G12 Chemistry: Class 16 Homework

1. Write the oxidation half-reaction, the reduction half-reaction, and the overall cell reaction for each of the following galvanic cells. Identify the anode and the cathode in each case. In part(b) platinum is present as an inert electrode.

   a. Sn(s) I Sn^{2+}(aq) II Tl^{+}(aq) I Tl(s) **[5 marks]**

oxidation : $Sn(s) \rightarrow Sn^{2+} + \cancel{2e^-}$ ✓ anode = Sn(s) ✓

reduction : $Tl^+(aq) + \cancel{e^-} \rightarrow Tl(s)$ x 2 ✓ cathode = Tl(s) ✓

$Sn(s) + 2Tl^+(aq) \rightarrow Sn^{2+} + 2Tl(s)$ ✓

   b. Cd(s) I Cd^{2+}(aq) II H^{+}(aq) I H_2(g) I Pt(s) **[5 marks]**

oxidation : $Cd(s) \rightarrow Cd^{2+} + \cancel{2e^-}$ ✓ anode : Cd ✓

reduction : $2H^+ + \cancel{2e^-} \rightarrow H_2(g)$ ✓ cathode : Pt ✓

$Cd(s) + 2H^+ \rightarrow Cd^{2+} + H_2(g)$ ✓

2. A galvanic cell involves the overall reaction of iodide ions with acidified permanganate ions to form manganese (II) ions and iodine. The salt bridge contains potassium nitrate.
   a. Write the half-reactions and the overall cell reaction **[1 mark]**
   b. Identify the oxidizing agent and the reducing agent **[2 marks]**
   c. The inert anode and the cathode are both made of graphite. Solid iodine forms on one of them. Which one? **[1 mark]**

$I^- + MnO_4^- \rightarrow Mn^{2+} + I_2$

a) $(2I^- \rightarrow I_2 + 2e^-) \times 5$ $10I^- \rightarrow 5I_2 + \cancel{10e^-}$

$(5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O) \times 2$ $\cancel{10e^-} + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 8H_2O$

overall: $10I^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$ ✓

b) oxidizing agent = MnO_4^- ✓
reducing agent = I^- ✓

c) oxidation = anode – solid iodine forms on the anode ✓

3. Pushing a zinc electrode and a copper electrode into a lemon makes a "lemon cell". In the following representation of the cell $C_6H_8O_7$ is the formula of citric acid. Explain why the representation does not include a double vertical line. **[2 marks]**

$$Zn(s) \mid C_6H_8O_7(aq) \mid Cu(s)$$

- double vertical line represents a porous barrier or a salt bridge.
- both reactions occur in the same lemon with no barrier.

4. Write the two half-reactions for the following redox reaction. Subtract the two reduction potentials to find the standard cell potential for a galvanic cell in which this reaction occurs. **[3 marks]**

$$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(l)$$

oxidation : $2Br^- \rightarrow Br_2 + 2e^-$ $E°$ anode = 1.066 V

reduction : $Cl_2(g) + 2e^- \rightarrow 2Cl^-$ $E°$ cathode = 1.358 V

$E°_{cell} = E°_{cathode} - E°_{anode}$

$= 1.358 - 1.066 = 0.292$ V

5. Write the two half-reactions for the following redox reaction. Subtract the two standard reduction potentials to find the standard cell potential for the reaction. **[3 marks]**

$$Sn(s) + 2HBr(aq) \rightarrow SnBr_2(aq) + H_2(g)$$

oxidation : $Sn(s) \rightarrow Sn^{2+} + 2e^-$ $E°$ anode = −0.138 V

reduction : $2H^+ + 2e^- \rightarrow H_2(g)$ $E°$ cathode = 0.000 V

$E°_{cell} = 0 - (-0.138) = +0.138$ V

6. Write the two half-reactions for the following redox reaction. Add the standard reduction potential and the standard oxidation potential to find the standard cell potential for the reaction. **[3 marks]**

