Chemistry 12 - Redox Review Answers

1. C
2. B
3. B
4. C
5. B
6. A
7. A
8. A
9. A
10. D
11. D
12. C
13. B
14. C
15. A
16. C
17. B
18. A
19. C
20. A
21. C
22. C
23. D
24. D
25. B
26. D
27. B
28. A
29. B
30. B
31. B
32. B
33. A
34. D
35. C
36. A
37. D
38. C
39. $Pd^{2+} + 2e^- <-> Pd$
    $Ti^{2+} + 2e^- <-> Ti$
    $Mo^{3+} + 1e^- <-> Mo^{2+}$
    $Mn^{2+} + 2e^- <-> Mn$
40. C
41. D
42. D
43. A
44. B
45. D
46. D
47. A
48. C
49. C
50. C
51. D
52. A
53. D
54. C
55. C
56. D
57. B
58. C
59. B
60. C
61. C
62. a) Cu reacts with HNO_3
    b) E^o R = 0.62V
63. $Ag^+ + e^- \rightarrow Ag$
    $Fe^{3+} + e^- \rightarrow Fe^{2+}$
64. $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$
    $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$
65. D
66. D
67. D
68. D
69. B
70. SEE ANSWER
71. SEE ANSWER
72. SEE ANSWER
73. SEE ANSWER
74. SEE ANSWER
75. SEE ANSWER
76. SEE ANSWER
77. SEE ANSWER
78. SEE ANSWER
79. SEE ANSWER
80. SEE ANSWER
81. SEE ANSWER
82. SEE ANSWER
83. SEE ANSWER
84. C
85. D
86. B

87. C
88. C
89. D
90. A) $Co + 2Ag+ \rightarrow Co2+ + 2Ag$
b) 1 mol Co: 2 Mol Ag^{+}
91. D
92. B
93. D
94. 0.48M
95. C
96. D
97. 0.1297g Sn = 17.3%
98. see answer
99. see answer
100. B
101. B
102. C
103. B
104. D
105. D
106. B
107. B
108. B
109. B
110. C
111. D
112. A
113. A
114. C
115. B
116. A
117. B
118. D
119. A
120. B
121. A
122. C
123. C
124. C
125. B
126. D
127. B
128. B
129. A
130. B
131. B
132. D
133. D
134. C
135. A
136. C
137. A
138. C
139. B
140. D
141. a) $Ti \rightarrow Ti^{2+} + 2e^{-}$
b) E^{o} Ox = 1.63V
142. A
143. D
144. A
145. B
146. SEE ANSWER
147. C
148. D
149. B
150. SEE ANSWER
151. SEE ANSWER
152. C
153. D
154. SEE ANSWER
155. C
156. C
157. A
158. A
159. D
160. A
161. A
162. C
163. D
164. A) $2I^{-} \rightarrow I^{2} + 2e^{-}$
b) $Cu^{2+} + 2e^{-} \rightarrow Cu$
c) -0.20 V
165. See answer
166. Water is more easily reduced than Na+
167. a) cathode/anode
b) $Sn^{2+} + Cu \rightarrow Cu^{2+} + Sn$
c) -0.48V
168. B
169. C
170. D
171. B

172. D
173. A
174. C
175. C
176. D
177. B
178. D
179. C
180. A
181. D
182. C
183. A
184. A
185. SEE ANSWER
186. SEE ANSWER
187. B
188. B
189. SEE ANSWER
190. SEE ANSWER
191. SEE ANSWER
192. D
193. B
194. SEE ANSWER
195. D
196. A
197. D
198. D
199. C
200. D
201. B
202. B
203. B
204. D
205. B
206. A
207. D
208. A
209. C
210. B
211. B
212. B
213. A
214. SEE ANSWER
215. B
216. D
217. A
218. C
219. A
220. D
221. a) Ti/Ni
b) $Ni^{2+} + 2e^- \rightarrow Ni$
c) 1.11V
222. C
223. SEE ANSWER
224. SEE ANSWER
225. C
226. B

Prescribed Learning Outcomes - Chemistry 12

Oxidation / Reduction Section

S: Oxidation-Reduction (Introduction)

S1: Define and apply the following:
- oxidation
- reduction
- oxidizing agent
- reducing agent
- half-reaction
- redox reaction

S2: Determine the following:
- the oxidation number of an atom in a chemical species
- the change in oxidation number an atom undergoes when it is oxidized or reduced
- whether an atom has been oxidized or reduced by its change in oxidation number

S3: Relate change in oxidation number to gain or loss of electrons

S4: From data for a series of simple redox reactions, create a simple table of reduction half-reactions

S5: Identify the relative strengths of oxidizing and reducing agents from their positions on a half-reaction table

S6: Use a table of reduction half-reactions to predict whether a spontaneous redox reaction will occur between any two species

T: Oxidation-Reduction (Balancing Redox Equations)

T1: Balance a half-reaction in solution (acid, base, neutral)

T2: Balance a net ionic redox reaction in acid and base solution

T3: Write the equations for reductionand oxidation half-reactions given a redox reaction

T4: Identify reactants and products for several redox reactions performed in a laboratory and balance the equations

T5: Select a suitable reagent to be used in a redox titration in order to determine the concentration of a specie:

T6: Determine the concentration of a species by preforming a redox titration

U: Oxidation-Reduction (Electrochemical Cells)

U1: Define, construct, and label the parts of an electrochemical cell

U2: Identify the half-reactions that take place at each electrode

U3: Predict the direction of movement of each type of ion in the cell

U4: Predict the directon of flow of electrons in an external circuit

U5: Predict which electrode will increase in mass and which will decrease in mass as the cell operates

U6: Predict the voltage of the cell when equilibrium is reached

U7: Assign voltages to the reduction half-reactions of oxidizing agents by comparison of several cells

U8: Describe the significance of the $E°$ of an electrochemical cell

U9: Predict the voltage ($E°$) of an electrochemical cell using the table of standard reduction half-cells

U10: Predict the spontaneity of the forward or reverse reaction from the $E°$ of a redox reaction

U11: Describe how electrochemical concepts can be used in various practical applications

V: Oxidation-Reduction (Corrosion)

V1: Describe the conditions necessary for corrosion to occur

V2: Analyze the process of metal corrosion in electrochemical terms

V3: Suggest several methods of preventing or inhibiting corrosion of a metal

V4: Describe and explain the principle of cathodic protection

W: Oxidation-Reduction (Electrolytic Cells)

W1:
Define *electrolysis* and *electrolytic cell*

W2:
Design and label the parts of an electrolytic cell capable of electrolyzing an aqueous salt

(use of overpotential effect not required)

W3:
Predict the direction of flow of all ions in the cell

W4:
Write the half-reaction occurring at each electrode

W5:
Demonstrate the principles involved in simple electroplating

W6:
Construct an electrolytic cell capable of electroplating an object

W7:
Describe the electrolytic aspects of metal refining processes

W8:
Draw and label the parts of an electrolytic cell used for electrolysis of a molten binary salt

S1: Define and apply the following:

- oxidation
- reduction
- oxidizing agent
- reducing agent
- half-reaction
- redox reaction

1. A reducing agent
   A. loses electrons and is reduced
   B. gains electrons and is reduced
   C. loses electrons and is oxidized
   D. gains electrons and is oxidized

2. Which of the following describes a strong oxidizing agent?
   A. a substance which loses electrons easily
   B. a substance which gains electrons easily
   C. a substance which has a large increase in oxidation numbers
   D. a substance which has a small increase in oxidation numbers

3. An oxidizing agent is
   A. reduced as it loses electrons
   B. reduced as it gains electrons
   C. oxidized as it loses electrons
   D. oxidized as it gains electrons

4. An equation for the rusting of iron is shown below:

$$4Fe + 3O_2 \rightarrow 2\,Fe_2O_3$$

Which of the following is **false**?
   A. This is a redox reaction.
   B. O_2 is the oxidizing agent.
   C. Metallic iron is reduced to Fe^{+3}.
   D. Metallic iron is the reducing agent.

5. Two separate reactions involved in the refining of copper ore are:

Reaction I	$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$
Reaction II	$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

What happens to the copper ions during this process?
   A. Copper ions are reduced in Reaction I.
   B. Copper ions are reduced in Reaction II.
   C. Copper ions are oxidized in Reaction I.
   D. Copper ions are oxidized in Reaction II.

S2: Determine the following:

- the oxidation number of an atom in a chemical species
- the change in oxidation number of an atom after undergoing reduction or oxidation

6. Which of the following could be produced by the reduction of NO_2?
   A. NO B. N_2O_4 C. N_2O_5 D. HNO_3

7. Consider the following redox reaction:

$$3NO + SO_4^{-2} + Fe^{+3} + 2H_2O \rightarrow FeS + 3NO_3^- + 4H^+$$

Which of the following is being oxidized?
   A. NO B. Fe^{+3} C. H_2O D. SO_4^{-2}

8. Consider the following redox reaction:

$$3NO + SO_4^{-2} + Fe^{+3} + 2H_2O \rightarrow FeS + 3NO_3^- + 4H^+$$

The oxidation number for nitrogen in this reaction has
   A. increased by 3 B. increased by 2 C. decreased by 1 D. decreased by 2

9. What is the oxidation number for chromium in $Cr_2O_7^{-2}$?
   A. +6 B. +7 C. +12 D. +14

10. Consider the following unbalanced half-reaction:

$$H_2SeO_3 \rightarrow Se$$

The oxidation number of Se
   A. increases as it undergoes oxidation
   B. increases as it undergoes reduction
   C. decreases as it undergoes oxidation
   D. decreases as it undergoes reduction

11. What is the oxidation number for sulfur in $S_2O_8^{-2}$?
   A. -2 B. +9 C. +8 D. +7

12. Consider the following equation:

$$16H^+ + 2MnO_4^- + 5C_2O_4^{-2} \rightarrow 10\,CO_2 + 2Mn^{+2} + H_2O$$

Identify the chemical species which is reduced.
   A. H^+ B. Mn^{+2} C. MnO_4^- D. $C_2O_4^{-2}$

13. Consider the following :

$H_3AsO_4 + 4Zn + 8H^+ \rightarrow As_2O_3 + 4Zn^{+2} + 4H_2O$

Which of the following statements is true?

