# 6.1 - Aromatic compounds, carbonyls and acids

## 6.1.1 - Aromatic compounds

|  |  |
| --- | --- |
| **What was wrong with Kekule’s benzene structure and why?** | * Doesn't react readily with halogens…   + If it had 3 C=C bonds it’s expected to react rapidly with Br2 by electrophilic addition.   + It doesn’t react readily as its e- is too low - requires a catalyst and does so by electrophilic substitution. * Bond lengths…   + C=C bonds are shorter than C-C bonds ∴ benzene should be irregular/deformed.   + When bond length were measured. They were all the same, **intermediate in length** between single and double carbon-carbon bonds ∴ **regular** hexagonal shape. * Enthalpy change of hydrogenation…   + Scientists measured it to be -120kJmol-1 for cyclohexene ∴ with benzene we’d expect -360kJmol-1.   + Was measured to be -208kJmol-1 ∴ more stable than expected. |
| **Describe the π-ring in benzene and its consequences** | 1. Sideways overlap of 6 p-orbitals (each containing 1 e-). 2. Electron density above and below the plane spread over 6 12C's ∴ low electron density ∴ unable to polarise many molecules ∴ reactions require catalysts. 3. **Delocalised electrons** meaning not attached to any single atom. |
| **How do these structures compare?** | * π-bond(s) are localised between 2 carbons in left structure (1) * π-bond(s) are delocalised in right structure (1) |
| **Why are the carbon-carbon bonds in benzene all equal in length?** | As the π bonds in benzene are delocalised. |
| **Describe the nomenclature for polysubstituted arenes** | * The lowest number is given to the lowest position of the alphabet:     1-bromo-4-chloro-2-ethylbenzene   * When benzene is attached to an alkyl group with 7 or more carbons **OR** an alkyl with a functional group on it, it is the substituent:     *Phenylethanone*    *2-phenylhexane* |
| **Give the 3 non-systematic arenes you need to know** | *Benzoic acid*    *Phenylamine*    *Benzaldehyde* |
| **What are the conditions, reactants, steps (with mechanism), and precautions of nitration?** | * Conditions/reactants: 50 °C, conc. HNO3 (nitric acid), conc. H2SO4 (sulfuric acid).  1. Form the nitronium ion…    1. **Stage 1:** H2SO4 + HNO3 → HSO4- + H2NO3+    2. **Stage 2:** H2NO3+ → NO2+ + H2O    3. **Overall:** HNO3 + 2H2SO4 → NO2+ + 2HSO4- + H2O 2. React nitronium ion with benzene…       *The catalyst H2SO4 has reformed.*   * Perform within a water bath ∵ reaction is exothermic. Any temperature too high will lead to polynitration rather than mononitration |
| **What are the reactants and steps (with mechanism) of the halogenation of benzene?** | * Reactants: halogen carrier (e.g., FeBr3/AlBr3 for bromination and FeCl3/AlCl3 for chlorination) as a catalyst.  1. The halogen carrier polarises the halogen allowing it to react with the halogen carrier to form a positive electrophile.    * Br2 + FeBr3 → Br+ + FeBr4- 2. React the electrophile with the benzene…       *A positive electrophile has to be formed because benzene isn’t very polarising.* |
| **What are the conditions, reactants, and mechanism for Friedel–Crafts alkylation of benzene?** | * Conditions: heating under reflux. * Reactants: haloalkane with its halogen carrier (e.g., AlCl3 for CH3Cl). * Mechanism: electrophilic substitution,       The CH3Cl + AlCl3 forms [CH3]+ + [AlCl4]-. |
| **What is an acyl halide?** | Where R is an alkyl group and X is a halogen. |
| **What are the conditions, reactants, equation, and mechanism for Friedel–Crafts acylation of benzene?** | * Conditions: heating under reflux, 50 °C. * Reactants: acyl halide and halogen carrier (e.g., CH3COCl for AlCl3). * Equation: CH3COCl + AlCl3 →[CH3CO]+ + [AlCl4]-. * Mechanism: electrophilic substitution, |
| **How does benzene compare to other alkenes? (3)** | 1) Bezene reacts by electrophilic substitution **WHEREAS** other alkenes react by electrophilic addition.  2) Benzene has 6 delocalised e-'s in π-ring, 12 localised σ e-'s (2 in each C-C) **WHEREAS** other alkenes have 2 localised e-'s in π-bond and 2 in σ-bond in C=C.    Benzene has 12 σ-bonds in total so 24 σ e-'s.  3) Benzene requires a cataylst (eg, halogen carrier) ∵ its e- density is too low to polarise molecules **WHEREAS** other alkenes react readily ∵ high e- density. |
| **How does the reactivity of methylbenzene and benzene compare?** | Methylbenzene is more reactive ∵ alkyl group releases electrons into π-ring ∴ increasing its electron density ∴ more polarising ∴ more reactive. |
| **What is phenol?** | A benzene group with a -OH directly attached. |
| **What type of acid is phenol and how will it react with metals and bases?** | 1. A weak acid.  2. Reacts with metals and strong bases (eg, NaOH):    **THIS INCLUDES ANY OTHER AROMATIC COMPOUND WITH AN -OH.**  3. Too weak to react with weak bases (eg, Na2CO3) unlike carboxylic acids. |
| **How do alcohols react with bases?** | They don’t because they’re not acidic. |
| **How can you distinguish between phenol and a carboxylic acid?** | Carboxylic acids will react with a weak base (e.g., NaCO3) leading to effervescence **HOWEVER** phenol will not. |
| **Describe the bromination of phenol (product, conditions, reactants)** | * Forms a white ppt (can be used to distinguish from alkene as the bromine decolourises). * No halogen carrier required, reacts **readily**, room temperature. |
| **Describe the nitration of phenol (with equation / diagrams)** | 1. Reacts readily with dilute nitric acid to form a mixture:    2. Reacts readily conc. nitric acid to produce 2,4,6-trinitrophenol: |
| **Why is phenol more reactive than benzene? (3)** | * The lone pair on the 16O **partially delocalises** into the π-ring (1) * Electron density increases (1) * Making it more polarising (1) as it incudes dipoles making molecules polar. |
| **Give 2 uses of phenol** | * Antiseptic (used by Lister, called carbolic acid). * Detergents. * Dyes. |
| **Describe the 3 cases with ‘directing groups’ with examples** | 1. **Unsubstituted ring** - electron density constant so electrophiles are equally likely to react with any carbon. 2. **Substituted with electron-donating group** (-OH or -NH2) - e-’s partially delocalise into the ring increasing its density at carbon 2, 4, 6 making them more likely to react. 3. **Substituted with electron-withdrawing group** (-NO2) - no e-’s to delocalise, withdraws density from the ring, particularly carbons 2, 4, 6 making 3, 5 more likely to react.   You can remember -NO2 as being an electron-withdrawing group since NO for "NOT OPEN". |

