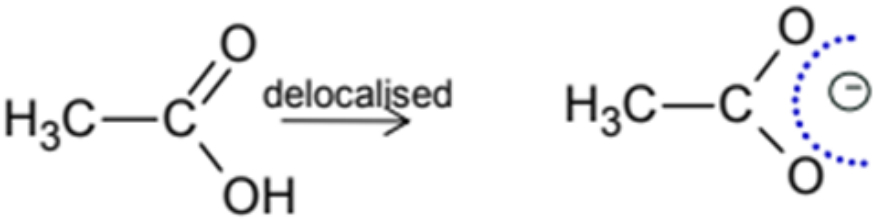
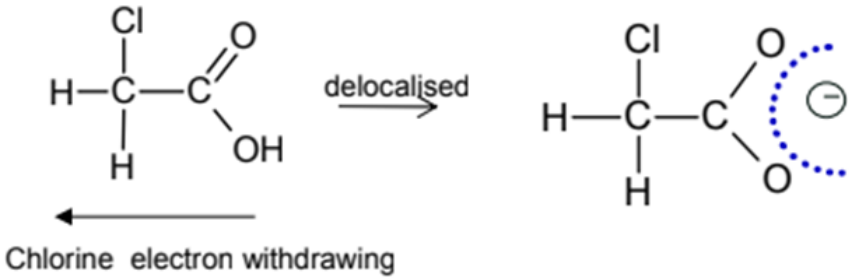
1.	What is ‘enthalpy of neutralisation’ (ΔneutH°)?	Enthalpy change when **one mole** of water is formed in a reaction between an acid and alkali in their standard states.
2.	What is ‘enthalpy of solution’ ($\Delta_{sol}H$)?	Enthalpy change when **one mole of an solid** dissolves in an excess of **water**. $MgCl_2$ (s) + H_2O (l) $\rightarrow$ Mg^{2+} (aq) + $2Cl^-$ (aq) *This involves breaking up the bonds and forming new bonds between the metal ions and water molecules.*
3.	What is ‘bond dissociation enthalpy’ ($\Delta_{de}H$)? (with an equation)	Enthalpy change when **one mole of covalent bonds** are **broken** in the **gaseous state**. I_2 (g) $\rightarrow$ 2 I (g)
4.	What is ‘lattice enthalpy of dissociation’ ($\Delta_{led}H$)? (with equation)	Enthalpy change when **one mole of an ionic solid** is broken up into its constituent ions in the **gas phase**. $MgCl_2$ (s) $\rightarrow$ Mg^{2+} (g) + $2Cl^-$ (g)
5.	What is the ‘enthalpy change of reaction’ (Δ_rH°) defined as?	Enthalpy change of a reaction in the **molar quantities expressed by the balanced chemical equation** with all substances in their standard states.
6.	What is ‘hydration enthalpy’ ($\Delta_{hyd}H$)?	- Enthalpy change when **one mole of gaseous ions** become hydrated (dissolved in water) forming **hydrated ions**. - Mg^{2+} (g) + H_2O $\rightarrow$ Mg^{2+} (aq)
7.	What is ‘enthalpy change of formation’ (Δ_fH°)?	Enthalpy change when **one mole** of a substance is formed from its constituent elements with all substances in their standard states. 2 Na (s) + ½ O_2 (g) $\rightarrow$ Na_2O (s) *For an element, this is zero.*
8.	What is 'enthalpy change of combustion’ (Δ_cH°)?	Enthalpy change when **one mole** of a substance undergoes complete combustion in oxygen with all substances in standard states. H_2 (g) + ½ O_2 (g) $\rightarrow$ H_2O (g)
9.	What is ‘ionisation enthalpy’ (ΔieH°)?	Enthalpy change when each atom/ion in **one mole of gaseous** atoms/ions loses one electron to form **one mole of gaseous ions**. Mg (g) $\rightarrow$ Mg^+ (g) + e^- **<u>OR</u>** Mg^+ (g) $\rightarrow$ Mg^{2+} (g) + e^- *Must be specific in the number of the charges when asked for something such as "define the second electron affinity".*
10.	What is enthalpy?	The stored energy in a chemical system.

11. What is 'electron affinity' ($\Delta_{ea}H°$)? (with equation)	- Enthalpy change when each atom/ion in **one mole of gaseous** atoms/ions gains one electron to form **one mole of gaseous** ions. - $Mg\ (g) + e^- \rightarrow Mg^-\ (g)$ **<u>OR</u>** $Mg^-\ (g) + e^- \rightarrow Mg^{2-}\ (g)$ *Must be specific in the number of the charges when asked for something such as "define the second electron affinity".*
12. What is 'standard enthalpy of atomisation' ($\Delta_{at}H°$)?	Enthalpy change when **one mole of gaseous** atoms is formed from its elements under standard state. $\frac{1}{2} I_2\ (s) \rightarrow I\ (g)$. *Must be specific in the number of negative charges if necessary.*
13. What is 'lattice enthalpy of formation' ($\Delta_{lef}H$)? (with example)	Enthalpy change when **one mole of an ionic solid** is **formed** from its constituent ions in the **gas phase**. $Mg^{2+}\ (g) + 2Cl^-\ (g) \rightarrow MgCl_2\ (s)$
14. What are the standard conditions?	- 1 atmosphere (101 kPa) - 298 K (25 °C) - 1 $moldm^{-3}$
15. How does an enthalpy definition change when "standard" is added before it?	Add "and under standard conditions" to the end
16. $[Cr(OH)_6]^{3-}$	Dark green solution
17. $[Cu(H_2O)_6]^{2+}$ / Cu^{2+}	Pale blue solution
18. MnO_4^-	Purple solution
19. $[Fe(OH)_3(H_2O)_3]$	Orange-brown ppt, darkens on standing
20. $[CuCl_4]^{2-}$	Yellow solution
21. $[Fe(H_2O)_6]^{3+}$ / Fe^{3+}	Pale yellow solution
22. Mn^{2+}	Pale pink solution
23. $[Cr(OH)_3(H_2O)_3]$	Grey-green ppt
24. $[Fe(H_2O)_6]^{2+}$ / Fe^{2+}	Pale green solution
25. $[Cr(NH_3)_6]^{3+}$	Purple solution

26. $Cr_2O_7^{2-}$	Orange solution
27. $[Cu(OH)_2(H_2O)_4]$	Blue ppt
28. $[Mn(OH)_2(H_2O)_4]$	Brown ppt, darkens on standing
29. CrO_4^{2-}	Yellow solution
30. $[Fe(OH)_2(H_2O)_4]$	Green ppt, darkens on standing
31. $[Cu(NH_3)_4(H_2O)_2]^{2+}$	Deep blue solution
32. $[Cr(H_2O)_6]^{3+}$/ Cr^{3+}	Pale purple solution
33. What is esterification and how do you do it?	Reacting carboxylic acids with alcohol to form esters. Delete as this isn't always necessarily the case, can you acid anhydrides.
34. What does the structural formula show?	The arrangement of atoms in compound (e.g., $CH_3(CH_2)_2CH_3$). Delete, pretty useless.
35. Why are poly(alkenes) non-biodegradable?	They are chemically inert due to the **STRONG** and **NONPOLAR** C-C and C-H bonds. Similar card exists for why organic molecules are mostly unreactive.
36. What is phenol?	A benzene group with a -OH directly attached. Obvious...
37. How are carboxylic acids stablised?	By delocalisation of e^-'s making dissociation into a carboxylate ion more likely.  *The bonds are drawn the same as they're actually identical.* don't need to know

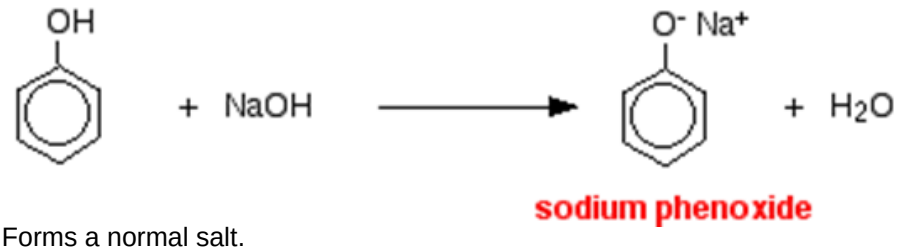
38. How does chloroethanoic acid differ from ethanoic acid and why?

-It's more acidic.
-The electronegative Cl withdraws e^- density from the COO^- ion making it less negative and more stable.



Delete

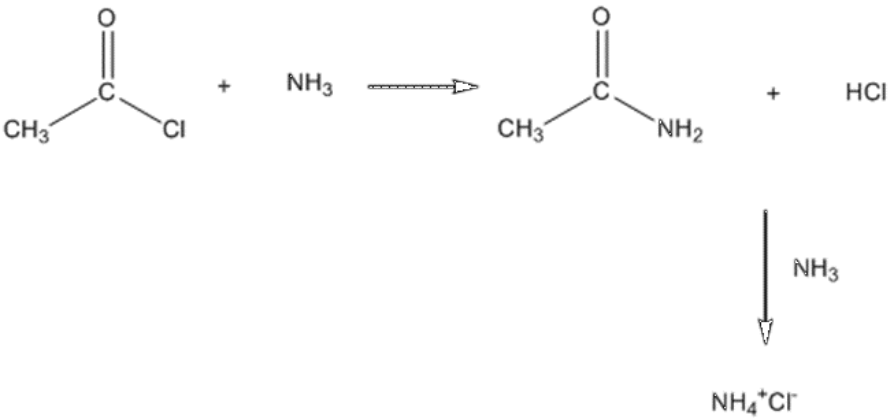
39. How does phenol react with metals and bases?



Forms a normal salt.
Delete, already have.

40. How do acyl chlorides react with ammonia?

To produce a primary amide.



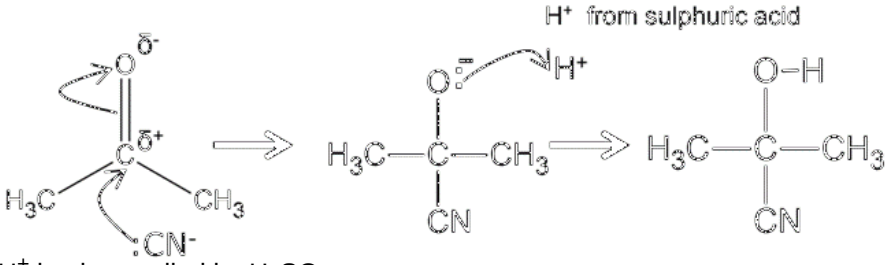
delete already have something like this

41. How can scientists monitor environmental pollution?

1. Using IR spectroscopy to identify the spectra of pollutants.
2. Matching the spectra to identify pollutants.
Ugh, delete.

42. What are the reagents, conditions, mechanism for converting a carbonyl to hydroxynitrile?

-Regants: $:CN^-$ (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 H_2SO_4.
HCN could be used yet it is a toxic gas and is difficult to gain.

---

43. How are secondary/tertiary **amides** formed?

By reacting acyl chlorides with primary/secondary amines. Eg,

This is different to forming a primary amide by reacting an acyl chloride with NH_3.
Delete, already have.

---

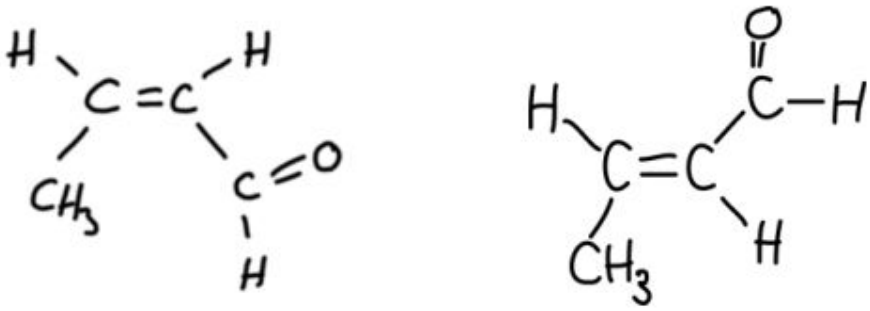
44. Difference between a reactant and a reagent

A reagent is a reactant that is consumed during the reaction.
Delete. It's contradictory.

---

45. What is cis-trans isomerism?

A special case of E/Z isomerism (and thus stereoisomerism) where a substituent group on one ^{12}C of the C=C group is the same as the other ^{12}C.
Eg,



The left is cis **whereas** the right is trans.
*Note that above, they only need 2 of the same groups, both groups on each carbon **don't** have to be the same. This also counts as E/Z isomerism as it can be named using the CIP convention too. It's just the cis-trans is a most specific form.*
Cis for same and trans for opposite.

---

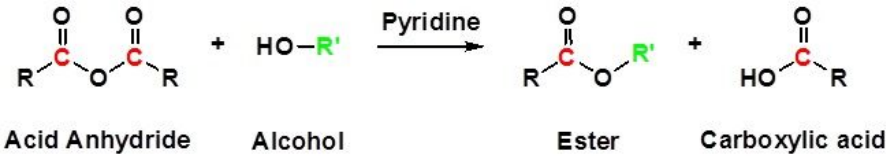
46. How do alcohols react with bases?

They don't because they're not acidic.

---

47. 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 + carboxylic acid
-Room temperature
-Higher yield achieved

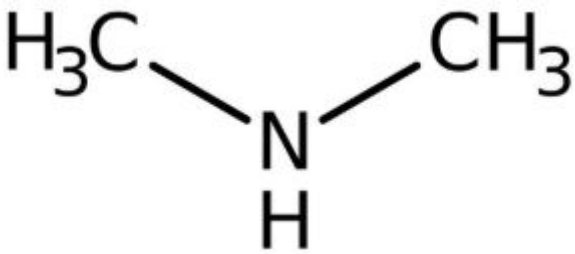


48. How are acyl chlorides formed? (with equation)

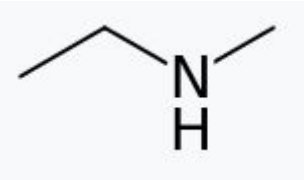
-By reacting carboxylic acid using $SOCl_2$ (thionyl chloride).
-$CH_3COOH + SOCl_2 \rightarrow CH_3COCl + SO_2 + HCl$

49. How should you name secondary and tertiary amines? (same AND not same substituent groups)

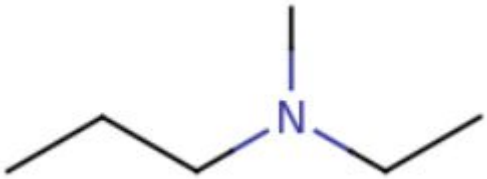
IF SAME:



Dimethylamine
IF NOT SAME:



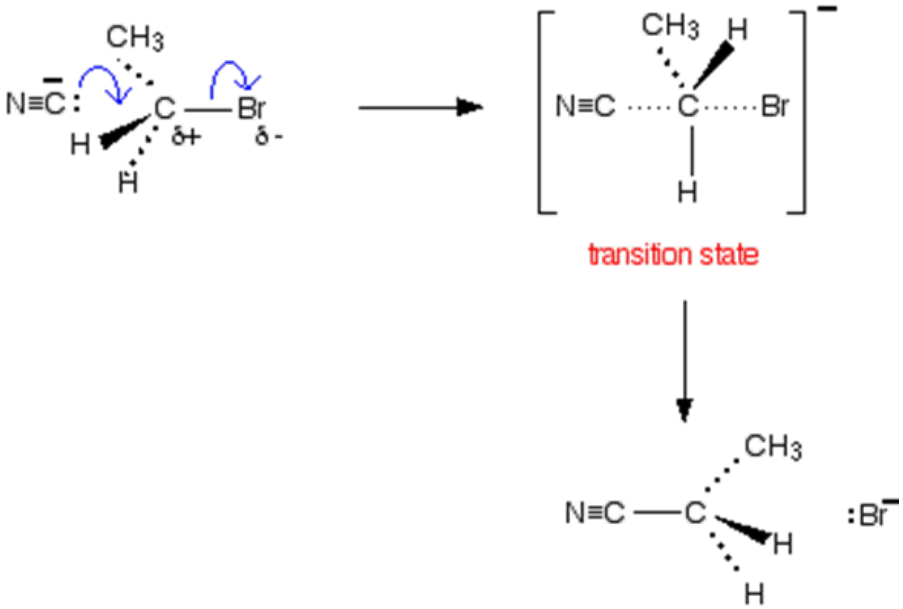
N-ethylmethylamine
OR



N,N-ethylmethylpropylamine

50. 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,



[redacted]

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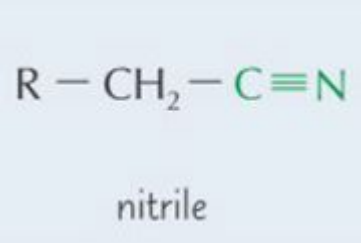
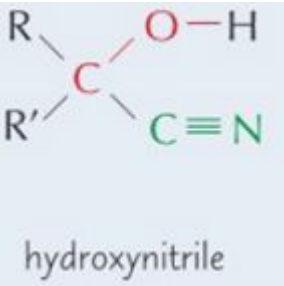
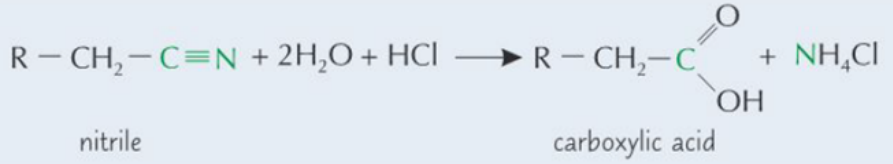
51. What are the reagents, conditions, type of reaction, and examples for converting nitriles or hydroxynitriles to carboxylic acids?
Examples:

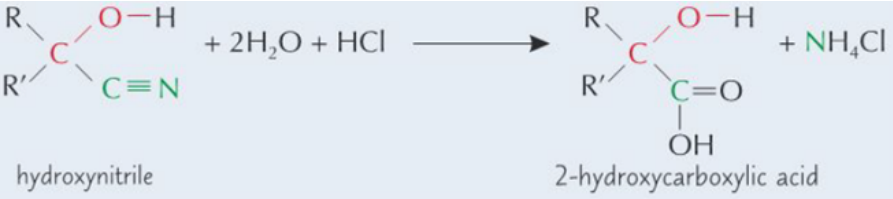


and



-Reagents: HCl (aq)
-Conditions: heating under reflux.
-Type: acid hydrolysis.
-Examples:





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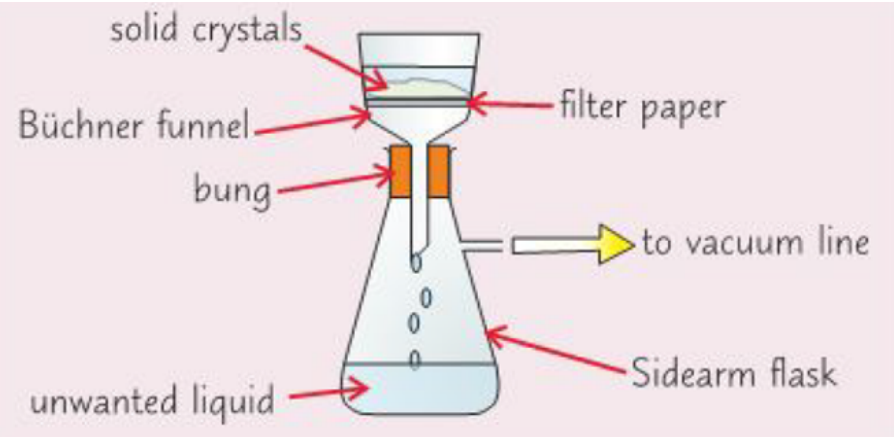
52. How can you purify an organic liquid?

1.**Pour** the distillate (somethng formed from distillation) of impure product into a separating funnel.
2.**Wash** with:
a.$NaHCO_3$ solution **TO NEUTRALISE ANY ACID IMPURITIES**, shake, and release pressure from CO_2 produced.
b.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.
Remember, PWARADR.
Decant means carefully pour off organic liquid leaving the drying agent in the conical flask.

---

53. How can you purify an organic solid by recrystallisation? Why is each step used?

1.**Dissolve** impure compound in minimum volume of hot solvent.
a.To ensure saturated solution.
2.**Filter** using filter paper quickly.
a.Removing any insoluble impurities.
3.**Cool** filtered solution by inserting beaker in ice.
a.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).
a.To remove soluble impurities.
7.**Dry** the crystals between absorbent paper.
REMEMBER THIS AS DFCSSWD: Dangerous Fat Colonels Sexually Stroked Wonderful Dancers.



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54. Give 2 ways melting point can be measured with a precaution

1.Using an electronic melting point machine.
2.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.

55. What problems are there with TLC and GC? Why?

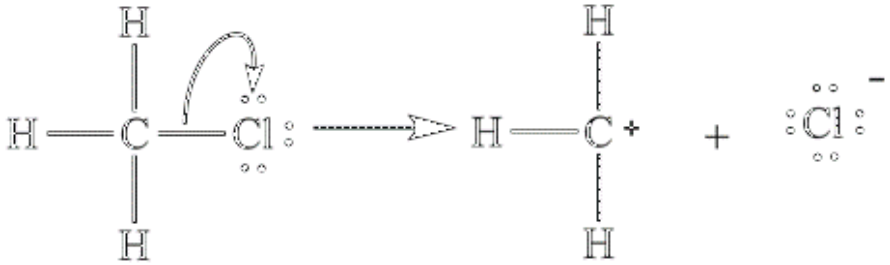
Some substances won't separate since they have similar retention factors / retention times ■ they're structurally similar.
It is often used alongside mass spectroscopy.

56. Give examples of homogeneous catalysis

- Acid catalyst in esterification.
- Depletion of atmospheric ozone by chlorine radicals.

57. What is heterolytic fission?

When a **COVALENT BOND BREAKS** (1) with one bonded atom getting both electrons forming ions (1).



58. Which important bonds are freely rotating in organic chemistry?

Single C-C and C-H bonds.

59. Describe and draw the general nucleophilic substitution of a haloalkane

Substitution here is swapping the halogen for another atom.
1.The nucleophile attacks the delta positive carbon in the carbon-halogen polar bond to form a covalent bond.
2.At the same time, the carbon-halogen bond breaks by heterolytic fission forming a halide ion.
3.The geometry of the product switches.
-The nucleophile approaches from behind as its repelled by the delta negative halogen.
For a tertiary haloalkane, this is a 2-step process because the carbocation intermediate is stable on its own.

60. What is hydrolysis?

A **type of reaction** involving the splitting of a molecule by water.

61. What are the conditions and products for the hydrolysis of haloalkanes? How can you use this to work out the haloalkane?

-Heating under reflux with NaOH (aq) or KOH (aq).
-The product is an alcohol and a compound of the halogen (e.g., NaBr or KBr for the hydrolysis of bromoalkanes).
- Use the halide test now to work out which halogen was used.
The NaOH and KOH is needed so it dissociates into HO^- nucleophiles. You can't just have a pure solution of OH ions.

62. What are CFCs, what are they used as and why?

- Chlorofluorocarbons (thus containing only carbon, chlorine, and fluorine).
- Used as propellants, aerosols, and refrigerants because of their stability/low-reactivity, non-toxicity, and volatility.

---

63. Describe how CFCs lead to the destruction of ozone and explain why this is so effective

-The weaker C-Cl bond is broken by homolytic fission under UV light forming Cl• which catalyses the breakdown of ozone:
$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$
$ClO\bullet + O\bullet \rightarrow O_2 + Cl\bullet$
-The overall equation is $O_3 + O\bullet \rightarrow 2O_2$
- The chlorine radical is reproduced so they have a long residence time.
Nitrogen oxides work in a similar way.

---

64. Why does the degree of haloalkane affect the rate of hydrolysis?

The higher the degree, the more stable the carbocation intermediate formed.

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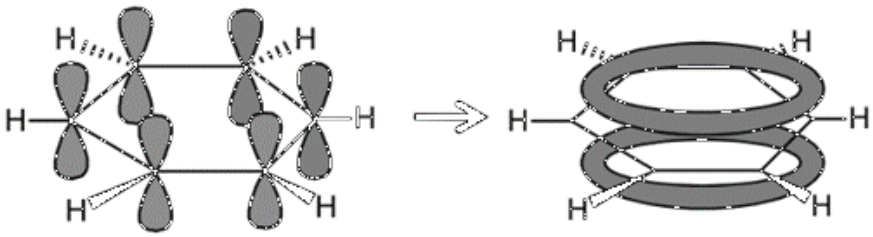
65. Describe the π-ring in benzene and its consequences

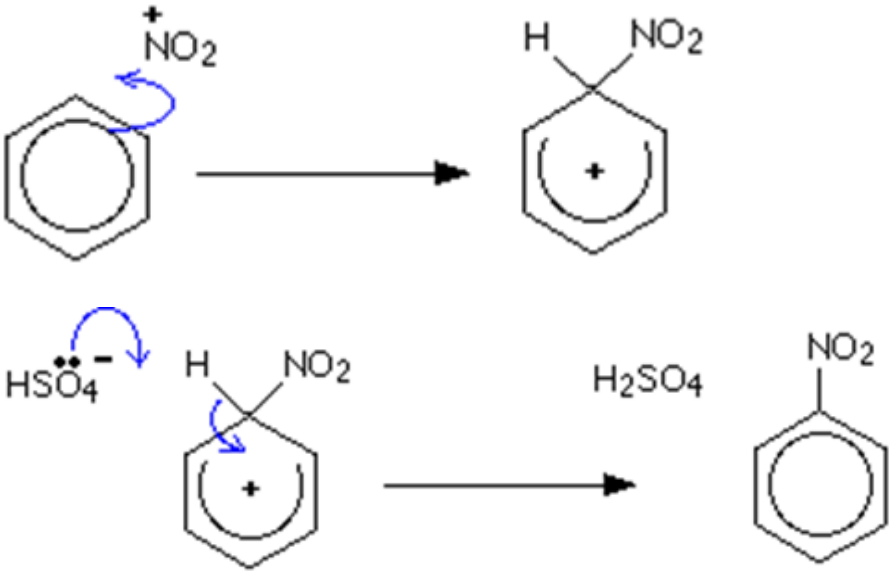


1) Sideways overlap of 6 p-orbitals (each containing 1 e^-).
2) Electron density above and below the plane spread over 6 ^{12}C's ∴ low electron density ∴ unable to polarise many molecules ∴ reactions require catalysts.
3) **Delocalised electrons** meaning not attached to any single atom.

---

66. What are the conditions, reactants, steps (with mechanism), type of reaction, and precautions of nitration of benzene?

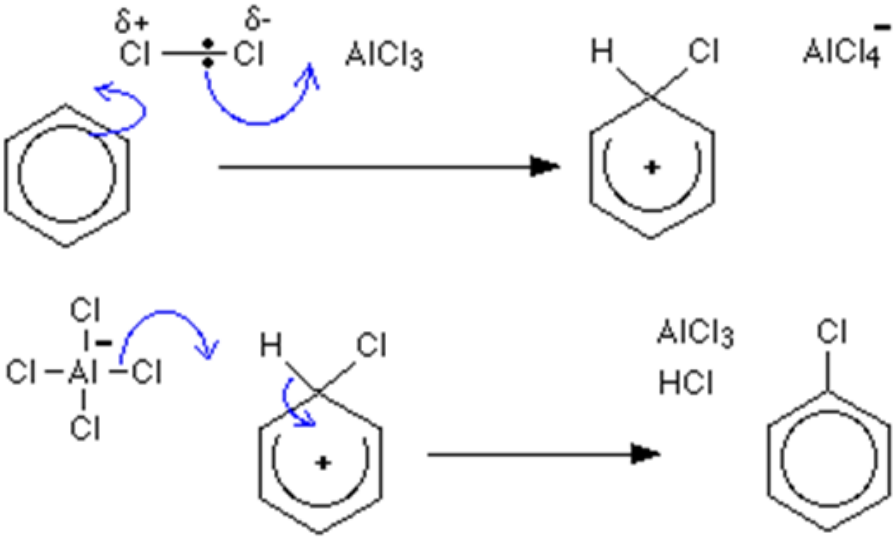
-Conditions/reactants: 50 °C, conc. HNO_3 (nitric acid), conc. H_2SO_4 (sulfuric acid) catalyst.
Form the nitronium ion…
Stage 1: $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^+$
Stage 2: $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$
Overall: $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$
React nitronium ion with benzene…



The catalyst H_2SO_4 has reformed.
- Type of reaction: electrophilic substitution.
-Perform within a water bath ■ reaction is exothermic. Any temperature too high will lead to polynitration rather than mononitration

67. What are the reactants and steps (with mechanism) of the halogenation of benzene?

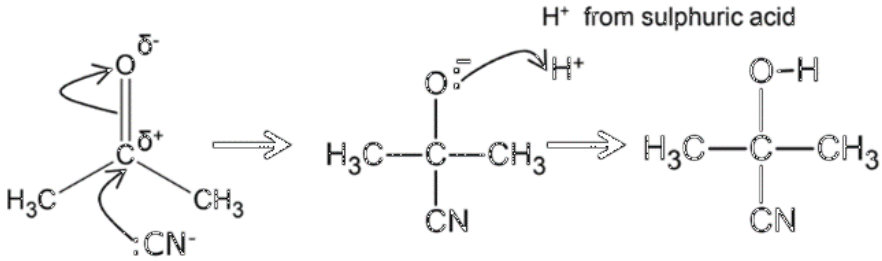
-Reactants: halogen, halogen carrier (e.g., $FeBr_3/AlBr_3$ for bromination and $FeCl_3/AlCl_3$ for chlorination) as a catalyst.
1.The halogen carrier polarises the halogen allowing it to react with the halogen carrier to form a positive electrophile.
$Br_2 + FeBr_3 \rightarrow Br^+ + FeBr_4^-$
2.React the electrophile with the benzene by electrophilic substitution…



A positive electrophile has to be formed because benzene isn't very polarising.

68. How can carbonyls become hydroxynitriles and why would you do this? (with reagents, conditions, mechanism)

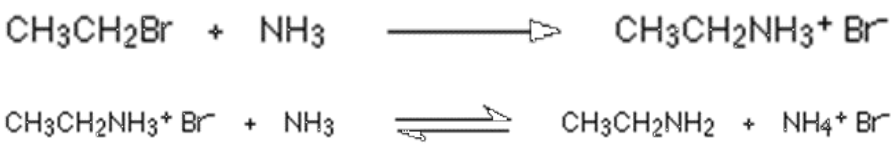
-Reagents: sodium cyanide (NaCN) and dilute H_2SO_4 **OR** HCN.
-Conditions: RTP.
-Mechanism: nucleophilic addition.
-In the case below, NaCN supplies CN^- ions and H_2SO_4 supplies H^+ ions.



-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.

69. How are primary aliphatic amines formed? (with reactants, conditions, and equations)

-Reactants: haloalkane and ammonia.
-Conditions: excess ammonia (to prevent further substitution thus maximising no. of primary amines) and ethanol as solvent (preventing hydrolysis of halolalkanes).
- Equations:



70. What is condensation polymerisation?

Two monomers that add together with a small molecule usually given off as a side-product (eg, H_2O or HCl).
These monomers usually have the same functional group on both ends of the molecule (eg, diamine, dicarboxylic acid, dioil, diacyl chloride).

---

71. How and why are polyesters and polyamides biodegradable?

- They can be hydrolysed.
- Due to their polar nature attracting attacking species.

