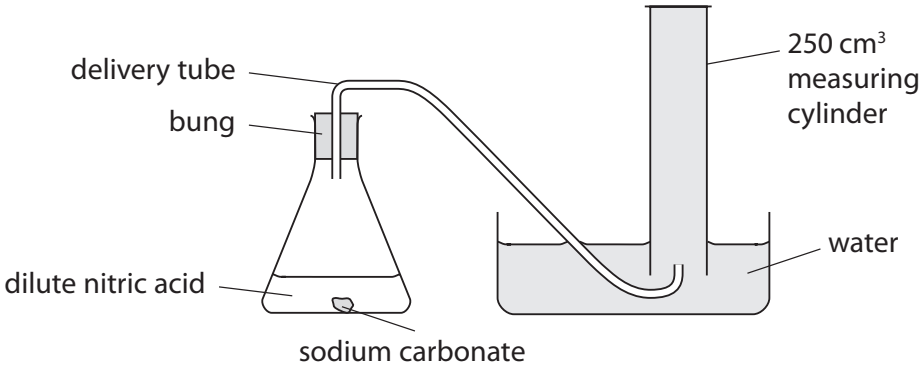
mark **/ 30**

= **%**

2 A student uses this apparatus to determine the volume of one mole of carbon dioxide gas.



This is the student's method.

- a solid lump of sodium carbonate of mass 0.53 g is placed into the conical flask
- an excess of dilute nitric acid is added and the bung is put in place
- when all of the sodium carbonate has reacted, the volume of carbon dioxide collected is measured

The equation for the reaction is

$$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$$

(a) (i) Calculate the amount, in moles, of sodium carbonate that reacts.
[M_r: Na_2CO_3 = 106]

(2)

moles = mass / RFM
moles = 0.53 / 106 = 0.005 moles

amount of sodium carbonate = ... mol

(ii) The volume of carbon dioxide collected is 110 cm³.

Use this information and your answer to (a)(i) to calculate the volume, in cm³, of one mole of carbon dioxide.

(2)

1/0.005 = 200
200 * 110 22,00cm^3

volume of one mole of carbon dioxide = ... cm³

(b) The correct value for the volume of one mole of carbon dioxide, under the conditions used in the experiment, is 24000 cm^3.

Suggest two reasons why the volume calculated from the experiment is less than the correct value.

(2)

1 **Some CO2 dissolved in the water**

Some CO2 escaped while the bung was unplugged.

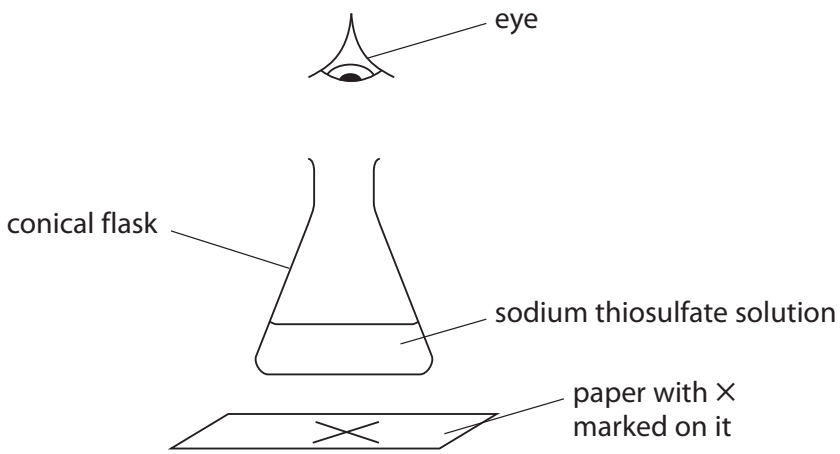
2 **The Sodium Carbonate was not pure.**

(Total for Question 2 = 6 marks)

5 Sodium thiosulfate solution and dilute hydrochloric acid react together slowly to form a precipitate of sulfur. This precipitate eventually makes the mixture go cloudy.

A student uses this method.

- place 20 cm^3 of sodium thiosulfate solution and 20 cm^3 of water in a conical flask
- add 10 cm^3 of dilute hydrochloric acid to the flask
- place the flask on a piece of paper marked with a black ×
- time how long it takes before the × can no longer be seen



(a) The equation for the reaction is

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

Before starting her experiments, the student considers the risk to her of sulfur dioxide escaping from the flask. She uses this information.

concentration of sodium thiosulfate solution = 0.300 mol/dm^3

volume of sodium thiosulfate solution = 20 cm^3

volume of water = 20 cm^3

volume of hydrochloric acid = 10 cm^3

(i) Calculate the mass of sulfur dioxide formed in this experiment.
The hydrochloric acid is in excess.

