

CHAPTER 10 LAB ACTIVITIES

INVESTIGATION 10.1.1 A POTASSIUM IODIDE ELECTROLYTIC CELL

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Evidence

(a)

Before the cell was connected,

the solution was completely colourless and both litmus and halogen tests gave negative results.

After the cell was connected and in operation for a few minutes,

at the black (negative) electrode and nearby solution:

- many colourless gas bubbles were continuously produced,
- red litmus turned blue,
- the hexane layer remained colourless.

at the red (positive) electrode and nearby solution:

- a yellow-brown colour of solution and some black precipitate formed and settled to the bottom of the tube,
- litmus did not change in colour,
- the hexane layer was purple.

Analysis

- (b) According to the evidence collected, a colourless gas and hydroxide ions were likely produced at the negative electrode. The observations strongly suggest the formation of iodine at the positive electrode.

Evaluation

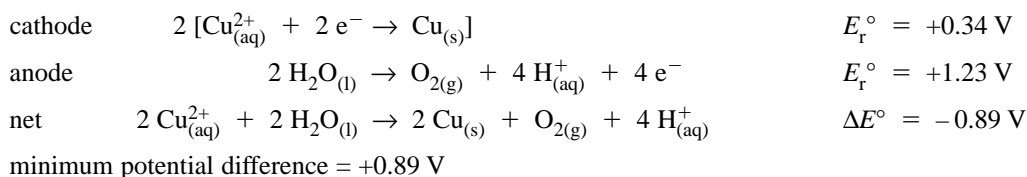
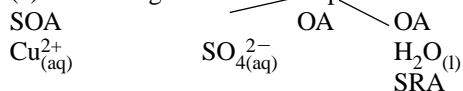
- (c) The design was mostly adequate to answer the question, except for the identification of the gas. An improvement would be to collect and test the gas produced. The presence of hydroxide ions could be further confirmed by an additional test such as a precipitation. The control tests were quite adequate to show changes.
- (d) It was not possible to identify the gas produced because it could not be collected in the apparatus used.
- (e) A Hoffmann apparatus could be used to conduct the electrolysis and collect the gas. (Alternatively, a test tube filled with solution and inverted over the electrode in a large beaker could be used.) A splint and matches should be provided to conduct the hydrogen and oxygen tests.
- (f) The electrodes should not touch because this would short-circuit the cell. The electricity would flow directly from one electrode to the other without being forced through the solution and little or no reaction would occur. (This may also be dangerous because the current in the circuit may become high enough to melt some components or blow a fuse.)
- (g) Iodine is formed at the positive electrode. Iodine solution and solid are more dense than water and therefore sink to the bottom of the tube.
- (h) The quality of evidence is quite good, except for the identification of the gas. The litmus and halogen tests, compared with the control, clearly showed that a basic solution and iodine were formed as a result of the reaction.

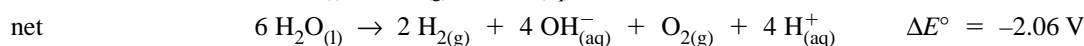
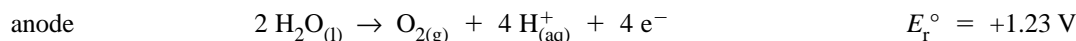
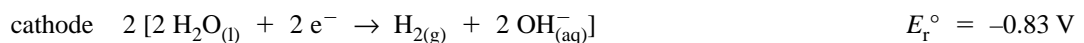
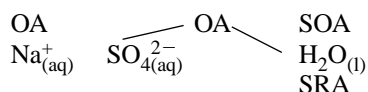
INVESTIGATION 10.1.2 INVESTIGATING SEVERAL ELECTROLYTIC CELLS

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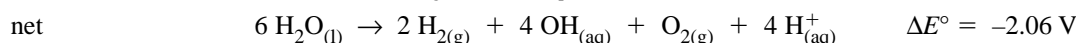
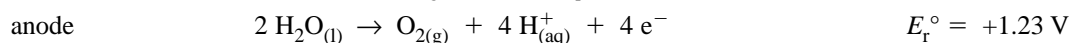
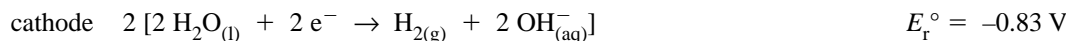
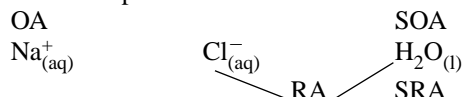
Prediction

- (a) According to redox concepts and the table of half-reactions,





minimum potential difference = +2.06 V



minimum potential difference = +2.06 V

Evidence

(b)

