HW11 - Electrochemical Potential, Free Energy, and Application

Question 1 — 1.0 pts

What is the $E°_{cell}$ for

$Zn(s) \mid Zn^{2+}(aq) \parallel Ce^{4+}(aq) \mid Ce^{3+}(aq)$

$Zn^{2+} + 2e^- \longrightarrow Zn \qquad E° = -0.76$

$Ce^{4+} + e^- \longrightarrow Ce^{3+} \qquad E° = +1.61$

a. 2.37 V

b. 1.61 V

c. -2.37 V

d. 0.85 V

Question 2 — 1.0 pts

Standard reduction potentials are established by comparison to the potential of which half-reaction?

a. $2H^+ + 2e^- \longrightarrow H_2$

b. $F_2 + 2e^- \longrightarrow 2F^-$

c. $Li^+ + e^- \longrightarrow Li$

d. $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

Question 3 — 1.0 pts

What is the standard cell potential of the strongest battery that could be made using these half-reactions?

$Br_2 + 2e^- \longrightarrow 2Br^- \qquad E° = +1.07$

$Fe^{3+} + 3e^- \longrightarrow Fe \qquad E° = -0.04$

$Co^{3+} + e^- \longrightarrow Co^{2+} \qquad E° = +1.80$

$Zn^{2+} + 2e^- \longrightarrow Zn \qquad E° = -0.76$

a. 2.56

b. -2.56

c. 1.11

d. 1.84

Question 4 — 1.0 pts

What would be the E° of an electrolytic cell made from the half-reactions below?

$AgCl(s) + e^- \longrightarrow Ag(s) + Cl^-(aq) \qquad E° = +0.22\ V$

$Al^{3+}(aq) + 3e^- \longrightarrow Al(s) \qquad E° = -1.66\ V$

a. -1.88

b. 1.88

c. 1.44

d. -1.44

Question 5 — 1.0 pts

Sodium is produced by the electrolysis of molten sodium chloride. What are the products at the anode and cathode, respectively?

a. $Cl_2(g)$ and Na(l)

b. $Cl_2(g)$ and $Na_2O(l)$

c. Na(l) and $O_2(g)$

d. $O_2(g)$ and Na(l)

Question 6 — 1.0 pts

The electrolysis of an aqueous sodium chloride solution using inert electrodes produces gaseous chlorine at one electrode. At the other electrode gaseous hydrogen is produced and the solution becomes basic around the electrode. What is the equation for the cathode half-reaction in the electrolytic cell?

a. $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

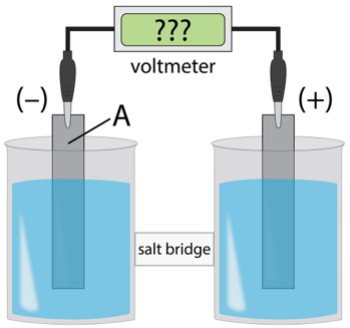
b. $Cl_2 + 2e^- \longrightarrow 2Cl^-$

c. $H_2 + 2OH^- \longrightarrow 2H_2O + 2e^-$

d. $2Cl^- \longrightarrow Cl_2 + 2e^-$

Question 7 — 1.0 pts

The galvanic cell below uses the standard half-cells $Mg^{2+} \mid Mg$ and $Zn^{2+} \mid Zn$, and a salt bridge containing KCl(aq).



Identify A and write the half-reaction that occurs in that compartment.

a. $Mg(s)$; $Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$

b. $Zn(s)$; $Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$

c. $Mg(s)$; $Mg^{2+}(aq) + 2e^- \longrightarrow Mg(s)$

d. $Zn(s)$; $Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$

Question 8 — 1.0 pts

Refer to the diagram in question 7. What happens to the size of the electrode A during the operation of the cell?

a. it increases

b. it decreases

c. it doesn't change

d. There is no way to tell.

Question 9 — 1.0 pts

Refer to the diagram in question 7. What should the voltmeter read?

a. +4.30 V

b. +3.40 V

c. +1.60 V

d. +2.50 V

Question 10 — 1.0 pts

How many moles of $Cl_2(g)$ are produced by the electrolysis of concentrated sodium chloride if 2.00 A are passed through the solution for 4.00 hours? The equation for this process (the "chloralkali" process) is given below.

