CfE Higher Chemistry – Unit Two - Summary

1) Esters

- An ester can be identified from the ester group and by the name containing the -'yl-oate' endings.
- An ester can be named given the names of the parent carboxylic acid and alcohol or from structural formulae.
- Structural formulae for esters can be drawn given the names of the parent alcohol and carboxylic acid or the names of esters.
- Esters have characteristic smells and are used as flavourings and fragrances.
- Esters are also used as industrial solvents.
- Esters are formed by the condensation reaction between carboxylic acid and an alcohol. The ester link is formed by the reaction of a hydroxyl group and the carboxyl group.
- In condensation reactions, the molecules join together with the elimination of a small molecule, in this case water.
- Esters can be hydrolysed to produce a carboxylic acid and alcohol.
- Given the name of an ester or its structural formula, the hydrolysis products can be named and their structural formulae drawn.
- The parent carboxylic acid and the parent alcohol can be obtained by hydrolysis of an ester. In a hydrolysis reaction, a molecule reacts with water breaking down into smaller molecules

2) Fats and Oils

- Fats and oils are a concentrated source of energy.
- Fats and oils can be classified as animal, vegetable or marine.
- Fats and oils are important in a balanced diet and supply the body with energy in a more concentrated form than carbohydrates. There is evidence of a link between a high intake of saturated fat in the diet and heart disease. Fats and oils are essential for the transport and storage of fat-soluble vitamins in the body.
- The lower melting points of oils compared to those of fats is related to the higher degree of unsaturation of oil molecules. The low melting points of oils are a result of the effect that the shapes of the molecules have on close packing, hence on the strength of van der Waals' forces of attraction.
- Fats and oils are esters formed from the condensation of glycerol (propane-1,2,3-triol) and three carboxylic acid molecules.
- The carboxylic acids are known as 'fatty acids' and are saturated or unsaturated straight-chain carboxylic acids, usually with long chains of carbon atoms.
- Bromine solution can be used to test fats and oils for the degree of unsaturation. The higher the unsaturation levels the lower the melting point.
- The hydrolysis of triglycerides produces one molecule of glycerol (a trihydric alcohol) and three molecules of fatty acids which can be identical to or different from each other.
- The fatty acids produced can be saturated or unsaturated and always contain even numbers of carbon atoms C_4 to C_{24}, primarily C_{16} and C_{18}.
- The conversion of oils into hardened fats involves the partial removal of unsaturation by the addition of hydrogen.

3) Proteins

- Nitrogen is essential for protein formation by plants and animals.
- Proteins are the major structural materials of animal tissue.
- Proteins are also involved in the maintenance and regulation of life processes.
- Enzymes are proteins.
- The structure of a section of protein is based on the constituent amino acids.
- Amino acids, the building blocks from which proteins are formed, are relatively small molecules which all contain an amino group (NH2), and a carboxyl group (COOH).
- The body cannot make all the amino acids required for body proteins and is dependent on dietary protein for supply of certain amino acids known as essential amino acids.
- Proteins are made of many amino acid molecules linked together by condensation reactions.
- Condensation polymers are made from monomers with two functional groups per molecule. A small molecule is also produced as condensation occurs.
- In these condensation reactions, the amino group on one amino acid and the carboxyl group on a neighbouring amino acid join together, with the elimination of water.
- The link which forms between the two amino acids can be recognised as an amide link (CONH) also known as the peptide link when in living things.
- Proteins which fulfil different roles in the body are formed by linking differing sequences of amino acids together.
- During digestion, enzyme hydrolysis of dietary proteins can produce amino acids.
- The structural formulae of amino acids obtained from the hydrolysis of proteins can be identified from the structure of a section of the protein.
- Chromatography can separate and identify these amino acids by comparison with a bank of known amino acids.

4) Chemistry of Cooking

a) Flavour Molecules:

- the olfactory and taste senses in humans can be described;
- food flavours mainly excite the senses of taste and smell;
- molecular size and functional groups present affect the volatility of food molecules;
- flavour molecules can be water- or oil-soluble, consequently cooking methods can affect the quality of the food;
- cooking methods might enhance or destroy the food's flavour;
- cooking changes (denatures) proteins, in particular it can make tough collagen palatable;
- different cooking methods would be appropriate for different foods

b) Proteins

- within proteins, the long-chain molecules may be twisted to form spirals, folded into sheets, or wound around to form other complex shapes;
- the chains are held in these forms by intermolecular bonding between the side chains of the constituent amino acids;
- when proteins are heated, during cooking, these intermolecular bonds are broken allowing the proteins to change shape (denature).
- these changes alter the texture of foods.

