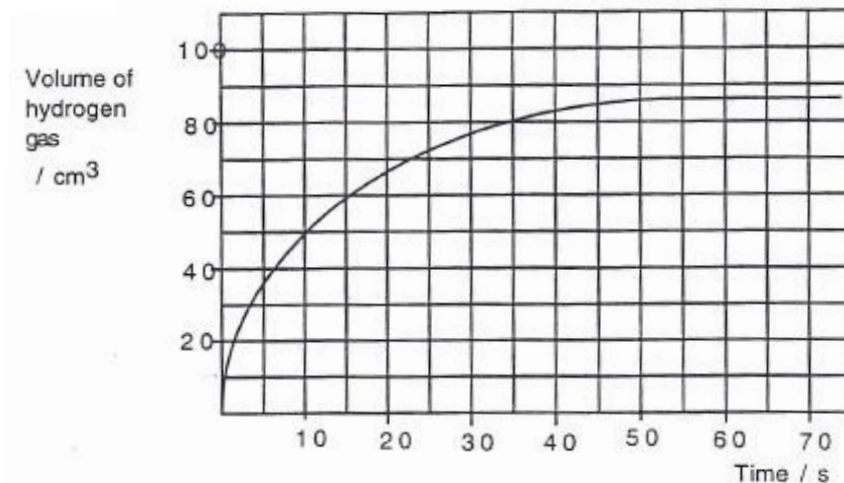


1. The graph below shows the volume of hydrogen given off when a 2 cm long strip of magnesium ribbon (mass 0.1g) was added to an excess of $1 \text{ mol } \ell^{-1}$ hydrochloric acid solution.



- a) Calculate the average rate of reaction (Show your working)
- over the first 10 seconds.
 - between 10 seconds and 20 seconds.
 - between 20 seconds and 30 seconds.
- b) i) How does the rate change as the reaction proceeds?
ii) Explain this change in rate.
- c) After what time does the reaction stop?
- d) Draw a labelled diagram of the apparatus that could be used in this experiment.
- e) Copy the graph shown above (no graph paper required) and
- add the curve you would expect to get 0.1 g of magnesium powder had been used instead of 0.1 g of magnesium ribbon.
 - add the curve you would expect to get if 0.05 g of magnesium ribbon had been added to an excess of $2 \text{ mol } \ell^{-1}$ hydrochloric acid solution. (Clearly label the new curves).

2. 1.0 g of zinc was placed in 20 cm³ of 2mol ℓ⁻¹ hydrochloric acid solution. After 20 seconds the zinc was removed, washed and dried. The piece of zinc was found to weigh 0.35 g.
- Write a balanced equation for the reaction.
 - Calculate the average rate of the reaction.
 - Calculate the number of moles of hydrochloric acid used in the reaction.
3. A pupil was investigating the effect of temperature on the rate of a chemical reaction in which dilute hydrochloric acid was added to sodium thiosulphate solution. In this reaction a precipitate of sulfur is formed as shown by the equation below.



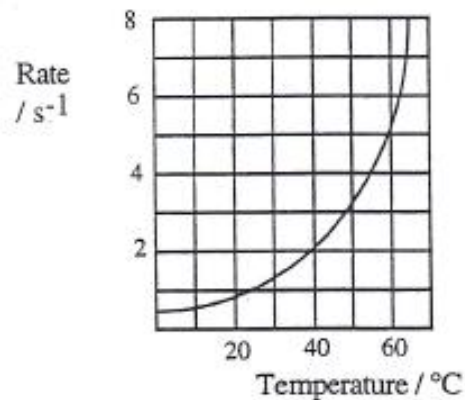
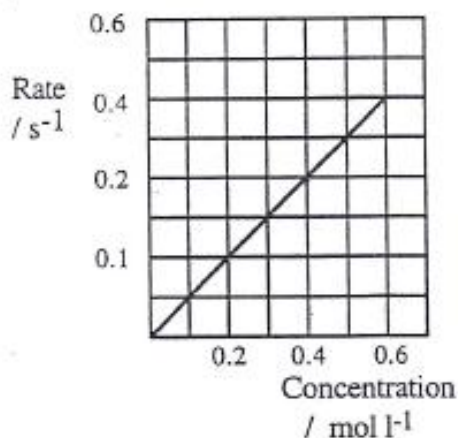
- Describe how the rate of this reaction varies with temperature can be investigated in the laboratory.
- The following results were obtained.

Temperature/ (°C)	15	25	33	37	42
Time taken for cross to disappear/(s)	154	67	44	30	22

Plot a graph of reaction rate (s⁻¹) against temperature.

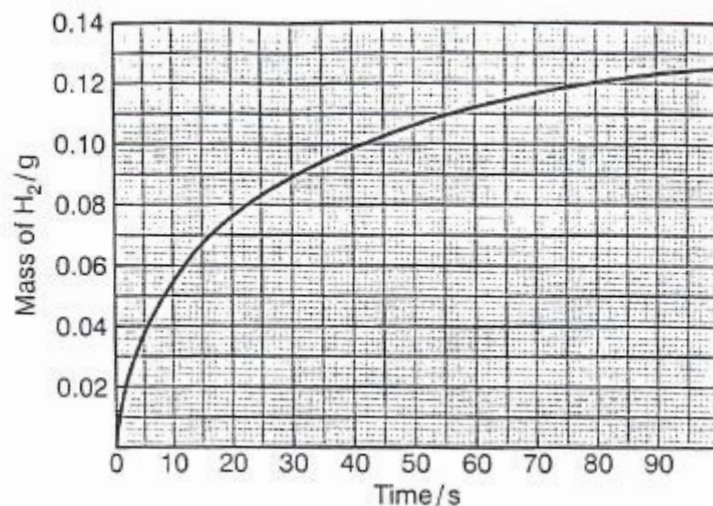
- Use the graph to predict the time the reaction will take at 50°C.
- Predict the rate of the reaction at 55°C.
- From the graph estimate the temperature rise needed to double the reaction rate.

