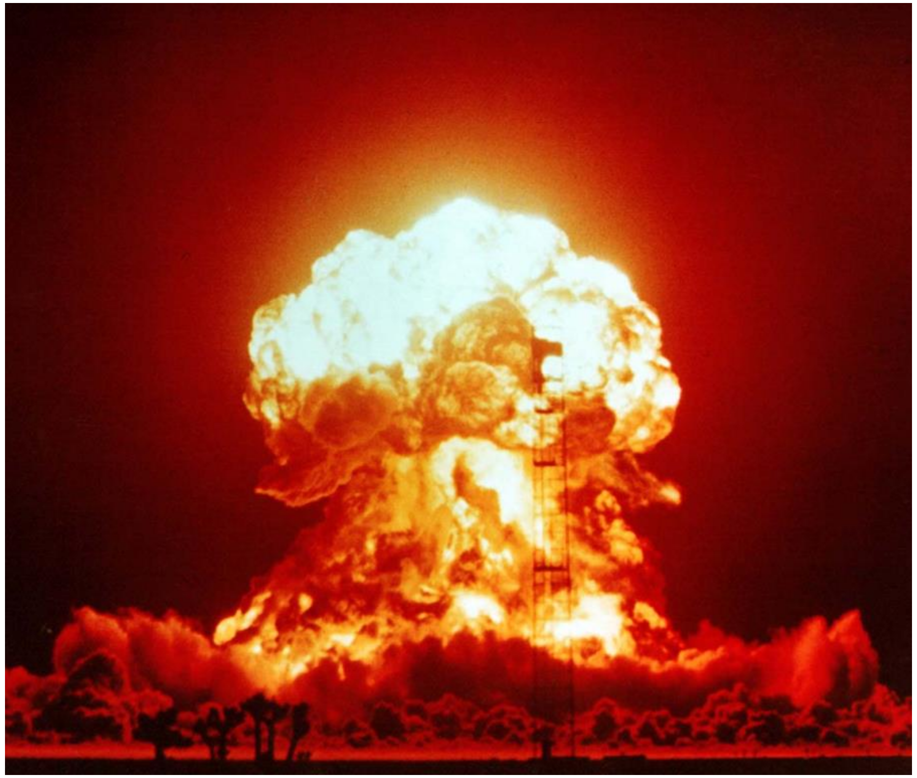
Factors Affecting Reaction Rate



Outcomes:

- Formulate an operational definition of reaction rate.
- State the collision theory.
- Perform a lab to identify factors that affect reaction rate.
- Describe, qualitatively, the relationship between factors that affect the rate of a reaction and the relative rate of a reaction.

Reaction Rates:

The **RATE** of the **DISAPPEARANCE** of the **REACTANTS** or the **RATE** of the **APPEARANCE** of the **PRODUCTS** over a given amount of **TIME**.

***Collision Theory* states:**

- In order for a **CHEMICAL REACTION** to occur, the reacting **PARTICLES** (**MOLECULES**/**ATOMS**) must **COLLIDE** with each other. If the particles do not **COLLIDE**, no **REACTION** occurs.

  ****Not all collisions produce a reaction.***

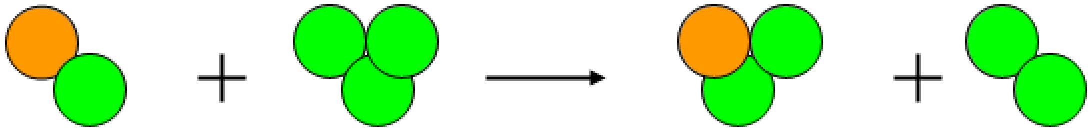
- The particles must **COLLIDE** with the **CORRECT ORIENTATION,** in the **APPROPRIATE PROPORTION**, with the right amount of **ENERGY**.

Reaction Rates:

For Example:

In the atmosphere, **OZONE** is converted to **O_2** and **NO_2** by reacting with **NITROGEN MONOXIDE**, according to this reaction:

$$NO(g) \quad + \quad O_3(g) \quad \rightarrow \quad NO_2(g) \quad + \quad O_2(g)$$



- If the **OXYGEN** atoms collide **NO REACTION** occurs. But if the **NITROGEN** atom collides with an **OXYGEN** atom the reaction **PROCEEDS**.