---

72. What are the possible reagents and type of reaction for converting nitriles to amines? (with example)

-Reagents: $LiAlH_4$ (lithium aluminium hydride) **OR** H_2 with Ni catalyst.
-Type: reduction.
-Examples:

$$CH_3CN + 4[H] \longrightarrow CH_3CH_2NH_2$$

$$CH_3CN + 2H_2 \xrightarrow{Pd} CH_3CH_2NH_2$$

This particular example uses a different catalyst.

---

73. How does adsorption and solubility affect chromatography? (include polarity)

1.Adsorption:
- Mobile phase interacts with surface of stationary phase by adsorption.
- More adsorption ⇒ more interaction ⇒ travels slower / less distance.
2.Solubility:
- If mobile phase is nonpolar and stationary phase is polar ⇒ less soluble ⇒ passes quicker.

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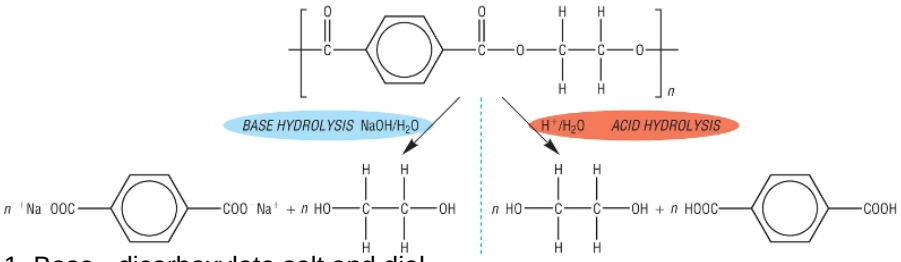
74. What does the base and acid hydrolysis of poly(esters) yield?



1. Base - dicarboxylate salt and diol.
2. Acid - dicarboxylic acid and diol.

---

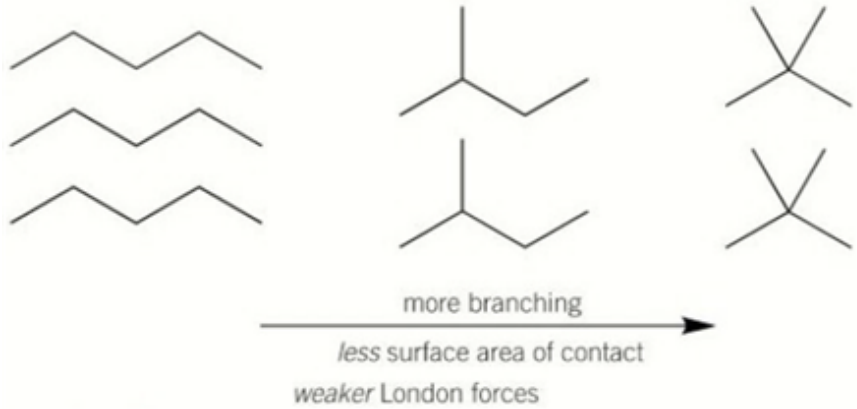
75. Define free radical

A reactive species with an unpaired electron.

---

76. What 2 factors affect the boiling points of a homologous series? How?

1. Length of the main chain:
- Longer ∴ **MORE** London forces ∴ stronger the attraction ∴ more energy required to overcome.
2. Surface area of contact:
- Greater ∴ **MORE** London forces ∴ stronger the attraction ∴ more energy required to overcome.
- Branching reduces this.



77. Describe the 3 steps of the synthesis of chloroalkanes (using methane) and a downside

1.Initiation - UV light is supplies enough energy to break Cl-Cl bonds by homolytic fission.
2.Propagation - chlorine radicals remove H atoms from methane to form methyl radicals. These react with Cl_2 molecules to form a chloromethane and Cl•. The new radical continues the chain reaction.
3.Termination - when all radicals meet other radicals.
- Further substitution occurs making it a poor method.

78. What are stereoisomers?

Same structural formulae but different spatial arrangement of atoms.

79. What is observed (colour-wise) under the oxidation of alcohols?

Orange to **green** colour change.

80. What are the products and conditions for the dehydration of alcohols and why?

- Forms an alkene and water.
- **HEAT** under reflux.
-Concentrated sulphuric or phosphoric acid.
-As we don't want any water to form alcohols again.
In short, the same catalyst, however, without water. There's no set temperature either.

81. How can the rate of the hydrolysis of haloalkanes be measured and why?

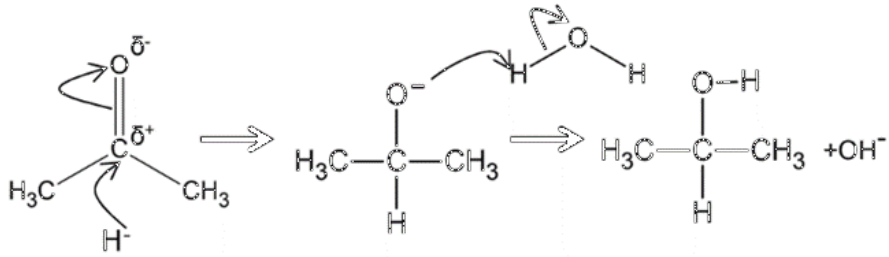
-By adding $AgNO_3$ (aq) and timing how long it takes for a precipitate for form. The quicker it does, the faster the rate of reaction.
-As soon as the halide ion is formed from nucleophilic substitution, it can react with the silver ion: Ag^+ (aq) + X^- (aq) → AgX (s).

82. What are the lines on a mass spectrum?

-If analysing elements, they're isotopes.
-If analysing compounds, they're fragment ions.

83. How are alcohols formed from carbonyls? (without catalyst method) (reagents, type of reaction, mechanism, example equation)

-$NaBH_4$ is used as a source of hydride (H^-) ions.
- Type of reaction: reduction,
-Mechanism:



-Examples:
$CH_3CH_2CHO + 2[H] \rightarrow CH_3CH_2CH_2OH$
$CH_3COCH_3 + 2[H] \rightarrow CH_3CH(OH)CH_3$
[H] just means some reducing agent.

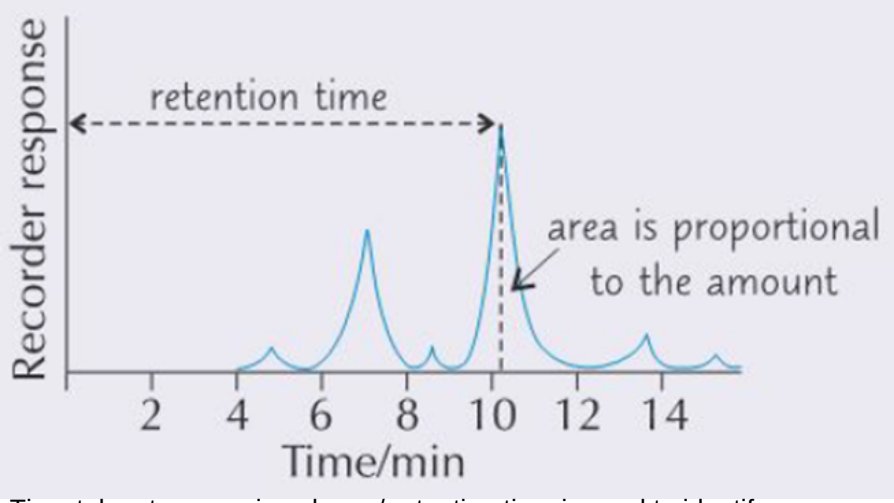
---

84. 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.

---

85. 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 **RELATIVE** concentration of components (called peak integration value).

---

86. How are primary amides converted to carboxylic acids? (reagents, type of reaction, equation)

- Reagents: HCl (aq)
- Type of reaction: acid hydrolysis
- Equation:
$CH_3CONH_2 + H_2O + HCl \rightarrow CH_3COOH + NH_4^+Cl^-$

---

87. Define chain isomers

Same molecular formula but **different arrangement of carbon atoms**.

---

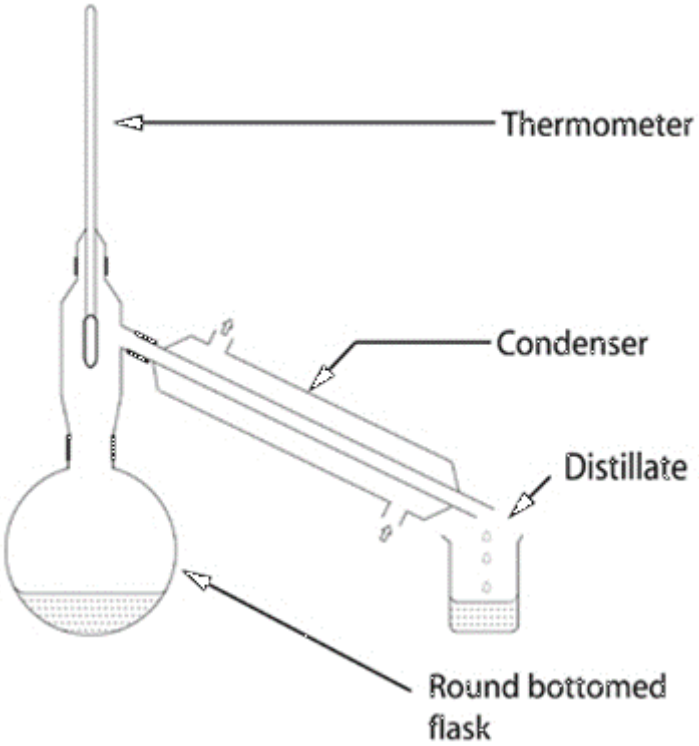
88. What conditions are required for polymerisation?

-High temperature.
-High pressure.
-A catalyst.
The specifics depend on the product you want to form.

89. Give 3 ways of dealing with waste polymers

1.Separating and recycling.
2.Used as feedstock for cracking.
3.Combusting for energy production.

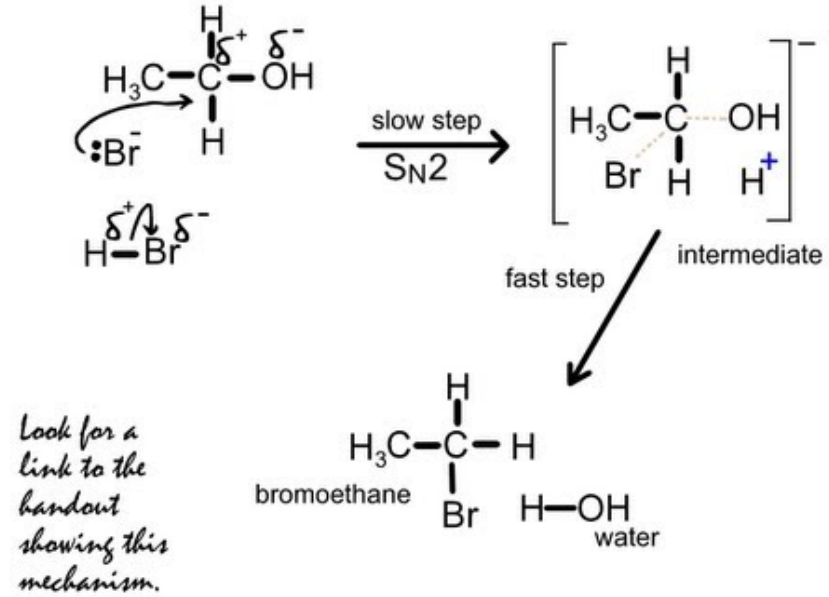
90. Describe the setup for distillation with an explanation for the key points



Some setups may have a receiver at the end of the condenser.
-Bulb of thermometer at T-junction - to display the correct b.p.
- Water entering via bottom of condenser - entire condenser will fill up before water exits.
-Electric heater - prevents highly flammable organic compounds setting alight under a live flame.
If water enters via the top of the condenser, it would trickle down and leave without filling the whole condenser.

91. How are haloalkanes formed from alcohols safely, and why? (conditions) (using hydrogen bromide and ethanol as an example)

1.Form the hydrogen halide in a substitution reaction between NaBr and H_2SO_4.
$NaBr + H_2SO_4 \rightarrow NaHSO_4 + HBr$
2.React the alcohol with the hydrogen halide.
$CH_3CH_2OH + HBr \rightarrow CH_3CH_2Br + H_2O$
- This is by nucleophilic substitution **UNDER REFLUX**.
-The HBr is highly toxic so has to be produced within the reaction mixture and reacted instantly.



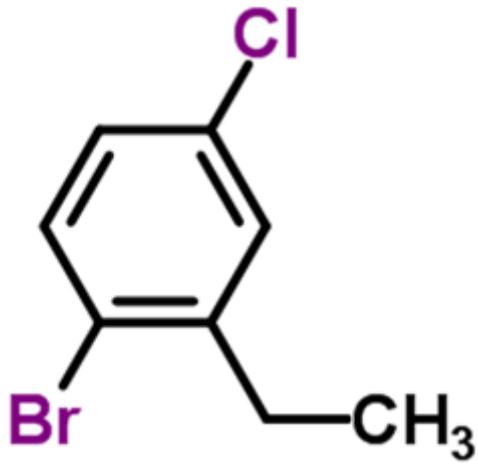
You can write an overall reaction for this.

92. What is in equilibrium in the upper atmosphere and how?

-The formation and destruction of ozone.
-$O_2 \rightarrow 2O$ (broken by UV light to form diradicals).
-O_3 ■ $O_2 + O$.

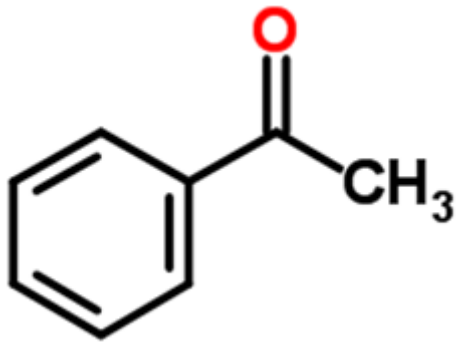
93. Describe the nomenclature for substituted arenes

-The lowest number is given to the lowest position of the alphabet:

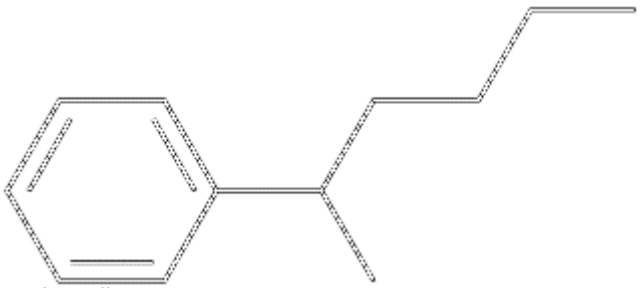


1-bromo-4-chloro-2-ethylbenzene

-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

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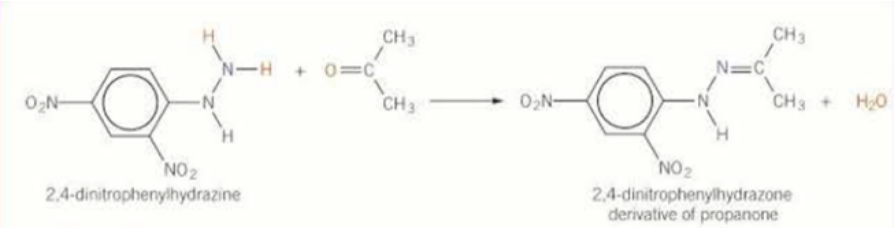
94. How is Brady's Reagent used to identify carbonyls? And how does it react? (4)

-Reacts with carbonyls to form a orange/yellow ppt (1)

(2)



-Recrystallise and determine melting point (3)

- Compare to database values (4)

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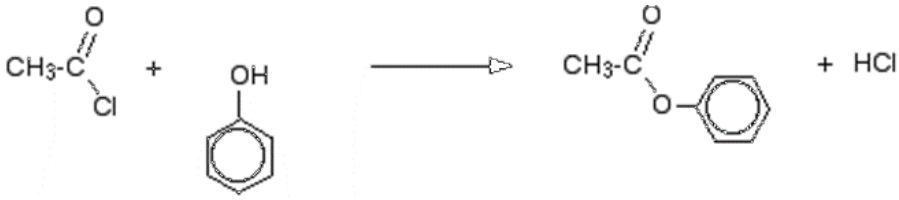
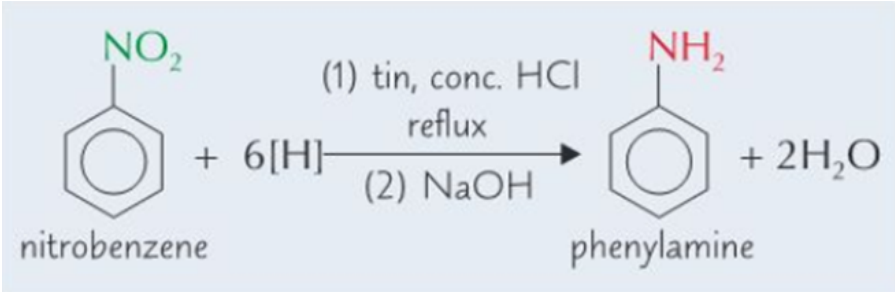
95. How do acyl chlorides react with phenol and why is this used?

-Form an ester.
-Phenol doesn't react readily with carboxylic acids.

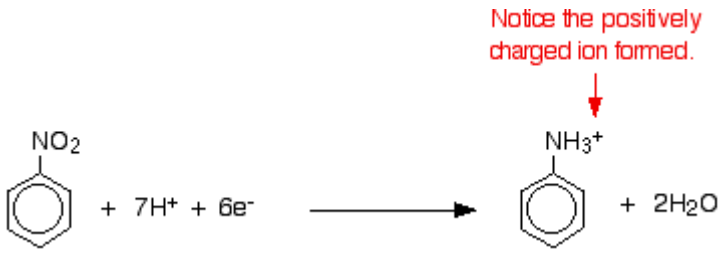


96. How is phenylamine formed from nitrobenzene? (conditions, reactants, type of reaction, and equation)

- Conditions: reflux.
- Reactants: Sn (tin), conc. HCl and excess NaOH.
-Type of reaction: reduction.



This catalyst is required as -NO_2 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.

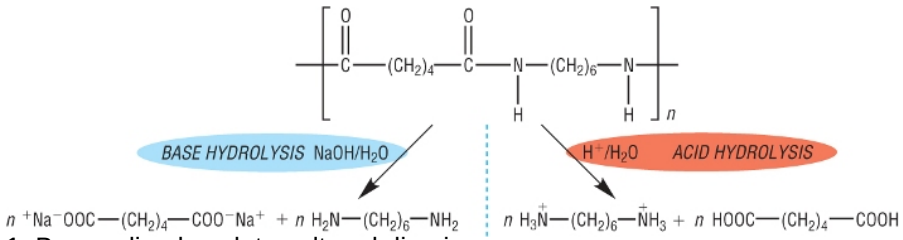
97. How is the solvent for recrystallisation chosen? Why? Otherwise what happens?

-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 when hot, the solute won't dissolve it all.
-If too soluble when cold, most of the solute remains in solution when cooling giving a low yield.

98. 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).

99. What does the base and acid hydrolysis of poly(amides) yield?



1. Base - dicarboxylate salt and diamine.
2. Acid - dicarboxylic acid and diammonium.

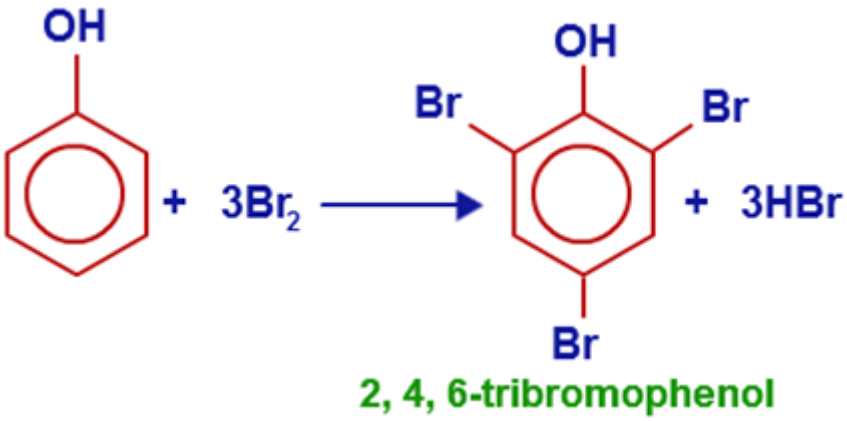
---

100. Why do alcohols have a low volatility and high b.p.?

As they can form hydrogen bonds which require more energy to overcome.

---

101. Describe the bromination of phenol (product, conditions, reactants)



-Forms a white ppt (can be used to distinguish as the bromine decolourises).
-No halogen carrier required, reacts **readily**, room temperature.

---

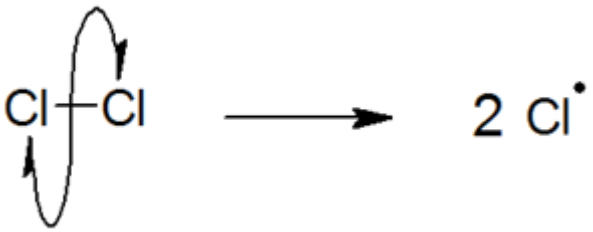
102. Give 2 ways esters can be hydrolysed (with conditions)

1. Heating with HOT AQUEOUS ACID:
-Use sulfuric acid catalyst under reflux.
-Forms the original reactants.
-$CH_3CH_2CO_2CH_2CH_3 + H_2O$ ■ $CH_3CH_2COOH + CH_3CH_2OH$ (reversible so doesn't give a good yield)
2. Heating with HOT AQUEOUS ALKALI (saponification):
-Use sodium hydroxide under reflux.
-Forms a carboxylate salt and alcohol.
- $CH_3CH_2CO_2CH_3 + NaOH \rightarrow (CH_3CH_2CO_2^-)Na^+ + CH_3OH$
The anion in the salt is resistant to attack by weak nucleophiles such as the alcohol so this reaction isn't reversible.

---

103. What is homolytic fission and what does it form?

A **COVALENT BOND BREAKS** (1) with each bonded atom getting an electron forming radicals (1).



104. Describe the process of fractional distillation

1.Heat the crude oil to the highest boiling point.
2.Funnel the vapours into a fractionating column which is cooler further up.
3.Let the hydrocarbons will rise up and condense and their respective b.p.'s.

---

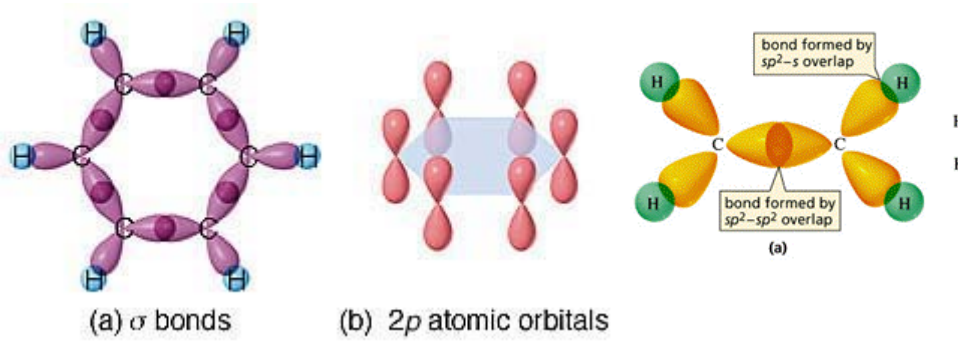
105. What is an elimination reaction?

A reaction involving the elimination of leaving group to form an unsaturated compound.

---

106. 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.

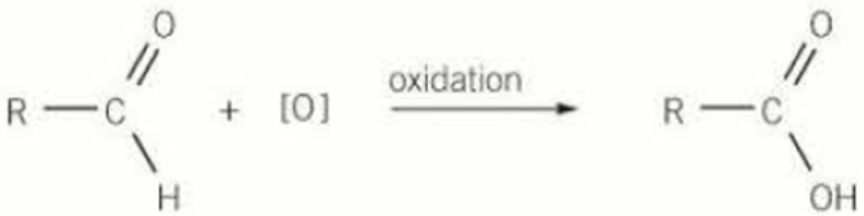


Benzene has 12 σ-bonds in total so 24 σ e^-'s.
3) Benzene requires a cataylst (eg, halogen carrier) ■ its e^- density is too low to polarise molecules **WHEREAS** other alkenes react readily ■ high e^- density.

---

107. How is Tollens' Reagent 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:
$Ag^+ (aq) + e^- \rightarrow Ag (s)$
and



This cannot happen with ketones as they cannot be oxidised.

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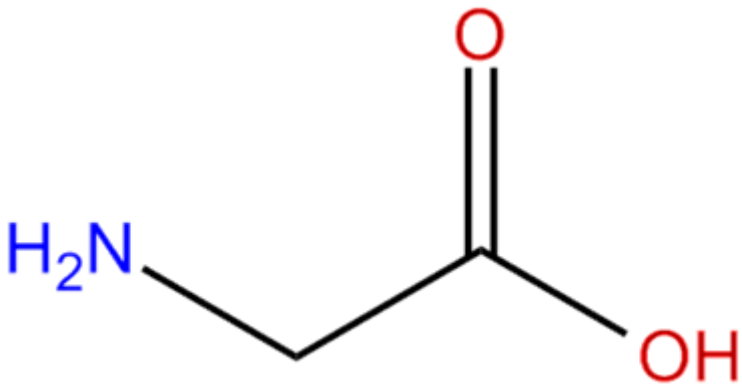
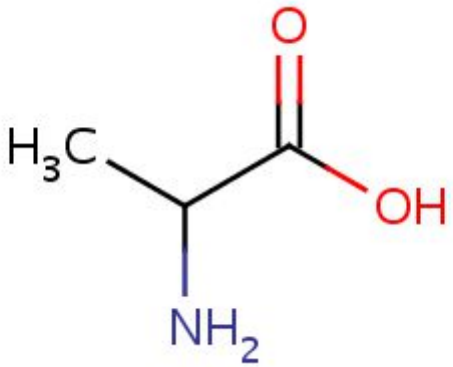
108. How are amino acids named? (with example)

Amino prefix, carboxylic acid suffix.



(2-)aminoethanoic acid
OR

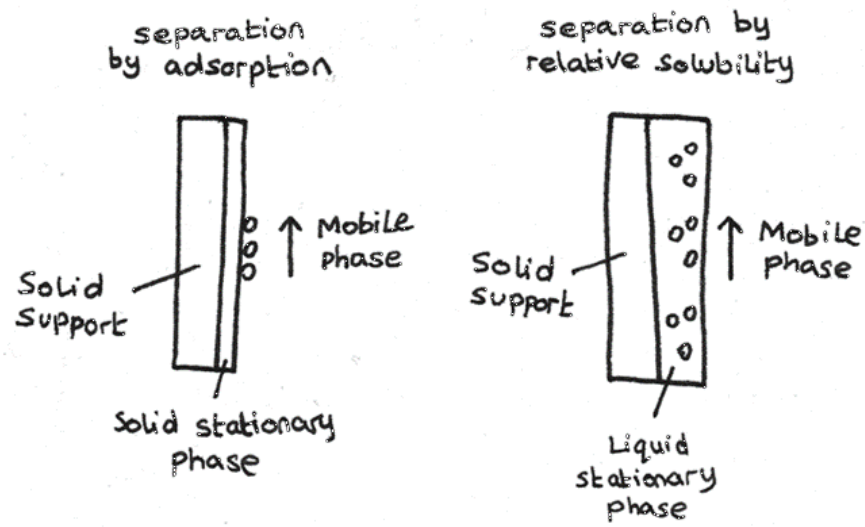


2-aminopropanoic acid

---

109. What are the 2 phases in chromatography? Describe them for both TLC and GC

1)Stationary phase - the solid on solid support (as in TLC) or liquid on solid support (as in GC).
2)Mobile phase - liquid (as in TLC) or gas (as in GC).



TLC is shown on the left whereas GC is shown on the right.

---

110. Define molecular formula

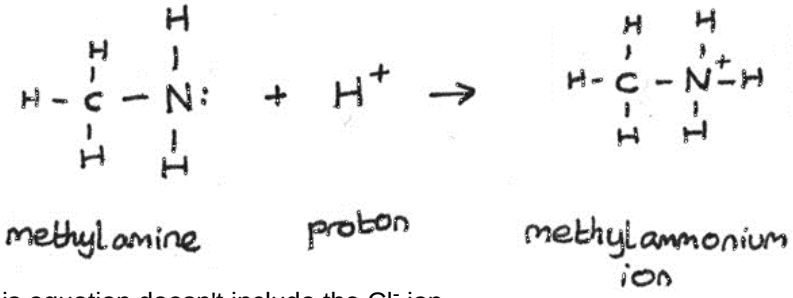
The **ACTUAL** number of atoms of **EACH ELEMENT** in an element/compound.

111.	What is redistillation?	Changing the beaker as soon as the b.p. on the thermometer changes as another substance is about to exit the condenser.
112.	Define empirical formula	The **SIMPLEST** ratio of atoms of **EACH ELEMENT** in an element/compound.
113.	What is Markovnikov's rule and what is it used to do? (both with and without ^{1}H)	- That a $H^{\delta+}$ in the hydrogen halide will attach to the carbon with more hydrogens attached to it -It's used to determine the major and minor products of electrophilic addition between hydrogen halides and asymmetric alkenes. - For ICl, the $I^{\delta+}$ will bond with the carbon with more hydrogens attached to it since it is less electronegative (just like $H^{\delta+}$).
114.	Define homologous series	A family of compounds with the same functional group yet each successive member differs in the addition of a $-CH_2-$ group.
115.	What is incomplete combustion, what does this form, and what does this mean in terms of energy?	-Combustion under limited oxygen forming CO and/or C (soot). - Produces less energy per mole (as less energy is released from bond making).
116.	Describe the 3 cases with 'directing groups' with examples	1.**<u>Unsubstituted ring</u>** - electron density constant so electrophiles are equally likely to react with any carbon. 2.**<u>Substituted with electron-donating group</u>** (-OH or $-NH_2$) - e^-'s partially delocalise into the ring increasing its density at carbon 2, 4, 6 making them more likely to react. 3.**<u>Substituted with electron-withdrawing group</u>** ($-NO_2$) - 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".
117.	How can carbonyls be converted to alcohols? (with **<u>CATALYST</u>**) (type, reagents, conditions, example)	- Type: reduction. -Reagents: H_2 and nickel catalyst. -Conditions: high pressure. -Example: $CH_3CHO + H_2 \rightarrow CH_3CH_2OH$

118. What do amines primarily react as? Why?

- Bases.
- As the nitrogen lone pair accepts a proton / H^+.

Eg, they react with HCl to produce methylammonium chloride (a salt)



This equation doesn't include the Cl^- ion

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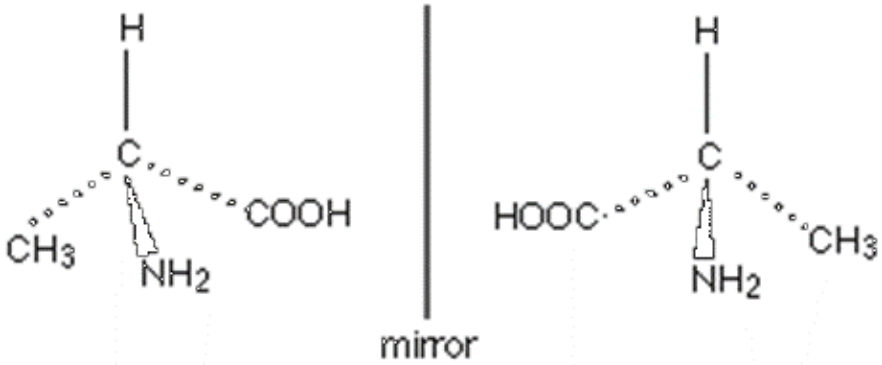
119. What are optical isomers and what is required of them?

