AP Chem Redox Study Sheet!!!
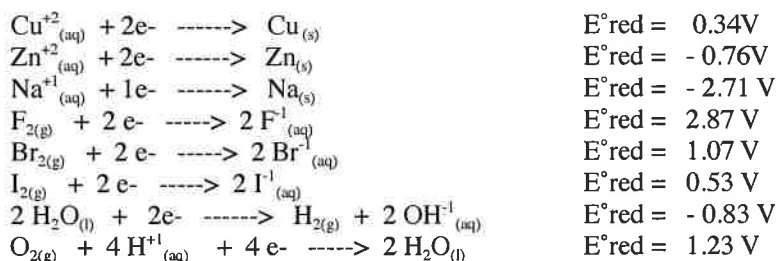
1. Rank from strongest to weakest oxidizing agent: NO_3^{-1} (in acid), Ag^{+1}, Ag, $Cr_2O_7^{-2}$ (in acid)

2. Rank from strongest to weakest reducing agent: I_2 Fe Fe^{+2}

$Cu^{+2}_{(aq)} + 2e- \longrightarrow Cu_{(s)}$ $E°red = 0.34V$

$Zn^{+2}_{(aq)} + 2e- \longrightarrow Zn_{(s)}$ $E°red = -0.76V$

$Na^{+1}_{(aq)} + 1e- \longrightarrow Na_{(s)}$ $E°red = -2.71$ V

$F_{2(g)} + 2 e- \longrightarrow 2 F^{-1}_{(aq)}$ $E°red = 2.87$ V

$Br_{2(g)} + 2 e- \longrightarrow 2 Br^{-1}_{(aq)}$ $E°red = 1.07$ V

$I_{2(g)} + 2 e- \longrightarrow 2 I^{-1}_{(aq)}$ $E°red = 0.53$ V

$2 H_2O_{(l)} + 2e- \longrightarrow H_{2(g)} + 2 OH^{-1}_{(aq)}$ $E°red = -0.83$ V

$O_{2(g)} + 4 H^{+1}_{(aq)} + 4 e- \longrightarrow 2 H_2O_{(l)}$ $E°red = 1.23$ V

3. If a voltage is applied to solution of $NaBr_{(aq)}$, and electrolysis occurs,
a. Write the half reaction that will occur at the cathode (this is the reduction half-reaction).

b. Write the half reaction that will occur at the anode (the oxidation half reaction).

c. Write the overall redox reaction that occurs, and calculate E°rxn (E°cell)

4. If a voltage is applied to solution of $ZnF_{2(aq)}$, and electrolysis occurs,
a. Write the half reaction that will occur at the cathode.

b. Write the half reaction that will occur at the anode.

c. Write the overall redox reaction that occurs, and calculate E°rxn (E°cell)

5. If a voltage is applied to solution of $CuI_{2(aq)}$, and electrolysis occurs,

a. Write the half reaction that will occur at the cathode.

b. Write the half reaction that will occur at the anode.

c. Write the overall redox reaction that occurs, and calculate E°rxn (E°cell)

d. What mass of Cu(s) can form, if a the solution is electrolyzed for 45 minutes, with an average current of 0.62 A?

**6.** Suppose that 24.42 mL of 0.50 M $K_2Cr_2O_7$ (in acidic solution) were needed to oxidize 7.59 g solid lead.
a. Write a balanced half reaction for the reduction of the dichromate ion to Cr^{+3}, in acid.

b. Which lead ion formed: Plumbous or plumbic?

7. A voltage was applied to a solution of "Tin sulfate." An electric current was 950 mA (milliamperes) applied over the course of 1.0 hour resulted in the production of 2.10 g solid tin. Was the compound "Tin II sulfate" or "Tin IV sulfate"?

8. (AP 2002)

The reaction between silver ion and solid zinc is represented by the following equation.

$$2 Ag^+(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + 2 Ag(s)$$
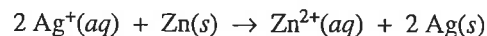
(a) A 1.50 g sample of Zn is combined with 250. mL of 0.110 M $AgNO_3$ at 25°C.

   (i) Identify the limiting reactant. Show calculations to support your answer.

   (ii) On the basis of the limiting reactant that you identified in part (i), determine the value of $[Zn^{2+}]$ after the reaction is complete. Assume that volume change is negligible.

