Theories on rates of reaction

Some reactions are slow, and some reactions are fast, it depends on the rate of reaction. The collision Theory helps to explain 2 things:

1. It helps explain how chemical reactions occur.
2. It also helps explain why the rates of reaction are different for different reactions.

When a reaction occurs slowly, this means they have a low rate of reaction. When a reaction occurs very fast, this means they have a high rate of reaction. In the Collision Theory, it suggests that for a chemical reaction to take place, the particles of the reactants must collide. Particles of a reactant must have energy to collide, and to produce a reaction, but if they don’t have enough energy to collide then the particles do not produce a reaction. The Activation Energy is when the smallest amount of energy required for a chemical reaction to occur.

There are lots of factors which affect the rate at which the reactant particles collide. The main factor which is going to be mentioned in this is Concentration. If the concentration of a a substance is increased, then there will be more particles in the substance

Some reactions are slow, such as rusting, and some are fast, like burning. The rate of reaction depends on the temperature and concentration of the reactants, and the surface area of any solid reactants.

The rate of reaction can be found by measuring the amount of reactant used up, or the amount of product formed, in a given time. Catalysts increase the rate of a reaction without being changed themselves by the end of the reaction.

Collision theory

Different reactions can happen at different rates. Reactions that occur slowly have a low rate of reaction. Reactions that happen quickly have a high rate of reaction. For example, rusting is a slow reaction: it has a low rate of reaction. Burning and explosions are very fast reactions: they have a high rate of reaction.

Collisions

For a chemical reaction to occur, the reactant particles must collide. But collisions with too little energy do not produce a reaction.

The particles must have enough energy for the collision to be successful in producing a reaction.

The rate of reaction depends on the rate of successful collisions between reactant particles. The more successful collisions there are, the faster the rate of reaction.

Measuring rates of reaction

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

- measure the rate at which a reactant is used up
- 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 a product that has been produced.

Things to measure

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

- the mass of a substance – solid, liquid or gas – is 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

Effect of temperature and concentration

The rate of a chemical reaction can be increased by raising the temperature. It can also be increased by increasing the concentration of a reactant in solution, or the pressure of a reactant gas.

Changing the temperature

If the temperature is increased:

- the reactant particles move more quickly
- they have more energy
- the particles collide more often, and more of the collisions result in a reaction
- the rate of reaction increases

Changing the concentration or pressure

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

- the reactant particles become more crowded
- there is a greater chance of the particles colliding
- the rate of reaction increases

Effect of surface area

The rate of a chemical reaction can be raised by increasing the surface area of a solid reactant. This is done by cutting the substance into small pieces, or grinding it into a powder.

Changing the surface area

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

- its surface area increases
- more particles are exposed to the other reactant
- there are more collisions
- the rate of reaction increases

Explosions

Explosions are very fast reactions in which a lot of gaseous product is released very quickly. For example:

- burning hydrogen
- explosions from TNT or dynamite

Fine powders can also cause explosions – for example, custard powder, flour or sulfur. This is a particular hazard in factories. Great care is needed to avoid naked flames or other sources of ignition.

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:

Some common catalysts used in industry and the reactions they catalyse

Calculating rates – higher

The faster the rate, the more reactant is used, or product is made, in a given time. The faster the reaction, the steeper the line on a graph showing total product against time will be.

A reaction finishes when one of the reactants is all used up. No more product is made, so the line on a graph of total product against time will become horizontal.

The rate can be calculated using this equation:

rate of reaction = total amount of reactant used or product made ÷ time taken