Chemistry 30

# Unit 6: Redox Reactions and Electrochemistry

Practice Set 4: Electrochemical Cells

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For questions 1 to 3, two half-cells are connected under standard conditions to make an electrochemical cell. Use the Table of Standard Reduction Potentials included with this assignment to obtain the half-reactions involved. For each:

a. write the equation for each half-reaction that will occur
b. label each half-reaction as oxidation or reduction
c. calculate the voltage of the electrochemical cell
d. the net overall **balanced** redox equation.
e. diagram the cell, clearly indicating the following
   - the electrodes in appropriate electrolytic solutions
   - label each electrode as anode or cathode
   - label each electrode as positive post or negative post
   - diagram the flow of electrons through the external circuit
   - a salt bridge with appropriate electrolytic solution
   - flow of ions from the salt bridge to the two half-cells

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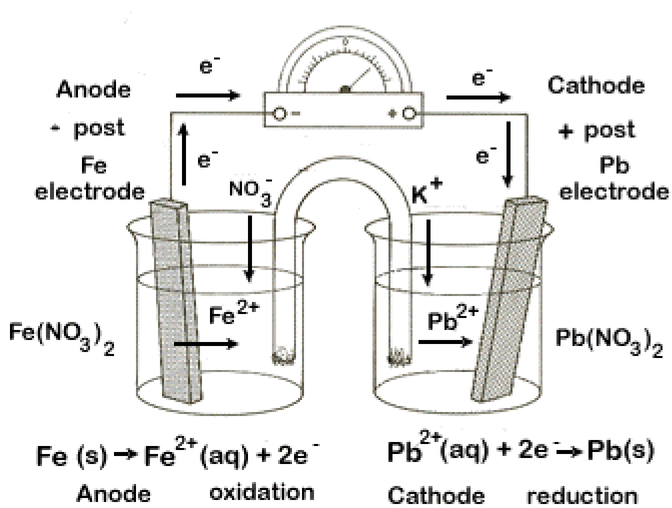
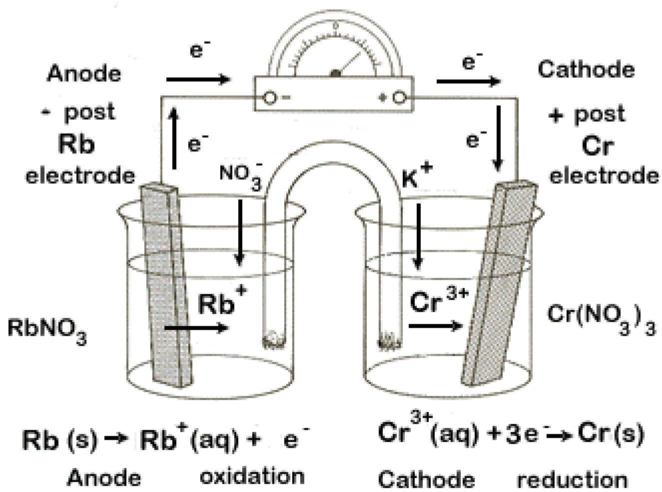
1. iron-iron(II) ion ($Fe|Fe^{2+}$) and lead-lead(II) ion ($Pb|Pb^{2+}$)

| | | | E° (V) | |
|---|---|---|---|---|
| cathode | reduction | $Pb^{2+} + 2e^- \rightarrow Pb(s)$ | -0.13 | + electrode |
| anode | oxidation | $Fe(s) \rightarrow Fe^{2+} + 2e^-$ | +0.45 | - electrode |
| | | **$Fe(s) + Pb^{2+} \rightarrow Pb(s) + Fe^{2+}$** | **+0.32** | |



2. chromium-chromium(III) ion ($Cr|Cr^{3+}$) and rubidium-rubidium ion ($Rb|Rb^{+}$)