(b) Determine the value of the standard potential, $E°$, for a galvanic cell based on the reaction between $AgNO_3(aq)$ and solid Zn at 25°C.

Another galvanic cell is based on the reaction between $Ag^+(aq)$ and $Cu(s)$, represented by the equation below. At 25°C, the standard potential, $E°$, for the cell is 0.46 V.

$$2 Ag^+(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + 2 Ag(s)$$
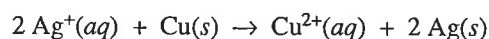
(c) Determine the value of the standard free-energy change, $\Delta G°$, for the reaction between $Ag^+(aq)$ and $Cu(s)$ at 25°C.

(d) The cell is constructed so that $[Cu^{2+}]$ is 0.045 M and $[Ag^+]$ is 0.010 M. Calculate the value of the potential, E, for the cell.

(e) Under the conditions specified in part (d), is the reaction in the cell spontaneous? Justify your answer.

9. (AP 1997)

In an electrolytic cell, a current of 0.250 ampere is passed through a solution of a chloride of iron, producing $Fe(s)$ and $Cl_2(g)$.

(a) Write the equation for the half-reaction that occurs at the anode.

(b) When the cell operates for 2.00 hours, 0.521 gram of iron is deposited at one electrode. Determine the formula of the chloride of iron in the original solution.

(c) Write the balanced equation for the overall reaction that occurs in the cell.

(d) How many liters of $Cl_2(g)$, measured at 25°C and 750 mm Hg, are produced when the cell operates as described in part (b) ?

(e) Calculate the current that would produce chlorine gas from the solution at a rate of 3.00 grams per hour.

10. (AP 2007)

Power Supply

$Cu^{2+}(aq) + 2\,e^- \longrightarrow Cu(s)$
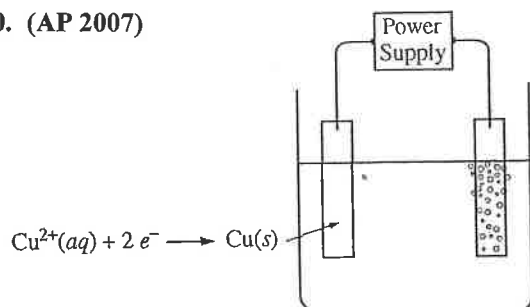
An external direct-current power supply is connected to two platinum electrodes immersed in a beaker containing $1.0\,M$ $CuSO_4(aq)$ at 25°C, as shown in the diagram above. As the cell operates, copper metal is deposited onto one electrode and $O_2(g)$ is produced at the other electrode. The two reduction half-reactions for the overall reaction that occurs in the cell are shown in the table below.

Half-Reaction	$E°(V)$
$O_2(g) + 4\,H^+(aq) + 4\,e^- \rightarrow 2\,H_2O(l)$	+1.23
$Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$	+0.34

(a) On the diagram, indicate the direction of electron flow in the wire.

(b) Write a balanced net ionic equation for the electrolysis reaction that occurs in the cell.

(c) Predict the algebraic sign of $\Delta G°$ for the reaction. Justify your prediction.

(d) Calculate the value of $\Delta G°$ for the reaction.

An electric current of 1.50 amps passes through the cell for 40.0 minutes.

(e) Calculate the mass, in grams, of the $Cu(s)$ that is deposited on the electrode.

(f) Calculate the dry volume, in liters measured at 25°C and 1.16 atm, of the $O_2(g)$ that is produced.
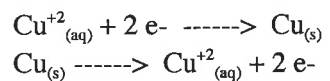
Multiple Choice Answers:

19 e	34 a	35 c	49 d	51 b	57 a	71b

Problem CC.
$$Cu^{+2}_{(aq)} + 2 e^- \longrightarrow Cu_{(s)} \qquad E^\circ_{reduction} = \quad 0.34 \quad V$$
$$Cu_{(s)} \longrightarrow Cu^{+2}_{(aq)} + 2 e^- \qquad E^\circ_{oxidation} = \underline{\qquad} V$$

A "concentration cell" is constructed using the above two half reactions.
The left beaker contains a piece of solid copper and a 2.0 M $CuSO_4$ solution. The right beaker contains a piece of solid copper, and a 0.080 M $CuSO_4$ solution. The salt bridge contains potassium nitrate.

a. Sketch a picture of the voltaic cell.
b. Fill in the oxidation half cell voltage, above, and determine E°_{cell} .

