CHAPTER 20 PRACTICE QUIZ Name________________________

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

1. Which of the following statements is true concerning the reaction shown above?

(A) Hydrogen is oxidized and oxygen is reduced.

(B) Oxygen is oxidized and hydrogen is reduced.

(C) Oxygen is both oxidized and reduced.

(D) No elements are oxidized or reduced; the reaction is not a redox reaction.

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

$$Ag^{+}(aq) + e^- \rightarrow Ag(s) \qquad E^o = +0.80\ V$$

2. According to the standard reduction potentials given above, which of the following mathematical operations correctly calculates the standard cell potential for the reaction represented below?

$$3\ Ag^{+}(aq) + Al(s) \rightarrow 3\ Ag(s) + Al^{3+}(aq)$$

(A) (–1.66 V) + [(3)(–0.80 V)] = –4.06 V

(B) (+1.66 V) + [(3)(+0.80 V)] = +4.06 V

(C) (–1.66 V) + (–0.80 V) = –2.46 V

(D) (+1.66 V) + (+0.80 V) = +2.46 V

Half-reaction	Standard Reduction Potential at 25°C (V)
$Li^{+}(aq) + e^- \rightarrow Li(s)$	–3.05
$2\ H_2O(l) + 2\ e^- \rightarrow H_2(g) + 2\ OH^-(aq)$	–0.83

3. A direct current is passed through a 1.00 *M* aqueous solution of lithium chloride (LiCl). Chlorine gas is observed as a product at the anode. Based on the information in the table above, which of the following identifies the chemical species that is formed at the cathode and gives the correct justification?

(A) Li(*s*) is produced at the cathode because | –3.05 | is greater than | –0.83 |.

(B) $H_2(g)$ is produced at the cathode because | –0.83 | is less than | –3.05 |.

(C) Li(*s*) is produced at the cathode because the reduction of water is more favorable than the reduction of lithium ions.

(D) $H_2(g)$ is produced at the cathode because the reduction of lithium ions is more favorable than the reduction of water.

Reaction #1: $3\ Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$

Reaction #2: $3\ F_2(g) + N_2(g) \rightarrow 2\ NF_3(g)$

4. Which of the following statements is true concerning the two reactions shown above?

(A) N_2 is oxidized in both reactions.

(B) N_2 is reduced in both reactions.

(C) N_2 is oxidized in Reaction #1, and reduced in Reaction #2.

(D) N_2 is oxidized in Reaction #2, and reduced in Reaction #1.

Questions 5 – 7 refer to galvanic cells made from different combinations of the three half-cells described below.

Half-cell 1: strip of Al(s) in 1.00 M $Al(NO_3)_3(aq)$

Half-cell 2: strip of Cu(s) in 1.00 M $Cu(NO_3)_2(aq)$

Half-cell 3: strip of Fe(s) in 1.00 M $Fe(NO_3)_2(aq)$

Galvanic Cell	Half-cells	Cell Reaction	E^o_{cell} (V)
X	1 and 2	$2\ Al(s) + 3\ Cu^{2+}(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ Cu(s)$	2.00
Y	1 and 3	$2\ Al(s) + 3\ Fe^{2+}(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ Fe(s)$	1.22
Z	2 and 3	$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$	?

5. What is the standard cell potential of galvanic cell Z?

(A) 0.26 V (B) 0.78 V (C) 2.34 V (D) 3.22 V

6. In galvanic cells Y and Z, which of the following takes place in half-cell 3?

(A) Reduction occurs in both cell Y and cell Z.

(B) Oxidation occurs in both cell Y and cell Z.

(C) Reduction occurs in cell Y, and oxidation occurs in cell Z.

(D) Oxidation occurs in cell Y, and reduction occurs in cell Z.

7. If the half-cell containing 1.00 M $Fe(NO_3)_2(aq)$ in galvanic cells Y and Z is replaced with a half-cell containing 5.00 M $Fe(NO_3)_2(aq)$, what will be the effect on the cell voltage of the two galvanic cells?

