CH 223 Spring 2026:
Problem Set #5
Instructions

Step One:

• **Learn the material** for Problem Set #5 by **reading Chapter 16** of the textbook and/or by watching the videos found on the website (https://mhchem.org/223video)

• **Try the problems** for Problem Set #5 found on the next pages on your own first. Write your answers in the space provided or write your answers on separate paper (your choice.) Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #5:

http://mhchem.org/3/5

Self correct *all* of the problems while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)

Step Three:

Turn the Problem Set in at the beginning of recitation to the instructor on **Monday, May 11 (section L1)** *or* **Wednesday, May 13 (section L2.)** The graded problem set will be returned to you the following week during recitation.

Do *not* include this page to avoid a point penalty; your front page should be page II-5-3.

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

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CH 223 Problem Set #5

Name:

Complete the problem set on your own first using these sheets for your work or separate paper (your choice.) **Self correct your work *(all problems!)*** using the recitation video for this problem set, found here: **http://mhchem.org/3/5**

***** *Covering:* **Chapter Sixteen** *and* **Chapter Guide Five**

***** *Important Tables and/or Constants:* **periodic table** found here: http://mhchem.org/pertab, **F = 96485 C/mol e^-**, **R = 8.3145 J mol^{-1} K^{-1}**, "**Redox Reactions**" *(Handout),* **Table of Redox Potentials** *at the end of this problem set*

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1. Write balanced equations for the following half-reactions. Specify whether each is an oxidation or reduction.
   a. $H_2C_2O_4(aq) \rightarrow CO_2(g)$ (in acid)

   b. $NO_3^{-1}(aq) \rightarrow NO(g)$ (in acid)

   c. $MnO_4^{-1}(aq) \rightarrow MnO_2(s)$ (in base)

2. Balance the following redox equations. All occur in acid solution.
   a. $Sn(s) + H^+(aq) \rightarrow Sn^{2+}(aq) + H_2(g)$

   b. $Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) \rightarrow Cr^{3+}(aq) + Fe^{3+}(aq)$

3. Balance the following redox reactions. All occur in basic solution.
   a. $NiO_2(s) + Zn(s) \rightarrow Ni(OH)_2(s) + Zn(OH)_2(s)$

   b. $Fe(OH)_2(s) + CrO_4^{2-}(aq) \rightarrow Fe(OH)_3(s) + [Cr(OH)_4]^{-1}$

4. The following **voltaic** cell is created: $Ag(s) \mid Ag^{+}(aq) \parallel Cl_2(g, 1\ atm) \mid Cl^{-1}(aq, 1.0\ M) \mid Pt(s)$
   a. Write equations for the oxidation and reduction half-reactions and for the overall (cell) reaction.

   b. Which half-reaction occurs in the anode compartment and which occurs in the cathode compartment?

   c. Complete the following sentences: Electrons in the external circuit flow from the _____ electrode to the _____ electrode. Negative ions move in the salt bridge from the _____ half-cell to the _____ half-cell.

5. Balance each of the following unbalanced equations, then calculate the standard reduction potential, $E°$, and decide whether each is product-favored as written. All reactions occur in acidic solution.
   a. $Fe^{2+}(aq) + Cu^{2+}(aq) \rightarrow Cu(s) + Fe^{3+}(aq)$

   b. $MnO_4^{-1}(aq) + NO(g) \rightarrow Mn^{2+}(aq) + NO_3^{-1}(aq)$

6. Consider the following half-reactions:

Half-Reaction	***E*° (V)**
$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$	+0.34
$Sn^{2+}(aq) + 2\ e^- \rightarrow Sn(s)$	-0.14
$Fe^{2+}(aq) + 2\ e^- \rightarrow Fe(s)$	-0.44
$Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$	-0.76
$Al^{3+}(aq) + 3\ e^- \rightarrow Al(s)$	-1.66

a. Based on $E°$ values, which metal is the most easily oxidized?

b. Which metals on this list are capable of reducing $Fe^{2+}(aq)$ to Fe?

c. Write a balanced chemical equation for the reaction of $Fe^{2+}(aq)$ with Sn(s). Is this reaction product-favored or reactant-favored?

d. Write a balanced chemical equation for the reaction of $Zn^{2+}(aq)$ with Sn(s). Is this reaction product-favored or reactant-favored?