A. The H_3AsO_4 is the reducing agent.
B. The oxidation number of arsenic decreases by 2.
C. The oxidation number of arsenic increases by 2.
D. The oxidation of hydrogen decreases by 1.

14. What is the oxidation number of iron in Fe_3O_4?

A. +4/3 B. +2 C. +8/3 D. +3

15. What is the oxidation number of iron in FeO_2?

A. +4 B. +2 C. +1/2 D. +3

16. In which of the following chemical changes will there be an oxidation number change of +3?

A. $Cr^{+3} \rightarrow Cr^{+2}$ B. $ClO^- \rightarrow ClO_2^-$ C. $Cr^{+3} \rightarrow Cr_2O_7^{-2}$ D. $Mn^{+2} \rightarrow MnO_4^-$

17. Which of the following represents an oxidation?

A. $2H^+ + S \rightarrow H_2S$
B. $2SO_4^{-2} \rightarrow S_2O_8^{-2}$
C. $Na^+ + Cl^- \rightarrow NaCl$
D. $SO_2 + H_2O \rightarrow 2H^+ + SO_3^{-2}$

18. Which equation represents a redox reaction?

A. $C + O_2 \rightarrow CO_2$
B. $NH_3 + HCl \rightarrow NH_4Cl$
C. $2CrO_4^{-2} + 2H^+ \rightarrow Cr_2O_7^{-2} + H_2O$
D. $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

19. Identify the oxidizing agent in the following equation:

$Pb + PbO_2 + 4H^+ + 2SO_4^{-2} \rightarrow 2PbSO_4 + 2H_2O$

A. H^+ B. Pb C. PbO_2 D. SO_4^{-2}

20. Which of the following is a redox equation?

A. $2H_2 + O_2 \rightarrow 2H_2O$
B. $Ag_2CrO_4 \rightarrow 2Ag^+ + CrO_4^{-2}$
C. $Ag(NH_3)^{2+} + 2H^+ + Cl^- \rightarrow AgCl + 2NH_4^+$
D. $Mn(OH)_2 + 2HC_2H_3O_2 \rightarrow Mn^{+2} + 2H_2O + 2C_2H_3O_2^-$

21. Which of the following contains molybedenum with its highest oxidation number?

A. $MoCl_5$ B. Mo_2S_3 C. MoO_4^{-2} D. Mo_6Cl_{12}

22. Which of the following skeletal half-reactions are **not** oxidations?

I. $ClO^- \rightarrow ClO_3^-$
II. $C_2H_5OH \rightarrow C_2H_4O_2$
III. $NO_2 \rightarrow N_2O_4$

A. I B. II C. III D. I and II

23. Which of the following is **not** a redox equation?

A. $Zn + S \rightarrow ZnS$
B. $Cl_2 + 2NaI \rightarrow 2NaCl + I_2$
C. $Sn^{+4} + 2Fe^{+2} \rightarrow 2Fe^{+3} + Sn^{+2}$
D. $K_3PO_4 + 3AgNO_3 \rightarrow Ag_3PO_4 + 3KNO_3$

24. What is the oxidation number of chromium in the complex $Cr(H_2O)Br_2^{+}$?

A. -1 B. +1 C. +2 D. +3

25. Consider the following redox equation:

$MnO_4^- + 5Fe^{+2} + 8H^+ \rightarrow Mn^{+2} + 5Fe^{+3} + 4H_2O$

Which of the following statements is **false**?

A. Iron is oxidized.
B. Hydrogen is reduced.
C. Manganese is reduced.
D. The equation is balanced.

26. Consider the following unbalanced redox equation:

$Pt + NO_3^- + Cl^- \rightarrow PtCl_6^{-2} + NO + H_2O$

Which chemical species is reduced?

A. Pt B. Cl^- C. H_2O D. NO_3^-

27. What is the oxidation number of carbon in $Mn(CH_3COO)_3$?

A. -1 B. 0 C. +1/2 D. +1

28. Identify the reducing agent in the following equation:

$Zn + 2MnO_2 + 2H_2O \rightarrow Zn(OH)_2 + 2MnO(OH)$

A. Zn B. H_2O C. MnO_2 D. $Zn(OH)_2$

29. Consider the following equation:

$$Co + SO_4^{-2} + 4H^+ \rightarrow Co^{+2} + H_2SO_3 + H_2O$$

Which statement is correct?

A. The sulphur is oxidized and the cobalt is reduced
B. The cobalt is oxidized and the sulphur is reduced
C. The hydrogen is reduced and the cobalt is oxidized
D. The hydrogen is oxidized and the sulphur is reduced

S3: Relate a change in oxidation number to gain or loss of electrons

30. When SO_4^{-2} reacts to form $S_2O_6^{-2}$, the sulphur atoms

A. lose electrons and are reduced
B. gain electrons and are reduced
C. lose electrons and are oxidized
D. gain electrons and are oxidized

31. Consider the following unbalanced redox reaction:

$$Sn^{+2} + MnO_4^- \rightarrow Sn^{+4} + Mn^{+2}$$

Which of the following describes the change in manganese in the MnO_4^-?

A. loses electrons and is reduced
B. gains electrons and is reduced
C. loses electrons and is oxidized
D. gains electrons and is oxidized

32. Consider the following equation for the breathalyzer reaction:

$$CH_3CH_2OH + K_2Cr_2O_7 + H_2SO_4 \rightarrow CH_3COOH + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$$

The change in oxidation number for each carbon is equivilent to

A. 1 electron lost B. 2 electrons lost C. 1 electron gained D. 2 electrons gained

33. Which of the following gives the correct oxidation numbers for the nitrogen atoms in all three chemical species?

	N_2	Li_3N	NO_2^-
A.	0	-3	+3
B.	-3	-3	-3
C.	0	+3	-3
D.	-3	-3	+3

34. The oxidation number of manganese changes as MnO_4^- is converted to MnO_2. How many electrons are gained or lost by the manganese during the change?

A. one electron lost
B. one electron gained
C. 3 electrons lost
D. 3 electrons gained

S4: From data for a series of simple redox reactions, create a simple table of reduction half-reactions

35. In an experiment Ag^+ reacts spontaneously with Ru but not with Pd. The relative strength of the metals from strongest to weakest reducing agent is

A. Ag > Ru > Pd B. Pd > Ag > Ru C. Ru > Ag > Pd D. Ru > Pd > Ag

36. A solution containing Pd^{+2} reacts spontaneously with Ga to produce Pd and Ga^{+3}. However, a solution containing Pd^{+2} does not react with Pt. The metals, in order of increasing strength as reducing agents, are:

A. Pt < Pd < Ga B. Pt < Ga < Pd C. Ga < Pt < Pd D. Ga < Pd < Pt

37. Consider the following spontaneous reactions:

$$3Cd^{+2} + 2Np \rightarrow 3\,Cd + 2Np^{+3}$$
$$Cd + Pd^{+2} \rightarrow Pd + Cd^{+2}$$
$$Np^{+3} + Ce \rightarrow Np + Ce^{+3}$$

Which is the strongest oxidizing agent?

A. Cd^{+2} B. Ce^{+3} C. Np^{+3} D. Pd^{+2}

38. The metals Hg, Cd, and Pd reacts as follows:

$$Hg^{+2} + Pd \rightarrow Pd^{+2} + Hg$$
$$Pd^{+2} + Cd \rightarrow Cd^{+2} + Pd$$
$$Hg^{+2} + Cd \rightarrow Cd^{+2} + Hg$$

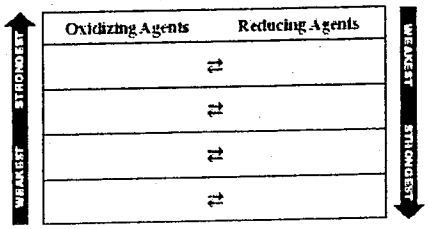
Put the metals in order from weakest reducing agents to strongest:

A. Pd < Hg < Cd B. Cd < Pd < Hg C. Hg < Pd < Cd D. Hg < Cd < Pd

39. Consider the following experimental results:

$Mo^{+3} + Mn \rightarrow Mn^{+2} + Mo^{+2}$
$Mo^{+3} + Pd \rightarrow$ no reaction
$Ti^{+2} + Mo^{+2} \rightarrow Mo^{+3} + Ti$
$Ti^{+2} + Pd \rightarrow$ no reaction

Use these results to complete the table of reduction half reactions below:



S5: Identify the relative strengths of oxidizing agents and reducing agents from their positions on a half-reaction table

40. Consider the following spontaneous reaction:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

Which of the following statements is correct?
A. Mg is a weaker reducing agent than H_2
B. Mg is a weaker reducing agent than H^+
C. Mg is a stronger reducing agent than H_2
D. Mg is a stronger reducing agent than H^+

