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EB Education Revision Guide

How to work with Rates of Reaction: Part 1

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Rates of Reaction

In a chemical reaction, the substances that react together are known as the **reactants**, while the substances that are formed are known as the **products**.

Reactants are found on the left of a chemical equation and products on the right

Reactants $\longrightarrow$ Products

The rate of reaction is how quickly the reaction takes place. It is a measure of how quickly a reactant is used up, or a product is formed.

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

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Collision Theory

What is it?

In order for a chemical reaction to take place, the particles must collide with each other with enough energy and in the correct orientation.

If the collision produces a reaction it is known as a **successful collision**.

The minimum amount of energy needed to cause a reaction is the **activation energy**.

The rate of the reaction depends on:

- How often the particles collide (the collision frequency) and how successful the collisions are - the more successful collisions there are, the faster the reaction is.
- The energy transferred during a collision – particles need to collide with at least the activation energy for the collision to be successful.

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Collision Theory

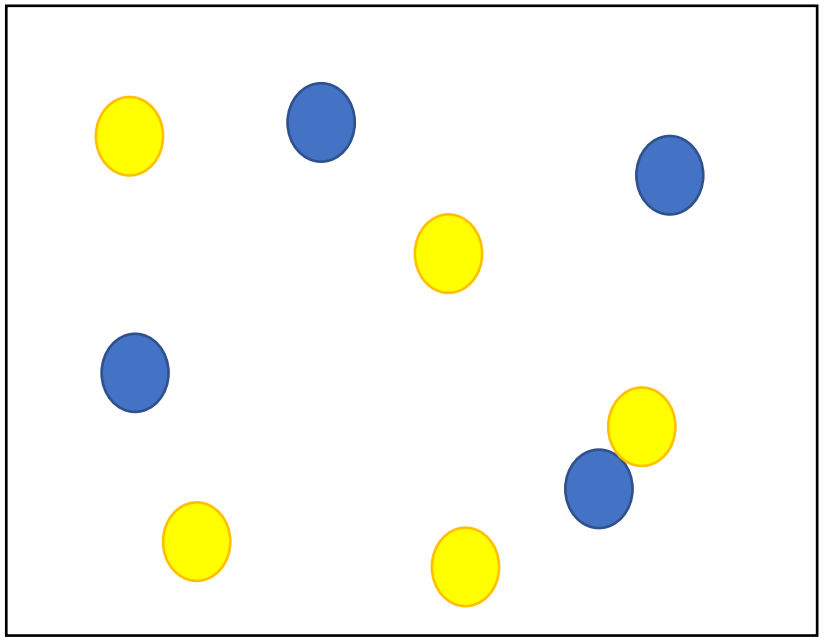
Factors affecting reaction rates

Increasing the number of collisions, or the energy with which particles collide will increase the rate of reaction.

The following factors all affect the rate of reaction:

- Temperature
- Surface Area
- Concentration (or pressure)
- Catalyst

(How catalysts increase the rate of reaction will be explained in Part 2 of our guide)

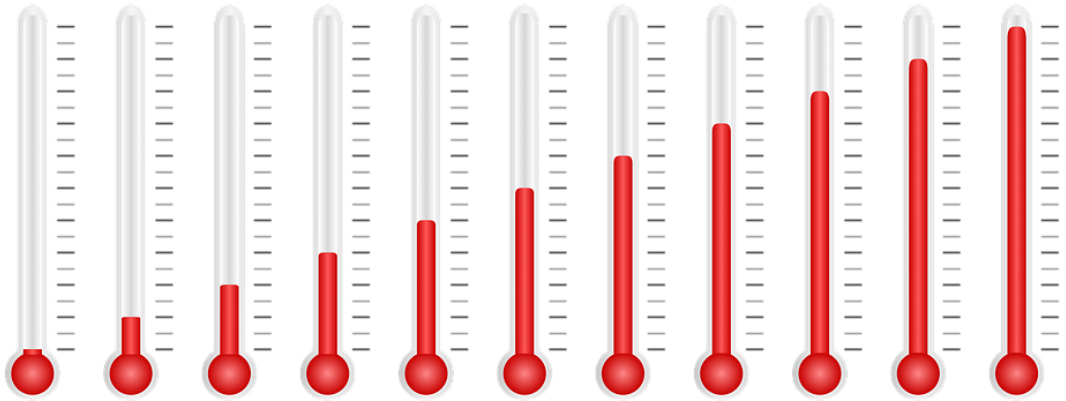


Temperature

How it affects the rate of reaction

If the temperature of a reaction is increased, the particles move faster. As they are moving faster, they collide more frequently.