$$Cr(s) + 3AgCl(s) \rightarrow CrCl_3(aq) + 3Ag(s)$$

oxidation : $Cr(s) \rightarrow Cr^{3+} + 3e^-$ $E°$ anode = −0.744 V

reduction : $3Ag^+ + 3e^- \rightarrow 3Ag(s)$ $E°$ cathode = +0.222 V

$E°_{cell} = 0.222 - (-0.744)$

$= 0.966$ V

7. Determine the standard cell potential for each of the following redox reactions. **[3 marks]**
   a. $3Mg(s) + 2Al^{3+}(aq) \rightarrow 3Mg^{2+}(aq) + 2Al(s)$

oxidation: $3Mg(s) \rightarrow 3Mg^{2+} + 3e^-$ $E°_{anode} = -2.372$
reduction: $2Al^{3+} + 3e^- \rightarrow 2Al$ $E°_{cathode} = -1.662V$

$E°_{cell} = 0.71V$

   b. $2K(s) + F_2(g) \rightarrow 2K^+(aq) + 2F^-(aq)$

oxidation: $2K(s) \rightarrow 2K^+ + 2e^-$ $E°_{anode} = -2.931V$
reduction: $F_2(g) + 2e^- \rightarrow 2F^-$ $E°_{cathode} = +2.866V$

$E°_{cell} = 5.797V$.

   c. $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Ag(s) \rightarrow 2Cr^{3+}(aq) + 6Ag^+(aq) + 7H_2O(l)$

oxidation: $6Ag(s) \rightarrow 6Ag^+ + 6e^-$ $E°_{anode} = 0.800V$
reduction: $Cr_2O_7^{2-} + 3e^- \rightarrow 2Cr^{3+}$. $E°_{cathode} = 1.232V$

$E°_{cell} = 0.432V$.

8. The cell potential for the following galvanic cell is given. **[2 marks]**

   Zn I Zn^{2+} (1mol/L) II Pd^{2+} (1mol/L) I Pd $E°_{cell} = 1.750V$

   Determine the standard reduction potential for the following half-reaction.

   $Pd^{2+}(aq) + 2e^- \text{<-->} Pd(s)$

Anode: $Zn(s) \rightarrow Zn^{2+} + 2e^-$ $E°_{anode} = -0.762V$.
cathode: $Pd^{2+} + 2e^- \rightarrow Pd(s)$ $E°_{cathode} = x$.

$E°_{cathode} = E°_{cell} + E°_{anode}$
$= 1.750V + (-0.762)$
$= 0.988V$

9. Calculate the mass of zinc plated onto the cathode of an electrolytic cell by a current of 750mA in 3.25h. **[4 marks]**

750 mA → 0.750 A.

3.25h x 3600 = 11700 sec.

$q = It$

$= 0.750 \times 11700$

$= 8775 C$

$n = \frac{q}{F}$

$= \frac{8775 C}{96500 C/mol}$

$= 0.091$ mol/2e

$= 0.045$ mol.

$Zn^{2+} + 2e^- \rightarrow Zn(s)$

$n = 0.045$ mol

$M = 65.39$ g/mol

$m = \underline{\underline{2.97 g}}$

10. Will the following reaction occur spontaneously at 25°C, given that $[Fe^{2+}] = 0.60M$ and $[Cd^{2+}] = 0.010M$? **[5 marks]**

$$Cd(s) + Fe^{2+}(aq) \rightarrow Cd^{2+}(aq) + Fe(s)$$

$E = E° - \frac{0.0257}{n} \ln Q$.

Anode : $Cd(s) \rightarrow Cd^{2+} + 2e^-$ $E_{anode} = -0.40$

Cathode : $Fe^{2+} + 2e^- \rightarrow Fe(s)$ $E_{cathode} = -0.44$

$E = -0.044 - \frac{0.0257}{2} \ln \frac{[0.010]}{[0.60]}$

$E°_{cell} = -0.447 - (-0.403)$

$= -0.044$ V

$E = 0.00861$ V.

$n = 2$ mol of e^-.

∴ spontaneous because E is ⊕