$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + Cl_2(g)$

a. 0.00248 mol

b. 0.149 mol

c. 0.298 mol

d. 0.0745 mol

Question 11 — 1.0 pts

A steel surface has been electroplated with 5.10g of vanadium (V, molar mass = 51 g/mol). If 2.90×10^4 C of charge were used, what was the original oxidation number of V?

a. +3

b. +4

c. +2

d. +1

Question 12 — 1.0 pts

How long will it take to deposit 0.00235 moles of gold by the electrolysis of $KAuCl_4(aq)$ using a current of 0.214 amperes?

a. 106 min

b. 70.7 min

c. 53.0 min

d. 26.5 min

Question 13 — 1.0 pts

Consider 3 electrolysis experiments:

1. One Faraday of electricity is passed through a solution of $AgNO_3$.

2. Two Faradays of electricity are passed through a solution of $Zn(NO_3)_2$.

3. Three Faradays of electricity are passed through a solution of $Bi(NO_3)_3$.

Which of the following statements is true?

a. Equal numbers of moles of all three metals are produced.

b. The reaction producing the smallest mass of metal is that of the silver solution.

c. Twice as many moles of metallic zinc are produced than metallic silver.

d. Equal masses of all three metals are produced.

Question 14 — 1.0 pts

What is $\Delta G°$ for the half-reaction below?

$ClO_3^- + 6H^+(aq) \longrightarrow 0.5Cl_2(g) + 3H_2O(l)$ $\quad E° = +1.47$

a. 194 kJ/mol

b. 194,000 kJ/mol

c. -709 kJ/mol

d. -709,000 kJ/mol

Question 15 — 1.0 pts

For the reduction of Cu^{2+} by Zn, $\Delta G° = -212$ kJ/mol and $E° = +1.10$ V. If the coefficients in the chemical equation for this reaction are multiplied by 2, $\Delta G° = -424$ kJ/mol. Does this mean E° for the cell would be +2.20V?

a. It is impossible to know without testing it empirically.

b. No.

c. Yes.

d. Not enough information is given.

Question 16 — 1.0 pts

Consider the cell:

$Zn(s) \mid Zn^{2+}(aq) \parallel Fe^{2+}(aq) \mid Fe(s)$

If run at standard conditions, calculate the value of $\Delta G°_{rxn}$ for the reaction that occurs when current is drawn from this cell.

a. -62 kJ/mol

b. +62 kJ/mol

c. -31 kJ/mol

d. -230 kJ/mol

Question 17 — 1.0 pts

Calculate the cell potential for a cell based on the reaction below:

$Cu(s) + 2Ag^+(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$

when the concentrations are as follows:

$[Ag^+] = 0.7$ M

$[Cu^{2+}] = 0.9$ M

(The temperature is 25°C and $E° = 0.4624$ V.)

a. 0.470 V

b. 0.455 V

c. 0.447 V

d. 0.459 V

Question 18 — 1.0 pts

Consider the cell:

$Pb(s) \mid PbSO_4(s) \mid SO_4^{2-}(aq, 0.60\ M) \parallel H^+(aq, 0.70\ M) \mid H_2(g, 192.5\ kPa) \mid Pt$

If E° for the cell is 0.36 V at 25°C, write the Nernst equation for the cell at this temperature.

a. $E = 0.36 - 0.01285 \cdot \ln \frac{1.90}{(0.70)^2(0.60)}$

b. $E = 0.36 - 0.01285 \cdot \ln \frac{192.5}{(0.70)^2(0.60)}$

c. $E = 0.36 - 0.02569 \cdot \ln \frac{192.5}{(0.70)^2(0.60)}$

d. $E = 0.36 - 0.01285 \cdot \ln \frac{1.90}{(0.70)(0.60)}$

Question 19 — 1.0 pts

A concentration cell consists of the same redox couples at the anode and the cathode and different concentrations of the ions in the respective compartments. Find the unknown concentration for the following cell:

$Pb(s) \mid Pb^{2+}(aq, ?) \parallel Pb^{2+}(aq, 0.1\ M) \mid Pb(s)$ E = 0.065 V

a. 7.97×10^{-3} M

b. 1.26 M

c. 6.35×10^{-4} M

d. 15.8 M

Question 20 — 1.0 pts

What is the ratio of $[Co^{2+}]$ / $[Ni^{2+}]$ when a battery built from the two half-reactions below reaches equilibrium?