7. Calculate the potential at 298 K developed by a voltaic cell using the following reaction if all dissolved species are 0.015 M: (hint: use the Nernst equation!)

$$2\ Fe^{2+}(aq)\ +\ H_2O_2(aq)\ +\ 2\ H^+(aq)\ \rightarrow\ 2\ Fe^{3+}(aq)\ +\ 2\ H_2O(\ell)$$

8. Calculate ΔG° and the equilibrium constant for the following reaction:

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

9. In the electrolysis of a solution containing $Ag^+(aq)$, metallic Ag(s) deposits on the cathode. Using a current of 1.12 A for 2.40 h, what mass of silver forms?

10. Electrolysis of a solution of $CuSO_4(aq)$ to give copper metal is carried out using a current of 0.66 A. How long should electrolysis continue to produce 0.50 g of copper?

Standard Reduction Potentials in Aqueous Solution at 25 °C

Reduction Half-Reaction		$E°$ (V)
$F_2(g) + 2\ e^-$	$\longrightarrow 2\ F^-(aq)$	+2.87
$H_2O_2(aq) + 2\ H^+(aq) + 2\ e^-$	$\longrightarrow 2\ H_2O(\ell)$	+1.77
$PbO_2(s) + SO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$	$\longrightarrow PbSO_4(s) + 2\ H_2O(\ell)$	+1.685
$MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^-$	$\longrightarrow Mn^{2+}(aq) + 4\ H_2O(\ell)$	+1.51
$Au^{3+}(aq) + 3\ e^-$	$\longrightarrow Au(s)$	+1.50
$Cl_2(g) + 2\ e^-$	$\longrightarrow 2\ Cl^-(aq)$	+1.36
$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6\ e^-$	$\longrightarrow 2\ Cr^{3+}(aq) + 7\ H_2O\ (\ell)$	+1.33
$O_2(g) + 4\ H^+(aq) + 4\ e^-$	$\longrightarrow 2\ H_2O(\ell)$	+1.229
$Br_2(\ell) + 2\ e^-$	$\longrightarrow 2\ Br^-(aq)$	+1.08
$NO_3^-(aq) + 4\ H^+(aq) + 3\ e^-$	$\longrightarrow NO(g) + 2\ H_2O(\ell)$	+0.96
$OCl^-(aq) + H_2O(\ell) + 2\ e^-$	$\longrightarrow Cl^-(aq) + 2\ OH^-(aq)$	+0.89
$Hg^{2+}(aq) + 2\ e^-$	$\longrightarrow Hg(\ell)$	+0.855
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	+0.799
$Hg_2^{2+}(aq) + 2\ e^-$	$\longrightarrow 2\ Hg(\ell)$	+0.789
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	+0.771
$I_2(s) + 2\ e^-$	$\longrightarrow 2\ I^-(aq)$	+0.535
$O_2(g) + 2\ H_2O(\ell) + 4\ e^-$	$\longrightarrow 4\ OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2\ e^-$	$\longrightarrow Cu(s)$	+0.337
$Sn^{4+}(aq) + 2\ e^-$	$\longrightarrow Sn^{2+}(aq)$	+0.15
$2\ H^+(aq) + 2\ e^-$	$\longrightarrow H_2(g)$	0.00
$Sn^{2+}(aq) + 2\ e^-$	$\longrightarrow Sn(s)$	−0.14
$Ni^{2+}(aq) + 2\ e^-$	$\longrightarrow Ni(s)$	−0.25
$V^{3+}(aq) + e^-$	$\longrightarrow V^{2+}(aq)$	−0.255
$PbSO_4(s) + 2\ e^-$	$\longrightarrow Pb(s) + SO_4^{2-}(aq)$	−0.356
$Cd^{2+}(aq) + 2\ e^-$	$\longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2\ e^-$	$\longrightarrow Fe(s)$	−0.44
$Zn^{2+}(aq) + 2\ e^-$	$\longrightarrow Zn(s)$	−0.763
$2\ H_2O(\ell) + 2\ e^-$	$\longrightarrow H_2(g) + 2\ OH^-(aq)$	−0.8277
$Al^{3+}(aq) + 3\ e^-$	$\longrightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2\ e^-$	$\longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.714
$K^+(aq) + e^-$	$\longrightarrow K(s)$	−2.925
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.045

Increasing strength of oxidizing agents

Increasing strength of reducing agents

* In volts (V) versus the standard hydrogen electrode.

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