

## The Basics

### Organic Compounds with Carbon and Hydrogen

STOP AND CHECK (PAGE 10)

- Naming alkanes:
  - Count the number of carbon atoms in the longest chain (the backbone). Determine the prefix based on this number and add “-ane” to the end (e.g. A six-carbon backbone becomes “hexane”). Check for any side groups. If there aren’t any you’re done! If there are, keep going.
  - Count the number of carbon atoms in the side chain.
  - Determine the prefix based on this number and add “-yl” or “-thyl”. (e.g. a two-carbon side group becomes “ethyl”).
  - Counting from one end of the longest chain, determine the number carbon the side chain is attached to. Write this number in front of the “-thyl” prefix and write them both in front of the backbone name. (e.g. 2 ethyl hexane).Repeat for any other side groups. (e.g. 2-ethyl-3-methyl hexane).
- A saturated hydrocarbon only contains single C-C and C-H bonds, while an unsaturated hydrocarbon contains at least one double or triple bond. Alkanes are always saturated.
- The functional group present in alkenes is the double C=C bond.
- Alkene molecules are named in the same way as alkanes, except the suffix is “-ene” and the position number of the double bond is inserted between the prefix and suffix. The position number of the double bond is the lower numbered carbon the double bond is attached to.
- The functional group present in alkynes is the triple C≡C bond.

- Alkyne molecules are named in the same way as alkenes, except the suffix is “-yne”.

## Organic Compounds with Other Atoms

### STOP AND CHECK (PAGE 13)

- Halogens are in group 17 of the periodic table.
- The most common halogens are fluorine (F), chlorine (Cl), bromine (Br), and iodine (I).
- Prefixes:
  - Fluorine: Fluoro-
  - Chlorine: Chloro-
  - Bromine: Bromo-
  - Iodine: Iodo-
- The functional group in alcohols is the hydroxyl group.
- The atoms in the functional group of alcohols are O and H. (-OH)
- Alcohols are named with the suffix “-anol”. The position number of the -OH group is written in between the “-an” and “-ol”.
- A diol contains two hydroxyl groups, while alcohol only contains one.
- Diols are named with the suffix “diol”. The position number of the two hydroxyl groups are listed in between the first part of the name and “diol”.

## Acidic and Basic Organic Compounds

### STOP AND CHECK (PAGE 16)

- The atoms that make up the carboxyl group are C, O, O, and H. (-COOH)
- Carboxylic acids are named with the suffix “-anoic acid”. Its position number is not needed but counts as 1 if other functional groups are on the molecule.
- The carboxyl functional group can only be attached to the end of a carbon chain, so its position number is always known.
- The -COOH group contains a hydrogen that can be donated. This makes it a proton donor, which is the definition of an acid.
- The atoms that make up the amine group are N and two Hs.
- Amines can be named with the prefix “amino” or the suffix “-amine”.

- The amino group contains a nitrogen that can bond to an extra hydrogen atom. This makes it a proton acceptor, which is the definition of a base.

## The Carbonyl Group

### STOP AND CHECK (PAGE 17)

- An ester group. The atoms that make up the ester group are C, O, and O.
- Esters can be made from carboxylic acids and alcohols.
- Esters names are made up of two parts. The carbon group bonded directly to the O (the alcohol part) is used for the prefix of the first part, and “-yl” is its suffix. The other carbon group (the carboxylic acid part) is used for the prefix of the second part, and “-anoate” is its suffix.

## Acyl Chlorides

### STOP AND CHECK (PAGE 18)

- The acyl chloride group.
- Acyl chlorides and carboxylic acids both have a C=O bond, and the same carbon bonded to something else (chloride and hydroxyl, respectively). They are both only found on the first carbon atom.
- Acyl chlorides are named with the suffix “-anoyl chloride”.

