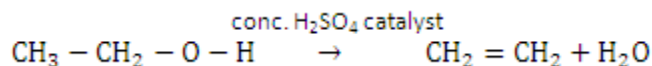


CHEM 9.2.3 ETHANOL

Other resources, such as ethanol, are readily available from renewable resources such as plants

3.1 Describe the **dehydration of ethanol** to ethylene and identify the need of a **catalyst** in this process and the catalyst used

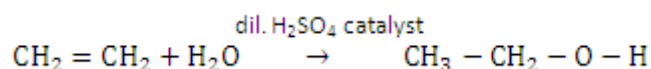
- **Dehydration:** chemical reaction, **water removed** from a compound @ 180



- Catalyst used is **concentrated sulphuric/phosphoric acid** + heat

3.2 Describe the **addition of water** to ethylene resulting in the **production of ethanol** and identify the need for a **catalyst** in this process and the catalyst used

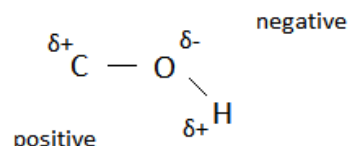
- **Hydration:** reverse reaction, **water added** to a compound



- Catalyst used is **dilute (aqueous) sulphuric acid** + heated
- Both reactions apply to any alkanol/alkene

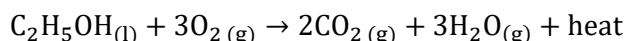
3.3 Describe and account for the many **uses of ethanol as a solvent** for polar and non-polar substances

- Dissolves **polar** substances, e.g. chloroform, CHCl_3 , common ether
 - **OH end** is very polar – O is much more electronegative than C and H
- Dissolves **non-polar** substances, e.g. non-polar iodine, short-chain hydrocarbons (pentane, heptane)
 - **Alkyl section** creates **dispersion forces** between tail and non-polar solute
- Forms **homogenous mixture w/ water** due to **H bonding**

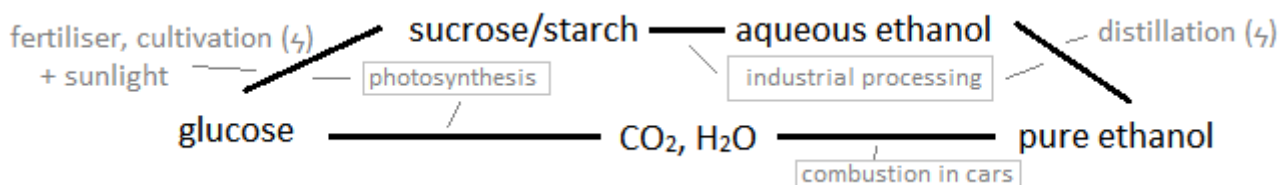


3.4 Outline the use of ethanol as a **fuel** and explain why it is called a **renewable resource**

- Ethanol **readily burns** (combustion)



- Easy to **transport** – use in internal combustion engines, **low C and CO emissions** due to oxygen atom
- Ethanol used as a **petrol extender** – 10-20% used w/o modification
 - Brazil 70s to reduce crude oil
- **Renewable** resource: made from CO_2 , H_2O + sunlight, and **returns CO_2 and H_2O** when burnt

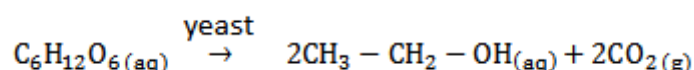


3.5 Describe **conditions** under which **fermentation of sugars** is promoted

- Suitable **micro-organism** – yeast
- Suitable **grain** or **fruit** to mash with water
 - High content of starch/sugars, e.g. **starchy grains** (wheat, corn), **tubers** (potatoes), **molasses**, **fruits**
- Low **oxygen**
- Around **37°C** (blood temperature)

3.6 Summarise the **chemistry** of the **fermentation process**

1. **Enzymes** (biological catalysts) convert starch/sucrose → glucose +/- fructose
2. Other enzymes convert it to ethanol + CO₂



- Bubbles of CO₂ released
3. Yeast produces ethanol approx. **15%** - higher level kills yeast
 4. **Distillation** of aqueous mixture to increase alcohol content → 95%

3.7 Define the **molar heat of combustion** of a compound and calculate the value for **ethanol** from first-hand data

- Molar heat of combustion: **heat liberated** when a **mole of substance undergoes complete combustion** w/ oxygen at standard atm. press. w/ final products being CO₂ and H₂O
 - ΔH – **enthalpy change** = -(energy absorbed) because combustion is exothermic
 - $\Delta H = mC\Delta T$ where: m = mass (g), C = heat capacity (j/g/K), ΔT = change in temperature (K)

heat absorbed by water = $mC\Delta T = 250 \times 4.18 \times (59 - 19) = 41800 \text{ J}$

ethanol used = $221.4 - 219.1 = 2.3 \text{ g}$

heat released per gram of ethanol = $\frac{41800}{2.3} = 18173.913 \dots \text{ J g}^{-1}$
= 18.17 kJ g^{-1}

Spirit burner contains ethanol

Mass of water = 250.0 g

Initial mass of burner = 221.4 g

Final mass of burner = 219.1 g

Initial temperature of water = 19.0°C

Final temperature of water = 59.0°C

molar mass of ethanol, C₂H₅OH = $2 \times 12.01 + 6 \times 1.008 + 16 = 46.068 \text{ g}$

∴ heat released per mole = $18.173913 \times 46.068 = 837.0 \text{ kJ mol}^{-1}$

3.8 Assess the potential of **ethanol as an alternative fuel** and discuss the **advantages and disadvantages** of its use

- Increase of **petrol prices**, **80% demand** for fuel is petroleum derived
- **30% Brazilian cars** run on >25% ethanol fuels
- **Australia + sugar cane and wheat** fermentation (currently uneconomic)

Advantages

- Renewable – reduce use of fossil fuel
- Greenhouse neutral
- Cleaner and more efficient (oxygen atom)

Disadvantages

- Large agricultural land req.
- Engines require modification for >20%
- Environment: soil erosion, deforestation, salinity

3.9 Identify the **IUPAC nomenclature** for straight-chained alkanols from C1 to C8

- Substitute H for OH → '-ol', include number where it appears, e.g. 2-propanol