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STANDARD ELECTRODE POTENTIALS

Ionic Concentrations 1 M Water At 298 K, 1 atm

<i>Half-Reaction</i>	<i>E⁰</i> (volts)
$F_2(g) + 2e^- \rightarrow 2F^-$	+2.87
$8H^+ + MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O$	+1.51
$Au^{3+} + 3e^- \rightarrow Au(s)$	+1.50
$Cl_2(g) + 2e^- \rightarrow 2Cl^-$	+1.36
$14H^+ + Cr_2O_7^{2-} + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	+1.23
$4H^+ + O_2(g) + 4e^- \rightarrow 2H_2O$	+1.23
$4H^+ + MnO_2(s) + 2e^- \rightarrow Mn^{2+} + 2H_2O$	+1.22
$Br_2(l) + 2e^- \rightarrow 2Br^-$	+1.09
$Hg^{2+} + 2e^- \rightarrow Hg(l)$	+0.85
$Ag^+ + e^- \rightarrow Ag(s)$	+0.80
$Hg_2^{2+} + 2e^- \rightarrow 2Hg(l)$	+0.80
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$I_2(s) + 2e^- \rightarrow 2I^-$	+0.54
$Cu^+ + e^- \rightarrow Cu(s)$	+0.52
$Cu^{2+} + 2e^- \rightarrow Cu(s)$	+0.34
$4H^+ + SO_4^{2-} + 2e^- \rightarrow SO_2(aq) + 2H_2O$	+0.17
$Sn^{4+} + 2e^- \rightarrow Sn^{2+}$	+0.15
$2H^+ + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+} + 2e^- \rightarrow Pb(s)$	-0.13
$Sn^{2+} + 2e^- \rightarrow Sn(s)$	-0.14
$Ni^{2+} + 2e^- \rightarrow Ni(s)$	-0.26
$Co^{2+} + 2e^- \rightarrow Co(s)$	-0.28
$Fe^{2+} + 2e^- \rightarrow Fe(s)$	-0.45
$Cr^{3+} + 3e^- \rightarrow Cr(s)$	-0.74
$Zn^{2+} + 2e^- \rightarrow Zn(s)$	-0.76
$2H_2O + 2e^- \rightarrow 2OH^- + H_2(g)$	-0.83
$Mn^{2+} + 2e^- \rightarrow Mn(s)$	-1.19
$Al^{3+} + 3e^- \rightarrow Al(s)$	-1.66
$Mg^{2+} + 2e^- \rightarrow Mg(s)$	-2.37
$Na^+ + e^- \rightarrow Na(s)$	-2.71
$Ca^{2+} + 2e^- \rightarrow Ca(s)$	-2.87
$Sr^{2+} + 2e^- \rightarrow Sr(s)$	-2.89
$Ba^{2+} + 2e^- \rightarrow Ba(s)$	-2.91
$Cs^+ + e^- \rightarrow Cs(s)$	-2.92
$K^+ + e^- \rightarrow K(s)$	-2.93
$Rb^+ + e^- \rightarrow Rb(s)$	-2.98
$Li^+ + e^- \rightarrow Li(s)$	-3.04

O

VAPOR PRESSURE OF WATER

°C	torr (mmHg)	°C	torr (mmHg)
0	4.6	26	25.2
5	6.5	27	26.7
10	9.2	28	28.3
15	12.8	29	30.0
16	13.6	30	31.8
17	14.5	40	55.3
18	15.5	50	92.5
19	16.5	60	149.4
20	17.5	70	233.7
21	18.7	80	355.1
22	19.8	90	525.8
23	21.1	100	760.0
24	22.4	105	906.1
25	23.8	110	1074.6

Name:

Period:

Date:

Electrochemical Cells

Answer the following eight questions for each cell.

Fig. 1

1. What gets oxidized?
2. What gets reduced?
3. Which electrode is the anode?
4. Which electrode is the cathode?
5. Which electrode gains mass?
6. Which electrode loses mass?
7. Which direction do the e^- 's flow?
8. Which direction do the ^{negative} ions flow?
9. What is the voltage of the cell?

Fig. 2

1. What gets oxidized?
2. What gets reduced?
3. Which electrode is the anode?
4. Which electrode is the cathode?
5. Which electrode gains mass?
6. Which electrode loses mass?
7. Which direction do the e^- 's flow?
8. Which direction do the ^{negative} ions flow?
9. What is the voltage of the cell?

fig. 3

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fig. 4

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5. Which electrode gains mass?
6. Which electrode loses mass?
7. Which direction do e^- 's the flow?
8. Which direction do the ^{negative} ions flow?
9. What is the voltage of the cell?