(A) The voltage will increase in both cells.

(B) The voltage will decrease in both cells.

(C) The voltage will increase in cell Y and decrease in cell Z.

(D) The voltage will decrease in cell Y and increase in cell Z.

Half-Reaction	E° (V)
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.28
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76

8. A standard voltaic cell is to be constructed using two different metals. Based on the standard reduction potentials listed in the table above, which combination will produce the largest cell potential?

(A) silver and copper

(B) silver and zinc

(C) nickel and copper

(D) nickel and zinc

Half-Reaction	E° (V)
$Cl_2(g) + 2e^- \rightarrow 2\,Cl^-(aq)$	+1.36
$Br_2(l) + 2e^- \rightarrow 2\,Br^-(aq)$	+1.06
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14

9. Based on the information in the table above, which of the following reactions is favored to occur under standard conditions?

(A) $Cl_2(g) + Fe(s) \rightarrow 2\,Cl^-(aq) + Fe^{2+}(aq)$

(B) $Fe^{2+}(aq) + 2\,Br^-(aq) \rightarrow Fe(s) + Br_2(g)$

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

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

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

10. The equilibrium constant for the reaction above is 4×10^{15}. Which of the following correctly describes the standard voltage (E°) and the standard free energy change (ΔG°) for this reaction?

(A) $\Delta G^\circ > 0$ and $E^\circ < 0$

(B) $\Delta G^\circ > 0$ and $E^\circ > 0$

(C) $\Delta G^\circ < 0$ and $E^\circ < 0$

(D) $\Delta G^\circ < 0$ and $E^\circ > 0$

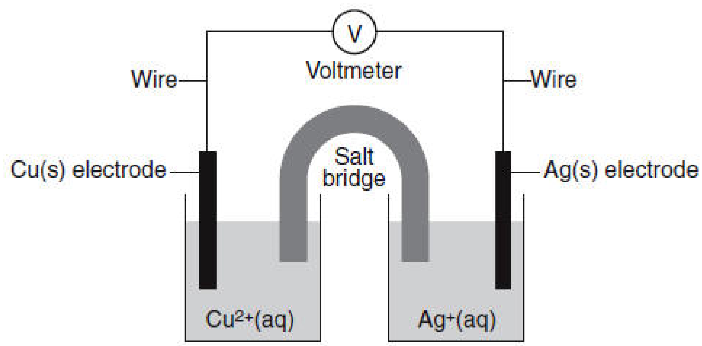
11. In a certain experiment, molten $CaCl_2$ undergoes electrolysis, and the electrical current is 12.0 amps. Which of the following calculations is set up correctly to determine the time (in seconds) required to produce 1.00 gram of calcium?

(A) $\dfrac{(2)(96485)(12.0)}{(40.08)}$

(B) $\dfrac{(2)(96485)}{(40.08)(12.0)}$

(C) $\dfrac{(96485)(12.0)}{(40.08)(2)}$

(D) $\dfrac{(96485)}{(2)(40.08)(12.0)}$



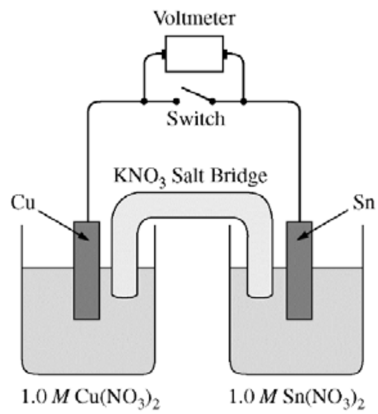
$$Cu(s) + 2\ Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2\ Ag(s) \qquad E^{o} = 0.46\ V$$

12. When the voltaic cell shown above is operated under standard conditions, the initial concentrations of $Cu^{2+}(aq)$ and $Ag^{+}(aq)$ are each equal to 1.0 *M*. The cell potential is equal to 0.46 V at 25°C. A few drops of concentrated hydrochloric acid, HCl(*aq*), are added to the beaker containing the cathode, and a precipitate forms. Which of the following correctly predicts the effect of this change on the cell potential and gives the correct justification for it?