(3)

mols of NA2S2O3 = 0.3 * 0.02 = 0.006mol
so 0.006 mol of SO2
mass = mols * RFM = 0.006 * (32 + 32) = 0.38g

mass of sulfur dioxide formed = ... g

(ii) The solubility of sulfur dioxide at room temperature is 100 g/dm^3.

Use this additional information to explain whether any sulfur dioxide gas escapes from the flask.

(2)

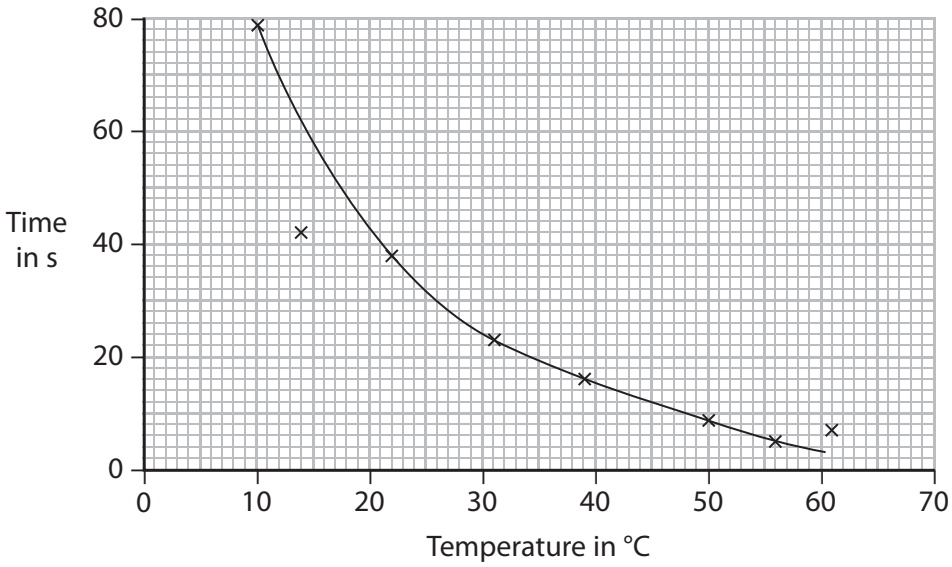
vol of liquid = 50cm3
0.38/0.05 = 7.6g/dm3
which is less than 100 so the gas will not escape

(b) At what point in the experiment should the student have started a timer?

(1)

When the HCl is added

(c) She repeats the experiment using the same volumes and concentrations of solutions, but at different temperatures. The graph shows her results.



(i) The result at (14, 42) is anomalous.

Explain one mistake the student may have made to cause this anomalous result.

(1)