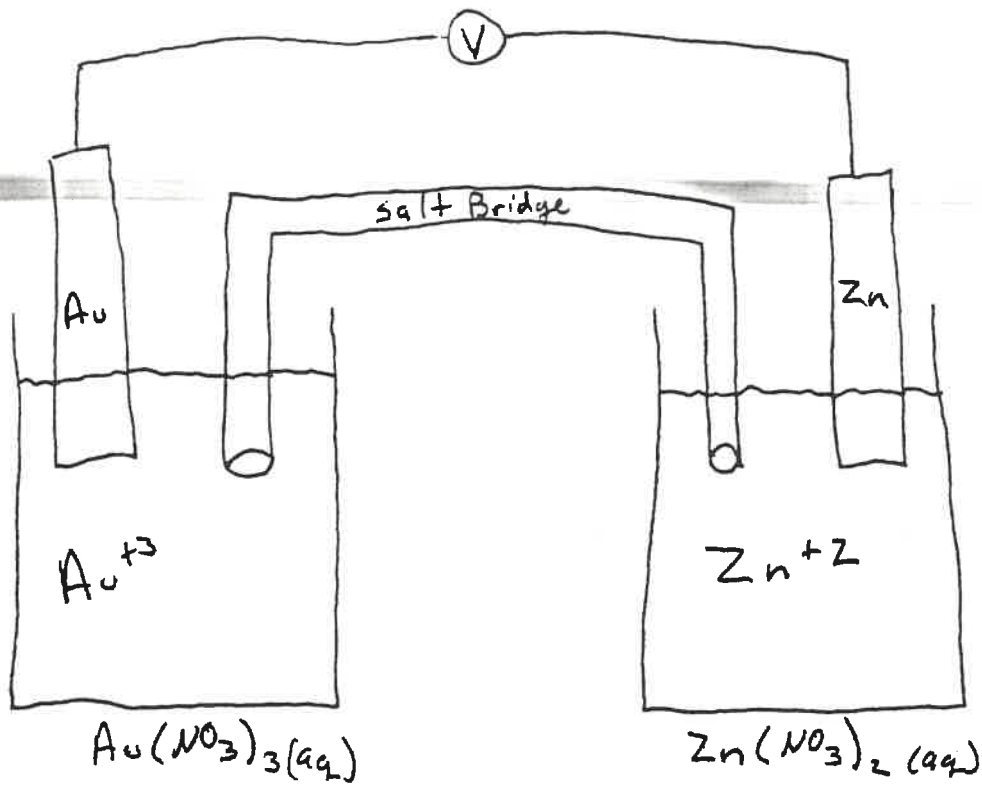
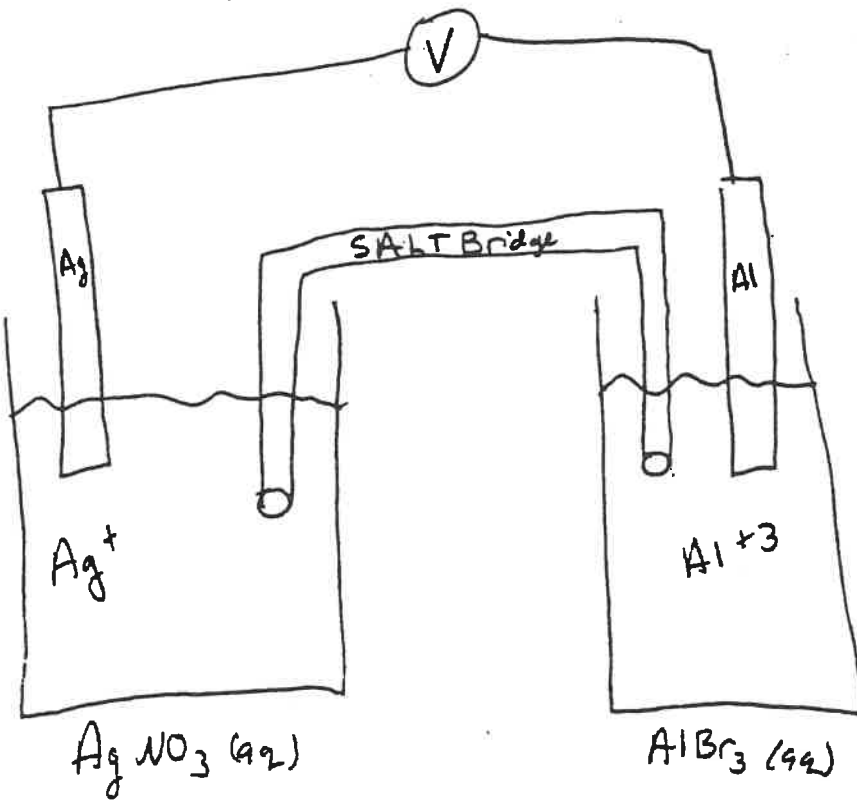


