Name:

Organic Chemistry	**Objectives**
22. Types of Reactions in Organic Chemistry	*Addition Reactions* -explain what is meant by an addition reaction -write balanced equations using structural formula for the reactions of the alkenes with hydrogen, chlorine, bromine, water and hydrogen chloride -outline the industrial importance of: • products of the addition reactions of ethene with chlorine, bromine, water and hydrogen chloride • hydrogenation of vegetable oils -explain what is meant by addition polymerisation -outline the polymerisation reaction of ethane and propene (reaction mechanism not required). -account for the unreactivity of benzene with regard to addition reactions relative to ethene -account for the use of alkenes as raw materials in the industrial manufacture of plastics -outline the range and scope of the petrochemical industry -list two synthetic products of the petrochemical industry (structures not required unless specified elsewhere on the syllabus) *Substitution Reaction* -define substitution reaction -recognise halogenation of alkanes as a substitution reaction -write balanced equations using structural formula for the halogenations of alkanes -prepare a sample of soap -discuss the manufacture of soap *Elimination Reactions* -explain what is meant by an elimination reaction -explain what is meant by a dehydration reaction write balanced equations using structural formula for the dehydration of alcohols *Redox Reactions* -write balanced half equations using structural formula for the oxidation (using $KMnO_4$ or $Na_2Cr_2O_7$) of: • alcohols to(i) aldehydes and (ii) acids • aldehydes to acids -demonstrate the properties of ethanal (limited to reactions with (i) acidified potassium manganate(VII) solution, (ii) Fehling's reagent and (iii) ammoniacal silver nitrate) -relate the production of ethanal to the metabolism of ethanol in the human body -carry out diagnostic tests on ethanoic acid (limited to reactions with sodium carbonate, magnesium) -recall that combustion is a reaction common to most organic compounds -recall that the fully halogenated alkanes are non-flammable, relate this property to their use in flame retardants and fire extinguishers -oxidise phenylmethanol (benzyl alcohol) to benzoic acid using potassium permanganate under basic conditions. -recall that benzaldehyde is a constituent of almond kernels (structure of benzaldehyde not required)

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	-purify a sample of benzoic acid by recrystallisation outline the use of melting point to confirm purity determine the melting point of benzoic acid *Reactions as acids* -write balanced equations using structural formulas for the reactions of alcohols with sodium -write balanced equations using structural formulas for the reactions of carboxylic acids with magnesium, with sodium hydroxide and with sodium carbonate *Organic synthesis: principles and examples* -recall that chemical synthesis involves (i) bond breaking and (ii) bond forming -describe the organic synthesis of PVC from ethene (structures and synthetic route not required)

ADDITION REACTIONS

Def^{n}: An **addition reaction** is one in which two substances react to form a single substance.

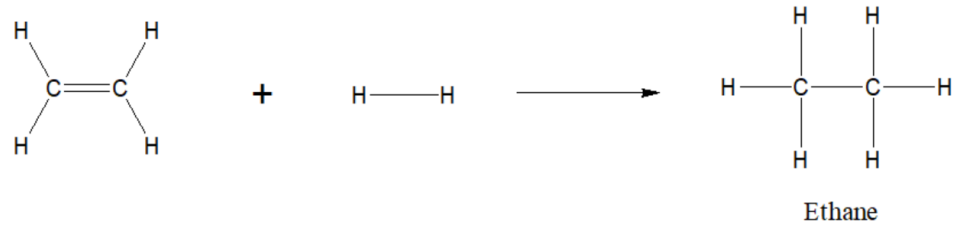
General Notes on add^{n} reactions:

1. Always will occur on a double/triple bond.
2. Geometry will change from planar (unsaturated C-C bonds) to tetrahedral (saturated C-C bonds).
3. Benzene does not undergo addition reactions as its delocalised electrons make it very stable and unreactive.