41. A piece of Ag does not react spontaneously with 1.0 M Ti^{+2} because
A. Ag^+ is a weaker reducing agent than Ti^{+2}
B. Ag^+ is a weaker oxiding agent than Ti^{+2}
C. Ag^+ is a stronger reducing agent than Ti^{+2}
D. Ag^+ is a stronger oxidizing agent than Ti^{+2}

42. Which of the following can act as an oxidizing agent, but **not** as a reducing agent?
A. Cr B. Cl^- C. Cu^+ D. Na^+

43. Which of the following can act as an reducing agent, but **not** as a oxidizing agent?
A. Sn B. Br_2 C. Fe^{+2} D. Ca^{+2}

44. Solid copper forms spontaneously in the following reaction:

$$V + Cu^{+2} \rightarrow Cu + V^{+2}$$

Based on these observations, V^{+2} is a
A. weaker reducing agent than Cu^{+2}
B. weaker oxidizing agent than Cu^{+2}
C. stronger reducing agent than Cu^{+2}
D. stronger oxidizing agent than Cu^{+2}

45. Which of the following is the strongest reducing agent?
A. H_2S B. H_2O C. H_2Se D. H_2Te

46. Which of the following is the strongest oxidizing agent?
A. Fe^{+2} B. H_2O C. Sn^{+2} D. I_2

47. Which of the following ions can be reduced by Pb (s) under standard conditions?
A. Cu^+ B. Cr^{+3} C. Sn^{+2} D. Ca^{+2}

48. Which of the following is more difficult to reduce than the $H^+_{(aq)}$ ion?
A. I_2 B. Ag^+ C. Zn^{+2} D. Cu^{+2}

S6: Use a table of reduction half-reactions to predict whether a spontaneous redox reaction will occur between any two species

49. A piece of Cu reacts spontaneously with 1.0 M Pd^{+2} because
A. Cu is a weaker reducing agent than Pd and $E^o > 0$
B. Cu is a weaker reducing agent than Pd and $E^o < 0$
C. Cu is a stronger reducing agent than Pd and $E^o > 0$
D. Cu is a stronger reducing agent than Pd and $E^o < 0$

50. Which two species will **not** react spontaneously at standard conditions?
A. Co with Cl_2 B. Cu with Ag^+ C. Ag with Zn^{+2} D. Mg with Cr^{+3}

51. Which of the following will not react spontaneously with H_2O at standard conditions?
A. F_2 B. Ca C. Na D. Sn

52. Which of the following will react spontaneously with Ag_2S at standard conditions?
A. Al B. Au C. Co D. Pb

53. Which of the following represents a spontaneous redox reaction?
A. $2Br^- + Mg^{+2} \rightarrow MgBr_2$
B. $Cu + Sn^{+4} \rightarrow Cu^{+2} + Sn^{+2}$
C. $Ag_2S + 2Fe^{+2} \rightarrow 2Fe^{+3} + 2Ag + S^{-2}$
D. $AuCl_4^- + 3Ag \rightarrow Au + 4Cl^- + 3\,Ag^+$

54. Which of the following will react spontaneously with Br_2 but not with I_2?
A. F^- B. Cr^{+2} C. Fe^{+2} D. Mn^{+2}

55. Consider the following:

$$Sn^{+4} + 2Cl^- \rightarrow Sn^{+2} + Cl_2$$

What is true for this reaction?
A. $E^o_{cell} = +1.51$ V and it is spontaneous
B. $E^o_{cell} = +1.21$ V and it is spontaneous
C. $E^o_{cell} = -1.21$ V and it is not spontaneous
D. $E^o_{cell} = -1.51$ V and it is not spontaneous

56. Which of the following could react spontaneously with Ag metal?
A. Cl^- B. Fe^{+2} C. acidified SO_4^{-2} D. acidified NO_3^-

57. Which of the following could react spontaneously with Fe^{+2}?
A. Cl^- B. Ag^+ C. acidified SO_4^{-2} D. MnO_4^- in base

58. Which of the following metals can oxidized by 1.0 M Fe^{+2}?
A. Sn B. Co C. Cr D. Ag

59. Consider the following half-reactions under standard conditions:

I. $ClO_2 + e^- \rightarrow ClO_2^-$
II. $PbSO_4 + 2e^- \rightarrow Pb + SO_4^{-2}$
III. $Fe^{+3} + 3e^- \rightarrow Fe$

In an experiment when ClO_2 and Fe were combined, they reacted. In a second experiment when $PbSO_4$ and Fe were combined, there was no observable change. Which of the following shows the reduction half-reactions I, II and III in order of decreasing E^o?

A. I, II, III B. I, III, II C. II, III, I D. III, II, I

60. Which of the following combinations will react spontaneously?
A. $I_2 + Cu^{+2}$ B. $Pb^{+2} + Ag$ C. $Zn^{+2} + Mg$ D. $Sn^{+2} + Ni^{+2}$

61. What reaction will occur when a solution containing 1.0 M $MgSO_4$ and 1.0 M $CoCl_2$ is stored in a galvanized (Zn coated) bucket?
A. $Mg_{(s)} + Cl_{2\,(g)} \rightarrow MgCl_2$
B. $Co^{+2}{}_{(aq)} + SO_4^{-2}{}_{(aq)} \rightarrow CoSO_{4\,(s)}$
C. $Co^{+2}{}_{(aq)} + Zn_{(s)} \rightarrow Co_{(s)} + Zn^{+2}{}_{(aq)}$
D. $Mg^{+2}{}_{(aq)} + Zn_{(s)} \rightarrow Mg_{(s)} + Zn^{+2}{}_{(aq)}$

62. A sample of copper is placed in $HNO_{3(aq)}$ and another sample of copper is placed in $HCl_{(aq)}$.
a. In which acid does a spontaneous redox reaction occur with the copper? _____

b. Calculate the E^o for the reaction that occurs. _____

63. An excess of copper solid is dropped into a solution which contains $AgNO_3$, $Fe(NO_3)_3$ and $Zn(NO_3)_2$. Write the equations for any reduction half-reactions that occur over time under standard conditions.

64. A reaction occurs when copper metal is dropped into a solution of silver nitrate. Write the balanced formula equation and the balanced net ionic equation for this reaction.

Formula equation: _____

Net ionic equation: _____

Γ1: Balance a half-reaction in solution (acid, base or neutral)

65. Which of the following is the balanced half-reaction for

$N_2O \rightarrow NH_3OH^+$ (acidic)

A. $N_2O + 4H^+ + 3e^- \rightarrow NH_3OH^+$
B. $N_2O + 2H^+ + H_2O + e^- \rightarrow NH_3OH^+$
C. $N_2O + 6H^+ + H_2O \rightarrow 2NH_3OH^+ + 4e^-$
D. $N_2O + 6H^+ + H_2O + 4e^- \rightarrow 2NH_3OH^+$

66. When the skeletal equation $S_2O_3^{-2} \rightarrow HSO_3^-$ is balanced in acidic solution H^+ and e^- will appear. Which of the following best describes the H^+ and e^- for the balanced half-reaction?

A. $1H^+$ on the left and $1e^-$ on the right
B. $1H^+$ on the left and $1e^-$ on the left
C. $4H^+$ on the left and $3e^-$ on the left
D. $4H^+$ on the right and $4e^-$ on the right

67. When the skeletal equation $Br_2 \rightarrow BrO_3^-$ is balanced in acidic solution, H_2O, H^+ and e^- will appear. Which of the following are the correct balancing coefficients?

	H_2O	H^+	e^-
A.	3	3	2
B.	3	6	4
C.	6	12	5
D.	6	12	10

68. Consider the following skeletal equation for a redox reaction in acidic solution:

$Br^- + BrO_3^- \rightarrow Br_2$

What is the equation for the balanced reduction half-reaction

A. $2Br^- \rightarrow Br_2 + 2e^-$
B. $2Br^- + 2e^- \rightarrow Br_2$
C. $5e^- + 6H^+ + BrO_3^- \rightarrow Br_2 + 3H_2O$
D. $10e^- + 12H^+ + 2BrO_3^- \rightarrow Br_2 + 6H_2O$

T2: Balance a net ionic redox reaction in solution (acid, base or neutral)

69. Consider the following balanced redox equation in acidic solution:

$5H_2O + 2CoCl_2 + OCl^- \rightarrow 2\,Co(OH)_3 + 5Cl^- + 4H^+$

Which of the following describes the amounts and locations of OH^- and H_2O if the equation is balanced in basic solution?

