**CAPS LESSON PREPARATION**

SUBJECT: **PHYSICAL SCIENCE** GRADE : **12**

KNOWLEDGE AREA : CHEMICAL CHANGE

SECTION/S : RATE OF REACTIONS

DURATION : ......30. **Minute / periods**

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| **LESSON OBJECTIVE**  **S** | **At the end of the lesson learners should know the following:**   * Define reaction rate * Calculate reaction rate from given data * List the factors that affect the rate of chemical reactions * Explain in terms of the collision theory how the various factors affect the rate of chemical reactions * Answer questions and interpret data (tables or graphs) on different experimental techniques for measuring the rate of a given reaction. * Define the term positive catalyst * Interpret graphs of distribution of molecular energies (number of particles against their kinetic energy or Maxwell-Boltzmann curves) to explain how a catalyst, temperature and concentration affect rate. |
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| **PRE-KNOWLEDGE** | * Kinetic Theory of Gases * Activation energy * Bond Theory * Energy |

**PRESENTATION**

* Define *reaction rate* as the change in concentration of reactants or products per unit time.
* Calculate reaction rate from given data.

 (Unit: 

Questions may also include calculations of rate in terms of change in mass/volume/ number of moles per time.

* List the factors that affect the rate of chemical reactions, i.e.
* Nature of reacting substances,
* Surface area,
* Concentration (pressure for gases),
* Temperature and
* The presence of a catalyst.
* **Explain in terms of the collision theory** how the various factors affect the rate of chemical reactions.

The collision theory is a model that explains reaction rate as the result of particles colliding with a certain minimum energy.

**VARIABLES**

* **Dependent:** What is measured?
* I**ndependent**: what I will change
* **Control**: Remains the same

**Measuring rates of reaction**

**Answer questions and interpret data** (tables or graphs) on different experimental techniques for measuring the rate of a given reaction.

**Mechanism of reaction and of catalysis**

**Defin**e the term positive catalyst as a substance that increases the rate of a chemical reaction without itself undergoing a permanent change.

**Interpret** graphs of distribution of molecular energies (number of particles against their kinetic energy or Maxwell-Boltzmann curves) to explain how a catalyst, temperature and concentration affect rate.

**Explain** that a catalyst increases the rate of a reaction by providing an alternative path of lower activation energy. It therefore decreases the net/total activation energy.

**What is required when you explain using Collision Theory?**

1. **Concentration of Reactants**

The higher the concentration of a reactant in solution, the higher the rate of the reaction.

**Explanation**

* Increasing the concentration, increases the number of solute particles in the solution.
* This will increase the effective collision between the particles per unit time (increase the frequency of the effective collisions).
* The reaction rate will therefore increase

1. **Temperature**

An increase in temperature increases the reaction rate**.**

**Explanation**

* Higher temperature implies higher average kinetic energy of molecules.
* More molecules have minimum energy equal to or higher than the activation energy.
* This will cause more effective collisions per unit time (increase in the collision frequency).
* That will speed up the rate of reaction.

1. **Surface area**

The reaction rate increases with an increase in the surface area of the reactants.

**The explanation**

**(Reaction sites - specific sites on molecules at which reactions occur).**

* Increasing the number of reaction sites increases the frequency of total collisions.
* More effective collisions per unit time will occur which will increase the reaction rate.

**N.B .The most effective way of increasing the surface area of a solid is to grind the solid into a powder.**

1. **Presence of Catalysts**

**Explanation**

* Catalyst increases the rate of a chemical reaction by providing a different/ alternative pathway of lower activation energy
* Collisions only result in a reaction if the particles collide with a certain minimum energy called the activation energy.
* Adding a catalyst provides an alternative route with lower activation energy for the reaction.
* The majority of particles will now react via the easier catalysed route with lower energy.
* More effective collisions per unit time will occur which will increase the reaction rate

**EXPLAINATION OF MAXWELL-BOLTZMANN CURVES)**

1. TEMPERATURE

* An increase in temperature implies an increase in the average kinetic energy of the gas.
* The peak of the graph drops and the graph slightly shifts to the right.

1. CONCENTRATION

An increase in the number of particles whose energy exceeds the activation energy (E Ea).

1. CATALYST

* A catalyst provides an alternative pathway with a lower activation energy (new catalysed Ea)
* The new catalysed Ea will shift to the left on the x-axis.
* The total shaded area shows more particles with E Ea

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| 1.1  1.2  1.3 | EXERCISE 1  Define the term *reaction rate* in words.  Learners use the reaction between IMPURE POWDERED calcium carbonate and excess hydrochloric acid to investigate reaction rate. The balanced equation for the reaction is:  CaCO3(s) + 2HCℓ(aq) → CaCℓ2(aq) + H2O(ℓ) + CO2(g)  They perform four experiments under different conditions of concentration, mass and temperature as shown in the table below. They use identical apparatus in the four experiments and measure the volume of gas released in each experiment.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **Experiment** | | | | |  | **1** | **2** | **3** | **4** | | Concentration of acid (mol·dm-3) | 1 | 0,5 | 1 | 1 | | Mass of impure calcium carbonate (g) | 15 | 15 | 15 | 25 | | Initial temperature of acid (°C) | 30 | 30 | 40 | 40 |   The results of experiments **1** and **3** are compared in the investigation.  Write down the:  1.2.1 Independent variable  1.2.2 Dependent variable  Use the collision theory to explain why the reaction rate in experiment **4** will be higher than that in experiment **3**.  Learners obtain graphs **A, B, C and D** below for their results. | (2)  (1)  (1)  (3) |
| 1.4 | Which ONE of the graphs **(A, B, C or D)** represents **Experiment 1**? Explain the answer by comparing **Experiment 1** with **Experiments 2, 3** and **4.** | (6) |
| 1.5 | When the reaction in **Experiment 4** reaches completion, the volume of gas formed is 4,5 dm3. Assume that the molar gas volume at 40°C is equal to 25,7 dm3∙mol-1.  Calculate the mass of the impurities present in the calcium carbonate. | (5)  **[18]** |