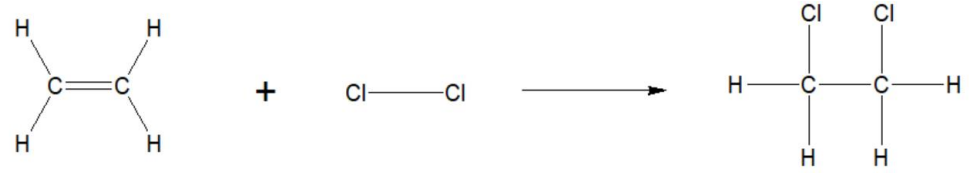
Uses of add^{n} reactions:

1. Hydrogenation of vegetable oils. Forms margarine. H_2 (with Ni catalyst) added to unsaturated oils to partially saturate them. This is also a *reduction* reaction as we are adding hydrogen.
2. Polymerisation reactions to make long chains of carbons we call plastics.

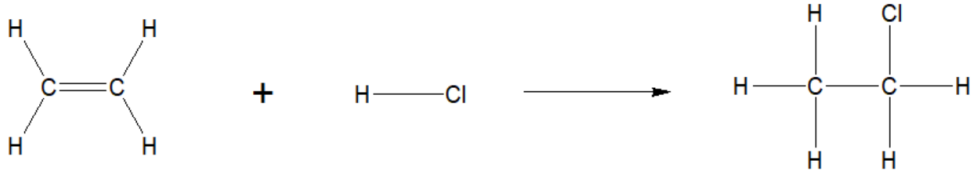
Ethene is often seen as the most important organic chemical, as it undergoes many addition reactions to form different organic compounds. Example we need to know are:



