Chapter 19 Worksheet 3 (cell potentials and free energy)

Name: UGA ID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname).
- Your UGA myID is a combination of letters and numbers (example: mine is wpe28548). **Do not use your 81x number.**
- If you do not have a printer, type your answers in the then upload the worksheet template to Gradescope by Saturday, May 1 at 11:59 pm. Write your work on separate sheets of paper, convert to a PDF and upload to eLC.
- If you have a printer download the worksheet, convert it to a PDF and upload to Gradescope by Saturday, May 1 at 11:59 pm. You do not need to upload anything to eLC.

1A. A. When hydrogen reacts with calcium metal, what are the oxidation numbers of the calcium and hydrogen in the CaH_2 product?

Ca: H:

B. What are the original and final oxidation numbers for iron in the smelting of iron from iron oxide?

$$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$$

$\longrightarrow$

2. Calculate the equilibrium constant for this electrochemical cell at 298 K.

$$Cr(s)|Cr^{3+}(aq, 1M)||Ag^{+}(aq)|Ag(s)$$

$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$ 0.799 V

$Cr^{3+}(aq) + 3\ e^{-} \rightarrow Cr(s)$ -0.41 V

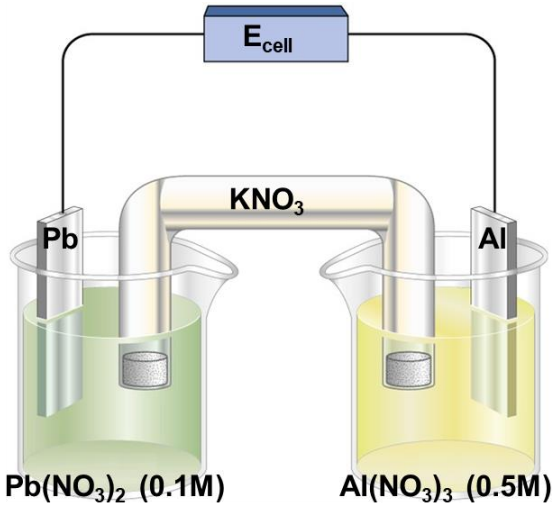
3. The Nernst equation for the electrochemical cell depicted is:

A. $E_{cell} = -1.551\ V - \frac{0.0592\ V}{6} \log \frac{[Pb^{2+}]^3}{[Al^{3+}]^2}$

B. $E_{cell} = 1.551\ V - \frac{0.0592\ V}{3} \log \frac{[Al^{3+}]}{[Pb^{2+}]}$

C. $E_{cell} = -1.551\ V - \frac{0.0592\ V}{6} \log \frac{[Al^{3+}]^2}{[Pb^{2+}]^3}$

D. $E_{cell} = -1.551\ V - \frac{0.0592\ V}{2} \log \frac{[Pb^{2+}]^2}{[Al^{3+}]^3}$



$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$ $E^o = -0.125\ V$

$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$ $E^o = -1.676\ V$

4. The observed cell potential for a voltaic cell is 2.067 V when the temperature is 298 K and the concentration of copper(II) ions is 1.07 M. What is the concentration of aluminum ions in this cell?

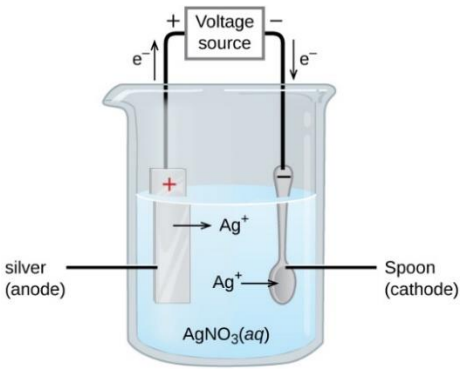
$Al(s)|Al^{3+}(aq,?M)||Cu^{2+}(aq, 1.07M)|Cu(s)$

$Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$ 0.337 V

$Al^{3+}(aq) + 3\ e^- \rightarrow Al(s)$ -1.66 V

M

5. In one process used for electroplating sliver, a current of 10.23 C/sec was passed through an electrolytic cell for exactly 1 hour.



A. How many moles of electrons passed through the cell?

$$Q = n \cdot F$$

Q: charge in Coulombs

*n: moles of electrons (*1 mol e^- = 96485 Coulombs)

F: Faraday's constant 96,485 C/mol e^-

B. What mass of silver was deposited at the cathode from the silver nitrate solution?

grams

6. In one application, a 0.010 mm layer of chromium must be deposited on a part with a total surface area of 3.3 m^2 from a solution containing chromium(III) ions. How long would it take to deposit the layer of chromium if the current was 33.46 Amp? The density of Cr metal is 7.19 g/cm^3.

A. What is the volume of Cr?

cm^3

B. What amount of Cr is needed?

moles

C. What is the total charge

Coulombs

D. How much time is needed?

hours

7. Methanol (CH_3OH) is used in fuel cells to generate energy and avoid using petroleum products. How many moles of electrons are transferred in this combustion reaction?

