EXPERIMENT 11: FACTORS THAT AFFECT RATES OF REACTION

Materials: Beakers, stirring rods, ring stand, iron ring, gauze, sugar cubes, tea bags, 3% hydrogen peroxide, sliced potato, $\text{MnO}_2$, dilute HCl, concentrated HCl, acetic acid (vinegar), magnesium strips, zinc strips, food coloring, alka seltzer tablets

Aim – What are some factors that can alter the rate of reaction?

$\text{C}_{12}\text{H}_{22}\text{O}_{11} (s) \rightarrow \text{C}_{12}\text{H}_{22}\text{O}_{11} (aq)$

The particles that comprise all substances are in constant motion and are constantly colliding with one another. When the particles collide with the right amount of energy and in the proper orientation, a chemical or physical change can occur. When sucrose is added to water, collisions occur between the molecules of sucrose and water. These collisions overcome the intermolecular forces between the molecules and cause the sucrose molecules to dissolve in water. In this experiment you will look at the different factors that affect the rates of reactions and physical changes, such as dissolving, and you will determine how they affect the rates according to collision theory.

A. Obtain two beakers. Fill one beaker with water to about $\frac{3}{4}$ full. Heat the water gently over the bunsen burner until it is hot but not boiling, or use water that has already been heated. Place an equal amount of cold water into a second beaker. At the same time, place 1 bag of tea into each beaker. Allow to stand for a few minutes.

1. What do you observe? [5 pts]

2. In terms of the collision theory, why does temperature affect the rate of tea brewing? [5 pts]

B. Obtain two beakers. Place an equal amount of tap water into each beaker. Drop a sugar cube into each beaker at the same time. Stir the contents of one of the beakers with a stir rod for 30 seconds and leave the other beaker alone.

5. In which beaker did the sugar cube dissolve more completely? [5 pts]

6. Touch both beakers. Does stirring significantly change the temperature of a solution? [5 pts]

7. In which mixture are the reactants more able to be in contact with one another? How does this affect the number of collisions? [5 pts]

C. Obtain two beakers. Place an equal amount of tap water into each beaker. Use a mortar and pestle to crush one sugar cube. Into one beaker drop the crushed sugar cube. At the same time drop a whole sugar cube into the other beaker. Stir both beakers 3-4 times.

3. Which sample of sugar dissolved more completely? Which sample of sugar has more surface area? [5 pts]

4. In terms of the collision theory, why does surface area affect the rate of sugar dissolving? [5 pts]
D. Place a small slice of potato into a beaker. Add a small amount of hydrogen peroxide (H₂O₂), just enough to cover the potato.

8. What do you observe happening at the surface of the potato? [5 pts]

9. The liquid hydrogen peroxide is being decomposed into liquid water and oxygen gas, which is an exothermic reaction. Write a balanced equation for this reaction, including the “energy” term on the correct side of the equation. [5 pts]

10. The potato contains an enzyme that catalyzes the decomposition reaction. How do catalysts speed up chemical reactions? [5 pts]

11. If available, in another test tube, mix a small amount of hydrogen peroxide with a small amount of manganese dioxide, MnO₂. How does the rate of this catalyzed reaction compared to the rate with the potato-catalyzed one?

E. Examine the substances on the teachers’ desk. You will design two experiments, one that tests how either concentration or nature of the reactants affects reaction rate, and one that tests how any other factor affects reaction rate. For each experiment, write a brief procedure, including what factors you will keep constant and what factor you will change. Have your instructor approve your procedures before continuing. Carry out each experiment, and then briefly state the result of each experiment. [10 pts each]

1. A) Factor being tested:
   B) Procedure:
   C) Results:

2. A) Factor being tested:
   B) Procedure:
   C) Results:

Instructor’s initials __________
Summary Questions:
1. Will any collision between reactant particles result in a reaction? Explain briefly. [4 pts]

2. List 5 factors that affect the rate of a chemical reaction. [5 pts]

3. List 2 methods you could use to slow down the rate at which a sugar cube dissolves. [3 pts]

4. Refer to part D of the lab, and draw a potential energy diagram for the decomposition of hydrogen peroxide, H₂O₂. You do not need to use actual numbers for PE values. Label with arrows PEₐ, PEₚ, PEₐₖ (activated complex) and ΔH. Also label Eₐ (activation energy) with and without the potato (a catalyst). [10 pts]

5. What is the sign of ΔS for the decomposition of H₂O₂? Why? [4 pts]

6. If the reaction is spontaneous, why do you need to add a catalyst? [4 pts]