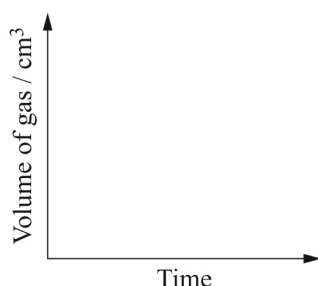


# Chapter 9: Rates of reaction

## Homework questions

- 1 When calcium carbonate and hydrochloric acid react they form calcium chloride, water and carbon dioxide gas.
- a Write the balanced symbol equation for the reaction. [1]
- b Excess  $0.5 \text{ mol dm}^{-3}$  hydrochloric acid is added to 1 g of calcium carbonate at room temperature and pressure.
- i Copy the axes below and sketch a line to show how the volume of carbon dioxide produced varies with time. Label this line **A**. Mark on your graph the value for the final volume of carbon dioxide gas produced. [4]



- ii On the same graph, sketch the line obtained if excess  $1 \text{ mol dm}^{-3}$  hydrochloric acid is reacted with 1 g of calcium carbonate. Label this line **B**. [2]
- iii Draw a third line that shows how the volume of carbon dioxide varies with time when the acid is at a concentration of  $1 \text{ mol dm}^{-3}$  and a temperature of  $40^\circ\text{C}$ . The carbon dioxide would be collected at room temperature and pressure. Label this line **C**. [2]
- c Explain the difference between the rates of reaction for **B** and **C** by drawing the Boltzmann distributions for both reactions. In your answer, refer to collision theory. [7]
- Total = 16

- 2 a When platinum wire is lowered into a flask containing concentrated ammonia solution, the wire glows red hot.
- The reaction taking place is represented by the equation:
- $$4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{l})$$
- Platinum acts as a heterogeneous catalyst in this reaction.
- i Explain the term **heterogeneous catalyst**, with reference to the equation above. [3]
- ii Outline the processes taking place on the surface of the catalyst. [4]
- iii Explain the action of the catalyst by referring to the Boltzmann distribution. [5]
- iv Write the expression for  $K_p$  for this reaction and give the units. [2]
- v Is the reaction endothermic or exothermic? Explain your answer. [1]
- b Another example of heterogeneous catalysis is the decomposition of ammonia into its constituent elements. The catalyst is tungsten.
- $$2\text{NH}_3(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \quad \Delta H = +92 \text{ kJ mol}^{-1}$$
- i Calculate the enthalpy of formation of ammonia. [2]
- ii The activation energy for the catalysed reaction is  $162 \text{ kJ mol}^{-1}$ . Draw an enthalpy profile for the reaction and on it sketch the curves representing the catalysed and uncatalysed reactions. [4]
- iii Calculate the activation energy for the reverse **catalysed** reaction. [1]
- Total = 22