1. What is the oxidizing agent in the following reaction?

\[
Pb + PbO_2 + 2 H_2SO_4 \rightarrow 2 PbSO_4 + 2 H_2O
\]

2. How many electrons are transferred in the following reaction?

\[
2 \text{Cr}^{3+} + 3 \text{SO}_4^{2-} + 4 \text{H}_2\text{O} \rightarrow \text{Cr}_2\text{O}_7^{2-} + 3 \text{H}_2\text{SO}_3 + 2 \text{H}^+
\]

3. Which of the following is the strongest oxidizing agent?

\[
\begin{align*}
\text{Zn}^{2+} + 2e^- & \rightarrow \text{Zn} & -0.76 \text{ V} \\
2\text{H}_2\text{O} + 2e^- & \rightarrow \text{H}_2 + 2\text{OH}^- & -0.83 \text{ V} \\
\text{Mn}^{2+} + 2e^- & \rightarrow \text{Mn} & -1.18 \text{ V}
\end{align*}
\]

4. What would be the standard cell potential at 298K if the energy of the following reaction could be harnessed as a Galvanic cell?

\[
4 \text{P} + 5 \text{O}_2 \rightarrow 2 \text{P}_2\text{O}_5 \quad \Delta G^\circ = -2698 \text{ kJ}
\]

5. Write the half reaction will take place at the anode of a Galvanic cell based on the following data?

\[
\begin{align*}
\text{Cl}_2 + 2e^- & \rightarrow 2\text{Cl}^- & 1.36 \text{ V} \\
\text{I}_2 + 2e^- & \rightarrow 2\text{I}^- & 0.54 \text{ V}
\end{align*}
\]

6. A Galvanic cell is described as follows:

\[
\text{Pt} \mid \text{H}_2 (1.0 \text{ atm}) \mid \text{H}^+ (1.0 \text{M}) \mid \mid \text{Fe}^{3+} (1.0 \text{M}), \text{Fe}^{2+} (1.0 \text{M}) \mid \text{Pt}
\]

Write the half reactions that occur at the anode and cathode.

7. Consider a Galvanic cell constructed using a solid silver electrode immersed in a 1.0 M Ag\(^+\) solution and a solid nickel electrode immersed in a 1.0 M Ni\(^{2+}\) solution. Which direction will the electrons flow?

\[
\begin{align*}
\text{Ag}^+ + e^- & \rightarrow \text{Ag} & 0.80 \text{ V} \\
\text{Ni}^{2+} + 2e^- & \rightarrow \text{Ni} & -0.23 \text{ V}
\end{align*}
\]

8. Determine the standard potential for the following reaction at 298K: \(\text{PbS} \rightleftharpoons \text{Pb}^{2+} + \text{S}^{2-}\) \(K = 8.0 \times 10^{-28}\)

Based on your answer; determine the standard reduction potential for the following half reaction:

\[
\text{PbS} + 2e^- \rightarrow \text{Pb} + \text{S}^{2-} \quad E^\circ = ???
\]

Note: \(\text{Pb}^{2+} + 2e^- \rightarrow \text{Pb} \quad E^\circ = -0.13 \text{ V}\)

9. What can silver spontaneously reduce based on the following data?

\[
\begin{align*}
\text{Cl}_2 + 2e^- & \rightarrow 2\text{Cl}^- & 1.36 \text{ V} \\
\text{Br}_2 + 2e^- & \rightarrow 2\text{Br}^- & 1.09 \text{ V} \\
\text{Ag}^+ + e^- & \rightarrow \text{Ag} & 0.80 \text{ V} \\
\text{Fe}^{3+} + e^- & \rightarrow \text{Fe}^{2+} & 0.77\text{V} \\
\text{Zn}^{2+} + 2e^- & \rightarrow \text{Zn} & -0.76 \text{ V}
\end{align*}
\]

10. Will solid lead dissolve in a 1.0M solution of NiCl\(_2\)?

\[
\begin{align*}
\text{Cl}_2 + 2e^- & \rightarrow 2\text{Cl}^- & 1.36 \text{ V} \\
\text{Pb}^{2+} + 2e^- & \rightarrow \text{Pb} & -0.13 \text{ V} \\
\text{Ni}^{2+} + 2e^- & \rightarrow \text{Ni} & -0.23 \text{ V}
\end{align*}
\]