	The cell potential should be…	Justification
(A)	less than 0.46 V	$[Cu^{2+}]$ has decreased
(B)	more than 0.46 V	$[Cu^{2+}]$ has decreased
(C)	less than 0.46 V	$[Ag^{+}]$ has decreased
(D)	more than 0.46 V	$[Ag^{+}]$ has decreased

CHAPTER 20 PRACTICE QUIZ Name________________________

FREE RESPONSE – CALCULATOR IS ALLOWED

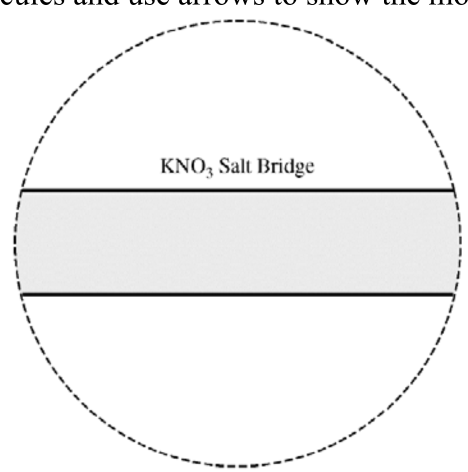


1. A student is given a standard galvanic cell, represented above, that has a Cu electrode and a Sn electrode. As current flows through the cell, the student determines that the Cu electrode increases in mass and the Sn electrode decreases in mass.

    (a) Identify the electrode at which oxidation is occurring. Explain your reasoning based on the student's observations.

    (b) As the mass of the Sn electrode decreases, where does the mass go?

    (c) In the expanded view of the center portion of the salt bridge shown in the diagram below, draw and label a particle view of what occurs in the salt bridge as the cell begins to operate. Omit solvent molecules and use arrows to show the movement of particles.



1. (d) A nonstandard cell is made by replacing the 1.0 *M* solutions of $Cu(NO_3)_2$ and $Sn(NO_3)_2$ in the standard cell with 0.50 *M* solutions of $Cu(NO_3)_2$ and $Sn(NO_3)_2$. The volumes of solutions in the nonstandard cell are identical to those in the standard cell.

(i) Is the cell potential of the nonstandard cell greater than, less than, or equal to the cell potential of the standard cell? Justify your answer.

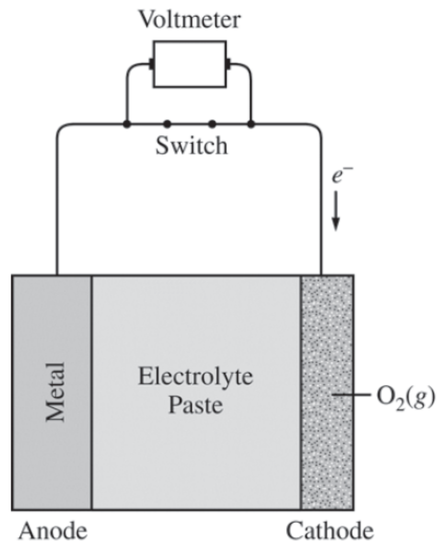
(ii) Both the standard and nonstandard cells can be used to power an electronic device. Would the nonstandard cell power the device for the same time, a longer time, or a shorter time as compared with the standard cell? Justify your answer.

(e) In another experiment, the student places a new Sn electrode into a fresh solution of 1.0 *M* $Cu(NO_3)_2$.

Half-Reaction	E° (V)
$Cu^{+}(aq) + e^{-} \rightarrow Cu(s)$	0.52
$Cu^{2+}(aq) + 2\,e^{-} \rightarrow Cu(s)$	0.34
$Sn^{4+}(aq) + 2\,e^{-} \rightarrow Sn^{2+}(aq)$	0.15
$Sn^{2+}(aq) + 2\,e^{-} \rightarrow Sn(s)$	–0.14

(i) Using information from the table above, write a net-ionic equation for the reaction between the Sn electrode and the $Cu(NO_3)_2$ solution that would be thermodynamically favorable. Justify that the reaction is thermodynamically favorable.

