Rate of Reaction

- **The rate of a reaction can be measured by the rate at which a *reactant* is used up, or the rate at which a *product* is formed.**
- **Chemical reactions can only happen if reactant particles collide with enough energy. The more frequently particles collide, and the greater the proportion of collisions with enough energy, the greater the rate of reaction.**

Rates of reaction

Different reactions can happen at different rates.

Reactions that happen slowly → have a low rate of reaction. Eg chemical **weathering** of rocks

Reactions that happen quickly→ have a high rate of reaction. Eg. Explosions

Reactants and products

There are two ways to measure the rate of a reaction:

1. Measure the rate at which a *reactant* is used up
2. Measure the rate at which a *product* is formed

The method chosen depends on the reaction being studied. Sometimes it is easier to measure the change in the amount of a reactant that has been used up; sometimes it is easier to measure the change in the amount of product that has been produced.

Things to measure

The measurement depends on the nature of the reactant or product:

- The mass of a substance - solid, liquid or gas → measured with a balance
- The volume of a gas is usually measured with a gas syringe, or sometimes an upside down measuring cylinder or burette

It is usual to record the mass or total volume at regular intervals and plot a graph. The readings go on the vertical axis, and the time goes on the horizontal axis.

$$\text{rate of reaction} = \frac{\text{amount of reactant used or amount of product formed}}{\text{time taken}}$$

For example, if 24 cm^3 of hydrogen gas is produced in two minutes,

Calculate the mean rate of reaction = 24 ÷ 2 = 12 cm^3 hydrogen / min.

Factors affecting the rates of reaction

You will be expected to remember the factors that affect the rate of reactions, and to plot or interpret graphs from rate experiments.

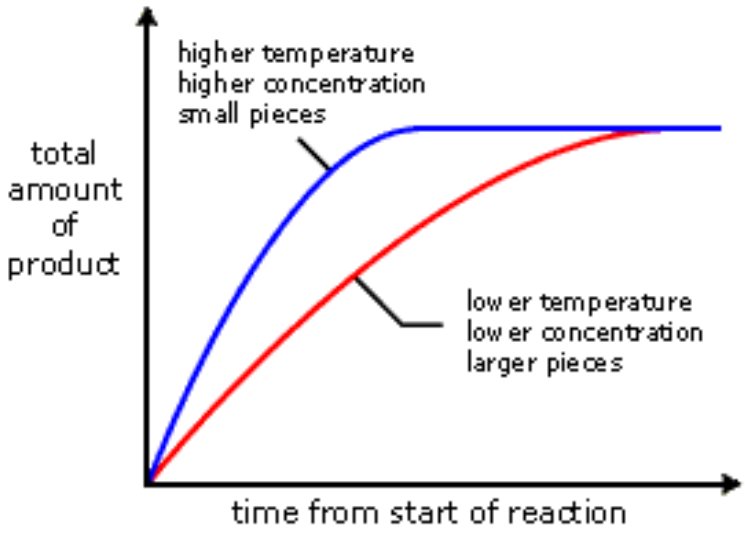
The rate of a reaction depends on,

1. **Temperature**
2. **Concentration**
3. **Pressure of reacting gases**
4. **Surface area of reacting solids**
5. **Use of catalysts**

How to increase the rate of a reaction

The rate of a reaction increases **if:**

- The temperature is increased
- The *concentration* of a dissolved *reactant* is increased
- The pressure of a reacting gas is increased
- Solid reactants are broken into smaller pieces
- A *catalyst* is used



Rate of reaction and changing conditions

The graph above summarises the differences in the rate of reaction at different temperatures, concentrations and size of pieces. The steeper the line, the greater the rate of reaction. Reactions are usually fastest at the beginning, when the concentration of reactants is greatest. When the line becomes horizontal, the reaction has stopped

Collisions

- For a chemical reaction to occur, the *reactant* particles must collide. Collisions with too little energy do not produce a reaction.
- The collision must have enough energy for the particles to react. The *minimum energy* ***needed*** **for particles to react is called** the **activation energy**.

Changing concentration or pressure

If the **concentration of a dissolved reactant** is i**ncreased, or the pressure of a reacting gas is increased**:

- There are more reactant particles in the same volume
- There is a greater chance of the particles colliding
- The rate of reaction increases

Changing particle size

If a solid reactant is broken into small pieces or ground into a powder:

- Its **surface area is increased**
- More particles are exposed to the other reactant
- There is a greater chance of the particles colliding
- The rate of reaction increases

Changing the temperature

If the temperature is increased:

- The reactant particles move more quickly
- More particles have the activation energy or greater
- The particles collide more often, and more of the collisions result in a reaction
- The rate of reaction increases

Using a catalyst

Catalysts increase the rate of reaction without being used up. They do this by lowering the activation energy needed. With a catalyst, more collisions result in a reaction, so the rate of reaction increases. Different reactions need different catalysts.

Catalysts are important in industry because they reduce costs.

Effect of catalysts

A *catalyst* is a substance that can increase the rate of a reaction. The catalyst itself remains unchanged at the end of the reaction it catalyses. Only a very small amount of catalyst is needed to increase the rate of reaction between large amounts of reactants.

Different catalysts catalyse different reactions. The table summarises some common catalysts used in industry and the reactions they catalyse

Catalyst	Reaction catalysed
Iron	Making ammonia from nitrogen and hydrogen
Platinum	Making ammonia from nitrogen and hydrogen
Vanadium(V) oxide	Making sulfuric acid

Catalytic converters

Modern cars have a catalytic converter to help reduce the production of toxic gases. Catalytic converters use a platinum and rhodium catalyst with a high surface area. This increases the rate of reaction of carbon monoxide and unburnt fuel from exhaust gases with oxygen from the air. The product from this is carbon dioxide and water, which is less harmful to the environment. The catalysts are designed to work best at the high temperatures found in the engine