INTERMEDIATE 1 CHEMISTRY

Unit 1: Chemistry in Action

a) Substances

(i) Elements

Everything in the world is made from about 100 elements.
Each element has a name and a symbol.
Chemists have arranged elements in the Periodic Table.
Each element in the Periodic Table has a number called the atomic number.
Most elements are solid at room temperature.
Mercury and bromine are liquid at room temperature.
Some elements are gases at room temperature.
Elements can be classified as metals or non-metals.
There are more metals than non-metals.
Some elements, including gold, silver and copper, have been known for a long time.
The most recently discovered elements have been made by scientists.
Many elements have everyday uses.
Elements in a column of the Periodic Table show similar chemical properties.

(ii) Compounds and mixtures

Compounds are formed when elements react together.
Most compounds with a name ending in '-ide' contain the two elements indicated; the ending '-ite' or '-ate' indicates the additional element oxygen.
Mixtures occur when two or more substances come together without reacting.
Air is a mixture of gases.
Air is approximately 80% nitrogen and 20% oxygen.
The test for oxygen is that it relights a glowing splint.
There is not enough oxygen in the air for the test to be positive.

(iii) Solutions

A solution is formed when a substance dissolves in a liquid.
A substance which dissolves in a liquid is soluble; a substance which does not dissolve is insoluble.
A saturated solution is one in which no more substance can be dissolved.
A dilute solution has a lower concentration of dissolved substance than a concentrated solution.
A solution is diluted by adding more liquid.
Carbon dioxide gas is dissolved in some drinks to make them fizzy.
The test for carbon dioxide is that it turns limewater milky.
Chlorine is dissolved in drinking water to kill bacteria.
Sodium fluoride is dissolved in drinking water to help to prevent tooth decay.
Lead compounds in drinking water can be harmful to health.

iv) Hazards

Regulations on the use of chemicals exist for the safety of everyone who uses chemicals at work.
Each hazard of toxic, corrosive, flammable, harmful/irritant is given a simple symbol which can be easily recognised.
Hazard warning labels are attached to all appropriate chemicals.
Hazard symbols are on road tankers to indicate dangers in the event of spillage.

b) Chemical reactions

(i) Identification

All chemical reactions involve the formation of one or more new substances.
Chemical reactions can be identified by changes in appearance of substance, including colour change, gas evolved, precipitate formed.
Chemical reactions can be identified by energy changes.
A wide variety of chemical reactions occur in the world around us.

(ii) Speed of reactions

Changes in particle size, temperature and concentration affect the speed of reactions, both in the laboratory and in our everyday life.
Catalysts are substances which speed up some reactions and are not used up by the reactions.
Enzymes are catalysts which affect living things.
There are many everyday examples of uses of catalysts and enzymes.

(iii) Word equations

A chemical reaction can be described by a word equation.

c) Bonding

(i) Molecules and ions

Every element is made up of very small particles called atoms**.**
Atoms of different elements are different.
Some substances are made up of molecules.
Molecules are made up of two or more atoms held together by strong bonds.
Bonds between molecules are weak.
Molecular substances tend to have low melting and boiling points.
Molecular substances do not conduct electricity.
Some substances are made up of ions.
Ions can be positively or negatively charged.
Ionic compounds are made up of oppositely charged ions.
Bonds between ions are strong.
Ionic compounds tend to have high melting and boiling
points.
Ionic compounds conduct electricity when dissolved in water and when molten.

(ii) Formulae: using models

Formulae are written from models or pictorial representations.

(iii) Formulae: using prefixes

Formulae are written using prefixes, eg ‘mono-’, ‘di-’,
‘tri-’, ‘tetra-’.

d) Acids and alkalis

(i) The pH scale

The pH scale ranges from below 0 to above 14.
Universal indicator, pH paper or a pH meter can be used to find the pH of solutions.
Acids have a pH of less than 7; pure water and neutral solutions have a pH equal to 7; alkalis have a pH of more than 7.
The lower the pH of an acid, the greater the acidity; the higher the pH of an alkali, the greater the alkalinity.
Diluting acids and alkalis decreases the acidity and alkalinity.

