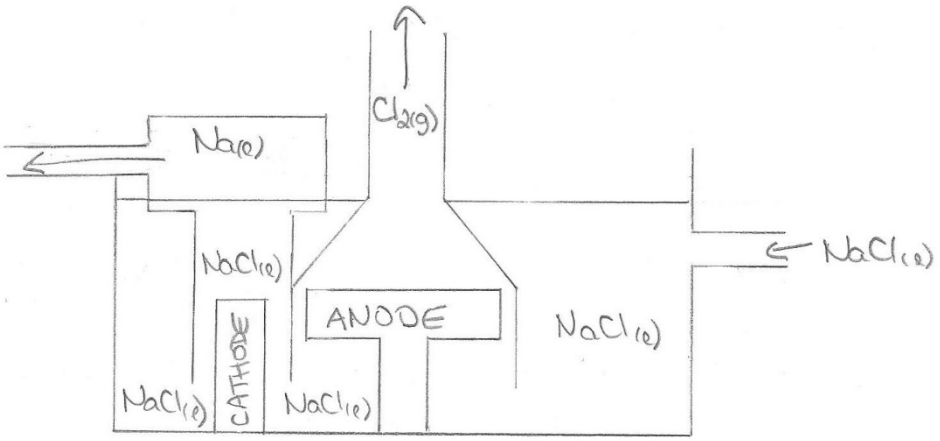
# Answers to Exercise 6.4
# Industrial Processes: Electrolysis of Sodium Chloride

1.

(a)




(b) $Na^+(l) + e^- \rightarrow Na(l)$

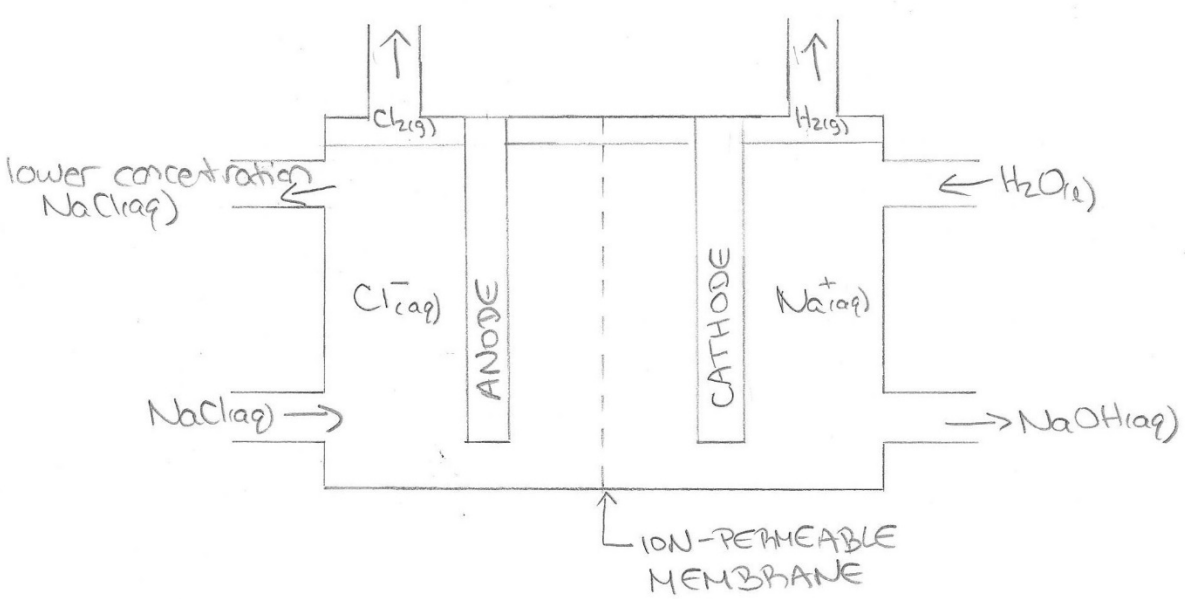
(c) $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$

(d) $2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

(e) As a gas, $Cl_2(g)$ can be piped directly out of the cell at the anode.

Na(l) is not soluble in NaCl(l). As such, the Na(l) floats on the NaCl(l) and can therefore be pumped out of the cell in pure form.

2.




A solution of NaCl(aq) is electrolyzed in an electrolytic cell.

The cell contains an ion-permeable membrane separating two chambers. This allows separation of the $Na^+$(aq) cations and the $Cl^-$(aq) anions.

The $Cl^-$(aq) anions are oxidized at the anode to $Cl_2$(g) which is piped out of the cell.

In the other chamber, $H^+$(aq) cations in the water are reduced at the cathode to give $H_2$(g) which is also piped out of the cell. As $H^+$(aq) cations are consumed, more $H^+$(aq) and $OH^-$(aq) are produced from the water. *Recall Le Châtelier's principle and what happens when a product is removed from a system at equilibrium.* This results in a build-up of $OH^-$(aq) anions which are pumped away along with the spectator $Na^+$(aq) cations as NaOH(aq).

At cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$ <u>and</u> $2H_2O(l) \rightleftharpoons 2H^+(aq) + 2OH^-(aq)$

*gives an overall reaction of:*

$$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$

At anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

Overall: $2H_2O(l) + 2Cl^-(aq) \rightarrow H_2(g) + 2OH^-(aq) + Cl_2(g)$

*or* $2H_2O(l) + 2NaCl(aq) \rightarrow H_2(g) + 2NaOH(aq) + Cl_2(g)$