total 10 marks)

Q2. (a) Iron powder is used in the manufacture of ammonia. Why is it used?

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(1)

(b) Ammonia is manufactured from nitrogen and hydrogen. The equation for the reaction between them is:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(i) Which **two** raw materials are used to make the hydrogen?

..... and .....

(1)

(ii) Why does increasing the pressure increase the chance of molecules of nitrogen reacting with molecules of hydrogen?

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.....

(1)

(iii) Calculate the mass, in tonnes, of ammonia which could be produced from 560 tonnes of nitrogen.

The relative atomic masses are: H 1; N 14.

Show clearly how you get to your answer.

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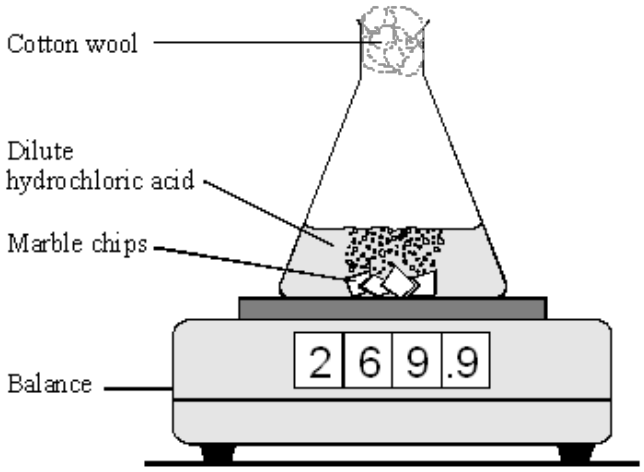
Mass of ammonia = ... tonnes

(3)

(Total 6 marks)

Q3. The apparatus shown in the diagram was used to investigate the rate of reaction of excess marble chips with dilute hydrochloric acid, HCl. Marble is calcium carbonate, formula $CaCO_3$. The salt formed is calcium chloride, $CaCl_2$.



(a) Write a balanced equation for the reaction.

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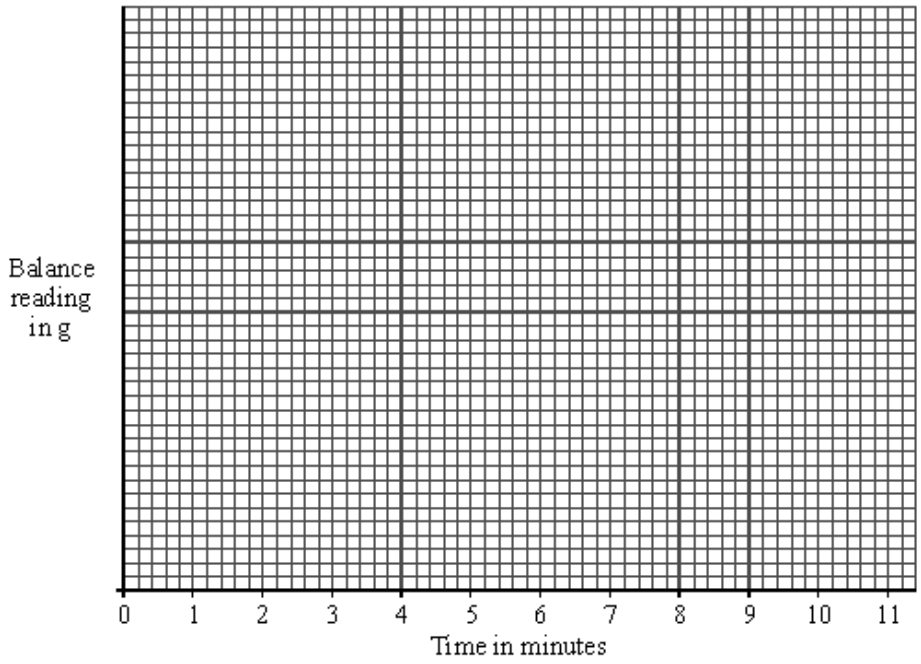
(2)

The following results were obtained from the experiment.