## 6.1.2 - Carbonyl compounds

|  |  |
| --- | --- |
| **What are carbonyl compounds?** | An aldehyde or ketone (containing C=O bond). |
| **Are carbonyls soluble and if so, why and which ones?** | * Yes as it forms hydrogen bonds. * The small ones. |
| **How is Tollens’ Reagent formed? (aka ammoniacal silver nitrate)** | 1. By mixing NaOH (aq) to AgNO3 (aq) until a brown ppt is formed. 2. Adding dilute ammonia drop-by-drop until the ppt re-dissolves. |
| **How is Tollens’ Reagent formed and used? (aka ammoniacal silver nitrate)** | Aldehydes are oxidised by Tollens’ into carboxylic acids with Ag+ ions being reduced and coating inside of the test tube with a silver mirror:  Ag+ (aq) + e- → Ag (s)  **and**    This cannot happen with ketones as they cannot be oxidised. |
| **How is Brady’s Reagent used to identify carbonyls? And how does it react? (4)** | * Reacts with carbonyls to form a orange/yellow ppt (1)   (2)   * Recrystallise and determine melting point (3) * Compare to database values (4) |
| **How are carbonyls reduced to alcohols? (without catalyst method) (reagents, conditions, mechanism, example equation)** | * NaBH4 is used as a source of hydride (H-) ions. * In ethanol solution. * Mechanism:      * Examples:   + CH3CH2CHO + 2[H] → CH3CH2CH2OH   + CH3COCH3 + 2[H] → CH3CH(OH)CH3   *[H] just means some reducing agent.* |
| **How can carbonyls be converted to alcohols? (with CATALYST) (type, reagents, conditions, example)** | * Type: reduction. * Reagents: H2 and nickel catalyst. * Conditions: high pressure. * Examples: CH3CHO + H2 → CH3CH2OH |
| **What are nitriles?** | An organic compound that has a C≡N functional group |
| **How are nitriles named?** | The C≡N becomes part of the main chain (e.g., 2-hydroxy-2-methylpropanenitrile). |
| **How can carbonyls become hydroxynitriles and why would you do this? (with reagents, conditions, mechanism)** | * Reagents: sodium cyanide (NaCN) and dilute H2SO4 **OR** HCN. * Conditions: RTP. * Mechanism: nucleophilic addition. * In the case below, NaCN supplies CN- ions and H2SO4 supplies H+ ions.      * This is useful for increasing the length of the carbon chain.   *Hydrogen cyanide (HCN) can be used as it dissociates in water to the ions but it’s highly toxic.* |