The increase in temperature also increases the energy of the collisions, as the particles gain kinetic energy, increasing the likelihood that the particles will have enough activation energy to collide successfully too.



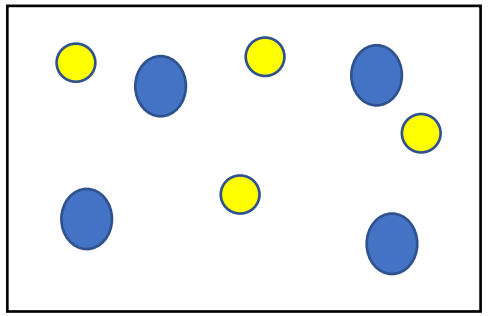
Concentration (or Pressure)

How it affects the rate of reaction

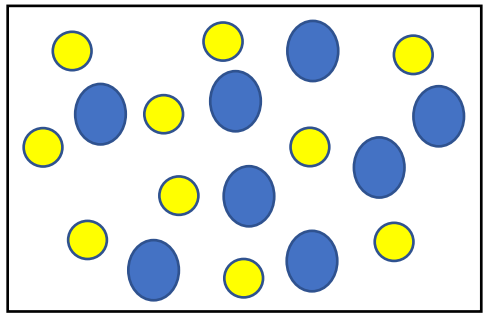
The more concentrated a solution is, the more particles of the reactant there will be in the same volume. This means it is more likely that particles will collide, and a greater chance of successful collisions. This will increase the reaction rate.

Increasing the pressure in a gas also means there are more particles in a smaller volume, they are moved closer together. This means the frequency of successful collisions will increase, and the rate of reaction will increase. This increase in pressure can be caused by reducing the volume.

Diagram



In this diagram there are only a few particles, resulting in fewer collisions. This means the rate of reaction is low.



In this diagram there are more particles, resulting in more collisions. This means the rate of reaction is faster.

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Surface Area

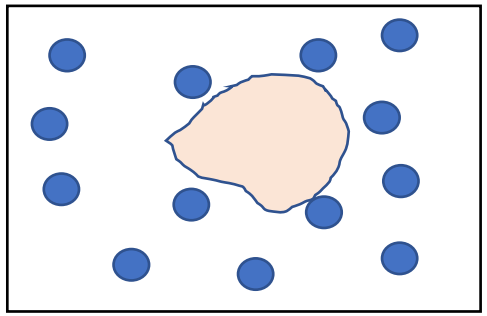
How it affects the rate of reaction

Breaking a reactant which is a solid into smaller pieces increases its surface area to volume ratio.

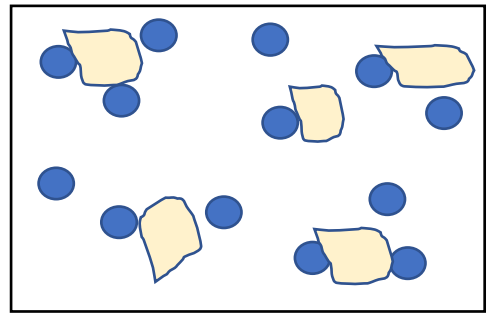
There will be more of the reactant particles exposed at the surface.

This means the other reactant particles will have a greater area where they can collide. As such, there will be an increased chance of successful collisions, the rate of reaction will increase.

Diagram



In this diagram there is a slower reaction as there is a smaller surface area.



The rate of reaction increases because the particles are smaller, providing a greater surface area.

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Your turn:

1a) When marble chips react with hydrochloric acid, carbon dioxide is produced.
The equation for the reaction is shown below.

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

Which of the below changes would **decrease** the rate of reaction?

A. Use smaller sized marble chips
B. Use marble chips which have a larger surface area
C. Use hydrochloric acid which is more dilute
D. Use a larger volume of the hydrochloric acid

b) Explain why increasing the temperature of a reaction increases the rate of reaction.