Time in minutes	Reading on balance in g
0.5	269.6
1.0	269.3
2.0	269.0
3.0	268.8
5.0	268.7
9.0	268.6

(b) (i) Plot the results and draw a graph on the axes below.



(3)

(ii) Continue the graph you have drawn to show the expected reading after11 minutes.

(1)

(iii) On the axes above, sketch a graph of the result which would be obtained if in a similar experiment the same mass of powdered marble was used instead of marble chips.

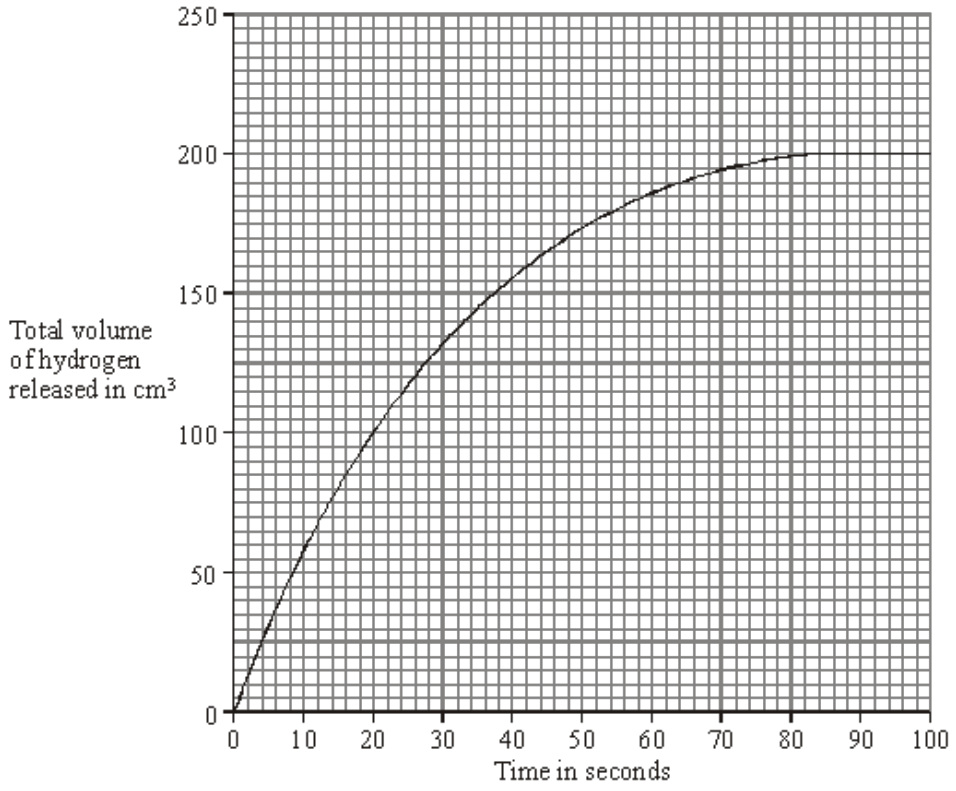
(2)

(Total 8 marks)

Q4. Magnesium reacts with dilute sulphuric acid.

magnesium + sulphuric acid → magnesium sulphate + hydrogen

A student measured the volume of hydrogen given off every 10 seconds. The results are shown on the graph.



(a) The average rate of hydrogen production in the first 10 seconds is
(60 cm^3 ÷ 10 s) = 6 cm^3/s.

(i) Calculate the average rate of production of hydrogen between 30 seconds and 50 seconds. Show clearly how you work out your answer.

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.....

.....

Rate ..... cm^3/s

(3)

(ii) Explain, as fully as you can, why the average rate between 30 and 50 seconds is different from the rate between 0 and 10 seconds.

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(2)

(b) In industry, enzymes are used in both batch processes and continuous processes.