## 6.1.3 - Carboxylic acids and esters

|  |  |
| --- | --- |
| **How does the strength of carboxylic acids vary with carbon chain length and why?** | * Increasing length means weaker acid. * Increasing the length pushes e- density onto the COO- making it more negative thus less stable thus less likely to form. |
| **What are salts of carboxylic acids called?** | Carboxylates. E.g, (CH3COO-)Na+ is called sodium ethanoate. |
| **What is different about methanoic acid to other carboxylic acids?** | It can be oxidised as its structure as it has an aldehyde group. |
| **How are esters named?** | The alcohol ends in -yl and is the prefix. The carboxylic acid ends in -anoate and is the suffix.    *This is called methyl-ethanoate.* |
| **Describe the 2 types of esterification** | 1. Esterification using acid catalyst:    * Carboxylic acid + alcohol ⇌ ester + water    * Sulfuric acid catalyst required for H+ ions    * Heat under reflux 2. Esterification using acid anhydrides:    * Acid anhydride + alcohol → ester    * Room temperature    * Higher yield achieved |
| **What is an acid anhydride?** | Two different carboxylic acids joined together.    *Ethanoic anhydride* |
| **Give 2 ways esters can be hydrolysed (with conditions)** | 1. **Heating with HOT AQUEOUS ACID**:    * Use sulfuric acid catalyst under reflux.    * Forms the original reactants.    * CH3CH2CO2CH2CH3 + H2O ⇌ CH3CH2COOH + CH3CH2OH (reversible so doesn’t give a good yield) 2. **Heating with HOT AQUEOUS ALKALI (saponification)**:    * Use sodium hydroxide under reflux.    * Forms a carboxylate and alcohol.    * CH3CH2CO2CH3 + NaOH → (CH3CH2CO2- )Na+ + CH3OH   *The anion in the salt is resistant to attack by weak nucleophiles such as the alcohol so this reaction isn’t reversible.* |
| **How and why are acyl chlorides better than carboxylic acids?** | They are more reactive than carboxylic acids as Cl is a good leaving group. |
| **How are acyl chlorides formed?** | * By reacting carboxylic acid using SOCl2 (thionyl chloride). * CH3COOH + SOCl2 → CH3COCl + SO2 + HCl |
| **How do acyl chlorides react with water?** | To produce a carboxylic acid. |
| **How do acyl chlorides react with alcohols and why is it good?** | * To produce an ester. * It’s faster (∵ more reactive) and not reversible. |
| **How do acyl chlorides react with ammonia?** | To produce a primary amide. |
| **How do acyl chlorides react with primary and secondary amines? (with example equation)** | * To produce secondary and tertiary amides respectively. * Example:     *The N means that the methyl group is bonded to the nitrogen rather than the main carbon chain.* |
| **How do acyl chlorides react with phenol and why is this used?** | * Form an ester. * Phenol doesn’t react readily with carboxylic acids. |
| **What 2 things are common for most reactions of acyl chlorides?** | 1. Carried out at room temperature. 2. Any HCl (g) is given off at steamy white fumes |