A. $1H_2O$ on the left and no OH^-
B. $1H_2O$ on the left and 4 OH^- on the left
C. $5H_2O$ on the left and 4 OH^- on the left
D. $1H_2O$ on the left and 4 OH^- on the right

70. Balance the following redox reaction:

$NO + SO_4^{-2} + Fe^{+3} \rightarrow FeS + NO_3^-$ (acidic)

71. Balance the following redox equation:

$SO_3^{-2} + MnO_4^- \rightarrow SO_4^{-2} + MnO_2$ (basic)

72. Balance the following redox reaction: (acidic)

$Ag_2O + Si \rightarrow Ag + SiO_3^{-2}$ (acidic)

73. Balance the following redox reaction: (acidic)

$Cr_2O_7^{-2} + I_2 \rightarrow Cr^{+3} + IO_3^-$ (acidic)

74. Balance the following redox equation:

$ClO_3^- + S_2O_3^{-2} \rightarrow S_4O_6^{-2} + Cl^-$ (acidic)

75. Balance the following skeletal redox equation in acidic solution:

$MnO_4^- + As_2O_3 \rightarrow Mn^{+2} + H_3AsO_4$ (acidic)

76. Balance the following skeletal redox equation in basic solution:

$NO_3^- + As_2S_3 \rightarrow N_2O + HAsO_4^{-2} + SO_4^{-2}$ (basic)

77. Balance the following redox reaction:

$Sb + NO_3^- \rightarrow Sb_2O_5 + NO$ (acidic)

78. Balance the following redox reaction:

$As_4 + CrO_4^{-2} \rightarrow Cr^{+3} + H_2AsO_4^-$ (basic)

79. Balance the following redox reaction:

$H_3As + H_2AsO_4^- \rightarrow As_2O_3$ (basic)

80. Balance the following equation.

$Cr_2O_7^{-2} + C_2O_4^{-2} \rightarrow Cr^{+3} + CO_2$ (acidic)

81. Balance the following equation.

$Cr_2O_7^{-2} + C_2H_5OH \rightarrow Cr^{+3} + CH_3COOH$ (acidic)

82. Balance the following redox reaction:

$H_2S + CrO_4^{-2} \rightarrow S_8 + Cr^{+3}$ (acidic)

83. Balance the following redox reaction in basic solution:

$ClO_3^- + N_2H_4 \rightarrow NO_3^- + Cl^-$ (basic)

T3: Write the equations for reduction and oxidation half-reactions given a redox reaction

84. Consider the following skeletal redox equation for a reaction in basic solution:

$$Zn + NO_3^- \rightarrow ZnO_2^{-2} + NH_3 \quad \text{(basic)}$$

Which of the following best represents the reduction half-reaction occurring in this solution?

A. $9H^+ + NO_3^- + 8e^- \rightarrow NH_3 + 3H_2O$
B. $3H_2O + NO_3^- + 5e^- \rightarrow NH_3 + 6OH^-$
C. $6H_2O + NO_3^- + 8e^- \rightarrow NH_3 + 9OH^-$
D. $4OH^- + Zn + 2e^- \rightarrow ZnO_2^{-2} + 2H_2O$

T4: Identify reactants and products for several redox reactions performed in a laboratory and balance the equations

85. When a piece of Ag is placed in 1.0 M $NiCl_2$

A. the $[Cl^-]$ increases B. the $[Ag^+]$ decreases C. the $[Ni^{+2}]$ decreases D. no changes occur

86. When a peice of Cu is placed in 1.0 M $AgNO_3$

A. the $[Ag^+]$ increases B. the $[Cu^{+2}]$ increases C. the $[NO_3^-]$ decreases D. no change occurs

87. When a piece of Cu is placed in 1.0 M HNO_3

A. the $[H^+]$ increases B. the $[Cu^{+2}]$ decreases C. the $[NO_3^-]$ decreases D. no change occurs

88. Consider the following equation for the breathalyzer reaction:

$$CH_3CH_2OH + K_2Cr_2O_7 + H_2SO_4 \rightarrow CH_3COOH + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$$

The balanced redox reaction would be:

A. $CH_3CH_2OH + K_2Cr_2O_7 + H_2SO_4 \rightarrow CH_3COOH + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$
B. $3CH_3CH_2OH + K_2Cr_2O_7 + 4H_2SO_4 \rightarrow 3CH_3COOH + Cr_2(SO_4)_3 + K_2SO_4 + H_2O$
C. $3CH_3CH_2OH + 2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 3CH_3COOH + 2Cr_2(SO_4)_3 + 2K_2SO_4 + 11H_2O$
D. $CH_3CH_2OH + K_2Cr_2O_7 + 4H_2SO_4 \rightarrow CH_3COOH + Cr_2(SO_4)_3 + K_2SO_4 + 8H_2O$

89. Nitric oxide (NO) can be prepared by the oxidation of Cu with NO_3^- in acidic solution. Which of the following equations correctly describes this process?

A. $Cu + NO_3^- + 3H^+ \rightarrow Cu^{+2} + NO + H_2O$
B. $Cu + NO_3^- + 4H^+ \rightarrow Cu^{+2} + NO_2 + 2H_2O$
C. $Cu + 2NO_3^- + 4H^+ \rightarrow Cu^{+2} + 2NO_2 + 2H_2O$
D. $3Cu + 2NO_3^- + 8H^+ \rightarrow 3Cu^{+2} + 2NO + 4H_2O$

90. A 2.000 g strip of cobalt metal is suspended in 100.0 mL of 0.20 M $AgNO_3$ and a reaction occurs. When the reaction is complete, there is an excess of cobalt. The excess cobalt is removed from the solution, washed and dried and its mass is found to be 1.411 g.

a. Using the table of Standard Reduction Potentials of Half-cells, write the balanced net ionic equation for the redox reaction.

b. Using the experimental data, calculate the moles of Co and Ag^+ reacting, and show how these values support the balanced equation

T5: Select a suitable reagent to be used in a redox titration in order to determine the concentration of a species

91. Which of the following could be used to determine the $[Fe^{+2}]$ by a redox reaction?

A. I_2 B. Cl^- C. Cu^{+2} D. MnO_4^- (acidified)

92. Which of the following could be used to determine the acidified $[BrO_3^-]$ by a redox reaction?

A. NO_3^- (acidified) B. I^- C. Cu^{+2} D. MnO_4^- (acidified)

93. Which of the following could be titrated using acidified MnO_4^- ions?

A. Na^+ B. IO_3^- C. SO_4^{-2} D. H_2O_2

T6: Determine the concentration of a species by performing a redox titration

94. Acidified potassium permanganate ($KMnO_4$) solution is often used in redox titrations. Permanganate reacts with Sn^{+2} as follows:

$$2MnO_4^- + 5Sn^{+2} + 16H^+ \rightarrow 2Mn^{+2} + 5Sn^{+4} + 8H_2O$$

A 10.0 mL solution containing Sn^{+2} is titrated with 19.3 mL of 0.10 M $KMnO_4$. What is the $[Sn^{+2}]$?

95. The titation of a 25.0 mL $SnCl_2$ sample, in acidic solution, requires 14.4 mL of 0.030 M $K_2Cr_2O_7$. The balanced equation for the reaction is shown below:

$$Cr_2O_7^{-2} + 14H^+ + 3Sn^{+2} \rightarrow 3Sn^{+4} + 2Cr^{+3} + 7H_2O$$

What is the number of moles of $SnCl_2$ in the original sample?

A. 1.4×10^{-4} moles B. 4.3×10^{-4} moles C. 1.3×10^{-3} moles D. 5.2×10^{-2} moles

96. A 10.0 mL water sample was analyzed for $[Fe^{+2}]$ using a redox titration with acidified $KMnO_4$. The equation for the reaction is:

$$MnO_4^- + 5Fe^{+2} + 8H^+ \rightarrow Mn^{+2} + 5Fe^{+3} + 4H_2O$$

A 10.0 mL sample was titrated with 12.5 mL of 0.10 M $KMnO_4$ solution. What is the $[Fe^{+2}]$ in the water sample?

A. 0.025 M B. 0.13 M C. 0.28 M D. 0.63 M

97. In the process of extracting tin from a sample of ore, the tin is removed as Sn^{+2} ions. A titration requires 21.43 mL of 0.0170 M $K_2Cr_2O_7$ to reach the equivilence point with the Sn^{+2} in a 0.750 gram sample of the ore.

$$3Sn^{+2} + Cr_2O_7^{-2} + 14H^+ \rightarrow 3Sn^{+4} + 2\,Cr^{+3} + 7H_2O$$

Using the reaction above, calculate the percent mass of tin in the ore sample.

98. Consider the following redox reaction in acidic solution: $MnO_4^- + H_2O_2 \rightarrow Mn^{+2} + O_2$

~~$KMnO_4 + H_2O_2 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + H_2O + O_2$~~

a. Balance the above redox reaction.

b. The above reaction was used for a redox titration. At the equivilence point 5.684×10^{-4} mol $KMnO_4$ was required to titrate 5.00 mL of H_2O_2 solution. Calculate $[H_2O_2]$

99. A titration is performed to determine the $[Fe^{+2}]$ in 25.00 mL of an $FeSO_4$ solution. It requires 22.52 mL of 0.015 M $KMnO_4$ to reach the equivilence point in which Mn^{+2} and Fe^{+3} are produced.

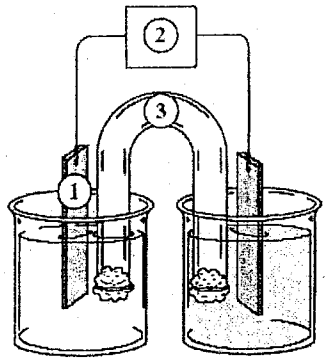
a. balance the redox reaction:

$$MnO_4^- + Fe^{+2} \rightarrow Mn^{+2} + Fe^{+3} \quad \text{(acidic)}$$

b. Calculate the $[Fe^{+2}]$

U01: Define, construct, and label the parts of an electrochemical cell

100. Consider the numbered components in the following diagram:



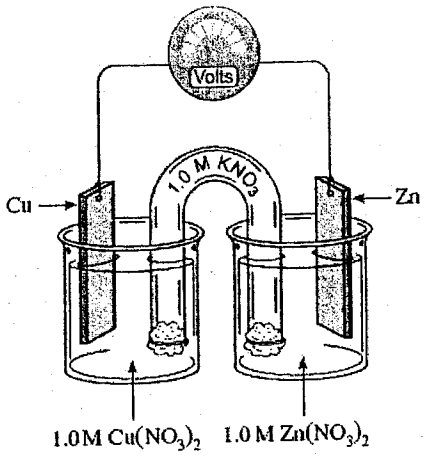
Which of the following would best describe the components of this electrochemical cell