Fig. 2



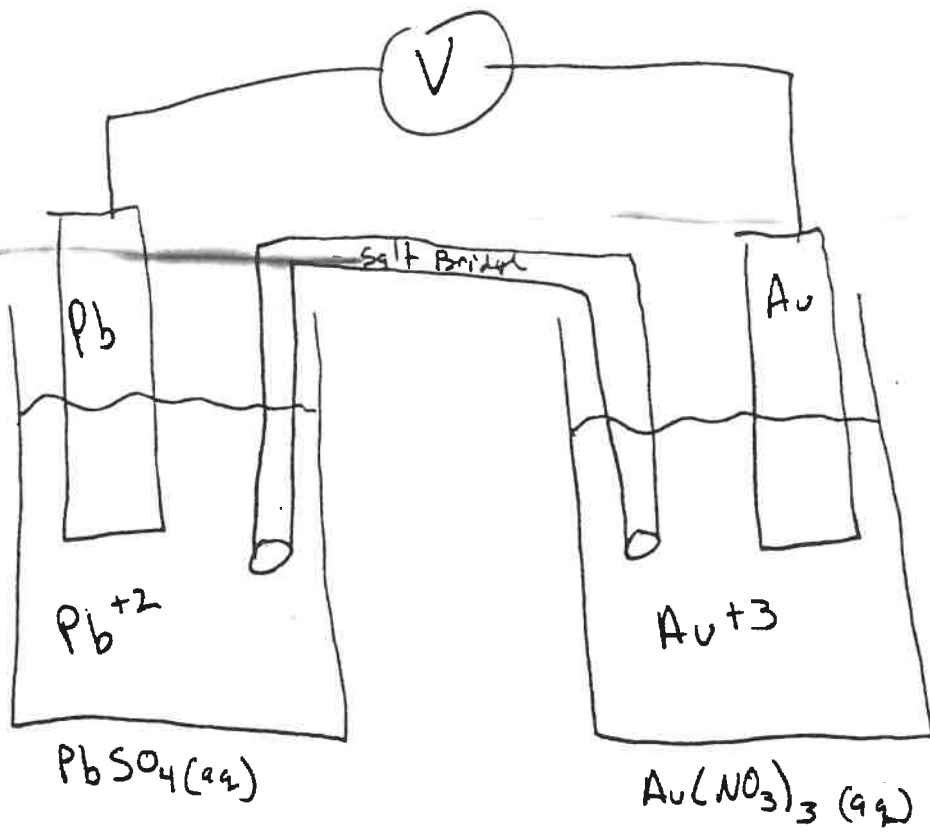
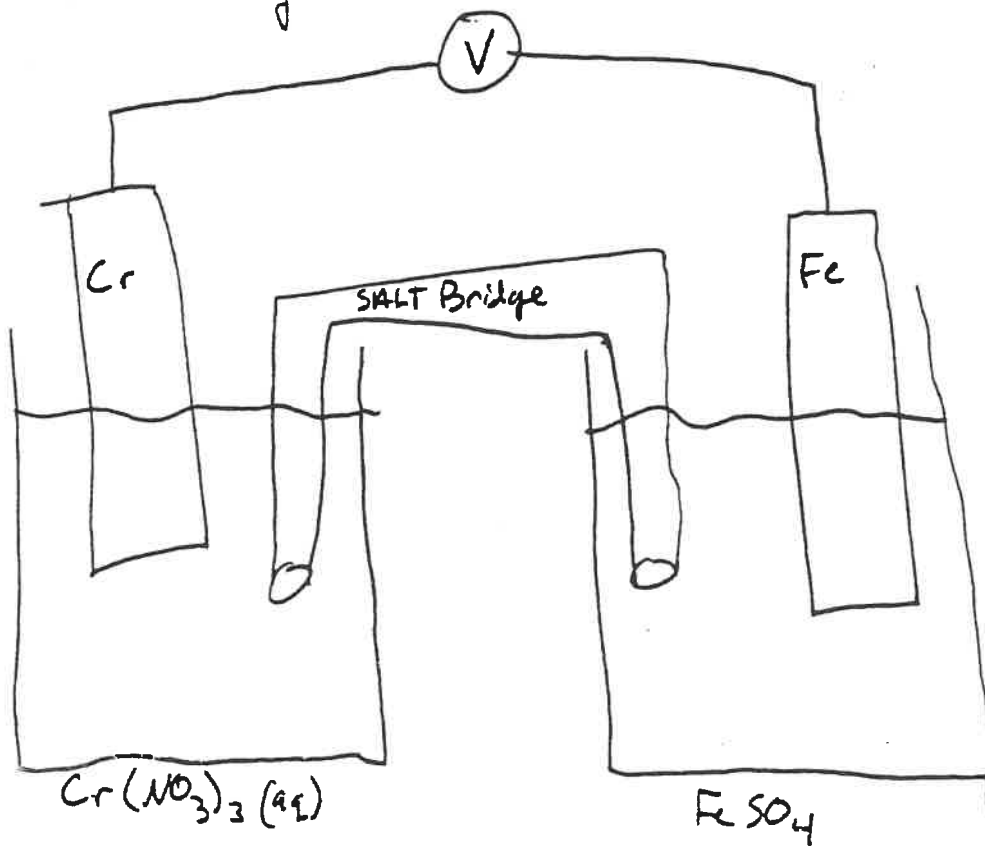
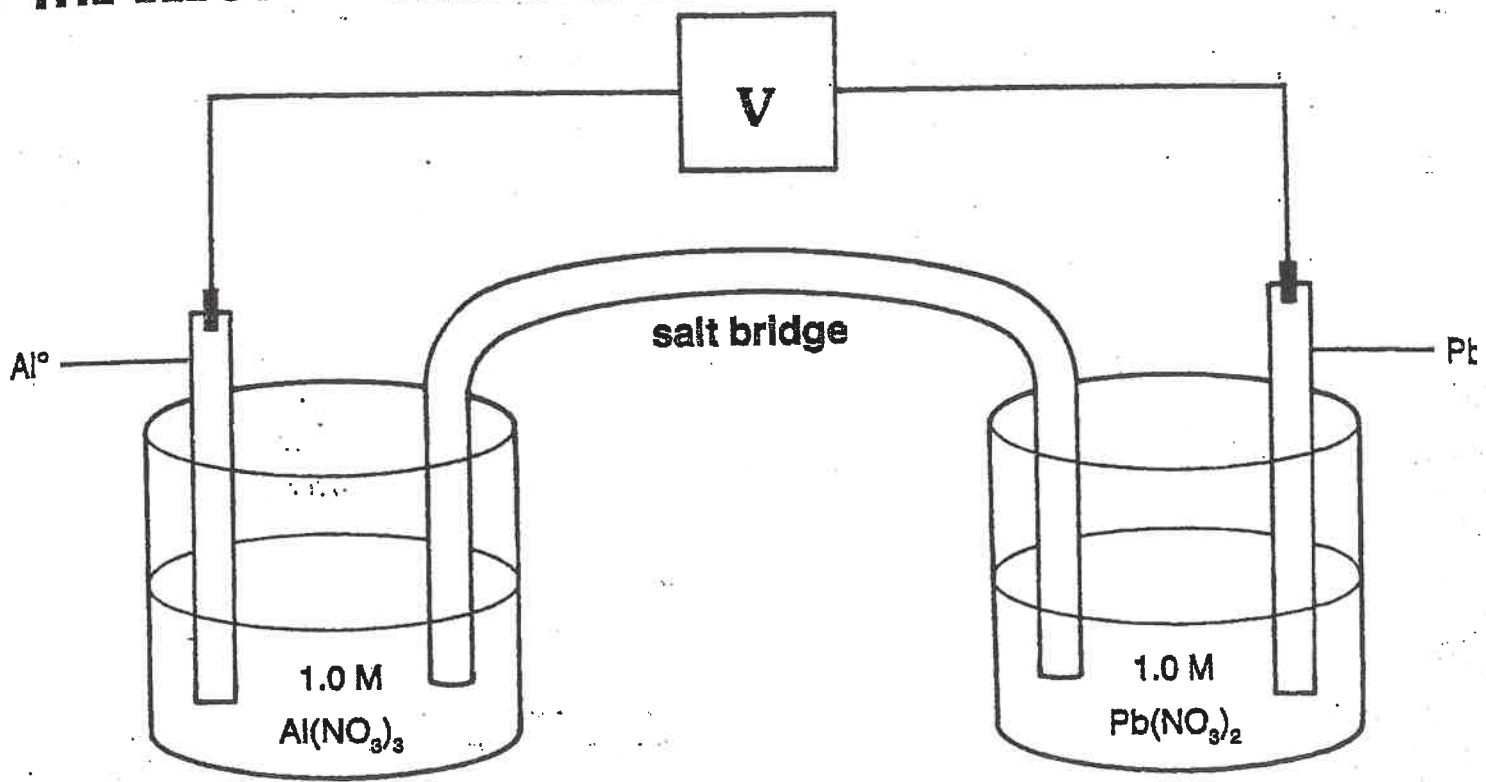