-Stereoisomers that are non-superimposable mirror images.
-4 different groups attached to a carbon (called the chiral centre).

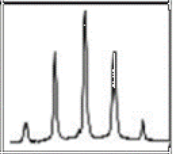


- They can referred to as both are enantiomers / optical isomers.
- They can be distinguished by shining plane-polarised light and seeing the angle of rotation.

---

120. What is spin-spin coupling in high-resolution NMR?

-Each signal can be split based on how many neighbouring **<u>NON-EQUIVALENT</u>** ^1H's (neighbouring means within 3 bonds, so atoms attached onto adjacent carbons).
- Yet, hydrogens bonded to nitrogen or oxygen don't split or are themselves split.

signal	singlet	doublet	triplet	quartet	quintet
appearance					
Split number of peaks	1	2	3	4	5
number of neighbouring inequivalent H atoms	0	1	2	3	4
relative size		1:1	1:2:1	1:3:3:1	1:4:6:4:1

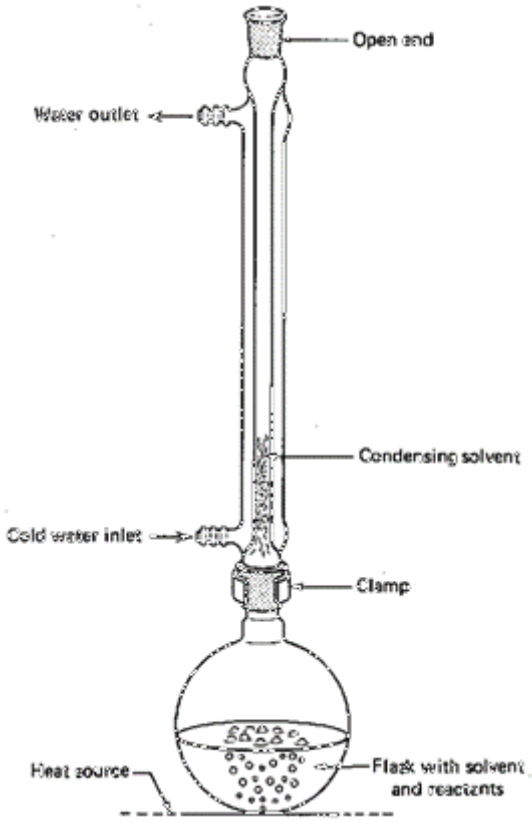
- Split number of peaks = number of nonequivalent ^1H's within 3 bonds + 1

The relative sizes follow Pascal's triangle.

121. What are the reaction conditions for the partial oxidation of primary alcohols and why?

Distilling the aldehyde as it forms otherwise it will continue onto forms carboxylic acid.

122. Describe reflux setup



- Open end - prevents build up of gas that can cause explosion
- Anti-bumping granules - prevents vigorous and uneven boiling by forming smaller bubbles

123. 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):

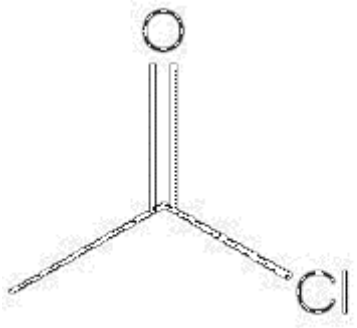
sodium phenoxide

THIS INCLUDES ANY OTHER AROMATIC COMPOUND WITH AN -OH.

3. Too weak to react with weak bases (eg, Na_2CO_3) unlike carboxylic acids.

124. How and why are acyl chlorides better than carboxylic acids?

They are more reactive than carboxylic acids as Cl is a good leaving group.



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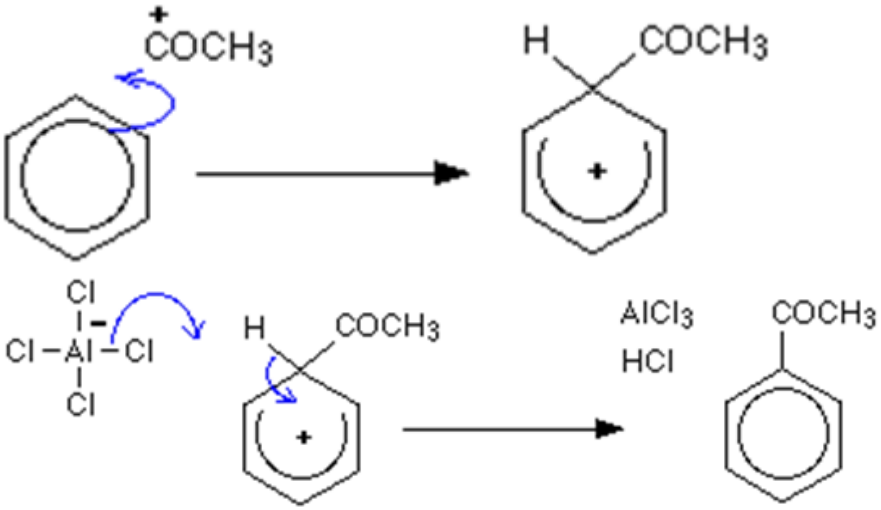
125. How are secondary and tertiary aliphatic amines formed? (with reactants, conditions)

●Reactants: haloalkane and primary / secondary amine.
●Conditions: ethanol as solvent (preventing hydrolysis of haloalkanes).

---

126. What are the conditions, reactants, equation, and mechanism for Friedel–Crafts acylation of benzene?

-Conditions: heating under reflux
-Reactants: acyl halide and halogen carrier (e.g., CH_3COCl for $AlCl_3$)
- Equation: $CH_3COCl + AlCl_3 \rightarrow [CH_3CO]^+ + [AlCl_4]^-$
-Mechanism: electrophilic substitution,



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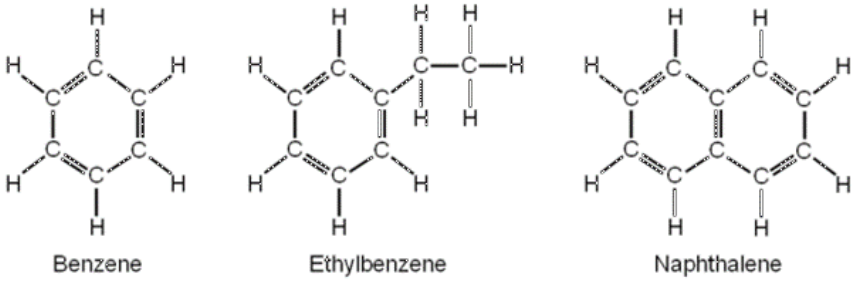
127. Define aromatic compounds / arenes

Containing benzene ring(s).



128. What is the equation for the full oxidation of a primary alcohol? Explain it

Primary alcohol + 2[O] → carboxylic acid + water

$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$

1.Two lots of oxidising agent is required; one for each stage
2.The water was produced at the first stage (when forming aldehyde)
You can distill afterwards to remove any unreacted alcohol molecules

---

129. Give 2 differences between σ and π bonds

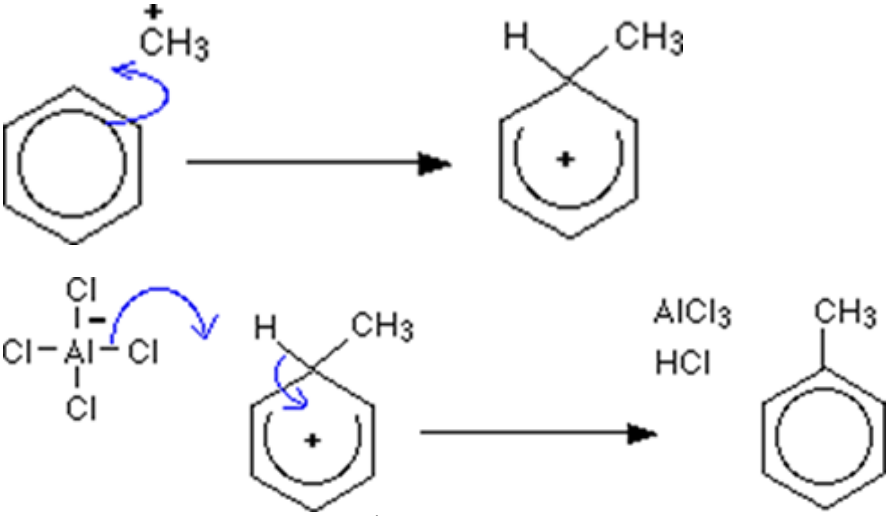
1. π bonds have a lower bond enthalpy than σ bonds.
2. σ bonds have electron density between bonding atoms **WHEREAS** π bond have electron density above and below bonding atoms (so are more exposed/prone to attack).

---

130. 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., $AlCl_3$ for CH_3Cl).
- Mechanism: electrophilic substitution,

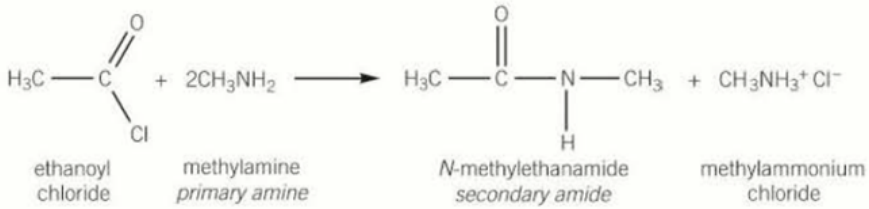


The $CH_3Cl + AlCl_3$ forms $[CH_3]^+ + [AlCl_4]^-$.

---

131. 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.

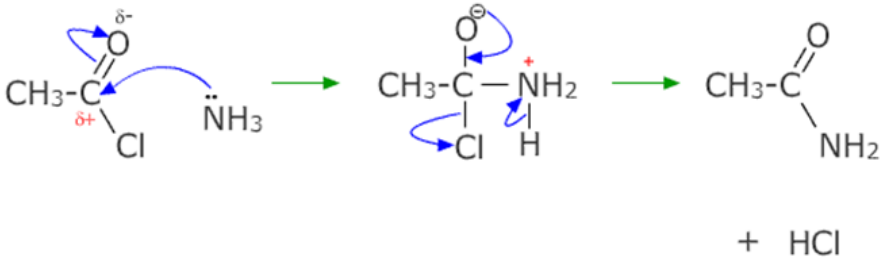
---

132. What 2 things are common for most reactions of acyl chlorides?

1.Carried out at room temperature.
2.Any HCl (g) is given off as a steamy white fume (as it reacts with H_2O, this is a good test for acyl chlorides).

133. How are primary amides formed? What precauation must be taken?

-By reacting acyl chlorides with excess ammonia.



-You require a lot of NH_3 to react with HCl to allow the reaction to go to completion.

---

134. How is Tollens' Reagent formed? (aka ammoniacal silver nitrate)

1. By mixing NaOH (aq) to $AgNO_3$ (aq) until a brown ppt is formed.
2. Adding dilute ammonia drop-by-drop until the ppt re-dissolves.

---

135. What is hydrogenation of alkenes and its conditions?

-$C_2H_4 + H_2 \rightarrow C_2H_6$.
-With **hydrogen** in the presence of a **nickel catalyst** at around **150°C**.

---

136. 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.

---

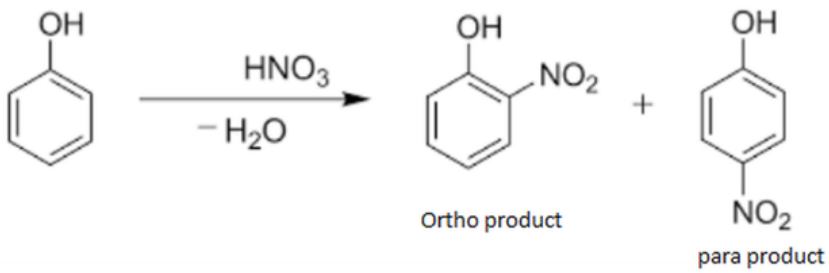
137. How does the strength of the carbon-halogen bond vary between different haloalkanes and why?

- Bond enthalpy (i.e., strength) decreases for halogens further down the group ∴ **broken more easily**.
- Due to decreased attraction between the bonding pair of electrons and the nuclei of bonding pairs due to increased shielding and atomic radius. *This factor overrides the polarity of the bonds.*

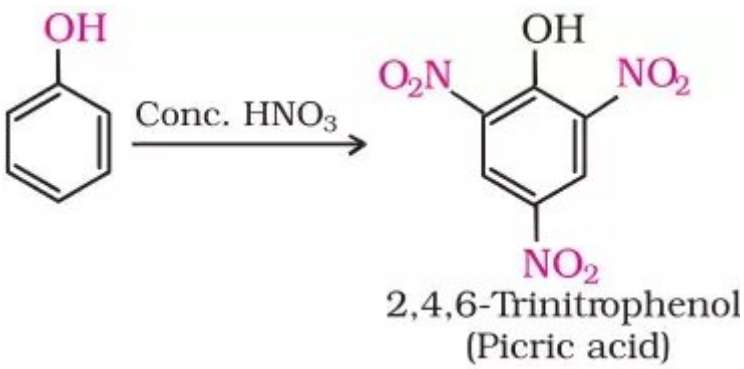
---

138. 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:



139. Why are shorter chain alcohols more soluble in water?

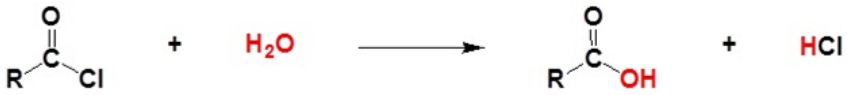
The functional group, which forms hydrogen bonds with water molecules making it soluble, forms a greater proportion of the molecule.

140. How and why must samples be dissolved in ^1H NMR? (with examples)

Dissolved in solvents without any ^1H's (eg, CCl_4 and $CDCl_3$) so you have no interference.

141. How do acyl chlorides react with water?

To produce a carboxylic acid and HCl (steamy white fume).



142. How can you distinguish between phenol and a carboxylic acid?

Carboxylic acids will react with a weak base (e.g., Na_2CO_3) leading to effervescence **HOWEVER** phenol will not.

143. 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.

144. What is the hydration of alkenes and its conditions?

- Forming alcohols from alkenes.
Conditions:
- Steam.
- Phosphoric acid catalyst.
- Around 300°C
Example:

- $C_2H_4 + H_2O \rightarrow C_2H_5OH$.

---

145. How does mass spectroscopy work?

By ionising atoms/molecules, accelerating them via an electric field, deflecting them by varying degrees using a magnetic field, and detecting.

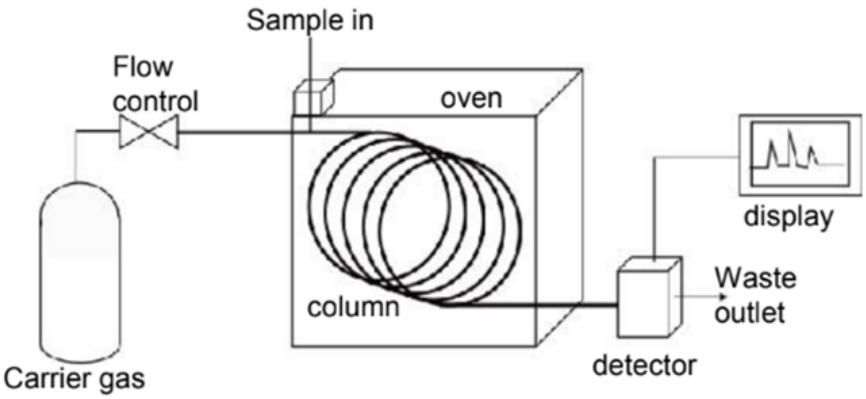
---

146. 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*

---

147. Describe the setup of gas chromatography (GC) (with mobile and stationary phase)



-Mobile phase is a mixture of gas.
-Stationary phase is high b.p. liquid coating the column.

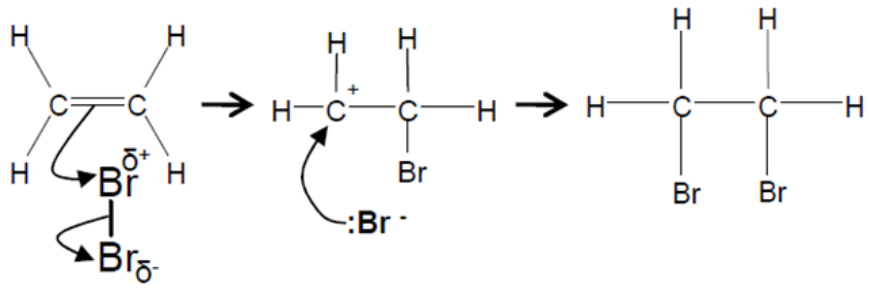
---

148. 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.

---

149. Describe and draw the electrophilic addition between bromine and ethene



1. Br_2 molecule approaches alkene.
2.Electrons in the π bond induce a temporary dipole the Br_2 thus causing the $Br^{\delta+}$ to attack the electron dense π bond whilst the Br-Br bond breaks by heterolytic fission.
3. The positive carbon on the carbocation intermediate attracts the Br^- ion.

---

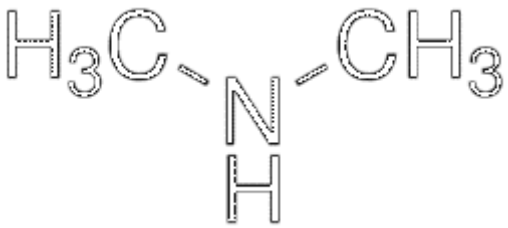
150. What should you ensure with the drying agent for purifying organic liquids?

-It's insoluble in the organic liquid.
-It doesn't react with the organic liquid.

---

151. What is an amine?

An organic compound containing $-NH_2$ group.

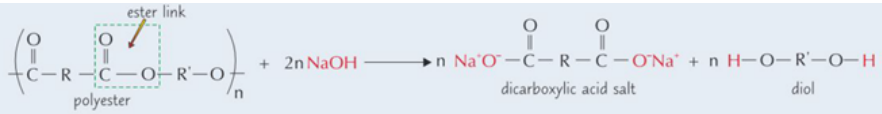


This is dimethylamine.

---

152. What are condensation polymers hydrolysed by? In what is each hydrolysed more easily?

-Hot (aq) acid or base.
-Poly(**a**mides) are hydrolysed more easily with strong **a**cid.
-Poly(esters) are hydrolysed more easily with strong base.



It can be hydrolysed by water but it's FAR too slow.

---

153. Describe the usual (cheaper) set up for determining melting point

-Thermometer and capillary tube strapped together in a Thiele tube.
-Heating oil with boiling point higher than sample and low flammability.
-Constant stirring.

---

154. 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.

---

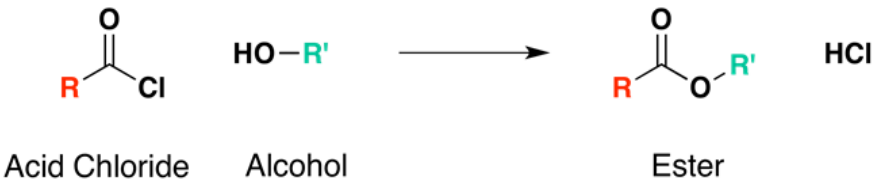
155. What does a liquid stationary phase separate organic compounds by?

By relative solubility.

---

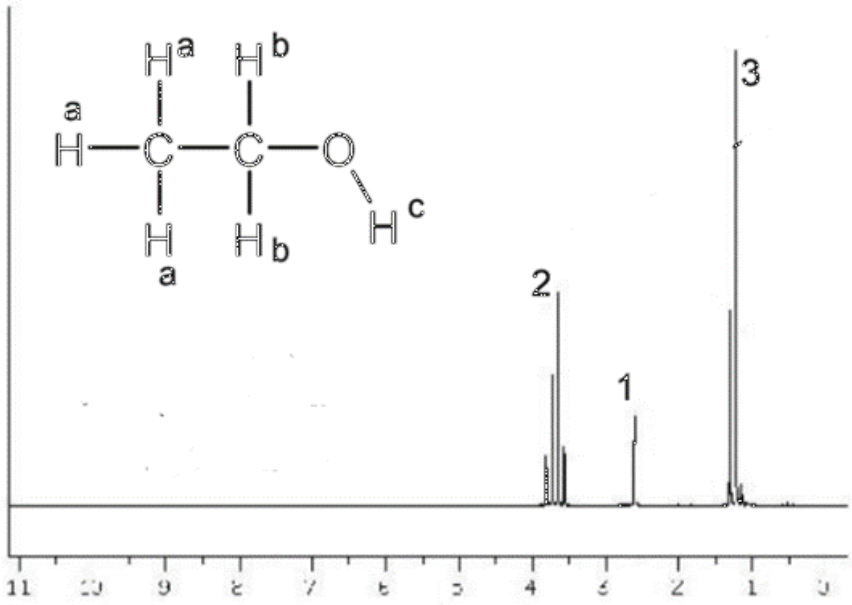
156. How do acyl chlorides react with alcohols and why is it good?

- To produce an ester.
-It's faster (■ more reactive) and not reversible.



157. How do equivalent hydrogens differ from equivalent carbons in NMR?

The intensity (peak integration value) ∝ number of equivalent H's it represents. Eg,

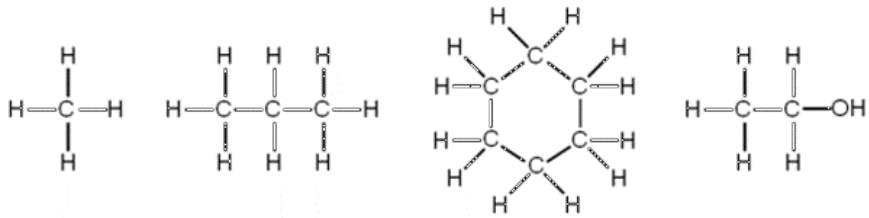


158. What is the test for unsaturated compounds?

Add bromine water which turns the solution from orange to colourless.

159. Define aliphatic

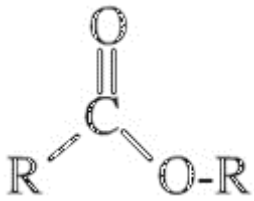
An organic compound joined in straight or branched chains, or **<u>non-aromatic</u>** rings.



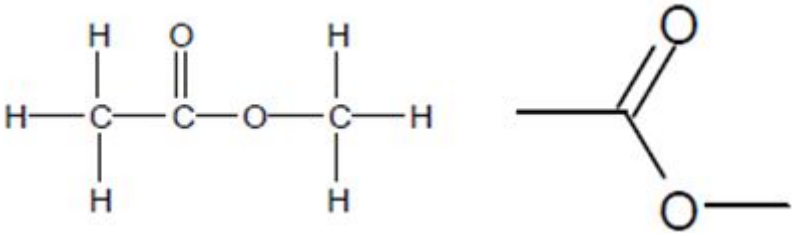
Cyclohexane is more specifically alicyclic yet also aliphatic. It is a non-aromatic ring.

160. Functional group and suffix of esters

-Functional group:



- Suffix: -yl-oate.



E.g., methyl ethanoate.

---

161. Give 2 problems with synthesising haloalkanes by free radical substitution

- Lots of termination steps lead to impurities (e.g., 2 •CH_3 meeting).
- Further substitution of termination products.

---

162. Define electrophile

A species that accepts a lone pair of electrons.
Think of 'phile' as meaning loving. It loves electrons.

---

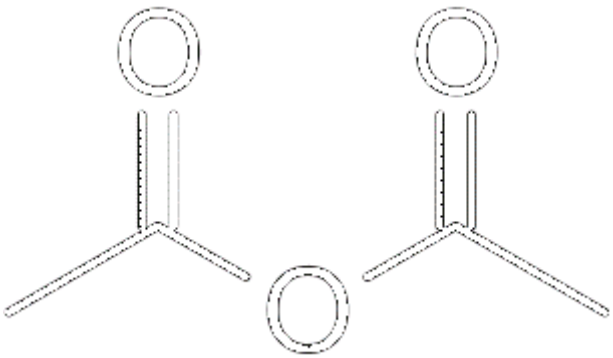
163. What does the destruction of the ozone mean for us?

Exposed to more UV light which means increased risk of skin cancer.

---

164. What is an acid anhydride?

Two carboxylic acids joined together.



Ethanoic anhydride

---

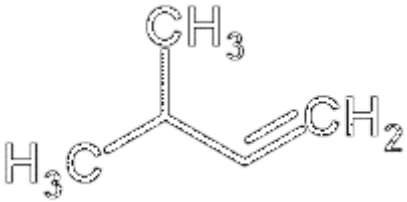
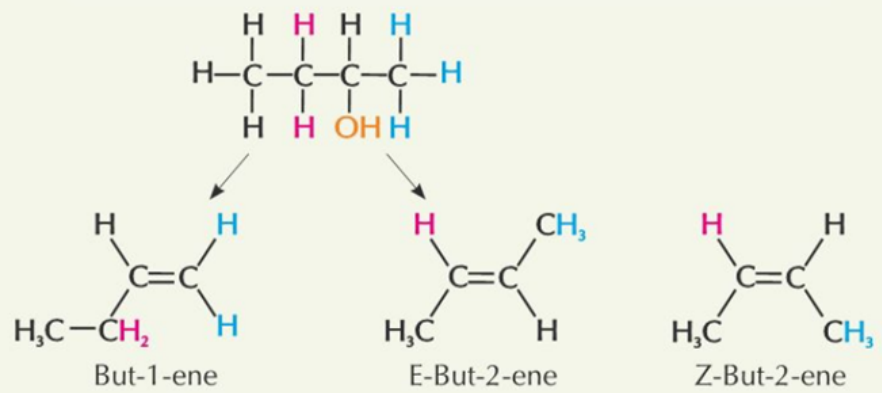
165. How is a separating funnel used?

1.Shake the reaction mixture then allow to settle into a dense aqueous layer (containing the impurities) and a less dense organic layer.
2.Open the tap to run off the aqueous layer.

---

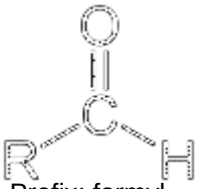
166. Difference between displayed and skeletal formulae

- Displayed - every bond is drawn.
- Skeletal - carbon to hydrogen bonds aren't drawn.
Every bond means -OH should be drawn as -O-H.

167.	What is addition polymerisation?	When unsaturated monomers react.
168.	Why may condensation polymers be photodegradable?	As the C=O bond absorbs radiation.
169.	What takes precedence when naming with branched chains?	-Functional groups. -E.g., 3-methylbut-1-ene is right, 2-methylbut-3-ene is wrong.  *Begin counting carbons from the functional group.*
170.	When and why are isomers formed from the dehydration of alcohols?	-From secondary or tertiary alcohols. - As an H is removed from either one of the two/three adjacent carbons to the carbon the -OH is bonded to.  *The one from which it's removed is purely random!*
171.	What makes HO^- a better nucleophile than H_2O?	Its full charge.
172.	What likely reasons are there for a reaction likely being more than one step (for a high overall order)?	1) Stoichomietry in rate equation does not match stoichomietry in overall equation. 2) Collision is unlikely between more than 2 ions/species. *Changed deck.*

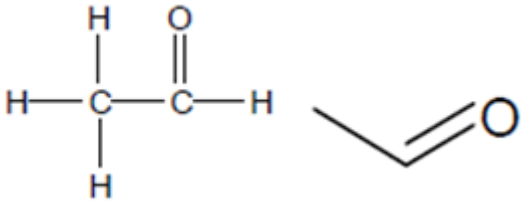
173. Functional group, prefix, and suffix of aldehydes

-Functional group:



-Prefix: formyl-.

-Suffix: -al



E.g., ethanal.

---

174. Define positional isomers

Same molecular formula but **different position of functional group** (e.g., propan-1-ol and propan-2-ol).

---

175. What is the equation for the partial oxidation of primary alcohols?

A primary alcohol reacts with [O] (the oxidising agent) to form an aldehyde and water.

$CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$

E.g., propan-1-ol to propanal.

---

176. What dangers are there with alcohols?

Methanol, ethanol, and propanol are very flammable.

---

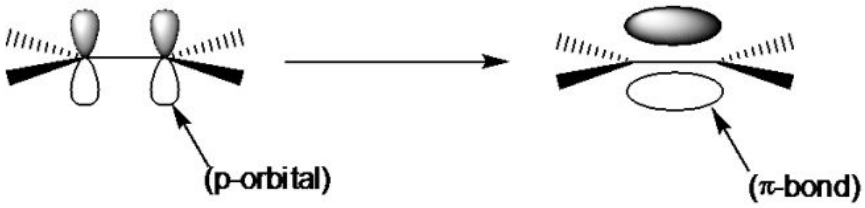
177. Give 3 things the Greenhouse Effect of a gas depends on

-Its atmospheric concentration.
-Its ability to absorb IR.
-Its residence time (how long it's in the atmosphere).

---

178. What is a π bond? (with diagram)

The sideways overlapping of p-orbitals.

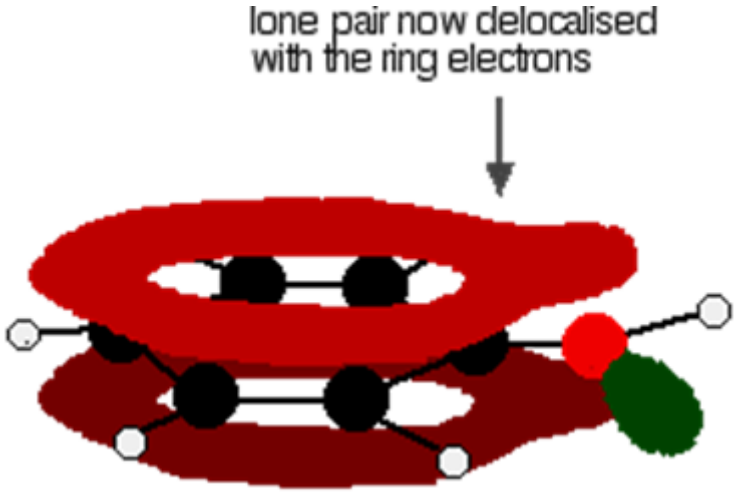


Draw the diagram above when asked.

---

179. Why is phenol more reactive than benzene? (3)

- The lone pair on the ^{16}O **partially delocalises** into the π-ring (1)
- Electron density increases (1)
- Making it more polarising (1) as it incudes dipoles making molecules polar.

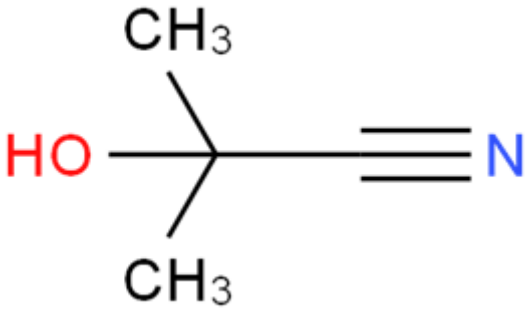


ACTIVATING RECEIVES NO CREDIT.

---

180. How are nitriles named?

The C≡N becomes part of the main chain (e.g., 2-hydroxy-2-methylpropanenitrile).