## Amides

### STOP AND CHECK (PAGE 19)

- The amide group.
- Amides and carboxylic acids both have a C=O bond, and the same carbon bonded to something else ( $\text{-NH}_2$  and  $\text{-OH}$ , respectively). They are both only found on the first carbon atom.
- Amides are named with the suffix “-anamide”.

## Ketones and Aldehydes

### STOP AND CHECK (PAGE 21)

- The functional group in both aldehydes and ketones is the C=O bond.
- Aldehydes have the C=O on the first carbon of a chain. Ketones have the C=O bond on any carbon except the first.
- Aldehydes are named with the suffix “-anal”. The position number is always 1, so it is not written.
- Ketones are named with the suffix “-anone”. The position number is written between the “an” and “one”.

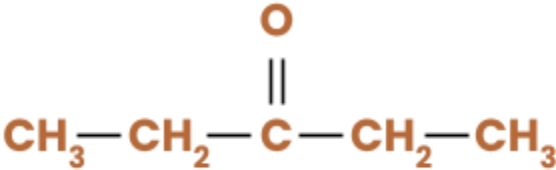
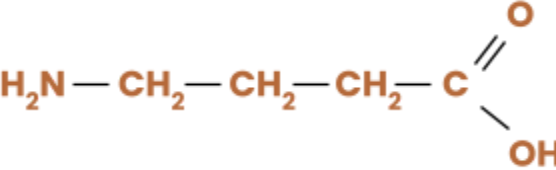
## Primary, Secondary, and Tertiary Groups

### STOP AND CHECK (PAGE 22)

- A primary haloalkane contains a halogen bonded to a carbon that is then bonded to only one other carbon atom. A secondary haloalkane contains a halogen bonded to a carbon that is then bonded to two other carbon atoms. A tertiary haloalkane contains a halogen bonded to a carbon atom that is then bonded to three other carbon atoms.

## Functional Groups

### QUICK QUESTIONS (PAGE 23)

Molecule name	Diagram
Pentan-3-one	
4-amino butanoic acid	

2-chloro-3,3-dibromohex-1-ene	$  \begin{array}{c}  \text{Br} \\    \\  \text{H}_2\text{C} = \text{C} - \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \\    \quad   \\  \text{Cl} \quad \text{Br}  \end{array}  $
2,2-dimethylhexanoic acid	$  \begin{array}{c}  \text{H}_3 \\    \\  \text{C} \\    \\  \text{H}_3\text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{C} - \text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{OH} \end{array} \\    \\  \text{C} \\    \\  \text{H}_3  \end{array}  $
3-chloropentanal	$  \begin{array}{c}  \text{Cl} \\    \\  \text{H}_3\text{C} - \text{CH}_2 - \text{CH} - \text{CH}_2 - \text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{H} \end{array}  \end{array}  $
1-aminobutan-2-ol	$  \begin{array}{c}  \text{H}_3\text{C} - \text{CH}_2 - \text{CH} - \text{CH}_2 - \text{NH}_2 \\    \\  \text{O} \\    \\  \text{H}  \end{array}  $
Propyl propanoate	$  \begin{array}{c}  \text{O} \\     \\  \text{H}_3\text{C} - \text{CH}_2 - \text{C} \\    \\  \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3  \end{array}  $
3-ethylpentan-3-ol	$  \begin{array}{c}  \text{OH} \\    \\  \text{H}_3\text{C} - \text{CH}_2 - \text{C} - \text{CH}_2 - \text{CH}_3 \\    \\  \text{CH}_2 \\    \\  \text{CH}_3  \end{array}  $

2-hydroxy ethanoyl chloride	
Butanamide	

- Naming molecules:

2-methylbutane	1-chloro-3-methylpentan-2-one
1-chlorobutan-2-ol	3-chloropropanamide
2-aminoethan-1-ol	2,3-dichloropropanoyl chloride
Methanoic acid	1-bromohex-2-ene-5-ol
Ethyl ethanoate	3-hydroxypropanamide
Butyl butanoate	1-amino-5,5-dimethylhexan-3-one

# Isomers

## Structural and Constitutional Isomers

STOP AND CHECK (PAGE 26)

- Structural isomers are two molecules with the same molecular formula but different structural formulas.
- Positional, branched-chain, and functional group isomers are all types of structural isomers. Positional isomers and branched-chain isomers all have the same functional group. Functional group isomers have different functional groups due to a different arrangement of the atoms. Positional isomers have the same overall carbon chain structure, the functional group is just on a different carbon, while branched-chain isomers have different main carbon chain lengths due to the formation of side chains.