Fig. 4.



THE ELECTROCHEMICAL CELL

Name _____



Answer the questions below referring to the above diagram and a Table of Standard Electrode Potentials.

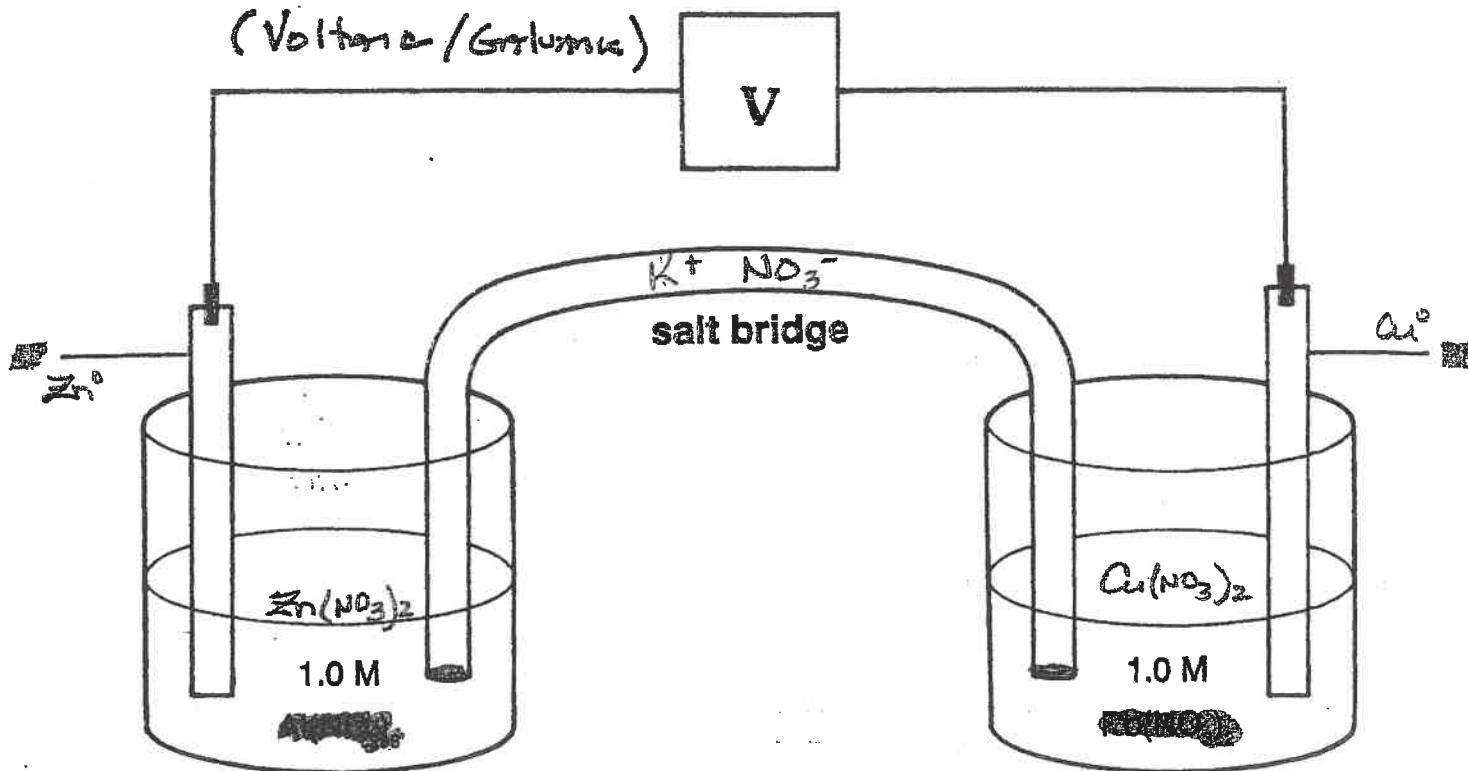
1. Which is more easily oxidized, metal, aluminum or lead? _____
2. What is the balanced equation showing the spontaneous reaction that occurs?

