

Things to remember in the last hour before the exam: Level 3 Demonstrate understanding of the properties of organic compounds

(This is not a revision sheet – you've done that by now – it's a list of things you might want to remind yourself about... and it can't possibly cover everything – although it has a very good try!)

1. 1 meth-, 2 eth-, 3 prop-, 4 but-, 5 pent-, 6 hex-, 7 hept-, 8 oct-.
2. Functional groups C=C (alkene), R-X (haloalkane where X is F, Cl, Br or I), R-NH₂ (amine), R-OH (alcohol), R-CHO (aldehyde), RC(=O)R (ketone), R-C(=O)OH (carboxylic acid), RC(=O)OR' (ester), R-C(=O)Cl (acyl chloride), RC(=O)NH₂ (amide). Amines and amides can also be substituted R-NH-R' or RC(=O)NH-R'.
3. Isomers - same # of atoms of each element, but have different arrangements of atoms.
 - Different connectivity – **constitutional** (structural) isomers e.g. straight vs branched, position of functional group (propan-1-ol vs propan-2-ol) or functional group (ester vs carboxylic acid)
 - Same connectivity but different spatial arrangements - **stereoisomers**
 - C=C bond restricts rotation & 2 diff atoms/groups on each C of the C=C: **geometrical isomers (cis and trans)**
 - Chiral/asymmetric C atom (C atom bonded to 4 different atoms/groups) leads to non-superimposable mirror images (enantiomers): **optical isomers (LEARN TO DRAW A TETRAHEDON IN 3D)**
Optical isomers rotate plane polarised light in opposite directions. Have same chemical & physical properties (apart from effect on light) e.g. m.pt, solubility & reactions, but different biochemical properties e.g. taste, smell). Equal mix of both isomers is racemix mix; no effect on light).
4. Types of reactions
 - **Substitution:** reactions using conc. HCl or HBr (alkene → haloalkane), SOCl₂ (alcohol to haloalkane AND c.acid to acyl chloride), NaOH(aq) / KOH(aq) (haloalkane → alcohol), conc. NH₃ (haloalkane → amine), primary amines (1° amine + haloalkane → 2° amine), primary alcohols/H⁺ (ester formation), H₂O/H⁺ OR H₂O/OH⁻ (hydrolysis reactions)
Substitution reactions include esterification, condensation, hydrolysis, and polymerisation.
 - **Esterification:** alcohol + c.acid ⇌ ester + H₂O OR alcohol + acyl chloride → ester + HCl
 - **Condensation:** two (larger) molecules join together and small one is eliminated – most often used when describing formation of polymers (see below)
 - **Hydrolysis:** substitution reaction; defined as “reaction with water” carried out in acidic conditions (H⁺/H₂O, heat OR NaOH(aq), heat).
 - **Polymerisation:** substitution reaction *usually described as condensation*, reactions involving formation of polyesters and polyamides - including proteins (from amino acids)
 - **Addition:** molecule combines with another, no other products; C=C to C-C. E.g. C₂H₄ + Br₂ → C₂H₄Br₂. (see later for test to distinguish alkane and alkene)
 - **Elimination:** reactions using KOH(alc), heat (haloalkane → alkene) OR conc. H₂SO₄ (alcohol → alkene): turns saturated molecule with C-C into unsaturated with a C=C.
 - **Oxidation:** reactions using the following reagents: MnO₄⁻/H⁺, Cr₂O₇²⁻/H⁺ (1° alcohol → aldehyde → carboxylic acid; 2° alcohol → ketone; MnO₄⁻ alkene → diol) AND Tollens', Fehling's and Benedict's (aldehyde → carboxylic acid)
 - **Reduction reaction** using NaBH₄ (aldehyde → 1° alcohol, ketone (but not c.acid) → 2° alcohol)
 - **Acid-base:** Makes salt of the carboxylic acid. RCOOH + NaOH → RCOO⁻ Na⁺ + H₂O. Also RCOOH + NH₃ → RCOO⁻ NH₄⁺ (NOTE: to make an amide heat the SALT made R-C(=O)O⁻ NH₄⁺ → R-C(=O)NH₂ + H₂O.)