	Component 1	Component 2	Component 3 (Contents)
A.	non-metal	power supply	$NaNO_{3\,(aq)}$
B.	metal	light bulb	$NaNO_{3\,(aq)}$
C.	metal	voltmeter	$CH_3OH_{\,(aq)}$
D.	metal	power supply	$CH_3OH_{\,(aq)}$

U02: Identify the half-reactions that take place at each electrode in an electrochemical cell

101. When MnO_2 changes to Mn_2O_3 in an alkaline battery, the manganese atoms
A. lose electrons and are reduced
B. gain electrons and are reduced
C. lose electrons and are oxidized
D. gain electrons and are oxidized

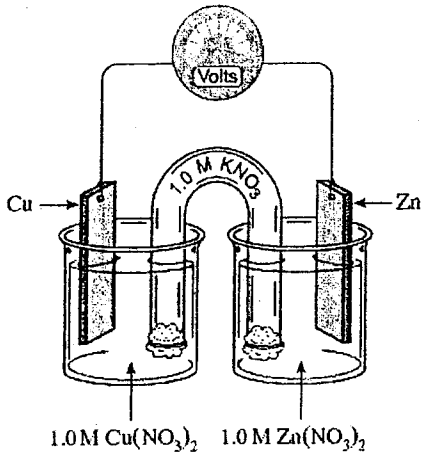
102. Consider the following cell:



The $[Cu^{+2}]$ in the copper half-cell will
A. increase as Cu loses electrons and is reduced.
B. increase as Cu loses electrons and is oxidized.
C. decrease as Cu^{+2} gains electrons and is reduced.
D. decrease as Cu^{+2} gains electrons and is oxidized.

14/07/2008

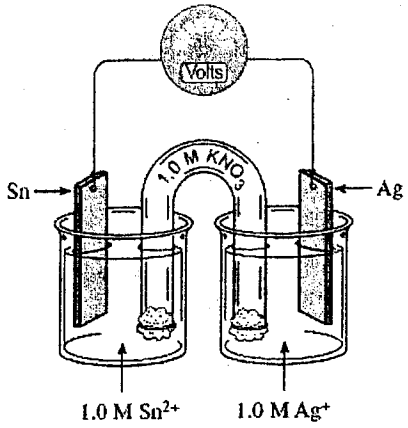
103. Consider the following cell:



The $[Zn^{+2}]$ in the zinc half-cell will

A. increase as Zn loses electrons and is reduced.
B. increase as Zn loses electrons and is oxidized.
C. decrease as Zn^{+2} gains electrons and is reduced.
D. decrease as Zn^{+2} gains electrons and is oxidized.

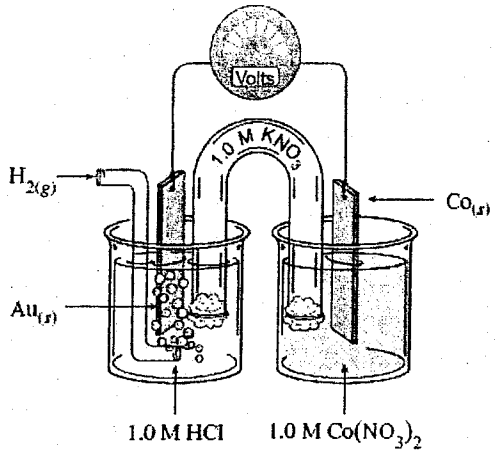
104. Consider the following cell:



What is the overall reaction:

A. $2Ag + Sn^{+2} \rightarrow Sn + 2Ag^{+}$
B. $2Ag + Sn \rightarrow Sn^{+2} + 2Ag^{+}$
C. $2Ag^{+} + Sn^{+2} \rightarrow Sn^{+2} + 2Ag^{+}$
D. $2Ag^{+} + Sn \rightarrow Sn^{+2} + 2Ag$

105. Consider the diagram below:



Identify the overall cell reaction

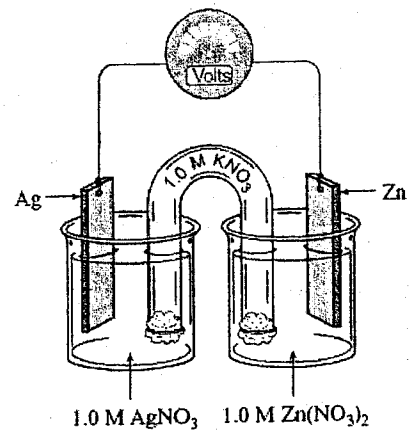
A. $Co^{+2} + H_2 \rightarrow 2H^+ + Co$

B. $2Au^{+3} + 3Co \rightarrow 2Au + 3Co^{+2}$

C. $Au^{+3} + Co^{+2} \rightarrow Au + Co$

D. $2H^+ + Co \rightarrow Co^{+2} + H_2$

106. Consider the following cell:



What is the equation for the half-reaction that occurs at the cathode?

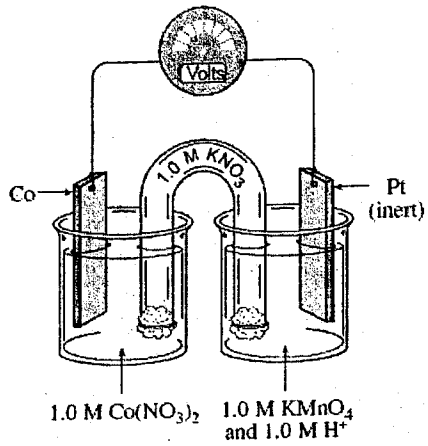
A. $Ag \rightarrow Ag^+ + e^-$

B. $Ag^+ + e^- \rightarrow Ag$

C. $Zn \rightarrow Zn^{+2} + 2e^-$

D. $Zn^{+2} + 2e^- \rightarrow Zn$

107. Consider the following cell:



Identify the anode reaction for the cell shown in the diagram.

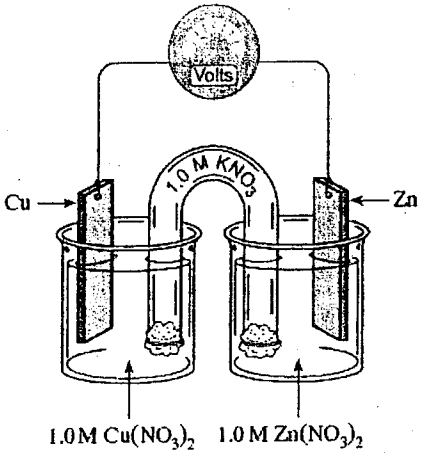
A. $H_2 \rightarrow 2H^+ + 2e^-$

B. $Co \rightarrow Co^{+2} + 2e^-$

C. $Co^{+2} + 2e^- \rightarrow Co$

D. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O$

108. Consider the following cell:



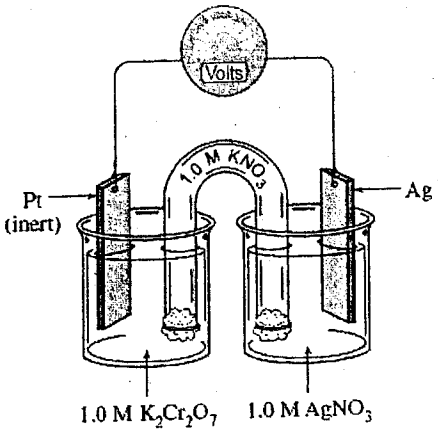
In what directions do the electrons and cations move?

	Direction of Electrons	Direction of cations
A.	towards the cathode	towards the anode
B.	towards the cathode	towards the cathode
C.	towards the anode	towards the anode
D.	towards the anode	towards the cathode

109. What is the function of the salt bridge in an electrochemical cell?

A. It provides a path for electrons
B. It maintains electrical neutrality in each half cell.
C. It allows the anode to become positively charged.
D. It allows the cathode to become negatively charged.

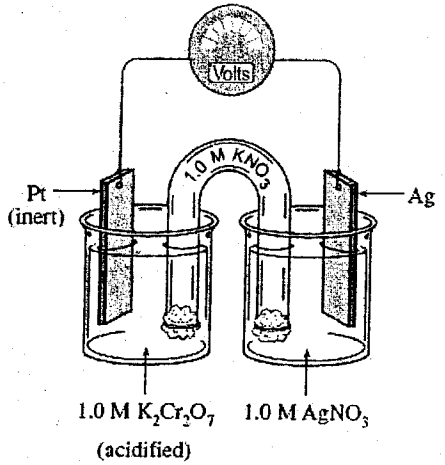
110. Consider the following electrochemical cell:



Which of the following represents the overall cell reaction?