(ii) Common acids and alkalis

Acids and alkalis are in common use in the home and the laboratory.
Common laboratory acids include hydrochloric acid, sulphuric acid and nitric acid.
Common laboratory alkalis include sodium hydroxide, lime water and ammonia solution.
Common household acids include vinegar, lemonade, soda water and Coke.
Common household alkalis include baking soda, oven cleaner, dishwashing powder and bleach.

(iii) Neutralisation

Alkalis neutralise acids (and vice versa) to form water and a salt.
Neutralisation moves the pH of the acid up towards 7.
Neutralisation moves the pH of the alkali down towards 7.
When neutralised, hydrochloric acid forms chloride salts, sulphuric acid forms sulphate salts and nitric acid forms nitrate salts.
Metal carbonates neutralise acids producing water, a salt and carbon dioxide gas.
Everyday examples of neutralisation include reducing soil acidity, reducing acidity in lakes and treatment of indigestion.

(iv) Acid rain

Carbon, sulphur and nitrogen react with oxygen to produce carbon dioxide, sulphur dioxide and nitrogen dioxide respectively.
Carbon dioxide, sulphur dioxide and nitrogen dioxide dissolve in water to form acidic solutions.
Sulphur dioxide, produced by the burning of fossil fuels, and nitrogen dioxide, produced by the sparking of air in car engines, dissolve in water in the atmosphere to produce acid rain.
Acid rain has damaging effects on buildings made from carbonate rock, structures made of iron or steel, soils and plant and animal life.

Unit 2: Everyday Chemistry

a) Metals

(i) Uses

Some metals, including gold, silver and copper, are found uncombined in the Earth's crust.
Most metals are found combined with other elements.
Some metals, including iron, are extracted from their ores by heating with carbon.
Some metals, including aluminium, are extracted from their ores using electricity.
Metal elements and carbon (graphite) are conductors of electricity and most non-metal elements are non-conductors of electricity.
The specific properties of metals, including density, thermal and electrical conductivity, malleability, strength, are related to their uses.
An alloy is a mixture of metals, or of metals with non-metals.
Brass, solder and 'stainless' steel are examples of alloys.
Metals are alloyed to change their properties for specific uses.

ii) Reactions

Metal oxides are produced in the reactions of metals with oxygen.
Reactions of metals with water produce hydrogen.
Reactions of metals with acid produce hydrogen gas and a salt.
Some metals, including copper, silver and gold, do not react with dilute acid.
Differences in the reactions give an indication of the reactivity of the metals.
The test for hydrogen is that it burns with a 'pop'.

(iii) Corrosion

Corrosion is a chemical reaction which involves the surface of a metal changing from an element to a compound.
Rusting is the corrosion of iron.

Rusting results in a loss of structural strength.
Both oxygen (from the air) and water are required for rusting.
Rust indicator can be used to show the extent of the rusting process.
Acid rain increases the rate of corrosion.
Salt increases the rate of corrosion.
Painting, greasing, electroplating, galvanising, tin-plating and coating with plastic give a surface barrier to air and water which can provide protection against corrosion.
Iron does not rust when attached to more reactive metals.
Zinc (galvanising) and scrap magnesium are used to protect iron.

(iv) Batteries

In a battery, electricity comes from a chemical reaction.
Batteries require to be replaced due to the chemicals being used up in the reaction.
The lead-acid (car) battery is an example of a rechargeable battery.
Electricity can be produced by connecting different metals together, with a solution containing ions, to form a cell.
The purpose of the ion solution is to complete the circuit.
The voltage is related to the difference in the reactivity of the metals.

b) Personal needs

(i) Keeping clean

When cleaning hair, skin and clothes the main problem is oil and grease; this is because oil and grease are insoluble in water alone**.**
Cleaning chemicals are required to break up the oil and grease into tiny droplets which can then mix with water; this happens because cleaning chemicals are soluble in both water and oil and grease.
Examples of manufactured products which contain cleaning chemicals include soaps, detergents, shampoos, washing-up liquids and powders.
Some soaps form a scum with hard water.
Soapless detergents are used to form a lather with hard water.
Dry-cleaning uses special solvents which are particularly good at dissolving oil and grease stains.