5. Tests for/to distinguish between

- Alkane: **orange** Br₂ water very slowly decolourised, needs UV light and/or heat. Forms 2 layers as alkane is non-polar.
 - Alkene: orange Br₂ water rapidly decolourised OR **purple** MnO₄⁻ to **brown** MnO₂(s) OR **purple** MnO₄⁻/H⁺ to colourless Mn²⁺(aq); All form 2 layers as organic alkene is non-polar.
 - Alcohol: 1° and 2° oxidised by MnO₄⁻/H⁺ (**purple** to colourless Mn²⁺), Cr₂O₇²⁻/H⁺ (**orange** to **green** Cr³⁺); 3° not oxidised. Lucas Test (anhydrous ZnCl₂/conc.HCl) 3° cloudy immediately, 2° 10-15 minutes, 1° not (v v v slow). Cloudiness due to insolubility of the haloalkane.
 - Amine: only basic chemical @ L3! Moist **red** litmus turns **blue**. Moist UI paper or solution turns **blue** – WEAK base. $\text{RNH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{RNH}_3^+ + \text{OH}^-$ (Do not confuse with amides which are neutral)
 - Carboxylic acid: Moist **blue** litmus turns **red**. Moist UI paper or solution turns **orange** – WEAK ACID. $\text{RCOOH} + \text{H}_2\text{O} \rightleftharpoons \text{RCOO}^- + \text{H}_3\text{O}^+$. As acids will also react with Mg (fizzing, colourless gas) or NaHCO₃ or Na₂CO₃ (fizzing, colourless gas)
 - Acyl chloride: VIGOROUS (and I mean vigorous) reaction with H₂O – exothermic reaction with steamy acidic gas! $\text{R-COCl} + \text{H}_2\text{O} \rightarrow \text{R-COOH} + \text{HCl}$; both products acidic!
 - Amide: Boil with NaOH(aq); $\text{R-CONH}_2 + \text{NaOH} \rightarrow \text{RCOO}^-\text{Na}^+ + \text{NH}_3$; NH₃ gas turns moist red litmus **blue**
 - Aldehydes: (1) warm with Tollens (Ag⁺/NH₃); colourless to silver mirror forms: $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$ (reduction) as aldehyde is oxidised to c. acid. (2) warm with Benedict's / Fehling's (contains Cu²⁺); **blue** solution to **orange-red** precipitate of Cu₂O: $\text{Cu}^{2+} + \text{e}^- \rightarrow \text{Cu}^+$ (reduction) as aldehyde is oxidised to c. acid. KETONES do not give these results (as ketone is not oxidised further).
 - Haloalkanes: warm with AgNO₃(alc) or NaOH(alc) followed by H⁺ and AgNO₃; ppt shows halide. Alc. is needed because the haloalkanes are insoluble/immiscible in water. (This test not usually examined)
 - Esters: Usually a colourless liquid with a pleasant 'odour', insoluble in water / immiscible. Learn how to name them _yl _oate "yl" bit from alcohol, "oate" bit from c.acid/acyl chloride)
6. Markovnikov's rule: addition reaction of HX (HCl, HBr etc) OR H₂O (H⁺/H₂O, heat) to an unsymmetrical alkene, the hydrogen atom of HX or H₂O becomes bonded to the carbon atom that had the greatest number of hydrogen atoms; "rich get richer" predicts MAJOR product.
7. Saytzeff's / Zaitsev's rule: elimination of H₂O (from unsymmetrical alcohol) or HX (from unsymmetrical haloalkane), hydrogen atom lost from the carbon atom that had least hydrogen atoms / more substituted alkene is formed; "poor get poorer" predicts major product. Hint: if Q says "three products made" look for a cis and trans for 2 of the 3!
8. Acid hydrolysis of ester / fat or oil – break C(=O)-O; get carboxylic acid + alcohol
Alkaline hydrolysis of ester / fat or oil – break C(=O)-O; get sodium salt of carboxylic acid + alcohol
9. Acid hydrolysis of polyamide / protein– break C(=O)-N; get R-COOH + R-NH₃⁺ (-NH₂ protonated)
Alkaline hydrolysis of polyamide / protein– break C(=O)-N; get R-COO⁻Na⁺ + R-NH₂.
10. Insoluble: all alkanes, alkenes, alkynes, haloalkanes, polymers, and fats/oils (triglycerides).
Soluble – because the functional group can hydrogen bond with water: alcohols (C 1-3/4), carboxylic acids (C 1-4/5), acyl chloride, amines (C 1-5), amides, aldehydes and ketones (C 1-4), and small esters - BUT.... and it is a BIG BUT... as # of C↑ their solubility ↓ as non-polar R portion gets bigger. *Please do not take the # of C atoms written here as EXACT.... hopefully NCEA will have the sense NOT to select borderline soluble/insoluble compounds.* E.g. ethanamine (C2) = soluble whereas hexane = insoluble!