Particles must also collide with enough **ENERGY** to **BREAK** and **MAKE BONDS**.

This energy is called **KINETIC ENERGY *(K.E.)***. If the colliding particles **DO NOT** possess sufficient ***K.E.*** the reaction will **NOT PROCEED**.

→ Also known as **ACTIVATION ENERGY**.

Factors Affecting Rate:

1. **The Nature (type) of Reactants**

The **NUMBER** and **TYPE** of **BONDS** that are required to be **CREATED** and **BROKEN** in a chemical reaction **AFFECTS** the **RATE** of reaction.

i) ***The fewer the number of bonds broken, the faster the rate.***

- For example:
  - the reaction: $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ is **FAST**
  - The reaction: $2C_8H_{18(l)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(g)}$ is **SLOW**

The formation of **NO_2** requires the breaking of only **1 COVALENT BOND** whereas the combustion of octane reaction requires the breaking of over **50 BONDS**.

Factors Affecting Rate:

1. **The Nature (type) of Reactants**

ii) ***The type of bonds to be broken***

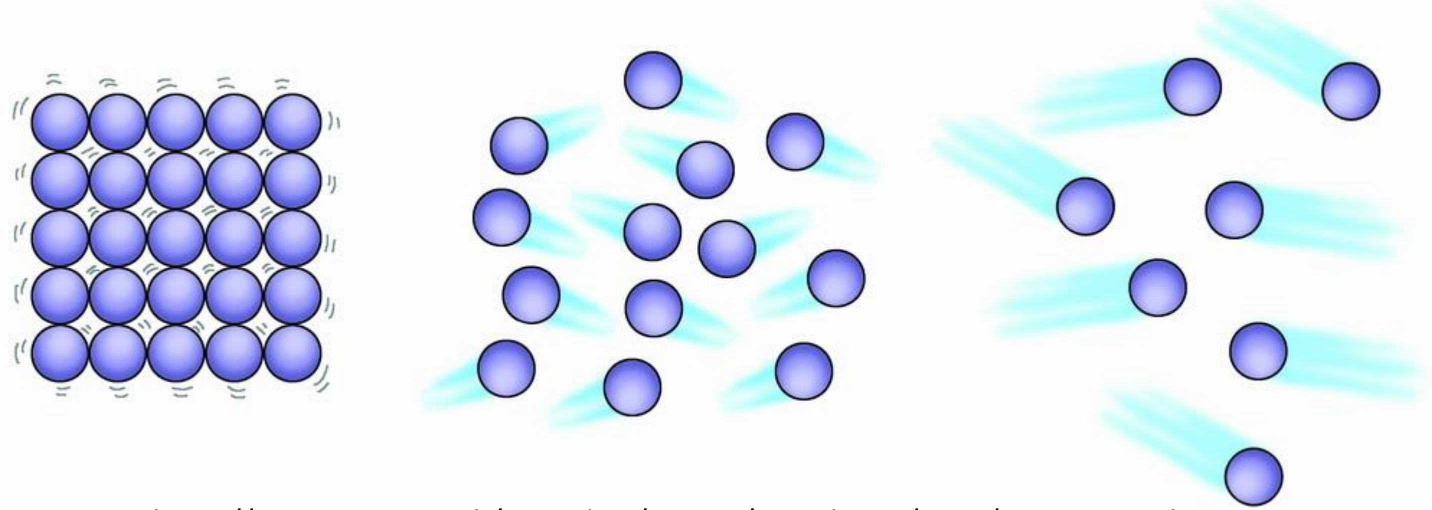
- Reactions between **IONIC** substances in **AQUEOUS SOLUTIONS** occur very **RAPIDLY** because there is no **ELECTRON REARRANGEMENT**.
- Reactions in which **COVALENT** bonds must be **BROKEN** occur very **SLOWLY** (at room temp) because they require **ELECTRON REARRANGEMENT**.