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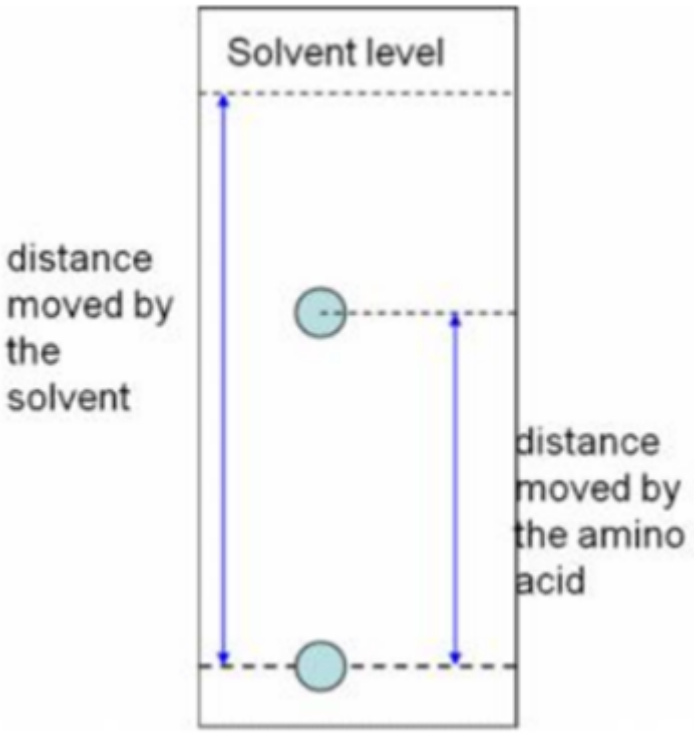
181. What is retention factor? How can it be used to identify a substance?

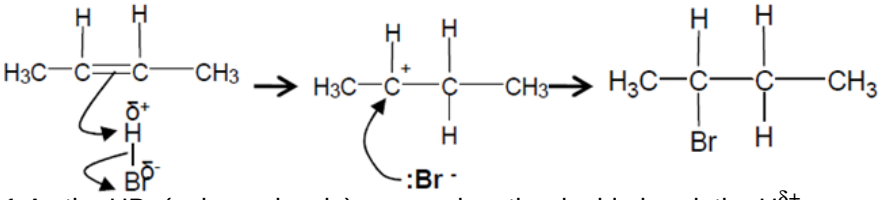
- Distance moved by compound / distance moved by solvent.
- By comparing to database values.



This case uses an amino acid.
Each substance has its own unique retention factor.

---

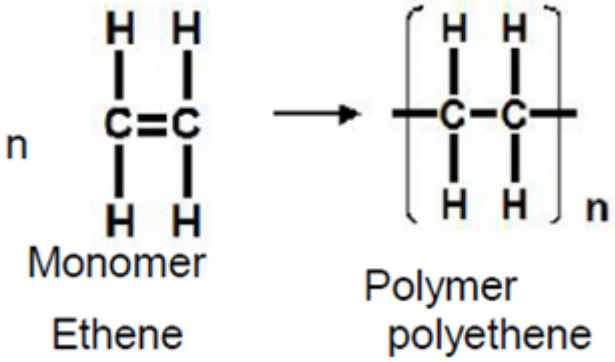
182. Describe the electrophilic addition of hydrogen bromide and butene



1.As the HBr (polar molecule) approaches the double bond, the $H^{\delta+}$ attacks the electron dense π bond whilst the hydrogen-halogen bond breaks by heterolytic fission.
2.This forms a carbocation intermediate which attracts the Br^- atom.

---

183. Draw polymerisation of monomers into a polymer



The bracket with the ethane inside is a repeat unit.

---

184. What are amides?

A compound containing a $-CONH_2$ group.

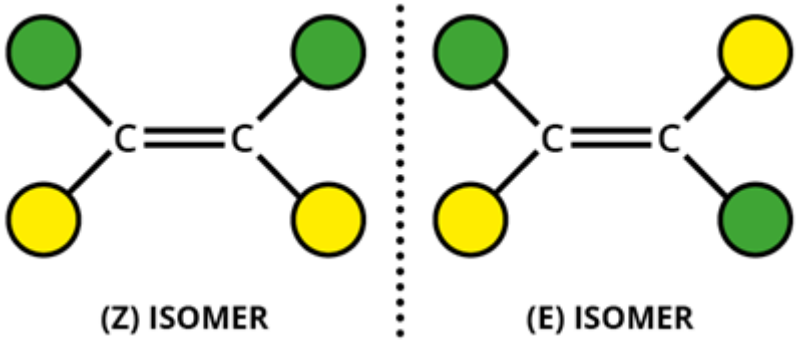
---

185. Why are the carbon-carbon bonds in benzene all equal in length?

As the π bonds in benzene are delocalised.

186. What 2 things are required for E-Z stereoisomerism to arise?

1. A double C=C bond (to provide limited rotation).
2. Two different groups on each carbon atom around the double bond.



187. Describe the Cahn-Ingold-Prelog (CIP) priority rule

- Identify the priority groups on either side (the atom with the larger atomic mass).
- If the priorities are on the same (**zame**) side, it is a Z-isomer. If the priorities are on opposite sides (**epposite**), it is a E-isomer.
- If the directly attached atoms are the same, move onto the next atom.

188. What is fragmentation under mass spectroscopy?

When a bond breaks in a molecular ion (due to instability) forming fragment ions.
The electron can go onto either side of the double bond. E.g., for CH_3CH_2OH, it may form $[CH_3CH_2]^+$ (with the positive charge on the second carbon) or HO^+

189. How does the reactivity of methylbenzene and benzene compare?

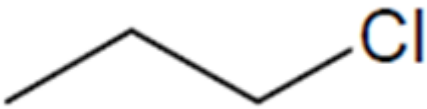
Methylbenzene is more reactive ■ alkyl group releases electrons into π-ring ∴ increasing its electron density ∴ more polarising ∴ more reactive.

190. What are carbonyl compounds?

An aldehyde or ketone (containing C=O bond).

191. Functional group and prefixes of haloalkanes

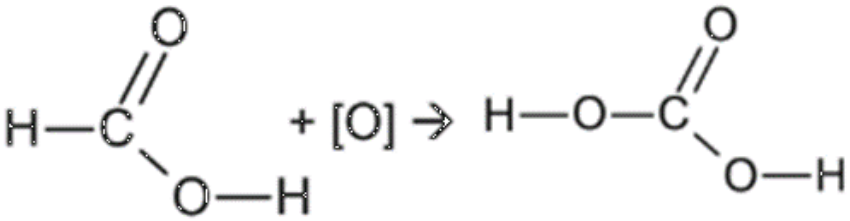
-Functional group: C-X.
-Prefix: fluro-, chloro-, bromo-, iodo-.



E,g., 1-chloropropane

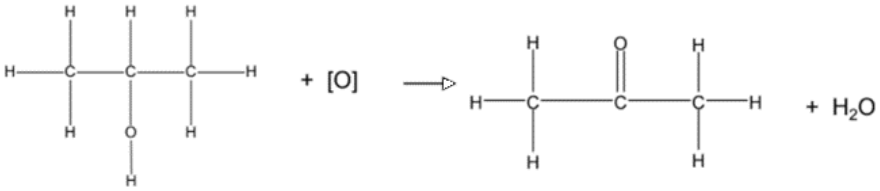
192. What 2 things does the rate of the hydrolysis of haloalkanes depend on and how?

- The bond enthalpy (i.e., strength) of the carbon-halogen bond, the weaker, the faster.
- The degree of the haloalkane; tertiary is faster than secondary which is faster than primary.

193.	Define saturated and unsaturated	-Saturated means **ONLY** single carbon-carbon bond. -Unsaturated means multiple carbon-carbon bonds (e.g., C=C and C≡C). *Remember, s in saturated for single.*
194.	Define alicyclic	An organic compound that is both aliphatic and cyclic.
195.	Where must curly arrows start?	At a lone pair or the centre of a bond.
196.	What limits biodegradable plastics?	Not having the right conditions to decompose (i.e., moisture and oxygen).
197.	What is a nucleophile (with examples)?	-A species that donates lone pair of electrons. -HO^-, H_2O, and NH_3.
198.	Give an everyday use of IR spectroscopy	Breathalyzers.
199.	What are nitriles?	An organic compound that has a C≡N functional group
200.	What is different about methanoic acid to other carboxylic acids?	It can be oxidised as its structure as it has an aldehyde group. 
201.	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.
202.	Define hydrocarbon	A compound consisting of **ONLY** hydrogen and carbon.
203.	What is cracking?	-Converting long chain hydrocarbons to smaller ones. - High M_r alkane → small M_r alkane + alkene.
204.	What are the reaction conditions for the full oxidation of primary alcohols and oxidation of secondary alcohols? Why?	Heating under reflux to prevent evaporation.

205. What is the equation for oxidation of secondary alcohols?

Secondary alcohol + [O] → ketone + water

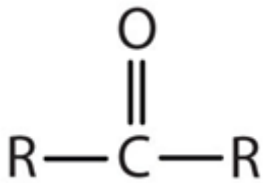


206. How do these structures compare?

- π-bond(s) are localised between 2 carbons in left structure (1)
- π-bond(s) are delocalised in right structure (1)

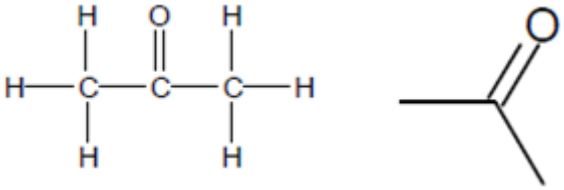
207. Functional group, prefix, and suffix of ketones

-Functional group:



-Prefix: oxo-.

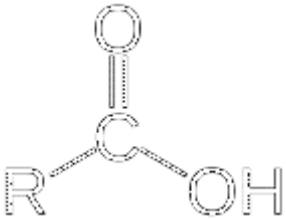
-Suffix: -one (more common).



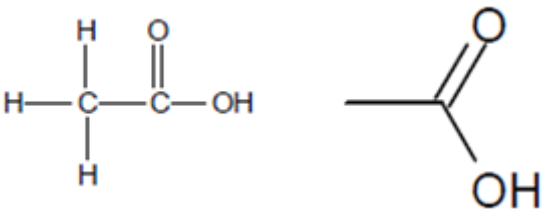
E.g., propone.

208. Functional group and suffix of carboxylic acids

-Functional group:



-Suffix: -oic acid.



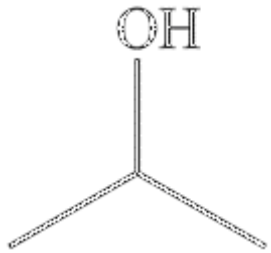
E.g., ethanoic acid.

209. What are the 3 degrees of alcohols?

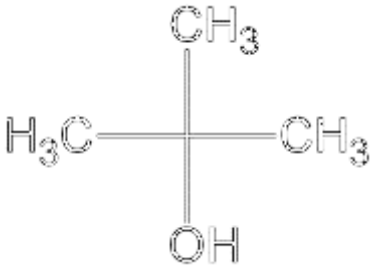
-Primary (1°):

The carbon which the functional group is attached to is only attached to one other carbon.

-Secondary (2°):



-Tertiary (3°):



---

210. What are the reagents for the oxidation of primary and secondary alcohols and where are they from?

-An excess of…

-$Cr_2O_7^{2-}$.

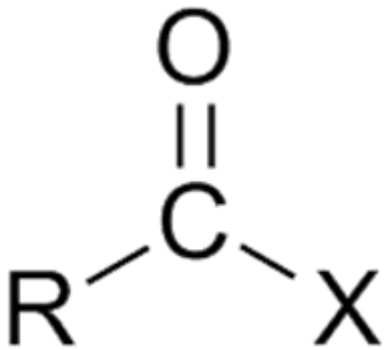
-H^+.

-From solution of potassium dichromate (VI) and dilute sulfuric acid.

Something such as hydrochloric acid cannot be used as the dichromate ions would rather oxidise this.

---

211. What is an acyl halide?

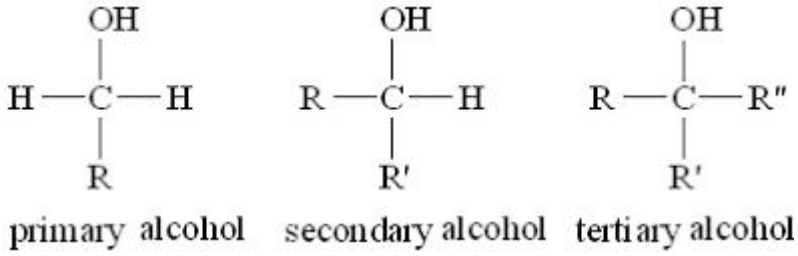


Where R is an alkyl group and X is a halogen.

---

212. Why won't tertiary alcohols oxidise?

As you need to remove a ^{1}H atom from the carbon the -OH is bonded to (alongside the ^{1}H from the -OH substituent group). Yet, no ^{1}H is bonded to said carbon.



---

213. Give 2 reasons why organic compounds are mostly unreactive

-C-C and C-H have high bond enthalpies.
-Very low bond polarity (essentially nonpolar).
However, they can react with radicals or anything else as reactive as a radical.

---

214. Give 2 uses of phenol

-Antiseptic (used by Lister, called carbolic acid).
-Detergents.
-Dyes.

---

215. Define functional group isomers

Same molecular formula but **different functional group** (e.g., but-2-one and butan-1-ol).

---

216. What absorbs IR in the atmosphere, what happens, and what can this lead to?

-The bonds of gaseous molecules such as CO_2 and H_2O.
- They vibrate more.
- Global warming.

---

217. 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.

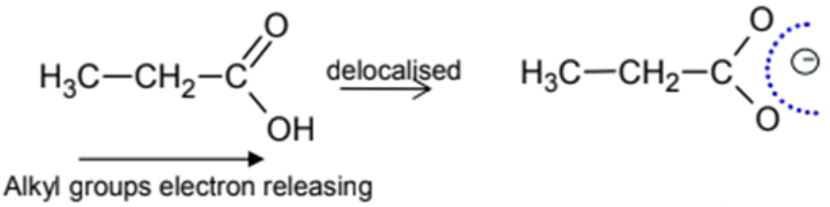
---

218. 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 Br_2 by electrophilic addition.
-It doesn't react readily as its e^- density is too low - requires a catalyst and does so by electrophilic substitution.
Bond length is intermediate:
-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 is less exothermic than expected:
-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.

---

219. 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.

---

220. How does electronegativity affect ^1H NMR?

If a ^1H is closer to more electronegative group, greater shift (further left).

---

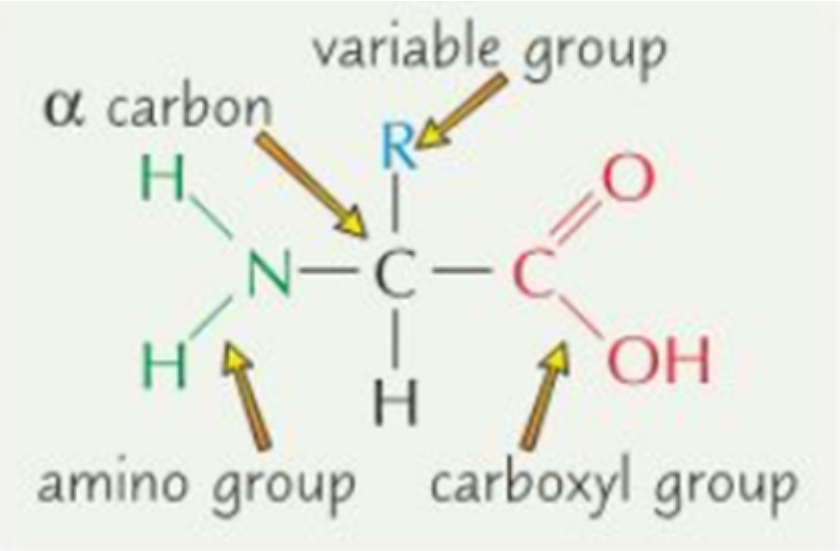
221. What is E/Z isomerism?

An example of stereoisomerism where...
- There is restricted rotation about the C=C.
- Two different groups attached to each ^{12}C of the C=C group.

---

222. What are amino acids?

A central carbon with an amino group and carboxyl group.



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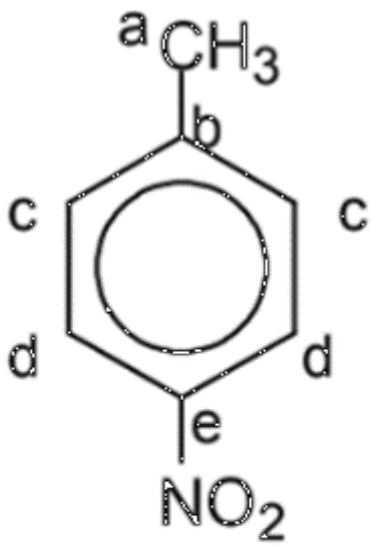
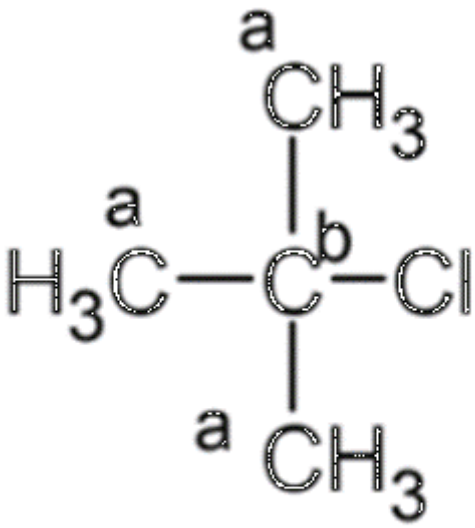
223. What are equivalent carbons? How do they show up in ^{13}C NMR?

Carbons which are in the same environment.



5 peaks



2 peaks

There is one signal peak for each set of equivalent carbons.

---

224. 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) or very close to it.
-One with impurities may have a **lower melting point** or may **melt over a range** of several degrees.

---

225. How are both types of NMR calibrated?

By adding a small amount of TMS (tetramethylsilane).

---

226. Functional group, prefix, and suffix of an alcohol

-Functional group: OH.
-Prefix: hydroxy-.
-Suffix: -ol (more common).

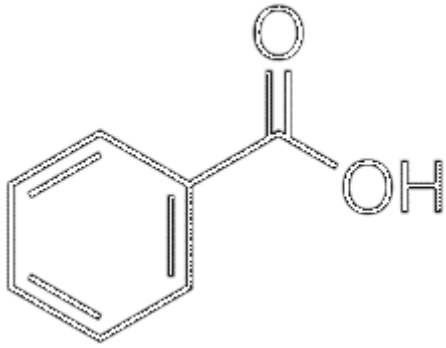
227. When is the reflux setup most often used?

When heating organic reaction mixtures for long periods.

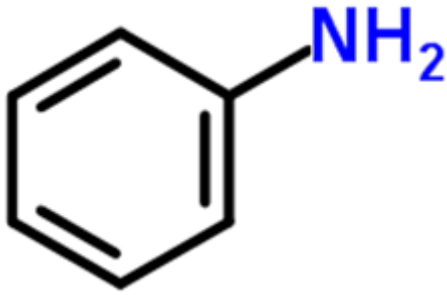
228. What type of reaction is the dehydration of alcohols? And why?

-Acid-catalysed **elimination**.
- The -OH group (and a ^{1}H on an adjacent carbon) is eliminated forming an unsatured molecule.

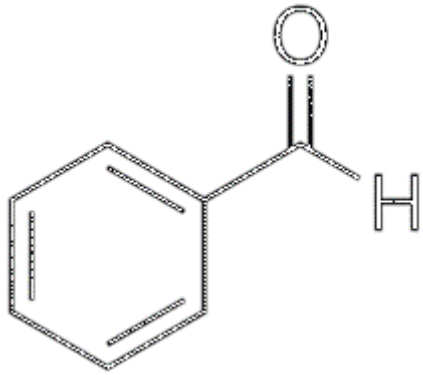
229. Give the 3 non-systematic arenes you need to know



Benzoic acid



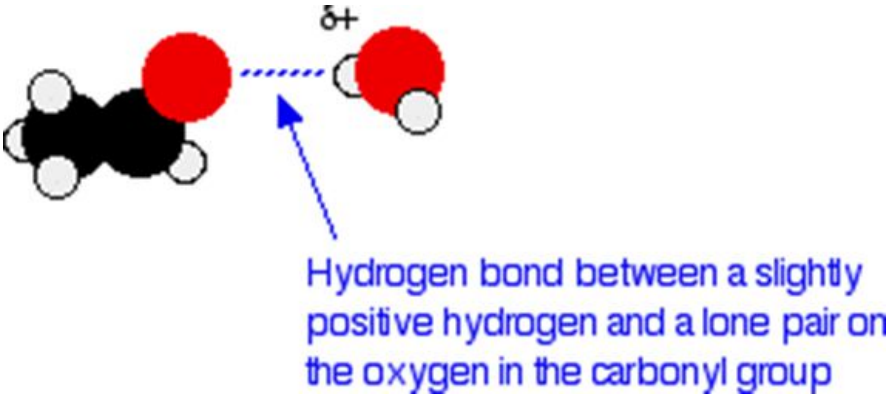
Phenylamine



Benzaldehyde

230. Are carbonyls soluble and if so, why and which ones?

-Yes as it can form hydrogen bonds with water.
-The small ones.



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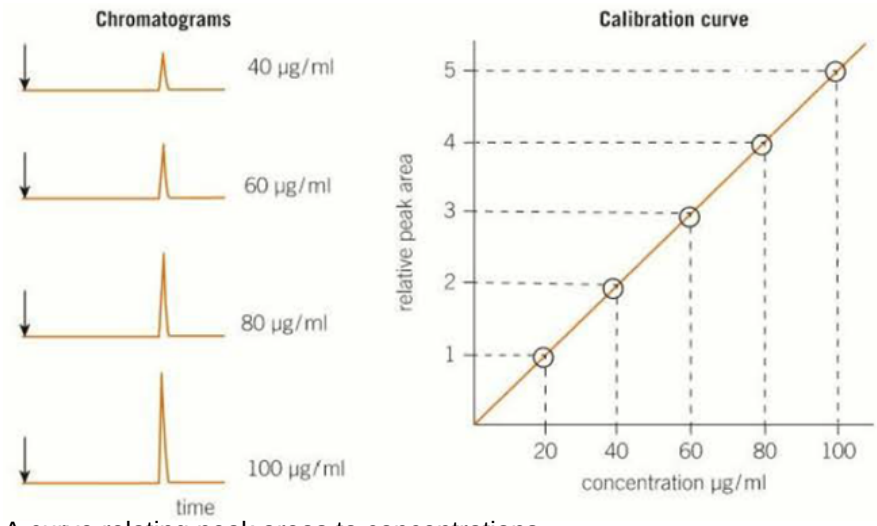
231. What is the issue with identifying -OH and -NH groups in ^1H NMR? How is this solved? What is this called?

-They're very variable and don't split.
1.Run two spectra of the molecule - one with D_2O added.
2.If -OH, -NH present, it'll swap proton as shown below:
Eg, $CH_3CH_2OH + D_2O \rightarrow CH_3CH_2OD + HOD$
- This is called **PROTON EXCHANGE**.
This works since deuterium doesn't absorb radio waves since even number of nucleons.

---

232. What is a calibration curve?

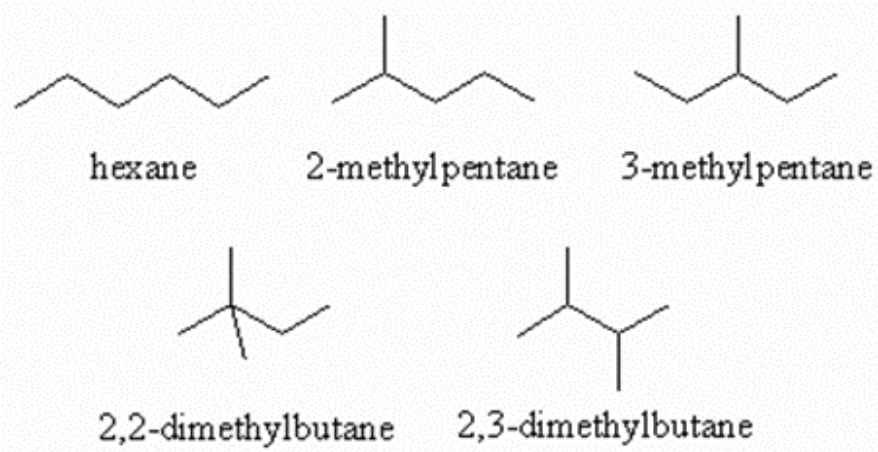


A curve relating peak areas to concentrations.

---

233. Define structural isomers

Same molecular formula but **different structural formula**. E.g.,



This has the subsets of chain isomers, positional isomers, and functional group isomers.

---

234. What are the 2 types of polymerisation?

1.Addition polymerisation.
2.Condensation polymerisation.

---

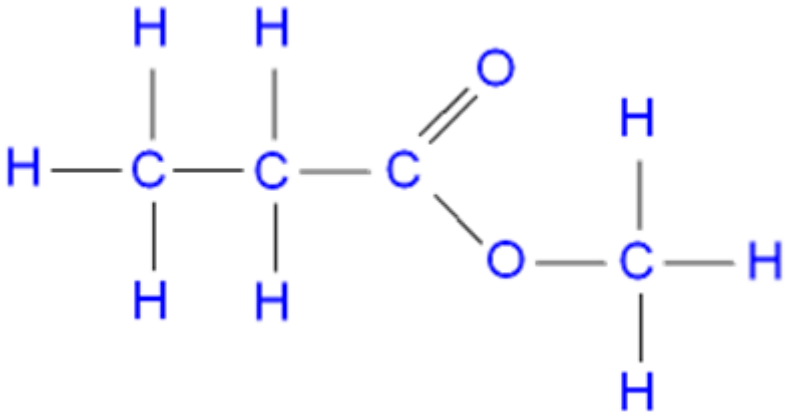
235. Define general formula

The algebraic formula for homologous series (e.g., C_nH_{2n}).

---

236. 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.

---

237. What are the problems of combusting polymers?

Can lead to toxic fumes (e.g., HCl).

---

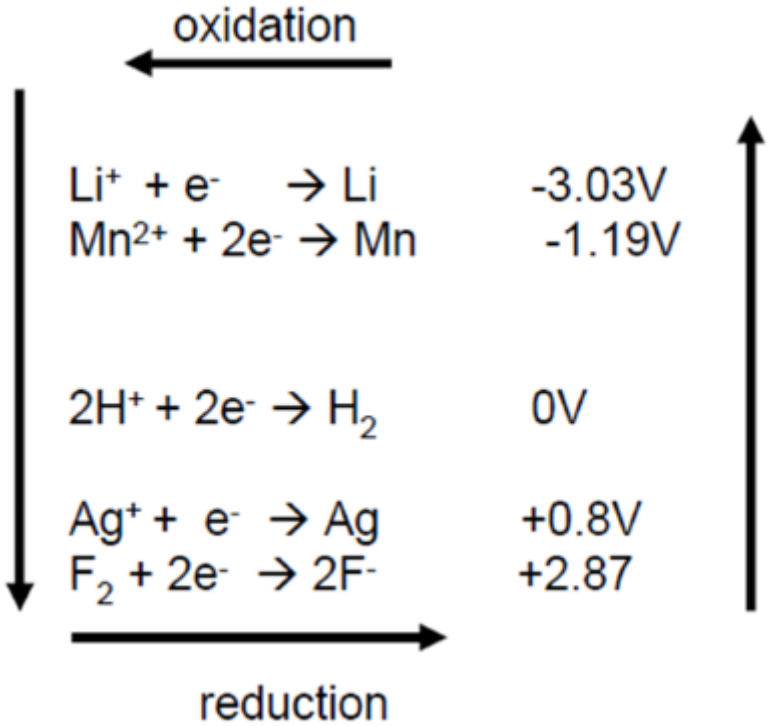
238. What are salts of carboxylic acids called?

Carboxylates. E.g, $(CH_3COO^-)Na^+$ is called sodium ethanoate.

---

239. What do standard electrode potentials tell us?

●The measure of the ability of a species to gain electrons. The more positive E^O is, the stronger the ability.
●When connected in an hydrogen electrode system.



I guess its intuitive?

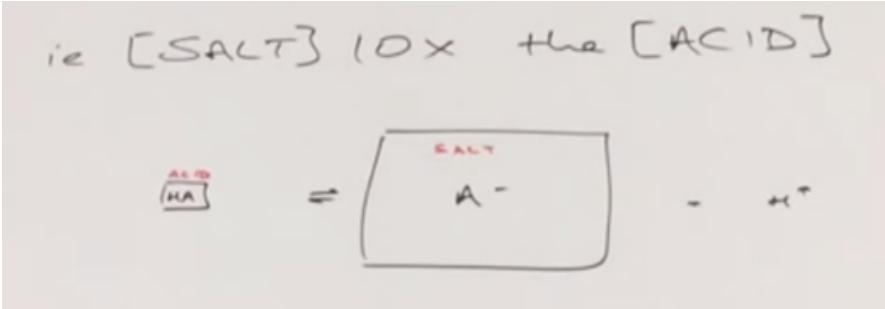
---

240. When do buffers work best and most effectively using the Henderson-Hasselbalch equation?

-Work best when pH = pKa.
-Work effectively when pH = pKa ± 1.

$$pH = pK_a + \log \frac{[Base]}{[Acid]}$$

So the $[A^-] = 10[HA]$ or $[HA] = 10[A^-]$.



As you can see, the buffer would struggle a lot if a lot of HO^- was added (as there isn't much H^+) but would be fine if H^+ was added.
Deleted.

---

241. What is lattice enthalpy?

Energy released when a lattice is formed.
This is since lattice enthalpy alone cannot be measured directly.
Delete as this is just lattice enthalpy of formation.

---

242. How is the energy change of a solution calculated?

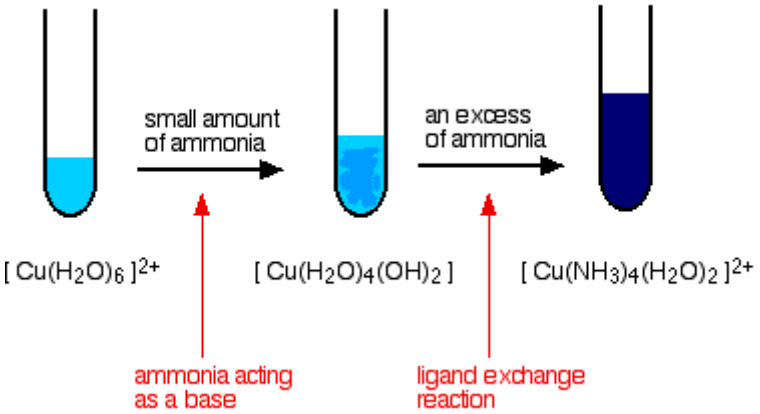
$$Q = mc\Delta T$$

Where m is the mass of solution (usually water) and c is the specific heat capacity of solution ($Jg^{-1}K^{-1}$).
Delete.

