Name _____

Class _____ Date _____

CHAPTER 21 WORKSHEET

Part I

If the following electrolytes were electrolyzed, predict what half reactions would occur at the anode and cathode. (Remember, 1.0*M* NaCl implies an aqueous solution of NaCl.)

1. Molten $ZnCl_2$; inert electrodes.

cathode $Zn^{2+} + 2e^- \longrightarrow Zn$

anode $2Cl^- \longrightarrow Cl_2 + 2e^-$

2. 1.0*M* Na_2SO_4; inert electrodes.

anode $H_2O \longrightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$

cathode $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

3. Molten CuI_2; inert electrodes.

cathode $Cu^{2+} + 2e^- \longrightarrow Cu$

anode $2I^- \longrightarrow I_2 + 2e^-$

4. 1.0*M* KI; inert electrodes.

anode $2I^- \longrightarrow I_2 + 2e^-$

cathode $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

5. 1.0*M* $NiSO_4$; nickel electrodes.

anode $Ni \longrightarrow Ni^{2+} + 2e^-$

cathode $Ni^{2+} + 2e^- \longrightarrow Ni$

6. 1.0*M* HI; lead electrodes.

anode $Pb_{(s)} \longrightarrow Pb^{2+} + 2e^-$

cathode $2H_3^+ + 2e^- \longrightarrow H_{2(g)}$

7. 1.0*M* $ZnSO_4$; inert electrodes.

anode $H_2O \rightarrow \frac{1}{2}O_{2(g)} + 2H^+ + 2e^-$

cathode $Zn^{2+} + 2e^- \rightarrow Zn_{(s)}$ overpotential effect

8. 1.0*M* NaCl; inert electrodes.

anode $2Cl^- \rightarrow Cl_{2(g)} + 2e^-$ overpotential effect

cathode $2H_2O + 2e^- \rightarrow H_{2(g)} + 2OH^-$

Part II

9. When a 1.0*M* KCl solution is electrolyzed using silver electrodes, a precipitate forms at the anode. Explain this result.

anode : $Ag_{(s)} \rightarrow Ag^+ + e^-$

The Ag^+ ions react with the Cl^- ions to produce $AgCl_{(s)}$.

10. If a 1.0*M* HCl solution is electrolyzed using platinum electrodes (inert), what minimum voltage must be applied? Predict the anode and cathode half-reactions, as well as the overall cell reaction.

anode $2Cl^- \rightarrow Cl_{2(g)} + 2e^-$ $E^\circ = -1.36$ v

cathode $2H^+ + 2e^- \rightarrow H_{2(g)}$ $E^\circ = 0.00$ v

overall $2Cl^- + 2H^+ \rightarrow Cl_{2(g)} + H_{2(g)}$ $E^\circ_{cell} = -1.36$ v

Therefore, 1.36 v must be applied.

11. a. In the electrorefining of lead, lead bullion is used as the anode and pure lead is used as the cathode in an electrolytic solution containing Pb^{2+} ions. Lead bullion is primarily lead, but it does contain impurities such as silver and gold. What happens to these three metals at the anode during electrolysis?

The Pb is oxidized to Pb^{2+}. The Ag + Au are "left behind". These metals can be recovered in subsequent electrolytic processes

11. b. **Lead bullion may also contain trace amounts of impurities such as zinc metal. Describe what happens to this zinc during electrolysis, and explain why the pure lead cathode does not become contaminated with zinc.**

Although both the $Zn(s)$ and the $Pb(s)$ are oxidized at the anode, the Zn^{2+} ions are "trapped" in solution. Since at the cathode the Pb^{2+} ions have a higher reduction potential than the Zn^{2+}, only the Pb^{2+} ions are reduced to $Pb(s)$

12. **Why can aluminum metal not be produced by electrowinning Al(s) from an aqueous solution containing Al^{3+} ions? Write the cathode half-reaction that would occur.**

Even with hydrogen's high overpotential, H_2O is reduced before Al^{3+}.

Cathode: $2H_2O + 2e^- \longrightarrow H_{2(g)} + 2OH^-$