UNIT 3 CHEMISTRY

BOOK 1

Energy from Cells

How Can Chemical Processes Be Designed to Optimise Efficiency?

Area of Study 1: What are the Options for Energy Production?
Area of Study 2: How Can the Yield of a Chemical Product be Optimised?

What is a Fuel?
Renewable and Non-Renewable Energy Sources
Carbon Neutral Fuels
Fuels Summary

Energy
Units for Energy
Energy Forms
The Laws Relating to Energy Conservation
Energy Efficiency
Maximising Energy Efficiencies
Energy Converters
Coal-Fired Power Stations
Gas-Fired Power Plants
Internal Combustion Engines

Combustion of Fuels
Enthalpy of Combustion

Energy Changes in Chemical Reactions
Activation Energy
Energy Profiles
Thermochemical Equations
Calculations Involving Thermochemical Equations
Molar Heat of Combustion
Combining Thermochemical Equations

Energy from Fuels
The Specific Heat Capacity of Water
Experimental Determination of Enthalpy of Combustion

Ignition Temperatures

Flash Point

Energy Density of Fuels

Book 2

Fossil Fuels and Biofuels

Fossil Fuels

How Fossil Fuels Form
Importance of Fossil Fuels
Environmental Considerations

Coal

Environmental Impacts of Mining Coal

Coal Seam Gas (CSG)
Hydraulic Fracking
Environmental Impacts of CSG Production
Local Fracking Issues

Crude Oil and Natural Gas
Uses of Crude Oil/Natural Gas Fractions
Liquefied Petroleum Gas
Environmental Impacts of Crude Oil/Natural Gas Production

Energy Content of Fossil Fuels
Molar Enthalpies of Combustion
Energy Densities & Specific Energies of Common Fuels
The Carbon to Hydrogen Ratio of Fuels
Comparing Energy Values Based on Volume

Biofuels
Renewability
Carbon Neutrality
Biomass
Biogases
Biogas by Fermentation
Syngas via Gasification
Electricity from Biogas
Efficiencies of Power Plants

Liquid Biochemical Fuels
Bioethanol
Biodiesel

The Energy Content of Biofuels

The Environmental Impacts of Sourcing Biofuels

The Environmental Impacts of Combusting Fuels
The Greenhouse Effect
The Effects of Emitting Carbon Monoxide into the Atmosphere
Acid Rain
Nitrogen Oxides
Sulfur Dioxide
Environmental Effects of Acid Rain
Effects of Emitting Heavy Metals
Effects of Emitting Particulate Matter
Smog
Damage to the Ozone Layer
Thermal Pollution
Burning Fossil Fuels – Other Considerations

Biofuels Summary

Fuel Comparisons
Fuel Comparisons in Terms of Energy Content
Energy Density vs Specific Energy
Sourcing Issues
Combustion Products
Fossil Fuels
Fuel Combustion Emissions

Biofuels

Fuel Choices: Energy for Electricity

Fuel Choices: Energy for Transport

Minimising Environmental Impacts

Petrol Diesel vs Biodiesel

Comparison of Petrodiesel and Biodiesel

Gases
Properties of Gases
Kinetic Molecular Theory of Gases
Limitations of the Kinetic Molecular Theory of Gases
Pressure
Partial Pressure
Pressure Units
Converting Between Pressure Units
Volume and Temperature Units

The Gas Laws
Boyle's Law
Charles' Law
Avogadro's Law
Comparing the Individual Gas Laws
The Combined Gas Equation
The Universal Gas Equation

Standard Gas Conditions

Other Calculations Involving Gases

Comparing Fuels

BOOK 3

Galvanic Cells

Section 1: Standard Galvanic Cells

Review in Redox Chemistry
Oxidants
Reductants
Summary of Redox Terminology
Oxidation Numbers
Determining the Oxidation Number of a Specific Element
Identifying Redox Reactions
Writing Redox Equations
Balancing Half-Equations
Adding Half Equations

Galvanic Cells/Voltaic Cells
The Daniell Cell
Half-Cells
The External Circuit
The Salt Bridge (Internal Circuit)
Overall Cell Reactions

Shorthand Notation for Galvanic Cells
Other Galvanic Cell Designs
Types of Electrodes

Standard Reduction Potentials

The Electrochemical Series
Determining the Relative Strengths of Oxidants and Reductants
Predicting Redox Reactions
Limitations of the Electrochemical Series
Writing Redox Reactions
EMF and Reaction Spontaneity
Dry Corrosion
Wet Corrosion
Corrosion Protection

Portable Power – Batteries
Primary Cells
Secondary Cells
The Daniell Cell (A 1°Cell)
The Dry Cell of Leclanché Cell (A 1° Cell)
The Alkaline Cell (A 1° Cell)
The Mercury/Button Cell (A 1° Cell)
Summary of Primary Cells and their Reactions
Battery Performance