## Optical Isomers

STOP AND CHECK (PAGE 28)

- The only difference between two optical isomers is the 3-dimensional orientation of atoms in space.
- Superimposable molecules can be rotated to have the same configuration. Non-superimposable molecules can never have the same configuration, so cannot be put on top of each other to get the same molecule.
- Left and right hands are mirror images of each other but can never be in the same configuration, both hands down and the thumbs are pointing the wrong direction, both thumbs one way and one hand will face palm up, the other palm down.

## Chiral Carbons

STOP AND CHECK (PAGE 28)

- If a carbon atom is bonded to four different atoms or groups of atoms, it is a chiral carbon.
- If a molecule has a chiral carbon, it has the ability to form optical isomers.

## Difference Between Optical Isomers

### STOP AND CHECK (PAGE 26)

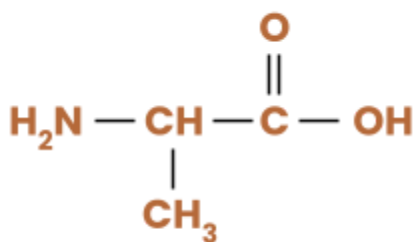
- The only difference between two optical isomers is that they rotate plane-polarised light in opposite directions.

## Isomers

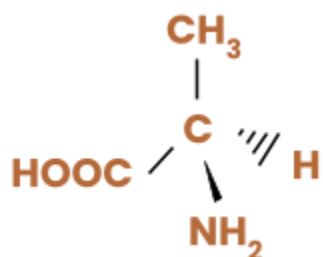
### QUICK QUESTIONS (PAGE 29)

- Alanine contains a chiral carbon, a carbon that has four different atoms/groups of atoms around it. This means alanine has two possible 3-dimensional orientations in space.
- Glycine has no chiral carbon, so it is superimposable with its mirror image.

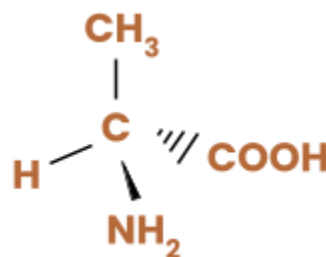
Alanine:



Orientation 1:



Orientation 2:





# Organic Compounds

## Addition Reactions

STOP AND CHECK (PAGE 34)

- An addition reaction occurs when new atoms are attached to the original organic molecule.
- Only molecules with a double or triple bond undergo addition reactions, i.e. alkenes and alkynes.
- Alkanes, haloalkanes, di-haloalkanes, and alcohols can be produced from alkene addition reactions.
- $\text{H}_2$  (to form alkanes),  $\text{HCl}/\text{HBr}$  (to form haloalkanes),  $\text{Cl}_2/\text{Br}_2$  (to form dihaloalkanes), and  $\text{H}_2\text{O}/\text{H}^+$  (to form alcohol).

## Markovnikov's Rule

STOP AND CHECK (PAGE 34)

- "The rich get richer" means that the hydrogen atom is added to the carbon that already has the most hydrogen atoms.
- The major product is formed according to Markovnikov's Rule and is the product produced in greater amounts. The minor product is the other, less common, product.