# 6.2 - Nitrogen compounds, polymers and synthesis

## 6.2.1 - Amines

|  |  |
| --- | --- |
| **What is an amine?** | A compound containing -NH2 group.    *This is dimethylamine.* |
| **How do you name amines if the substituent groups aren’t the same?** | As an N-substituted derivative of the longest carbon chain. Eg, N-ethylpropylamine: |
| **What do amines primarily react as?** | Bases. Eg, they react with HCl to produce methylammonium chloride (a salt)    This equation doesn't include the Cl- ion |
| **How are primary aliphatic amines formed? (with reactants, conditions, and equations)** | * Reactants: haloalkane and ammonia. * Conditions: excess ammonia (to prevent further substitution maximising no. of primary amines) and ethanol as solvent (preventing hydrolysis of haloalkanes). * Equations: |
| **How are secondary and tertiary aliphatic amines formed? (with reactants, conditions, and equations)** | * Reactants: haloalkane and primary / secondary amine. * Conditions: ethanol as solvent (preventing hydrolysis of haloalkanes). * Equations: |
| **How is phenylamine formed from nitrobenzene? (conditions, reactants, type of reaction, and equation)** | * Conditions: reflux. * Reactants: Sn, conc. HCl and excess NaOH (required for hydroxide ions). * Type of reaction: reduction.     *This catalyst is required as -NO2 is an electron-withdrawing group so lowers electron density.*  *This is because during step 1, we have the H+ ions from the HCl and the e-'s from the Sn forming phenylammonium.*    *Then in the step 2, we have the HO- reacting to form phenylamine.* |

## 6.2.2 - Amino acids, amides and chirality

|  |  |
| --- | --- |
| **What are amides?** | A compound containing a -CONH2 group. |
| **How are primary amides formed? What precauation must be taken?** | * By reacting acyl chlorides with ammonia.      * You require a lot of NH3 to react with HCl to allow the reaction to go to completion. |
| **What are amino acids?** | A central carbon with an amino group and carboxyl group. |
| **How are amino acids named?** | (2-)aminoethanoic acid |
| **What are optical isomers and what is required of them?** | * Stereoisomers that are non-superimposable mirror images. * 4 different groups attached to a carbon (called the chiral centre).     There are enantiomers / optical isomers.  *- They can referred to as both are enantiomers / optical isomers.*  *- They can be distinguished by shining plane-polarised light and seeing the angle of rotation.* |
| **How can you look for the chiral centre on a cyclic molecule?** | Going around the ring in 2 directions and seeing if you encounter molecules the same way **OR** trying to draw a line of symmetry. If not either then they are enantiomers. |
| **How are primary amides converted to carboxylic acids? (reagents, type of reaction, equation)** | * Reagents: HCl (aq) * Type of reaction: acid hydrolysis * Equation: CH3CONH2 + H2O + HCl → CH3COOH + NH4+Cl- |

## 6.2.3 - Polyesters and polyamides

|  |  |
| --- | --- |
| **What are the 2 types of polymerisation?** | 1. Addition polymerisation. 2. Condensation polymerisation. |
| **What is addition polymerisation?** | When unsaturated monomers react. |
| **What is condensation polymerisation?** | Two different monomers that add together with a small molecule usually given off as a side-product (eg, H2O or HCl).  *These monomers usually have the same functional group on both ends of the molecule (eg, diamine, dicarboxylic acid, dioil, diacyl chloride).* |
| **Give the 2 most common types of condensation polymers with their linkage** | 1. Poly(esters) which contain an ester link (-COO-). 2. Poly(amides) which contain an amide link (-CONH-).   They form what is called an ester linkage or amide linkage. |
| **How and why are polyester and polyamides biodegradable?** | * They can be broken down by hydrolysis. * Due their polar nature attracting attacking species. |
| **Why may condensation polymers be photodegradable?** | As the C=O bond absorbs radiation. |
| **What are condensation polymers hydrolysed by? In what is each hydrolysed more easily?** | * Hot (aq) acid or alkali. * Poly(**a**mides) are hydrolysed more easily with strong **a**cid. * Poly(esters) are hydrolysed more easily with strong bases.     *It can be hydrolysed by water but it’s FAR too slow.* |
| **What does the base and acid hydrolysis of poly(esters) yield?** | 1. Base - dicarboxylate salt and diol. 2. Acid - dicarboxylic acid and diol. |
| **What does the base and acid hydrolysis of poly(amides) yield?** | 1. Base - dicarboxylate salt and diamine. 2. Acid - dicarboxylic acid and diammonium. |