$Ni^{2+} \longrightarrow Ni$ E° = -0.25 V

$Co^{2+} \longrightarrow Co$ E° = -0.28 V

a. 0.31

b. 3.20

c. 0.10

d. 10.33

Question 21 — 1.0 pts

If E° for the disproportionation of $Cu^+(aq)$ to $Cu^{2+}(aq)$ and Cu(s) is +0.37 V at 25°C, calculate the equilibrium constant for the reaction.

a. 3.2×10^{12}

b. 1.3×10^{3}

c. 1.8×10^{6}

d. 2.4×10^{2}

Question 22 — 1.0 pts

The standard potential of the cell:

$Pb(s) \mid PbSO_4(s) \mid SO_4^{2-}(aq) \parallel Pb^{2+}(aq) \mid Pb(s)$

is +0.23 V at 25°C. Calculate the equilibrium constant for the reaction of 1 M $Pb^{2+}(aq)$ with 1 M $SO_4^{2-}(aq)$.

a. 7.7×10^{3}

b. 8.0×10^{17}

c. 1.7×10^{-8}

d. 6.0×10^{7}

Question 23 — 1.0 pts

The standard voltage of the cell:

$Ag(s) \mid AgBr(s) \mid Br^-(aq) \parallel Ag^+(aq) \mid Ag(s)$

is +0.73 V at 25°C. Calculate the equilibrium constant for the cell reaction.

a. 2.2×10^{12}

b. 2.0×10^{-15}

c. 4.6×10^{-13}

d. 5.1×10^{14}

Question 24 — 1.0 pts

The equilibrium constant for the reaction below:

$2Hg(l) + 2Cl^-(aq) + Ni^{2+}(aq) \longrightarrow Ni(s) + Hg_2Cl_2(s)$

is 5.6×10^{-20} at 25°C. Calculate the value of $E°_{cell}$ for this reaction.

a. -1.14 V

b. +1.14 V

c. -0.57 V

d. +0.57 V

Question 25 — 1.0 pts

You turn on a flashlight containing brand new NiCad batteries and keep it lit for a minute or two. Which of the following can be considered TRUE regarding the chemical state of these batteries?

I. ΔG for the battery reaction is negative.

II. $E_{cell} > 0$

III. The batteries are at equilibrium.

IV. E_{cell} is substantially decreasing during this time.

a. I and II only

b. All but III

c. All are true.

d. III only

e. All but IV

Question 26 — 1.0 pts

Which of the following batteries are rechargeable?

I. Alkaline Battery

II. NiMH Battery

III. Lithium Battery

IV. Lithium Ion Battery

V. Lead-Acid Battery

a. I and III only

b. II, IV, and V only

c. II and V only

d. All except I

Question 27 — 1.0 pts

Here is the discharge reaction for an alkaline battery:

$Zn(s) + 2MnO_2(s) + H_2O(l) \longrightarrow Zn(OH)_2(s) + Mn_2O_3(s)$

Which species is reduced as the battery is discharged?

a. $Mn_2O_3(s)$

b. $H_2O(l)$

c. $Zn(s)$

d. $MnO_2(s)$

Question 28 — 1.0 pts

What metal (in various oxidation states) is present at both the cathode and the anode in a typical car battery?

a. lead

b. cadmium

c. lithium

d. nickel

e. zinc

Question 29 — 1.0 pts

The net redox reaction in a fuel cell is given below:

$2H_2 + O_2 \longrightarrow H_2O$

What is the reaction at the anode in a fuel cell?

a. $H^+ + OH^- \longrightarrow H_2O$

b. $O_2 \longrightarrow 2O^{2+} + 4e^-$

c. $O_2 + 4e^- \longrightarrow 2O^{2-}$

d. $H_2 \longrightarrow 2H^+ + 2e^-$

Question 30 — 1.0 pts

Which of the following is NOT an important characteristic of the proton exchange membrane (PEM) in a PEM fuel cell?

a. It must withstand the high operating temperatures of the fuel cell.

b. It is coated with catalysts that increase the rates of both the oxidation and reduction reactions.

c. It physically separates the half-reactions.

d. It must be stable in an acidic environment.

e. It is permeable to protons.