---

243. Describe the reaction of copper (II) with ammonia and **EXCESS** ammonia (with colours)

$[Cu(H_2O)_6]^{2+}$ (aq) + $2NH_3$ (aq) → $[Cu(H_2O)_4(OH)_2]$ (s) + $2NH_4^+$ (aq)
-Goes from pale blue to blue ppt.
- In excess NH_3, $[Cu(H_2O)_2(NH_3)_4]^{2+}$ (aq) is formed which is dark blue
- THE ABOVE REACTION IS THE ODD ONE OUT



All 6 water molecules can be replaced with a very high conc. NH_3 but you don't need to know this.
DELETE merged with another

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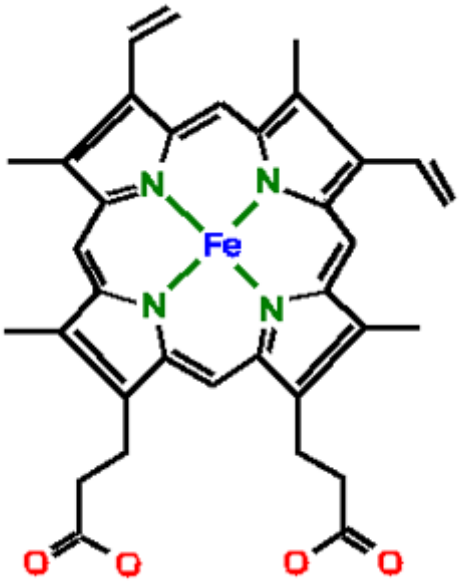
244. What is 'haem?'

An Fe (II) complex with a multidentate ligand.



Don't think this is useful...

245.	What 3 things are metallic bonds affected by?	1. No. of protons (the more, the stronger). 2. No. of delocalised electrons per atom (the more, the stronger). 3. No. of shells (the more, the weaker ■ electron shielding).
246.	Why will chlorine and water bleach universal indicator?	The ClO^- ion from the $HClO_{(aq)}$ produced is a powerful oxidising agent.
247.	What is the test for ammonium ions?	-Add sodium hydroxide solution and **HEAT GENTLY**. -$NaOH_{(aq)} + NH_4Cl_{(aq)} \rightarrow NH_{3\,(g)} + NaCl_{(aq)} + H_2O_{(l)}$ -If NH_3 is produced then you can… -Smell for it. -Use damp litmus paper and hover it over the tube. This will turn blue under NH_3 as NH_4OH will form on the paper.
248.	Why does reactivity decrease down group 7?	- Increased atomic radius and increased shielding due to more shells ⇒ less attraction between the nucleus ⇒ gains electrons less readily. - The increase in proton number and thus **<u>nuclear charge</u>** is outweighed by an increase in shielding.
249.	What compromises must be made when altering the equilibrium position and why?	**<u>Pressure:</u>** - A lower pressure when favouring the side with less moles ■ **high pressures** are **difficult to produce** (high electrical costs in pumping gas) and **difficult to contain** (to withstand high pressures). - A higher pressure when favouring side with more moles otherwise the **rate of reaction will be too low**. **<u>Temperature:</u>** - A higher temperature when favouring the exothermic side otherwise the **rate of reaction will be too low**. - A lower temperature when favouring the endothermic side ■ **expensive to use too much fuel**. - Because this allows for a reasonable rate of reaction / costs without shifting the equilibrium too far to the left/right. - You will have a smaller equilibrium yield but more product produced in unit time.
250.	How can half-equations containing ^{12}O be balanced under acid conditions?	1. **<u>W</u>**ater - balance atoms using H^+'s and H_2O. 2. **<u>O</u>**xidation - balance oxidation numbers using e^-'s. 3.**<u>C</u>**heck - check that atoms and charges balance. *This can be remembered as dodgy WOC.*

251. What is the problem with the endpoint of a thiosulfate redox titration? What should be done? Why does this work? (with colours)

●The colour change is hard to spot.
●Starch indicator is added **NEAR THE ENDPOINT** to emphasise it (otherwise you get a false positive).
●It turns from from **blue-black to colourless**.
●Since with starch and I_2, you have blue-black. Yet once it is all used up (by adding thiosulfate), it becomes colourless. See below:
$2S_2O_3^{2-}$ (aq) + I_2 (aq) → $2I^-$ (aq) + $S_4O_6^{2-}$ (aq)

---

252. Give 3 advantages and 3 disadvantages of hydrogen fuel cells

Advantages:
+Less pollution, CO_2 (only H_2O produced).
+More efficient.
+Large supply of water
Disadvantages:
- Needs to be stored as a liquid **AND** under high pressurised vessels (liquid fuels like methanol are much easier to store).
-Have a limited lifetime (require regular replacement/disposal)
-Uses toxic chemicals in their production.
-H_2 isn't readily available.
-No H_2 infrastructure.

---

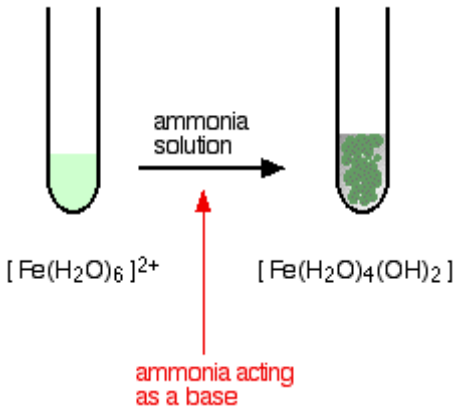
253. What are the 4 characteristics of all transition elements?

1. Formation of coloured ions.
2.Variable oxidation state:
Eg, Fe (II) and Fe (III) since their 4s and 3d energy levels are so close, they can easily lose another e^-.
3.Catalytic activity.
4. Complex ion formation in solution.
They form coloured ions due their electronic configuration.

---

254. Describe the reaction of iron (II) with hydroxide ions and ammonia (with colours)

WITH HYDROXIDE IONS / AMMONIA:
●$[Fe(H_2O)_6]^{2+}$ (aq) + $2HO^-$ (aq) → $[Fe(OH)_2(H_2O)_4]$ (s) + $2H_2O$ (l)
●$[Fe(H_2O)_6]^{2+}$ (aq) + $2NH_3$ (aq) → $[Fe(OH)_2(H_2O)_4]$ (s) + $2NH_4^+$ (aq)
●**Ionic equation:** Fe^{2+} (aq) + $2HO^-$ (aq) → $Fe(OH)_2$ (s)
●From pale green solution to dark green ppt.
●Insoluble in excess



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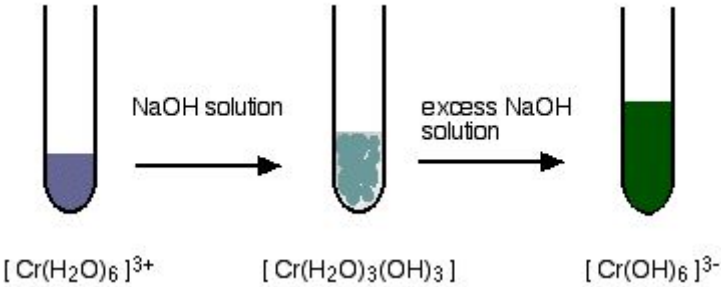
255. Describe the reaction of chromium (III) with hydroxide ions and ammonia (with colours)

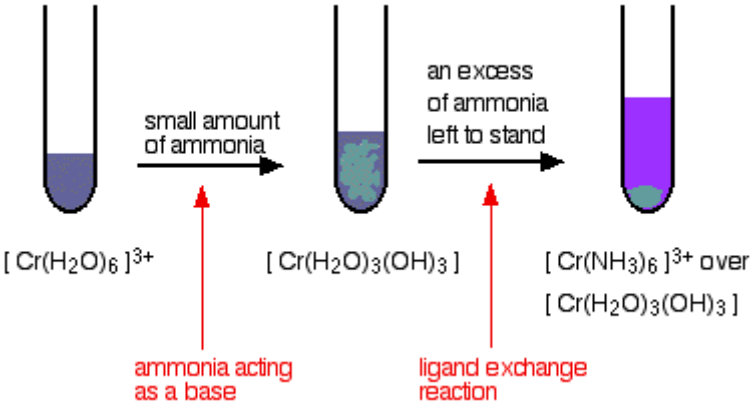
WITH HYDROXIDE IONS:

- **Dilute:** $[Cr(H_2O)_6]^{3+}$ (aq) + $3HO^-$ (aq) → $[Cr(OH)_3(H_2O)_3]$ (s) + $3H_2O$ (l)
- From pale purple solution to grey-green ppt
- **Excess:** $[Cr(H_2O)_6]^{3+}$ (aq) + $6HO^-$ (aq) → $[Cr(OH)_6]^{3-}$ (aq) + $6H_2O$ (l)
- From pale purple solution to dark green solution
- Soluble in excess



WITH AMMONIA:

- **Dilute:** $[Cr(H_2O)_6]^{3+}$ (aq) + $3NH_3$ (aq) → $[Cr(OH)_3(H_2O)_3]$ (s) + $3NH_4^+$ (aq)
- From pale purple solution to grey-green ppt
- **Excess:** $[Cr(H_2O)_6]^{3+}$ (aq) + $6NH_3$ (aq) → $[Cr(NH_3)_6]^{3+}$ (aq) + $6H_2O$ (l)
- From pale purple solution to purple solution
- Soluble in excess



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256. Describe how iron (II) is oxidised (with colours)

- Fe^{2+} → Fe^{3+} using acidified manganate (VII) which is H^+/MnO_4^- .
- The reaction goes from purple (MnO_4^-) to colourless (Mn^{2+}).
- Yet, Fe^{2+} (aq) is pale green and Fe^{3+} (aq) is yellow.

Oxygen in the air can bring this change also.

The equation below is not required according to the specification, relevant information will be provided to work it out.

Overall Equation:

- MnO_4^- (aq) + $8H^+$ (aq) + $5Fe^{2+}$ (aq) → Mn^{2+} (aq) + $4H_2O$ (l) + $5Fe^{3+}$ (aq)

Formed From:

- MnO_4^- (aq) + $8H^+$ (aq) + $5e^-$ → Mn^{2+} (aq) + $4H_2O$ (l)
- Fe^{2+} → Fe^{3+} + e^-

257.	Describe how Cr^{3+} is oxidised to $Cr_2O_7^{2-}$ or Cr^{6+} (with colours)	**Step One:** ● Cr^{3+} in $[Cr(OH)_6]^{3-}$ (easier to oxidise than $[Cr(H_2O)_6]^{3+}$) is oxidised to CrO_4^{2-} by warming with H_2O_2 in alkaline conditions. ● This goes from green to yellow. **Step Two:** ● Add dilute sulfuric acid to the chromate (VI) solution to produce dichromate (VI) $Cr_2O_7^{2-}$ ● This goes from yellow to orange. *The equation below is not required according to the specification, relevant information will be provided to work it out.* **Step 1 full equation:** ● $3H_2O_2 + 2Cr(OH)_6^{3-} \rightarrow 2HO^- + 2CrO_4^{2-} + 8H_2O$ **Step 1 half equations:** ● $H_2O_2 + 2e^- \rightarrow 2HO^-$ ● $2Cr(OH)_6^{3-} + 4HO^- \rightarrow 2CrO_4^{2-} + 8H_2O + 6e^-$. **Step 2 full equation:** ● $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$
258.	Describe the disproportionation of Cu^+ (equation and why it happens)	● $2Cu^+$ (aq) $\rightarrow$ Cu (aq) + Cu^{2+} (aq) ● This spontaneous disproportion happens since Cu^+ is unstable.
259.	What happens to Fe^{2+} on standing?	Turns rusty brown at the surface as Fe^{2+} is oxidised to Fe^{3+}.
260.	What does each electrode do in fuel cells and why?	- Fuel always **gives up** its electrons (less +ve E^O) at the negative anode (OXANA). - Oxygen always **gains** electrons (more +ve E^O) at the positive cathode (REDCAT).
261.	Which transition metals have anomalous e^- structures and why?	●Copper ([Ar] $3d^{10}$ $4s^1$) and chromium ([Ar] $3d^5$ $4s^1$). ●Having half-built/full-built 3d subshells is lower in energy than a full-built 4s subshell.
262.	Why do electronegativites and ionisation energies decrease down groups?	- Increased atomic radius and more shells $\Rightarrow$ more shielding $\Rightarrow$ less attraction $\Rightarrow$ easier to remove. - Increased shielding outweighs the increase in proton no. and thus nuclear charge.
263.	Why does electronegativity and ionisation energy increase across periods?	- Greater nuclear charge/attraction $\Rightarrow$ reduced atomic radius $\Rightarrow$ greater attraction $\Rightarrow$ harder to remove. - During this, shielding stay the same.
264.	What is the test for carbonates?	1. Add nitric acid. If you see effervescence, it **COULD** contain a carbonate ■ a gas is produced. 2. Bubble this gas through limewater. If cloudy then gas was CO_2 and thus carbonate was present.

265. What is ΔH°r equal to? (using bond enthalpies)

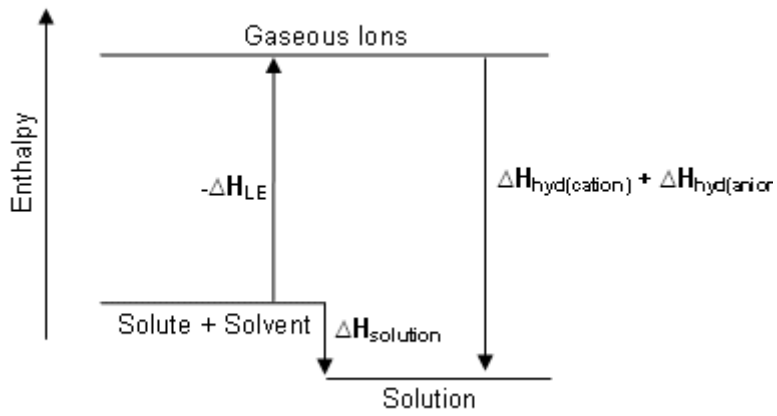
ΔH°r = ΣΔH (bonds broken) - ΣΔH (bonds formed)

266. How does the pH and pKa of strong acids compare with weak?

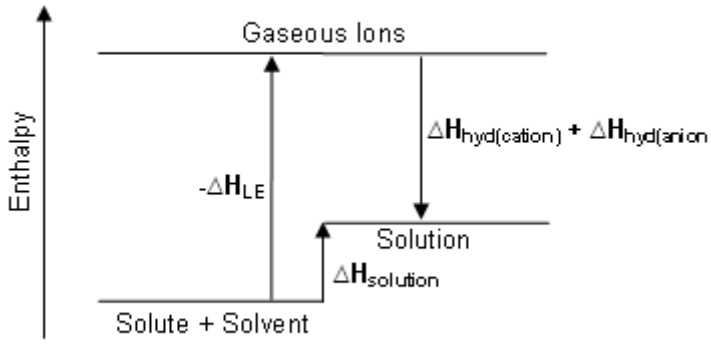
The pH and pKa values for for strong acids are lower as they fully dissociate (ie, $[H^+]_{final} = [HA]_{initial}$)

267. Draw the cycle relating enthalpy of hydration, lattice enthalpy, and enthalpy of solution for both cases

For $\Delta H_{sol} < 0$ (soluble):



For $\Delta H_{sol} > 0$ (insoluble):



268. Why can some endothermic reactions still be feasible?

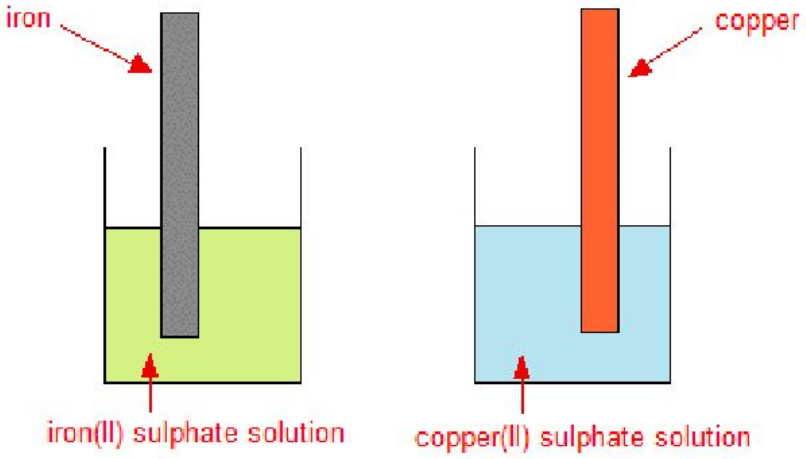
As these substances become more energetically stable when there is disorder.

269. Why may Gibbs free energy not be useful?

While a reaction may be feasible, it can still…
-Have a very high activation energy.
-Be incredibly slow that you won't see it happening at all.

270. What do simple half-cells usually consist of?

A metal (acting as an electrode) and a solution of compound containing said metal. Eg, Cu and $CuSO_4$.

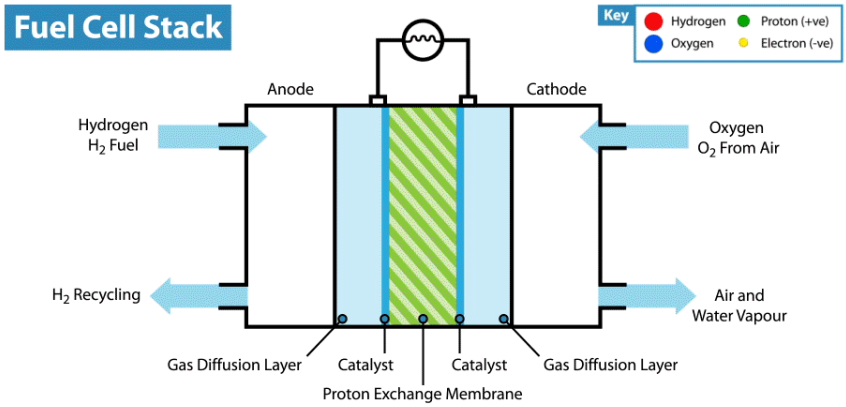


271. What is the standard electrode potential (E^O) defined as?

E.m.f (of a half-cell) compared with a standard hydrogen half-cell under sandard conditions
This is by convention, we cannot measure an absolute potential for obvious reasons.

272. Draw and describe the hydrogen fuel cell

With a semi-permeable membrane in the middle to keep the fuel and O_2 apart.



273. What is a ligand?

An atom, ion, or molecule that can forms a coordinate bond to a central metal ion.

274. Describe the reaction of manganese (II) with hydroxide ions and ammonia (with colours)

WITH HYDROXIDE IONS / AMMONIA:

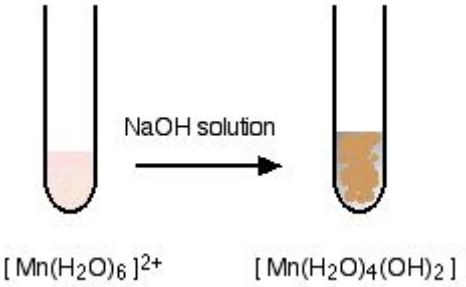
●$[Mn(H_2O)_6]^{2+}$ (aq) + $2HO^-$ (aq) → $[Mn(OH)_2(H_2O)_4]$ (s) + $2H_2O$ (l)

●$[Mn(H_2O)_6]^{2+}$ (aq) + $2NH_3$ (aq) → $[Mn(OH)_2(H_2O)_4]$ (s) + $2NH_4^+$ (aq)

●**Ionic Equation:** Mn^{2+} (aq) + $2HO^-$ (aq) → $Mn(OH)_2$ (s)

●From pale pink solution to brown ppt.

●Insoluble in excess



275. Describe how iron (III) is reduced (with colours)

● Fe^{3+} (aq) is yellow and Fe^{2+} (aq) is pale green.

● Using iodide ions, I^-.

The equation below is not required according to the specification, relevant information will be provided to work it out.

● Fe^{3+} → Fe^{2+} using I^- (from KI).

● Equation: $2Fe^{3+}$ (aq) + $2I^-$ (aq) → I_2 (aq) + $2Fe^{2+}$ (aq)

276. How should you tackle a buffers question? (not a calculation)

1) Write down the equation:

a) eg, HCOOH (high) ■ $HCOO^-$ (low) + H^+ (low)

2) State what happens when acid is added:

- H^+ ions reacts with $HCOO^-$ so equlibrium (a) shifts left to make more HCOOH (by Le Chatlier's).

3) State what happens when base is added:

- HO^- ions reacts with H^+ forms H_2O so equlibrium (a) shifts right to to replace H^+

277. How can half-equations containing ^{12}O be balanced under alkaline conditions?

1. **Oxidation** - balance oxidation numbers using e^-'s.

2. **H**ydroxides and waters - balance atoms using HO^-'s and H_2O.

3.**C**heck - check that atoms and charges balance.

This can be remembered as OHC.

278. How is bleach formed, why this way, and what is used as the bleach? (with equation)

-By reacting chlorine with **cold dilute sodium hydroxide solution** as it has a higher solubility.

-$Cl_{2\ (aq)}$ + $2NaOH_{\ (aq)}$ → $NaClO_{\ (aq)}$ + $NaCl_{\ (aq)}$ + $H_2O_{\ (l)}$

- The mixture of NaClO (called sodium chlorate (I)) is used as bleach.

279. How does temperature affect the rate of reaction?

Increasing temperature ⇒ higher % of particles with K_E greater than E_A (1) ⇒ more frequent successful collisions (1) ⇒ increased rate of reaction (1).

280. Give 2 reasons for why catalysts are useful

1. Allow reactions to occur at lower temperatures and pressures ∴ less (thermal) energy demand.
2. Allow for reactions with better atom economies ∴ less waste.

281. What is Le Chatelier's Principle?

If a dynamic equilibrium is changed, the position of the equilibrium shifts to oppose this change.

282. What is the rate determining step?

The slowest step in a reaction mechanism which determines the overall rate of reaction.

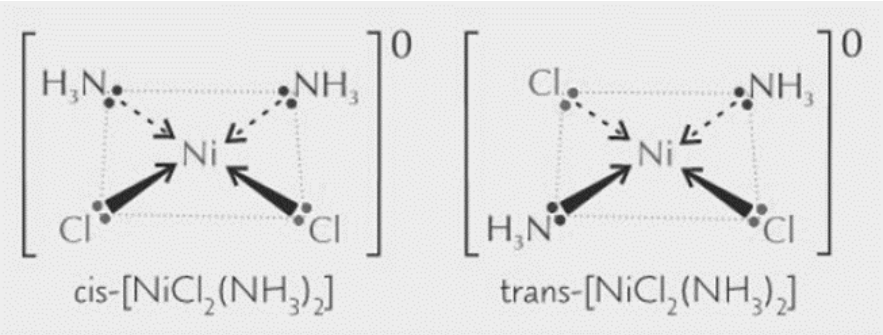
283. What is a bidentate ligand? (with examples of both ligands and complex ions)

●Ligands that form 2 dative/coordinate bonds **BY** donating 2 lone pairs.
●Examples: $C_2O_4^{2-}$ (ethanedioate), ethene-1,2-diamine / en.
●This is used as shown below with Fe (III).

Above, each ligand reduces the charge by 2 so you have 3 hence 3- charge.

284. What complex ions show cis-trans isomerism?

Square planar and octahedral complex ions with **at least two pairs of different ligands**.



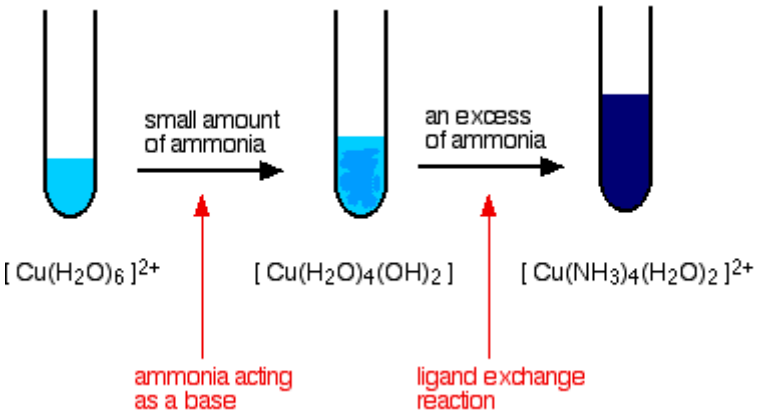
285. Describe the reaction of copper (II) with hydroxide ions and ammonia (with colours)

WITH HYDROXIDE IONS / DILUTE AMMONIA:

- $[Cu(H_2O)_6]^{2+}$ (aq) + $2HO^-$ (aq) → $[Cu(H_2O)_4(OH)_2]$ (s) + $2H_2O$ (l)
- $[Cu(H_2O)_6]^{2+}$ (aq) + $2NH_3$ (aq) → $[Cu(H_2O)_4(OH)_2]$ (s) + $2NH_4^+$ (aq)
- **IONIC EQUATION:** Cu^{2+} (aq) + $2HO^-$ (aq) → $Cu(OH)_2$ (s)
- Goes from pale blue solution to blue ppt
- Insoluble in excess HO^-

WITH EXCESS AMMONIA:

- $[Cu(H_2O)_6]^{2+}$ (aq) + $4NH_3$ (aq) →$[Cu(H_2O)_2(NH_3)_4]^{2+}$ (aq) + $4H_2O$ (aq)
- Goes from pale blue solution to deep blue solution
- The blue ppt re-dissolves / soluble in excess



All 6 water molecules can be replaced with a very high conc. NH_3 but you don't need to know this.

---

286. Describe the reaction of copper (II) react with chlorine ions (with colours)

- $[Cu(H_2O)_6]^{2+}$ (aq) + $4Cl^-$ (aq) ■ $[CuCl_4]^{2-}$ (aq) + $6H_2O$ (l)
- Goes from blue to yellow.
- Reversible reaction so greenish colour.

Remember this as BLUE COPPER YELLOW CHLORIDE (BCYC).

---

287. How does CO affect haemoglobin?

It forms a coordinate bond with haemoglobin stronger than O_2 (more stable) preventing O_2 from attaching.

---

288. Describe how $Cr_2O_7^{2-}$ or Cr^{6+} is reduced to Cr^{3+} (with colours)

- $Cr_2O_7^{2-}$ is reduced to Cr^{3+} by acidified zinc (H^+/Zn)
- This goes from orange to green.

The equation below is not required according to the specification, relevant information will be provided to work it out.

Full equation:

- $Cr_2O_7^{2-} + 14H^+ + 3Zn \rightarrow 2Cr^{3+} + 7H_2O + 3Zn^{2+}$

Half equations:

- $Zn \rightarrow Zn^{2+} + 2e^-$
- $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

289.	Describe how Cu^{2+} is reduced to Cu^{+} (with colours)	- Cu^{2+} is reduced to copper (I) iodide by iodide ions, I^{-}. - From pale blue to off-white ppt. *The equation below is not required according to the specification, relevant information will be provided to work it out.* **Full equation:** ● $2Cu^{2+}$ (aq) + $4I^{-}$ (aq) → 2CuI (s) + I_2 (aq)
290.	What are the limitations of calorimetry?	● Heat loss to surroundings. ● Non-standard conditions. ● Heat capactiy of container not included. ● Contents of calorimeter may evaporate.
291.	What is displacement of group 7 elements (with an example)?	-More reactive halogen displacing less reactive halide from its aqueous solution. -$F_{2\ (g)}$ + 2NaCl $_{(aq)}$ → 2NaF $_{(aq)}$ + $Cl_{2\ (g)}$
292.	Give the test for sulfate ions	1. Add nitric acid to dissolve any carbonates to prevent the formation of $BaCO_3$ precipitate (aka a false positive which can mask desired observations). 2. Add barium nitrate solution (or anything with Ba^{2+}). 3. If white ppt forms, you have a sulfate present. *This is because $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\ (s)}$.*
293.	What happens to the equilibrium position if pressure is increased?	- Favous the side producing the least moles of gas (1). - To minimise the effect of pressure increase by reducing the number of particles. *Remember that each mole takes $24dm^3$ under standard conditions!*
294.	Give 2 ways of determining orders of reaction and state the benefit of one over the other	1.Continually monitor [A] and form a concentration-time graph for many different conc.'s then use this to plot a rate-concentration graph whose shape you can use. 2.Use a clock reaction to get a good approximation of the initial rate. -Then use the initial rates method. -The latter method is far less time consuming as a graph doesn't have to be plotted each time.
295.	What 2 factors affect lattice enthalpy and enthalpy change of hydration?	**Charge difference between ions:** - Greater ⇒ stronger bonds ⇒ more energy released when broken ⇒ more exothermic enthalpy **Ionic radius:** - Smaller ⇒ stronger bonds ⇒ more energy released when broken ⇒ more exothermic enthalpy

296. What is platin?

The square planar molecule shown below:

[redacted]

297. Describe the reaction of iron (III) with hydroxide ions and ammonia (with colours)

WITH HYDROXIDE IONS / AMMONIA:

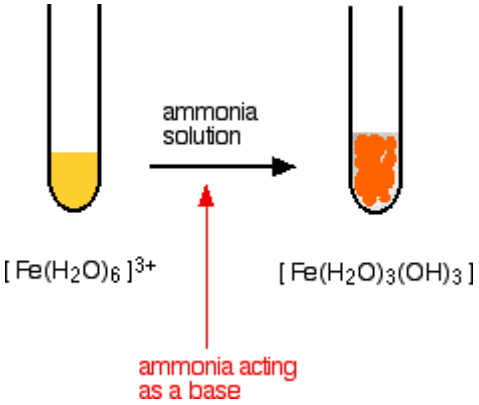
●$[Fe(H_2O)_6]^{3+}$ (aq) + $3HO^-$ (aq) → $[Fe(OH)_3(H_2O)_3]$ (s) + $3H_2O$ (l)

●$[Fe(H_2O)_6]^{3+}$ (aq) + $3NH_3$ (aq) → $[Fe(OH)_3(H_2O)_3]$ (s) + $3NH_4^+$ (aq)

Ionic equation: Fe^{3+} (aq) + $3HO^-$ (aq) → $Fe(OH)_3$ (s)

●From pale yellow solution to orange-brown ppt.

●Insoluble in excess



298. What **MUST BE** true for any neutral solution?

$[H^+] = [HO^-]$

Since temp. changes the value of K_w ⇒ $[H^+]$ and $[HO^-]$ must change ⇒ $[H^+]$ is no longer 10^{-7} ⇒ pH no longer 7 ⇒ pH of a neutral solution @ any temp. =/= 7. Ultimately, the pH scale changes with temp.

299. In what order should you carry out anion tests? Why?

● Carbonate - Sulfate - Halide (Ca - S - H).

● Continue iff it is negative.

● Adding Ba^{2+} to CO_3^{2-} produces a white ppt of $BaCO_3$.

● Adding Ag^+ to CO_3^{2-} produces a yellow-grey ppt of Ag_2CO_3.

● Adding Ag^+ to SO_4^{2-} produces a white ppt of Ag_2SO_4.