## 6.2.4 - Carbon–carbon bond formation

|  |  |
| --- | --- |
| **What are the reagents, conditions, mechanism for converting a haloalkane to nitrile?** | * Regant: :CN- (from NaCN / KCN) * Conditions: heating under reflux, dissolved in ethanol (since water will form alcohols) * Mechanism: nucleophilic substitution, |
| **What are the reagents, conditions, mechanism for converting a carbonyl to hydroxynitrile?** | * Regents: :CN- (from NaCN / KCN dissolved in ethanol since water will form alcohols) and dilute sulfuric acid. * Conditions: RTP. * Mechanism: nucleophilic addition.     H+ ion is supplied by H2SO4.  *HCN could be used yet it is a toxic gas and is difficult to gain.* |
| **What are the possible reagents and type of reaction for converting nitriles to amines? (with example)** | * Reagents: LiAlH4 **OR** H2 with Ni catalyst. * Type: reduction. * Examples:       *This particular example uses a different catalyst.* |
| **What are the reagents, conditions, type of reaction, and examples for converting (hydroxy-)nitriles to carboxylic acids?**  **Examples:**  **and** | * Reagents: dilute acid (eg, dilute HCl). * Conditions: heating under reflux. * Type: hydrolysis. * Examples: |

## 6.2.5 - Organic synthesis

*You can learn the synthesis routes by learning the other flashcards.*

|  |  |
| --- | --- |
| *Covered distillation and reflux.* | |
| **How can you purify an organic liquid?** | 1. **Pour** the distillate (somethng formed from distillation) of impure product into a separating funnel. 2. **Wash** with:    1. NaHCO3 solution **TO NEUTRALISE ANY ACID IMPURITIES**, shake, and release pressure from CO2 produced.    2. Saturated NaCl solution to seperate layers. 3. **Allow** layers to separate and discard aqueous layer (the organic layer will on top usually due to a lower density). 4. **Run** organic layer into clean dry conical flask. 5. **Add** drying agent (eg, anhydrous sodium sulphate or calcium chloride) to dry liquid. When dry, it should be clear. 6. **Decant** liquid into flask. 7. **Redistill** to collect pure product.   *Decant means carefully pour off organic liquid leaving the drying agent in the conical flask.* |
| **What should you ensure with the drying agent for purifying organic liquids?** | * Be insoluble in the organic liquid. * Not react with the organic liquid. |
| **How can you purify an organic solid by recrystallisation? Why is each step used?** | 1. **Dissolve** impure compound in minimum volume of hot solvent.    1. To ensure saturated solution. 2. **Filter** using filter paper quickly.    1. Removing any insoluble impurities. 3. **Cool** filtered solution by inserting beaker in ice.    1. Crystals will reform but soluble impurities will remain in solution. They are present in small quantities so not saturated. 4. **Scratch** with glass rod to initiate crystallisation. 5. **Suction** filtrate with a buchner flask to separate out crystals. 6. **Wash** the crystals with COLD solvent (otherwise it will dissolve in hot).    1. To remove soluble impurities. 7. **Dry** the crystals between absorbent paper.   REMEMBER THIS AS DFCSSWD: Deaf Fruity Crayons Scramble Standard Warm Distances. |
| **By what 3 ways is yield lost under recrystallisation?** | 1. Crystals lost when filtering/washing. 2. Some product stays in solution afterwards. 3. Side reactions occurring. |
| **How is the solvent for recrystallisation chosen? Why? Otherwise what happens?** | * A solvent in which the product (to be purified) is very soluble when solvent is hot and nearly soluble when cold. * If not soluble enough, hot solvent won’t dissolve it all. * If too soluble in cold solvent, most will remain in solution about cooling giving low yield. |
| **How can measuring melting point of a product indicate purity?** | * A very pure sample will have a sharp melting point (as quoted in data books). * One with impurities may have a **lower melting point** or may **melt over a range** of several degrees. |
| **Give 2 ways melting point can be measured with a precaution** | * Using an electronic melting point machine. * Putting a capillary tube (with the product inside) into heating oil with a thermometer. * Heat slowly near melting point to record accurate temperature when it **JUST** melts. |
| **Describe the usual set up for determining melting point** | * Thermometer and capillary tube strapped together. * Heating oil with boiling point higher than sample and low flammability. * Constant stirring. |
| **What problems are there with producing chiral drugs? How is it solved?** | **Problems:**   * Seperation is expensive. * Can have different effects than intended.   **Solutons:**   * Use chiral synthesis. * Use a chiral catalyst. |

