Q1. Some antacid tablets contain sodium hydrogencarbonate, sucrose and citric acid.

(a) Analysis of a pure sample of citric acid showed that it contained 37.50% of carbon and 4.17% of hydrogen by mass, the remainder being oxygen. Use these data to show that the empirical formula of the acid is $C_6H_8O_7$.

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(3)

(b) When the antacid tablet is added to water, sodium hydrogencarbonate and citric acid react together to form a gas. Identify this gas.

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(1)

(c) A weighed portion of this antacid was added to water. The gas formed was collected and its volume measured.

(i) Draw a diagram to show how this experiment could have been carried out to collect and measure the volume of the gas.

(ii) The experiment was repeated with further weighed portions of the same antacid.

The results are shown below.

Experiment	1	2	3	4	5
Mass of antacid / g	2.60	1.17	0.88	2.31	1.80

Volume of gas collected / cm^3	168	86	57	149	116

1 On the graph paper below, plot a graph of mass of antacid (x-axis) against volume of gas collected.

(3)

2 Draw a line of best fit on the graph, ignoring any anomalous points.

(1)

3 Use the graph to determine the volume of gas which would have been collected using 2.00 g of antacid.

Volume of gas collected .....

(1)

(d) Suggest **one** reason why the presence of sodium hydrogencarbonate in the stomach may cause a person to suffer some extra discomfort for a short time.

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(1)

(e) Explain why the value for the M_r of citric acid does not need to be an exact value to deduce the molecular formula of citric acid from its empirical formula.

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(2)

(f) Apart from misreading the gas volume, suggest **two** reasons why the volumes of gas collected may be lower than the volumes of gas produced.

Reason 1 .....

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Reason 2 .....

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(2)

(g) Explain why it is important to record the temperature and pressure when measuring the volume of a gas.

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(1)

(h) Suggest why, in an analysis of an antacid, it is important to test samples from more than one bottle of the antacid.

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(1)

(i) In the industrial production of sodium hydrogencarbonate, ammonia and carbon dioxide are bubbled through a saturated solution of sodium chloride. The equation for this reaction, and some solubility data, are shown below.

$$NaCl(aq) + NH_3(aq) + CO_2(g) + H_2O(l) \rightarrow NaHCO_3(s) + NH_4Cl(aq)$$

Compound	Solubility in water at 20 °C / g dm^{-3}
sodium chloride	360
sodium hydrogencarbonate	96
ammonium chloride	370

(i) Suggest **one** reason why sodium hydrogencarbonate precipitates from the reaction mixture at this temperature.

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(1)

(ii) Explain how this reaction could be used to remove carbon dioxide from the gases formed when fossil fuels are burned.

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(1)

(j) The thermal decomposition of sodium hydrogencarbonate produces sodium

carbonate. The other products are water and carbon dioxide. Write an equation for this thermal decomposition.

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(1)

(k) Sodium carbonate is produced on an industrial scale by a multi-step process. The equation which summarises the reactions taking place is shown below.

$$CaCO_3 + 2NaCl \rightarrow CaCl_2 + Na_2CO_3$$

Calculate the percentage atom economy for the production of sodium carbonate by this reaction.

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(1)

(Total 20 marks)