Summary

Energetics - Unit 5 and 15

Subject	Year	Start date	Duration
Chemistry	IB1	Week 2, January	4 weeks 15 hours

Course Part

Core curriculum - Unit 5 and Higher level extension - Unit 15

Description

The chemical energy in the atoms and bonds of a substance is very important. One of the most obvious energy transfers in chemical reactions is the transfer of heat. A car engine gets hot when energy is transferred from the burning fuel. Fireworks release a lot of energy as heat (as well as light and sound) when they explode. Our bodies keep warm because of the continuous oxidation of the food we eat.

Some chemical reactions are capable of releasing vast amounts of energy. For example, at the end of the Gulf War in 1991, oil and gas fires in the oil fields were left burning out of control. The heat given out was sufficient to turn the sand around the burning wells into the glass. Forest fires can rage impressively, producing overpowering and devastating waves of heat. Bringing such fires under control requires great expertise and a great deal of courage!

Curriculum

Aims

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 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

5. Energetics/thermochemistry

5.1 Measuring energy changes

Nature of science:

Fundamental principle - conservation of energy is a fundamental principle of science.

Making careful observations - measurable energy transfers between systems and surroundings.

Understandings:

Heat is a form of energy.

Temperature is a measure of the average kinetic energy of the particles.

Total energy is conserved in chemical reactions.

Chemical reactions that involve transfer of heat between the system and the surroundings are described as endothermic or exothermic.

The enthalpy change ($\triangle H$) for chemical reactions is indicated in kJ mol^{-1}.

$\triangle H$ values are usually expressed under standard conditions, given by $\triangle H^{0}$, including standard states.

Applications and skills:

Calculation of the heat change when the temperature of a pure substance is changed using $q=mc\triangle T$.

A calorimetry experiment for an enthalpy of reaction should be covered and the results evaluated.

5.2 Hess's Law

Nature of science:

Hypotheses - based on the conservation of energy and atomic theory, scientists can test the hypothesis that if the same products are formed from the same initial reactants then the energy change should be the same regardless of the number of steps.

Understandings:

The enthalpy change for a reaction that is carried out in a series of steps is equal to the sum of the enthalpy changes for the individual steps.

Applications and skills:

Application of Hess’s Law to calculate enthalpy changes.

Calculation of $\triangle H$ reactions using $\triangle H^{0}f$ data.

Determination of the enthalpy change of a reaction that is the sum of multiple reactions with known enthalpy changes.

5.3 Bond enthalpies

Nature of science:

Models and theories - measured energy changes can be explained based on the model of bonds broken and bonds formed. Since these explanations are based on a model, agreement with empirical data depends on the sophistication of the model and data obtained can be used to modify theories where appropriate.

Understandings:

Bond-forming releases energy and bond-breaking requires energy.

Average bond enthalpy is the energy needed to break one mol of a bond in a gaseous molecule averaged over similar compounds.

Applications and skills:

Calculation of the enthalpy changes from known bond enthalpy values and comparison of these to experimentally measured values.

Sketching and evaluation of potential energy profiles in determining whether reactants or products are more stable and if the reaction is exothermic or endothermic.

Discussion of the bond strength in ozone relative to oxygen in its importance to the atmosphere.

Additional higher level

15. Energetics/thermochemistry

15.1 Energy cycles

Nature of science:

Making quantitative measurements with replicates to ensure reliability - energy cycles allow for the calculation of values that cannot be determined directly.

Understandings:

Representative equations (eg $M^+(g) \rightarrow M^+(aq)$) can be used for enthalpy/energy of hydration, ionization, atomization, electron affinity, lattice, covalent bond and solution.

Enthalpy of solution, hydration enthalpy and lattice enthalpy are related in an energy cycle.

Applications and skills:

Construction of Born-Haber cycles for group 1 and 2 oxides and chlorides.

Construction of energy cycles from hydration, lattice and solution enthalpy. For example dissolution of solid NaOH or NH_4Cl in water.

Calculation of enthalpy changes from Born-Haber or dissolution energy cycles.

Relate size and charge of ions to lattice and hydration enthalpies.

Perform lab experiments which could include single replacement reactions in aqueous solutions.

15.2 Entropy and spontaneity

Nature of science:

Theories can be superseded - the idea of entropy has evolved through the years as a result of developments in statistics and probability.

Understandings:

Entropy (S) refers to the distribution of available energy among the particles. The more ways the energy can be distributed the higher the entropy.

Gibbs free energy (G) relates the energy that can be obtained from a chemical reaction to the change in enthalpy ($\triangle H$), change in entropy ($\triangle S$), and absolute temperature (T).

Entropy of gas>liquid>solid under same conditions.

Applications and skills:

Prediction of whether a change will result in an increase or decrease in entropy by considering the states of the reactants and products.

Calculation of entropy changes ($\triangle S$) from given standard entropy values (S^{0}).

Application of $\triangle G^{0}=\triangle H^{0}-T\triangle S^{0}$ in predicting spontaneity and calculation of various conditions of enthalpy and temperature that will affect this.

Relation of $\triangle G$ to position of equilibrium.

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

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

Thinkers

Communicators