1. The diagram shows a membrane cell used for the electrolysis of sodium chloride solution.

   (a) Add the following labels to the diagram:

   - chlorine gas
   - concentrated sodium chloride solution
   - concentrated sodium hydroxide solution
   - dilute sodium chloride solution
   - dilute sodium hydroxide solution
   - hydrogen gas
   - membrane

   (b) Which ions pass through the membrane from left to right?

   _______________________________________________________[1]

   (c) Finish the ionic equations for the reactions at the positive and negative electrodes.

   Positive electrode .......Cl\(^-\) → Cl\(_2\) + .....e\(^-\)

   Negative electrode .....H\(_2\)O + 2e\(^-\) → H\(_2\) + .....OH\(^-\) [2]

   (d) Suggest why the cost of setting up a mercury cell is greater than setting up a membrane cell.

   _______________________________________________________[1]
2. Potassium hydroxide can be produced by the electrolysis of aqueous potassium chloride solution.

The overall process is summarised by the equation:

$$2\text{KCl} + 2\text{H}_2\text{O} \rightarrow 2\text{KOH} + \text{H}_2 + \text{Cl}_2$$

(a) Hydrogen and chlorine are produced in equal volumes.

Explain why a much greater mass of chlorine is produced than of hydrogen. (Relative atomic masses: $\text{H} = 1$, $\text{Cl} = 35.5$)

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_____________________________________________________________________________________[2]

(b) Calculate the mass of potassium chloride required to produce 5.6 tonnes of potassium hydroxide. Assume that all of the potassium chloride is converted into potassium hydroxide. (Relative atomic masses: $\text{H} = 1$, $\text{O} = 16$, $\text{Cl} = 35.5$, $\text{K} = 39$)

__________________________________________________________________________________________tonnes [3]
(c) This scientist is finding the concentration of a dilute solution of potassium hydroxide in mol/dm$^3$. Describe how they do this experiment, naming the pieces of apparatus they are using. Complete the equation written on the board.

Equation: ____________________________________________________________[6]
3. Salt can be mined from deposits deep underground by solution mining.
   (a) Outline the process of solution mining.

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   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________[3]

   (b) Why is it possible to mine salt but not coal by solution mining?

   ________________________________________________________________[1]

   (c) Why is hot water not used in the process?

   ________________________________________________________________[2]

   (d) Suggest any social, economic or environmental problems caused by solution mining.

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________[2]
4. The map shows an area in North Cheshire. Electrolysis of brine is carried out in this area.

(a) What are the raw materials and products of this process?

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______________________________________________________________[3]

(b) List reasons why a factory producing sodium hydroxide using membrane cells might be built at the place labelled on this map.

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______________________________________________________________[5]