18.0.0 ACIDS, BASES AND SALTS (25 Lessons)

18.1.0 Specific Objectives

By the end of this topic, the learner should be able to:

a) define acids, bases and salts
b) explain the differences between aqueous solutions of weak and strong acids; weak and strong bases; based on the degree to which they dissociate into ions
c) write formulae and ionic equations for specified acid-base and precipitation reactions
d) explain the effect of solvent in acid-base character
e) test for the presence of specified cations and anions
f) identify the precipitates and complex ions produced by specified cation-anion reactions
g) explain the use of solubility curves in salt extraction
h) state the types and causes of hardness of water
i) state the effects and explain the methods of removal of water hardness.

18.2.0 Content

18.2.1 Acids and Bases

- Acids as substances which dissociate in water to give hydrogen ions
- Bases as substances which dissociate in water to give hydroxide ions
- Weak and strong acids and bases; pH scale and electrical conductivity, (use aqueous solutions of; hydrochloric acid, ethanoic acid, sodium hydroxide and ammonia of the same concentration to illustrate)

18.2.2 Characteristics of Amphoteric oxides and hydroxides

- Reaction with acids and alkalis (aluminium oxide, zinc(II) oxide, zinc hydroxide lead hydroxide, and aluminium hydroxide).

18.2.3 Effect of solvent.

- Characteristics of hydrogen chloride in methyl benzene and aqueous solution, (illustrate with dry litmus, magnesium and marble chips)
- Reactions of dry and aqueous ammonia

18.2.4 Salts

- Salts as ionic compounds formed when cations derived from bases combine with anions derived from acids
- Precipitation reactions (use ionic equations)
- Reactions involving the following cations in aqueous solutions: magnesium, calcium, iron(II), iron(III), Barium(II), Zinc(II), Aluminium(III), Copper(II) with; sodium hydroxide, ammonia solution, Chloride, Carbonate, sulphite and sulphate ions

18.2.5 Complex ions

Dissolving of specific metal hydroxides in excess aqueous ammonia and sodium hydroxide solution

Formulae of the following required,
$[Cu(NH_3)_4]^{2+}$
$[Zn(NH_3)_4]^{2+}$ $[Al(OH)_4]^-$
$[Pb(OH)_4]^{2-}$ and $[Zn(OH)_4]^{2-}$
Equations not required

- Solubility; definition and relationship with temperature
- Solubility curves for sodium chloride, potassium nitrate, potassium chlorate(V), calcium sulphate and sodium carbonate.
- Fractional crystallization of salts
- Extraction of sodium carbonate from Lake Magadi and sodium chloride at Ngomeni

18.2.6 Water hardness

- Types of water hardness: causes and effects
- Methods of removal of water hardness; boiling, distillation, precipitation and use of ion exchange

18.3.0 Projects

a) Salt extraction from ash or soil.
b) Investigation of water hardness and its removal

19.0.0 ENERGY CHANGES IN CHEMICAL AND PHYSICAL PROCESSES (25 Lessons)

19.1.0 Specific Objectives

By the end of this topic, the learner should be able to:

a) define exothermic and endothermic reactions using ΔH notation
b) draw energy level diagrams
c) explain fusion and vaporisation as evidence of inter-particle forces
d) explain that energy changes in chemical reactions are due to bond formation and bond breaking
e) define and explain various types of heat changes
f) carry out experiments to determine enthalpy changes for some reactions
g) write correct simple thermochemical equations
h) state Hess' Law and carry out related calculations
i) state and explain the factors that influence the choice of fuel
j) explain the environmental effects of fuels.

19.2.0 Content

19.2.1 Endothermic and Exothermic reactions

- Enthalpy notation (ΔH) for exothermic reactions and endothermic reactions

19.2.2 Latent heat

- Molar heat of fusion and vaporisation as evidence of overcoming forces of attraction between particles.

19.2.3 Quantitative determination of enthalpies

- Formation of hydrogen chloride gas from hydrogen gas and chlorine gas;
  formation of chloromethane from methane and chlorine gas
- Quantitative determination of enthalpies of:

- Solution (e.g. ammonium nitrate, sodium hydroxide and conc. sulphuric acid)
- Combustion (e.g. methanol/ethanol)
- Displacement (e.g. copper from copper (II) ions by iron or zinc)
- Neutralization (e.g. sodium hydroxide and dilute hydrochloric acid).

19.2.4 Simple energy level diagrams

- Hess' Law (energy level diagrams and thermo chemical cycles) (use molar enthalpy of formation for illustration)
- Relate heat of solution to hydration and lattice energy

19.2.5 Common fuels; Energy contents of:

- Charcoal, fuel oil, ethanol (methylated spirit), liquid petroleum gas (LPG), petroleum, kerosene and diesel
- Choice of fuel;
- Precautions necessary when using fuels

19.2.6 Pollution by common fuels e.g. internal combustion engine

19.3.0 Projects

Comparison of heat energy values of fuels

20.0.0 REACTION RATES AND REVERSIBLE REACTIONS (15 Lessons)

20.1.1 Specific objectives

By the end of this topic, the learner should be able to:

a) define rate of reaction
b) explain the term activation energy
c) describe some methods used to measure rates of reaction
d) explain the effects of different factors on reaction rates
e) illustrate reaction rates graphically and interpret experimental data
f) state examples of simple reversible reactions
g) explain chemical equilibrium as a state of 'balance'
h) explain the effect of different factors on the position of equilibrium.