Section 2: Fuel Cells
Fuel Cell Design
Specific Fuel Cell Components
Hydrogen/Oxygen Fuel Cells
Predicting Hydrogen/Oxygen Fuel Cell Reactions
The Acidic Hydrogen/Oxygen & Phosphoric Acid Fuel Cell
The Alkaline Hydrogen/Oxygen Fuel Cell (AFC)
Proton Exchange Membrane Fuel Cell (PEMFC)
Solid Oxide Fuel Cell (SOFC)
Molten Carbonate Fuel Cell (MCFC)
Fuels Other than Hydrogen
Reforming
Efficiencies of Fuel Cells
Other Advantages of Fuel Cell Technology
Disadvantages of Fuel Cell Technology
Applications of Fuel Cell Technology
Comparison of Fuel Cell Technologies
Fuel Cells vs Standard/Traditional Galvanic Cells

BOOK 4

AREA OF STUDY 2 – HOW CAN THE YIELD OF A CHEMICAL PRODUCT BE OPTIMISED?

Section 1: Rates & Yields of Chemical Reactions

Rates of Reactions
Rates and Yield of Chemical Reactions
The Collision Theory of Reactions
Changing Reaction Rates
A. Increasing the Frequency of Collisions
Increasing the Surface Area of Contact Between Reactants
Increasing Reactant Concentrations
Decreasing the Volume of a Gaseous System
Increasing the Temperature
Adding Catalysts
Exactly How Do Catalysts Work?
B. Increasing the Force of Collisions
The Maxwell-Boltzmann Distribution Curve
Catalysts and the Maxwell-Boltzmann Distribution Curve

Measuring Reaction Rates
Method
Variation in Rates During Chemical Reactions

Questions to Consider when Given a Rate Question

Chemical Equilibrium
Changes in Reaction Rates as Systems Approach Equilibrium
Important Points Regarding Systems at Equilibrium

The Equilibrium Constant
Properties of the Equilibrium Constant
Units for the Equilibrium Constant

The Significance of K

Calculations Involving Systems at Equilibrium

The Concentration Fraction/Reaction Quotient

Equilibrium Calculations Based on Initial Mole / Concentrations

Forced Changes to Equilibrium Systems

Analysing Changes to Equilibrium Systems
Le Chatelier's Approach
The Concentration Fraction Approach
Concentration-Time Graph Approach
Rate-Time Graph Approach

Concentration Changes at Constant Temperature and Volume
The Effects of Adding a Reactant at Constant Temperature and Volume
Le Chatelier's Approach
The Concentration-Time Graph Approach
The Rate-Time Graph Approach
The Effects of Adding a Product at Constant Temperature and Volume
The Effects of Removing a Reactant at Constant Temperature and Volume

The Effects of Removing a Product at Constant Temperature and Volume

Volume Changes at Constant Temperature
Volume Changes to Gas Phase Equilibria at Constant Temperature
Le Chatelier's Approach
The Concentration Fraction Approach
Concentration and Rate Graph Approach
Summary of Pressure Changes to Gaseous Systems

Volume Changes to Aqueous Equilibria at Constant Temperature

Temperature Changes
Exothermic Reactions
Endothermic Reactions

Extension Material: The Effect of Temperature on the Ionisation of Water

Extension Material: Acidic & Basic Solutions & the Self Ionisation of Water

Addition of a Catalyst at Constant Temperature and Volume

Graphical Representations of Systems Approaching Equilibrium
Concentration-Time Graphs
Rate-Time Graphs

Applications of Le Chatelier's Principle
Competing Equilibria
Oxygen & Haemoglobin
Carbon Monoxide & Haemoglobin
Buffers
The Hydrogen Carbonate Buffer System
Acidosis
Alkalosis

Rates and Yields and the Chemical Industry
The Production of Ammonia
The Production of Sulfuric Acid

Section 2: Electrolysis

Electrolysis
A Comparison Between Galvanic and Electrolytic Cells

Predicting Electrolytic Reactions
Electrolysis of Water
Factors that Determine Which Reactions Occur
Factors that Affect the Rate of Electrolysis
The Chlorine Exception

Electroplating
Factors that Affect the Quality of Electroplating
Electrorefining

Faraday's Laws
Faraday's Constant
Faraday's First Law of Electrolysis
Faraday's Second Law of Electrolysis
Stoichiometry Involving Electrolytic Reactions

Secondary Cells

The Recharging Process

The Lead Acid Battery (A 2° Cell)
The Discharge Process (Production of Electricity)
The Recharging Process

The Lithium Cell (A 2° Cell)

The Nickel Cadmium Cell (NiCad)

Commercial Electrolytic Cells
Electrolytic Cell Design
The Downs Cell
The Membrane Cell
The Hall-Heroult Cell

Important Considerations in Industrial Electrolytic Processes