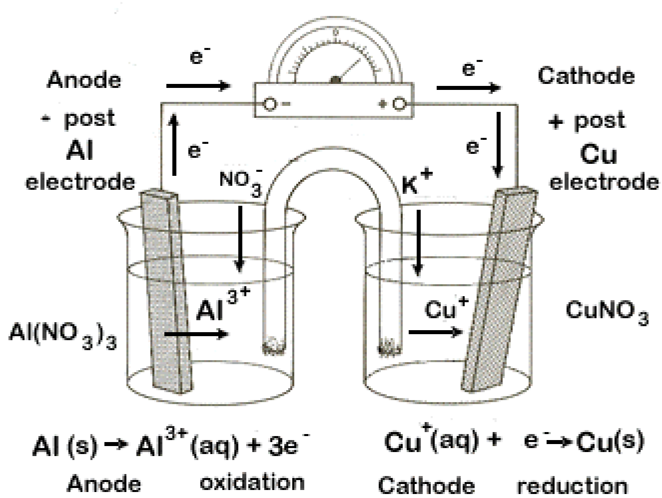
| | | balance for $e^-$ | | E° (V) | |
|---|---|---|---|---|---|
| cathode | reduction | | $Cr^{3+} + 3e^- \rightarrow Cr(s)$ | -0.74 | + electrode |
| anode | oxidation | × 3 | $Rb(s) \rightarrow Rb^+ + e^-$ | +2.98 | - electrode |
| | | | **$3\,Rb(s) + Cr^{3+} \rightarrow Cr(s) + 3Rb^+$** | **+2.24** | |




3. copper-copper(I) ion ($Cu|Cu^{+}$) and aluminum-aluminum ion ($Al|Al^{3+}$)

(NOTE: Be sure to use the $Cu^{1+}$ half-reaction, not $Cu^{2+}$)

| | | balance for $e^-$ | | E° (V) | |
|---|---|---|---|---|---|
| cathode | reduction | × 3 | $Cu^+ + e^- \rightarrow Cu(s)$ | +0.52 | + electrode |
| anode | oxidation | | $Al(s) \rightarrow Al^{3+} + 3e^-$ | +1.66 | - electrode |
| | | | **$Al(s) + 3\,Cu^+ \rightarrow 3Cu(s) + Al^{3+}$** | **+2.18** | |



4. a. An electrochemical cell is created using gold and magnesium half-cells. Determine which half-cell will undergo oxidation and which will undergo reduction, identify anode and cathode, and calculate the voltage for the cell. You do not need to diagram the cell.

   b. If the mass of the magnesium electrode changes by 5.0 g, what will be the change in mass of the gold electrode, and will its mass increase or decrease?

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Part a.

| | | **balance for $e^-$** | | **E° (V)** | |
|---|---|---|---|---|---|
| cathode | reduction | $\times$ 2 | $Au^{3+} + 3e^- \rightarrow Au(s)$ | +1.50 | + electrode |
| anode | oxidation | $\times$ 3 | $Mg(s) \rightarrow Mg^{2+} + 2e^-$ | +2.37 | - electrode |
| | | | **$3Mg(s) + 2Au^{3+} \rightarrow 2Au(s) + 3Mg^{2+}$** | **+3.87** | |

Part b.

The balanced equation is required to answer part b:

$$\mathbf{3Mg(s) + 2Au^{3+} \rightarrow 2Au(s) + 3Mg^{2+}}$$

From this equation we see that 3 moles of Mg react with 2 moles of Au to give us the ratio $\frac{3Mg}{2Au}$

Since the question concerns mass, we will need to know the molar masses of each element, in order to convert between moles and mass. Molar masses are equivalent to atomic masses, found in the periodic table. The unit for molar mass is g/mol

molar mass of Mg = $\frac{24.3g}{mol \cdot Mg}$ molar mass of Au = $\frac{197.0g}{mol \cdot Au}$

The question gives us the mass of Mg and asks us to find mass of Au. Set up the equation so that all units will cancel except g Au (mass of Au):

$$g \cdot Au = 5.0 \cdot g \cdot Mg \times \frac{1 \cdot mol \cdot Mg}{24.3 \cdot g} \times \frac{197.0 \cdot g}{mol \cdot Au} \times \frac{2 \cdot mol \cdot Au}{3 \cdot mol \cdot Mg} = 27.0g \cdot Au$$

The mass of gold will change by 27.0 g. Our half-reactions tell us that gold ions combine with gold ions to produce solid gold. Thus our gold electrode will ***increase*** it's mass by 27.0 g.