20.2.0 Content

20.2.1 Reaction rates

- Definition of rate of reaction
- Collision theory and activation energy (qualitative treatment only)
- Qualitative treatment of the effects of concentration, pressure, temperature, surface area, light and catalysts on rates of reactions. (No reaction mechanisms required).
- Experiments involving the following reactions:
  - calcium carbonate (marble chips) with dilute acid (hydrochloric or nitric acid).
  - sodium thiosulphate with dilute hydrochloric acid
  - metal with dilute acid (e.g. magnesium with hydrochloric acid).
  - hydrogen peroxide with various catalysts e.g. manganese (IV) oxide (Graphical representation of results required)

20.2.2 Reversible reactions

- Equilibrium as the state of balance (example acid/alkali plus indicator, chromate/dichromate, hydrated and anhydrous copper(II) sulphate)

- The effect of changing concentration, pressure and temperature on position of equilibrium. Le Chatelier's Principle
- Uses in industrial processes (Contact and Haber processes).

21.0.0 ELECTROCHEMISTRY (25 Lessons)

21.1.0 Specific objectives

By the end of this topic, the learner should be able to:

a) explain redox reactions in terms of gain and loss of electrons
b) identify changes in oxidation numbers during redox reactions
c) write balanced redox equations
d) explain an electrochemical cell in terms of electron transfer process
e) draw cell diagrams and write the cell notations
f) explain the construction and working of an electrochemical cell such as zinc - copper cell
g) compare oxidizing and reducing power of ions from displacement reactions
h) Calculate Electromotive Force of a cell given the standard electrode potentials
i) state and explain the factors that affect preferential discharge of ions during electrolysis
j) relate the quantity of electricity passed to amount of substances liberated at the electrodes
k) describe some applications of electrolysis.

21.2.0 Content

21.2.1 Redox reactions

- Electron transfer (gain and loss of electrons)
- Determination of oxidation numbers
- Use an illustration of iron(II) (acidified with dilute sulphuric acid) to iron(III) with hydrogen peroxide.
- Identify reactant - Iron(II) (aq), and product Iron(III) (aq), with hydroxide ion.
  Other examples; sodium/water magnesium/dilute acid (hydrochloric acid/sulphuric acid)

21.2.2 Displacement reactions; (as redox reactions)

- Reducing power
  - Reaction of metal/metal - cation ($M/M^{2+}(aq)$).
  Calcium, magnesium, zinc, iron, lead, copper.
- Oxidizing power of halogens: chlorine, bromine and iodine only.

21.2.3 Electrochemical cell

- Qualitative treatment of the electron flow in:
  $Zn(s) \mid Zn^{2+}(aq) \mid\mid Cu^{2+}(aq) \mid Cu(s)$ cell
  Note: Conventions, vertical line (|) represents a phase boundary where a potential difference develops e.g. Zn (s) | Zn^{2+} (aq); two vertical parallel lines (||) represent a salt bridge.
- Standard electrode potentials (simple calculations involving $E\theta$ values required)

21.2.4 Electrolysis

- The role of water in electrolysis.
- Preferential discharge in electrolysis of the following solutions:
  - Sodium chloride
  - Dilute sulphuric acid (acidified water).
  - Magnesium sulphate
  - Electrolysis of copper (II) sulphate using graphite and copper electrodes. (product changes in electrolytes)
- Factors affecting preferential discharge
  - Quantitative treatment of electrolysis (Note: First Faraday's law only).

21.2.5 Applications

- Extraction of metals
- Manufacture of sodium hydroxide, chlorine, hydrogen (electrolysis of brine).
- Copper refining, electroplating

21.3.0 Projects

- Investigating further electroplating processes, prevention of rusting (cathodic protection), investigate various types of cells.

22.0.0 METALS (20 Lessons)

22.1.0 Specific objectives

By the end of this topic, the learner should be able to:

a) name the chief ores of some metals
b) describe and explain general methods used in the extraction of metals from their ores
c) select and describe suitable methods for the extraction of some metals from their ores
d) describe and explain physical and chemical properties of some metals
e) state and explain various uses of these metals and their alloys
f) describe the effects of the industrial production processes of metals on the environment.

22.2.0 Content

22.2.1 Metals; methods of extraction:

- Chief metal ores of: sodium, aluminium, zinc, iron, copper and lead
- General methods of extraction (electrolysis and reduction)
- The electrolytic production of sodium and aluminium
- Extraction of iron, copper, and zinc from their ores.

