

Reaction rates 3: Controlling reactions

Components

NAME	DESCRIPTION	AUDIENCE
	<i>Controlling reactions</i> teacher guide	The guide shows how this resource may be used to explain concepts of collision theory, energy profile diagrams and kinetic energy distribution graphs.
	<i>Looking at reactions</i> learning object	Computer animations show students relationships between reaction rates, collision theory, energy profile diagrams and kinetic energy.
	<i>Factors affecting reactions</i> worksheet	This student worksheet questions students' understandings of concepts demonstrated in the learning object.

Purpose

To **Explain** to students, the relationship between reaction rates, collision theory, energy profile diagrams and kinetic energy distribution graphs, through the use of computer animations.

Outcomes

Students:

- explain rates of different reactions in terms of energy changes and collision theory;
- interpret energy profile diagrams to show transition state, activation energy, uncatalysed and catalysed pathways, and heat of reaction; and
- explain the relationship between collision theory, kinetic energy distribution graphs, and rate of reaction.

Activity summary

ACTIVITY	POSSIBLE STRATEGY
Students work through the computer-based learning object. This may be done in one lesson, but is best to complete over two or three lessons with supplementary class activities or discussion.	individuals or pairs (depending on computer access)
Students complete the worksheet while using the learning object.	individuals or in pairs

Use of the learning object

The learning object may be used together with the worksheet, *Factors affecting reactions*, to provide opportunities for discussion of concepts involved when considering reaction rates.

The first two screens in the learning object address two aspects of collision theory: energy of collisions and orientation of particles.

The screen titled 'Burning magnesium' explores bond-breaking and bond-making processes, and energy transfers that are involved.

The next screen explores effects of changing concentration, temperature and particle size (surface area to mass ratio) on reaction rate.

The screen titled 'Kinetic energy distribution' introduces the idea of activation energy and how it relates to energy distribution of a large number of molecules.

The screen 'Energy profile diagrams' may be used to explore energy changes within endothermic and exothermic reactions.

'Transition states' introduces the role of activated complexes in transition states within reactions. This enables later discussion of acid-catalysed reactions, such as decomposition of methanoic acid.

The final screen may be used to compare energy profile and energy distribution of uncatalysed and catalysed reactions.

Experiment to demonstrate the presence of a reaction intermediate

The reaction between hydrogen peroxide and tartaric acid is very slow at room temperature, without a catalyst. If cobalt (II) ions are added and the reaction mixture warmed, evolution of oxygen and carbon dioxide is readily observed. The effect of the catalyst is also easily observed as the solution changes from pink (CoCl_2) to green as the cobalt(III)-tartrate intermediate complex forms and the reaction becomes vigorous. As reactants are used up, the catalyst is regenerated as CoCl_2 and the pink colour returns.

Solutions required:

- 0.3M potassium sodium tartrate (dissolve 84.6 g $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ make up to 1.00 L of solution);
- 6% hydrogen peroxide (dilute 100 mL 30% H_2O_2 to make 500 mL of solution, or use 20 volume H_2O_2);
- 0.3M cobalt(II) chloride (dissolve 10.0 g to make up to 250 mL of solution).

Procedure:

Set up two beakers, one to be used as a control. Place 200 mL of potassium sodium tartrate solution and 65 mL of 6% hydrogen peroxide in each beaker and warm these to approximately 65 °C.

Point out that the reaction is proceeding very slowly, if at all, as no gas bubbles are visible.

Add 15 mL of pink cobalt chloride solution to one of the beakers. **TAKE CARE** as the reaction will be vigorous and may overflow. A green cobalt-tartrate activated complex will be visible throughout the reaction.

On completion of the reaction the pink colour of the cobalt chloride will return.

More reaction mixture from the control can be added to demonstrate that the catalyst has been regenerated and not consumed during the reaction.

Safety:

Handle hydrogen peroxide with care – gloves and safety glasses are recommended. Watch out for splattering during the catalysed reaction.

Technical requirements

The learning object can be placed on a web or file-server and run either locally or remotely in a web browser. It requires Adobe Flash Player version 8 or later on the client machine (this is a free download from adobe.com).

The guide and worksheet require Adobe Reader (version 5 or later), which is a free download from adobe.com.

Acknowledgements

Image: 'Ice crystals on glass' by James. CC-BY-2.0, commons.wikimedia.org/wiki/File:Ice_crystals_on_glass.jpg

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Associated SPICE resources

Reaction rates 3: Controlling reactions may be used with related SPICE resources to address the broader topic of reaction rates.

DESCRIPTION	LEARNING PURPOSE
<p><i>Reaction rates (overview)</i></p> <p>This learning pathway shows how a number of SPICE resources can be combined to teach the topic of reaction rates.</p>	
<p><i>Reaction rates 1: Photochemical smog</i></p> <p>A video shows how environmental factors can increase chemical reactions that occur in the atmosphere, to produce photochemical smog.</p>	Engage
<p><i>Reaction rates 2: Investigating reaction rates</i></p> <p>Students investigate how they can change the rate of a real-life chemical reaction in the laboratory.</p>	Explore
<p><i>Reaction rates 3: Controlling reactions</i></p> <p>An interactive learning object explains relationships between reaction rates, collision theory, energy profile diagrams and kinetic energy distribution graphs.</p>	Explain
<p><i>Reaction rates 4: Enzymes</i></p> <p>Students extend their knowledge of catalysts by studying how enzymes work.</p>	Elaborate