Reaction Kinetics Lab

Learning Outcomes
Demonstrate awareness that reactions occur at differing rates
Experimentally determine rate of a reaction
Demonstrate knowledge of collision theory
Apply collision theory to explain how reaction rates can be changed

Purpose:
To help students appreciate the importance of reaction kinetics in everyday life. We will investigate how *concentration* and *surface area* affect reaction rate, and demonstrate how kinetics information can be displayed graphically.

Materials:
- 4 individual 600mL beakers
- 4 pieces of 0.1g aluminum foil (Al; 1 piece shredded)
- 1 portion of 100mL 3M hydrochloric acid (HCl)
- 3 portions of 100mL 6M hydrochloric acid (HCl)
- 2 stop watches

Basic Procedures:

Hook: What chemical makes detergents for cleaning surfaces very effective?
Answer: Hydrochloric acid is commonly used on porcelain toilet bowls to remove the worst of mineral build-ups. However, it must be used with extreme care because it is highly corrosive.

1. Before the demonstration, place the 4 portions of hydrochloric acid into the individual 600mL beakers. To test *concentration*, we will compare the 3M HCl solution with the 6M using identical pieces of aluminum foil. To test *surface area*, we will compare the shredded piece of Al with the un-shredded using the 6M solutions.
2. Probe student understanding of *Reaction Kinetics* and its relevance to everyday life.
3. Ask the class to identify some factors that affect reaction rate, as well as how these rates can be measured.
4. Write the balanced equation: $6HCl_{(aq)} + 2Al_{(s)} \rightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$, indicating that we will be specifically investigating the factors *concentration* and *surface area.*

Testing Concentration:

5. Have students predict what will happen to the aluminum foil when placed in hydrochloric acid. Compare the results when added to the 3M HCl solution versus the 6M.
6. Conduct the experiment and qualitatively examine the reaction that occurs. What products are formed? How can we tell? Is it exothermic or endothermic? Which reaction occurred faster? Why?

Testing Surface Area:

7. Have students predict what will happen to the aluminum foil when placed in the 6M hydrochloric acid, except with one piece shredded.
8. Request for two volunteers to time the reactions with separate stopwatches and conduct the experiment. Quantitatively examine the reaction that occurs. Which reaction occurred faster? Why?
9. Graph the change in mass with change in time, and calculate the average reaction rate from the slope.

Closure/Assessment:

10. Consider how the rate would compare if 4.5M HCl was used instead? Why?
    What is another way to change the surface area of Al? How would that rate compare?

Explanation:

Kinetics deals with motion; in terms of *Reaction Kinetics*, the motion of particles. Reaction rates can be controlled to suit our needs: faster reactions are preferred in industry for efficiency, whereas slower reactions are desired for destructive processes like rusting. Some factors that affect reaction rates include temperature, pressure and surface area. Depending on the reaction, these can be measured using changes in mass, concentration, temperature or colour intensity with time. Reaction rates are expressed as a change in quantity per unit time. For example, a unit for rate when monitoring change in mass is *g/s*. For the products, the bubbles formed from the evolution of H_2 gas, and the light yellowish-brown compound was $AlCl_3$. The reaction was exothermic since the beaker felt warm on the outside.

The reaction occurred faster in the 6M HCl solution because there were more acid molecules per unit volume, resulting in a greater likelihood of effective collisions. As well, the rate should be higher for the shredded piece of aluminum because more particles were available to collide. However, recall during the demonstration, we observed that the shredded piece actually reacted slower. Some explanations include the fact that the aluminum was not fully submerged, especially for the shredded foil as it was difficult managing so many pieces. One colleague mentioned that simply cutting it into strips may not have increased the surface area enough, since the foil was already so thin. For next time, subdividing it into smaller pieces should help. Moreover, the beakers can be stirred at a constant rate to ensure particles have an adequate opportunity to react.

The rate with a 4.5M HCl solution should be faster than the 3M, though slower than the 6M. There are more acid molecules per unit volume in the 4.5M solution relative to the 3M, resulting in a greater probability for successful collisions. Conversely, there are less acid molecules per unit volume relative to the 6M, resulting in the slower rate. As per surface area, the aluminum foil can be crumpled into a ball, decreasing the amount of particles available to react, and thus slowing the reaction. The demonstration can be used as an introduction for collision theory: Atoms are in constant motion with velocities specified by temperature. For a successful reaction to occur, particles must collide with favourable geometry and sufficient energy to overcome the activation energy barrier to form products.