# 6.3 Analysis

## 6.3.1 - Chromatography and qualitative analysis

|  |  |
| --- | --- |
| **What are the 2 phases in chromatography?** | * Stationary phase - the solid on solid support (as in TLC) or liquid on solid support (as in GC). * Mobile phase - liquid (as in TLC) or gas (as in GC).     *TLC is shown on the left whereas GC is shown on the right.* |
| **How does adsorption and solubility affect chromatography? (include polarity)** | 1. Adsorption:    1. Mobile phase interacts with surface of stationary phase by adsorption.    2. More adsorption ⇒ more interaction ⇒ travels slower / less distance. 2. Solubility:    1. If mobile phase is nonpolar and stationary phase is polar ⇒ less soluble ⇒ passes quicker. |
| **What problems are there with TLC and GC? Why?** | * Distance moved by compound / distance moved by solvent. * By comparing to database values.     *This case uses an amino acid.*  *Each substance has its own unique retention factor.* |
| **What problems are there with TLC and GC? Why?** | Some substances won’t separate since they have similar retention factors / retention times ∵ they're structurally similar.  *It is often used alongside mass spectroscopy.* |
| **What 3 factors affect retention TIMES? And why?** | 1. **Solubility** - more soluble compounds will take longer to move via the tube. 2. **Boiling point** - a substance with a high boiling point will spend more time condensed as a liquid than a gas (taking longer). 3. **Temperature** of gas chromatography instrument - high means more evaporated as gas so move quickly. |
| **Describe the setup of gas chromatography (GC)** | * Mobile phase is a mixture of gas. * Stationary phase is high b.p. liquid coating the column. |
| **How do you interpret a gas chromatogram?** | * Time taken to pass via column / retention time is used to identify substance. * Area under each peak is proportional to amount of substance (called peak integration value). |
| **What is a calibration curve?** | A curve relating peak areas to concentrations. |
| **How is a calibration curve set up?** | 1. Prepare several standard solutions of known concentrations. 2. Obtain gas chromatograms for each standard solution. 3. Plot a calibration curve of peak area against concentration. |
| **What does a liquid stationary phase separate organic compounds by?** | By relative solubility. |
| *Many of the functional groups tests are elsewhere, the ones which aren’t are below.* | |

## 6.3.2 - Spectroscopy

*Few cards since this is primarily a skill.*

|  |  |
| --- | --- |
| **What are equivalent carbons? How do they show up in 13C NMR?** | Carbons which are in the same environment.    There is one signal peak for each set of equivalent carbons. |
| **How do equivalent hydrogens differ from equivalent carbons?** | The intensity (peak integration value) ∝ number of equivalent H’s it represents. Eg, |
| **How and why must samples be dissolved in 1H NMR? (with examples)** | Dissolved in solvents without any 1H’s (eg, CCl4 and CDCl3) meaning no interference. |
| **How are both types of NMR calibrated?** | By adding a small amount of TMS (tetramethylsilane). |
| **Why is TMS used in calibrating both types of NMR?** | 1. Non-toxic. 2. Inert. 3. Low b.p. so easily removed afterwards. 4. Signal is far away from others. |
| **What does chemical shift / δ represent in NMR?** | It is how far the frequency of signal is shifted from TMS measured in parts per million (ppm). |
| **How does electronegativity affect 1HNMR?** | If a 1H is closer to more electronegative group, greater shift (further left). |
| **What is the issue with identifying -OH and -NH groups in 1H NMR? How is this solved?** | * They’re very variable and don’t split.  1. Run two spectra of the molecule - one with D2O added. 2. If -OH, -NH present, it’ll swap proton as shown below:   Eg, CH3CH2OH + D2O → CH3CH2OD + HOD   * This is called **PROTON EXCHANGE**.   *This works since deuterium doesn’t absorb radio since even number of nucleons.* |
| **What is spin-spin coupling in high-resolution NMR?** | * Each signal can be split based on how many neighbouring **NON-EQUIVALENT** 1H’s (neighbouring means within 3 bonds). * Yet, hydrogens bonded to nitrogen or oxygen don't split or are themselves split.      * Split number of peaks = number of nonequivalent 1H’s within 3 bonds + 1   *The relative sizes follow Pascal’s triangle.* |
| **What table should be drawn for 1H NMR?** | |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Chemical shift / ppm** | **Type of 1H environment** | **Relative 1H’s** | **Assignment** | **Splitting** | | *Range* | *Structure* | *Number* | *Colour / Shape* | *No. Peaks* | |