Give **one** reason why continuous processes are usually more profitable than batch processes.

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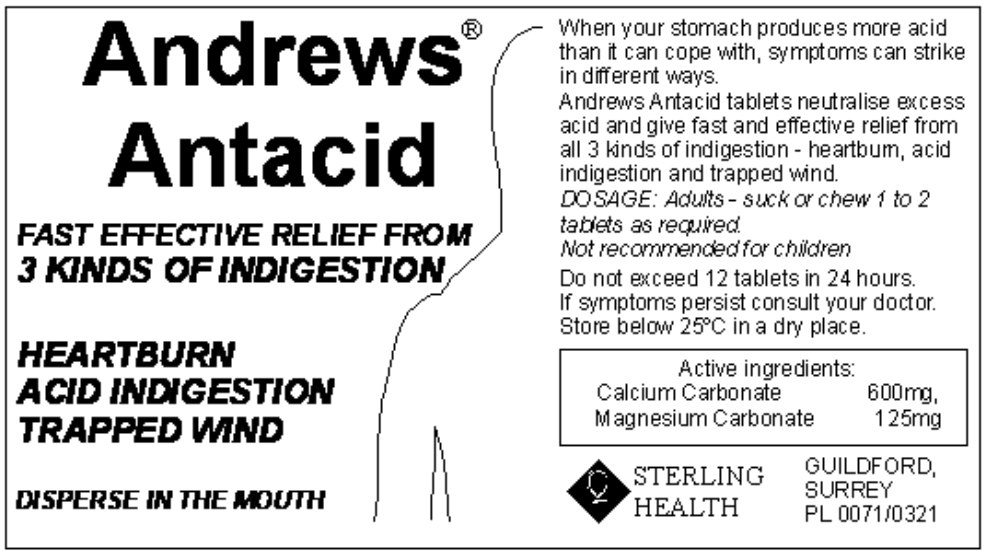
(1)

(Total 6 marks)

Q5. (a) This label has been taken from a packet of *Andrews Antacid*.



(i) Write the simplest ionic equation which represents a neutralisation reaction.

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(1)

(ii) Chewing the tablet cures indigestion faster than swallowing the tablet whole. Explain why.

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(1)

(iii) Write the formula of the magnesium compound present in *Andrews Antacid*. You may find the Data Sheet helpful.

.....

(1)

(b) The active ingredients in the *Antacid* react with hydrochloric acid in the stomach to give salts, water and carbon dioxide.

A student investigated how quickly the tablets react with **excess** hydrochloric acid.

40 cm^3 of dilute hydrochloric acid were placed in a conical flask. The flask was placed on a direct reading balance. Two *Antacid* tablets were quickly added to the flask. The apparatus was weighed immediately. At the same time, a stop clock was started. The mass was recorded every half minute for 5 minutes.

The results are shown in the table below.

Mass of flask + contents (g)	92.0	90.0	89.0	88.3	87.8	87.5	87.3	87.1	87.0	87.0	87.0
Time (minutes)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0

The main active ingredient in *Andrews Antacid* is calcium carbonate.

(i) Balance the equation which represents the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_{3(s)} + \text{.....} HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

(1)

(ii) State the meaning of the symbol "(aq)".

.....

(1)

(iii) Why does the mass of the flask and contents decrease?

