Investigation 13.B: Electrolysis of Aqueous Potassium Iodide Answer Key

Answers to Prediction Question

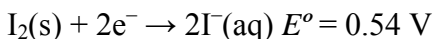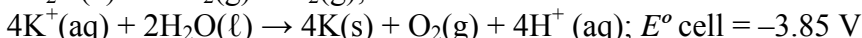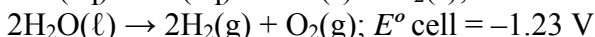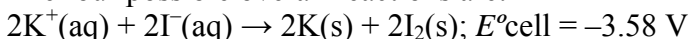1. The K^+(aq) and I^-(aq) concentrations are 1 mol/L, so the standard reduction potentials for the half-reactions that involve these ions should be used. The non-standard values for water should be used.

    $I_2(s) + 2e^- \rightarrow 2I^-(aq)\ E^o = 0.54$ V
    $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(\ell)\ E^o = 0.81$ V
    $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)\ E^o = -0.41$ V
    $K^+(aq) + e^- \rightarrow K(s)\ E^o = -3.04$ V
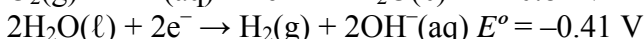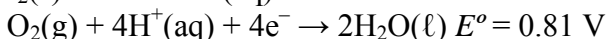
    The four possible overall reactions are:
    $2K^+(aq) + 2I^-(aq) \rightarrow 2K(s) + 2I_2(s);\ E^o\text{cell} = -3.58$ V
    $2H_2O(\ell) \rightarrow 2H_2(g) + O_2(g);\ E^o\text{ cell} = -1.23$ V
    $4K^+(aq) + 2H_2O(\ell) \rightarrow 4K(s) + O_2(g) + 4H^+(aq);\ E^o\text{ cell} = -3.85$ V
    $2H_2O(\ell) + 2I–(aq) \rightarrow H_2(g) + 2OH^-(aq) + I_2(s);\ E^o\text{ cell} = -0.95$ V

    The cell reaction that produces hydrogen gas, hydroxide ions, and iodine requires the lowest external voltage. Therefore, you should predict the formation of these products. The hydrogen gas and hydroxide ions should form at the cathode, and the iodine should form at the anode.

Answers to Analysis Questions

1.
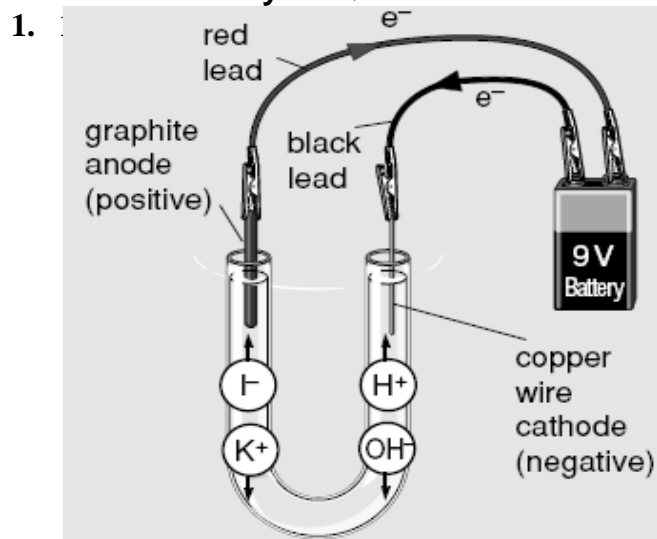
2. Adding the starch solution to the electrolyte at the anode results in a purple solution, indicating the presence of molecular iodine. At the cathode, the clear, colourless phenolphthalein solution will turn pink, indicating that the solution is basic and suggesting the presence of hydroxide ions. (Hydrogen gas is also formed at the cathode, but students do not test for the gas.)

3. $2I^-(aq) \rightarrow I_2(s) + 2e^-$

4. $2H_2O(\ell) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

5. $2I^-(aq) + 2H_2O(\ell) \rightarrow I_2(aq) + H_2(g) + 2OH^-(aq)$

6. E^ocell $= E^o$cathode $- E^o$anode
    $= -0.83$ V $- (+0.54$ V$)$
    $= -1.37$ V

    The calculated external voltage needed is 1.36 V. The actual voltage needed to carry out this electrolytic process is greater than this. As you learned on p. 505 of the textbook, this excess is called overpotential. This is the reason that the external voltage used in this investigation was significantly higher than the calculated value.

Answer to Conclusion Question

7. The products from the electrolysis of 1 mol/L KI(aq) are iodine, hydrogen gas, and hydroxide ions. These are the products that you should have predicted using the method shown in the Sample Problem on p. 507 of the textbook.

Answers to Application Questions

8. The observations would probably not change. Consider the four possible reactions. The electrolysis of aqueous sodium iodide requires greater external voltage than the electrolysis of water. The reaction producing sodium metal and hydrogen ions also requires greater external voltage than the electrolysis of water. However, the reaction producing iodine, hydroxyl ions, and hydrogen gas requires less external voltage than the electrolysis of water. These are the same products that were observed in the investigation.

9. The procedure would need to be changed. The investigation would need to be carried out at a temperature higher than the melting point of potassium iodide. Also, inert electrodes would need to be used. Refer to the discussion of the electrolysis of molten salts on p. 509 of the textbook.