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c) If a reaction takes place in a solution, the rate of reaction is affected by the concentration in the solution.
Explain why the rate of reaction increases when the concentration of one of the reactants is increased.

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d) During any reaction, the rate of reaction decreases as the reactants are used up.

Explain in terms of particles why the rate of reaction decreases.

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Your turn:

e) When particles collide, reactions can occur.
Rates of reactions can be changed by changing conditions.

Explain how the rate of reaction between a liquid and a solid is altered by changing the temperature of the liquid and the size of the pieces of the solid.

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2a) Abi investigated the rate of a reaction between zinc and sulphuric acid. These react together to produce zinc sulphate and hydrogen.

Write the balanced equation for this reaction.

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b) She carried out two experiments, using the same mass of zinc and the same sized pieces of zinc.
Her results are shown below.

	Experiment 1	Experiment 2
Concentration of sulphuric acid (mol $dm^{-3)}$	0.5	1.5
Temperature (°C)	25	45
Rate of reaction	slow	fast

Evaluate these results, explaining why the rate of reaction in Experiment 2 is faster than the rate of reaction in Experiment 1.

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Answers:

1a) When marble chips react with hydrochloric acid, carbon dioxide is produced.
The equation for the reaction is shown below.

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

Which of the below changes would **decrease** the rate of reaction?

A. Use smaller sized marble chips
B. Use marble chips which have a larger surface area
C. Use hydrochloric acid which is more dilute X
D. Use a larger volume of the hydrochloric acid

b) Explain why increasing the temperature of a reaction increases the rate of reaction.

Particles/reactants have more energy. This means they will move faster and there will be more frequent collisions. More particles have the required activation energy so there will be more successful collisions.

c) If a reaction takes place in a solution, the rate of reaction is affected by the concentration in the solution.
Explain why the rate of reaction increases when the concentration of one of the reactants is increased.

There will be more particles in the same volume. This will result in more frequent collisions between the reactant particles and the rate of reaction will increase.

d) During any reaction, the rate of reaction decreases as the reactants are used up.

Explain in terms of particles why the rate of reaction decreases.

There will be fewer particles to react as the reactants are used up. This means there will be fewer collisions and the rate of reaction will decrease.

Answers:

e) When particles collide, reactions can occur.
Rates of reactions can be changed by changing conditions.

Explain how the rate of reaction between a liquid and a solid is altered by changing the temperature of the liquid and the size of the pieces of the solid.

Smaller pieces of solid:
If the solid is cut into smaller pieces, it will have a larger surface area. This will result in more frequent collisions and a higher rate of reaction.

Higher temperature:
This will result in the particles moving faster, therefore more frequent collisions.
The particles have more energy, so there will be more collisions at the activation energy levels, so more successful collisions, and a higher rate of reaction.

2a) Abi investigated the rate of a reaction between zinc and sulphuric acid. These react together to produce zinc sulphate and hydrogen.

Write the balanced equation for this reaction.

$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

b) She carried out two experiments, using the same mass of zinc and the same sized pieces of zinc.
Her results are shown below.

	Experiment 1	Experiment 2
Concentration of sulphuric acid (mol dm^{-3})	0.5	1.5
Temperature (°C)	25	45
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Evaluate these results, explaining why the rate of reaction in Experiment 2 is faster than the rate of reaction in Experiment 1.

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Answers:

b) She carried out two experiments, using the same mass of zinc and the same sized pieces of zinc.
Her results are shown below.

	Experiment 1	Experiment 2
Concentration of sulphuric acid (mol $dm^{-3)}$	0.5	1.5
Temperature (°C)	25	45
Rate of reaction	slow	fast

Evaluate these results, explaining why the rate of reaction in Experiment 2 is faster than the rate of reaction in Experiment 1.

Reactions occur when particles collide.
More frequent collisions cause a higher rate of reaction.
Mass and size of zinc pieces are the same, so this has no effect on rate of reaction because they are the same surface area.
Two factors have been altered – so cannot be certain of the effect of each.

Concentration:
Experiment 2 – triple concentration of acid, so more particles in the same volume, so more frequent successful collisions.

Temperature:
Experiment 2 – higher temperature.
Particles move faster as they have more energy, so more frequent collisions and increased rate of reaction.
More energetic collisions between particles as more particles have the activation energy required to react.

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