THE REPUBLIC OF UGANDA
Ministry of Education and Sports

SENIOR FOUR
SELF STUDY MATERIALS
SCIENCE PACKAGE

NCDC
NATIONAL CURRICULUM DEVELOPMENT CENTRE

CHEMISTRY

Topic: Reaction Rates and Reversible Reactions

By the end of this topic, you should be able to observe and explain the effects of different factors on reaction rates.

Introduction

Why are some reactions much faster than others? Is it possible to change how fast a reaction occurs? In this ***lesson***, you will learn what the rate of a chemical reaction is. You will also discover how factors such as temperature, concentration, surface area, and catalysts impact reaction rates.

Reaction Rate

When you hear the word rate, what do you think of? A loan interest rate? A rate of speed? A growth rate? Or maybe a rate of pay? Most rates have something happening in a specific amount of time, like the percentage of interest you pay on a bank loan every month, how far you drive in an hour, how fast you grow in a year, or how much you are paid every hour.

In Chemistry, the rate of a reaction describes how fast a reaction proceeds over time. In other words, a rate of reaction measures how quickly **reactants are changed into products**.

Reaction rate is the change in concentration of reactants over time or the change in concentration of products over time. Units for reaction rates are in terms of Mass/time. For faster reactions, seconds are used for units of time; for longer reactions, minutes are used.

Reaction rates may be expressed in terms of any chemical substances involved in the reaction. Reaction rate can be written for the disappearance of a reactant or the appearance of a product.

As an example of a reaction, take the reaction between hydrochloric acid and zinc metal. When combined, the acid "eats away" the metal to produce hydrogen gas and some dissolved metal salts. The rate of this reaction could be measured in terms of the disappearance of the zinc or the rate of appearance of hydrogen gas.

If we were expressing reaction rate in terms of disappearance of zinc metal, we would write:

$$\text{Reaction rate} = \frac{-\,change\ [zinc]}{time}$$

(If you were to draw a graph for this reaction, the slope of the line would be negative, because the concentration of our reactant is constantly decreasing).

If we were expressing reaction rate in terms of appearance of hydrogen gas, we would write:

$$\text{Reaction rate} = \frac{change\ [hydrogen\ gas]}{time}$$

(If you were to draw a graph for this reaction, the slope of the line would be positive, because the concentration of our reactant is constantly increasing.)

This reaction happens quickly, but think ... What are some ways that we could increase the rate of reaction? What are some ways that we could decrease the rate of reaction?

Before we talk about factors that influence reaction rate, let us look at a chemical reaction on the molecular level.

Chemical Reactions: A Molecule's View

Remember, molecules are made up of atoms bonded together by the sharing of electrons. These bonds are relatively strong and require a certain amount of energy to break. The random bumping and colliding of molecules with each other generally does not contain enough energy to break these bonds and cause a **chemical reaction**. Additionally, molecules must collide with proper orientation.

According to the collision theory, in order for a chemical reaction to happen, there needs to be an effective collision between the reactants. To be effective, a collision must meet the following two requirements:

i) Molecules collide with enough energy to break bonds

ii) Molecules collide with a favourable orientation

Any factor that affects the likelihood of an effective collision also affects the rate of reaction. Chemical reaction rates can differ when different factors are present. In this lesson, you will focus on the main rate changing contributors: temperature, concentration, surface area, and catalysts.

Temperature

Activity 1: You will investigate the effect of temperature on the rate of the reaction.

Things you will need: An anti-acid tablet (e.g. magnesium/activated charcoal tablets) two plastic cups labelled A and B, cold/iced water, hot water

Procedure

1. In cup A, put the iced/cold water and add ½ a tablet of anti-acid tablet.
2. In cup B, put the hot water add ½ a tablet of anti-acid tablet.
3. Observe which reaction is the quickest.

Questions

1. Which reaction had the fastest rate? How were you able to tell this?
2. Explain what could be occurring at the molecular level. (How are the molecules moving or acting?)

Concentration

Activity 2: You will investigate the effect of concentration on the rate of a reaction.

You will use the different concentrations of vinegar and baking soda for these reactions.

Things you will need: Vinegar/lemon juice, baking soda, water, cup, tea spoon

Procedure:

1. In one cup, use pure vinegar/lemon juice (3mL) and place one tea spoonful of baking soda.
2. In another cup, add pure vinegar/ lemon juice (1.5mL) and water (1.5 mL) before you add the tea spoonful of baking soda.
3. Observe what is happening in the cups.