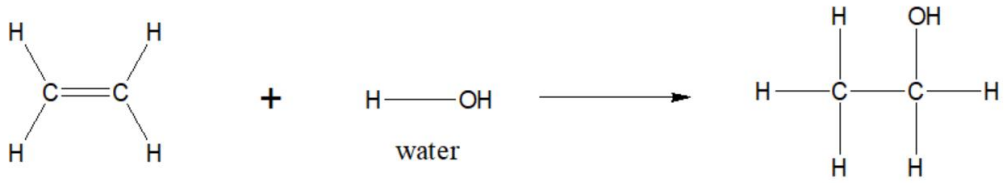
Ethane

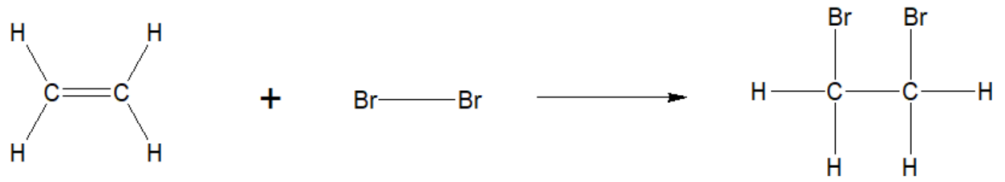


1,2-dichloroethane



Chloroethane

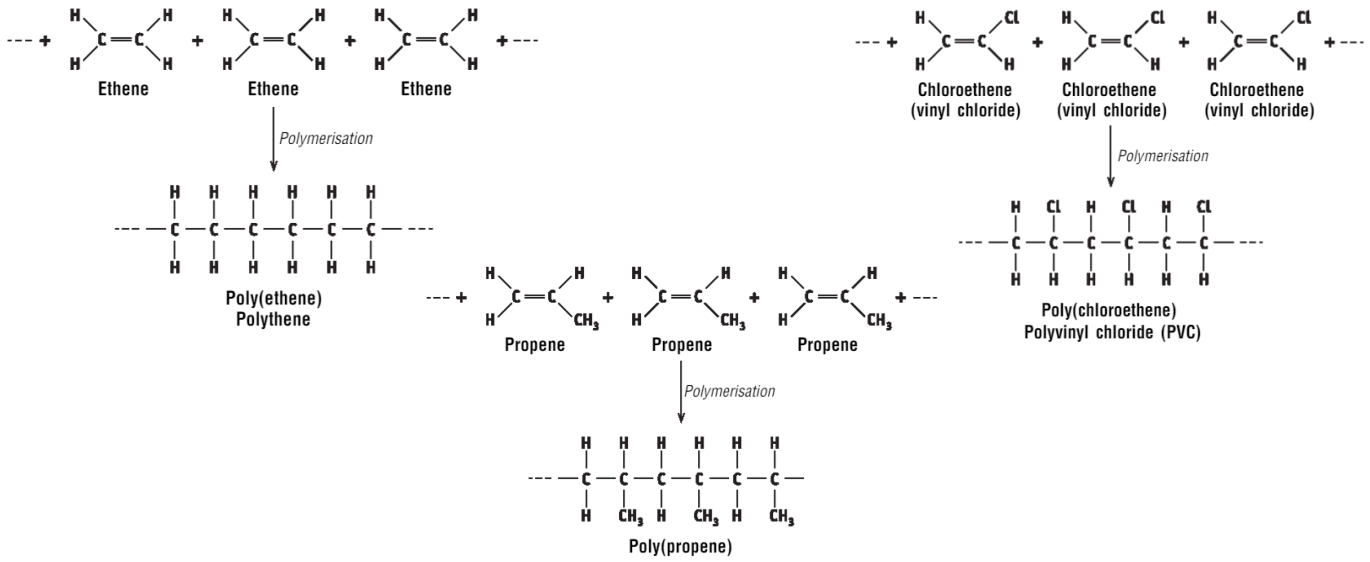




<u>Polymerisation</u> reactions are also a type of addition reaction.

Def^{n}: **Polymers** are long chain molecules made by joining many small molecules (monomers).

Polymers are made up of many repeating units.

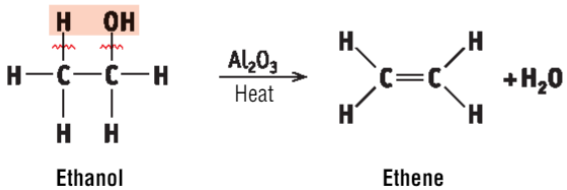


<u>ELIMINATION REACTIONS</u>

Def^{n}: An **elimination reaction** is one in which a small molecule is removed from a larger molecule, leaving a double bond on the larger molecule.

General Notes on elim^{n} reactions:

1. Geometry changes from tetrahedral to planar as a double bond is formed.
2. Generally involved the removal of a water molecule (H_2O) – these are also called *dehydration* reactions.



This example is the reaction you carried out when producing ethene gas. Notice that water is removed from the ethanol.

Know that Al_2O_3 and heat is used to remove water in a dehydration reaction.

SUBSTITUTION REACTIONS

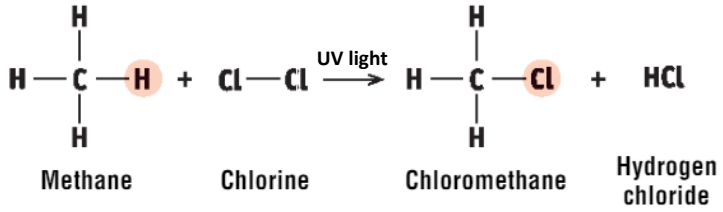
Def^{n}: A **substitution reaction** is one in which an atom (or group of atoms) in a molecule is replaced with another atom (or group of atoms).

There are 2 main types we study:

1. **Halogenation of Alkanes**

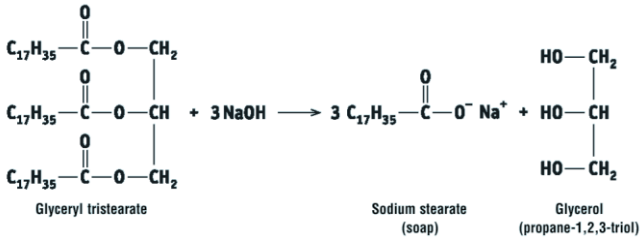
This involves substituting hydrogen atoms in alkanes with halogens (F, Cl, Br, I, etc.).

Fully halogenated alkanes e.g. CCl_4 are used as flame retardants. Less common now as they damage the ozone layer.



You need to be able to replace 1 H atom with a halogen atom in a balanced formula, like in the diagram on the left.

2. **Saponification**



How does soap work?

Soap molecules contain a long, non-polar carbon chain which will dissolve oils (e.g. from skin). The opposite end of the molecule contains a polar $COO^{-}Na^{+}$ which will dissolve salts from sweat and will also dissolve in water. This allows soap to pick up oils and salts and then be washed down the drain.