11. Predict what will happen when a piece of Sn (s) is placed in an aqueous solution of FeCl\(_2\).
\[
\begin{align*}
\text{Cl}_2 + 2\text{e}^- & \rightarrow 2\text{Cl}^- & 1.36 \text{ V} \\
\text{Sn}^{2+} + 2\text{e}^- & \rightarrow \text{Sn} & -0.44 \text{ V} \\
\text{Fe}^{2+} + 2\text{e}^- & \rightarrow \text{Fe} & -0.14 \text{ V} \\
\end{align*}
\]

a. \(\text{Sn}^{2+}\) will be produced  
b. \(\text{Cl}_2\) will be produced  
c. \(\text{Fe}\) will be produced  
d. No reaction will occur  
e. More than one of these will occur

12. You want to plate out nickel from a nickel (III) nitrate solution by inserting a piece of metal. Should you use copper, zinc, either copper or zinc, neither copper or zinc will plate out nickel.

\[
\begin{align*}
\text{Cu}^{2+} + 2\text{e}^- & \rightarrow \text{Cu} & 0.34 \text{ V} \\
\text{Ni}^{2+} + 2\text{e}^- & \rightarrow \text{Ni} & -0.23 \text{ V} \\
\text{Zn}^{2+} + 2\text{e}^- & \rightarrow \text{Zn} & -0.76 \text{ V} \\
\end{align*}
\]

13. Based on the following information, what can reduce \(\text{Ni}^{2+}\) but not \(\text{Al}^{3+}\)?

\[
\begin{align*}
\text{Cu}^{2+} + 2\text{e}^- & \rightarrow \text{Cu} & 0.34 \text{ V} \\
\text{Ni}^{2+} + 2\text{e}^- & \rightarrow \text{Ni} & -0.23 \text{ V} \\
\text{Fe}^{2+} + 2\text{e}^- & \rightarrow \text{Fe} & -0.44 \text{ V} \\
2\text{H}_2\text{O} + 2\text{e}^- & \rightarrow \text{H}_2 + 2\text{OH}^- & -0.83 \text{ V} \\
\text{Al}^{3+} + 3\text{e}^- & \rightarrow \text{Al} & -1.66 \text{ V} \\
\text{Na}^+ + \text{e}^- & \rightarrow \text{Na} & -2.71 \text{ V} \\
\end{align*}
\]

14. Consider a Galvanic cell based on the following half reactions:

\[
\begin{align*}
\text{Pb}^{2+} + 2\text{e}^- & \rightarrow \text{Pb} & -0.13 \text{ V} \\
\text{Cr}^{3+} + 3\text{e}^- & \rightarrow \text{Cr} & -0.73 \text{ V} \\
\end{align*}
\]

Determine what will happen to the cell potential for the following if initially \([\text{Pb}^{2+}] = 1.0\text{M}\) and \([\text{Cr}^{3+}] = 1.0\text{M}\).

a. Water is added to both sides causing the volume to double in each compartment.

b. Sodium hydroxide is added to the chromium half cell causing \(\text{Cr(OH)}_3\) to precipitate.

c. The mass of the lead electrode is doubled.

15. Consider the Galvanic cell at 25 °C described as follows:

\[
\begin{align*}
\text{X} | \text{X}^{2+} | | \text{Y}^{3+} | \text{Y}
\end{align*}
\]

Where X and Y are unknown metals. Given the standard reduction potential for \(\text{Y}^{3+}\) is 1.5 V and that K for the overall reaction in this Galvanic cell is \(1.2 \times 10^{20}\) what is the standard reduction potential of \(\text{X}^{2+}\)?

16. Calculate the potential for the following galvanic cell at 320K.
17. Consider the Galvanic cell below to answer the following:

Initially the masses of the aluminum electrode and the zinc electrode are 116 g and 150 g respectively. Assuming the reaction goes to completion calculate the final mass of the aluminum electrode.

