Summary

Chemical Equilibrium Unit 7 and 17

Subject	Year	Start date	Duration
Chemistry	IB1	Week 3, April	4 weeks 10 hours

Course Part

Core curriculum - unit 7 and higher level extension - unit 17

Description

Essential idea: Many reactions are reversible. These reactions will reach a state of equilibrium when the rates of the forward and reverse reaction are equal. The position of equilibrium can be controlled by changing the conditions.

Until now, we have assumed that chemical reactions go to **completion**, meaning that almost all reactants are converted to products. This is indicated by the use of a one-way arrow (→) when writing chemical equations. Many reactions, however, do not go to completion and are reversible. These reactions reach a point when they are said to be at **equilibrium**.

Curriculum

Aims

Appreciate scientific study and creativity within a global context through stimulating and challenging opportunities

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 an appreciation of the possibilities and limitations of science and technology

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

7. Equilibrium

7.1 Equilibrium

Nature of science:

Obtaining evidence for scientific theories - isotopic labelling and its use in defining equilibrium.

Common language across different disciplines - the term dynamic equilibrium is used in other contexts, but not necessarily with the chemistry definition in mind.

Understandings:

A state of equilibrium is reached in a closed system when the rates of the forward and reverse reactions are equal.

The equilibrium law describes how the equilibrium constant (Kc) can be determined for a particular chemical reaction.

The magnitude of the equilibrium constant indicates the extent of a reaction at equilibrium and is temperature dependent.

The reaction quotient (Q) measures the relative amount of products and reactants present during a reaction at a particular point in time. Q is the equilibrium expression with non-equilibrium concentrations. The position of the equilibrium changes with changes in concentration, pressure, and temperature.

A catalyst has no effect on the position of equilibrium or the equilibrium constant.

Applications and skills:

The characteristics of chemical and physical systems in a state of equilibrium.

Deduction of the equilibrium constant expression (Kc) from an equation for a homogeneous reaction.

Determination of the relationship between different equilibrium constants (Kc) for the same reaction at the same temperature.

Application of Le Châtelier's principle to predict the qualitative effects of changes of temperature, pressure and concentration on the position of equilibrium and on the value of the equilibrium constant.

Additional higher level

17. Equilibrium

17.1 The equilibrium law

Nature of science:

Employing quantitative reasoning - experimentally determined rate expressions for forward and backward reactions can be deduced directly from the stoichiometric equations and allow Le Châtelier's principle to be applied.

Understandings:

Le Châtelier's principle for changes in concentration can be explained by the equilibrium law.

The position of equilibrium corresponds to a maximum value of entropy and a minimum in the value of the Gibbs free energy.

The Gibbs free energy change of a reaction and the equilibrium constant can both be used to measure the position of an equilibrium reaction and are related by the equation, $\triangle G = -RT\ln K$.

Applications and skills:

Solution of homogeneous equilibrium problems using the expression for K c.

Relationship between ΔG and the equilibrium constant.

Calculations using the equation $\triangle G = -RT\ln K$.

18. Acids and bases

18.1 Lewis acids and bases

Nature of science:

Theories can be supported, falsified or replaced by new theories - acid-base theories can be extended to a wider field of applications by considering lone pairs of electrons. Lewis theory doesn't falsify Brønsted-Lowry but extends it.

Understandings:

A Lewis acid is a lone pair acceptor and a Lewis base is a lone pair donor.

When a Lewis base reacts with a Lewis acid a coordinate bond is formed.

A nucleophile is a Lewis base and an electrophile is a Lewis acid.

Applications and skills:

Application of Lewis' acid-base theory to inorganic and organic chemistry to identify the role of the reacting species.

18.2 Calculations involving acids and bases

Nature of science:

Obtaining evidence for scientific theories - application of the equilibrium law allows strengths of acids and bases to be determined and related to their molecular structure.

Understandings:

The expression for the dissociation constant of a weak acid (K a) and a weak base (K b).

For a conjugate acid base pair, $K_a \times K_b = K_w$.

The relationship between K a and pK a is (pK a = -log Ka), and between Kb and pK b is (pK b = -log K b).

Applications and skills:

Solution of problems involving [H+ (aq)], [OH-(aq)], pH, pOH, K a, pK a, K b and pK b.

Discussion of the relative strengths of acids and bases using values of K a, pK a, K b and pK b.

18.3 pH curves

Nature of science:

Increased power of instrumentation and advances in available techniques - development in pH meter technology has allowed for more reliable and ready measurement of pH.

Understandings:

The characteristics of the pH curves produced by the different combinations of strong and weak acids and bases.

An acid–base indicator is a weak acid or a weak base where the components of the conjugate acid–base pair have different colours.

The relationship between the pH range of an acid–base indicator, which is a weak acid, and its pK a value.

The buffer region on the pH curve represents the region where small additions of acid or base result in little or no change in pH.

The composition and action of a buffer solution.

Applications and skills:

The general shapes of graphs of pH against volume for titrations involving strong and weak acids and bases with an explanation of their important features.

Selection of an appropriate indicator for a titration, given the equivalence point of the titration and the end point of the indicator.

While the nature of the acid–base buffer always remains the same, buffer solutions can be prepared by either mixing a weak acid/base with a solution of a salt containing its conjugate, or by partial neutralization of a weak acid/base with a strong acid/base.

Prediction of the relative pH of aqueous salt solutions formed by the different combinations of strong and weak acid and base.

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

Self-management

- In this unit, we will

  set deadlines for students to meet

  require students to revise and improve on work previously submitted

  ask students to set their own learning goals

  ask students to break down a larger task into specific steps

  ask students to look for personal relevance in the subject matter

  practise or discuss strategies to increase concentration

  give students feedback on their approach to a task

  model positive skills and behaviours such as being well organized and punctual

  help students to learn from failures or mistakes

  create an atmosphere where students do not think they have to get everything right first time

  discuss planning and approaches to revision

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
- Communicators
- Reflective