Questions

1. Which reaction had the fastest rate? How were you able to tell this?

2. Explain what could be occurring at the molecular level in each example. (How are the molecules moving or acting?)
3. Why are high concentration reactions faster than low concentrations?

Surface area

What is surface area? Surface area is the exposed matter of a solid substance. Imagine that you are holding a perfect cube of magnesium. The surface area is the sum of the area of all six sides of the cube. The surface area of the cube can be increased by dividing the cube into smaller cubes. Surface area is maximized when a single large cube is crushed to fine powder.

Activity 3: You will investigate the effect of surface area on the rate of a reaction.

You will use **steel wool** and the lighter/source of heat for the reactions.

Things you will need: Steel wool, box of matches

Procedure

1. Ball up pea size amount of steel wool. Burn the piece for 10 seconds.
2. Spread out the same amount of steel wool. Burn the spread-out piece for another ten seconds.
3. Make observations of what happens in both cases.

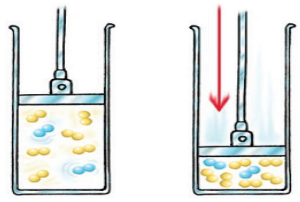
Questions

1. Which reaction had the fastest rate? How were you able to tell this?
2. Explain what could be occurring at the molecular level for the balled piece versus the spread-out piece. (How are the molecules moving or acting?)
3. If left to burn for more than 10 seconds, which would take longer, the balled piece or the spread-out piece? Explain your answer.

Pressure

How does pressure affect the reaction rate?

The concentration of a gas is a function of the pressure on the gas. Increasing the pressure of a gas is exactly the same as increasing its concentration. If you have a certain number of gas molecules, you can increase the pressure by forcing them into a smaller volume.



Under higher pressure or at a higher concentration, gas molecules collide more frequently and react at a faster rate. Conversely, increasing the volume of a gas decreases pressure which in turn decreases the collision frequency and thus reduces the reaction rate.

It is important to note, however, that there are reactions involving gases in which a pressure change does not affect the reaction rate. For this reason, the rates of reactions involving gases have to be determined by experiment. Also note that solids and liquids are not affected by pressure changes.

Catalyst

Activity 4: You will investigate the effect of catalysts on the rate of a reaction.

You will use the catalyst provided with the vinegar and baking soda for these reactions.

Things you will need: Vinegar, baking soda, yeast, balloon, plastic bottle

Procedure

1. In a small plastic bottle, use pure vinegar and place one tea spoonful of baking soda and cover with a balloon.
2. In another small plastic bottle, add pure vinegar and add catalysts (yeast) before you add the tea spoonful of baking soda covered with a balloon.
3. Make observations of what happens in both cases.

Questions

1. Which reaction had the fastest rate? How were you able to tell this?
2. Explain what could be occurring at the molecular in each example. (How are the molecules moving or acting?)
3. How does the catalyst cause this effect? (**Hint**: Think of the structure of the catalyst)

Follow-up Activity

1. Utilise your knowledge of reaction rates to explain why we keep most foods in the refrigerator.
2. Utilise your knowledge of reaction rates to explain why highly concentrated medications can be deadly.
3. If the temperature, concentration or surface area were increased in the following scenario, hypothesize how it would change the reaction.

Reactant A + Reactant B -> Product

PHYSICS

INTRODUCTION TO CURRENT ELECTRICITY

Lesson 1

Competence:
By the end of this lesson, you should be able to:

1. Explain what is meant by electromotive force (emf).
2. Construct a simple electric cell using local materials.
3. Describe how dry cells convert chemical energy into electrical energy.

Introduction:
Have you ever used a torch that uses a dry cell (battery)? Have you ever noticed that such a torch does not work without the dry cell(s)? What is it that these dry cells have that make the torch to light?

Materials you need:

- A lemon/orange fruit
- A dry cell (e.g. Tiger head)
- Two copper nails
- Two zinc nails
- Four crocodile clips
- A torch bulb or LED
- Two connecting wires

Procedures:

1. Look around your home/community and get the following:Two copper nails
   i. Two zinc nails
   ii. Four crocodile clips
   iii. A torch bulb or a LED
   iv. Connecting wires.
2. Pick a lemon or an orange fruit (You can buy one from the market).
3. Connect the circuit shown in Figure 1.1. (In absence of the crocodile clips you may connect the connecting wires directly to the nails and the terminals of the LED or bulb).