HSC Chemistry Sample

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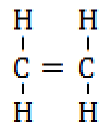
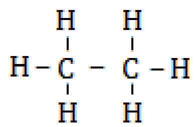
Production of Materials

<u>- identify that ethylene, because of the high reactivity of its double bond, is readily transformed into many useful products</u>

- **Chemical properties** are determined by the **intramolecular bonding** of substances.
  - Alkanes have unreactive single bonds.
  - Alkenes such as ethylene have a highly reactive double bond. Thus they can undergo a variety of addition and substitution reactions across the double bond whilst alkanes are unreactive. Such reactions are addressed in the table below:



Ethene

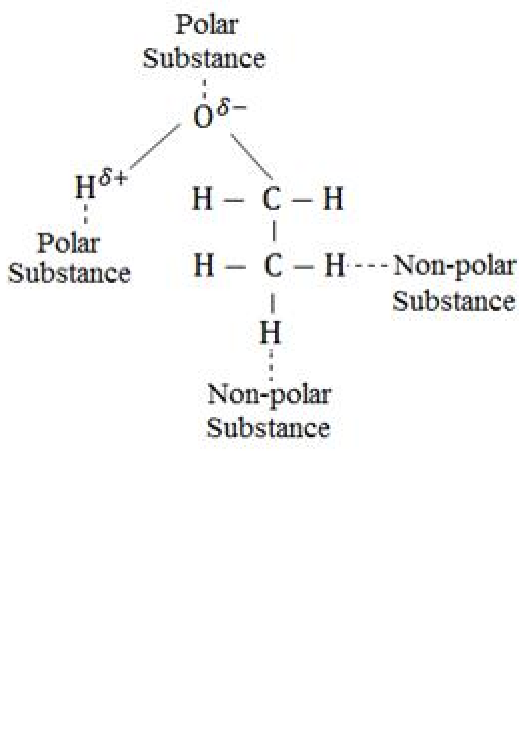


Ethane

Reaction	Description	Example
Substitution	An atom within a molecule is replaced by another atom/s	$C_6H_{14\,(l)} + Br_{2(l)} \rightarrow C_6H_{13}Br_{(l)} + HBr_{(l)}$
Addition reactions		
Hydrogenation	H_2 added	$C_2H_{4(g)} + H_{2(g)}$ —Pt catalyst → $C_2H_{6(g)}$
Hydration	H_2O added	**Covered later**
Halogenation	Halogen group (Cl_2, Fl_2 Br_2) added	$C_2H_{4(g)} + Cl_{2(g)} \rightarrow C_2H_4Cl_{2(l)}$
Hydrohalogen	Hydrohalogen (HFl, HCl) added	$C_2H_{4(g)} + HFl_{(g)} \rightarrow C_2H_5Fl_{(g)}$

<u>-describe and account for the many uses of ethanol as a solvent for polar and non-polar substances</u>

- Ethanol consists of 2 ends
  - The polar (-OH) end allows it to dissolve polar substances via dipole-dipole and H-bonding.
  - The non polar hydrophobic (CH_3) end allows it to dissolve non-polar substances via dispersion forces.
  - Thus, many non-polar, water insoluble substances are ethanol soluble. Ethanol is used as a solvent in cosmetics, antiseptics, methylated spirits and food colourings.

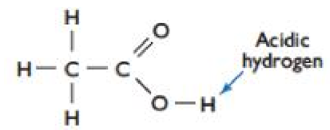
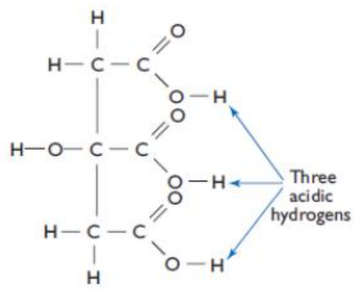
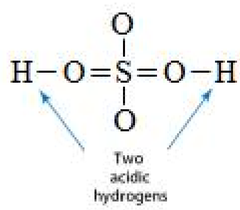


The Acidic Environment

-explain the need for refluxing during esterification

- **Esterification** is a slow reaction at room temperature so heat is required to increase reaction rate by increasing the kinetic energy of molecules.
- However the reactants and products are volatile and flammable and readily vaporise on heating.
  - **Refluxing** is the process of heating a liquid mixture with a condenser attached vertically above the reaction vessel. Cold water circulates to cool the vapours, condensing them back into liquid which falls back into the reaction mixture, preventing the loss of reactants or products.
  - A **water bath** ensures even heating and avoids the ignition of flammable reactants and products by a naked flame.
  - **Boiling chips** encourage the mixing of reactants to distribute heat. It prevents 'bumping' by providing a large surface area upon which vaporisation can occur without the risks of sudden superheating of liquids and explosive ejection of vapours.