4. The overall rate of a chemical reaction is often taken as the reciprocal of time (1/time). Graphs of reaction rate against concentration and reaction rate against temperature are shown below.



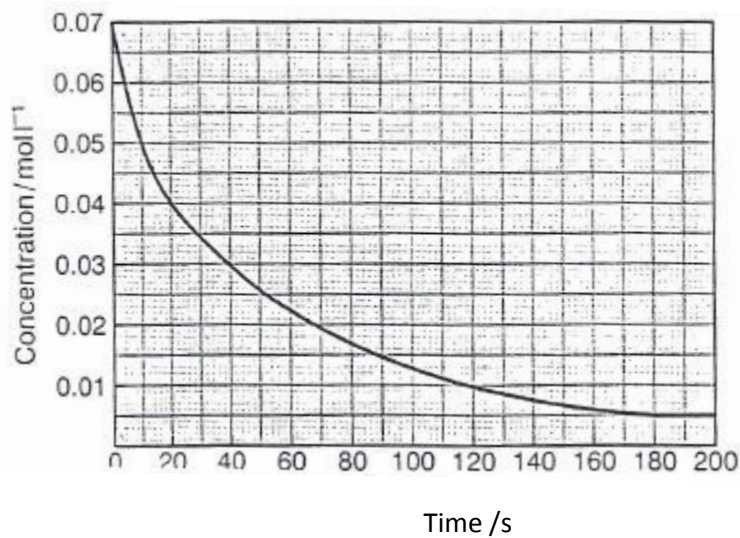
- a) From graph 1:-
- Calculate the time taken for the reaction when the concentration is 0.4 mol l^{-1} .
 - Explain why the rate increases as the concentration increases.
- b) From graph 2 :-
- Find the temperature rise needed to double the reaction rate.
 - Explain why the rate increases very rapidly as the temperature increases.

5. The graph below shows the mass of hydrogen given off plotted against time in a chemical reaction.



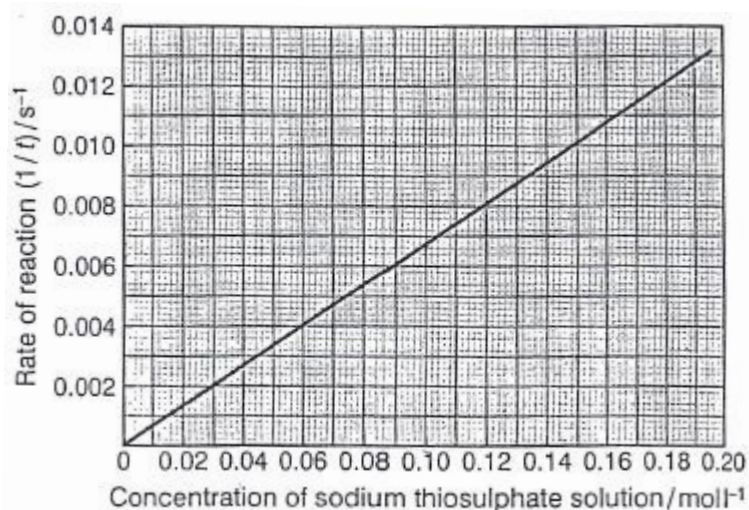
- a) Calculate the average rate of reaction during the first 10 seconds of the reaction.
- b) Calculate the average rate of reaction between 20 and 40 seconds.

6. The graph below shows the change in concentration of an acid plotted against time during a chemical reaction.



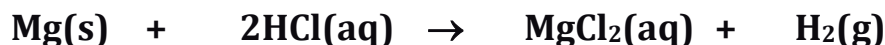
- a) Calculate the average rate of reaction during the first 20 seconds of the reaction.
- b) Calculate the average rate of reaction between 30 and 70 seconds.

7. The graph below shows the rate of formation of a fixed amount of solid sulfur when sodium thiosulphate solution reacts with hydrochloric acid. The mixture becomes cloudy as the reaction proceeds and the time is measured for a cross on a piece of paper beneath the reaction flask to be obscured. This is done for different starting concentrations of sodium thiosulphate. The rate is expressed as the reciprocal of the reaction time, $1/t$.



- Explain why the reciprocal of the reaction time can be taken as a measure of the rate of the reaction.
- How long did the cloudiness take to appear when the concentration of the sodium thiosulphate solution was 0.10 mol l^{-1} ?
- For what concentration of sodium thiosulphate solution would the cloudiness take 80s to appear?

8. The reaction between magnesium and dilute hydrochloric acid:



is followed on a top pan balance.

- Why do the balance readings show a decrease in mass as the reaction proceeds?
- Draw a rough graph (no graph paper necessary) to show how the balance readings vary with time for the reaction.