22.2.2 Properties of Metals (sodium, aluminium, iron, copper and zinc):

- Physical properties (melting point, boiling point, thermal and electrical conductivity, density, malleability and ductility)
- Chemical properties (reaction with air, water, chlorine, dilute hydrochloric acid and oxidizing acids (concentrated nitric and sulphuric acid)

(**Note**: the reaction of sodium and dilute acid is explosive)

22.2.3 Uses of metals and their alloys (alloys: brass, bronze, steel, duralumin) - construction (air craft, bridges etc.), electrical materials (copper)

22.2.4 Pollution effect of the industrial production of metals on the environment

22.3.0 Projects

- Analysis of ores
- Construction of a mini-blast furnace
- Carrying out iron - smithing

23.0.0 ORGANIC CHEMISTRY II (ALKANOLS AND ALKANOIC ACIDS) (20 Lessons)

23.1.0 Specific Objectives

By the end of this topic, the learner should be able to:

a) name and draw the structures of simple alkanols and alkanoic acids
b) describe the preparation and explain the physical and chemical properties of alkanols and alkanoic acids
c) state the main features of the homologous series
d) state and explain the uses of some alkanols and alkanoic acids
e) describe the preparation, properties and uses of detergents
f) explain the effect of hard water on detergents
g) list some natural, synthetic polymers, fibres and state their uses
h) describe the preparation, properties and uses of some synthetic polymers
i) identify the structure of a polymer given the monomer
j) state the advantages and disadvantages of synthetic materials compared to those of natural origin in terms of both structure and properties.

23.2.0 Content

23.2.1 Alkanols

- General formula (ROH)
  Nomenclature (primary alcohols upto 10 carbon atoms)
- Preparation of alkanols from:
  - Hydrolysis of alkenes
  - Fermentation of carbohydrates
- Physical properties:
  Gradual changes in physical properties of primary alkanols (mention hydrogen bonding)
- Chemical properties:
  Reactions with oxygen (burning), sodium, concentrated sulphuric acid (to give alkenes), ester formation and oxidation to give alkanoic acids
- Uses - solvents, fuels and pharmaceuticals.

23.2.2 Alkanoic acids

- General formula - RCOOH
- Nomenclature (primary alkanoic acids up to 10 carbon atoms)
- Preparation by oxidation of primary alkanols
- Physical properties
  - gradual change in physical properties of alkanoic acids (mention hydrogen bonding)
- Chemical properties
  - acid properties; salt and ester (alkanoates) formation [up to 2 carbons only]

Note: equations involving these reactions are required (state symbols are not required)

23.2.3 Detergents

- Soapy detergents (soaps)
  - laboratory preparation by hydrolysis of fats or oils with alkalis
  - mode of action
  - water hardness

- pollution effects

- Soapless detergents
  - manufacture
  - mode of action
  - pollution effect
- Polymers
- Names of some natural polymers and fibres
  - cellulose materials (cotton, wood, paper;silk)
  - hydrocarbons (rubber and its vulcanisation)
- Names of some synthetic polymers and fibres
  - Polythene, polychloroethene (pvc)
  - polyphenylethene (polystyrene)
  - terylene, nylon, and Perspex.
- Synthetic rubber
  - Preparation properties and uses of synthetic polymers
  - Equations to show addition polymerisation for example formation of polythene, polychloroethene and polyphenylethene
- Advantages and disadvantages of synthetic polymers and fibres over those of natural origin should be mentioned. (include biological degradability of the materials).
- Uses of polymers and fibres, manufacture of beer, spirits, soaps and detergents, drugs, textiles, packaging materials, pipes and tyres.

23.3.0 Projects

- fermentation of various carbohydrates to produce ethanol
- soap preparation
- investigate effects of soap and detergents on aquatic life
- investigate methods of recycling and disposal of plastics
- investigation of strength of polymers and fibres

24.0.0 RADIOACTIVITY (10 Lessons)

24.1.0 Specific Objectives

By the end of this topic, the learner should be able to:

a) define radioactivity, half-life, radioisotope and nuclides
b) state types of radioactivity
c) name the particles emitted during radioactive decay and state their properties
d) carry out simple calculations involving half-life (t1/2)
e) write balanced nuclear equations
f) distinguish between nuclear fission and fusion
g) state uses of some radioisotopes
h) state dangers associated with radioactivity.

24.2.0 Content

24.2.1 Stability of isotopes of elements

- Stability of isotopes of elements
- Radioactivity, types of radiation, (alpha (α), beta (β) particles and gamma (γ) rays; characteristics and properties
- Radioactive decay as measured by half-life ($t_{\frac{1}{2}}$), calculations involving half - life ($t_{\frac{1}{2}}$)
- Nuclear equations: changes in nuclei resulting from radioactive decay by alpha (α), beta (β) particles and gamma (γ) rays
- Qualitative treatment of fission and fusion

- mention nuclear reactions as source of energy

NB: Nuclear reactions are different from chemical reactions.

24.2.2 Applications

Uses and importance of radioisotopes in chemistry, medicine, carbon dating and agriculture.

24.2.3 Pollution effects of radioactivity

Dangers of radio isotopes
Environmental pollution e.g. the chernobyl disaster, titanium mining in Kwale

SUGGESTED ASSESSMENT METHODS

- Oral Questions
- Observation of individual/group activities
- Short answer questions
- Practical test/assignments
- Written assignments
- Project work
- Field trips