3) Sulfuric acid is one of the most important industrial chemicals:

3.1 Outline three uses of sulfuric acid in industry –

1. **Production of Fertilisers (MAIN USE OF SULFURIC ACID):**
   - **Superphosphate Fertiliser & Ammonium Sulfate are commercial fertilisers:**

$$2NH_{3\,(g)} + H_2SO_{4\,(aq)} \rightarrow (NH_4)_2SO_{4\,(aq)}$$

2. **Pickling Steel**
   - **Galvanising requires steel to be free of defects (pure) otherwise it is ineffective**
   - **H_2SO_4 removes rust (Fe_2O_3) and other impurities before galvanising the steel item**

$$FeO_{\,(s)} + H_2SO_{4\,(aq)} \rightarrow FeSO_{4\,(aq)} + H_2O_{\,(l)}$$

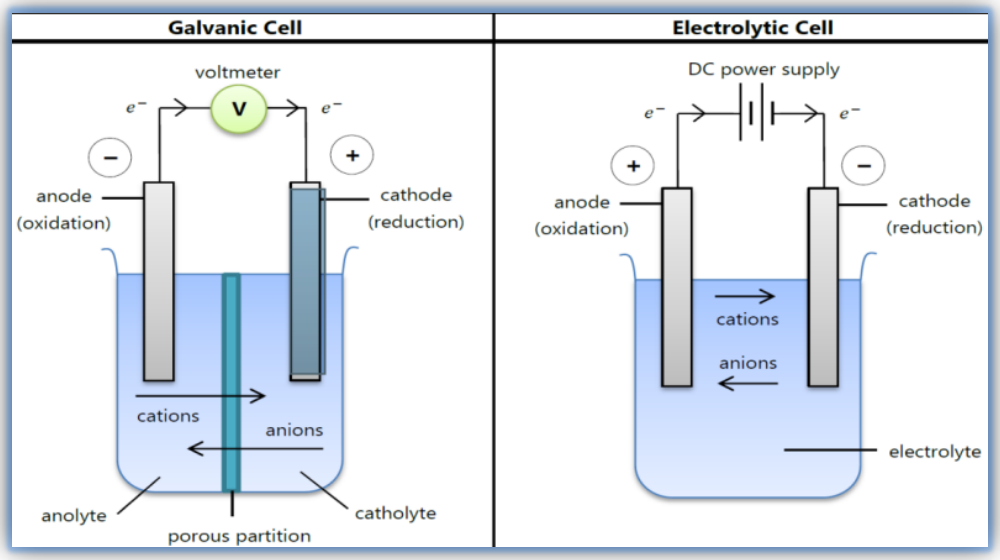
3. **Dehydrating Agent**
   - **Concentrated H_2SO_4 is a strong dehydrating agent → dehydration of ethanol**

$$C_2H_5OH_{\,(l)} \xrightarrow{Conc.H_2SO_4} C_2H_{4\,(g)} + H_2O_{\,(l)}$$

4) The industrial production of sodium hydroxide requires the use of electrolysis:

4.1 Explain the difference between galvanic cells and electrolytic cells in terms of energy requirements –

- Galvanic Cells convert chemical potential energy into electrical energy via spontaneous redox reactions (chemical energy → electrical energy)
- Electrolytic Cells convert external DC electrical energy into chemical energy to drive a non-spontaneous reaction (electrical energy → chemical energy)



Galvanic Cell	Electrolytic Cell
• Spontaneous reaction converts chemical energy → electrical energy	• Electrical energy → chemical energy to produce a non-spontaneous reaction
• Voltage of cell must be positive for reaction to occur ($E^{\emptyset}$>0)	• Applied voltage causes reaction so $E^{\emptyset}$ can be negative (<0) (electrical energy required)
• Anode is negative → oxidation • Cathode is positive → reduction	• Anode is positive → oxidation • Cathode is negative → reduction
• Electrons: Anode → cathode (negative to positive terminal)	• Electrons: Negative battery terminal → cathode, then anode → positive battery terminal
• 2 Half-Cells have separate electrolytes, allowing current to be collected by an external circuit	• 1 compartment with electrodes immersed in one electrolyte • DC source removes electrons from anode and pushes electrons onto cathode → circuit is completed by ion flow

SIMILARITIES:

- Electrolyte conducts electricity in the cell → electrical charge is carried by anions & cations
- Oxidation at anode, reduction at cathode
- In external circuit, current travels through wire from anode → cathode

6.2 Describe the uses of sodium carbonate –

- **Anhydrous sodium carbonate (Soda Ash) is a white crystalline substance that is readily soluble in water → sodium carbonate exists as hydrated salts, the most common being sodium carbonate decahydrate (Washing Soda): $Na_2CO_3 \cdot 10H_2O$**

Uses:

1. **Glass Making: Main use of Na_2CO_3 is in glass making → glass is made by melting a mixture of Na_2CO_3, $CaCO_3$ (limestone) and SiO_2 (silicon dioxide → sand**
2. **Softening Agent: Na_2CO_3 in form of washing soda is used in water treatment to soften water → CO_3^{2-} ions precipitate with Ca^{2+} and Mg^{2+} ions, reducing hardness:**

$$Ca^{2+}_{(aq)} + CO_3^{2-}_{(aq)} \rightarrow CaCO_{3\,(s)}$$

3. **Soap and Detergent Production: Na_2CO_3 is used as a base in the production of soap/detergents, as a cheaper alternative to stronger alkalis e.g. NaOH**
4. **Primary Standard: Na_2CO_3 is a moderately weak base, has high molar mass, remains pure, is a solid and is air-stable, thus can be weighed accurately and used as a primary standard**
5. **Electrolyte: Na_2CO_3 is a very good conductor in electrolysis. CO_3^{2-} ions are not corrosive to the anodes**