3. What is the maximum voltage that the above cell can produce? _____
4. What is the direction of electron flow in the wire? _____
5. What is the direction of positive ion flow in the salt bridge? _____
6. Which electrode is decreasing in size? _____
7. Which electrode is increasing in size? _____
8. What is happening to the concentration of aluminum ions? _____
9. What is happening to the concentration of lead ions? _____
10. What is the voltage in this cell when the reaction reaches equilibrium? _____
11. Which is the anode? _____
12. Which is the cathode? _____
13. What is the positive electrode? _____
14. What is the negative electrode? _____

THE ELECTROCHEMICAL CELL

Name _____

(Voltaic / Galvanic)



Answer the questions below referring to the above diagram and a Table of Standard Electrode Potentials.

1. Which is more easily oxidized, metal, ^{Zn} ~~zinc~~ or ^{Cu} ~~copper~~? _____
2. What is the balanced equation showing the spontaneous reaction that occurs?

~~DO~~ 3. What is the maximum voltage that the above cell can produce? _____

4. What is the direction of electron flow in the wire? _____

5. What is the direction of positive ion flow in the salt bridge? _____

6. Which electrode is decreasing in size? _____

7. Which electrode is increasing in size? _____

8. What is happening to the concentration of ^{Zn} ~~zinc~~ ions? _____

9. What is happening to the concentration of ^{Cu} ~~copper~~ ions? _____

~~DO~~ 10. What is the voltage in this cell when the reaction reaches equilibrium? _____

11. Which is the anode? _____

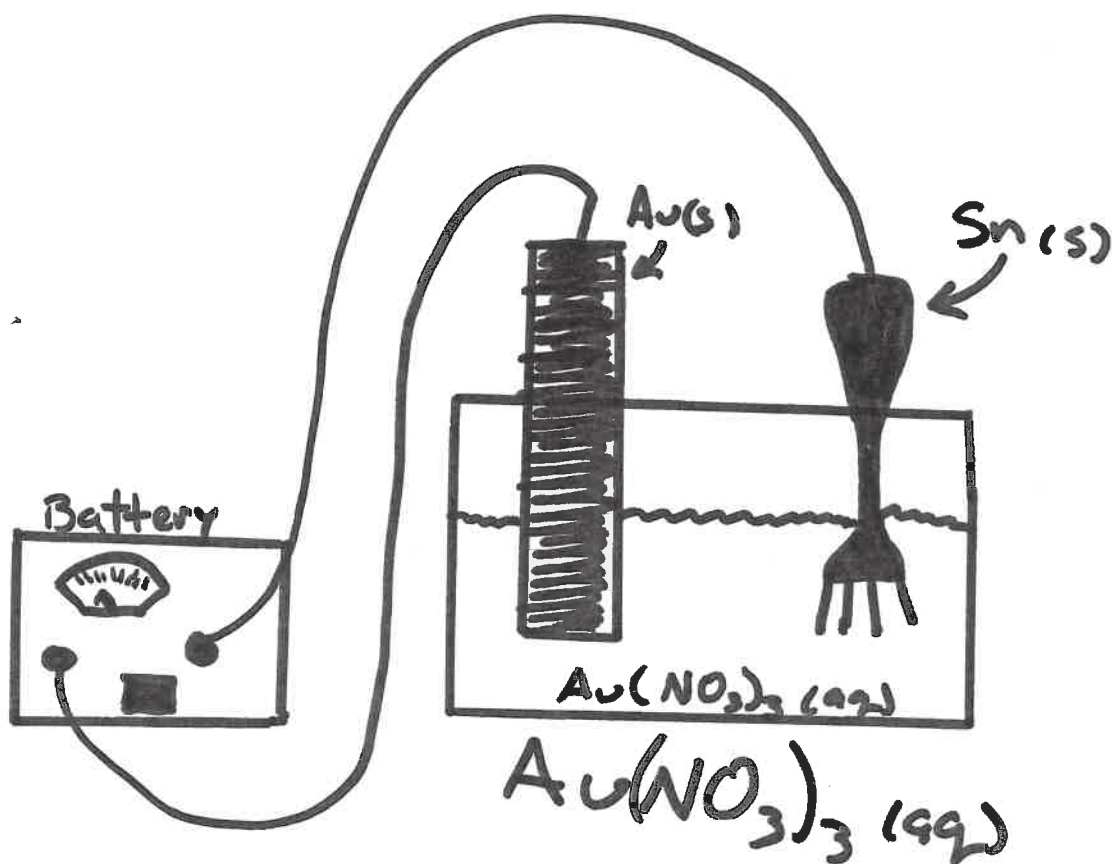
12. Which is the cathode? _____

13. What is the positive electrode? _____

14. What is the negative electrode? _____

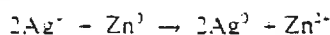
Electrolytic cells

1. Which electrode does oxidation occur?
2. Which electrode does reduction occur?
3. Write the oxidation $\frac{1}{2}$ reaction.
4. Write the reduction $\frac{1}{2}$ reaction.
5. The object to be plated will be which electrode?
6. Is this a spontaneous reaction?
7. Which is the positive electrode?
8. Which is the negative electrode?



