Assignment: Rates of Reaction

SCH4UE 04-05

1. What is meant by 'rate of a chemical reaction'?

2. Give three ways that the progress of a chemical reaction can be followed experimentally. Show by means of a graph how these data can be used to determine the rate of the reaction.

3. Why do the rates of most chemical reactions change with time?

4. What is meant by the term 'average rate of the reaction' and the 'instantaneous rate of the reaction'. Explain how these may be determined from a graph.

5. Some powdered zinc, 0.0100 mol, was reacted with 50.0 cm^3 of 2.00 mol L^{-1} hydrochloric acid, $HCl_{(aq)}$ at 35.0 ^{O}C.
The volume of hydrogen formed was measured at 100 kPa over a period of time and the results are given below. Use the graph to answer the following questions.

a. Write an equation for the reaction of zinc metal with hydrochloric acid.
b. Calculate the volume of 2.00 mol L^{-1} hydrochloric acid that is required to react completely with 0.0100 mol of zinc.
c. How long did it take for the reaction to come to completion?
d. Why is the final part of the graph horizontal?
e. A second experiment was carried out using the same mass of zinc, but this time the metal was in a more finely powdered state. Compare the volumes of hydrogen produced in this experiment with those measured in the original experiment after:
(i) 50 s (ii) 500 s
Explain your answer.
f. Other metals also react with $HCl_{(aq)}$ to evolve hydrogen.
(i) What property of a metal determines the final volume of hydrogen produced by 0.0100 mol of that metal.
(ii) What property of a metal (other than particle size) affects the rate of hydrogen evolution.
g. If 2.00 mol L^{-1} acetic acid, CH_3COOH, was used with 0.0100 mol of zinc metal, how would this affect the rate of hydrogen evolution. Explain.

6. The reaction between ammonium chloride and sodium nitrite in aqueous solution can be represented by the following equation:

$$NH_4Cl_{(aq)} + NaNO_{3(aq)} \longrightarrow N_{2\,(g)} + NaCl_{(aq)} + H_2O_{(l)}$$

a. Sketch a graph which shows the volume of nitrogen gas produced at 30 s intervals from a mixture of ammonium chloride and sodium nitrite in aqueous solution at 20°C.

b. State how the rate of formation of nitrogen changes with time. Explain your answer in terms of collision theory.
c. Explain why the volume of nitrogen gas collected eventually would remain constant.
d. State how the rate of formation of nitrogen would change if the temperature were increased from 20°C to 40 ^{O}C. State two reasons for this change and explain which of the two is more important in causing the change.
e. The reaction between solid ammonium chloride and aqueous sodium nitrite can be represented by the following equation:

$$NH_4Cl_{(s)} + NaNO_{3(aq)} \longrightarrow N_{2\,(g)} + NaCl_{(aq)} + H_2O_{(l)}$$

State and explain how the rate of formation of nitrogen would change if the same amount of ammonium chloride were used as lumps instead of as a fine powder.