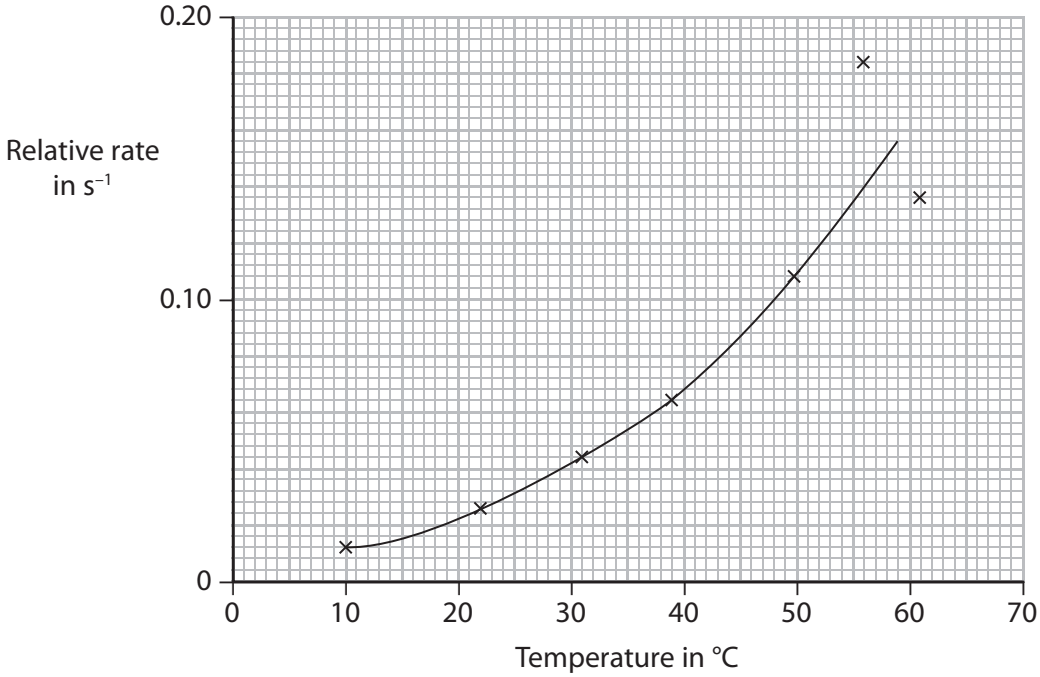
read the timer incorrectly

(ii) Use the graph to find the time taken for the × to be no longer seen at 35 °C.

(1)

19.5 s

(d) The student repeats the experiments using nitric acid in place of hydrochloric acid. She records the times for the × to no longer be seen, then uses the times to calculate the rate of reaction at each temperature.
The graph shows the results she plots.



(i) Suggest two reasons why the results are least accurate at higher temperatures.

(2)

1 **because the time is very short**

2 **heat loss to the environment is greater at higher temperatures**

(ii) The student wrote this explanation for the shape of the graph.

As the temperature increases, the rate of reaction increases. This is because there are more frequent collisions between particles of reactants.

Use the particle collision theory to explain another more important reason for the increase in reaction rate.

(2)

At higher particle speeds a greater proportion of collisions exceed the reaction's activation energy.

(e) Another student uses the same reaction to investigate the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

Give three variables that the student must control in this investigation to obtain valid results.

(3)

1 **temperature**

2 **concentration of the acid**

3 **volume of the acid**

(Total for Question 5 = 15 marks)

4 Sodium azide (NaN_3) is a stable compound at room temperature but decomposes when heated to 300 °C. The equation for the decomposition is:

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

Sodium azide is used to produce nitrogen gas to inflate car airbags.

If a car is involved in a collision, the sodium azide decomposes.

The nitrogen gas is produced very rapidly and the airbag inflates almost immediately.

(a) (i) A fully-inflated airbag has a total volume of 108 dm^3.
Calculate the amount of nitrogen, in moles, in a fully-inflated airbag.
[You should assume that the volume of one mole of nitrogen inside the airbag is 24 dm^3]

(2)

108/24 = 4.5 moles

Amount of nitrogen = ... mol

(ii) Use your answer to (a)(i) to calculate the mass, in grams, of sodium azide required to produce 108 dm^3 of nitrogen.

(3)

4.5 / 3 * 2 = 3moles of NaN3

mass = moles * RFM = 3 * (23 + 42) = 195g

Mass of sodium azide required = ... g

(b) The airbag also contains potassium nitrate. This reacts with sodium formed in the decomposition of sodium azide. The equation for the reaction is:

$$10Na(l) + 2KNO_3(s) \rightarrow K_2O(s) + 5Na_2O(s) + N_2(g)$$

(i) Suggest **one** reason why the makers of the airbag might want this reaction to occur.

(1)

It removes pure Sodium which is dangerous.

(ii) The airbag also contains silicon dioxide (SiO_2) which reacts with the oxides produced in the reaction above. This forms a glassy solid which seals all the products into the airbag.

The glassy solid contains potassium silicate (K_2SiO_3).

Construct an equation for the formation of potassium silicate from potassium oxide. **Include state symbols**.

(1)

K2O(s) + SiO2(s) -> K2SiO3(s)

(c) Another use of sodium azide is to make lead(II) azide, which can be used as a detonator for explosives. Lead(II) azide has the formula of $Pb(N_3)_2$

Lead(II) azide can be made by the following reaction:

$$Pb(NO_3)_2(aq) + 2NaN_3(aq) \rightarrow Pb(N_3)_2(s) + 2NaNO_3(aq)$$

(i) What name is given to this type of reaction?

(1)

precipitation

(ii) What method would you use to remove the lead(II) azide from the final reaction mixture?

(1)

filtration

(Total for Question 4 = 9 marks)