## Elimination Reactions

STOP AND CHECK (PAGE 38)

- An elimination reaction occurs when atoms are removed from two neighbouring carbon atoms.
- Alcohols and haloalkanes can undergo elimination reactions.
- All elimination reactions produce alkenes.
- Concentrated sulfuric acid,  $\text{H}_2\text{SO}_{4(\text{conc.})}$ , used to remove water ( $\text{H} + \text{OH}$ ) from an alcohol; alcoholic potassium hydroxide,  $\text{KOH}_{(\text{alc.})}$ , used to remove  $\text{HCl}$  or  $\text{HBr}$  from haloalkanes.  $\text{H}_2\text{O}$  and  $\text{HCl}/\text{HBr}$  are the side products, respectively.

## Reverse Markovnikov's Rule

STOP AND CHECK (PAGE 39)

- Reverse Markovnikov's Rule is used when forming an alkene from i) an alcohol or ii) a haloalkane.
- "The poor get poorer" means that the hydrogen atom is removed from the carbon that has the fewest hydrogen atoms.
- The major product is formed according to Reverse Markovnikov's Rule, and is the product produced in greater amounts. The minor product is the other, less common, product.

# Oxidation and Reduction Reactions

## Oxidation and Reduction Reactions

STOP AND CHECK (PAGE 42)

- In an oxidation reaction, the molecule gains bond(s) to oxygen.
- Primary alcohols (forming aldehydes and carboxylic acids), aldehydes (forming carboxylic acids), secondary alcohols (forming ketones), and alkenes (forming diols) can all undergo oxidation.
- Acidified dichromate,  $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}$ , and acidified permanganate,  $\text{H}^+/\text{MnO}_4^{2-}$ .

## Substitution Reactions

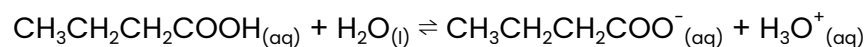
STOP AND CHECK (PAGE 46)

- Substitution reaction occurs when atoms leave the molecule and are replaced by others.
- Haloalkanes ( $-\text{Cl}$  or  $-\text{Br}$ ), alcohols ( $-\text{OH}$ ), carboxylic acids ( $-\text{OH}$ ), and acyl chlorides ( $-\text{Cl}$ ) all undergo substitution reactions. For all of these, the  $-\text{Cl}/-\text{Br}$  can be swapped with  $-\text{OH}$  or  $-\text{NH}_2$ , and similarly the  $-\text{OH}$  can be swapped with  $-\text{Cl}$ ,  $-\text{Br}$ , or  $-\text{NH}_2$ .

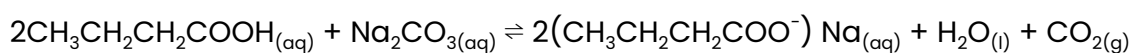
## Neutralisation Reactions with Carboxylic Acids

STOP AND CHECK (PAGE 46)

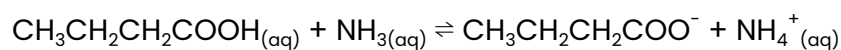
- Carboxylic acid + water:



- Carboxylic acid + metal carbonate:



- 3. Carboxylic acid + base:

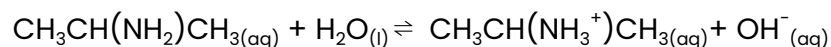


## Acid-Base Reactions Involving Amines

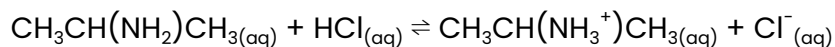
STOP AND CHECK (PAGE 48)

- Example with 2-amino-propane:

- Amine + water:



- Amine + acid:



- When ammonia and a carboxylic acid are mixed, they undergo an acid-base reaction.

## Condensation Reactions

### STOP AND CHECK (PAGE 52)

- A condensation reaction involves joining two molecules to create one large molecule, with a smaller molecule removed.
- Condensation reactions needed:
  - Carboxylic acid + alcohol  $\rightarrow$  Ester + water
  - Acyl chloride + alcohol  $\rightarrow$  Ester + hydrochloric acid
  - Acyl chloride + amine  $\rightarrow$  Amide

## Hydrolysis

### STOP AND CHECK (PAGE 52)

- The role of water in hydrolysis reactions is to break up a large molecule into smaller ones.
- In acid hydrolysis, any products will be protonated if possible. This means amine or carboxyl groups will have as many hydrogens as possible attached. In base hydrolysis, any products that can be deprotonated will be. This means amine or carboxyl groups will have as few hydrogens attached as possible.
- Polymers, triglycerides, polypeptides, and esters can all be hydrolysed.