300. Why must **EXCESS** sulphuric acid be used in a manganate redox titration?

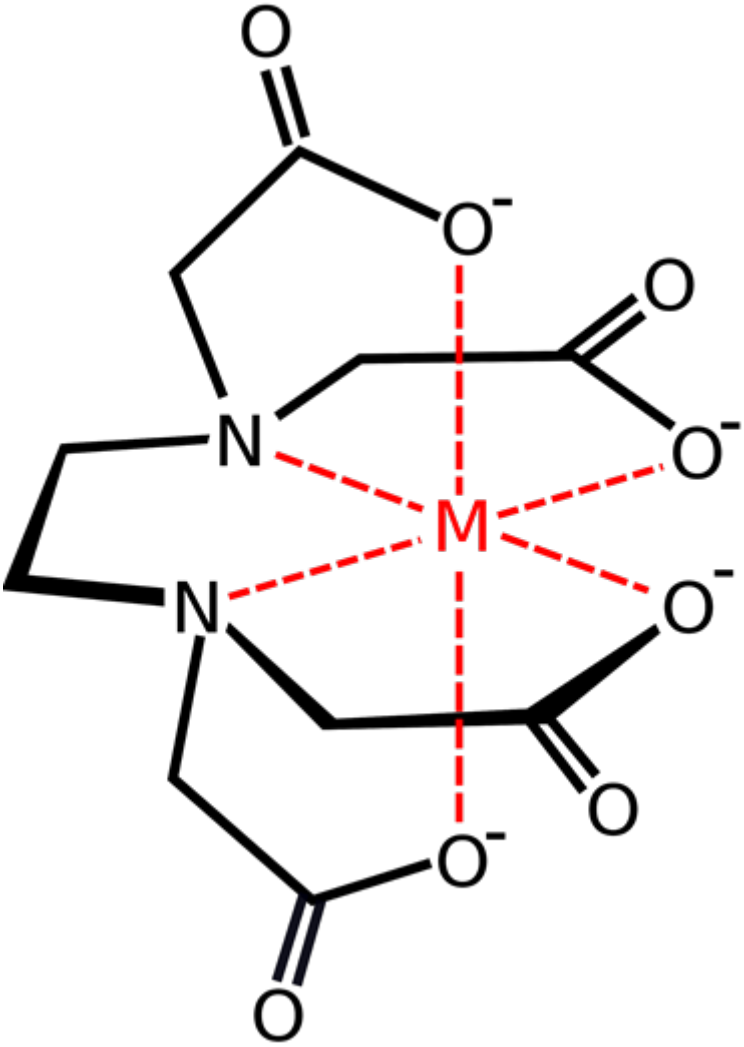
Otherwise, the solution won't be acid enough and MnO_2 will be produced instead of Mn^{2+}.

Remember MnO_4^- *(aq) + 8H*$^+$ *(aq) + 5Fe*$^{2+}$ *(aq) → Mn*$^{2+}$ *(aq) + 4H*$_2$*O (l) + 5Fe*$^{3+}$ *(aq)*

301.	How do indicators work?	-Considered as weak acids. -HA (aq) ■ A^- (aq) + H^+ (aq) -Colour A ■ Colour B -Using Le Chatelier's, if H^+ acid is added, it will shift to the left forming colour A and vice versa for HO^- base. - At end point, equal amounts of HA and A^- so inbetween colour.
302.	What does haemoglobin do and how?	Enables O_2 to be transported in the blood as... 1) O_2 bonds to Fe^{2+} ions (1) 2) O_2 released when required (1)
303.	What is thiosulfate redox titration equation and its color change?	$2S_2O_3^{2-}$ (aq) + I_2 (aq) $\rightarrow$ $2I^-$ (aq) + $S_4O_6^{2-}$ (aq) -By combining $2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$ and $I_2 + 2e^- \rightarrow 2I^-$. Left is yellow/brown solution. Right is colourless. *Iodine is brown in solution. Since both then become ions, it becomes colourless.*
304.	What is the key idea behind the 'Boltzmann Distribution'?	Particles gain or lose energy in collisions with others and thus travel at different speeds.
305.	What is a halide?	A binary compound of a halogen.
306.	What is a fuel cell?	A cell where fuel reacts with oxygen to give **electrical** energy/voltage.
307.	Give 2 ways of improving an experiment that uses a gas syringe	1. Let the reaction carry on until the gas syringe has stopped moving. 2. Wait for the gas to cool to room temperature before reading.
308.	Describe both ways of making acidic buffers using examples and comment on how this is similar for basic buffers	1.React a weak acid with a salt of its conjugate base: Since CH_3COOH ■ CH_3COO^- + H^+ and $CH_3COO^-Na^+ \rightarrow CH_3COO^-$ + Na^+, combing the two forms CH_3COOH ■ CH_3COO^- + H^+ of which there is lots of weak acid and ions. 2. React an excess of weak acid with a strong base: So you get $CH_3COOH + NaOH \rightarrow CH_3COO^-Na^+ + H_2O$ where the salt will dissociate and do (1). Similarly, for basic buffers, you can react a weak base with a salt of its conjugate weak acid or react a weak base with a strong acid.

309. What is a multidentate ligand? (with an example)

●Ligands that form several coordinate bonds BY donating (several) lone pairs
●Examples include: $EDTA^{4-}$ (forming 6 coordinate bonds).

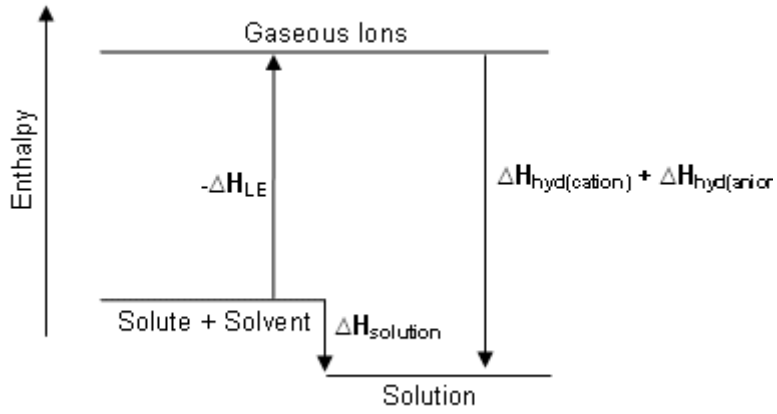


310. Give 5 ways of determining the rate of reactions

1.Use a gas syringe to measure the change in volume of gas.
2.Use a top pan balance to measure the change in mass as gases escapes (works best with a heavy gas like CO_2).
3.Measure the time taken for a precipitate to form.
4.Measure a change in electricity conductivity (works well if ions are released).
5.Use colorimetry to measure absorbance of a wavelength by a chemical. This can be useful in having a different way to confirm a rate.

311. When does a ionic substance generally dissolve?

If the magnitude of hydration enthalpy > magnitude of lattice enthalpy (or hydration enthalpy < lattice enthalpy) so the overall enthalpy change of solution is negative.



See above, the 'aqueous ions' will be lower than the 'ionic lattice'.

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312. How are thiosulfate reactions useful and why?

You can determine the concentration of oxidising agent **SINCE** [O] + $2I^-$ → I_2 and then you can measure the conc. of I_2 by doing a thiosulfate titration. Since $2S_2O_3^{2-}$ (aq) + I_2 (aq) → $2I^-$ (aq) + $S_4O_6^{2-}$ (aq).

---

313. Give the test for halides with a precaution and example equation

1. Add nitric acid to dissolve any carbonates to prevent the formation of Ag_2CO_3 precipitate (aka a false positive which can mask desired observations).
2. Add silver nitrate solution.
3. If the precipitate formed is **white** it's silver **chloride**, if it's **cream** then it's silver **bromide**, and if it's **yellow** then it is silver **iodide**.

Ag^+ (aq) + Br^- (aq) → AgBr (s)

To remember it, learn the halides in alphabetical order **BCI** then the colours in alphabetical order **CWY**.

---

314. How is enthalpy change calculated from calorimetry?

$$\Delta H = \frac{\pm q}{n}$$

The plus or minus depends on whether the reaction was exothermic or endothermic.

---

315. What things should you look out for when proposing mechanisms from overall reactions and rate equations?

1)A catalyst appearing in the rate equation as it will reform later.
2)When the slowest step contains an intermediate (not a reactant). It should be replaced by substances that make up the previous step.
- E.g.,

Example 2

<u>overall reaction</u>

$A + 2B + C \rightarrow D + E$

<u>Mechanism</u>

Step 1	$A + B \rightarrow X + D$	fast
Step 2	$X + C \rightarrow Y$	slow
Step 3	$Y + B \rightarrow E$	fast

$r = k\,[X]^1[C]^1$

The intermediate X is not one of the reactants so must be replaced with the substances that make up the intermediate in a previous step

$A + B \rightarrow X + D$

$r = k[A]^1[B]^1[C]^1$

Example 4

Using the rate equation rate = $k[NO]^2[H_2]$ and the overall equation $2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$, the following three-step mechanism for the reaction was suggested. X and Y are intermediate species.

Step 1 $NO + NO \rightarrow X$
Step 2 $X + H_2 \rightarrow Y$
Step 3 $Y + H_2 \rightarrow N_2 + 2H_2O$

Which one of the three steps is the rate-determining step?

Step 2 – as H_2 appears in rate equation and combination of step 1 and 2 is the ratio that appears in the rate equation.

You need both to be able to propose the mechanism.

---

316. Give 3 examples of giant covalent molecules

- Diamond.
- Graphite.
- Silicon dioxide (SiO_2).

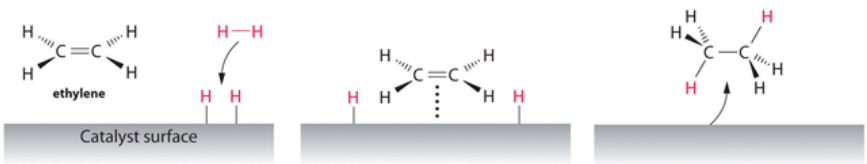
---

317. Describe what occurs on the surface of the nickel catalyst (hetrogeneous catalyst) in the hydrogenation of ethene

1. The reactants (H_2 and C_2H_4) are **ADSORBED** onto the catalyst surface.
2. The bonds weaken (1) and they react to form C_2H_6.
3. The product (C_2H_6) is **DESORBED** from the surface.

Thus…

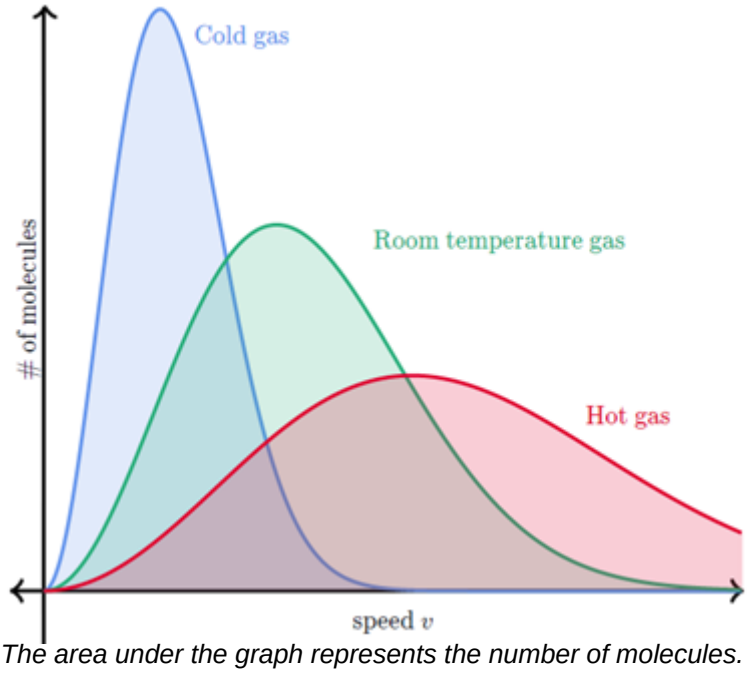
$C_2H_4 + H_2 \rightarrow C_2H_6$.



318.	What happens to the equilibrium constant or position if a catalyst is present and why?	- **NO CHANGE** is made to equilibrium position or constant. - Catalyst increases rate of forward and reverse reactions by **SAME** factor. - Equilibrium reached in less time.
319.	What is K_P and why do we use it?	- An equilibrium constant calculated from partial pressures. - As it's difficult to get concentrations for gases. E.g., $H_{2\,(g)} + I_{2\,(g)}$ ■ 2HI (g) so $K_P = p(HI)^2 / p(H_2)p(I_2)$.
320.	What is the manganate redox titration equation and its color change?	-MnO_4^- (aq) + $8H^+$ (aq) + $5Fe^{2+}$ (aq) → Mn^{2+} (aq) + $4H_2O$ (l) + $5Fe^{3+}$ (aq) -From purple to colourless. -As MnO_4^- is purple and Mn^{2+} is colourless.
321.	What 3 assumptions are made during a clock reaction?	1. The concentration of reactant doesn't change significantly over the timescale. 2. Constant temperature. 3. When the endpoint is observed, the reaction has not proceeded too far. This allows us to assume a constant rate.
322.	What is a homogeneous catalyst and its benefits and drawbacks?	A catalyst in the same phase/state as the reactants. + It means more molecules can react. - It makes separating molecules at the end harder.
323.	How are buffers used in the body?	-To keep the pH of the blood between 7.35 and 7.45. -An equilibrium exists between H_2CO_3 (carbonic acid) and HCO_3^- (hydrogen carbonate). -The amount of H_2CO_3 is controlled by respiration: H_2CO_3 ■ $H_2O + CO_2$
324.	Why is cisplatin used as an anticancer drug? What are its drawbacks?	●Prevents replication of of cancer cells by binding to the DNA. ●Can prevent replication of healthy cells (∴ suppresses immune system).

325. What does the 'Boltzmann Distribution' look like at different temperatures and why?

Increasing the temperature shifts the distribution towards more particles having higher energies (more than any E_A) **AND** wider range of energies due to more frequent collisions.



The area under the graph represents the number of molecules.
The x-axis is also energy / kinetic energy of the molecules.

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326. Derive the ionic product equation of water and when is it true

The following equilibrium is true for all (aq) substances and pure water:
H_2O (l) ■ H^+ (aq) + HO^- (aq)

$$K_c = \frac{[H^+][HO^-]}{[H_2O]}$$

$$K_c \cdot [H_2O] = [H^+][HO^-]$$

$$K_w = [H^+][HO^-]$$

Since the $[H_2O] >> [H^+]$, we can treat it as constant to form a new constant.

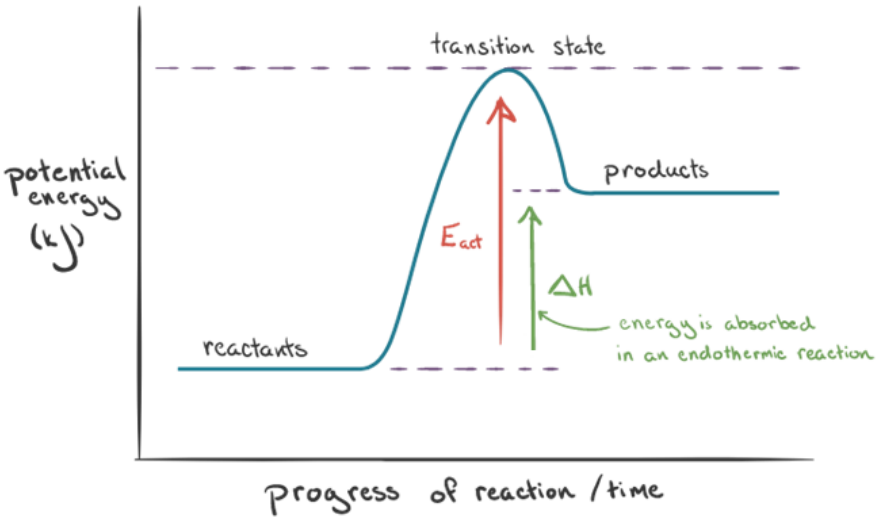
---

327. How does chlorine react with water? What type of reaction is this?

- Cl_2 (g) + H_2O (l) → HCl (aq) + HClO (aq)
- This is a disproportion reaction.

---

328. Draw and label the energy profile diagram for an endothermic reaction



ΔH is positive as energy is **EN**tering the system from the surroundings and thus **EN**dothermic. Taking up to be the positive direction, we have the arrow pointing downwards.

---

329. Which is more acidic and why, CH_3COCl or CH_3COOH?

CH_3COCl as it will form HCl in water.

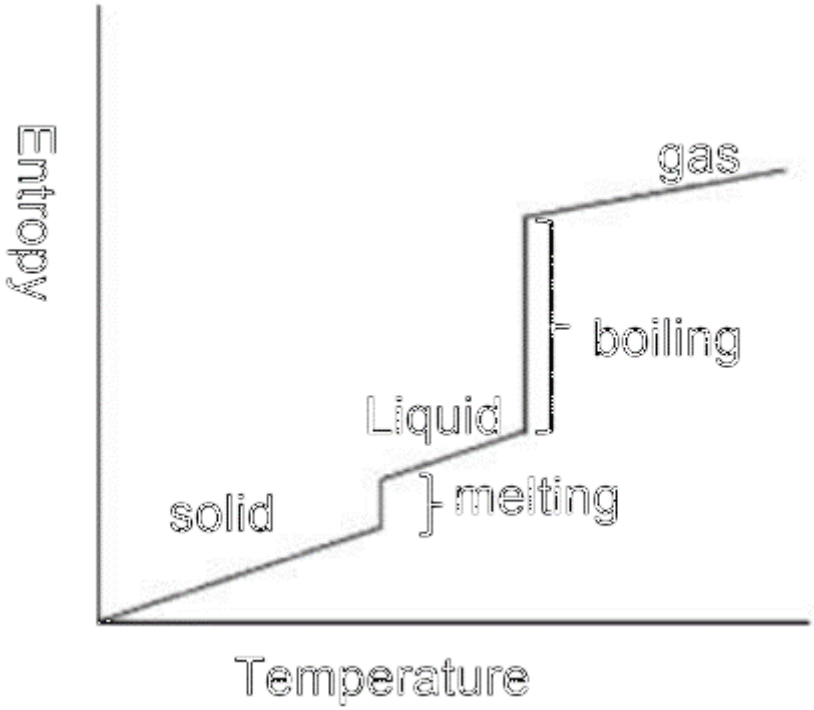
---

330. How should you choose an indicator for a titration appropriately?

Make sure the equivalence point lies within the colour change range.

---

331. Draw the entropy v. temperature graph



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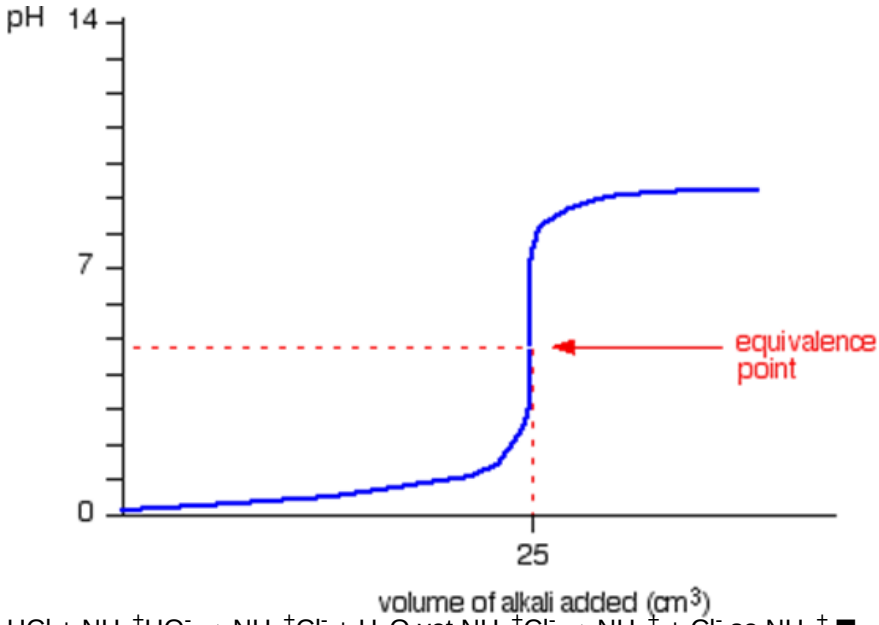
332. Draw the titration curve for a strong-acid weak-base titration with the equivalence point and explain it using...
$HCl + NH_4^+HO^- \rightarrow NH_4^+Cl^- + H_2O$



$HCl + NH_4^+HO^- \rightarrow NH_4^+Cl^- + H_2O$ yet $NH_4^+Cl^- \rightarrow NH_4^+ + Cl^-$ so NH_4^+ ■ $NH_3 + H^+$ where the H^+ makes the solution slightly acidic.

---

333. What acid should be used for manganate redox titrations? Why?

Dilute sulphuric acid ■ other acid can set up alternative redox reactions (leading to inaccurate titres).

---

334. Why is boron ($1s^22s^22p^1$)'s first ionisation energy less than beryllium ($1s^22s^2$)'s?

p-orbital e^- has a higher energy than the s-orbital e^- ∴ easier to remove. *It's all about a new factor now having an effect when compared to the previous element.*

---

335. What is dynamic equilibrium and what does this mean in terms of concentration?

- When the forward and backward reactions are occurring at the same rates.
- Thus, the concentrations stay constant. Yet, the amounts of each may differ.

---

336. How do you calculate pH and pKa?

$$pH = -\log[H^+]$$

$$pK_a = -\log[K_a]$$

Using pKa allows for an easier comparison.

---

337. What does a buffer solution do?

Minimise pH changes (1) when **SMALL** amounts of acid or base is added (1)

---

338. What does enthalpy change of solution tell you about solubility and why?

The more negative/exothermic the more soluble ■ bond making is exothermic and bonds are made when water molecules bond to ions.

339. When is a substance thermodynamically stable?

When it reaches its maximum entropy state (lowest energy state).

340. How are electrode potentials represented? (with sign)

-Li^+ (aq) | L (s) **OR** Li^+ (aq) + e^- ■ Li (s)
-Oxidation **ALWAYS** going right to left.
-Negative ⇒ favours oxidation (**LOSS**) ⇒ negative electrode potential.

$$Mg^{2+}\ (aq) + 2e^- \rightarrow Mg(s) \quad E = -2.37V$$
$$Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s) \quad E = +0.34V$$

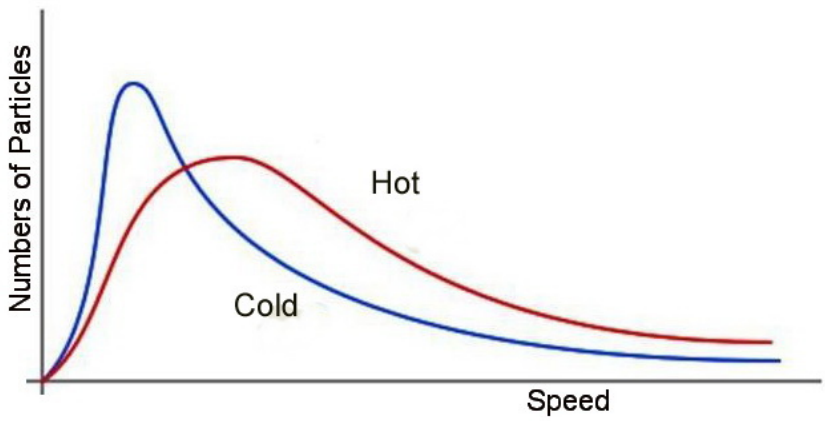
341. Give the colours and states of the first 4 halogens at room temperature

Name	Colour	State
F_2	Pale yellow	Gas
Cl_2	Green	Gas
Br_2	Red-brown (like bromine water)	Liquid
I_2	Grey	Solid

You Guys Read Gore.
YELLOW GREEN RED GREY (down the group).

342. Give the key features of the 'Boltzmann Distribution'

-It starts at the origin because no particles have no energy.
-The peak (E_{mp}) is the most probable energy (which is different from the mean).
-It never meets the x-axis as there is no maximum energy for particles.



The x-axis can also be (kinetic) energy.

343. What method should you use for K_C questions?

- Initial moles.
- Change in moles.
- Equilibrium moles.

344. What does the emf of a cell represent in electrode potentials?

How far from equilibrium the cell lies (the more positive, the more likely the reaction is to occur).

---

345. How does temperature affect cell emf?

Most cells are exothermic in the forwards direction. Using Le Chatelier's, increasing temperature decreases emf.

---

346. What would happen if water was added to the Cu^{2+}/Cu half-cell in the following redox system?

Redox system	$E^{\ominus}$/V
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80

The cell potential increases (1) since...
- $[Cu^{2+}]$ decreases so equilibrium shifts left (1)
- More electrons released by Cu (1)
- Cell have bigger difference in E^O (1).

This is from F325 June 2014 (7bii).

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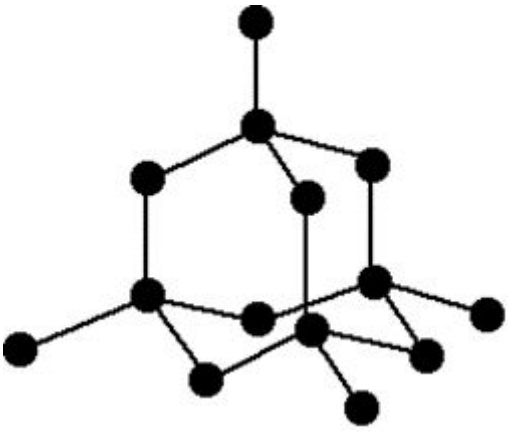
347. What shape do group 4 elements form?

Tetrahedral.



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348. Why does the reactivity increase down group 2?

First ionisation energy decreases ⇒ less energy required to remove the outermost electron.

---

349. Why should you not use certain acids when performing qualitative analysis?

- As the acid releases the ions you're testing into the solution so you will **OBVIOUSLY** get a positive test for follow-up tests.
- Only use these if you plan to perform **ONE TEST / NO FOLLOW-UP TESTS**.

If you use HCl or H_2SO_4 then you will obviously get a positive test for Cl_2 and SO_4 respectively. This is why we use $AgNO_3$.

---

350. How does surface area affect the rate of reaction?

Increasing surface area ⇒ more sites are exposed (1) ⇒ more frequent successful collisions (1) ⇒ increased rate of reaction (1).

---

351. What are the 2 types of equilibria?

- Homogeneous - reactants and products are in the same physical states.
- Heterogeneous - reactants and products are in different physical states.

---

352. How do the K_C and K_P expressions change for heterogeneous equilibria?

Only gases and aqueous reactants/products are used.
E.g., $Cu_{(s)} + 2Ag^+_{(aq)}$ ■ $Cu^{2+}_{(aq)} + 2Ag_{(s)}$ so $K_C = [Cu^{2+}] / [Ag^+]^2$.

353. What is a Bronsted-Lowry acid/base? (use equations)

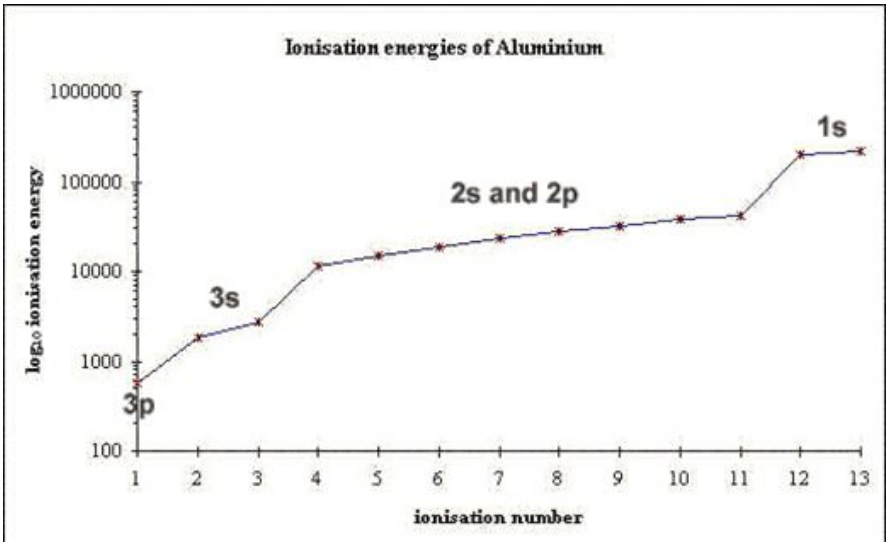
-A substance that **DONATES** or **ACCEPTS** a proton respectively.
-Acid (A): $H_2O + HA$ ■ $H_3O^+ + A^-$
-Base (B): $B + H_2O$ ■ $BH^+ + HO^-$
The H_3O^+ is called the hydronium ion but it is usually ignored / written as H^+.
It's donates, not releases.

354. What will the stronger oxidising agent have in terms of E^O? Why?

It will have a higher E^O as it is a measure of how well a species gains e^-'s which an oxidising agent does as its reduced.

355. Why are there sharp and slight increases in successive ionisation energies?

- Slight increases ■ removing an electron ⇒ smaller atomic radius (■ less repulsion between subshells) ⇒ stronger attraction which requires more energy to overcome.
- Sharp increase ■ less shielding and smaller atomic radius ⇒ stronger attraction which requires more energy to overcome.



356. What is the equation for the equilibrium constant (K_c)?

aA + bB ■ cC + dD

$$K_c = \frac{[C]^c\,[D]^d}{[A]^a\,[B]^b}$$

357. What should be ensured when continually monitoring [A] and why? (in rates of reaction)

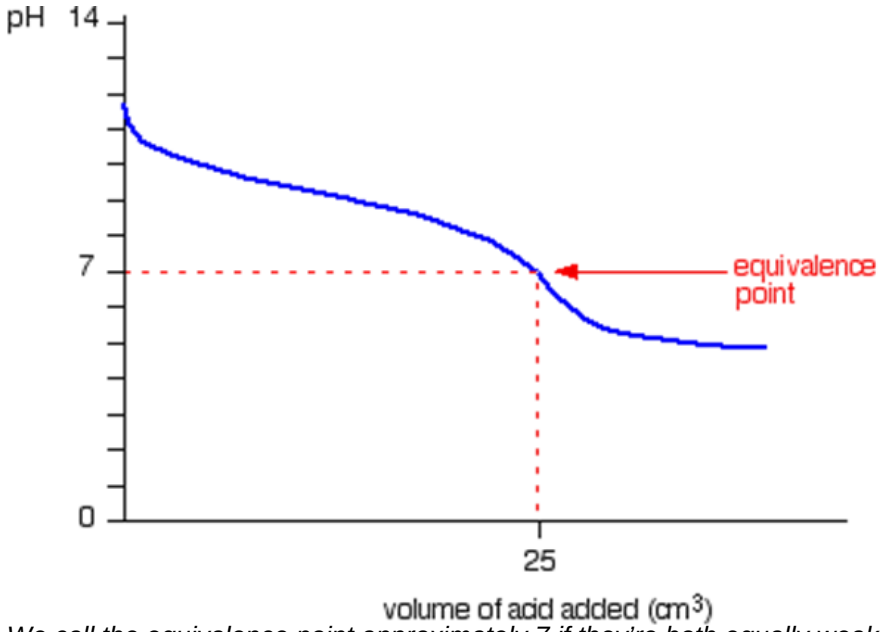
Having a large excess of everything else so their conc. is effectively constant ∴ its conc. won't change much during the reaction ∴ won't affect the reaction.

358. Why isn't a wire used as the 'salt bridge'?

It would set up its own electrode system with solutions.

