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32) a) cell - mercury cell

- brine is pumped into the cell & the Cl^- reacts at the anode

$$Cl^-_{(aq)} \rightleftharpoons \tfrac{1}{2} Cl_{2(g)} + e^-$$ forming chlorine gas

- the Na forms an amalgam with the mercury $Na(Hg)$ & is carried to the decomposer

- at the decomposer the Na reacts with the water

$$2Na_{(aq)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$$

forming the desired product NaOH & also hydrogen gas.

- the mercury is then pumped around again to repeat the process

b) molten NaCl forms $Cl^-_{(aq)} \rightleftharpoons \tfrac{1}{2} Cl_{2(g)} + e^-$

$$Na^+_{(aq)} + e^- \rightleftharpoons Na_{(s)}$$

$$Na^+_{(aq)} + 2Cl^-_{(aq)} \rightleftharpoons Cl_{2(g)} + Na_{(s)}$$

when molten there is high enough concentration for both the Na & the Cl to react, which means that the Na cannot form NaOH with water

aqueous NaCl forms $Cl^-_{(aq)} \rightleftharpoons \tfrac{1}{2} Cl_{2(g)} + e^-$

$$H_2O_{(l)} + e^- \rightleftharpoons \tfrac{1}{2} H_{2(g)} + OH^-$$

- because it is aqueous there is less Na $\therefore$ the E° value is lowered to H_2O, which forms OH^- ions

$$2Cl^-_{(aq)} + 2H_2O_{(l)} \rightleftharpoons Cl_{2(g)} + H_{2(g)} + 2OH^-$$

allowing for NaOH to form:

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

- molten NaCl forms $Cl_{2(g)}$ & $Na_{(s)}$ because there is a high enough concentration for both to react, however we do not get the desired product
- aqueous NaCl forms $Cl_{2(g)}$ & $H_{2(g)}$ & OH^- ions, because there is a lower conc. of Na in solution & it is more difficult to react ∴ water reacts instead. This enables the desired product NaOH to form.

c) i) $K = \dfrac{[\text{products}]}{[\text{reactants}]}$: $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$= \dfrac{[SO_3]^2}{[SO_2]^2 \times [O_2]}$

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

$= 1.85185\ldots$

$= 1.9$

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

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ is an exothermic reaction

therefore the temperature decreased as we see a rise in SO_3 which means the $\rightleftharpoons$ is pushing to the right to try & restore itself by creating more heat.

by doing so it minimises the impact of the drop in temperature & a $\rightleftharpoons$ is restored.

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Q32) d) i) reaction type - saponification

reactant A - NaOH

ii) carried out in a school laboratory:

1) ~~excess~~ place 100mL of vegetable oil in a beaker

2) place 100mL of NaOH into beaker as well

3) place on a hot plate & stir

4) 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 occassionally 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 ~~esse~~ used. There is often large amounts of NaOH left unreacted & there is no attempt to remove the glycerol.

e) Limestone is an integral part of the solvay process. Limestone is used both ~~because~~ in the carbonator of the solvay process & in the recovery of ammonia.

the limestone is broken up in the kiln to CaO & CO_2

$$CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$$

The CO_2 is then used in the carbonator to form $NaHCO_3$

$$H_2O_{(l)} + CO_{2(g)} \rightleftharpoons H_2CO_{3(aq)}$$

$$H_2CO_{3(aq)} + NH_{3(aq)} \longrightarrow HCO_{3(aq)}^- + NH_{4(aq)}^+$$

$$HCO_{3(aq)}^- + NH_{4(aq)}^+ + NaCl_{(aq)} \longrightarrow NH_4Cl_{(aq)} + NaHCO_{3(s)}$$

→ the $NaHCO_3$ is then converted into Na_2CO_3

$$2\,NaHCO_{3(aq)} \longrightarrow \underset{\text{product}}{Na_2CO_{3(aq)}} + H_2O_{(l)} + CO_{2(g)}$$

→ furthermore the limestone ^CaO is used to convert NH_4Cl back to NH_3 in the ammonia recovery

$$CaO_{(aq)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)}$$

$$Ca(OH)_{2(aq)} + NH_4Cl_{(aq)\,(\text{from carbonator})} \longrightarrow NH_{3(g)} + CaCl_{2(aq)} + H_2O_{(l)}$$

→ limestone is therefore a highly important part of the solvay process.

- yet it has significant detrimental environmental impacts. The $CaCl_2$ formed in the ammonia recovery from the limestone is a waste product. It can be used to de-ice roads however is most often dumped. However it must be disposed of in large bodies of water or in the ocean, because it can cause a build up of $CaCl_2$ in waterways forming a solid precipitate. This can lead to excess Ca^{2+} ions & increased hardness of

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water in waterways. Furthermore Limestone must be mined in large amounts for use in the solvay process. This mining ~~is~~ is very damaging to the environment. It damages & destroys ecosystems & can cause land subsadies which are potentially dangerous. Mining causes the destruction of landscape & of other significant resources such as land to grow crops & fragile ecosystems.

~~The Solvay process~~

Limestone is an integral part of the solvay process, yet it has highly detrimental environmental effects.

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