## Triglycerides and their Hydrolysis

### STOP AND CHECK (PAGE 54)

- Triglycerides are made up of glycerol (a triol with 3 carbons that each have one hydroxyl group) and fatty acids (carboxylic acids with long hydrocarbon chains).
- Triglycerides are produced through an esterification reaction.
- Saturated triglycerides contain no carbon double or triple bonds in the long hydrocarbon chains. Unsaturated triglycerides do contain some double or triple bonds in the long hydrocarbon chains.
- Triglycerides can be hydrolysed in acid to form glycerol and three carboxylic acids. They can also be hydrolysed in base to form glycerol and three

carboxylate ions (or three carboxylate salts). The only difference is whether or not the carboxyl group is protonated (has a hydrogen attached).

## Distillation, Reflux, and Separating Funnels

### STOP AND CHECK (PAGE 57)

- The purpose of distillation is to purify products by separating them based on their boiling points. This is done by heating a solution at a specific temperature, so that one liquid will become a gas (the liquid with the lowest boiling point) while the other(s) remain liquid. The gas moves into a condenser, which cools it back to a liquid because of the cold water pumped around the outside. This liquid drips into a separate flask, and the mixtures have been purified.

Another purpose of distillation is to separate a product from a reaction before it can react further. When oxidising a primary alcohol, an aldehyde is formed first. Under distillation it will evaporate and condense into a separate flask before they can form a carboxylic acid. And even if some carboxylic acid molecules are produced, they have a higher boiling point and will not be separated with the aldehyde.

- The purpose of reflux is to allow a solution to be heated without letting molecules escape the reaction. Any molecules that evaporate move into a condenser, which has cold water pumped around it, causing the molecules to cool and condense back into the reaction mixture again.
- The purpose of separating funnels is to allow us to separate two liquids with different densities. The liquid with a higher density settles on the bottom of the funnel, and can be let out with a tap until only the lower density liquid remains in the funnel and the liquids have been separated.

## Polymers, Amino Acids and Proteins

### Polymers

#### STOP AND CHECK (PAGE 61)

- Polymers can be formed by condensation of a dicarboxylic acid or diacyl chloride monomer and a diol monomer, or a single monomer with a carboxylic acid or acyl chloride at one end and a hydroxyl group at the other, to form a series of ester links.
- Polymers can also be formed by condensation of a diacyl chloride monomer and diamine monomer, or a single monomer with an acyl chloride at one end and a hydroxyl group at the other, to form a series of amide links.

## Amino Acids and Proteins

### QUICK QUESTIONS (PAGE 62)

- A polymer is a very large molecule composed of repeating units. They can be made by reacting one monomer with itself many times to form a long chain, or by reacting two monomers with each other to form an alternating chain.
- Polypeptides are polymers of amino acids, a monomer with a carboxyl group and amine group attached to the same carbon. They are formed by removing the -OH group from one carboxyl group and an -H from one amine group and joining the remaining molecules. This is a condensation reaction that forms water as the side product and creates an amide bond.

# Properties of Organic Compounds

## Introduction to Polarity

### STOP AND CHECK (PAGE 66)

- Polarity is the separation of charge over a covalent bond.
- Polar molecules have a positively-charged region and a negatively-charged region. In a polar covalent bond, one atom will be partially positively charged, and the other will be partially negatively charged.
- Electronegativity is the tendency of an atom to attract bonding electrons.
- Atoms at the top right of the periodic table have the highest electronegativity values (N, O, and F) and atoms at the bottom left have the lowest values (Cs, Fr).