359.	Why aren't zinc and scandium transition elements?	Zinc can only form 2+ ion which has a **COMPLETE** d-subshell. ●Zn has [Ar] $3d^{10}4s^2$ whereas Zn^{2+} has [Ar] $3d^{10}4s^0$. Scandium can only form 3+ ions which has an **EMPTY** d-subshell. ●Sc has [Ar] $3d^14s^2$ whereas Sc^{3+} has [Ar] $3d^04s^0$.
360.	How are group 2 compounds used in farming?	- To neutralise acidic soils. - E.g., CaO, $Ca(OH)_2$, or $CaCO_3$.
361.	What is the only thing that can affect K_C and K_P and why not the others?	- **Temperature**. - Changing the concentration/pressure of a substance won't have an effect as the system restores equilibrium so it's the **SAME**.
362.	What can lattice enthalpy be used as a measure of?	Ionic bond strength.
363.	How do hydrogen fuel cells maintain a constant voltage?	They are continuously fed fresh O_2 and H_2 thus maintaining concentration of reactants.
364.	What is activation energy defined as?	The minimum energy required of particles to collide to start a reaction.
365.	Describe the following general rate equation: $r = k[A]^m[B]^n$	-Based on the reaction… aA + bB → products. -Unit of **r** (rate) is $moldm^{-3}s^{-1}$, unit of [A] and [B] (conc. of A and B) are $moldm^{-3}$, and unit of k (rate constant) varies. -The rate constant is **ONLY** dependent on temperature (i.e., it increases with temperatures). -The values m and n are called reaction orders and have nothing to do with the stoichiometric coefficients in the balanced equations. **They are worked out experimentally and can be 0, 1, or 2**. -The overall order is m + n.
366.	What is the equivalence point of a titration?	When there are equal moles of acid and base.

367. Draw the graph of a weak-acid weak-base titration



We call the equivalence point approximately 7 if they're both equally weak.

368. How are electrode potentials used to determine whether a reaction occurs? What's wrong with this?

-If the E_{cell} is positive, the reaction may occur.
Yet...
-The rate may be so slow that it appears not to be happening.
-The reaction has a high activation energy.

369. How can you use TLC to monitor the course of a reaction?

By taking samples at regular intervals.

370. Define first ionisation energy

Energy required to remove an electron from each atom (1) in one mole of gaseous atoms (1).

371. Give a group 2 compound used in medicine, how it's used, and why it's used

- $Mg(OH)_2$ (milk of magnesia) is used to neutralise excess stomach acid ■ not too strong an alkaline.
- E.g., $Mg(OH)_2$ (aq) + 2HCl (aq) → Mg_2Cl_2 (aq) + H_2O (l).

372. What is disproportionation and what can it happen with?

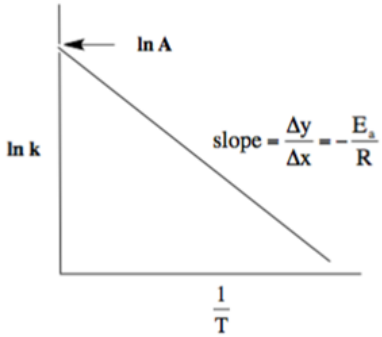
- A reaction where same element is both oxidised and reduced.
- Any halogen (except fluorine ■ very powerful oxidising agent).

373. What do catalysts do?

Provide an alternate reaction pathway with a lower activation energy without being used up.

374. What is the Arrhenius Plot, what can it be used to find, and what does it use?

Arrhenius equation: $k = Ae^{-E_a/RT}$ or $\ln k = -E_a/RT + \ln A$



$$k = Ae^{-Ea/RT}$$

$$\ln k = \ln(Ae^{-Ea/RT})$$

$$\ln k = \ln A + \ln e^{-Ea/RT}$$

$$\ln k = \ln A + \frac{-Ea}{RT}$$

Plot-Wise Approach $\left\{ \boxed{\ln k = \left(\frac{-E_a}{R}\right)\cdot\left(\frac{1}{T}\right) + \ln A} \right.$

Used to determine the pre-exponential factor and activation energy using a set of temperatures and rate constants.

---

375. How do you work out the electrode potential of a cell **NUMERICALLY**?

$-E_{cell} = E_{red} - E_{ox}$
-The more positive - less positive since more positive half-cell will always reduce (gain electrons).

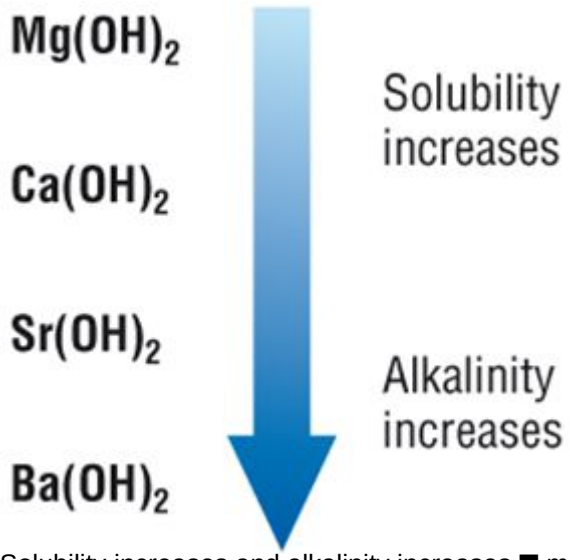
---

376. Describe the 3 observations of a group 2 element in acid and how they vary with reactivity

1. Fizzing. More vigorous, further down.
2. Metal (ribbon) dissolving. Faster, further down.
3. Solution heating. More heat, further down.

---

377. What changes for group 2 hydroxides down the group and why?



Solubility increases and alkalinity increases ■ more HO^- ions are released ∴ higher pH.

378. How will Br_2 and I_2 appear when in cyclohexane compared to water?

-Br_2 is orange in both.
-I_2 is brown in water (solution) and violet in cyclohexane.

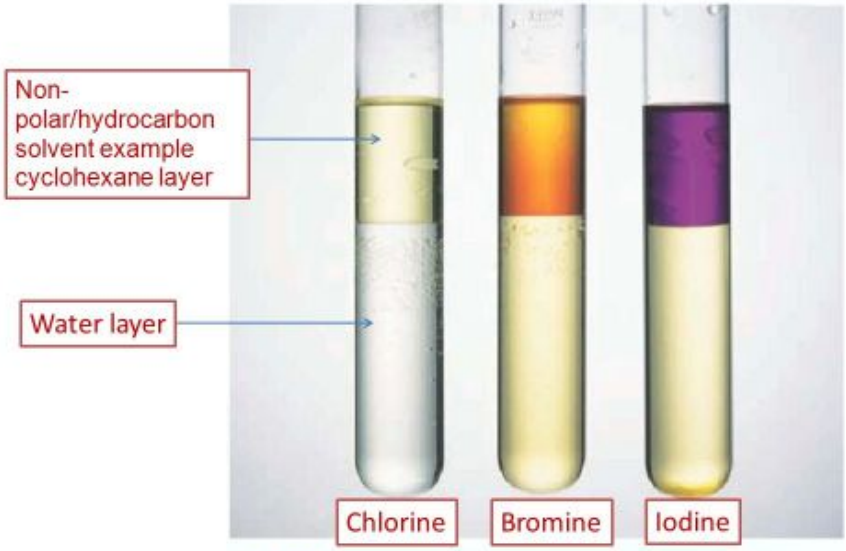


fig. 2.5.13 Halogens are more soluble in organic solvents such as cyclohexane than in water.

Br_2 being orange can be remembered by bromine water being orange.

---

379. Give 1 pro and 1 con of adding Cl_2 to water

+ It kills bacteria (1).
- It could form chlorinated hydrocarbons which are toxic/carcinogenic (1).

---

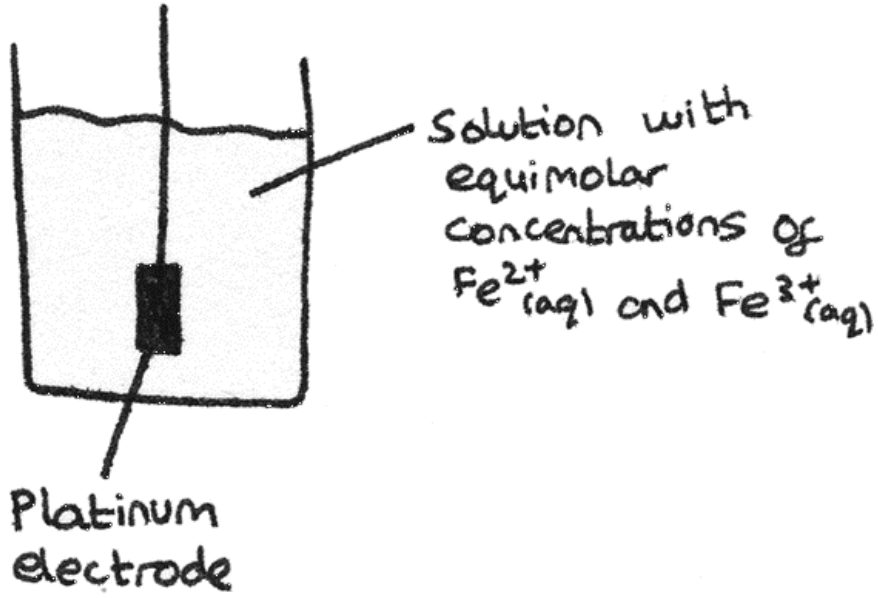
380. In what 2 ways is the ionic product of water used?

1.To work out the pH of water since, for pure water, $[H^+] = [HO^-]$.
2.To convert between the $[H^+]$ or $[HO^-]$ for a dissolved substance.
Good for working out the $[H^+]$ ions in strong alkalis.

---

381. When is a inert platinum electrode used in electrode potentials and why? (with example)

-When there is no metal surface for the reaction to take place on. This transfers e^-'s into or out of the cell.
-Fe^{3+} (aq) + e^- ■ Fe^{2+} (aq)



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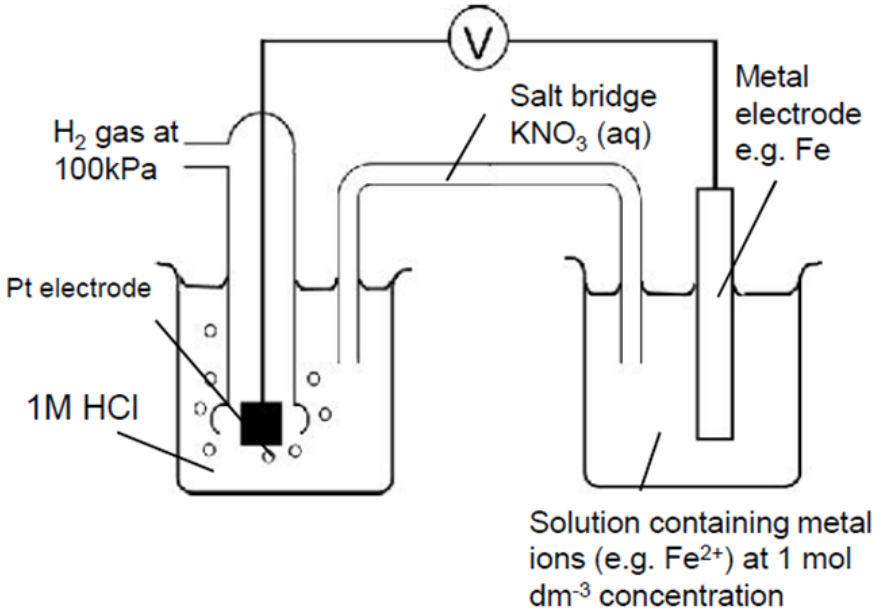
382. What is the standard hydrogen electrode, its equation and its conditions?

-A half-cell using hydrogen.
-Has the following equilibrium: H_2 (g) ■ $2H^+$ (aq) + $2e^-$
-Has the following conditions:
H_2 (g) @ 1 atm.
Solution containing H^+ ions @ 1 M (usually HCl).
Temperature @ 298K.



383. How does concentration of reactants affect cell emf?

By Le Chatelier's, increasing [reactants] increases emf.

384. What is a complex ion?

A central transition metal ion surrounded by ligands.

385. What is coordination number?

The number of coordinate bonds formed to a central metal ions.
This won't always equal the number of ligands.

386. When does a precipitation reaction occur (with an example)?

- When cations and anions in aqueous solution combine to form an insoluble ionic solid.
- Eg,
$Ag^+ + Cl^- \rightarrow AgCl$
$Ni^{2+} + 2HO^- \rightarrow Ni(OH)_2$

387. What is rate of reaction?

The change in concentration of a substance per unit time.
This is used for consistency as it's better than say change in mass per unit time.

388. How is entropy change (ΔS^O) calculated? What is it measured in? And what does it being +ve and -ve mean?

●$\Delta S^O = \Sigma S^O_{products} - \Sigma S^O_{reactants}$
●Measured in $JK^{-1}mol^{-1}$
●+ve means increase in disorder/entropy.
●-ve means decrease in disorder/entropy.
S^O alone is the entropy per molecule which is always positive.

389. How are (aq) complex ions written?

●When they contain ligands that aren't water or hydroxide ions, you need to include all water ligands.
●Eg, $[Cu(NH_3)_4(H_2O)_2]^{2+}$ cannot be rewritten whereas $[Cu(OH)_2(H_2O)_4]^{2+}$ can be written as $Cu(OH)_2$.

---

390. Why is oxygen ($1s^2 2s^2 2p^4$)'s first ionisation energy less than nitrogen ($1s^2 2s^2 2p^3$)'s?

Electrons now pair in the same orbital ⇒ repel one another ⇒ easier to remove.

---

391. What is a heterogeneous catalyst and its benefits and drawbacks?

A catalyst in a different phase/state to the reactants.
+ Can be easily separated.
- Reactions only take place on the catalyst's surface.

---

392. What is a closed system?

A container in which nothing cannot enter or leave except for heat.

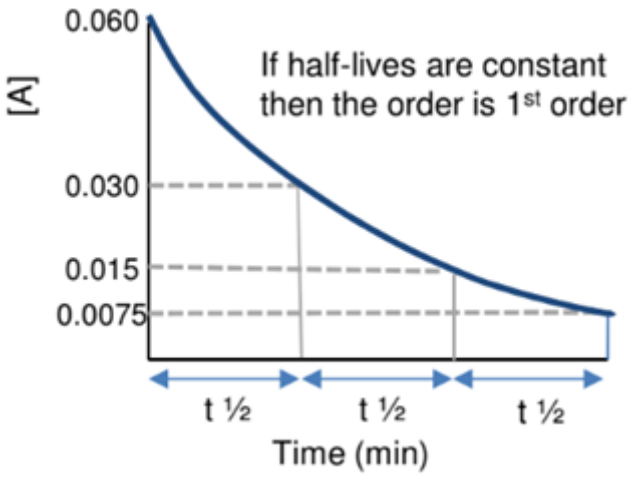
---

393. What is the half-life of a reaction? How can you show a reaction is 1st order? What's the equation?

-Time taken for the conc. of reactants to half.
- By showing the half-life is constant.
-The half-life equation for first order is:

$$t_{1/2} = \frac{\ln 2}{k}$$

-Shown on the graph:



*If the half-life **rapidly** increases then the reaction is second-order. If the half-life decreases then it's zero-order.*

---

394. How do you find acid-base conjugate pairs? What will act as the acid?

Look forwards and backwards for substances that differ by H^+.

$$\underset{\text{Acid 1}}{HCOOH} + \underset{\text{Base 2}}{CH_3(CH_2)_2COOH} \rightleftharpoons \underset{\text{Base 1}}{HCOO^-} + \underset{\text{Acid 2}}{CH_3(CH_2)_2COOH_2^+}$$

$$\underset{\text{Acid 1}}{HNO_3} + \underset{\text{Base 2}}{HNO_2} \rightleftharpoons \underset{\text{Base 1}}{NO_3^-} + \underset{\text{Acid 2}}{H_2NO_2^+}$$

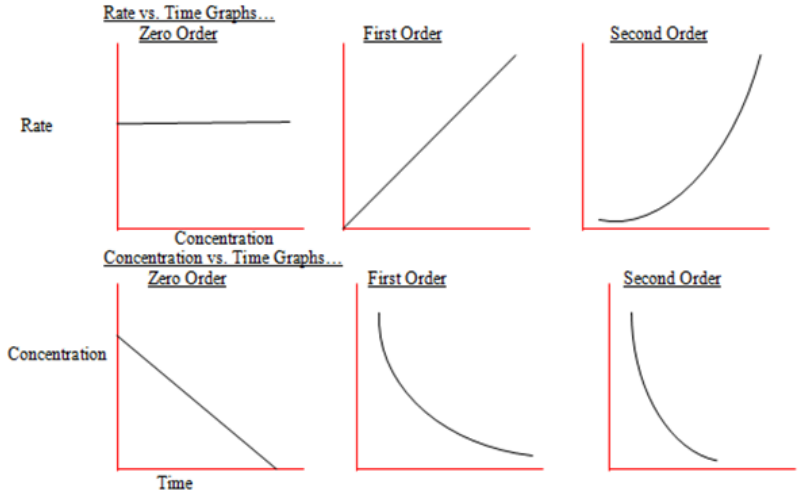
The substances with a bigger K_a will act as the acid.

395. Why are metals malleable?

Layers of cations can slide over each other easily.

396. What are the 3 orders of reaction with their associated rate-concentration and concentration-time graphs of the reactant(s)?

-Zero-order reaction - rate is independent of concentration.
-First-order reaction - rate $\propto$ conc.
-Second-order rate - rate $\propto$ $conc^x$ (by some factor).



The concentration-time graph for a second-order reaction isn't required.

397. What is a metallic bond?

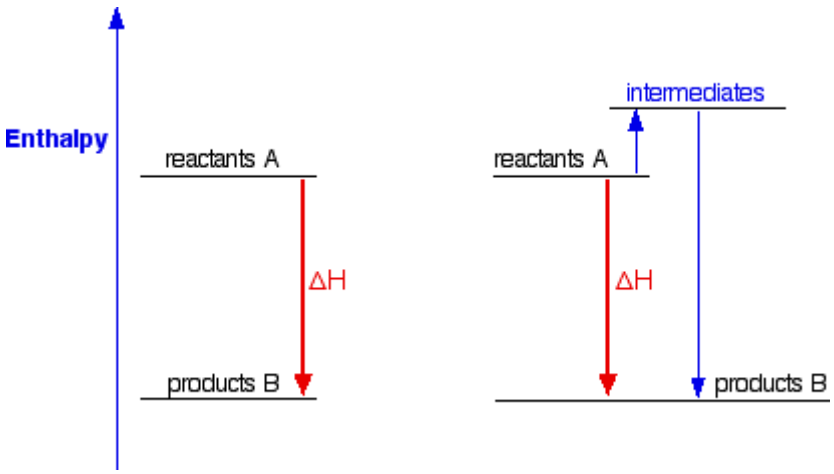
Strong electrostatic force of attraction (1) between cations and delocalised electrons (1).

398. How can you be certain of the result of the halide test?

1. Add ammonia solution.
2. Silver **chloride** dissolves under dilute solution. Silver **bromide** dissolves under concentrated solution. Silver **iodide** will not dissolve at all.

399. What does Hess' Law state?

The enthalpy change of reaction is independent of the route taken.



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400. How does concentration affect the rate of reaction?

Increasing concentration ⇒ more particles per unit volume (1) ⇒ more frequent successful collisions (1) ⇒ increased rate of reaction (1).
If the question explicitly says double concentration, say double particles and thus double frequency of successful collisions.

---

401. What is different about the meniscus in a manganate redox titration?

The purple colour of the manganate can make it hard to see the bottom of the meniscus ⇒ measure from top of meniscus.

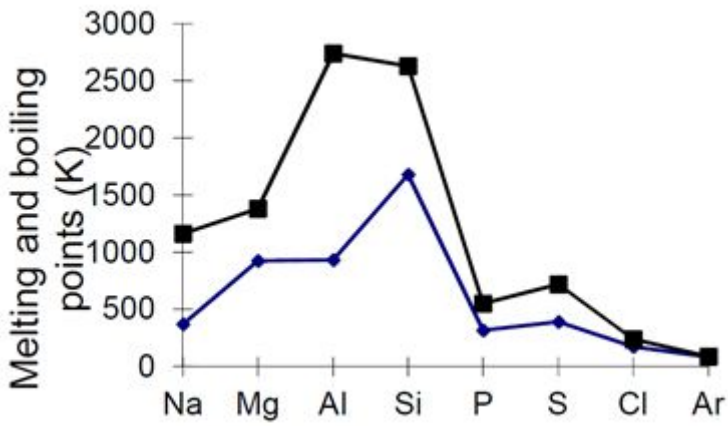
---

402. What is decomposition (with an example equation)?

- The separation of a single compound into two or more elements/compounds.
- $2ClO_2 \rightarrow Cl_2 + 2O_2$.

---

403. Why do P_4 and S_8 have high boiling and melting points?



They have more electrons ∴ more London forces which require more energy to overcome.

---

404. Breaking bonds is **[...]** because **[...]**.

Breaking bonds is **endothermic** because **energy is put into the system**.
Atoms become less stable as they have no bonds and lots of energy.

---

405. What is periodicity?

A repeating pattern across different periods.

---

406. What happens to the equilibrium position if the temperature is increased and why?

- Favours the endothermic side.
- To minimise the effect of temperature rise by absorbing heat.

---

407. What are mole fractions and partial pressures? How do they relate?

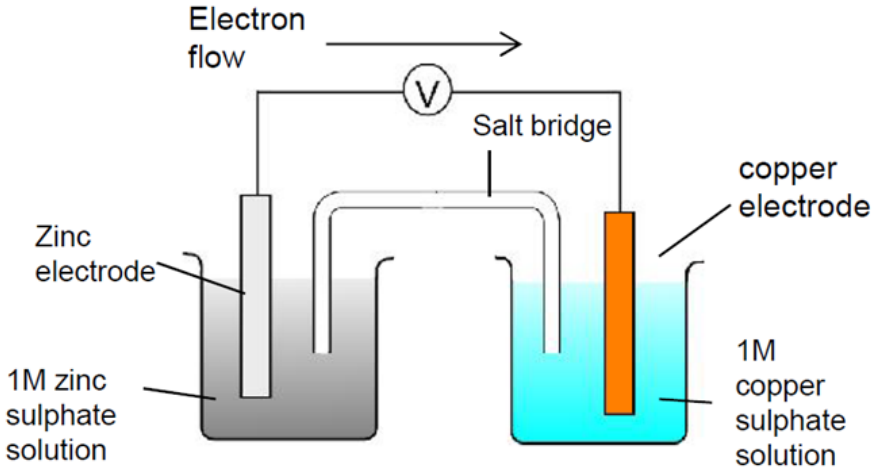
- Mole fraction of A - fraction of the total number of moles.
- Partial pressure of A - the pressure of A if it alone occupied the same volume vessel alone
- $p(A) = x_A \cdot P_{tot}$

This means the total pressure is the sum of the partial pressures.

---

408. Why do half-cells produce a voltage (using an example)?

The zinc half-cell has a tendency to oxidise / release e^-'s and copper half-cell has tendency to reduce / gain e^-'s leading to electrons flowing.



Thus…

-$Zn\ (s) \rightarrow Zn^{2+} + 2e^-$

-$Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)$

This is measured using a high-resistance voltmeter to stop current from flowing whilst preventing a significant reaction. If this was replaced with a bulb, current will flow. Reactions will then occur at each electrode yet the voltage would fall to zero as the reactants are used up.

---

409. How may the Standard Hydrogen Electrode (SHE) be used indirectly and why?

By using a different standard electrode (which is calibrated against the SHE) since it's easier to use.

---

410. How can the weak acids be quantified? What assumptions are made in doing so?

Weak acids form an equilibrium mixture: HA ■ $H^+ + A^-$.

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

1.We can assume $[H^+] = [A^-]$ so all the H^+ ions come from the dissociation of the acid and not the water.
2.The dissociation is so small that $[HA]_{initial} = [HA]_{eqm}$.
The first assumption doesn't work for buffers whilst the second doesn't work for 'stronger' weak acids.

---

411. How can you work out reaction orders using experimental initial rate data?

Experiment	Initial concentration of X/ mol dm^{-3}	Initial concentration of Y/ mol dm^{-3}	Initial rate/ mol dm^{-3} s^{-1}
1	0.05	0.1	0.15 x 10^{-6}
2	0.10	0.1	0.30 x 10^{-6}
3	0.20	0.2	2.40 x 10^{-6}

1.You have some equation $r = [X]^a[Y]^b$. Comparing (1) and (2), the order of reaction w.r.t. [X] is 1 (as initial rate doubles when initial conc. doubles).
2.Comparing (2) and (3), both X and Y double whilst the initial rate increases x 8. Know [X] is order 1 so Y doubling increases initial rate x 4 ∴ order 2.
Say you have $r = k[A][B]^2$. The effect of individual changes in conc. are multiplied. E.g., if [A] x 2 and [B] x 3 then initial rate x 18

---

412. Describe the salt bridge used in electrochemical cells (structure and reason)

-Usually filter paper soaked in salt solution (eg, KNO_3).
-Allows ions to move preventing imbalance (which would otherwise repel incoming metals).
The salt should be unreactive. Eg, KCl will form complexes instead.

---

413. What is a transition element?

A d-block element with at least one ion with an incomplete d-orbital / d-subshell.
Eg, Cu has [Ar] $3d^{10}4s^1$ where Cu^{2+} has [Ar] $3d^9 4s^0$.

---

414. Give 2 reasons for why graphite is soft

- Layers can easily slide of each other.
- Weak London forces.

---

415. Why must experiments with halogens be done in a well-ventilated area?

They're powerful oxidising agents ∴ toxic.

416. What is a spontaneous process?

A process that proceeds on its own without external influence (so no continuous energy supply).
Eg, diffusion.

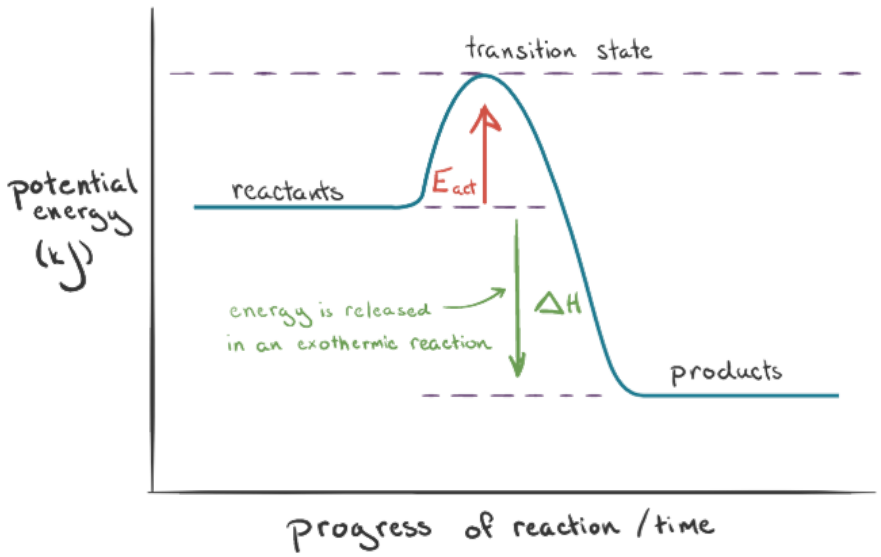
---

417. Why do transition elements make good catalysts?

They can change oxidation states by gaining/losing e^-'s ⇒ can transfer e^-'s to speed up reactions.

---

418. Draw and label the energy profile diagram for an exothermic reaction



ΔH is negative as energy is **EX**iting the system to surroundings and thus **EX**othermic. Taking up to be the positive direction, we have the arrow pointing downwards.

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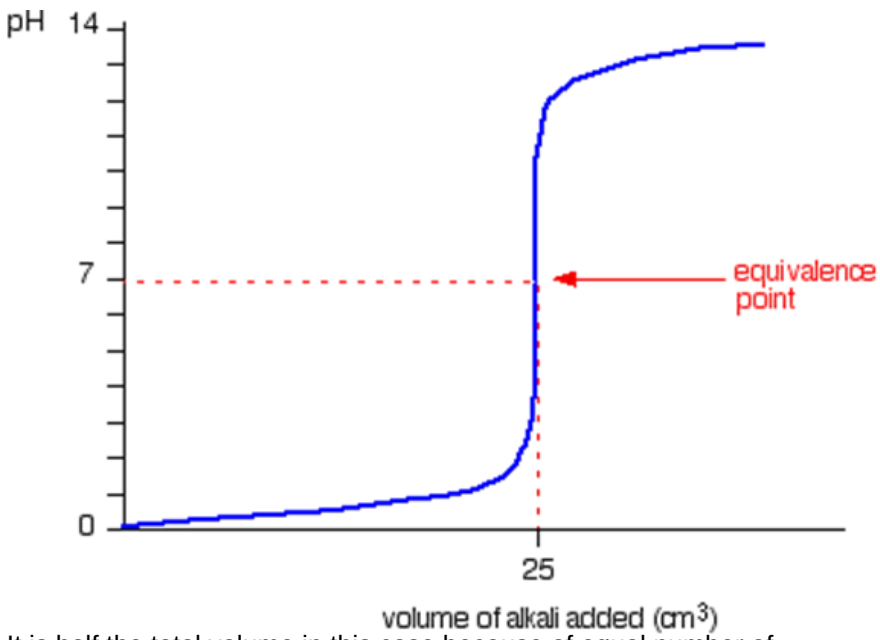
419. Draw the graph of a strong-acid strong-base titration (with equivalence point)



It is half the total volume in this case because of equal number of hydrogen and hydroxide ions from monoprotic acids and base.

---

420. Which ligands are similar in size and which are different? What does this mean?

●H_2O, HO^-, NH_3 and CN^- are **SIMILAR** in size so coordinate number doesn't change under ligand substitution.
● H_2O and Cl^- are **DIFFERENT** in size (ie, Cl^- is larger) so coordination number and shape changes under ligand substitution.

---

421. What is the Gibbs free energy equation? What are the outcomes?

$\Delta G = \Delta H - T\Delta S$
$\Delta G < 0 \Rightarrow$ feasible (more negative $\Rightarrow$ more feasible).
$\Delta G = 0 \Rightarrow$ equilibrium (this is similar for a puddle in equilibrium).
$\Delta G > 0 \Rightarrow$ not feasible.
Note that ΔS can be in $JK^{-1}mol^{-1}$ rather than $kJK^{-1}mol^{-1}$.

---

422. How can **SIMPLE** half-equations be combined?

$Br_2 + 2e^- \rightarrow 2Br^-$
$2I^- \rightarrow I_2 + 2e^-$
These can be combined by adding them such that the electrons on either side cancel.

---

423. What changes for group 2 carbonates down the group?

Ease of thermal decomposition decreases.

---

424. What 2 things are required of particles to react?

- Minimum kinetic energy (i.e., activation energy).
- Correct orientation.

---

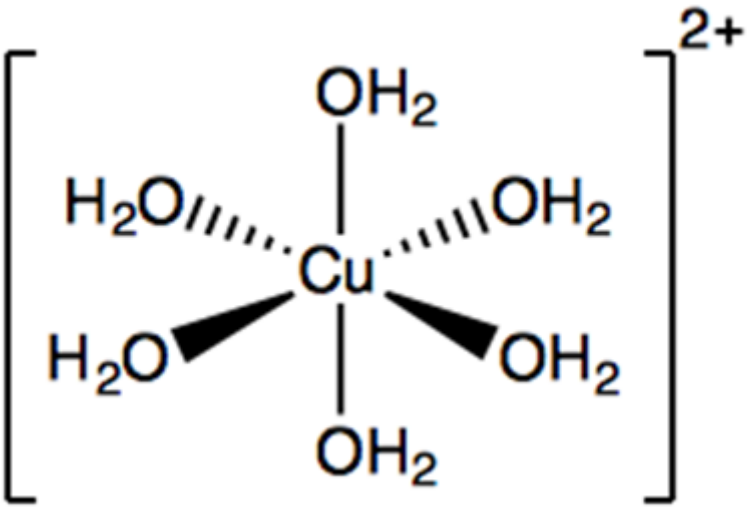
425. Which indicator is required for a weak-acid weak-base titration?

None as they won't work as there's no sharp pH change.

