Summary

Chemical Kinetics Unit 6 and 16

Subject	Year	Start date	Duration
Chemistry	IB1	Week 2, February	4 weeks 10 hours

Course Part

Core Curriculum - Chemical Kinetics Unit 6 and Higher Level extension - Unit 16

Description

We live in a dramatically active world. We are being bombarded by molecules travelling at incredible speeds every moment of our lives. There are a staggering number of collisions and reactions taking place in our bodies at any one moment in time. We, and the lives we lead, are the stuff of chemistry; the product of millions of successful and productive collisions taking place in and around us.

What controls the rate of chemical reactions? Some reactions are spontaneously fast – sometimes devastatingly so. Oxygen is a reactive gas, but not all of its reactions are fast. One economically significant reaction of oxygen is its reaction with iron, which we know as rusting. Vast sums of money are spent worldwide each year to protect objects from the consequences of this reaction. Thankfully, it is a relatively slow, progressive reaction that is sped up in the presence of acid rain or sea water

Curriculum

Aims

- Acquire a body of knowledge, methods and techniques that characterize science and technology
- Apply and use a body of knowledge, methods and techniques that characterize science and technology
- Develop an ability to analyse, evaluate and synthesize scientific information
- Develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities
- Develop experimental and investigative scientific skills including the use of current technologies

Objectives

Demonstrate knowledge and understanding of

- facts, concepts, and terminology
- methodologies and techniques
- communicating scientific information

Apply

- facts, concepts, and terminology
- methodologies and techniques

methods of communicating scientific information

Formulate, analyse and evaluate

hypotheses, research questions and predictions

methodologies and techniques

primary and secondary data

scientific explanations

Syllabus Content

Core

6. Chemical kinetics

6.1 Collision theory and rates of reaction

Nature of science:

The principle of Occam's razor is used as a guide to developing a theory - although we cannot directly see reactions taking place at the molecular level, we can theorize based on the current atomic models. Collision theory is a good example of this principle.

Understandings:

Species react as a result of collisions of sufficient energy and proper orientation.

The rate of reaction is expressed as the change in concentration of a particular reactant/product per unit time.

Concentration changes in a reaction can be followed indirectly by monitoring changes in mass, volume and colour.

Activation energy (Ea) is the minimum energy that colliding molecules need in order to have successful collisions leading to a reaction.

By decreasing Ea , a catalyst increases the rate of a chemical reaction, without itself being permanently chemically changed.

Applications and skills:

Description of the kinetic theory in terms of the movement of particles whose average kinetic energy is proportional to temperature in Kelvin.

Analysis of graphical and numerical data from rate experiments.

Explanation of the effects of temperature, pressure/concentration and particle size on rate of reaction.

Construction of Maxwell–Boltzmann energy distribution curves to account for the probability of successful collisions and factors affecting these, including the effect of a catalyst.

Investigation of rates of reaction experimentally and evaluation of the results.

Sketching and explanation of energy profiles with and without catalysts.

Additional higher level

16. Chemical kinetics

16.1 Rate expression and reaction mechanism

Nature of science:

Principle of Occam's razor - newer theories need to remain as simple as possible while maximizing explanatory power. The low probability of three molecule collisions means stepwise reaction mechanisms are more likely.

Understandings:

Reactions may occur by more than one step and the slowest step determines the rate of reaction (rate determining step/RDS).

The molecularity of an elementary step is the number of reactant particles taking part in that step.

The order of a reaction can be either integer or fractional in nature. The order of a reaction can describe, with respect to a reactant, the number of particles taking part in the rate-determining step.

Rate equations can only be determined experimentally.

The value of the rate constant (k) is affected by temperature and its units are determined from the overall order of the reaction.

Catalysts alter a reaction mechanism, introducing a step with lower activation energy.

Applications and skills:

Deduction of the rate expression for an equation from experimental data and solving problems involving the rate expression.

Sketching, identifying, and analysing graphical representations for zero, first and second order reactions.

Evaluation of proposed reaction mechanisms to be consistent with kinetic and stoichiometric data.

16.2 Activation energy

Nature of science:

Theories can be supported or falsified and replaced by new theories - changing the temperature of a reaction has a much greater effect on the rate of reaction than can be explained by its effect on collision rates. This resulted in the development of the Arrhenius equation which proposes a quantitative model to explain the effect of temperature change on reaction rate.

Understandings:

The Arrhenius equation uses the temperature dependence of the rate constant to determine the activation energy.

A graph of 1/T against ln k is a linear plot with gradient $-E_a/R$ and intercept, lnA.

The frequency factor (or pre-exponential factor) (A) takes into account the frequency of collisions with proper orientations.

Applications and skills:

Analysing graphical representation of the Arrhenius equation in its linear form $\ln k=-E_a/RT+\ln A$.

Using the Arrhenius equation $k=Ae(-E_a/RT)$.

Describing the relationships between temperature and rate constant; frequency factor and complexity of molecules colliding.

Determining and evaluating values of activation energy and frequency factors from data.

ATL Skills

Approaches to Learning

Thinking

- In this unit, we will

  ask students to formulate a reasoned argument to support their opinion or conclusion

  give students time to think through their answers before asking them for a response

  reward a new personal understanding, solution or approach to an issue

  ask open questions

  set students a task which required higher-order thinking skills (such as analysis or evaluation)

  build on a specific prior task

  help students to make their thinking more visible (for example, by using a strategy such as a thinking routine)

  require students to take an unfamiliar viewpoint into account when formulating arguments

  ask questions that required the use of knowledge from a different subject from the one you are teaching

  include a reflection activity

  make a link to TOK

Communication

- In this unit, we will

  ask students to explain their understanding of a text or idea to each other

  construct a task around the use of different vocabulary and examples when speaking to different audiences

  have students give an oral presentation without reading from their notes

  ask students to monitor and check the quality of their writing

  construct a task so that students practise their listening skills

  assess or give feedback on speaking or writing concisely

  provide opportunities for students to read and understand different types of texts

  encourage or require students to plan a response before they begin

  ask students to formulate arguments clearly and coherently

  encourage all students to contribute to discussions

Research

- In this unit, we will

  require students to formulate/construct a focused research question (either in class or in a homework assignment)

  reward or encourage correct citing and referencing

  assign a task that required students to use the library

  require students to practise effective online search skills (for example, use of Booleans and search limiters)

  provide opportunities for students to reflect on how they determine the quality of a source, or analyse contradictory sources

  require students to record their search for sources in steps (types of search engines, search terms, and so on)

  give students advice on (or provide an opportunity for students to practise) narrowing the scope of a task to make it more manageable

  discuss or model the importance of academic honesty and clear acknowledgment of sources

Developing IB Learners

Learner Profile

Inquirers

Knowledgeable

Open-minded

Risk-takers (Courageous)