c. On your sketch, show the direction of electron flow through the external circuit, and the direction of anion and cation flow in the salt bridge.
d. Label the anode and cathode of the cell, and label each electrode as + or −
e. Which electrode will gain mass during the reaction? which will lose mass?

f. How will the appearance and concentration (of Cu^{+2}) of the solutions change as the cell operates?

g. Write an overall reaction for the cell, and an expression for Q. (Since the Cu^{+2} ions will be on each side, indicate whether you mean the $Cu^{+2}_{(aq)}$ in the concentrated solution or in the dilute solution.)

h. Calculate the cell voltage, E_{cell}.

i. Calculate the cell voltage after it has been operating for a while, so that the left beaker has a cupric ion concentration of 1.2 M, and the right beaker has a cupric ion concentration of 0.88 M.

j. If this voltaic cell is allowed to run until equilibrium is reached,

    i. what will happen to the molarities?
    ii. What will be the value of Q?
    iii. what will happen to the cell emf?

right after problem 10 of this packet

AP Multiple Choice (Answers are ~~on the previous page.~~)
This part of the packet is optional, but good practice. I'll put a few MC on your quiz/test.

19. In which of the following species does sulfur have the same oxidation number as it does in H_2SO_4 ?

(A) H_2SO_3

(B) $S_2O_3^{2-}$

(C) S^{2-}

(D) S_8

(E) SO_2Cl_2

Questions 34-35 refer to an electrolytic cell that involves the following half-reaction.

$$\dot{A}lF_6^{3-} + 3\ e^- \rightarrow \ Al + 6\ F^-$$
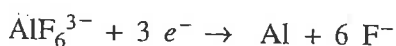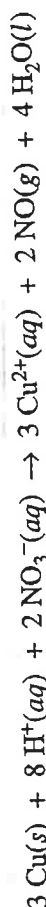
34. Which of the following occurs in the reaction?

(A) AlF_6^{3-} is reduced at the cathode.
(B) Al is oxidized at the anode.
(C) Aluminum is converted from the -3 oxidation state to the 0 oxidation state.
(D) F^- acts as a reducing agent.
(E) F^- is reduced at the cathode.

35. A steady current of 10 amperes is passed through an aluminum-production cell for 15 minutes. Which of the following is the correct expression for calculating the number of grams of aluminum produced? (1 faraday $= 96,500$ coulombs)

(A) $\dfrac{(10)\ (15)\ (96,500)}{(27)\ (60)}\ g$

(B) $\dfrac{(10)\ (15)\ (27)}{(60)\ (96,500)}\ g$

(C) $\dfrac{(10)\ (15)\ (60)\ (27)}{(96,500)\ (3)}\ g$

(D) $\dfrac{(96,500)\ (27)}{(10)\ (15)\ (60)\ (3)}\ g$

(E) $\dfrac{(27)\ (3)}{(96,500)\ (10)\ (15)\ (60)}\ g$

71. In the electroplating of nickel, 0.200 faraday of electrical charge is passed through a solution of $NiSO_4$. What mass of nickel is deposited?
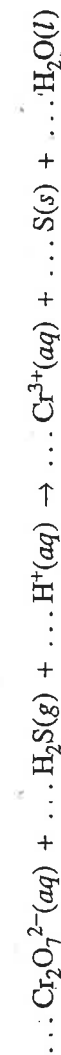
(A) 2.94 g
(B) 5.87 g
(C) 11.7 g
(D) 58.7 g
(E) 294 g

$$3\ Cu(s) + 8\ H^+(aq) + 2\ NO_3^-(aq) \rightarrow 3\ Cu^{2+}(aq) + 2\ NO(g) + 4\ H_2O(l)$$

51. True statements about the reaction represented above include which of the following?

I. $Cu(s)$ acts as an oxidizing agent.
II. The oxidation state of nitrogen changes from +5 to +2.
III. Hydrogen ions are oxidized to form $H_2O(l)$.