A. $Cr_2O_7^{-2} + H^+ + Ag \rightarrow Ag^+ + Cr^{+3} + H_2O$
B. $Cr_2O_7^{-2} + 14H^+ + 9Ag \rightarrow 9Ag^+ + Cr^{+3} + 7H_2O$
C. $Cr_2O_7^{-2} + 14H^+ + 6Ag \rightarrow 6Ag^+ + 2Cr^{+3} + 7H_2O$
D. $Cr_2O_7^{-2} + 14H^+ + 6Ag^+ \rightarrow 6Ag + 2Cr^{+3} + 7H_2O$

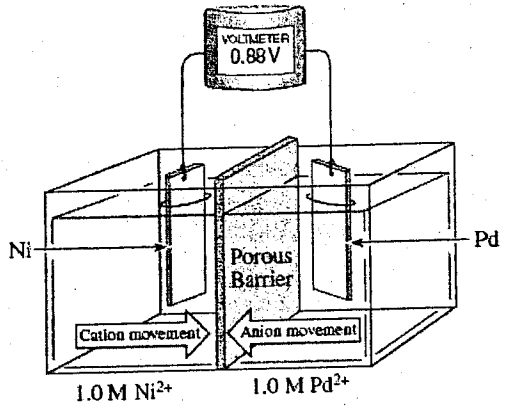
111. Consider the following electrochemical cell:



What happens to the pH at each electrode?

	pH at anode	pH at cathode
A.	increases	decreases
B.	increases	increases
C.	stays the same	decreases
D.	stays the same	increases

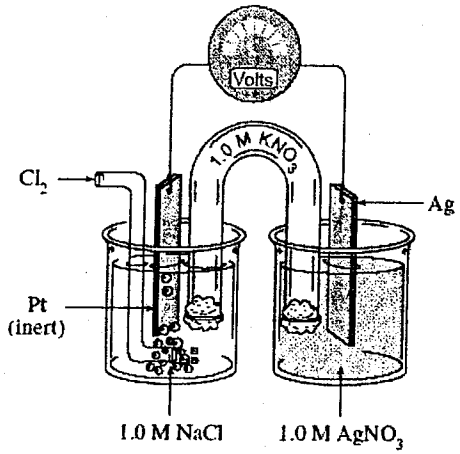
112. Consider the following diagram:



What is the half-cell reactionat the anode?

A. $Ni \rightarrow Ni^{+2} + 2e^-$
B. $Pd \rightarrow Pd^{+2} + 2e^-$
C. $Ni^{+2} + 2e^- \rightarrow Ni$
D. $Pd^{+2} + 2e^- \rightarrow Pd$

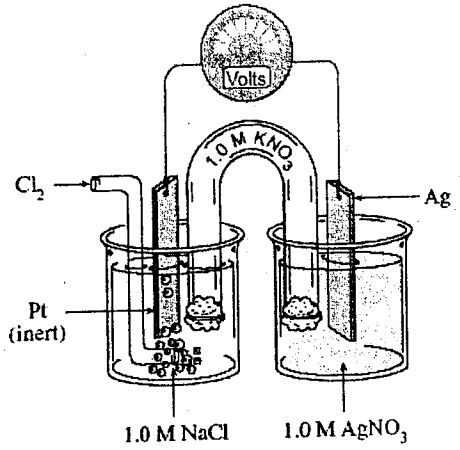
113. Consider the following cell:



Which of the following represents the anode half-cell reaction?

A. $Ag \rightarrow Ag^+ + e^-$
B. $Ag^+ + e^- \rightarrow Ag$
C. $Cl_2 + 2e^- \rightarrow 2Cl^-$
D. $2Cl^- \rightarrow Cl_2 + 2e^-$

114. Consider the following cell:



Which of the following represents the cathode half-cell reaction?

A. $Ag \rightarrow Ag^+ + e^-$
B. $Ag^+ + e^- \rightarrow Ag$
C. $Cl_2 + 2e^- \rightarrow 2Cl^-$
D. $2Cl^- \rightarrow Cl_2 + 2e^-$

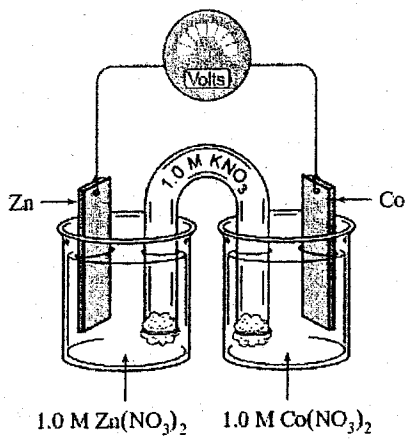
U03: Predict the direction of movement of each type of ion in an external circuit

115. What is the function of the salt bridge in an electrochemical cell?
   A. It provides a path for electrons
   B. It maintains electrical neutrality in each half cell.
   C. It allows the anode to gain mass.
   D. It allows the cathode lose mass.

116. As a standard Zn/Ag electrochemical cell operates, in which direction do anions move and how does the mass of the cathode change?

	Anion direction	Mass of Cathode
A.	towards Zn electrode	increases
B.	towards Ag electrode	increases
C.	towards Zn electrode	decreases
D.	towards Ag electrode	decreases

117. Consider the following diagram:

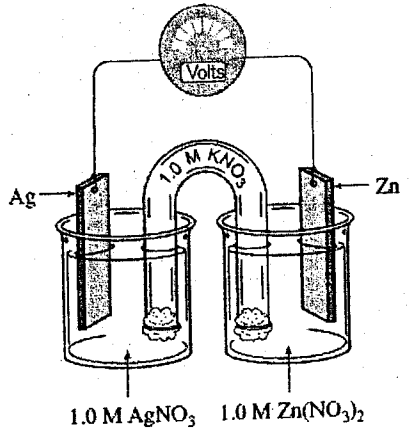


Which of the following best describes the Co^{+2} ion movement and the mass of the zinc electrode as the cell operates?

	Co^{+2} movement	Mass of zinc electrode
A.	toward the Co electrode	increases
B.	toward the Co electrode	decreases
C.	toward the Zn electrode	increases
D.	toward the Zn electrode	decreases

U04: Predict the direction of flow of electrons in an external circuit

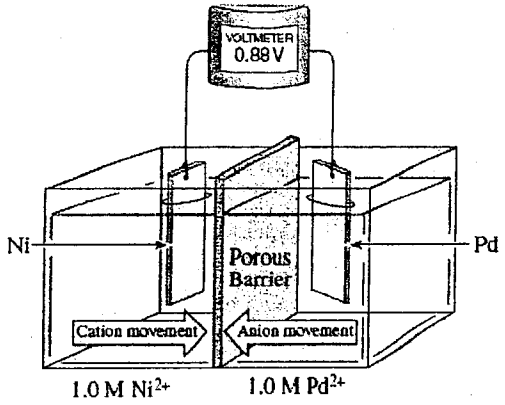
118. Consider the following cell:



Which of the following is true about the flow of electrons and anions?

	Electrons flow towards	Anions move towards
A.	Zn electrode	Zn electrode
B.	Zn electrode	Ag electrode
C.	Ag electrode	Ag electrode
D.	Ag electrode	Zn electrode

119. Consider the following diagram:

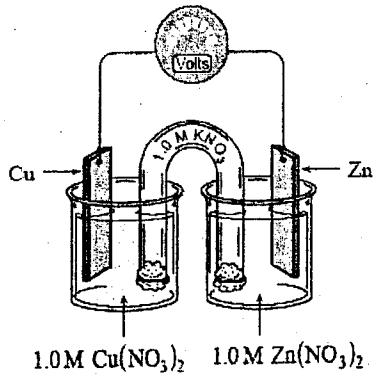


What best describes the flow of electrons?

A. from Ni to Pd
B. from Pd to Ni
C. from cathode to anode
D. into the solution around the Ni electrode

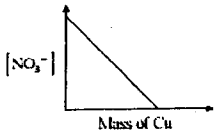
U05: Predict which electrode will increase in mass and which will decrease in mass as a cell operates

120. Consider the following cell:

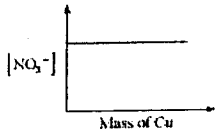


Which of the following represents the relationship between $[NO_3^-]$ and the mass of the Cu electrode in the copper half cell as its operates?

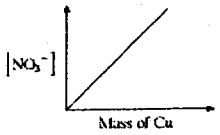
A.



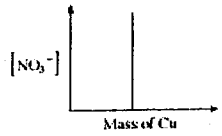
B.



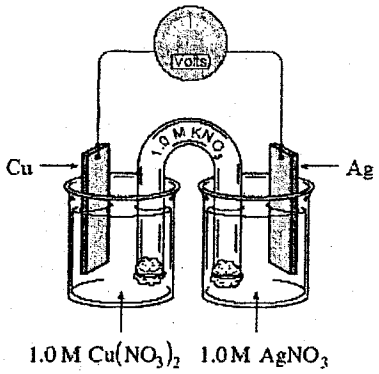
C.



D.

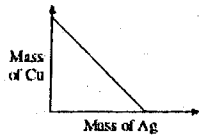


121. Consider the following cell:

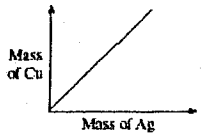


Which of the following diagrams represents the relationship between the mass of the Cu electrode and the mass of the Ag electrode as the cell is in operation?

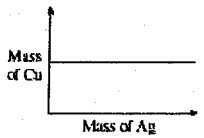
A.



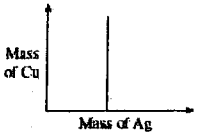
B.



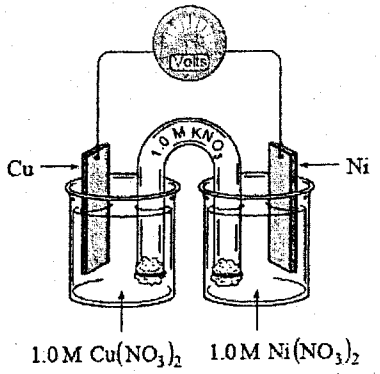
C.



D.



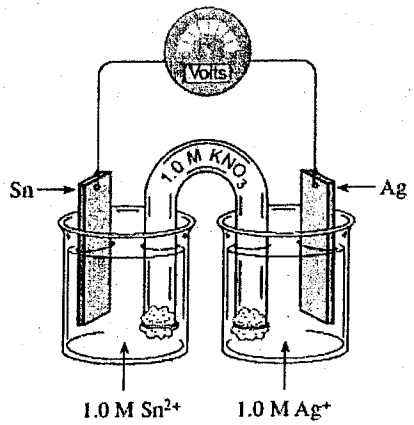
122. Consider the following cell:



What happens to the nickel electrode?

