Teaching Rates of Reaction Post-16

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Ideas and strategies to help your students get to grips with graphs when exploring reaction dynamics and mechanisms

Rates of reaction covers a broad range of practical, mathematical and conceptual ideas. You can open a window into the sub-microscopic world of reaction kinetics, mechanisms and energetics by applying experimental and empirical data obtained from rate of reaction experiments. This article explores how you can use graphical representations with your students to interrogate reaction dynamics and mechanisms.

The applications of reaction kinetics are critical in many areas. Students will be familiar with the Haber process and how the manipulation of factors can optimise yields. These play a key role in food technology and the making of chemicals and pharmaceuticals. Food producers require accurate information about the rates that foods deteriorate and the way factors such as levels of oxygen, microbes, light and temperature affect these reactions. Furthermore, understanding the timing for drugs to be absorbed into our body and the time for elimination is critical.

What students need to know

To understand the importance of applying reaction kinetics to reveal potential reaction mechanism and energetics profiles, students should have a good grasp of:

- what constitutes a chemical reaction and how we measure and record the rate of a reaction;
- how to represent the changes in a reaction by applying graphical approaches;
- the chemical significance of the slope and intercept of a rate graph;
- the construction and use of straight-line graphs ($y=mx+c$).

Threshold concepts

Students’ confidence in understanding reaction kinetics requires a good understanding of controlling variables and representing them graphically (seeing how concentration of reactants influences the rate of a reaction); the power series and their manipulation; and the concept of a rate determining step. Download the checklist to get more detail on these concepts and how to present them to students.

Staying with real-world applications, you can link students’ rates of reaction knowledge with the ever-increasing need to develop antibiotics to fight infections caused by bacteria. For background reading, share the article, Antibiotics: solving an evolving problem, with students. Ask them to sketch graphs for first and zero order antibiotic–pathogen interactions and suggest possible mechanisms. Can they support their mechanism using a model? You can then ask them to write a possible rate equation for the interaction between the antibiotic and the pathogen. In small groups or as a class discussion, you can then ask students what other interactions or reactions might influence the rate determining step in these processes.

Antibiotics and fighting infections

The rate at which an antibiotic molecule binds with a target pathogen can be conceptualised as $A + T = AT$ (A = antibiotic, T = target). Most antibiotic interactions with pathogens are either zero or first order processes. Some antibiotics need to be delivered over a range of time intervals, so coatings that degrade at different rates in the blood stream have been developed. You could also introduce an investigation angle and ask students to investigate the effectiveness of different glues using a rates approach or the decomposition of hydrogen peroxide using different catalysts. You might find some background reading useful to help your students build the foundations for their study of rates of reactions. There are helpful ideas for introducing the topic in the article, Rates of reactions; evidence-based teaching tips in 6 tips for teaching reaction rates using graphs, and an examination of teaching issues in Gradients and rates of change.

Video demonstrations can help students grasp some of the practical aspects of rates of reaction. The RSC has collated a selection of videos to that end; they cover monitoring the rate of reaction, identifying the effects of changing temperature and concentration, and using initial rate and continuous monitoring methods. To make the most of practical videos and ensure students learn from their viewing, try using some of the approaches, including flipped learning, outlined in this article. Assessment Assessing understanding is always done best by observing how students apply their knowledge. The examples above provide students with challenging scenarios in which to apply their knowledge and understanding of rates. The RSC's Starters for 10 on kinetics offers assessment activities on collision theory and sketching Maxwell–Boltzmann and the importance of Maxwell–Boltzmann. You'll also find the Starters for 10: Advanced level 2 on kinetics useful for assessing the rate determining step, calculating reaction rate and determining the rate equation plus Arrenhius and rate

Take-home points

- Use real-life examples of reaction rates to highlight the relevance of the topic and engage students. For example, understanding reaction mechanisms can optimise yields, thereby saving money, or enhance the efficacy of medication.
- Assess students' understanding by looking at how they apply their knowledge to different questions and scenarios.
- Use demos and videos to cover the practical aspects of the topic with demos or videos.

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