1. Oxidation-reduction reactions occur because of the competition between particles for (1) neutrons (2) electrons (3) protons (4) positrons

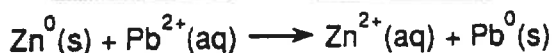
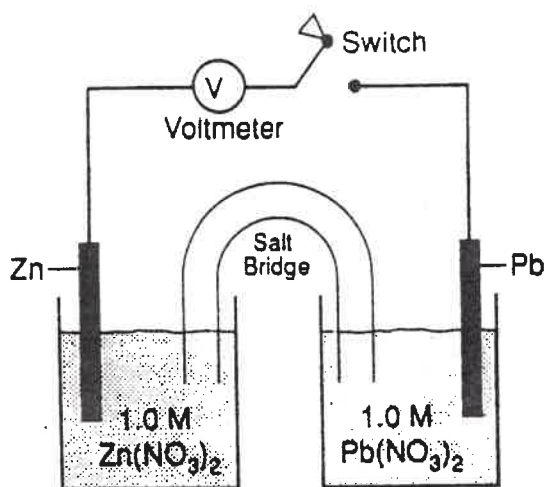
3. Given the chemical cell reaction:



What is the net potential (E°) for the cell?

- (1) 1.56 V (2) 2.36 V (3) 0.84 V (4) 0.04 V

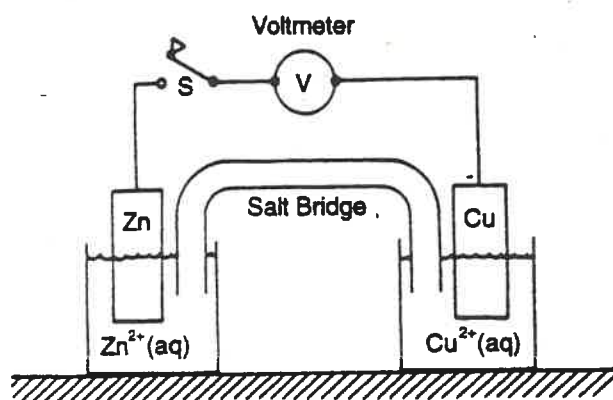
Base your answers to questions 14 and 15 on the diagram of the chemical cell shown below. The reaction occurs at 1 atmosphere and 298 K.



14. When the switch is closed, what occurs?
 (1) Pb is oxidized and electrons flow to the Zn electrode.
 (2) Pb is reduced and electrons flow to the Zn electrode.
 (3) Zn is oxidized and electrons flow to the Pb electrode.
 (4) Zn is reduced and electrons flow to the Pb electrode.

15. When the switch is closed, the cell voltage (E°) is
 (1) +0.63 V (2) +0.89 V (3) -0.63 V (4) -0.89 V

16. The diagram below represents an electrochemical cell



When switch S is closed, which particles undergo reduction?

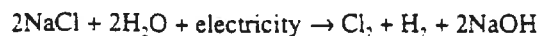
- (1) Zn^{2+} ions (2) Zn atoms (3) Cu^{2+} ions (4) Cu atom

17. A chemical cell is made up of two half-cells connected by a salt bridge and an external conductor. What is the function of the salt bridge? (1) to permit the migration of ions (2) to prevent the migration of ions (3) to permit the mixing of solutions (4) to prevent the flow of electrons

7. How many moles of electrons would be required to completely reduce 1.5 moles of Al^{3+} to Al? (1) 0.50 (2) 1.5 (3) 3.0 (4) 4.5

19. In the reaction $\text{Zn}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu}(\text{s})$, the reducing agent is (1) Zn(s) (2) Cu(s) (3) $\text{Cu}^{2+}(\text{aq})$ (4) $\text{Zn}^{2+}(\text{aq})$

18. Which statement best describes the reaction represented by the equation below?



- (1) The reaction occurs in a chemical cell and releases energy.
 (2) The reaction occurs in a chemical cell and absorbs energy.
 (3) The reaction occurs in an electrolytic cell and releases energy.
 (4) The reaction occurs in an electrolytic cell and absorbs energy.

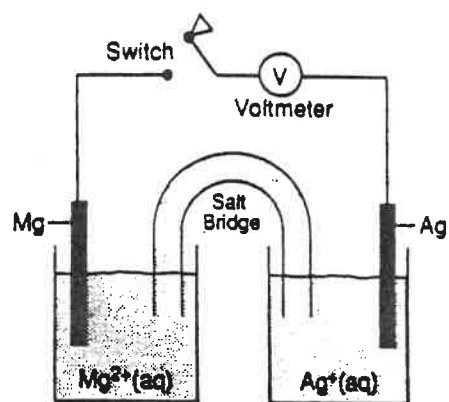
19. During the electrolysis of fused KBr, which reaction occurs at the positive electrode? (1) Br^- ions are oxidized. (2) Br^- ions are reduced. (3) K^+ ions are reduced. (4) K^+ ions are oxidized.

20. In an electrolytic cell, a Cl^- ion would be attracted to the (1) positive electrode and oxidized (2) positive electrode and reduced (3) negative electrode and oxidized (4) negative electrode and reduced

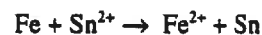
21. What occurs when an electrolytic cell is used for silverplating a spoon? (1) A chemical reaction produces an electrical current. (2) An electric current produces a chemical reaction. (3) An oxidation reaction takes place at the cathode. (4) A reduction reaction takes place at the anode.