-identify acids including acetic (ethanoic), citric (2-hydroxypropane-1,2,3-tricarboxylic), hydrochloric and sulfuric acid

Common name	Systematic name	Formula	Type/strength	Structure
Acetic acid	Ethanoic acid	CH_3COOH	Weak monoprotic	
Citric acid	2-hydroxypropane-1,2,3-tricarboxylic acid	$C_6H_8O_7$	Weak triprotic	
Hydrochloric acid	[redacted]	HCl	Strong monoprotic	H—Cl
Sulfuric acid	[redacted]	H_2SO_4	Strong diprotic	

Chemical Monitoring and Management

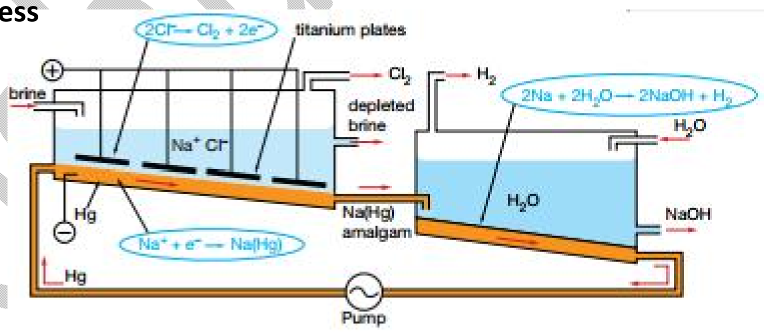
-outline the role of a chemist employed in a named industry or enterprise, identifying the branch of chemistry undertaken by the chemist and explaining a chemical principle that the chemist uses

- The **Maritime Museum** employs **analytical chemists** to restore marine artefacts.
- These analytical chemists identify the materials making up an artefact and plan the best procedure to restore it.
- Wooden objects are submerged in water for long periods, so salts can leech out of the cells in the wood and help preserve it.
- The chemist uses a knowledge of ***equilibrium*** to monitor the salt concentration in the water.
- When the concentration ceases to rise, the salts are in equilibrium between the cells and the surrounding water and:
    - the water can be replaced (if the salt concentration in the wood is still too high)
    - or the artefact can be removed from the water

Industrial Chemistry

-**distinguish between the three electrolysis methods used to extract sodium hydroxide:**
–mercury process –diaphragm process –membrane process
by describing each process and analysing the technical and environmental difficulties involved in each process

Mercury process



1. Brine is introduced to the electrolysis cell.
2. Cl^- ions are oxidised at the inert Ti anode plates, forming Cl_2 gas which is removed.

Anode: $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$

3. Na^+ ions (rather than H_2O) are reduced at the flowing Hg cathode, dissolving in it to form an Na(Hg) amalgam.

Cathode: $Na^+_{(aq)} + e^- \rightarrow Na_{(s)}$ amalgam

Net ionic: $2Na^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2Na_{(s)}$ amalgam

4. The amalgam flows from the electrolysis cell into a chamber containing pure water. The Na reacts with water and is decomposed at the surface of graphite catalyst balls.
   This forms NaOH solution and H_2 gas. H_2 gas is removed, and Hg is recycled.

$$2Na_{(s)\ \text{amalgam}} + 2H_2O_{(l)} \rightarrow 2NaOH_{(l)} + H_{2(g)}$$

Overall: $2NaCl_{(aq)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + Cl_{2(g)} + H_{2(g)}$

- This process makes high purity NaOH as the products as H_2 and Cl_2 are separated, as their reaction is explosive, and there is no Cl^- ion contamination.
- Carcinogenic asbestos isn't used, and the Hg is recycled, ensuring efficient resource use.

- **But it still has difficulties:**

Technical	Environmental
- Hg cells have require high working voltages, meaning significant electricity costs. A smaller gap between the electrodes lowers voltage requirements. - Despite Hg recycling, some is inevitably lost in the process, incurring significant costs to replace it as Hg is expensive. - Requires very pure brine which is expensive to purify.	- Hg, is a dangerous bio-accumulating neurotoxin that is inevitably released to the environment by this process. - Avoiding Hg poisoning was a major catalyst for changing the production process.

END OF SAMPLE

Bibliography

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