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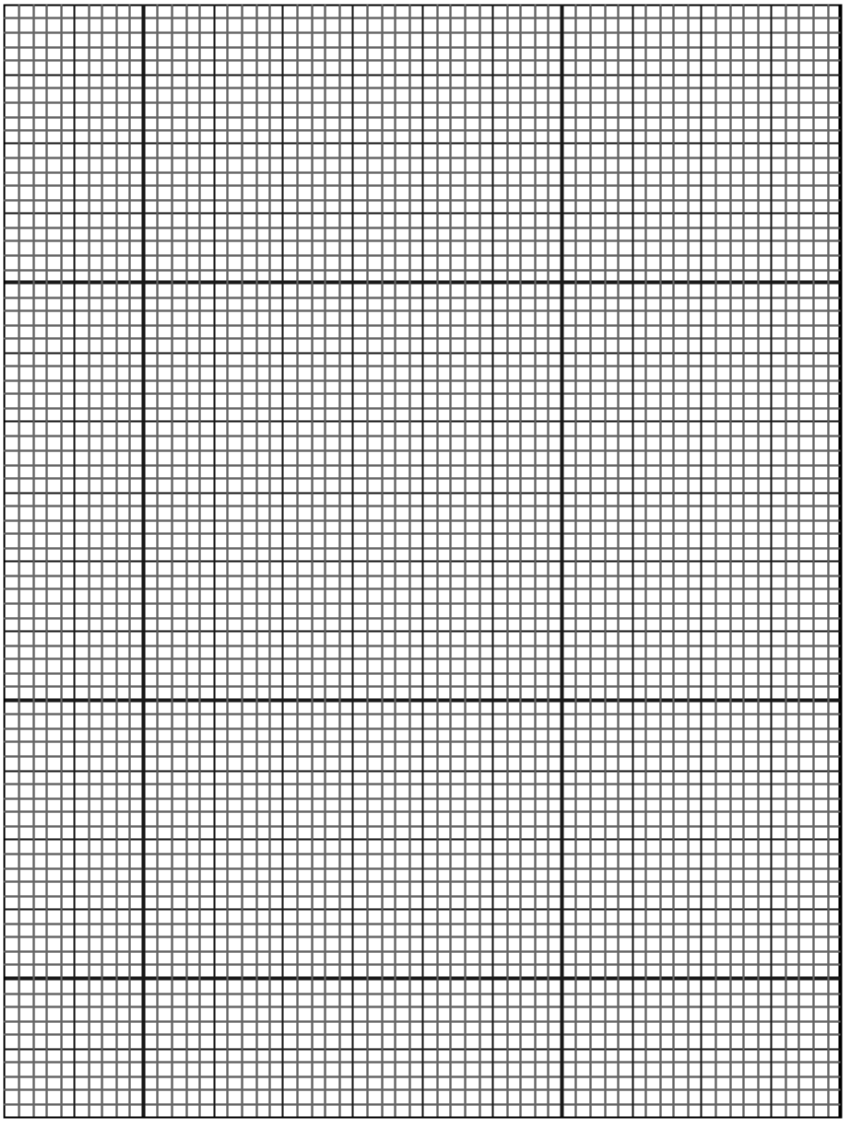
(1)

(c) (i) Plot the results on the graph below and draw a smooth curve to show how the mass of the flask and its contents changes with time. Label this curve “A”.



(3)

(ii) One of the results does not appear to fit the pattern. Circle this result on the graph.

(1)

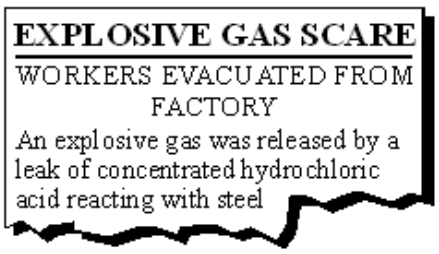
(d) The student did a second experiment. The only change was that the acid was twice as concentrated.

On the graph, sketch a second curve to show a possible result for this experiment. Label this curve “B”.

(2)

(Total 12 marks)

Q6. This article appeared in a newspaper.



(a) The balanced chemical equation shows the reaction between steel and hydrochloric acid.

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

(i) Which metal in steel reacted with the hydrochloric acid?

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(1)

(ii) The gas released was described as explosive. Explain why.

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(3)

(b) In the factory hydrogen chloride is manufactured by reacting hydrogen with chlorine. Hydrochloric acid is formed when hydrogen chloride forms a solution in water.