22. The type of reaction in an electrochemical cell is best described as a (1) spontaneous oxidation reaction, only (2) nonspontaneous oxidation reaction, only (3) spontaneous oxidation-reduction reaction (4) nonspontaneous oxidation-reduction reaction

Base your answers to questions 23 and 24 on the equation and diagram below which represents an electrochemical cell at 298 K and 1 atmosphere.



23. Which species is oxidized when the switch is closed? (1) Mg(s) (2) $\text{Mg}^{2+}(\text{aq})$ (3) Ag(s) (4) $\text{Ag}^+(\text{aq})$
 24. When the switch is closed, electrons flow from
 (1) Mg(s) to Ag(s) (2) Ag(s) to Mg(s)
 (3) $\text{Mg}^{2+}(\text{aq})$ to $\text{Ag}^+(\text{aq})$ (4) $\text{Ag}^+(\text{aq})$ to $\text{Mg}^{2+}(\text{aq})$
 25. Given the reaction:



What is the potential difference (E°) of this cell?

- (1) 0.14 V (2) 0.31 V (3) 0.45 V (4) 0.59 V

26. In both the electrochemical cell and the electrolytic cell, the anode is the electrode at which (1) reduction occurs and electrons are lost (2) reduction occurs and protons are lost (3) oxidation occurs and electrons are lost (4) oxidation occurs and protons are lost

27. Based on Reference Table N, which reaction will take place spontaneously?

- (1) $\text{Mg}(\text{s}) + \text{Ca}^{2+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{Ca}(\text{s})$
 (2) $\text{Ba}(\text{s}) + 2\text{Na}^+(\text{aq}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{Na}(\text{s})$
 (3) $\text{Cl}_2(\text{g}) + 2\text{F}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{F}_2(\text{g})$
 (4) $\text{I}_2(\text{g}) + 2\text{Br}^-(\text{aq}) \rightarrow 2\text{I}^-(\text{aq}) + \text{Br}_2(\text{g})$

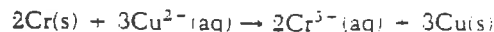
2. In the reaction $\text{Mg} + \text{Cl}_2 \rightarrow \text{MgCl}_2$, the correct half-reaction for the oxidation that occurs is
 (1) $\text{Mg} + 2\text{e}^- \rightarrow \text{Mg}^{2+}$ (2) $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$
 (3) $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ (4) $\text{Cl}_2 \rightarrow 2\text{Cl}^- + 2\text{e}^-$
3. Based on Reference Table N, which of the following ions is most easily oxidized? (1) F^- (2) Cl^- (3) Br^- (4) I^-
4. Based on Reference Table N, which half-cell has a greater reduction potential than the standard hydrogen half-cell?
 (1) $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}(\text{s})$ (2) $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$
 (3) $\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$ (4) $\text{Sn}^{4+} + 2\text{e}^- \rightarrow \text{Sn}^{2+}$
5. According to Reference Table N, which will reduce Mg^{2+} to $\text{Mg}(\text{s})$?
 (1) $\text{Fe}(\text{s})$ (2) $\text{Ba}(\text{s})$ (3) $\text{Pb}(\text{s})$ (4) $\text{Ag}(\text{s})$
6. Which ion will oxidize Fe ?
 (1) Zn^{2+} (2) Ca^{2+} (3) Mg^{2+} (4) Cu^{2+}
7. Which ion can be both an oxidizing agent and a reducing agent?
 (1) Sn^{2+} (2) Cu^{2+} (3) Al^{3+} (4) Fe^{3+}
8. Which reaction will take place spontaneously?
 (1) $\text{Cu} + 2\text{H}^+ \rightarrow \text{Cu}^{2+} + \text{H}_2$ (2) $2\text{Au} + 6\text{H}^+ \rightarrow 2\text{Au}^{3+} + 3\text{H}_2$
 (3) $\text{Pb} + 2\text{H}^+ \rightarrow \text{Pb}^{2+} + \text{H}_2$ (4) $2\text{Ag} + 2\text{H}^+ \rightarrow 2\text{Ag}^+ + \text{H}_2$
9. Which overall reaction in a chemical cell has the highest net potential (E°)?
 (1) $\text{Zn}(\text{s}) + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2(\text{g})$ (2) $\text{Ni}(\text{s}) + 2\text{H}^+ \rightarrow \text{Ni}^{2+} + \text{H}_2(\text{g})$
 (3) $\text{Mg}(\text{s}) + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2(\text{g})$ (4) $\text{Sn}(\text{s}) + 2\text{H}^+ \rightarrow \text{Sn}^{2+} + \text{H}_2(\text{g})$
10. Given the reaction:

$$2\text{Al}(\text{s}) + 3\text{Pb}^{2+}(\text{aq}) \rightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{Pb}(\text{s})$$

 The potential for (E°) for the overall reaction is (1) 1.53 V
 (2) 1.79 V (3) 2.93 V (4) 3.71 V
- Base your answers to questions 11 and 12 on the following reaction:

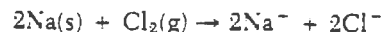
$$\text{Mg}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$$
11. Which species undergoes a loss of electrons?
 (1) $\text{Mg}(\text{s})$ (2) $\text{Ag}^+(\text{aq})$ (3) $\text{Mg}^{2+}(\text{aq})$ (4) $\text{Ag}(\text{s})$
12. What is the cell voltage (E°) for the overall reaction?
 (1) +1.57 V (2) +2.37 V (3) +3.17 V (4) +3.97 V
21. Given the redox reaction: $\text{Ni} + \text{Sn}^{4+} \rightarrow \text{Ni}^{2+} + \text{Sn}^{2+}$
 Which species has been oxidized? (1) Ni (2) Sn^{4+} (3) Ni^{2+}
 (4) Sn^{2+}
22. In which substance is the oxidation number of nitrogen zero?
 (1) N_2 (2) NH_3 (3) NO_2 (4) N_2O
23. What is the oxidation number of Pt in K_2PtCl_6 ? (1) -2 (2) +2
 (3) -4 (4) +4
24. In the reaction $2\text{H}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{SO}_2 + 2\text{H}_2\text{O}$, the oxidizing agent is (1) oxygen (2) water (3) sulfur dioxide (4) hydrogen sulfide
25. In the reaction $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{Na}^+ + 2\text{OH}^- + \text{H}_2$, the substance oxidized is (1) H_2 (2) H^+ (3) Na^+ (4) Na
26. Given the reaction: $3\text{Cu} + 8\text{HNO}_3 \rightarrow 3\text{Cu}(\text{NO}_3)_2 + 2\text{NO} + 4\text{H}_2\text{O}$
 The reducing agent is (1) Cu^0 (2) N^{+5} (3) Cu^{+2} (4) N^{+2}
27. Given the reaction: $\text{Sn}^{2+}(\text{aq}) + 2\text{Fe}^{3+}(\text{aq}) \rightarrow \text{Sn}^{4+}(\text{aq}) + 2\text{Fe}^{2+}(\text{aq})$
 The oxidizing agent in this reaction is (1) Sn^{2+} (2) Fe^{3+} (3) Sn^{4+}
 (4) Fe^{2+}

1. Given the reaction:



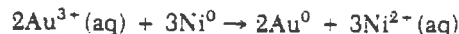
The potential difference (E°) of the cell is (1) 0.40 v
 (2) 1.08 v (3) 1.25 v (4) 2.50 v

2. Given the reaction:



What is the potential (E°) for the overall reaction? (1)
 -1.35 v (2) +1.35 v (3) -4.07 v (4) +4.07 v

3. Given the reaction:



The cell potential (E°) for the overall reaction is (1)
 3.75 v (2) 2.25 v (3) 1.76 v (4) 1.25 v

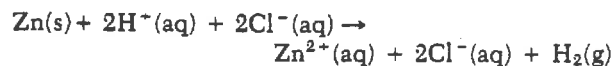
4. What is the potential (
- E°
-) for the reaction



(1) 1.06 v (2) 1.31 v (3) 2.37 v (4) 3.46 v

5. Which species can act either as an oxidizing agent or a reducing agent? (1)
- Na^0
- (2)
- Fe^{2+}
- (3)
- Sn^0
- (4)
- Zn^{2+}

6. Given the reaction:



Which species is oxidized?

(1) $\text{Zn}(\text{s})$ (2) $\text{H}^+(\text{aq})$ (3) $\text{Cl}^-(\text{aq})$ (4) $\text{H}_2(\text{g})$

7. Which pair will react spontaneously at 298 K? (1)

$\text{Cl}_2 + \text{F}^-$ (2) $\text{I}_2 + \text{Br}^-$ (3) $\text{F}_2 + \text{I}^-$ (4) $\text{Br}_2 + \text{Cl}^-$

8. Which pair will react spontaneously at 298 K? (1)

$\text{Cu} + \text{H}_2\text{O}$ (2) $\text{Ag} + \text{H}_2\text{O}$ (3) $\text{Ca} + \text{H}_2\text{O}$ (4) $\text{Au} + \text{H}_2\text{O}$

9. What is the standard reduction potential for the
- $\text{Cu}^{2+}(\text{aq})/\text{Cu}$
- half-cell? (1) +0.52 v (2) +0.34 v (3) -0.52 v (4) -0.34 v

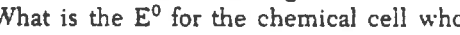
10. Which species can oxidize
- Sn^{2+}
- to
- Sn^{4+}
- ? (1)
- Ag^+
- (2)
- Fe^0
- (3)
- Al^{3+}
- (4)
- H_2O

11. Which of the following Group 17 elements is the strongest oxidizing agent? (1)
- I_2
- (2)
- Br_2
- (3)
- Cl_2
- (4)
- F_2

12. Which of the following alkaline earth elements is the strongest reducing agent? (1)
- Mg
- (2)
- Sr
- (3)
- Ca
- (4)
- Ba

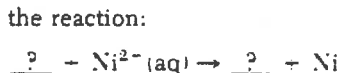
13. Which species can be reduced by
- Zn
- ? (1)
- Na^+
- (2)
- H^-
- (3)
- Ca^{2+}
- (4)
- Mg^{2+}

14. What is the
- E°
- for the chemical cell whose net reaction is



(1) 0.66 volt (2) 0.79 volt (3) 0.94 volt (4) 1.09 volt

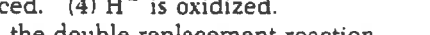
15. Given the reaction:



If this reaction is spontaneous, the missing reactant could be (1) Zn^0 (2) Pb^0 (3) Cu^0 (4) Sn^0

10. In the decomposition reaction
- $2\text{LiH} \rightarrow 2\text{Li} + \text{H}_2$
- (1)
- Li^-
- is oxidized. (2)
- Li^0
- is oxidized. (3)
- H_2^0
- is reduced. (4)
- H^-
- is oxidized.

11. In the double replacement reaction



(1) AgNO_3 is reduced. (2) AgNO_3 is oxidized. (3) NaCl is reduced. (4) AgNO_3 is neither reduced nor oxidized.