(ii) Clothing

Clothing fabrics are made from thin strands called fibres.
Natural fibres come from plants and animals.
Synthetic fibres are made by the chemical industry.
Examples of natural fibres include silk, wool and cotton; examples of synthetic fibres include nylon and polyesters, eg Terylene.
Synthetic fibres can be used to make fabrics with specific properties.
Fibres are made up of long chain molecules called polymers.
Dyes are coloured compounds which are used to give bright colours to clothing.
Chemists have developed ways of treating fabrics to improve their properties.

c) Fuels

(i) Fire

A fuel is a chemical which is burned to produce energy.
When a substance burns it reacts with oxygen.
Combustion is another word for burning.
A fire needs a fuel, oxygen (usually from the air) and a temperature high enough to start the fire and keep it going; take away any one of the three and the fire goes out.
Fire-fighting methods in the lab and the home include the use of a fire blanket, sand, water, and carbon dioxide gas and foam.
Water must not be used with oil, petrol and electrical fires.

(ii) Finite resources

Fossil fuels include coal, natural gas, oil and peat.
Coal and peat are formed from plant remains.
Oil is formed from the remains of marine life.
The formation of fossil fuels occurs over a very long period of time.
Fossil fuels are finite resources, ie they cannot be replaced.
Over-use of fossil fuels may lead to a fuel crisis.
Oil spillages can cause great damage to marine life and the environment.
The compounds which are found in fossil fuels are mainly hydrocarbons.
A hydrocarbon is a compound which contains hydrogen and carbon only.
Hydrocarbons burn in a plentiful supply of air to produce carbon dioxide and water.

(iii) Renewable resources

Methane, ethanol and hydrogen are renewable sources of energy, ie they can be replaced.
Methane is found in biogas which can be generated by the decomposition of waste plant material.
Ethanol is obtained from sugar cane and can be mixed with petrol to make a fuel for cars.
Hydrogen, which can be obtained from water, is a likely fuel for the future.

(iv) Important processes

Crude oil is a mixture of hydrocarbons.
A fraction is a group of hydrocarbons with boiling points within a given range.
Fractional distillation is the process used to separate crude oil into fractions according to the boiling points of the components in the fractions.
Hydrocarbons which consist of smaller molecules tend to boil more easily than hydrocarbons which consist of larger molecules.
The uses of fractions are related to the ease of evaporation, viscosity, flammability and boiling point range of the fractions.
Fractional distillation of crude oil yields more long chain hydrocarbons than are useful for present-day industrial purposes.
Cracking is an industrial method for producing a mixture of smaller, more useful molecules.

(v) Pollution problems

Carbon, and carbon monoxide, a poisonous gas, can be produced when hydrocarbons burn in a low supply of oxygen.
The burning of some fuels releases sulphur dioxide, a poisonous gas, into the atmosphere.
Nitrogen and oxygen from the air can react inside a car engine to form nitrogen dioxide which is a poisonous gas.
Sulphur dioxide and nitrogen dioxide are the main causes of acid rain.
Lead free/unleaded petrol has been developed to reduce lead pollution.
Benzene fumes in unleaded petrol are toxic.
Soot particles produced by the incomplete combustion of diesel are harmful.
Air pollution from the burning of hydrocarbons can be reduced by the use of catalytic converters which convert the pollutant gases to harmless gases.

d) Plastics

(i) Uses

Plastics are synthetic materials, ie made by the chemical industry.
Most plastics are made from oil.
Examples of plastics include polythene, polystyrene, perspex, PVC, nylon, Kevlar, bakelite, formica and silicones.
The everyday uses of plastics are related to their properties.

For some uses, plastics have advantages over natural materials and vice versa.
Biodegradable materials are broken down by bacteria in the soil and rot away.

Most plastics are not biodegradable and their durability and lightness can cause environmental problems.
Degradable plastics have been developed by chemists to alleviate the problems of plastic waste.
Some plastics burn or smoulder to give off toxic fumes, including carbon monoxide.
Options for disposal of plastics include incineration, recycling and burying.
With incineration the heat generated can be used as a source of energy but there are problems with emissions.
Since oil is a finite resource, recycling is to be encouraged and chemists are looking for renewable sources of plastics.
Recycling can be difficult because of the many different kinds of plastic in common use.