(ii) Calculate the value of $\Delta G°$ for the reaction. Include units with your answer.



2. Metal-air cells are a relatively new type of portable energy source consisting of a metal anode, an alkaline electrolyte paste that contains water, and a porous cathode membrane that lets in oxygen from the air. A schematic of the cell is shown above. Reduction potentials for the cathode and three possible metal anodes are given in the table below.

Half Reaction	Potential (E) at pH 11 and 298 K
$O_2(g) + 2\ H_2O(l) + 4\ e^- \rightarrow 4\ OH^-(aq)$	+0.34 V
$ZnO(s) + H_2O(l) + 2\ e^- \rightarrow Zn(s) + 2\ OH^-(aq)$	–1.31 V
$Na_2O(s) + H_2O(l) + 2\ e^- \rightarrow 2\ Na(s) + 2\ OH^-(aq)$	–1.60 V
$CaO(s) + H_2O(l) + 2\ e^- \rightarrow Ca(s) + 2\ OH^-(aq)$	–2.78 V

(a) Early forms of metal-air cells used zinc as the anode. Zinc oxide is produced as the cell operates according to the overall equation below.

$$2\ Zn(s) + O_2(g) \rightarrow 2\ ZnO(s)$$

(i) Using the data in the table above, calculate the cell potential for the zinc-air cell.

(ii) The electrolyte paste contains OH^- ions. On the diagram of the cell above, draw an arrow to indicate the direction of migration of OH^- ions through the electrolyte as the cell operates.

2. (b) A fresh zinc-air cell is weighed on an analytical balance before being placed in a hearing aid for use.

(i) As the cell operates, does the mass of the cell increase, decrease, or remain the same?

(ii) Justify your answer to part (b)(i) in terms of the equation for the overall cell reaction.

(c) The zinc-air cell is taken to the top of a mountain where the air pressure is lower.

(i) Will the cell potential be higher, lower, or the same as the cell potential at the lower elevation?

(ii) Justify your answer to part (c)(i) based on the equation for the overall cell reaction and the information above.

(d) Metal-air cells need to be lightweight for many applications. In order to transfer more electrons with a smaller mass, Na and Ca are investigated as potential anodes. A 1.0 g anode of which of these metals would transfer more electrons, assuming that the anode is totally consumed during the lifetime of a cell? Justify your answer with calculations.

$$2\ Al_2O_3(l) + 3\ C(s) \rightarrow 4\ Al(l) + 3\ CO_2(g)$$

3. An electrolytic cell produces 235 g of Al(*l*) according to the equation above.

   (a) Calculate the number of moles of electrons that must be transferred in the cell to produce 235 g of Al(*l*).

   (b) A steady current of 152 A was used during the process. Determine the amount of time, in seconds, that was needed to produce 235 g of Al(*l*).

   (c) Calculate the volume of $CO_2(g)$, measured at 300 K and 1.00 atm, that is produced in the process.

When Al(*s*) is placed in a concentrated solution of KOH at 25°C, the reaction represented below occurs.

$$2\ Al(s) + 2\ OH^-(aq) + 6\ H_2O(l) \rightarrow 2\ Al(OH)_4^-(aq) + 3\ H_2(g)$$

Half-reaction	E^o (V)
$Al(OH)_4^-(aq) + 3\ e^- \rightarrow Al(s) + 4\ OH^-(aq)$	–2.35
$2\ H_2O(l) + 2\ e^- \rightarrow H_2(g) + 2\ OH^-(aq)$	–0.83

   (d) Using the table of standard reduction potentials shown above, calculate the following.

      (i) E^o, in volts, for the formation of $Al(OH)_4^-(aq)$ and $H_2(g)$ at 25°C.

      (ii) ΔG^o, in kJ/mol$_{rxn}$, for the formation of $Al(OH)_4^-(aq)$ and $H_2(g)$ at 25°C.