Electrolysis – predicting the products at each electrode.

Lesson 1a

Consider the following conditions when predicting products at each electrode during electrolysis.

- At the positive terminal (anode) oxidation will occur and it is the strongest reductant present, making contact with the anode or forming the anode, that will react.
- At the negative terminal (cathode) reduction will occur and it is the strongest oxidant present making contact with the anode, or forming the anode, that will react.

eg 1.

Consider the electrolytic cell shown in diagram 1

Write the half reactions occurring at the anode and cathode.

Step 1 Find all the reductants present in the solution and in contact with the anode(+).

Cu(s)

$H_2O(l)$

Step 2 Find the strongest reductant in contact with the anode(+).

Cu(s) (in fact Cu is the anode)

Step 3 Find all the oxidants present.

$Ni^{2+}(aq)$

$H_2O(l)$

Step 3 Find the strongest oxidant in contact with the cathode(-).

$Ni^{2+}(aq)$

Step 4 Write the half equations

Reaction taking place at the anode

$Cu(s) \rightarrow Cu^{2+} + 2e^-$ (oxidation)

Reaction taking place at the cathode

$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$

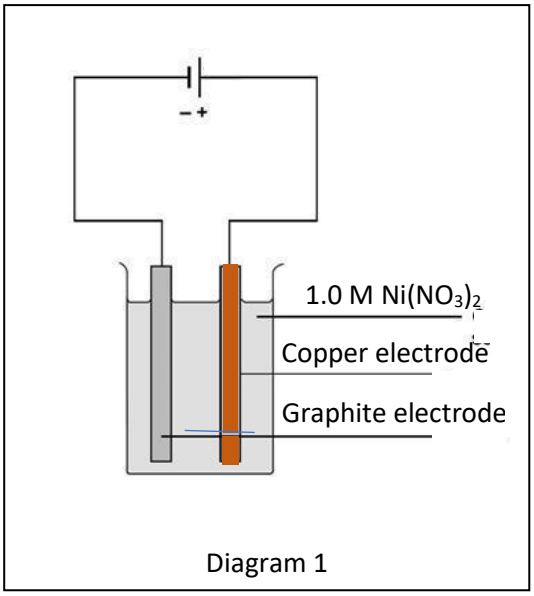


Diagram 1

1. Consider the electrolytic cell shown in diagram 2.
   a. Write the balanced equations to the reactions occurring at the:
      i. Anode

      ii. Cathode

   b. What will happen to the pH of the electrolyte solution? Explain.

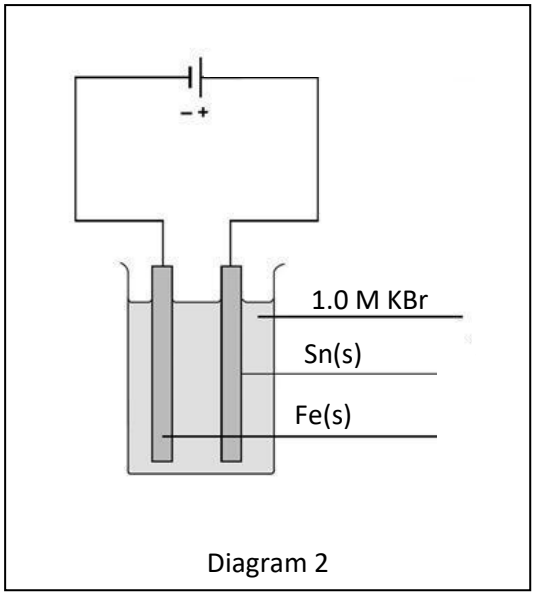


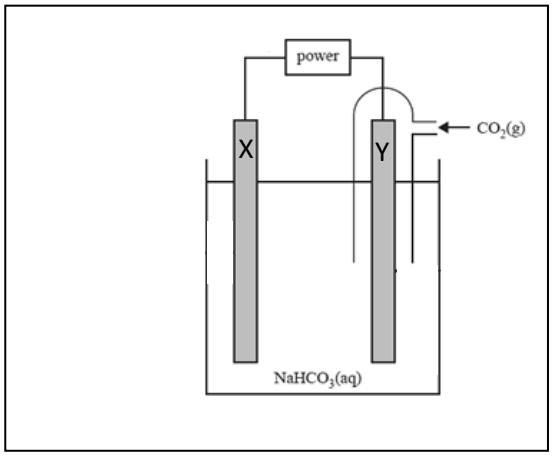
Diagram 2

   c. Explain how each electrode changes as the cell operates.

2. Consider the electrolytic cell shown on the right. It is used to produce ethanol from water and carbon dioxide gas. Given the following two half-cell reactions answer the following questions.

i. $O_2(g)+2H_2O(l)+4e^- \rightarrow 4OH^-(aq)$ $E^o= +0.40V$

ii. $2CO_2(g)+9H_2O(l)+12e^- \rightarrow C_2H_5OH(l)+12OH^-(aq)$ $E^o= -0.33V$



a. Identify the :
   i. Anode ____ , Polarity _____
   ii. Cathode ____ , Polarity _____

b. Give the overall cell equation, states included.

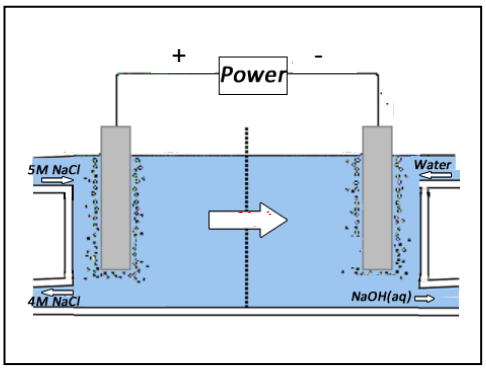
c. What material can be used for electrodes X and Y? Justify your answer.

d. Identify the reducing agent in the cell and justify your answer with the use of oxidation numbers.

e. What cell voltage should be applied to run the electrolytic cell?

f. How does the pH of the electrolyte ($NaHCO_3(aq)$) change. Justify your answer given that HCO_3^- is weak base and CO_3^{-2} is an even weaker base..

3. NaOH and Cl_2 gas are important chemicals in industry. They are both produced via the electrolysis of brine solution, which is concentrated NaCl. Consider the membrane electrolytic cell shown on the right. During the operation of this cell gas is produced at both electrodes. During the cell's operation a smell of chlorine is noticed coming from one of the electrodes.



a. Give the balanced equation for the reaction occurring at the anode.

b. Give the balanced equation for the reaction occurring at the anode.

c. Indicate in the diagram the ions that flow in the direction pointed to by the arrow.

d. Explain how the synthesis of NaOH and Cl_2 may be impacted if the fresh water supply to the cell was contaminated with nitric acid from a near by fertiliser synthesis facility. Make reference to the E^0 series in your explanation.

e. A chemical engineer suggested making a change to this electrolytic cell in order to keep costs down. She suggested that an iron anode be used. Explain, with the use of a chemical equation and reference to the E^o series, how the products may change with the use of an iron anode.

f. The reaction between H_2 and Cl_2 is explosive. What is the purpose of the semi-permeable membrane in this cell and how does it function?