(i) Water was sprayed on the steel and hydrochloric acid. This slowed the rate of reaction. Explain why.

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(2)

(ii) It would have been better to neutralise the acid with an alkali rather than to just add water. Hydrochloric acid can be neutralised by reaction with sodium hydroxide. Complete the ionic equation for the neutralisation reaction.

(aq) + (aq) $\rightarrow$ $H_2O(l)$

(2)

(iii) In the factory the acid leak was neutralised with slaked lime, $Ca(OH)_2$, and not sodium hydroxide, NaOH. Suggest why.

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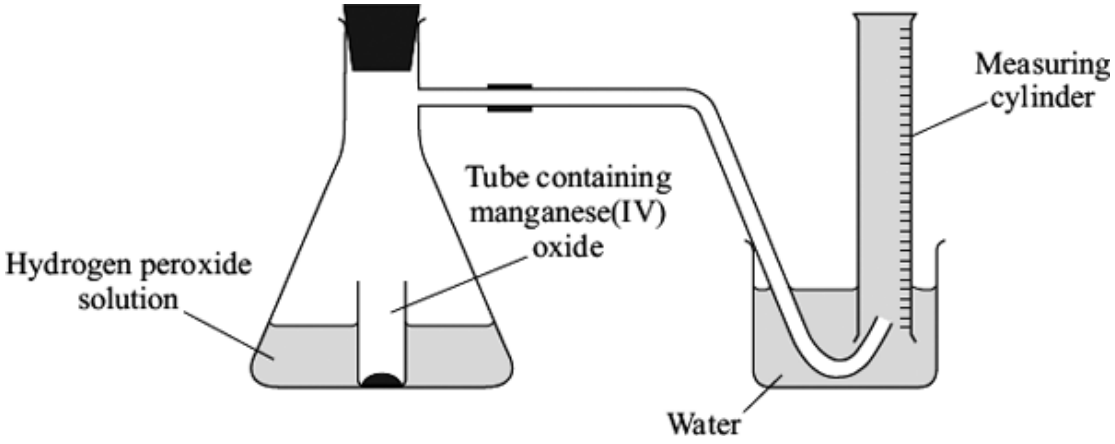
(2)

(Total 10 marks)

Q7. A student investigated the effect of temperature on the decomposition of hydrogen peroxide. Hydrogen peroxide decomposes to oxygen and water when a manganese(IV) oxide catalyst is added.

The student measured the time taken to collect 5 cm^3 of oxygen gas.

The apparatus shown below was used for the investigation. The reaction was started by shaking the flask so that the manganese(IV) oxide and hydrogen peroxide were mixed.



The student did the investigation at two different temperatures. All the other variables were kept constant.

The student's results are shown in the table.

Temperature of the hydrogen peroxide solution in °C	**Volume of oxygen collected in cm^3**	**Time taken to collect the oxygen in seconds**	**Rate of reaction in cm^3 per second**
20	5	40	0.125
25	5	25	

(a) (i) Calculate the rate of reaction at 25 °C.

.....

Rate of reaction = ... cm^3 per second

(2)

(ii) The teacher said that the student should repeat the investigation to get more results.

Suggest why.

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(1)

(b) The student concluded that:

'the rate of reaction increases when the temperature is increased'.

Explain, in terms of particles, why the rate of reaction increases.

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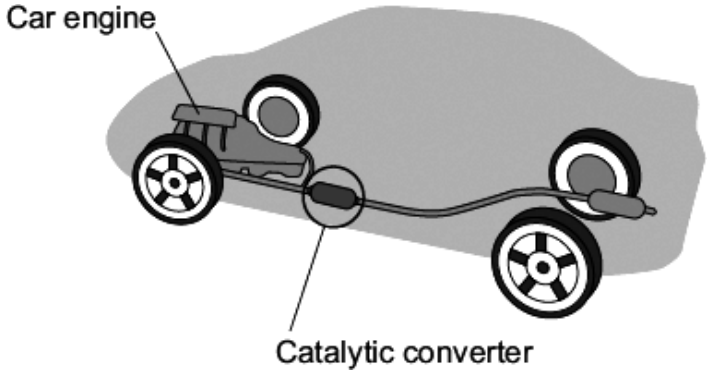
(2)
(Total 5 marks)

Q8. Read the information about car engines.