Cell	Cathode	Anode
C _(s) CuSO _{4(aq)} C _(s) applied voltage 6 V	<ul style="list-style-type: none"> blue litmus turned red before and after the cell operated red-brown solid formed on C_(s) 	<ul style="list-style-type: none"> blue litmus turned red before and after the cell operated gas bubbles formed on C_(s)
Pt _(s) Na ₂ SO _{4(aq)} Pt _(s) applied voltage 6 V	<ul style="list-style-type: none"> no change in litmus before the cell operated red litmus turned blue in final solution about 31 mL of gas collected a loud, squeaky sound heard when gas sample was ignited 	<ul style="list-style-type: none"> no change in litmus before the cell operated blue litmus turned red in final solution about 16 mL of gas collected a glowing splint burst into flame in gas sample
Pt _(s) NaCl _(aq) Pt _(s) applied voltage 6 V	<ul style="list-style-type: none"> no change in litmus before the cell operated red litmus turned blue in final solution about 31 mL of gas collected a loud, squeaky sound heard when gas sample was ignited 	<ul style="list-style-type: none"> no change in litmus before the cell operated both red and blue litmus turned white in final solution a strong odour of bleach detected yellow-brown colour appeared on addition of NaI_(aq) to a sample of the solution purple colour of hexane layer observed

Analysis

(c) According to the evidence collected, the products of the electrolytic cells are:

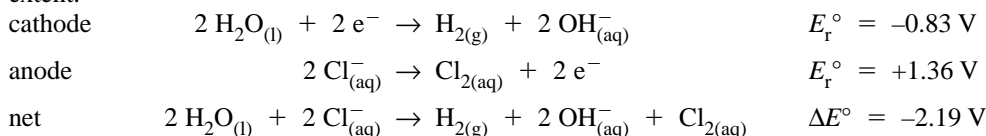
Cell	Cathode products	Anode products
CuSO _{4(aq)}	Cu _(s)	colourless gas
Na ₂ SO _{4(aq)}	H _{2(g)} , OH ⁻ _(aq)	O _{2(g)} , H ⁺ _(aq)
NaCl _(aq)	H _{2(g)} , OH ⁻ _(aq)	Cl _{2(aq)}

Evaluation

- (d) The experimental design is judged to be adequate with no obvious flaws. The problem was answered with reasonable certainty and the controls for the litmus test were adequate. There are two ways to improve the electrolysis of aqueous copper(II) sulfate. One is to use an apparatus so that the gas can be collected and identified. The other is to use pH paper or a pH meter instead of litmus paper. These changes would increase the certainty of the results.
- (e) The overall quality of the evidence is good. There is some uncertainty about the results for the litmus test on the copper(II) sulfate solution. This could be solved by using pH paper or a pH meter. Overall, I am quite certain because the majority of the products were clearly identified with the diagnostic tests.
- (f) The predictions for the cathode product of copper(II) sulfate and the cathode and anode products of the sodium sulfate solution were verified because the predicted products clearly agree with the experimental results. The prediction of the anode product for copper(II) sulfate could not be judged with sufficient certainty. The prediction for the cathode products of sodium chloride was also verified but the prediction for the anode products was falsified by the evidence obtained.
- (g) The redox concepts and table remain acceptable until further results are obtained. Most of the predictions were verified except for the anode product of the sodium chloride electrolysis. It is necessary to determine how unique the result for sodium chloride is. It may be necessary to restrict or revise the concepts or procedure used to predict the products.

Synthesis

- (h) The oxidation of water at the anode of the sodium chloride cell did not seem to occur, or occurred to a very limited extent.



The minimum potential difference is +2.19 V.

- (i) The minimum potential difference for oxygen as a product is 2.06 V and for chlorine as a product is 2.19 V. There is only 0.13 V difference between the two.
- (j) The applied voltage in the electrolysis was 6 V, which is considerably higher than both minimum potential differences. Based on this fact and the fact that the minimum potential differences are so close, it is possible that the production of chlorine is much faster than that of oxygen. This could explain the larger quantity of chlorine produced.
- (k) The rules should be retained until additional electrolyses of chloride solutions are conducted. If the same results appear, then the rules should be revised to account for this new information.

INVESTIGATION 10.3.1 INVESTIGATING AN ELECTROLYTIC CELL

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Prediction

- (a) According to a modern reference, the value of the Faraday, F , is $9.65 \times 10^4 \text{ C/mol}$.

Evidence

Electrode	Masses of copper electrodes	
	Initial mass (g)	Final mass (g)
labelled A	2.88	2.35
labelled C	2.74	3.28

- electric current decreased slightly near the start and was adjusted to a relatively constant 0.75 A
- elapsed time = 35 min 4 s
- cathode developed some dark brown crystals particularly at the edges
- some very thin, darker-coloured flakes fell off the anode when dipped in distilled water and acetone
- the final masses did not change when remeasured after a few minutes

Analysis

- (b) for the cathode: $\Delta m = 3.28 \text{ g} - 2.74 \text{ g}$
 $= 0.54 \text{ g}$
 for the anode: $\Delta m = 2.88 \text{ g} - 2.35 \text{ g}$
 $= 0.53 \text{ g}$