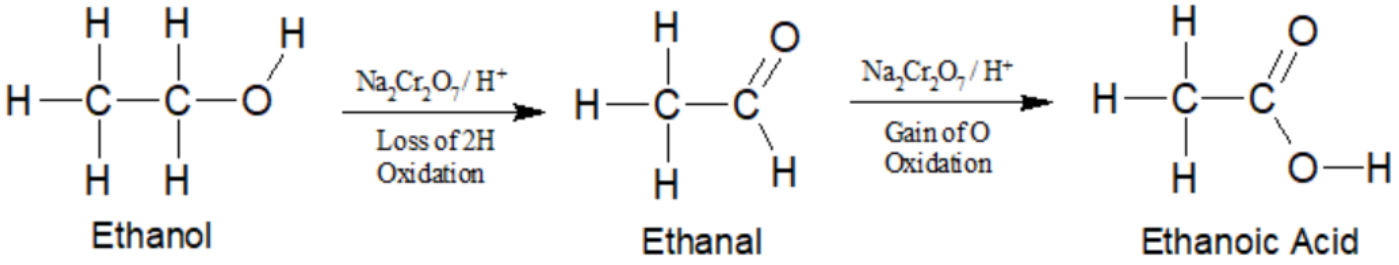
REDOX REACTIONS

General Notes on redox reactions:

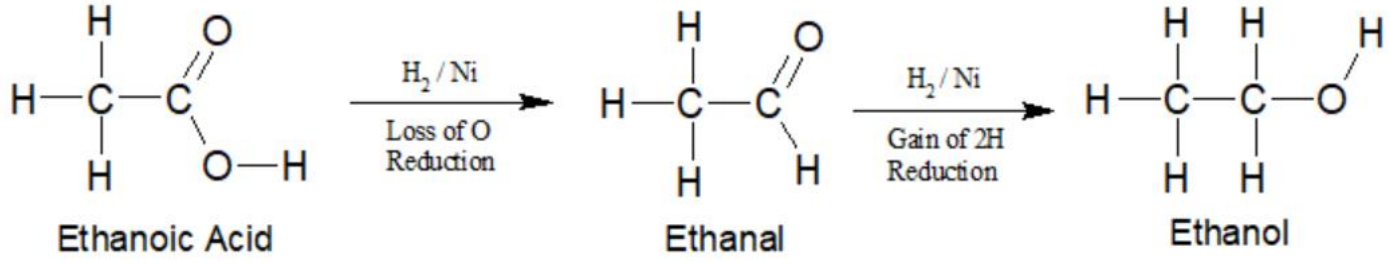
1. Oxidation is the addition of O or the removal of H.
2. Reduction is the removal of O or the addition of H
3. Oxidation carried out using either:
    a. Acidified Sodium Dichromate ($Na_2Cr_2O_7/H^{+}$) Cr(VI) [orange] gets reduced to Cr(III) [green].
    b. Acidified Potassium Permanganate ($KMnO_4/H^{+}$) Mn(VII) [purple] gets reduced to Mn(II) [colourless].
4. Reduction is carried out using Hydrogen gas and a Nickel catalyst (H_2/Ni)

Primary Alcohols

Primary alcohols get oxidised to aldehydes. If there is excess oxidising agent present, the aldehydes can then be further oxidised to carboxylic acids.

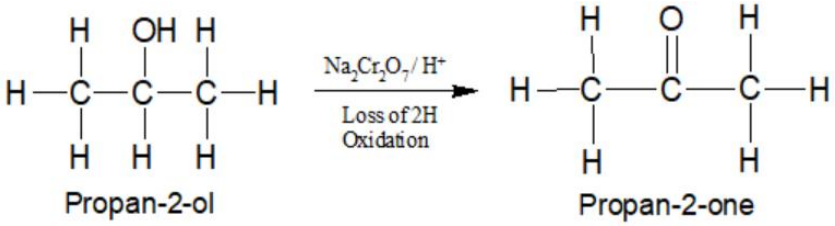


Carboxylic acids get reduced to aldehydes. If there is excess reducing agent, the aldehydes can be further reduced to alcohols.



Secondary Alcohols

Secondary alcohols get oxidised to ketones.