(iii) Thermoplastic/thermosetting plastics

Plastics can be either thermoplastic or thermosetting.
A thermoplastic is one which can be reshaped on heating.
A thermosetting plastic cannot be reshaped by heating.
The uses of thermosetting plastics are related to their heat and electrical insulation properties.

(iv) Making plastics

Plastics are made up of polymers.
Polymer molecules are made from many small molecules called monomers.
The process of making a polymer by joining many monomers together is called polymerisation.
Some polymers can be named by adding the prefix, 'poly', to the name of the monomer, eg poly(ethene), polystyrene.
Poly(ethene) is also called polythene.

Unit 3: Chemistry and Life

a) Photosynthesis and respiration

(i) Photosynthesis

Plants make their own food by taking in substances from the environment.
Plants use light energy to produce glucose from carbon dioxide and water in a process called photosynthesis; oxygen gas is also produced.
During photosynthesis carbon dioxide is absorbed through the leaves of plants.
Water is drawn up through the roots and oxygen gas is released into the air through the leaves.
The light energy required for photosynthesis is absorbed by the chlorophyll in the leaves.

(ii) Respiration

Animals require sources of energy for use in a number of ways, including warmth and movement.
Animals can obtain energy by the reaction of glucose with oxygen to produce water and carbon dioxide in a process called respiration.
Animals obtain glucose by eating food which has come from plants.
Respiration is the reverse of photosynthesis.
The processes of photosynthesis and respiration maintain constant amounts of oxygen and carbon dioxide in the air.

(iii) The greenhouse effect

Carbon dioxide in the atmosphere causes the greenhouse effect.
Extensive clearing of forests reduces the amount of carbon dioxide removed from the atmosphere by photosynthesis.
Increased levels of carbon dioxide in the air may also be due to increased combustion of fuels.
An increase in the level of carbon dioxide in the atmosphere could cause the atmosphere to retain more of the sun’s energy as heat, a process known as global warming.

b) The effects of chemicals on the growth of plants

(i) Using chemicals to save plants

The yield of healthy crops can be reduced in the following ways:

- crops are eaten by pests, eg insects and slugs
- bacteria and fungi can cause plants to become diseased
- weeds can inhibit growth of plants by using up essential substances in the soil.

Pesticides are used to control pests, fungicides prevent diseases and herbicides kill weeds.
Pesticides are toxic and so must be used with care.
Natural predators can also be used to safely control pests.

(ii) Fertilisers

Nitrogen, phosphorus and potassium are essential elements for healthy plant growth.
These elements are taken in through the roots of plants as compounds which are in solution.
In areas of natural vegetation, decay of vegetable and animal remains returns all essential elements to the soil.
Harvesting of crops prevents the natural return of essential elements to the soil.
Fertilisers are added to the soil to restore essential elements.
Examples of natural fertilisers include compost and manure.
Increased demand for food has resulted in the use of artificial fertilisers.
Artificial fertilisers are made by the chemical industry.
The major artificial fertilisers are ammonium, nitrate, phosphate and potassium compounds.
To be effective, fertilisers must be soluble in water.
The extensive use of nitrate fertilisers may have increased the levels of nitrate in rivers and lochs, and the public water supply.
The presence of large quantities of nitrates can leave the water lifeless.
Some plants such as clover, beans and peas have root nodules in which nitrogen from the air is converted into nitrates.
Plants which convert nitrogen from the air into nitrates can be used to increase soil fertility.

c) Food and diet

(i) Elements in the body

A balanced diet provides the body with all the essential elements and compounds.
The major constituent elements of the human body are oxygen, carbon, hydrogen and nitrogen.
Elements are present in the diet and in the body as chemical compounds and not as the free elements.
Essential compounds include carbohydrates, fats and proteins.
More than 60% of body weight is made up of water.
Minerals supply the body with small quantities of calcium for bones and teeth, iron for the blood, as well as trace elements.
Some trace elements if taken in too large quantities are toxic.