- A nonpolar covalent bond must be between atoms of the same element, with the same electronegativity.
- Nonpolar covalent bonds have no separation of charge because the atoms pull on the electrons with the same strength, so the electrons spend the same amount of time around each.
- A polar covalent bond is between two different kinds of atoms; atoms with different electronegativities.
- Polar covalent bonds have separation of charge because one atom will have a greater tendency to attract the bonding electrons. Electrons will spend more time around this atom, giving it a partial negative charge, and leaving the other atom with a partial positive charge.

## Polarity of Organic Compounds

### STOP AND CHECK (PAGE 68)

- Alkanes, alkenes, and alkynes are all symmetrical, so the C-H polar covalent bonds all cancel out, and the overall molecule is nonpolar.
- Haloalkanes are considered nonpolar, as the partial charge on the halogen is usually small enough to not impact the overall molecule very much.
- Compounds containing oxygen or nitrogen (alcohols, amines, carboxylic acids, esters, amides, acyl chlorides, ketones, and aldehydes) are considered polar when the carbon chain is small (less than 5 carbons). A molecule with a long carbon chain, even containing oxygen or nitrogen, is considered nonpolar.

## Introduction to Melting/Boiling Point

### STOP AND CHECK (PAGE 70)

- Solids are converted to liquids by partially overcoming the intermolecular forces within the compound. Liquids are converted to gases by completely overcoming the intermolecular forces within the compound.
- The strongest intermolecular force is hydrogen bonding, the next strongest is permanent dipole-dipole forces, and weakest is instantaneous dipole-dipole forces.

## Melting/Boiling Point of Organic Compounds

### STOP AND CHECK (PAGE 71)

- Intermolecular forces hold molecules together.
- Alcohols contain a -OH group which forms hydrogen bonds, the strongest intermolecular force, so the molecules are held together strongly and require a lot of heat to break these bonds, hence a higher boiling point. Alkanes, alkenes, alkynes, and haloalkanes are all nonpolar and so are only held together with weak instantaneous dipole forces, meaning not much energy is required to their intermolecular bonds, and so they all have lower boiling points.
- The melting/boiling increase as the carbon chain increases.
- Straight chained molecules have higher melting/boiling points because the molecules can move closer to each other than a branched chain molecule, leading to better intermolecular forces, and so more heat required to break these bonds.

## Introduction to Solubility

### STOP AND CHECK (PAGE 72)

- Solubility is how likely something is to dissolve in something else.
- The rule that determines whether something will dissolve in something else is “like dissolves like”. If the solute and solvent are both polar, or both nonpolar, the solute will dissolve in the solvent. If one is polar and one nonpolar, the solute will not dissolve.

## Solubility of Organic Compounds

### STOP AND CHECK (PAGE 73)

- Alkanes, alkenes, and alkynes are all nonpolar molecules, so do not dissolve in polar water.
- If you tried to mix a haloalkane and water, once you stop stirring they would separate, forming two layers.



- Small carboxylic acids and amines are polar molecules, so will dissolve in polar water. When the carbon chain gets too long, the nonpolarity of the molecule becomes too much and they no longer dissolve.