Organic Redox reactions in everyday life

1. A bottle of wine left open to the air will start to taste "vinegary" after some time. This is because oxygen in the air oxidises the ethanol in the wine to ethanoic acid.

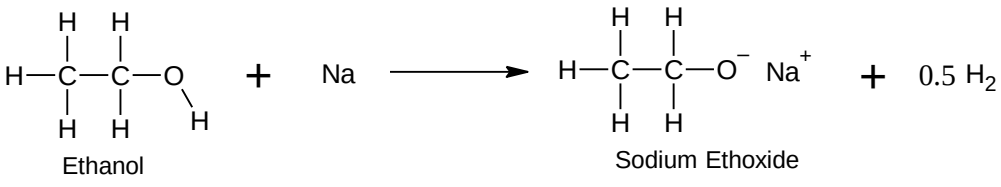
2. When ethanol is consumed, the liver works hard to break it down, as it is a foreign toxin to the body. The liver oxidises the ethanol to ethanal, which is even more toxic! The ethanal is what causes some of the bad symptoms of a hangover. Eventually, when given enough time, the ethanal is further oxidised by the liver to carbon dioxide and water, which are excreted through the lungs and urine.

3. Old-style breathalysers (these can still be bought in your local pharmacy!) contained potassium dichromate crystals [Cr(VI) - orange]. If alcohol was in a person's system and they breathed through a tube containing the crystals, the ethanol in the breath would be oxidised. This would reduce the Cr(VI) [orange] to Cr(III) [green], showing that ethanol was present.

REACTIONS AS ACIDS

Alcohols reacting with Sodium

The H on the –OH of an alcohol can act as an acid when reacted with the *extremely* reactive metal, sodium. This forms the sodium salt of the alcohol, and hydrogen gas.



Common reactions with carboxylic acids:

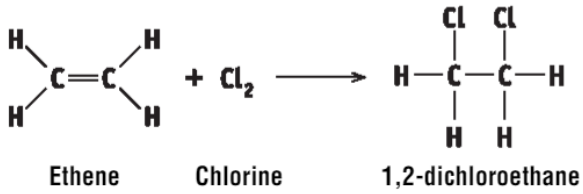
1. Acid + Base → Salt + Water
   e.g. $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

2. Acid + Carbonate → Salt + Carbon Dioxide + Water
   $2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 + H_2O$

3. Acid + Metal → Salt + Hydrogen
   $2CH_3COOH + Mg \rightarrow (CH_3COO)_2Mg \rightarrow H_2$

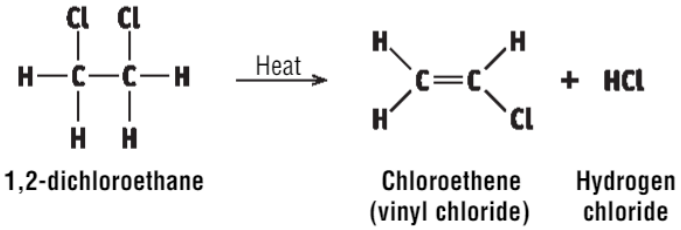
SYNTHESIS OF PVC FROM ETHENE

Step 1:



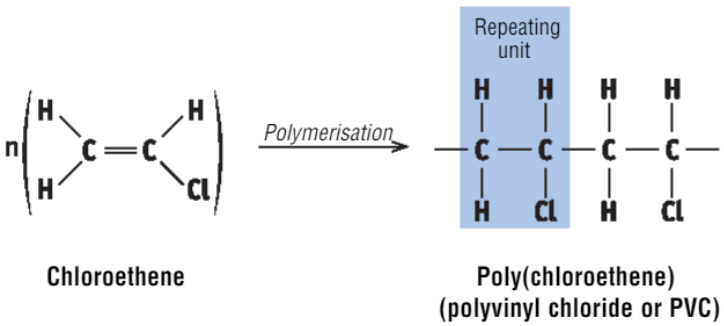
Ethene and chlorine react to form 1,2-dichloroethane. (Addition reaction of which we know the mechanism)

Step 2:



Heat is used to thermally crack the 1,2-dichloroethane into chloroethene and HCl.

Step 3:



The chloroethene undergoes a polymerisation reaction to form polychloroethene (PVC)

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