Summary

Oxidation and Reduction

Subject	Year	Start date	Duration
Chemistry	IB2	Week 3, November	3 weeks 12 hours

Course Part

Core and Higher level

Description

Redox (reduction–oxidation) reactions play a key role in many chemical and biochemical processes. The air that we breathe is composed of approximately 20% oxygen (O_2). There are many chemical reactions that depend on this oxygen. These include the combustion of fossil fuels to produce energy, respiration in human body cells and the corrosion of metals such as iron. Corrosion is a **redox reaction** that involves both **oxidation** and **reduction**.

Oxidation and reduction can be defined in different ways. Oxidation was originally defined as the gain of oxygen and reduction as the loss of oxygen. The two processes always take place together; if one reactant is oxidised during a reaction, then another reactant must be reduced. The reaction is referred to as a redox reaction.

Inquiry & Purpose

Inquiry / Higher Order Questions

Type	Inquiry Questions
Concept-based	How do the two processes coordinate in the same reaction to create redox reactions?

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 experimental and investigative scientific skills including the use of current technologies

Objectives

Demonstrate knowledge and understanding of

facts, concepts, and terminology

Apply

methodologies and techniques

Formulate, analyse and evaluate

hypotheses, research questions and predictions

Syllabus Content

Core

9. Redox processes

9.1 Oxidation and reduction

Nature of science:

How evidence is used - changes in the definition of oxidation and reduction from one involving specific elements (oxygen and hydrogen), to one involving electron transfer, to one invoking oxidation numbers is a good example of the way that scientists broaden similarities to general principles.

Understandings:

Oxidation and reduction can be considered in terms of oxygen gain/hydrogen loss, electron transfer or change in oxidation number.

An oxidizing agent is reduced and a reducing agent is oxidized.

Variable oxidation numbers exist for transition metals and for most main-group non-metals.

The activity series ranks metals according to the ease with which they undergo oxidation.

The Winkler Method can be used to measure biochemical oxygen demand (BOD), used as a measure of the degree of pollution in a water sample.

Applications and skills:

Deduction of the oxidation states of an atom in an ion or a compound.

Deduction of the name of a transition metal compound from a given formula, applying oxidation numbers represented by Roman numerals.

Identification of the species oxidized and reduced and the oxidizing and reducing agents, in redox reactions.

Deduction of redox reactions using half-equations in acidic or neutral solutions.

Deduction of the feasibility of a redox reaction from the activity series or reaction data.

Solution of a range of redox titration problems.

Application of the Winkler Method to calculate BOD.

9.2 Electrochemical cells

Nature of science:

Ethical implications of research - the desire to produce energy can be driven by social needs or profit.

Understandings:

Voltaic (Galvanic) cells:

Voltaic cells convert energy from spontaneous, exothermic chemical processes to electrical energy.

Oxidation occurs at the anode (negative electrode) and reduction occurs at the cathode (positive electrode) in a voltaic cell.

Electrolytic cells:

Electrolytic cells convert electrical energy to chemical energy, by bringing about non-spontaneous processes.

Oxidation occurs at the anode (positive electrode) and reduction occurs at the cathode (negative electrode) in an electrolytic cell.

Applications and skills:

Construction and annotation of both types of electrochemical cells.

Explanation of how a redox reaction is used to produce electricity in a voltaic cell and how current is conducted in an electrolytic cell.

Distinction between electron and ion flow in both electrochemical cells.

Performance of laboratory experiments involving a typical voltaic cell using two metal/metal-ion half-cells.

Deduction of the products of the electrolysis of a molten salt.

Additional higher level

19. Redox processes

19.1 Electrochemical cells

Nature of science:

Employing quantitative reasoning - electrode potentials and the standard hydrogen electrode.

Collaboration and ethical implications - scientists have collaborated to work on electrochemical cell technologies and have to consider the environmental and ethical implications of using fuel cells and microbial fuel cells.

Understandings:

A voltaic cell generates an electromotive force (EMF) resulting in the movement of electrons from the anode (negative electrode) to the cathode (positive electrode) via the external circuit. The EMF is termed the cell potential (E^0).

The standard hydrogen electrode (SHE) consists of an inert platinum electrode in contact with 1 mol dm-3 hydrogen ion and hydrogen gas at 100 kPa and 298 K. The standard electrode potential (E^0) is the potential (voltage) of the reduction half-equation under standard conditions measured relative to the SHE. Solute concentration is 1 mol dm-3 or 100 kPa for gases. E^0 of the SHE is 0 V.

When aqueous solutions are electrolysed, water can be oxidized to oxygen at the anode and reduced to hydrogen at the cathode.

$\triangle G^0 = -nFE^0$. When E^0 is positive, $\triangle G^0$ is negative indicative of a spontaneous process. When E^0 is negative, $\triangle G^0$ is positive indicative of a non-spontaneous process. When E^0 is 0, then $\triangle G^0$ is 0.

Current, duration of electrolysis and charge on the ion affect the amount of product formed at the electrodes during electrolysis.

Electroplating involves the electrolytic coating of an object with a metallic thin layer.

Applications and skills:

Calculation of cell potentials using standard electrode potentials.

Prediction of whether a reaction is spontaneous or not using E^0 values.

Determination of standard free-energy changes ($\triangle G^0$) using standard electrode potentials.

Explanation of the products formed during the electrolysis of aqueous solutions.

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

Determination of the relative amounts of products formed during electrolytic processes.

Explanation of the process of electroplating.

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

Developing IB Learners

Learner Profile

Thinkers

Reflective