<u>Factors Affecting Rate:</u>

1. **<u>The Nature (type) of Reactants</u>**

iii) The state/phase of reactants

- Reactions with **<u>GASES</u>** are usually **<u>FASTER</u>** than those with **<u>LIQUIDS</u>**, but **<u>BOTH</u>** are **<u>FASTER</u>** than **<u>SOLIDS</u>**. Aqueous ionic is fastest
- **<u>HOMOGENEOUS</u> <u>REACTIONS</u>** (reactants in **<u>SAME</u> <u>STATE</u>**)are faster than **<u>HETEROGENEOUS</u> <u>REACTIONS</u>** (reactants in **<u>DIFFERENT</u>** states)

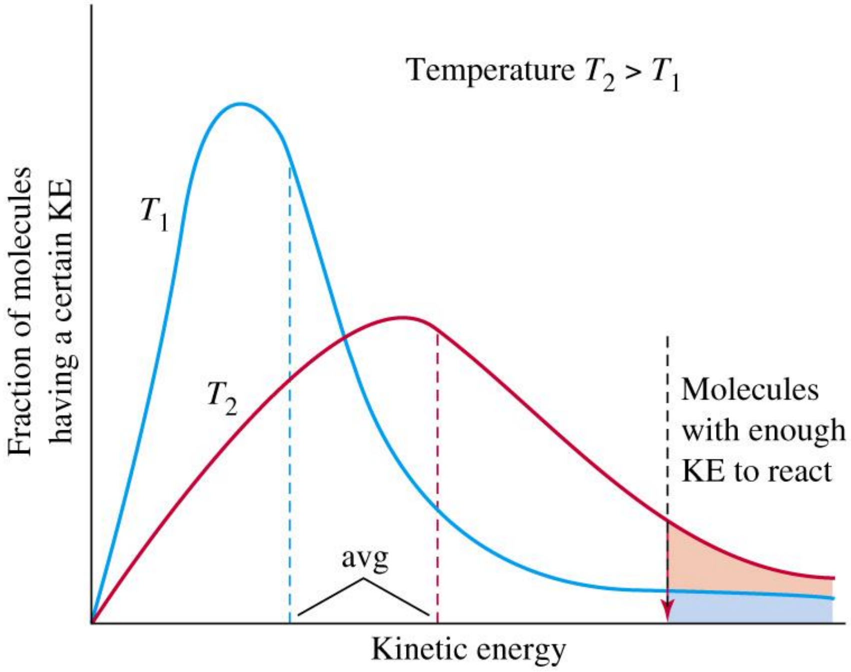


https://www.patana.ac.th/secondary/science/anrophysics/unit5/commentary.htm

Factors Affecting Rate:

2. Temperature:

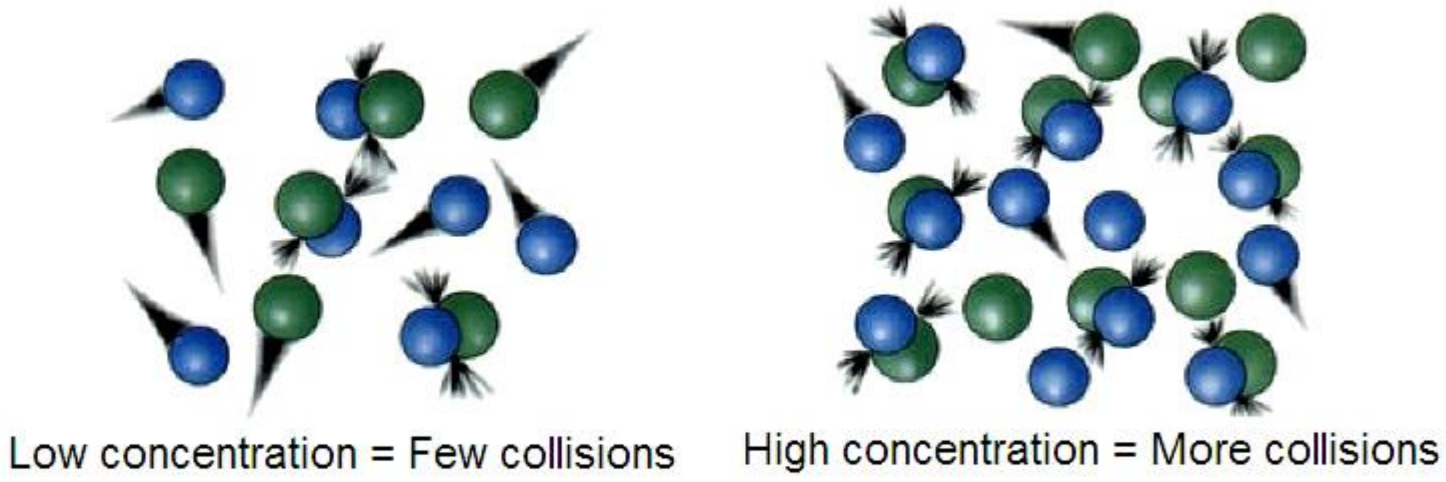
- According to **KINETIC MOLECULAR THEORY**, the **K.E** (**SPEED**) of molecules **INCREASES** with the **TEMPERATURE** increase causing **MORE COLLISIONS**.
- As **ENERGY INCREASES**, a greater number of molecules acquire more **KINETIC ENERGY**.
- **INCREASE** the **TEMPERATURE**, **INCREASE** reaction **RATE**.