## Properties of Organic Compounds

### QUICK QUESTIONS (PAGE 75)

- Alkanes, alkenes, and alkynes are all nonpolar molecules, as their symmetry causes the polarity of the C-H bonds to cancel out. They all have low melting/boiling points, though the melting/boiling points get higher as the carbon chain gets longer, and straight chains have higher melting/boiling points than branched. This is because their only intermolecular force is instantaneous dipoles, which are very weak but get stronger with more electrons and by the proximity of molecules. Alkanes, alkenes, and alkynes are all immiscible in water but will dissolve in nonpolar solvents.
- Haloalkanes are considered nonpolar as the polarity of the halogen-carbon bond is overwhelmed by the nonpolar carbon chain. This means they behave very similarly to alkanes: they have low melting/boiling points as their only intermolecular forces are instantaneous dipoles, their melting/boiling points increase with longer and straighter chains, and they will only dissolve in nonpolar solvents.
- Alcohols and diols contain a very polar -OH group, so are polar molecules unless the chain becomes too large (five or more carbon atoms). They have high melting/boiling points as the -OH group allows hydrogen bonding between the molecules. This is the strongest intermolecular force, requires a lot of energy to overcome. As the short-chained alcohols/diols are polar, they will dissolve in water and other polar solvents, but won't dissolve in nonpolar solvents. Long-chained alcohols/diols will only dissolve in nonpolar solvents.
- Carboxylic acids also contain a very polar -OH group, as well as another polar C=O bond, making the molecules very polar (up to about five carbons in the chain). They have high melting/boiling points as the -OH group allows hydrogen bonding, and the polar C=O bond also contributes to strong intermolecular forces which take a lot of energy to overcome. Short-chained carboxylic acids are soluble in water and other polar solvents, and immiscible in nonpolar solvents. Long-chained carboxylic acids are immiscible in polar solvents and soluble in nonpolar solvents.

- Amines contain very polar N-H bonds, so short-chained amines are polar. They have high melting/boiling points because the N-H allows hydrogen bonding between the molecules, resulting in high intermolecular forces that require a lot of energy to overcome. Short-chained amines are soluble in water and other polar solvents, and immiscible in nonpolar solvents. Long-chained amines are immiscible in polar solvents and soluble in nonpolar solvents.
- Esters, amides, acyl chlorides, ketones, and aldehydes all contain a polar C=O bond, so are polar if the carbon chain is short enough. They have higher melting/boiling points than similar alkanes, though lower melting/boiling points than similar alcohols and amines. This is because the C=O bond allows permanent dipole interactions, which are strong intermolecular forces, but do not participate in hydrogen bonding, so the energy required to overcome the intermolecular forces is about middling.
- Polar organic molecules have strong permanent dipole interactions holding molecules together, while nonpolar organic molecules only have weak instantaneous dipoles holding them together. This means it takes more energy to overcome the intermolecular forces of polar molecules than nonpolar molecules, so the polar molecules will always have higher melting/boiling points than corresponding nonpolar molecules. Polar organic molecules will dissolve in polar solvents, like water, and will not dissolve in nonpolar solvents, while nonpolar organic molecules will dissolve in nonpolar solvents, but will not dissolve in polar solvents. This is because “like dissolves like”.

Functional Group	Polarity	Melting/ Boiling Point	Solubility
Alkanes/alkenes /alkynes	Nonpolar	Low	Soluble in nonpolar solvents like hexane. Immiscible in water.
Haloalkanes	Nonpolar	Low	Soluble in nonpolar solvents like hexane. Immiscible in water.
Alcohols (and diols)	Short chains are polar	High	Short chains are soluble in water but not nonpolar

			solvents. Long chains are immiscible in water but soluble in nonpolar solvents.
Carboxylic acids	Short chains are polar	High	Short chains are soluble in water but not nonpolar solvents. Long chains are immiscible in water but soluble in nonpolar solvents.
Amines	Short chains are polar	Medium	Short chains are soluble in water but not nonpolar solvents. Long chains are immiscible in water but soluble in nonpolar solvents.
Esters, amides, acyl chlorides, ketones, and aldehydes	Short chains are polar	Medium	Short chains are soluble in water but not nonpolar solvents. Long chains are immiscible in water but soluble in nonpolar solvents.

## Identification Tests

### Red and Blue Litmus Paper

#### STOP AND CHECK (PAGE 75)

- Red litmus paper does not change in the presence of an acid. Blue litmus paper turns red in the presence of an acid.
- Red litmus paper turns blue in the presence of a base. Blue litmus paper does not change in the presence of a base.
- Neither red nor blue litmus paper change colour in the presence of a neutral solution.

