a) Mercury cell

- Brine is electrolysed in the electrolysis cell, where the anode reaction occurs:

\[
\text{Br}^- \rightarrow \text{Br}_2 + 2e^- \\
\]

and aqueous Na\(^{+}\) is dissolved in the flowing mercury.

- Aqueous Na\(^{+}\) is then electroplated passed through the decomposer, where the cathode reaction occurs:

\[
2\text{H}_2\text{O} \rightarrow \text{H}_2 + 2\text{OH}^- \\
\]

As the product OH\(^-\) ion then forms with Na\(^{+}\) in mercury,

\[
\text{Na}^{+} + \text{OH}^- \rightarrow \text{NaOH} \quad \text{(aq)} \\
\]

and so sodium hydroxide is extracted.

<table>
<thead>
<tr>
<th>Component</th>
<th>Anode Reaction</th>
<th>Cathode Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>2Cl(^-) \rightarrow Cl(_2) + 2e(^-)</td>
<td>\text{due to presence of Na}_2\text{O}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>\text{due to loss of Na}_2\text{O}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>\text{Na}^{+} + e(^-) \rightarrow \text{Na} \quad \text{(aq)}</td>
</tr>
</tbody>
</table>

Overall:

\[
2\text{Cl}^- + 2\text{Na}^{+} \rightarrow \text{Cl}_2 + 2\text{Na} \quad \text{(aq)} \\
\]

\[
2\text{Cl}^- + 2\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{Cl}_2 + 2\text{OH}^- \\
\]
Though both are similar in some respects, there are differences in electrode reactions, due to lack of hydroxide. Solid NaCl is formed from electrolysis of molten NaCl.

\[ 2 \text{SO}_2 + \text{O}_2 \rightleftharpoons 2 \text{SO}_3 \]

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

\[ \begin{array}{c|c|c|c}
2 \text{SO}_2 & + & \text{O}_2 & \rightleftharpoons 2 \text{SO}_3 \\
0.80 & & 0.40 & 0 \\
\Delta n & -0.30 & -0.15 & +0.30 \\
n_e & 0.50 & 0.25 & 0.75 \\
\Delta n & 5.0 & 2.5 & 3.0 \\
\end{array} \]

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

\[ = \frac{[3.0]^2}{[8.0]^2[2.5]} \]

\[ = 0.104 \]

\[ \frac{1}{0.14} \text{ at time A} \]

\[ \text{eq} \text{ start at time A & 0.14}. \]

ii) The temperature could have been lowered.

\[ 2 \text{SO}_2 + \text{O}_2 \rightleftharpoons 2 \text{SO}_3 \]

\[ \Delta H = -\text{ve} \]

The forward reaction is exothermic.

By reducing the temperature of the system, the excess of NO(g) according to Le Chatelier's principle, would counteract the changes applied to it. Therefore, the system would release heat to counteract the drop in temperature, thus the exothermic reaction.

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is favored, and so is the forward reaction. Thus, more SO₂ is produced and the excess mole of SO₂ is decreased, eqn shifts to the right.
Start here.

- Reactant A: sodium hydroxide

- Saponification

- Safety: sodium hydroxide is caustic and so gloves should be worn when handling it.

- Oil is placed in a 50 ml test tube (olive oil).

- A 200 mL water bath is prepared.

- The excess sodium chloride around 20 mL is added to the test tube and the test tube is put in the hot water bath.

- The mixture is stirred for 10 minutes.

- The concentrated NaOH solution is then added.

- The soap is then further stirred until all the soaps has precipitated out.

- The soap is taken out and dried.

- Safety: water bath is used to prevent the oil from lighting up as the oil can possibly be volatile, though unlikely.
c) Importance: Lime stone is used to generate CO₂

\[ \text{CaCO}_3(s) \xrightarrow{4} \text{CaO(s)} + \text{CO}_2(g) \]

which is used to produce sodium bicarbonate

\[ \text{CaO(s)} + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}_2\text{CaO}(s) \]

\[ \text{H}_2\text{O}_2\text{CaO}(s) + \text{NH}_3(g) \rightarrow \text{NH}_4\text{H}_2\text{O}_2\text{CaO}(s) \]

\[ \text{NH}_4\text{H}_2\text{O}_2\text{CaO}(s) + \text{Na}^+ \rightarrow \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(l) \]

and used to produce sodium carbonate

the CaO is also used to recover ammonia

\[ \text{NH}_4^+(aq) \rightarrow \text{NH}_3(g) + \text{H}^+(aq) \]

\[ 2\text{NH}_3(g) + \text{CaO(s)} \rightarrow 2\text{NH}_4^+(aq) + \text{CaCl}_2(aq) + \text{H}_2\text{O}(aq) \]

Thus, lime stone is a vital part of the Solvay process, as it is not only used for production of Na₂CO₃ but also for recycling of NH₃, which is also used in the production.

- By using lime stone, there are both positive and negative environmental impact.

- Positive:
  - assist in recycling of ammonia.
  - CaO obtained from generating CO₂ can be used to recycle ammonia from ammonium ion.

Thus, there is no need of using none ammonia.

- Also, there is no need to dispose ammonia, which is very toxic to the environment
  - causes respiratory problems if inhaled.

However, there is also the bad environmental impact.

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- Mining of limestone
  - Mining of limestone can cause noises and particles in the air.
  - The noise can disturb the wildlife around the mining area.
  - The increase in particles in the air is also bad for various organisms and structures.
    - The particles can block the plant's leaves, preventing the plant's respiration and also hinder the plant's photosynthesis.
    - The small particles are bad to breathe in.
  - Mining in sensitive area can also cause instability of land and so, collapse.

This, the mine must be considered to minimise the impact on the environment.

You may ask for an extra Writing Booklet if you need more space.