Factors Affecting Rate:

3. Concentration:

- The **MORE MOLECULES**, more **COLLISIONS** occur between molecules → **LESS SPACE** between them.
- **INCREASING** the number of **PARTICLES** in a container will also **INCREASE** the **CHANCES** of a **COLLISION**.



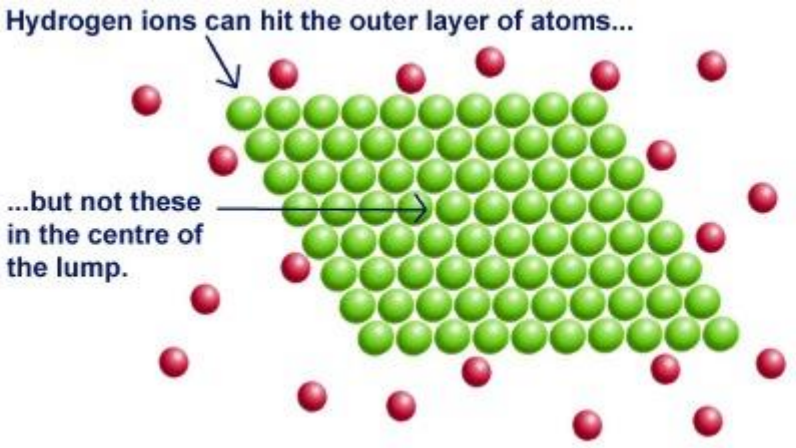
https://en.wikipedia.org/wiki/Chemical_kinetics

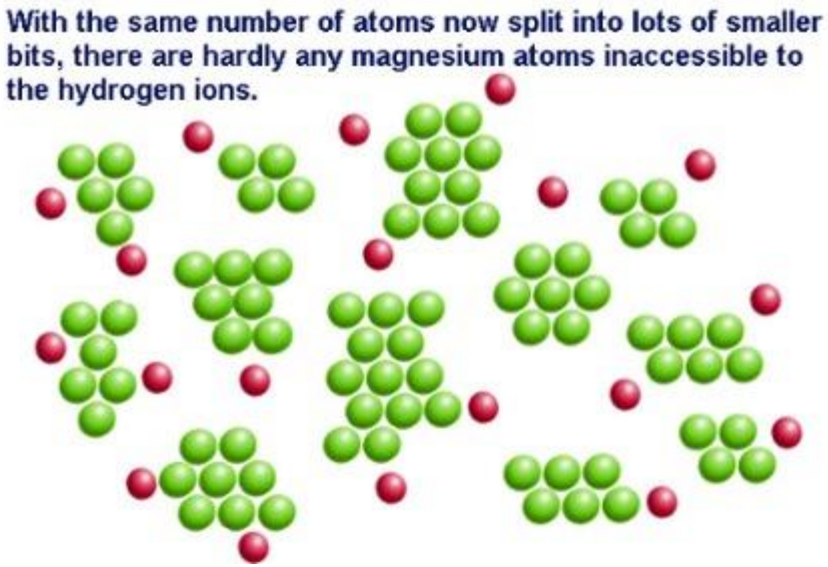
- **DECREASE VOLUME**, **INCREASE CONCENTRATION**, which results in an **INCREASE** of **COLLISIONS** and possible combinations of collisions.
- **INCREASE CONCENTRATION**, **INCREASE** in reaction **RATES**