## Distinguishing Between Types of Alcohols

STOP AND CHECK (PAGE 77)

- Primary alcohols form carboxylic acids when oxidised.
- Orange dichromate will turn green when added to a primary or secondary alcohol, but will stay orange when added to a tertiary alcohol.
- When dichromate reacts with a primary alcohol, a carboxylic acid and  $\text{Cr}^{3+}$  are both formed.
- Purple permanganate will turn colourless when added to a primary or secondary alcohol, but will stay purple when added to a tertiary alcohol.
- When permanganate reacts with a primary alcohol, a carboxylic acid and  $\text{Mn}^{2+}$  are both formed.
- Dichromate and permanganate don't react with tertiary alcohols because oxidising tertiary alcohols would require removing a side chain.

## Bromine Water

STOP AND CHECK (PAGE 78)

- When bromine water is added to an alkene, the orange-brown turns colourless straight away.
- When bromine water is added to an alkane without UV light the orange-brown colour does not change.

# Distinguishing Aldehydes and Ketones

## Benedict's and Fehling's Solution

STOP AND CHECK (PAGE 79)

- Both Benedict's and Fehling's solutions contain  $\text{Cu}^{2+}$ .
- When you add an aldehyde to a Benedict's / Fehling's solution a red precipitate will form in the blue solution. When you add a ketone to a Benedict's / Fehling's solution, no precipitate forms and the blue colour remains (no reaction occurs).

## Tollen's Reagent (Silver Mirror Test)

STOP AND CHECK (PAGE 79)

- Tollens reagent contains  $\text{Ag}^+$ .
- When an aldehyde is added to Tollens reagent, a silver precipitate coats the surface of the container, forming a mirror-like surface. When a ketone is added to Tollens reagent, no reaction occurs.

## Acyl Chlorides and Water

STOP AND CHECK (PAGE 82)

- When water is added to an acyl chloride, a vigorous reaction will occur and a gas will be produced. If damp blue litmus paper is held in this gas, it will turn red, confirming that the solution is indeed an acyl chloride.
- When reacted with water, acyl chlorides produce HCl gas.

## Distinguishing Aldehydes and Ketones

QUICK QUESTIONS (PAGE 82)

- First, test each solution with red litmus paper. The solution that turns it blue is ethanamine (the only base). Then test each remaining solution with blue litmus paper. The solution that turns it red is ethanoic acid (the only acid).
- Next, add the remaining solutions to water. Ethanol is polar so will dissolve, while both hexane and hex-1-ene are nonpolar so will form two layers when added. Finally, add bromine water to the remaining two solutions. The one that reacts immediately to decolourise the orange-brown colour is hex-1-ene, an alkene that undergoes a quick addition reaction with the  $\text{Br}_2$ . The final solution is hexane.
- Methylpropan-2-ol is a tertiary alcohol, so will not react with oxidising agents like the other two alcohols. If an oxidant like permanganate is added to all three, only methyl propane-2-ol will not decolourise the purple. Butan-1-ol is a primary alcohol so will oxidise to form a carboxylic acid, while butan-2-ol is a secondary alcohol so will form a ketone when oxidised. Carboxylic acids are

acidic, while ketones neutral, so once both solutions have been oxidised as before, test both with blue litmus paper. The solution that was originally butan-1-ol will turn the blue litmus paper red.

- If Benedict's/Fehling's solution is added to each, propanal will cause a red precipitate to form in the blue solution, while propanone will not react. If Tollens reagent is added to each, propanal will cause a silver mirror to form on the side of the reaction flask, while propanone will not react. Additionally, oxidants like permanganate (propanal will decolourise the purple) or dichromate (propanal will cause the orange solution to go blue/green) can be used to distinguish the two. In all cases, the principle is that ketones cannot be oxidised with these substances, so will not react, while aldehydes are easily oxidised to form carboxylic acids, and show a clear reaction.
- Prop-1-amine is basic, so will turn red litmus paper blue. Propanamide is neutral, so will not change red litmus paper.