(A) I only
(B) II only
(C) III only
(D) I and II
(E) II and III

$$\ldots Cr_2O_7^{2-}(aq) + \ldots H_2S(g) + \ldots H^+(aq) \rightarrow \ldots Cr^{3+}(aq) + \ldots S(s) + \ldots H_2O(l)$$

When the equation above is correctly balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $H^+(aq)$ is

(A) 2   (B) 4   (C) 6   (D) 8   (E) 14

49
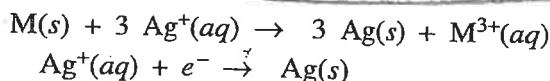
$$M(s) + 3\ Ag^+(aq) \rightarrow \ 3\ Ag(s) + M^{3+}(aq) \qquad E° = +\ 2.46\ V$$
$$Ag^+(aq) + e^- \rightarrow \ Ag(s) \qquad\qquad\qquad E° = +\ 0.80\ V$$

57. According to the information above, what is the standard reduction potential for the half-reaction $M^{3+}(aq) + 3\ e^- \rightarrow M(s)$?

(A) -1.66 V
(B) -0.06 V
(C) 0.06 V
(D) 1.66 V
(E) 3.26 V

Redox Test Topics:

(A volt table, the Nernst equation, and R and $\mathscr{F}$ values will be given. Memorize all other constants/formulas.)

Finding oxidation number.
Identify the substance oxidized and/or substance reduced in a chemical reaction or half-reaction.
Identify the oxidizing agent (or "oxidant") and reducing agent (or "reductant") in a chemical rxn.
Balancing redox reactions with the half-reaction method, in acid or in base.
$\mathscr{F}$ will be given ($\mathscr{F}$ = 96485 C/mole e-)
R will be given (R = 0.0821 L-atm/K mole = 8.314 J/K-mole)

Stoichiometry problems with electrical current, voltage, and the Faraday.
(Examples: if a solution of zinc iodide is electrolyzed for 5 hours at 2.00 amps, what mass of zinc would form? What is the minimum electrical energy required?
If 1.0 grams of Zinc react in a battery, how much energy would be released (if you were given the half reactions?)

Redox Titration, like the questions on the $KMnO_4/H_2O_2$ lab

Calculating voltages for overall reactions (E°cell / E°rxn) based on looking up reduction potentials in the chart.

$\Delta G° = $ - n $\mathscr{F}$E°   or $\Delta G = $ - n $\mathscr{F}$E
$\Delta G° = $ - RT ln K_{eq}

Sign conventions:
  Voltaic cells (aka Galvanic cells) have a positive E°cell, negative ΔG°rxn, Keq >1.
  (these involve a spontaneous rxn, and can do electrical work.)
  Electrolytic cells have a negative E°cell, positive ΔG°rxn, Keq <1.
  (these involve a non spontaneous reaction. You must do work to make the rxn occur.)

Battery (Voltaic cell) Details:
  Given the overall balanced reaction, which substances go where in the battery?
  Label the anode, cathode, +/- terminals
  Show the direction of electron flow through the external circuit
  Show the direction of + and – ion flow in the salt bridge
  Which side's electrode, if any, will lose mass during the the reaction? Which side's will gain mass?
  How will the solute concentrations on each side change as the battery operates?
  As a battery operates, Q increases, so E decreases (this can be calculated using the Nernst equation)

Use a volt table to compare substances in terms of strength as oxidizing or reducing agents.
Use a volt table to determine which oxidation and reduction reactions will happen if an aqueous solution is electrolyzed.
How does a volt table (in numerical order) relate to the activity series of metals? to the halogen activity series?
For the "standard hydrogen electrode," what is the oxidation half reaction? the reduction half reaction?
  what are the values for E°$_{ox}$ and E°$_{red}$ for these half reactions?

$E = E° - (RT/n\mathscr{F})$ ln Q   (Nernst Equation)
  Use Nernst equation to find voltage for a given concentration, and understand that:
  If E = 0, rxn is at equilibrium
  If E is positive, rxn needs to shift forward to reach eqm; spontaneous in forward direction.
  If E is negative, rxn needs to shift left to reach eqm; not spontaneous in forward direction.
  (note, a battery will only function so long as E stays positive!)
  If Q > 1, how will the actual voltage (E) compare to the "standard" voltage (E°)?
  If Q < 1, how will the actual voltage (E) compare to the "standard" voltage (E°)?

Concentration Cells: What is a concentration cell?
  Given the solute concentrations on each side of a concentration cell:
    Which way will the e- flow in the external circuit?
    Which directions do anions/cations flow through the salt bridge?
    Which side is the anode/cathode?
    How will the solute concentrations change over time on each side?
    Use Nernst equation to calculate E$_{cell}$ for the concentration cell.