Moles of electrons

8. For this redox reaction, which statement, A–D, is **incorrect**?

$$2\ Au + 4\ Cl_2 \rightarrow 2\ AuCl_4^{-2}$$

A. Au is the reducing agent.

B. The equation is fully balanced.

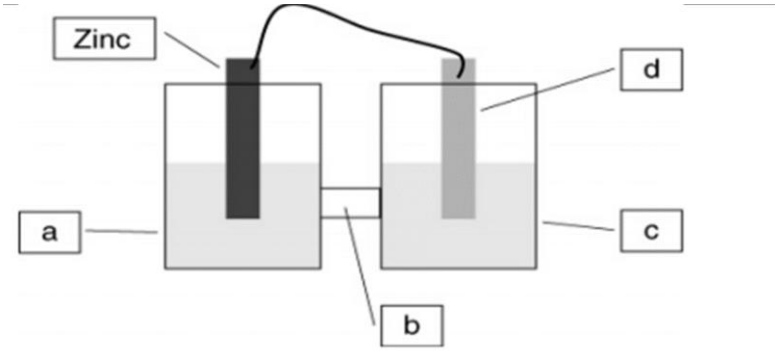
C. Cl_2 is the oxidizing agent

D. Au is oxidized.

E. More than one statement is not correct.

9. A voltaic cell is constructed based on the oxidation of zinc metal and the reduction of silver cations. Solutions of silver nitrate and zinc nitrate also were used.

A. Identify the silver and the silver nitrate on the diagram.



A. silver = b; silver nitrate = a

B. silver = d; silver nitrate = b

C. silver = d; silver nitrate = c

D. silver = d; silver nitrate = a

B. Locate the zinc nitrate on the diagram, and identify the anode.

A. Zinc nitrate = a; anode = d

B. Zinc nitrate = a; anode = Zinc

C. Zinc nitrate = c; anode = d

D. Zinc nitrate = c; anode = Zinc

C. Which statement is true regarding the direction of electron flow through the external wire?

A. Electrons flow from left to right, from the Zinc

B. Electrons flow from right to left, to the Zinc

C. The zinc electrode will get larger as more zinc forms.

D. Anions will flow through the “bridge” from the zinc side to the silver side

10. On the TV sitcom, *Gilligan's Island*, the professor frequently constructed voltaic cells to use as substitutes for their radio's dead batteries. Which scraps of metal from their damaged boat, the *Minnow*, could best be used to create a 1.5 V voltaic cell? (Assume that coconuts make great beakers and that seawater is a strong electrolyte!)

Metal/Metal ion	**$E°_{cell}$**
lead/lead(II) (fishing weights)	–0.126
iron/iron(II) (the anchor)	–0.44
silver/silver(I) (Mrs. Howell's brooch)	–0.799
aluminum/aluminum(III) (the boat's flagpole)	–1.677

A. silver anode and lead cathode

B. aluminum anode and silver cathode

C. aluminum anode and lead cathode

D. lead cathode and silver anode

E. iron anode and aluminum cathode

11. A chemist in the laboratory made the observation seen below. Which statement is **NOT TRUE**?

$$Mg + NiBr2 \rightarrow Ni + MgBr2$$

$$Ni + MgBr2 \rightarrow \text{No Reaction}$$

A. Ni is more attracted to electrons than Mg. That's why Mg gives electrons to Ni^{2+}

B. Mg is less attracted to electrons than Ni. That's why Mg^{2+} doesn't take electrons from Mg

C. When a redox reaction does NOT occur (equation 2), it means that the reduced form of nickel is a weaker reducing agent than the reduced form of Mg

D. When a redox reaction DOES occur (equation 1), it means that the reduced form of Mg is a stronger reducing agent than the reduced form of Ni

E. When a redox reaction does NOT occur (equation 2), it means that the reduced form of nickel is a stronger reducing agent than the reduced form of Mg

12. The combustion reaction of methanol has a ΔG° value of –937.9 kJ/mol. What is the standard cell potential for a methanol fuel cell?

[ ] Volts

13. Which of the statements must be true for the reaction in the standard state?

$$Zn\ (s) + SnBr_2\ (aq) \rightarrow ZnBr_2\ (aq) + Sn\ (s) \qquad E^\circ_{Cell} = +0.60\ V$$

[ ]

A. The reaction would be product-favored as written

B. ΔG° for the reaction as written is positive

C. Zinc is undergoing reduction

D. None are correct answers

14. What is the cell potential for this reaction?

$$Zn(s) + Fe^{2+}(aq) \rightarrow Zn^{+2}(aq) + Fe(s) \qquad K_c = 4.38 \times 10^{10}$$

[ ] Volts

15. What is the value of E_{cell} when the concentration of Cu^{2+} is 1.0 M and the concentration of Zn^{2+} is 0.025 M? The value of E°_{cell} for this reaction is 1.10 V.

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

[ ] Volts

16. Most cars use a lead-sulfuric acid battery for starting it. If 1.00 g of Pb is consumed at the anode, how long will it take to recharge the battery, using a current of 0.500 amps to turn the $PbSO_4$ that was produced back into Pb?

[ ] Minutes

17A. Using the Table of Standard Reduction Potentials table, which is the strongest oxidizing agent?

[ ]

B. What is the standard cell potential for a voltaic cell using the Al^{3+}/Al and Fe^{3+}/Fe half-reactions and which metal is the anode?

[ ] Volts Anode: [ ]

C. What is the standard cell potential for a voltaic cell using the Pb^{2+}/Pb and Mg^{2+}/Mg half-reactions and which metal is the cathode?

[ ] Volts Anode: [ ]

Standard Reduction Potentials (volts) in Aqueous Solution	
$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$	+1.80
$Au^{3+} + 3e^- \rightarrow Au$	+1.50
$Fe^{3+} + 3e^- \rightarrow Fe$	+0.771
$I_2 + 2e^- \rightarrow 2\ I^-$	+0.535
$Pb^{2+} + 2e^- \rightarrow Pb$	–0.124
$Al^{3+} + 3e^- \rightarrow Al$	–1.66
$Mg^{2+} + 2e^- \rightarrow Mg$	–2.37
$K^+ + e^- \rightarrow K$	–2.93