A. It loses mass as it is reduced.
B. It gains mass as it is reduced.
C. It loses mass as it is oxidized.
D. It gains mass as it is oxidized.

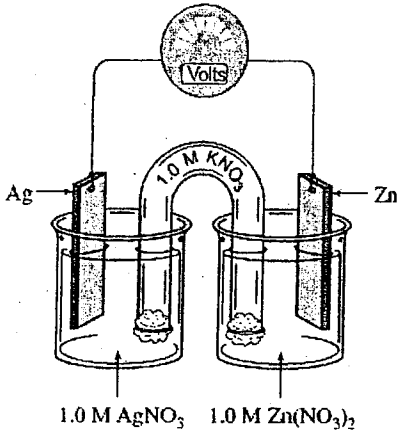
123. Consider the following cell:



In the above cell, how do the mass of the anode and the $[Ag^+]$ change as the cell operates?

	Mass of anode	$[Ag^+]$
A.	decreases	increases
B.	increases	increases
C.	decreases	decreases
D.	no change	decreases

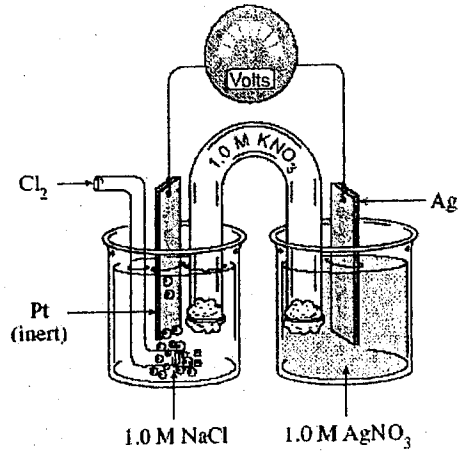
124. Consider the following cell:



What happens to the mass of each electrode as the cell operates?

	$Ag_{(s)}$ electrode	$Zn_{(s)}$ electrode
A.	increases	increases
B.	decreases	decreases
C.	increases	decreases
D.	decreases	increases

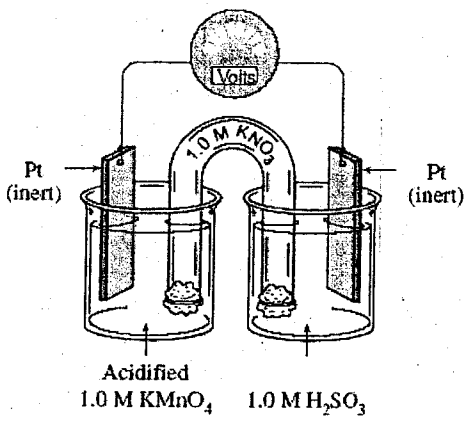
125. Consider the following electrochemical cell:



What changes in mass occur to the anode and cathode?

	Anode mass	Cathode mass
A.	decreases	increases
B.	decreases	no change
C.	increases	decreases
D.	increases	no change

126. Consider the following:

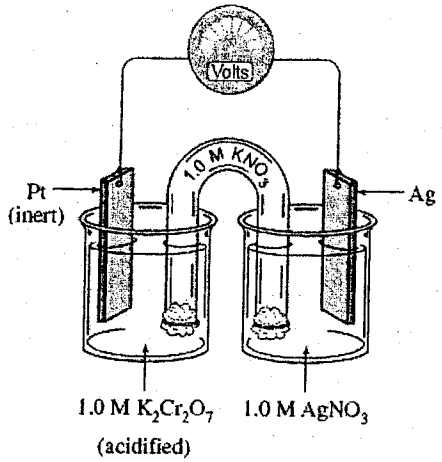


Which of the following best describes what happens to the mass of the anode and the mass of the cathode as the cell operates?

	Anode Mass	Cathode Mass
A.	decreases	increases
B.	decreases	stays constant
C.	stays constant	decreases
D.	stays constant	stays constant

U06: Predict the voltage of the cell when equilibrium is reached

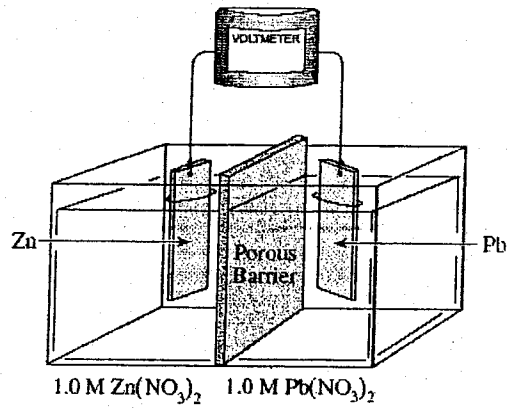
127. Consider the following electrochemical cell:



What is the cell voltage at equilibrium?

A. -0.43 V B. 0.00 V C. +0.43 V D. +2.03 V

128. Consider the following diagram:



As the cell operates, the voltage gradually changes. Which of the following is responsible for this change?

A. The $[Pb^{+2}]$ is increasing
B. The $[Pb^{+2}]$ is decreasing
C. The $[Zn^{+2}]$ is decreasing
D. The mass of the $Pb_{(s)}$ electrode is decreasing.

U07: Assign voltages to the reduction half-reactions of oxidizing agents by comparison of several cells

129. Consider the following:

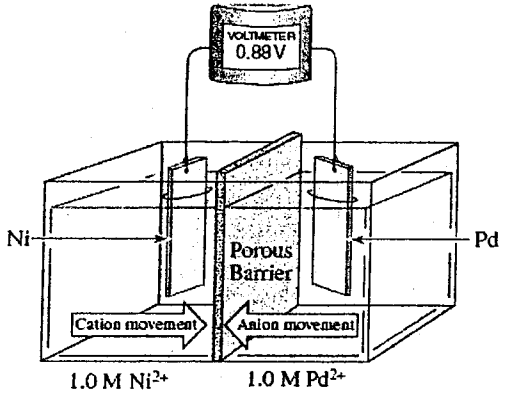
$$2\,Cr^{+2} + Tl^{+3} \rightarrow 2Cr^{+3} + Tl^{+1} \quad E^o = +1.19\ V$$

Identify the standard potential for the half-cell reaction:

$$Tl^{+} \rightarrow Tl^{+3} + 2e^{-}$$

A. -0.78 V B. +1.60 V C. +0.78 V D. +1.19 V

130. Consider the following diagram:



What is the voltage for the ~~oxidation~~ Reduction half reaction of Pd

A. -0.62 V B. +0.62 V C. +0.88 V D. -0.88 V

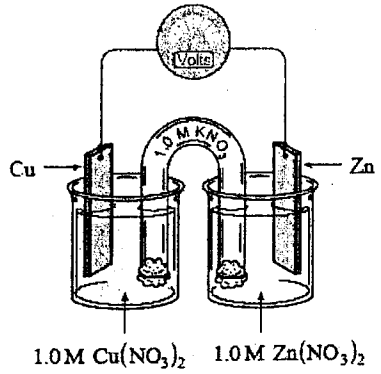
U08: Describe the significance of the E^o of an electrochemical cell

131. The value of E^o for a cell can be used to determine

A. rate B. spontaneity C. temperature D. activation energy

U09: Predict the voltage of an electrochemical cell using the table of standard reduction half-cells

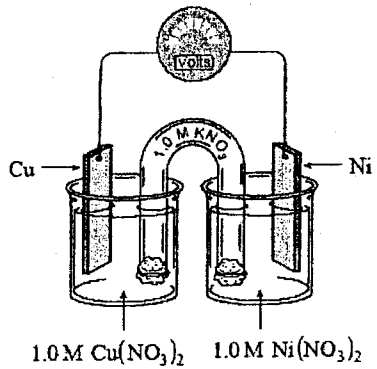
132. Consider the following cell:



The E^o for the above cell is

A. -1.10 V B. -0.42 V C. +0.42 V D. +1.10 V

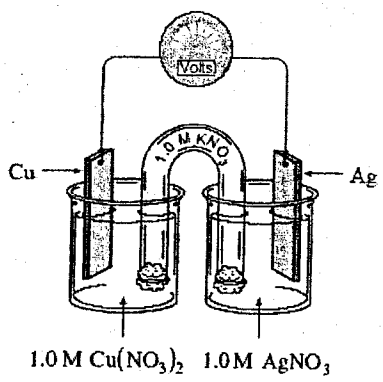
133. Consider the following cell:



The E^o for the above cell is

A. -0.04 V B. -0.60 V C. +0.04 V D. +0.60 V

134. Consider the following cell:



The E^o for the above cell is

A. -1.14 V B. -0.46 V C. +0.46 V D. +1.14 V

135. Consider the following equation: $E^o_{cell} = -0.94$ V

$$Cd^{+2} + 2I^- \rightarrow Cd + I_2 \quad E^o_{cell} = -0.94 \text{ V}$$

What is the E^o for the reduction of Cd^{+2}

A. -0.40 V B. -1.48 V C. +1.48 V D. +0.40 V

136. What is the standard cell potential for the following reaction:

$$2\,Cr_{(s)} + 3Cu^{+2} \rightarrow 2\,Cr^{+3} + 3Cu_{(s)}$$

A. -1.08 V B. +0.40 V C. +1.08 V D. -0.40 V

137. What is the standard cell potential for the following reaction:

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

A. +2.46 V B. +0.74 V C. +4.06 V D. -0.86 V

138. Given the following half-reactions:

$$PbO_2 + 4H^+ + SO_4^{-2} + 2e^- \leftrightarrows PbSO_4 + 2H_2O \quad E^o = +1.69 \text{ V}$$
$$PbSO_4 + 2e^- \leftrightarrows Pb + SO_4^{-2} \quad E^o = -0.36 \text{ V}$$

Which of the following best describes the overall reaction and the standard cell voltage in a lead acid storage battery?

