32) a) cell - mercury cell
- dye is pumped into the cell at the C\textsuperscript{2-} electrode
  \[ \text{Cl}^- \overset{\text{e}}{\rightarrow} \frac{1}{2} \text{Cl}_2 (g) \text{ at the anode} \]
- the Na forms an amalgam with the mercury Na (Hg)
- it is carried to the decomposer
- at the decomposer the Na reacts with the water
  \[ 2\text{Na} (s) + 2\text{H}_2 \text{O} (l) \rightarrow 2\text{Na} \text{OH} (aq) + \text{H}_2 (g) \]
- forming the desired product NaOH and also hydrogen gas.
- the mercury is then pumped around again to repeat the process.

b) molten NaCl forms
  \[ \text{Cl}^- (aq) \overset{\text{e}}{\rightarrow} \frac{1}{2} \text{Cl}_2 (g) \text{ and Na} (aq) \]
  \[ \text{Na}^+ (aq) + \text{e}^- \overset{\text{Na} (aq)}{\rightarrow} \]
- when molten there is high enough concentration for both the Na and Cl to react, which means that the Na cannot form NaOH
- with water.

- aqueous NaCl forms
  \[ \text{Cl}^- (aq) \overset{\text{e}}{\rightarrow} \frac{1}{2} \text{Cl}_2 (g) + \text{e}^- \]
  \[ \text{H}_2 \text{O} (l) + \text{e}^- \overset{\text{H}_2 (g) + \text{OH}^-}{\rightarrow} \]
- because it is aqueous here is less Na\textsuperscript{+}. the E\textsubscript{o} value is lower than \text{H}_2 \text{O} and which forms \text{OH}^- ions
  \[ 2\text{Cl}^- (aq) + 2\text{H}_2 \text{O} (l) \rightarrow 2\text{Cl}^- (aq) + \text{H}_2 (g) + 2\text{OH}^- \]
- allowing for \text{NaOH} to form.
  \[ 2\text{NaCl} (aq) + 2\text{H}_2 \text{O} (l) \rightarrow 2\text{Na} \text{OH} (aq) + \text{Cl}_2 (g) + \text{H}_2 (g) \]

Office Use Only – Do NOT write anything, or make any marks below this line.
in order NaCl forms Cl₂(g) & Na⁺ because there is a high enough concentration for both to react, however we do not get the desired product

species NaCl forms Cl₂(g) & H₂(g) & OH⁻ ions, because there is a lower conc. of Na⁺ in solution & it is more difficult to react with water react & instead. This enables the desired for product NaOH to form.

c) i) \[ K = \frac{[\text{products}]}{[\text{reactants}]} \]

\[ \frac{2 \text{SO}_2(g) + \text{O}_2(g)}{\text{2SO}_3(g)} \]

\[ = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 \times [\text{O}_2]} \]

\[ = \frac{[5]^2}{[3]^2 \times [1.5]} \]

\[ = 1.85 \times 1.85 \cdots \]

\[ = 3.409 \]

ii) The change in the graph is a change of temperature.

\[ 2 \text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g) \]

is an exothermic reaction. Therefore the temperature decreased as we see a rise in \( \text{SO}_3 \) which means the \( \rightarrow \) is pushing to the right to try a restore itself by creating more heat. By doing so it minimises the impact of the drop in temperature & a \( \rightarrow \) is restored.
Q32) d) reaction type - saponification
   reactant A - NaOH

ii) carried out in a school laboratory:
   1) set up place vegetable oil in a beaker
   2) place 100-L of NaOH into beaker as well
   3) place on a hot plate & stir
   d) a white/yellowish scum forms as the product
   or the soap

   Safety precautions - wear gloves & goggles
   → NaOH can be irritating to the skin & eyes
   → contents of the beaker can occasionally spit
   - wear heat gloves when handling hot plate & ensure the hot plate is cool before touching to ensure you don’t burn yourself.

   In a school laboratory high quality oils & excess NaOH is used. There is often large amount of NaOH left unreached & there is no attempt to remove the glycerol.
(e) Limestone is an integral part of the solvay process. Limestone is used both in the carbonator of the solvay process and in the recovery of ammonia.

The limestone is broken up in the kiln to CaO and CO₂:

\[ \text{CaCO}_3(\text{s}) \xrightarrow{\Delta} \text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \]

The CO₂ is then used in the carbonator to form NaHCO₃:

\[ \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) \xrightarrow{} \text{H}_2\text{CO}_3(\text{aq}) \]

\[ \text{Na}_2\text{CO}_3(\text{aq}) + \text{NH}_3(\text{g}) \xrightarrow{} \text{HCO}_3^- + 2\text{Na}^+ + \text{NH}_4^+ \]

\[ \text{HCO}_3^- + \text{NH}_4^+ + \text{Na}^+ \xrightarrow{} \text{H}^+ + \text{Cl}^- + \text{NaHCO}_3(\text{aq}) \]

The NaHCO₃ is then reacted to form Na₂CO₃:

\[ 2\text{NaHCO}_3(\text{aq}) \xrightarrow{} \text{Na}_2\text{CO}_3(\text{s}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) \]

Furthermore, the lime from CaO is used to convert NH₄Cl back to NH₃ in the ammonia recovery:

\[ \text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{g}) \xrightarrow{} \text{Ca(OH)}_2(\text{aq}) \]

\[ \text{Ca(OH)}_2(\text{aq}) + \text{NH}_4\text{Cl}(\text{aq})(\text{from carbonator}) \xrightarrow{} \text{NH}_3(\text{g}) + \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{g}) \]

Limestone is therefore a highly important part of the solvay process.

- Yet it has significant detrimental environmental impacts. The CaCl₂ formed in the ammonia recovery from the limestone is a waste product. It can be used to de-ice roads however it must often be done. However, it must be disposed of in large bodies of water or in the ocean because it can cause a build up of CaCl₂ in waterways forming a solid precipitate. This can lead to excess Ca²⁺ ions and increased hardness of
Limestone must be mined in large amounts for use in the salting process. This mining is very damaging to the environment. It damages and destroys ecosystems and causes land subsidence, which are potentially dangerous. Mining causes the destruction of landscape and other significant resources such as land to grow crops and fragile ecosystems.

The salting process uses limestone as an integral part of the salting process, yet it has highly detrimental environmental effects.