Factors Affecting Rate:

4. Surface area (solids/liquids):

- **GRINDING**, pulverizing of solids produces **SMALLER PIECES**, which are available for chemical reactions.
- **INCREASE SURFACE AREA**, **INCREASE REACTION RATE**.



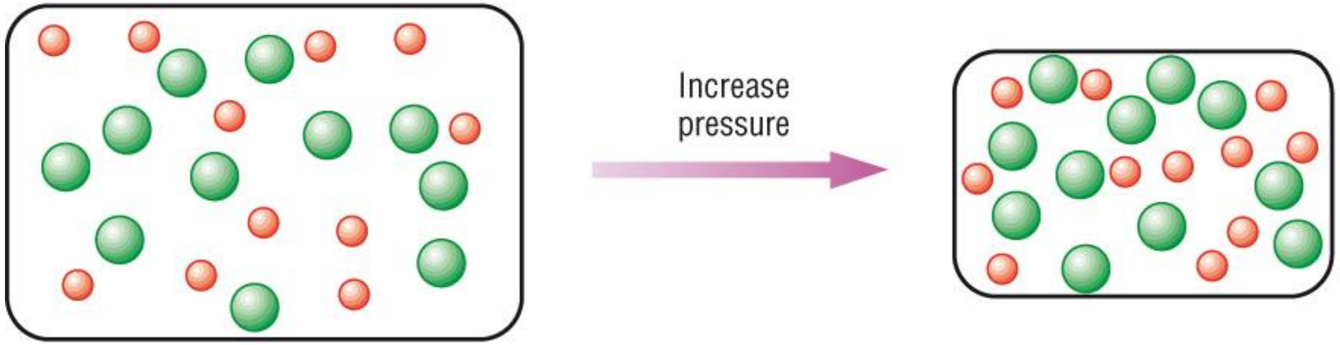


https://www.cdli.ca/sampleResources/chem3202/unit01_org01_ilo03/b_activity.html

Factors Affecting Rate:

5. Pressure (gases only):

- There are 3 ways to change pressure:
    - **DECREASE** or **INCREASE VOLUME**.
    - **ADD** more **PRODUCT** or **REACTANT**
    - **ADD** an **INERT** or **UNREACTIVE GAS**
- A **DECREASE** in **VOLUME** results in an **INCREASE** in **CONCENTRATION**, similarly an **INCREASE** in **VOLUME** will **DECREASE** the **CONCENTRATION**.
- **INCREASE** in **PRESSURE INCREASE** reaction **RATE**.



Here we have a number of gaseous molecules. The molecules have space to move around and there is little chance of a collision.

Increasing the pressure decreases the volume and increases the concentration. The molecules have less space to move in and are more likely to collide.

http://www.chemhume.co.uk/ASCHEM/Unit%203/14%20Reaction%20rates/Ratesc.htm

Factors Affecting Rate:

6. Catalysts:

- A substance that **ALTERS** reaction rates (**SPEEDS** them up). There are 2 types:

i) ***Heterogenous catalyst***

- **DIFFERENT PHASE** as the **REACTANTS**. It provides a **SURFACE** where the reaction can **TAKE PLACE**.

ii) ***Homogenous catalyst***

- **SAME PHASE** as the **REACTANTS**. It **PROVIDES** or forms an **INTERMEDIATE COMPOUND** for the reactants to react **UPON**.

Factors Affecting Rate:

6. Catalysts:

- Catalysts are **NEVER USED** up or permanently **CHANGED** during a chemical **REACTION**.
- Catalysts **SPEED** up chemical reactions by **LOWERING** the **ACTIVATION ENERGY**.