Burning petrol in air is an *exothermic* reaction. This reaction is used in car engines.

When petrol burns it produces harmful substances such as nitrogen oxides and carbon monoxide.

A catalytic converter stops these harmful substances being released into the air.



(a) The reaction is *exothermic*. What is the meaning of *exothermic*?

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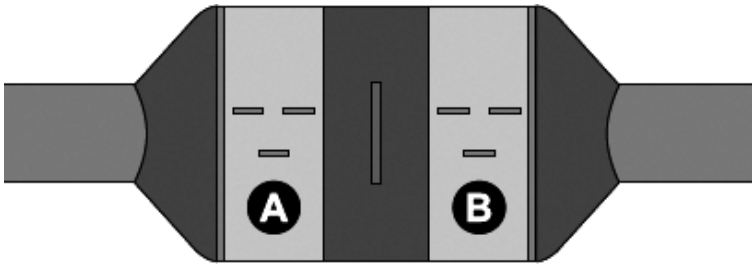
(1)

(b) The catalytic converter has two parts shown as **A** and **B** in the diagram.



Part **A** contains a catalyst made from platinum and rhodium.

Part **B** contains a catalyst made from platinum and palladium.

(i) Why are catalysts used in chemical reactions?

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(1)

(ii) One reaction in part **A** is shown by this equation.

$$2NO \rightarrow N_2 + O_2$$

Suggest why this reaction helps the environment.

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(1)

(iii) The equation for one of the reactions in part **B** is shown below.

Balance this equation.

$$\text{.....}\ CO + O_2 \rightarrow \text{.....}\ CO_2$$

(1)

(iv) The catalytic converter works for many years without replacing the catalyst.

Explain why the catalyst does not need to be replaced.

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(1)

(v) Suggest why different catalysts are used in parts **A** and **B**.

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(1)

(c) Modern catalytic converters contain nanosized particles of catalyst. Using nanosized particles reduces the cost of the catalytic converter.

Suggest and explain why the use of nanosized catalyst particles reduces the cost of the catalytic converter.

Your answer should include information about the size and surface area of the particles.

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(3)

(Total 9 marks)

Q9. This question is about gold (Au).

(a) An atom of gold is represented as:

$$^{197}_{79}Au$$

How many neutrons are in this atom of gold? .....

(1)

(b) Gold ions are used as a catalyst.

How does a gold atom (Au) become a gold ion (Au^{3+})?

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(2)

(c) A gold catalyst can be used when carbon monoxide reacts with oxygen to make carbon dioxide.

(i) Complete and balance the equation for this reaction.

.... CO + ... → ..... CO_2

(2)

(ii) Carbon dioxide has a very low boiling point.

Explain why.

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(3)

(d) Gold is used as a catalyst in industrial processes. Gold is rare and increasingly expensive.

Suggest **three** reasons why gold is still used in industrial processes.

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(3)
(Total 11 marks)

Q10. Thermosoftening polymers can be used to make plastic bottles and food packaging.

(a) The reaction to produce polymers uses a catalyst.

Why does the catalyst work for a long time before it needs replacing ?

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(1)

(b) Thermosoftening polymers would **not** be suitable for packaging very hot food.

Explain why in terms of their properties and structure.

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(2)

(c) Compounds from food packaging must not contaminate the food.

Food can be tested for contamination using gas chromatography linked to mass spectroscopy (GC-MS).

(i) Gas chromatography can separate substances in a mixture of compounds.

Describe how, as fully as you can.

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(3)

(ii) What information does the molecular ion peak give about the molecule?

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(1)

(Total 7 marks)