---

426. What is a monodentate ligand? (with examples of both ligands and complex ions)

●Ligands that form 1 dative/coordinate bond by donating 1 lone pair.
●Examples include: H_2O, NH_3 and Cl^-.
●One is used as shown below:



In this case, the water ligands have no charge so the charge stays as 2+ from Cu^{2+}.

---

427. What method should you use for K_P questions?

ICE followed by X_A P_A.

428. How can Gibbs free energy be plotted? What does the gradient tell you?

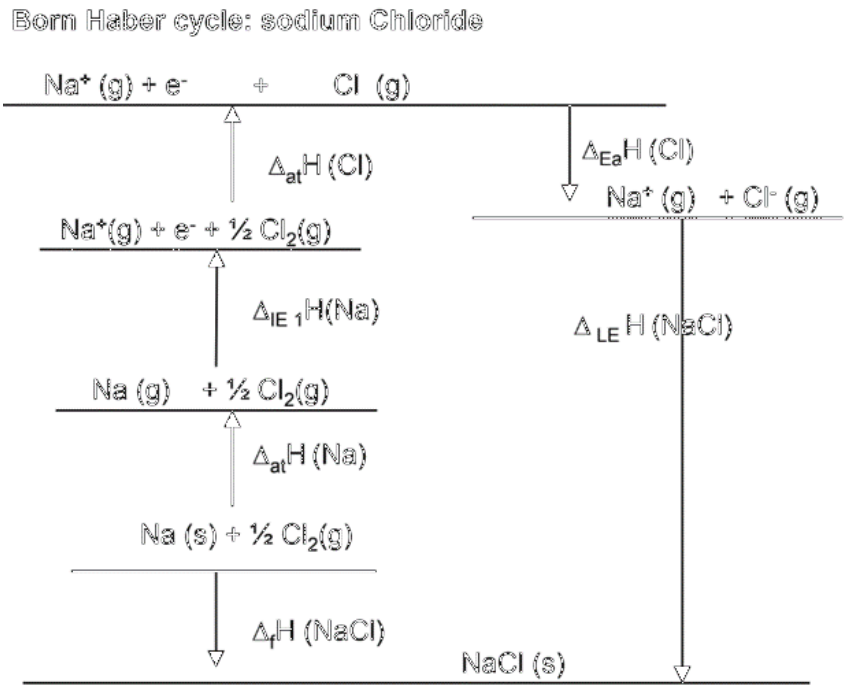
-Plot the ΔG v T of $\Delta G = \Delta H - T\Delta S$ as y = mx + c.
-The gradient tells you the entropy change.
You can see when a reaction becomes feasible under this.

429. Making bonds is **[...]** because **[...]**.

Making bonds is **exothermic** because **energy is released to the surroundings**.
Despite the little energy needed to make a bond, the molecule becomes more stable when bonded and thus releases energy.

430. What are the key points / features of a Born-Haber cycle?

-Downwards arrows - exothermic. Upwards arrows - endothermic.
-May have to double or triple numbers occasionally.



Consider directions carefully - much like vector addition.

431. What is entropy?

A measure of the dispersal of energy in a system **OR** how disordered something is.

432. How are the atoms ionised for use in mass spectrometry?

By firing high energy electrons at them to knock off other electrons.

delete

433. What are the 2 types of errors?

1. Random (eliminated by repeating)
2. Systematic
Delete.

434.	What are ionic equations?	1. **B**alance the equation. 2. **B**reak each (aq) substance into ions. 3. **C**ancel any ions on both sides (these being the spectator ions). Chemical Equation: $NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$ Total Ionic Equation: $\cancel{Na^{+}_{(aq)}} + Cl^{-}_{(aq)} + Ag^{+}_{(aq)} + \cancel{NO_3^{-}{}_{(aq)}} \rightarrow \cancel{Na^{+}_{(aq)}} + \cancel{NO_3^{-}{}_{(aq)}} + AgCl_{(s)}$ Net ionic Equation: $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$ Delete?
435.	Formula of a nitrate ion	NO_3^-
436.	Why are chemists able to predict the shapes of molecules?	As electron pairs **REPEL** (1) and the shape is determined by the no. of bonding pairs and the no. of lone pairs (1).
437.	What are the 2 rules for all orbitals of the same energy?	1. Electrons won't pair in the same subshell if they don't have to. 2. Electrons in the same orbitals must have opposite spin. This is to avoid repulsion.
438.	How does the structure of elements change across period 3?	1. Na, Mg, Al - giant metallic lattices. 2. S - giant covalent lattice. 3. P_4, S_8, Cl_2, Ar - simple molecular.
439.	How do isotopes of the same element vary?	In physical properties (e.g., density).
440.	What is a coordinate/dative bond?	Where both electrons in a covalent bond are from the same atom.
441.	How should you tackle an ‘explain the shape of molecule’ question in 4 steps?	1. State the no. of **BONDING PAIRS** and lone pairs ‘surrounding the central atom‘. 2. State that ‘electrons repel and try to get as far apart as possible’ (1). 3. If there are lone pairs, state lone pairs repel more than **BONDING PAIRS** (1). Otherwise state electron pairs get repelled equally (1). 4. State the shape of molecule with the bond angle. *Treat double bonds as single bonds here. Regions are considered pairs here.*

442.	Why do the strength of induced dipole-dipole interactions increase down groups?	The no. of electrons increases leading to stronger temporary dipoles (due to stronger charges) therefore stronger attraction. *This is why oxygen has a higher b.p. than hydrogen.*
443.	Give 3 reasons why water has a higher m.p. and b.p. to structurally similar compounds	1. Hydrogen bonding provide it with stronger intermolecular forces. 2. Forms up to four hydrogen bonds. 3. O is the second most electronegative meaning stronger hydrogen bonds.
444.	What are the 3 exceptions to oxidation rules?	1. Hydrogen is always +1 **except** when in a hydride where it's -1. 2. Oxygen is always -2 **except** with fluorine (more electronegative) where it's +2 and as peroxides where it's -1. 3. Chlorine is always -1 **except** when bonded with oxygen and fluorine (more electronegative) where it's different.
445.	Describe and explain the conductivity of ionic compounds under different states	- Doesn't conduct when solid (1) because the ions are fixed in a lattice (1) so cannot carry a charge. - Conducts when molten or dissolved because the ions are **MOBILE** and thus act as charge carriers (2).
446.	Give 3 strong acids and 1 weak acid	- Strong acids include: HCl, H_2SO_4, and HNO_3. - Weak acids include carboxylic acids such as CH_3COOH (ethanoic acid) or HCOOH (methanoic acid).
447.	What are oxidation numbers?	The no. of electrons removed from an atom.
448.	What is an -ide?	A binary compound in which the nonmetal is given an -ide suffix (e.g., sodium oxide).
449.	What is a σ-bond?	The overlap of orbitals directly between atoms.
450.	By what 2 ways can you purify products?	1. Solids by recrystallisation 2. Liquids by separating funnel or distillation
451.	How is PF_5 formed (electron-wise)?	By freeing up 5 orbitals by moving electrons into unoccupied d subshell orbitals. *This is an spd hybrid that can hold more than 8 unlike the sp hybrid.*

452.	What 3 things should you ensure when making standard solutions?	1. Use **clean dry equipment**. 2. **Make washings** to remove any salt **BEFORE MAKING** up the solution to the specified amount. 3. **Invert the volumetric flask** several times to ensure everything is dissolved.
453.	Give 3 reasons for why a high atom economy is good	- Environmental friendly (due to less waste). - Economical (due to not separating materials). - Sustainable (as it prolongs finite materials).
454.	What is a salt?	The **product of a neutralisation reaction** where the **H^+ IONS** from the **acid** is **replaced** by **metal or ammonium IONS**.
455.	How should burette measurements be recorded?	- Should be recorded to 2 d.p - Should end in 0 or 5 *This does not include theme titre which doesn't have to end in 5 or 0.*
456.	How should you perform mean titres?	1. Repeat titrations until there are two concordant titres (within 0.10 cm^3) 2. Take an average of the concordant titres 3. Round to 2 d.p. (if required)
457.	Why are ionic compounds soluble?	As water molecules are polar solvents (1) so will surround each ion (1).
458.	How should you read from a burette?	Reading from the bottom of the meniscus at eye-level against a constant background.
459.	Define electronegativity	The ability of an atom to attract electrons (1) in a covalent bond (1) towards itself.
460.	What are bases and alkalis?	- Bases are H^+ ion acceptors. - Alkalis are soluble bases that release HO^- ions into solution.
461.	What is 1 L equal to (in volume)?	1 dm^3
462.	What is the end point in a titration?	The point where the indicator changes colour.
463.	When can you tell a bond is polar?	Generally, if the two atoms are of different elements, it's polar (except for carbon-hydrogen).
464.	How can you work out if a molecule is symmetrical?	Generally, if it has no lone pairs and the same bond pairs then it's symmetrical. *You may have to rotate it in different planes to confirm this.*

465.	Give a weak base	NH_3
466.	Does every structure have London Forces? If so which ones don't?	No. Lattices like SiO_2.
467.	Why doesn't I_2 dissolve in water?	- It is nonpolar. - It doesn't form any ^1H bonds.
468.	What causes high surface tension in water and why?	Hydrogen bonding because it leads to a strong and flexible lattice structure.
469.	What are standard solutions?	A solution for which its concentration is known accurately.
470.	Give 2 reasons for the percentage yield being less than 100%	- Reaction may have **not had enough time** to go to completion. - A **side reaction** has taken place (e.g., in the glassware). - Product was **lost under purification**.
471.	What are the 3 wedges for shape of molecules?	1. Solid line is a bond on the plane of the page. 2. Solid wedge is a bond that comes out of the plane of the page. 3. Dotted line is a bond going into the plane of the page.
472.	What are oxidising and reducing agents?	- Oxidising agents gain electrons leading to oxidation elsewhere - Reducing agents lose electrons leading to reduction elsewhere
473.	What is the A_r of a proton, neutron, and electron?	1, 1, and 1/1836 respectively.
474.	Define relative isotopic mass	The mass of one **isotope** compared to **1/12** of the mass of **one carbon-12 atom**.
475.	What is used to show a coordinate bond?	An arrow from the atom providing the coordinate bond. E.g., in an ammonium ion.
476.	By what 4 ways can you heat reactions?	1. Water bath 2. Electric heater 3. Sand bath 4. Bunsen burner
477.	Define isotopes	Atoms of **same element** with the same number of protons but **different numbers of neutrons**.

478. What is the equation linking mol (n), volume of gas (dm^3), and molar gas volume (24 dm^3)?

$$n = \frac{\text{volume of gas}}{\text{molar gas volume}}$$

This is used for anything under standard conditions.

---

479. Define covalent bond

The strong **electrostatic attraction** between a **shared pair of electrons** and the **nuclei** of the bonded atoms.

---

480. How can a molecule be nonpolar yet contain polar bonds?

As it's symmetrical (1) so dipoles cancel each other out (1).

---

481. What is a hydrated/hydrous salt?

A salt molecule loosely attached to water (called waters of crystallization).
Thus anhydrous means the opposite.

---

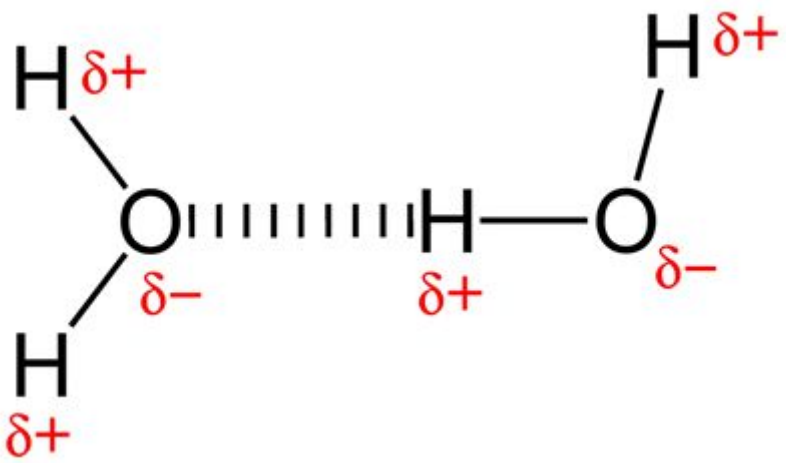
482. What must an atom have access to for expansion of the octet to occur?

Its d subshell meaning the atom must have 3 or more shells.
You can only hold 8 electrons in an sp hybrid so require the d subshell to hold more.

---

483. What is a hydrogen bond?

The electrostatic attraction between a hydrogen atom bonded to an electronegative atom and a lone pair on an electronegative atom of a different molecule.



The bond is represented by a dashed line and the line must be parallel to the covalent bond from the hydrogen.

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484. What are diprotic and triprotic acids (with examples) and what does this mean for neutralisation?

- Diprotic acids and triprotic acids donate two and three protons respectively.
- Examples: H_2SO_4 and H_3PO_4.
- They need 2x or 3x the number of moles of base to be neutralised.

---

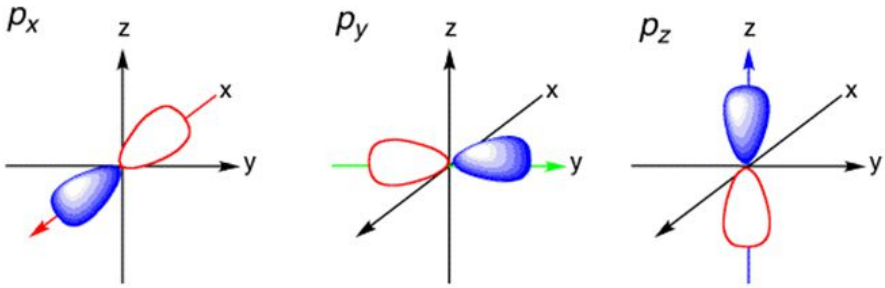
485. Reaction between an acid and metal oxide

acid + metal oxide → a salt + water

486.	What is atom economy and how is it calculated?	A measure of how efficient a reaction is. $$\text{atom economy} = \frac{\text{Mr of desired products}}{\text{Mr of reactants}}$$
487.	Give 2 ways of improving atom economy	1. Use an alternate reaction pathway with a higher atom economy. 2. Find a use for the waste products.
488.	Define both cation and anion	Cation - positively charged ion. Anion - negatively charged ion. *Remember as cats make you positive.*
489.	Which shells have which subshells?	- 1st has s. - 2nd has s p. - 3rd has s p d. - 4th has s p d f.
490.	Formula of a sulfate ion	SO_4^{2-}
491.	In what contexts is 'relative molecular mass' and 'relative formula mass' used?	- **Relative molecular mass** - used for **easily defined structures** in which you know the exact no. of atoms (e.g., O_2). - **Relative formula mass** - used for **giant structures** in which you don't know the exact no. of atoms (e.g., lattices such as NaCl).
492.	Reaction between an acid and metal hydroxide	acid + metal hydroxide $\rightarrow$ a salt + water.
493.	What are the 2 types of reactions under atom economy?	- **Addition** - the reactants form a **single DESIRED product** (100%). - **Substitution** - the atoms from a reactant are substituted by others leading to **more than one product**. *Addition reactions are usually where a reactant isadded to ann unsaturated molecule to make saturated molecule.*
494.	Describe and explain the 2 anomalous properties of ice	1. Ice is less dense than water as the molecules are held apart by hydrogen bonds in an open lattice. 2. Ice has a higher m.p. than expected as hydrogen bonds provides it with strong intermolecular forces.
495.	What does a mass spectrometer measure?	Mass to charge ratio (m/z).

496. What are the shapes of the p-orbitals?

Dumbbells.



497. Formula of a silver ion

Ag^+

498. Reaction between an acid and metal carbonate

acid + metal carbonate → a salt + water + carbon dioxide

499. What is a limiting reagent?

The **reactant that runs out** first and thus limits how much product can be formed.

500. Formula of a phosphate ion

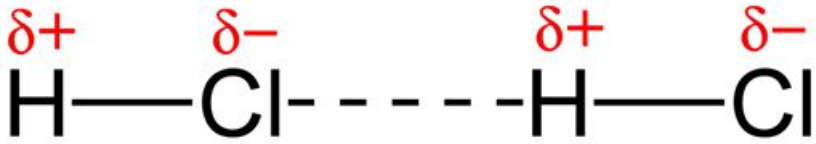
PO_4^{3-}

501. Describe the pyramidal shape of molecule

-3 bonding pairs and 1 lone pair.
-107 degrees (because tetrahedral minus 2.5 degrees).

502. What are permanent dipole-dipole interactions?

Electrostatic forces of attraction between polar molecules



503. What are the 4 main rules for oxidation numbers?

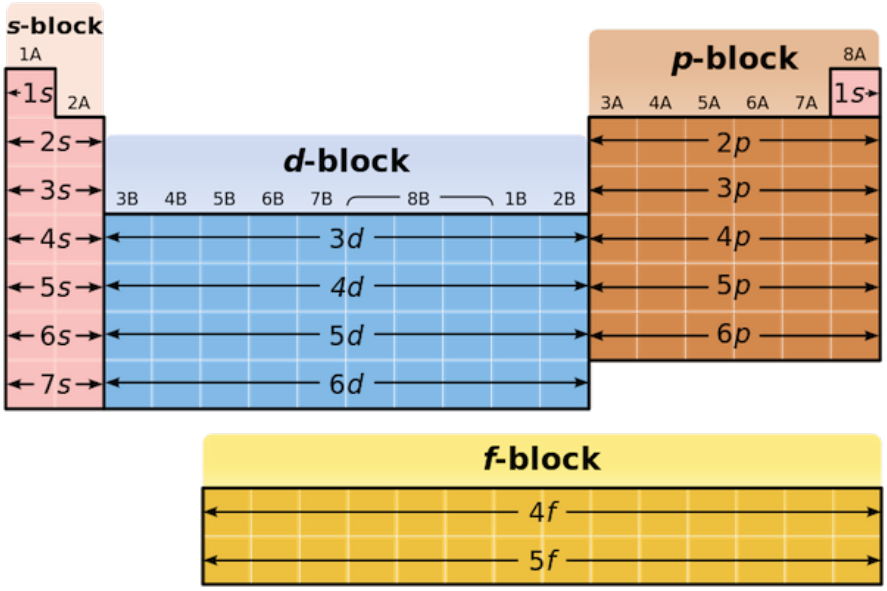
1. **Elements** always have an oxidation **no. of 0**.
2. **Sum** of oxidation no.'s in a **compound** = 0.
3. **Sum** of oxidation no.'s of an **ion** = its **charge**.
4. The most electronegative element in a compound is **always negative** (so work with this first).

504. What is the ideal gas equation and what is each unit measured in?

$$pV = nRT$$

Where p is pressure (Pa), V is volume (m^3), n is moles (mol), R is the gas constant, T is temperature (K).

505. What are the blocks of the periodic table?



506. Why are some ionic compounds less soluble than others?

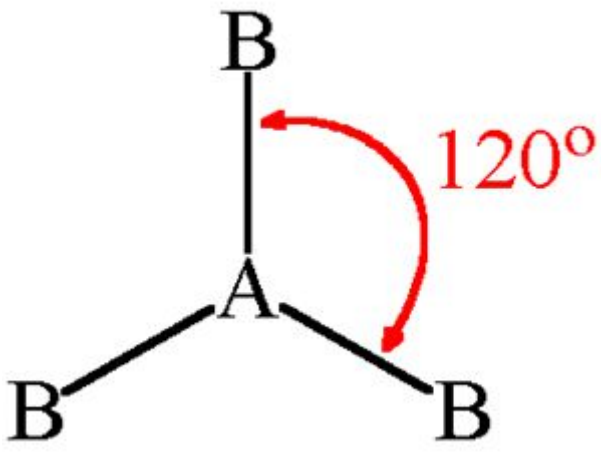
Greater charge difference (e.g., Mg^{2+} and O^{2-}) means stronger attraction which is less easily overcome.

507. What do lone pairs repel by and why?

An extra 2.5° as they're closer to the nucleus and thus take up more space.

508. Describe the trigonal planar shape of molecule with an example

-Planar meaning flat on the page
-3 bonding pairs and 0 lone pairs.
-120 degrees.
-An example is BF_3.



509. Describe the nonlinear shape of molecule

- 2 bonding pairs and 2 lone pairs.
- 104.5 degrees between bonding pairs (because tetrahedral minus 2 x 2.5 degrees).
The angle between the two lone pairs is the greatest.

510. Which will have a higher b.p., HF or HCl, and why?

HF ■ stronger permanent dipole-dipole interactions (due to the difference in electronegativity being greater) which requires more energy to overcome.

511.	Reaction between an acid and metal (+ type of reaction)	acid + metal → salt + hydrogen. **redox** (not neutralisation as water isn't formed)
512.	What are the strongest to the weakest intermolecular forces?	1. Hydrogen bonds 2. Permanent dipole-dipole interactions. 3. Induced dipole-dipole interactions. *Yet, London forces can become stronger than the other 2 if there are a lot of electrons.*
513.	Why won't all CO_2 be released from a reaction involving a solution?	As CO_2 is slightly soluble. *This is because the water molecules are slightly attracted to the polar areas of a CO_2 molecule.*
514.	What is a reduction reaction? What is a oxidation reaction?	- Reduction reactions are the loss of oxygen atoms or gaining of electrons. - Opposite for oxidation.
515.	Which key orbital fills first and empties first, when, and why?	- The s-orbital, past and including the 4th shell. - It has less energy than the d-orbital but when the d-orbital gains electrons, it drops below s-orbital.
516.	Formula of an ammonium ion	NH_4^+
517.	How do atoms fill up with electrons?	In subshells, in order of increasing energy.
518.	Define ionic bond	The **electrostatic force** of attraction between **oppositely charged ions** formed by electron transfer.
519.	Describe induced dipole-dipole interactions	Unequal distribution of electrons (1) ⇒ temporary/instantaneous dipole (1) ⇒ induces a dipole in a nearby molecule (1) leading to attraction.
520.	Why doesn't water and oil mix?	Water is polar and oil is nonpolar and the strongest bonds oil can make is with other oil molecules and this is the same for water. This need for stability leads to separation.
521.	Give 4 bases/types of bases	Metal oxides, metal hydroxides, metal carbonates, and ammonia.
522.	What do -ate compounds contain?	Oxygen and at least one other element. *Examples include: chlorate, nitrate, and carbonate.*
523.	Define one mole	The amount of substance which contains the same amount of particles as there are atoms in 12 grams of carbon-12.

524. What is a solvent?

The liquid in which a solute is dissolved in to form a solution.

525. Which electronegative elements will hydrogen bonding happen with and why?

Oxygen, nitrogen, and fluorine ■ they're the most electronegative and most dense in electrons.
Chlorine's electron density is too low due to its extra shell.

526. What is a hydride?

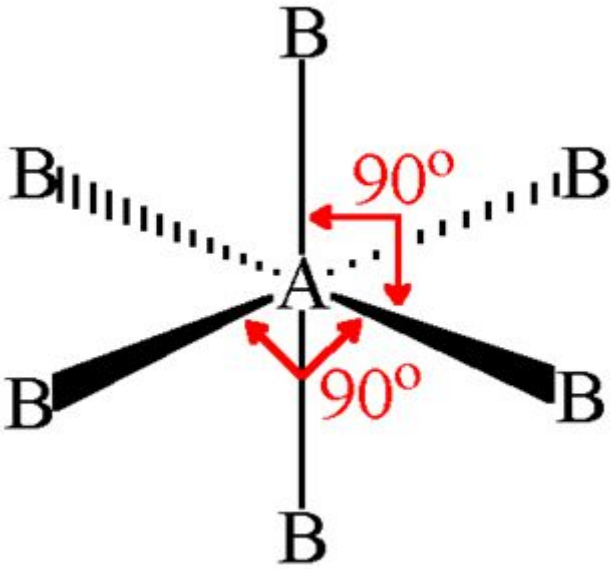
A binary compound of hydrogen and a metal.

527. Give 3 examples of readings and 3 examples of measurements

Reading (one judgement only)	Measurement (two judgements required)
thermometer	ruler
pH meter	stopwatch
top pan balance	analogue meter
measuring cylinder	burette
volumetric flask	

528. Describe the octahedral shape of molecule with an example

-6 bonding pairs.
-90 degrees.
-An example is SF_6



529. What are orbitals?

Regions around the nucleus that can hold 2 electrons with opposite spins.

530. What does a binary compound contain?

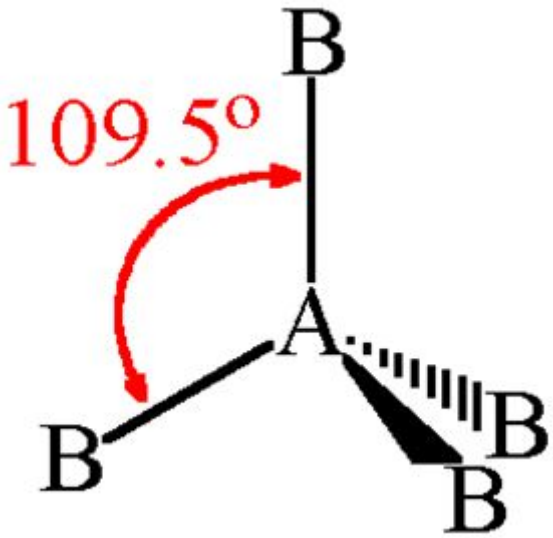
ONLY two different elements.

531. What is a solute?

What is being dissolved into the solvent.

532. Describe the tetrahedral shape of molecule with an example

-4 bonding pairs.
-109.5 degrees.
-An example is NH_4.



533. How does ammonia react with acid?

- ammonia + acid → ammonium salt
- E.g., $NH_{3\,(aq)} + HNO_{3\,(aq)} \rightarrow NH_4NO_{3\,(aq)}$

534. Give the 3 bond angles largest to smallest

1.The bond angle between lone pairs.
2.The bond angle between a lone pair and a bonding pair.
3.The bond angle between bonding pairs.

535. Why is a p-block element considered a p-block element?

As its highest energy electron occupies a p-orbital.

536. What can polar molecules and nonpolar molecules dissolve into?

Polar solvents and nonpolar solvents respectively.
This means nonpolar molecules (e.g., oil) are insoluble in water.

537. What is the formula for the A_r of a sample?

$$\frac{\sum(\text{isotopic mass} \cdot \text{relative abundance})}{\text{total relative abundance}}$$

538. Formula of a zinc ion

Zn^{2+}

539. What is the mnemonic for remembering the diatomic elements?

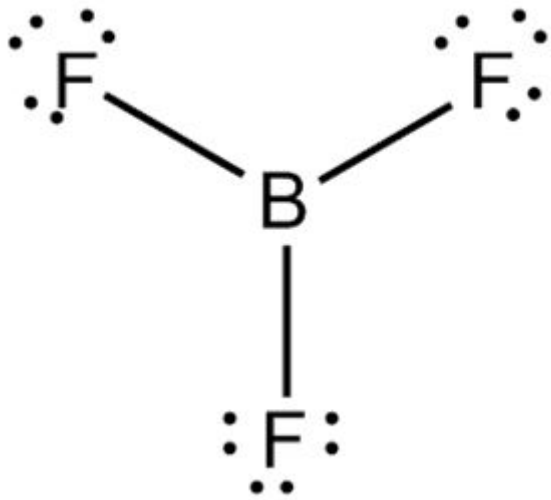
Have **N**o **F**ear **O**f **I**ce **C**old **B**eer.
H_2, N_2, O_2, I_2, Cl_2, Br_2.

540. What is a peroxide?

A compound containing two oxygen atoms bonded together (O-O).

541. Give an example of a covalent molecule whose central atom has fewer than 8 electrons in its outermost shell

BF_3.



542. What are degenerate orbitals?

Orbitals that have the same energy level.
Eg, p-subshell consists of 3 degenerate p-orbitals.

543. Define relative atomic mass

The **weighted mean mass** of one atom compared to **1/12** of the mass of **one carbon-12 atom**.

544. What do chemical properties depend on?

Electronic structure.
Thus isotopes have the same chemical properties.

545. What are spectator ions?

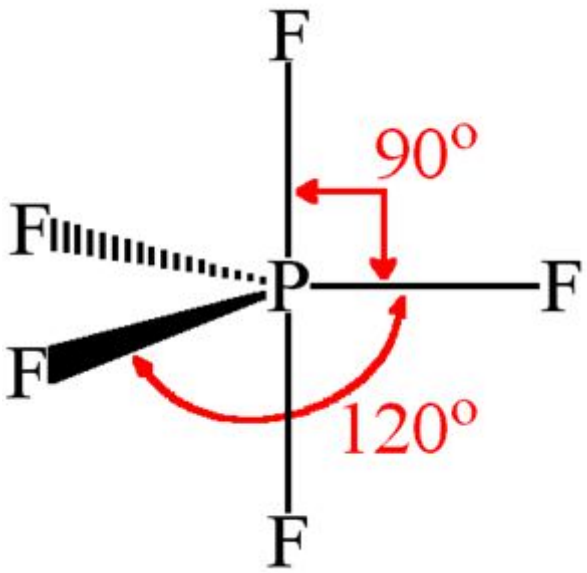
Ions that don't change state or oxidation number.

546. What is the conversion factor between Kelvin and Celsius?

Add 273 to C to get K.

547. Give an example of a molecule which expands the octet

PF_5.



Trigonal bipyramidal.

548. What should be done near endpoint of a titration?

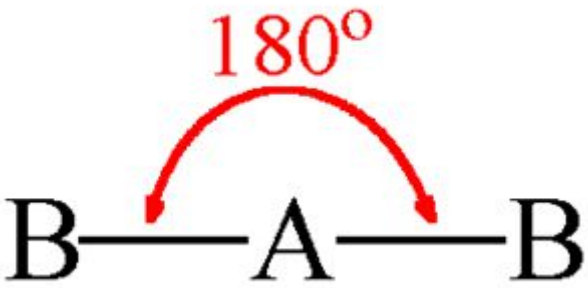
Add the solution dropwise.

549. How many orbitals does each subshell have?

- s has 1 orbital.
- p has 3 orbitals.
- d has 5 orbitals.
- f has 7 orbitals.

550. Describe the linear shape of molecule with an example

-2 bonding pairs.
-180 degrees.
-An example is CO_2.



551. What are 'London Forces' also called?

Induced-dipole-dipole interactions.
Calling them 'Van der Waals' is too ambiguous.

552. Define molar mass

The mass in grams of 1 mol of a substance given in $gmol^{-1}$.

553. What is the shape of an s-orbital/s-subshell?

Sphere.
The greater the shell number, the greater the radius.

554. What do most noble gases have an outermost electron structure of?

ns^2np^6

555. What is the equation linking mol (n), mass (m), and molar mass (M_r)?

$$n = \frac{m}{M_r}$$

556. Formula of a carbonate ion

CO_3^{2-}

557. The symbols for atomic no. and mass no. are...

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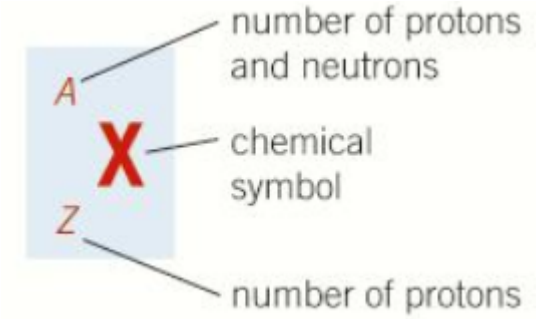

Z and A respectively

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558. Formula of a nitride ion

N^{3-}