18. Calculate $\Delta G$ for the following electrochemical cell at 298K.

$$\text{Mg} | \text{Mg}^{2+} \ (2.3 \ M) \ || \ \text{Cr}^{3+} \ (0.16M) | \text{Cr}$$

- $\text{Cr}^{3+} + 3e^- \rightarrow \text{Cr} \quad -0.73 \ V$
- $\text{Mg}^{2+} + 2e^- \rightarrow \text{Mg} \quad -2.37 \ V$

19. Consider the following cell: 

$$\text{Al} \ (s) | \text{Al}^{3+} \ (1.0 \ M) \ || \ \text{Pb}^{2+} \ (1.0 \ M) | \text{Pb} \ (s)$$

- $\text{Pb}^{2+} + 2e^- \rightarrow \text{Pb} \quad -0.13 \ V$
- $\text{Al}^{3+} + 3e^- \rightarrow \text{Al} \quad -1.66 \ V$

Calculate the cell potential for the reaction when the $[\text{Al}^{3+}]$ has changed by 0.66 M at 25 °C.

20. A concentration cell is created using copper electrodes and aqueous Cu$^{2+}$ solutions. Which of the following will cause a positive cell potential if the concentration of copper (II) ion is 1.0 M at the cathode?

- $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \quad 0.34 \ V$

  a. The concentration of the copper (II) ion at the anode must be less than 1.0 M
  b. The concentration of the copper (II) ion at the anode must be greater than 1.0 M
  c. The concentration of the copper (II) ion at the anode must be equal to 1.0 M
  d. The cell potential will be zero regardless of the concentration of the copper (II) ion

21. A concentration cell is constructed in which one half cell contains a Cr (s) electrode immersed in a 0.21 M Cr$^{3+}$ solution and the other half cell contains a Cr (s) electrode immersed in a 1.8 M Cr$^{3+}$ solution. Which direction will the potassium ions flow if the salt bridge is composed of KNO$_3$ solution?
22. Consider the following concentration cell at 298K: \( \text{Fe} | \text{Fe}^{2+} (0.001 \text{ M}) || \text{Fe}^{2+} (0.1 \text{ M}) | \text{Fe} \) Calculate the cell potential if the standard reduction potential for \( \text{Fe}^{2+} \) is \(-0.44 \text{ V}\).

23. Three separate solutions are electrolyzed using the same current to plate out solid metals. Which of the following will take the longest amount of time?
   a. Plating 5 grams of solid Al from an \( \text{Al}^{3+} \) solution
   b. Plating 15 grams of solid Ca from a \( \text{Ca}^{2+} \) solution
   c. Plating 40 grams of solid Rb from a \( \text{Rb}^{+} \) solution
   d. All three processes take the same amount of time

24. How long will it take (in min) to plate out 10.0 g of Bi from a solution of \( \text{Bi}^{3+} \) using a current of 25.0 A?

25. In an electrolysis experiment, a student passes the same current through two electrolytic cells for the same amount of time. One cell contains \( \text{Ag}^{+} \) ion and the other contains \( \text{Mn}^{2+} \). Determine the value of \( x \) if 7.6 grams of Ag and 0.77 grams of Mn were plated out.

26. To determine the molar mass of an unknown metal \( M \), the metal is plated out from a solution containing \( M^{3+} \) ions. Determine the molar mass of the metal if 61.8 grams of \( M \) is plated out after electrolyzing the solution with a current of 25.1 A for 85 minutes.

27. Consider an electrochemical cell described as follows: \( \text{Mg(s)} | \text{Mg}^{2+} (0.85 \text{ M}) || \text{Al}^{3+} (0.85 \text{ M}) | \text{Al(s)} \) If each compartment has a volume of 1.0L, what will be the concentration of the \( \text{Al}^{3+} \) after the cell delivers 0.22 A of current for 31.6 hr?

28. A solution of NaCl is electrolyzed to produce \( \text{Cl}_2 \) gas. What volume of \( \text{Cl}_2 \) at 298 K and 1 atm is generated if the solution is exposed to a current of 54 A for 13 minutes?