5) Oxidation of Food

- When applied to carbon compounds, oxidation reactions result in an increase in the oxygen to hydrogen ratio.

a) Oxidation of alcohols

- Primary and secondary alcohols can be oxidised by a number of oxidising agents, including copper(II) oxide and acidified potassium dichromate.
- Primary alcohols are oxidised first to aldehydes and then to carboxylic acids. Secondary alcohols are oxidised to ketones.
- Tertiary alcohols are resistant to oxidation.

b) Aldehydes and ketones

- Alkanals and alkanones are homologous series of aldehydes and ketones respectively, identified by the presence of the carbonyl functional group. They are named in a similar way to alkanols.
- Aldehydes and ketones can be identified from the '-al' and '-one' name endings respectively.
- Straight-chain and branched-chain aldehydes and ketones, with no more than eight carbon atoms in their longest chain, can be named from structural formulae.
- Given the names of straight-chain or branched-chain aldehydes and ketones, structural formulae can be drawn and molecular formulae written.

c) Oxidation of food molecules

- Aldehydes, but not ketones, can be oxidised to carboxylic acids.
- Fehling's solution, Tollens' reagent and acidified dichromate solution can be used to differentiate between an aldehyde and a ketone.

d) Antioxidants

- Oxygen reacts with edible oils giving the food a rancid flavour.
- Antioxidants are molecules which will prevent these oxidation reactions taking place.
- Ion-electron equations can be written for the oxidation of many antioxidants.

6) Soaps, detergents and emulsions

a) Soaps

- production of soaps by the alkaline hydrolysis of fats and oils to form water-soluble ionic salts called soaps;
- soap ions have a long covalent tail, readily soluble in covalent compounds (hydrophobic), and an ionic carboxylate head which is negatively charged and water soluble (hydrophilic);
- during cleaning using soaps and detergents, the hydrophobic tails dissolve in a droplet of oil or grease, whilst the hydrophilic heads face out into the surrounding water;
- agitation of the mixture results in ball-like structure forming with the hydrophobic tails on the inside and the negative hydrophilic head on the outside;
- repulsion between these negative charges results in an emulsion being formed and the dirt released;

b) Detergents

- detergents are particularly useful in hard water areas;

c) Emulsions

- an emulsion contains small droplets of one liquid dispersed in another liquid. Emulsions in food are mixtures of oil and water;
- to prevent oil and water components separating into layers, a soap-like molecule known as an emulsifier is added;
- emulsifiers for use in food are commonly made by reacting edible oils with glycerol to form molecules in which either one or two fatty acid groups are linked to a glycerol backbone rather than the three normally found in edible oils;
- the one or two hydroxyl groups present in these molecules are hydrophilic whilst the fatty acid chains are hydrophobic;
- when applied to carbon compounds, reduction reactions result in a decrease in the oxygen to hydrogen ratio

7) Fragrances

a) Essential oils

- essential oils are concentrated extracts of the volatile, non-water soluble aroma compounds from plants;
- essential oils can be extracted from suitable plant sources by steam distillation or solvent extraction;
- essential oils are widely used in perfumes, cosmetic products, cleaning products and as flavourings in foods;
- essential oils are mixtures of organic compounds;
- terpenes are key components in most essential oils;

b) Terpenes

- terpenes are unsaturated compounds formed by joining together isoprene (2-methylbuta-1,3-diene) units;
- terpenes are components in a wide variety of fruit and floral flavours and aromas;
- terpenes can be oxidised within plants to produce some of the compounds responsible for the distinctive aroma of spices

8) Skin Care

a) UV radiation

- ultraviolet radiation (UV) is a high-energy form of light, present in sunlight;
- exposure to UV light can result in molecules gaining sufficient energy for bonds to be broken;
- this is the process responsible for sunburn and also contributes to aging of the skin;
- sun-block products prevent UV light reaching the skin;

b) Free radicals

- when UV light breaks bonds, free radicals are formed;
- free radicals have unpaired electrons and, as a result, are highly reactive;
- free radical chain reactions include the following steps: initiation, propagation and termination;

c) Free radical scavengers

- many cosmetic products contain free radical scavengers;
- free radical scavengers are also added to food products and to plastics.