(ii) Different carbohydrates

Carbohydrates form an important class of food made by plants.
Carbohydrates are used by the body to produce energy.
Carbohydrates are compounds which contain carbon, hydrogen and oxygen.
Carbohydrates can be divided into sugars and starches.
Examples of sugars include glucose, fructose, maltose and sucrose (table sugar).
Most sugars can be detected by the Benedict's test; sucrose is an exception.
Starch can be distinguished from other carbohydrates by the iodine test.
Starch is not sweet and does not dissolve readily in water; sugars are sweet and very soluble in water.

(iii) Reactions of carbohydrates

Sugars are carbohydrates with small molecules.
Starch is a polymer made of many glucose molecules linked together.

Plants convert the glucose into starch for storing energy.
During digestion starch is broken down to glucose which is carried by the blood stream to body cells where respiration occurs.
Starch can be broken down by acid and by enzymes.
Body enzymes function best at body temperature and are destroyed at higher temperatures.

(iv) Fats and oils

Fats and oils form an important class of food obtained from both plants and animals.
Fats and oils are much more concentrated sources of energy than carbohydrates.
Fats and oils can be detected by a filter paper test.
Saturates are believed to increase the cholesterol level in the bloodstream and this in turn may cause heart disease.
Polyunsaturates are considered to be less potentially harmful to the heart.
Medical opinion suggests that total fat consumption should be reduced and, where possible, foods with polyunsaturates should be eaten.

(v) Proteins

Proteins form an important class of food obtained from both plants and animals.
Proteins provide material for body growth and repair.
Proteins can be detected by heating with soda lime and testing for an alkaline gas.
Proteins are chemical compounds of carbon, hydrogen, oxygen and nitrogen.
Proteins are polymers made up of many amino acid molecules linked together.
In the body, animals make particular proteins for specific purposes.
The amino acids required to make animal proteins are obtained from animal and vegetable foods.
During digestion proteins in foods are broken down to amino acids.
A vegetarian diet must include a wide variety of vegetables to supply all the necessary amino acids.

(vi) Fibre, vitamins and food additives

Fibre keeps the gut working well, preventing constipation.
Fibre absorbs water and swells; this provides bulk for the gut muscles to work on as food is squeezed along.
Vitamins are complex carbon compounds which are required to keep the body healthy.
Lack of important vitamins can cause poor health.
Food additives can be used to:

- supply or enhance the nutritional value of food, eg vitamins and minerals,
- improve the keeping qualities of food, eg food preservatives,
- alter the appearance of food, eg food colouring, and
- alter the flavour of food, eg food flavouring.

Food additives can be used only if they have been tested and approved.

d) Drugs

(i) Alcohol

A drug is a substance which alters the way the body works.
Drugs can damage health because of the way they can affect the body and lifestyle.
Alcohol is a drug which, if taken in excess, can have many harmful effects on the body, particularly the liver and the brain.
A bottle of alcopop or a pint of beer contains approximately 2 units of alcohol; a pub measure of spirit or a glass of wine contains approximately 1 unit of alcohol.
Alcohol is broken down by the body at about 1 unit per hour.
Alcoholic drinks can be made by the fermentation of starch and sugars present in fruit and vegetables.
The type of alcoholic drink varies with the plant source of the carbohydrate.
During fermentation glucose is broken down to form alcohol; carbon dioxide is also produced.
The fermentation process is catalysed by enzymes present in yeast.
The alcohol produced by fermentation is called ethanol.
The concentration of alcohol produced by fermentation is limited.
Distillation is a method of increasing the alcohol concentration of fermentation products.

Water and alcohols can be partially separated by distillation because they have different boiling points.

(ii) Other drugs

Some drugs, including medicines, alcohol, nicotine and caffeine are legal; others, including cannabis, LSD and ecstasy are illegal.

Being unable to manage without a drug is called addiction.

Methanol, another alcohol, is very toxic causing blindness and death.

Methylated spirits (meths) contains methanol and has both a colour and a bad tasting substance added to it to prevent people from drinking it.

Chemical reactions are going on all the time to keep the body working properly.

Medicines contain drugs which help the body when it is not working correctly.

Some drugs, including antibiotics, can fight micro-organisms which interfere with the chemical reactions.

Medicines are usually made up of many chemicals and only the active ingredient works on the body.