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-NH_2 (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)NH_2 (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 racemic mix; no effect on light).
4. Types of reactions
   - **Substitution**: reactions using conc. HCl or HBr (alkene → haloalkane), $SOCl_2$ (alcohol to haloalkane AND c.acid to acyl chloride), NaOH(aq) / KOH(aq) (haloalkane →alcohol), conc. NH_3 (haloalkane →amine), primary amines (1° amine + haloalkane → 2° amine), primary alcohols/H^+ (ester formation) , H_2O/H^+ OR H_2O/OH^- (hydrolysis reactions)
     Substitution reactions include esterification, condensation, hydrolysis, and polymerisation.
     - **Esterification:** alcohol + c.acid ⇌ ester + H_2O 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^+/H_2O, 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. $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$. (see later for test to distinguish alkane and alkene)
   - **Elimination:** reactions using KOH(alc), heat (haloalkane → alkene) OR conc. H_2SO_4 (alcohol → alkene): turns saturated molecule with C-C into unsaturated with a C=C.
   - Oxidation: reactions using the following reagents: MnO_4^-/H^+, $Cr_2O_7^{2-}/H^+$ (1° alcohol →aldehyde →carboxylic acid; 2° alcohol → ketone; MnO_4^- alkene → diol) AND Tollens', Fehling's and Benedict's (aldehyde →carboxylic acid)
   - Reduction reaction using $NaBH_4$ (aldehyde → 1° alcohol, ketone (but not c.acid) → 2° alcohol)
   - Acid-base: Makes salt of the carboxylic acid. RCOOH + NaOH → $RCOO^- Na^+ + H_2O$. Also RCOOH + NH_3 → $RCOO^- NH_4^+$ (NOTE: to make an amide heat the SALT made R-C(=O)$O^- NH_4^+$ → R-C(=O)NH_2 + H_2O.)

5. Tests for/to distinguish between
   - Alkane: orange Br_2 water very slowly decolourised, needs UV light and/or heat. Forms 2 layers as alkane is non-polar.
   - Alkene: orange Br_2 water rapidly decolourised OR purple MnO_4^- to brown $MnO_2(s)$ OR purple MnO_4^-/H^+ to colourless $Mn^{2+}(aq)$; All form 2 layers as organic alkene is non-polar.
   - Alcohol: I° and 2° oxidised by MnO_4^-/H^+ (purple to colourless Mn^{2+}), $Cr_2O_7^{2-}/H^+$ (orange to green Cr^{3+}); 3° not oxidised. Lucas Test (anhydrous $ZnCl_2$/conc.HCl) 3° cloudy immediately, 2° 10-15 minutes, I° not (v 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. $RNH_2 + H_2O \rightleftharpoons RNH_3^+ + OH^-$ (Do not confuse with amides which are neutral)
   - Carboxylic acid: Moist blue litmus turns red. Moist UI paper or solution turns orange – WEAK ACID. $RCOOH + H_2O \rightleftharpoons RCOO^- + H_3O^+$. As acids will also react with Mg (fizzing, colourless gas) or $NaHCO_3$ or Na_2CO_3 (fizzing, colourless gas)
   - Acyl chloride: VIGOROUS (and I mean vigorous) reaction with H_2O – exothermic reaction with steamy acidic gas! R-COCl + H_2O → R-COOH + HCl; both products acidic!
   - Amide: Boil with NaOH(aq); $R\text{-}CONH_2 + NaOH \rightarrow RCOO^-Na^+ + NH_3$; NH_3 gas turns moist red litmus blue
   - Aldehydes: (I) warm with Tollens (Ag^+/NH_3); colourless to silver mirror forms: $Ag^+ + e^- \rightarrow Ag$ (reduction) as aldehyde is oxidised to c. acid. (2) warm with Benedict's / Fehling's (contains Cu^{2+}); blue solution to orange-red precipitate of Cu_2O: $Cu^{2+} + e^- \rightarrow Cu^+$ (reduction) as aldehyde is oxidised to c. acid. KETONES do not give these results (as ketone is not oxidised further).
   - Haloalkanes: warm with $AgNO_3$(alc) or NaOH(alc) followed by H^+ and $AgNO_3$; 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 H_2O (H^+/H_2O, heat) to an unsymmetrical alkene, the hydrogen atom of HX or H_2O 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 H_2O (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 + $R\text{-}NH_3^+$ ($-NH_2$ protonated)
   Alkaline hydrolysis of polyamide / protein– break C(=O)-N; get $R\text{-}COO^-Na^+ + R\text{-}NH_2$.
10. Insoluble: <u>all</u> alkanes, alkenes, alkynes, haloalkanes, polymers, and fats/oils (triglycerides).
    Soluble – because the functional group <u>can hydrogen bond with water</u>: 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!