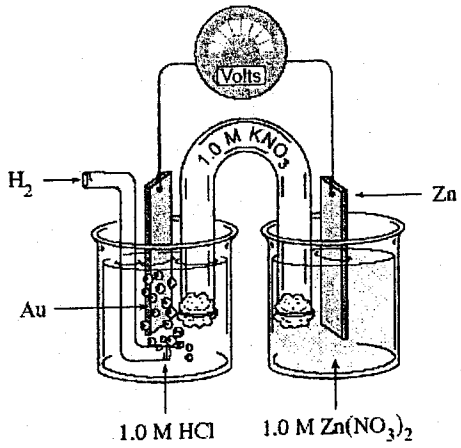
A. $Pb + 2H_2O \rightarrow PbO_2 + 4H^+ + 4e^-$ $E^o_{cell} = +1.33$ V

B. $PbO_2 + 4H^+ + 4e^- \rightarrow Pb + 2H_2O$ $E^o_{cell} = +1.33$ V

C. $Pb + PbO_2 + 2SO_4^{-2} + 4H^+ \rightarrow 2PbSO_4 + 2H_2O$ $E^o_{cell} = +2.05$ V

D. $2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2SO_4^{-2} + 4H^+$ $E^o_{cell} = +2.05$ V

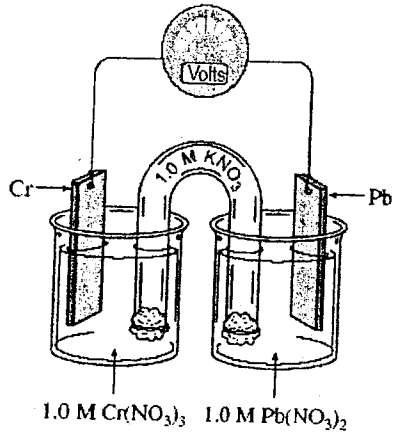
139. Consider the following cell:



What is the value of the standard cell potential?

A. -0.76 V B. +0.76 V C. +2.12 V D. +2.26 V

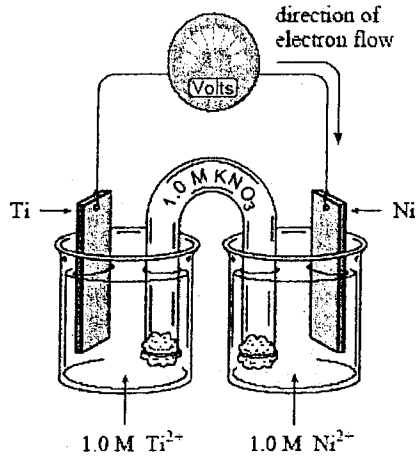
140. Consider the following cell:



At equilibrium what is the cell voltage?

A. +0.87 V B. +0.61 V C. +0.65 V D. +0.00 V

141. Consider the following electrochemical cell:



E° cell = 1.37 V

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

b. Calculate the E^o for the reduction of Ti^{+2}

U10: Predict the spontaneity of the forward or reverse reaction from the E^o of a redox reaction

142. Which of the following describes an electrochemical cell?

	E^o_{cell}	Type of reaction
A.	positive	spontaneous
B.	positive	non-spontaneous
C.	negative	spontaneous
D.	negative	non-spontaneous

143. Which of the following describes an electrolytic cell?

	E^o_{cell}	Type of reaction
A.	positive	spontaneous
B.	positive	non-spontaneous
C.	negative	sponstaneous
D.	negative	non-spontaneous

144. Consider the following reaction:

$$Ni^{+2} + 2Ag \rightarrow 2Ag^{+} + Ni$$

Which of the following is true?

	E^o	Reaction
A.	-1.06 V	non-spontaneous
B.	-.54 V	non-spontaneous
C.	+0.54 V	spontaneous
D.	+1.06 V	spontaneous

145. Consider the following reaction:

$$Ni + Ag_2S \rightarrow 2Ag + Ni^{+2} + S^{-2}$$

Which of the following is true?

	E^o	Reaction
A.	-0.95 V	non-spontaneous
B.	-0.45 V	non-spontaneous
C.	+0.45 V	spontaneous
D.	+1.06 V	spontaneous

U11: Describe how electrochemical concepts can be used in various practical applications

146. In a fuel cell, the following spontaneous redox reaction occurs in a basic solution:

$$2H_{2\,(g)} + O_{2\,(g)} \rightarrow 2\,H_2O_{\,(l)} \quad \text{(basic)}$$

a. Write the balanced half reaction that occurs at the anode:

b. Write the balanced half reaction that occurs at the cathode:

c. Determine the E^o for the fuel cell.

V1: Describe the conditions necessary for corrosion to occur

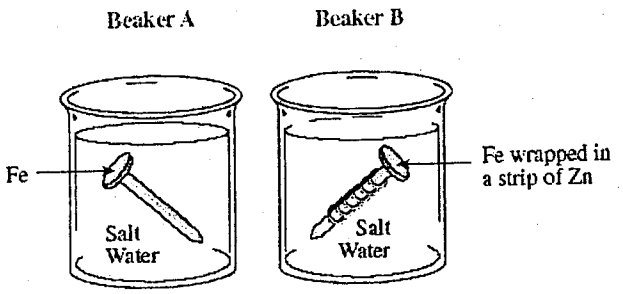
V2: Analyze the process of metal corrosion in electrochemical terms

147. What happens to iron as it corrodes?
A. It loses electrons and is reduced.
B. It gains electrons and is reduced.
C. It loses electrons and is oxidized.
D. It gains electrons and is oxidized.

148. Why is aluminum a good choice for the manufacture of outdoor structures?
A. Pure aluminum is easily reduced.
B. Pure aluminum is not easily oxidized.
C. Pure aluminum is easily reduced, but forms a protective coating.
D. Pure aluminum is easily oxidized, but forms a protective coating.

149. Why is gold a good choice for the manufacture of jewelry?
A. Pure gold is not easily reduced.
B. Pure gold is not easily oxidized.
C. Pure gold is easily reduced, but forms a protective coating.
D. Pure gold is easily oxidized, but forms a protective coating.

150. Consider the following diagrams:



a. Predict what should happen to the Fe in Beaker A.

Prediction: _____

Explanation: _____

b. Predict what should happen to the Fe in Beaker B.

Prediction: _____

Explanation: _____

151. A sample of Zn corrodes in moist air.
a. Write the reduction half-reaction.

b. What metal could be attached to the sample to prevent the corrosion of the zinc? Explain.

V3: Suggest several methods of preventing or inhibiting corrosion of a metal

152. Which of the following will inhibit the corrosion of iron?
A. high $[O_2]$
B. wet conditions
C. coating with zinc
D. increasing the temperature

153. How is the formation of rust on an iron can inhibited by a tin coating?
A. The tin is a sacrificial anode
B. The tin cathodically protects the iron
C. The tin is a weaker reducing agent than iron
D. The tin keeps the oxygen away from the iron

154. Describe two chemically different methods of preventing the corrosion of iron. Explain how each method works.

Method #1: _____

Explanation : _____

_____

Method #2: _____

Explanation : _____

_____

V4: Describe and explain the principles of cathodic protection

155. Which of the following metals could be used to cathodically protect iron?
A. tin B. lead C. zinc D. copper

156. Which of the following metals could be used to cathodically protect iron?
A. gold B. lead C. aluminum D. cobalt

W1: Define electrolysis and electrolytic cell

157. Consider the following:

I. Electrolysis of water
II. Electroplating of copper
III. Fuel cell

Which of the above involve non-spontaneous redox reactions?
A. I and II only B. I and III only C. II and III only D. I, II and III

158. Which of the following best describes a car battery as it is being charged?
A. It is an electrolytic cell
B. It is an electrochemical cell
C. It is an example of a short circuit
D. It is a system moving to a state of lower potential energy

159. Which of the following describes an operating electolytic cell?

	E^o	Type of reaction	Direction of Electron Flow
A.	positive	spontaneous	from anode; to cathode
B.	negative	non spontaneous	from cathode; to anode
C.	positive	spontaneous	from cathode; to anode
D.	negative	non-spontaneous	from anode; to cathode

160. Which of the following describes an operating electrochemical cell?

	E^o	Type of reaction	Direction of Electron Flow
A.	positive	spontaneous	anode to cathode
B.	negative	spontaneous	cathode to anode
C.	positive	non-spontaneous	anode to cathode
D.	negative	non-spontaneous	cathode to anode

161. Consider the following:

I. Electrolysis of water
II. Electroplating of copper
III. Rusting of iron

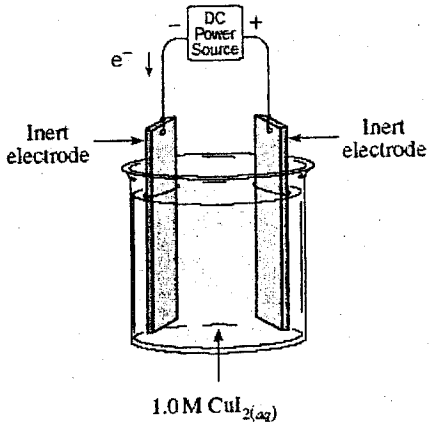
Which of the above involve non-spontaneous redox reactions?
A. I and II only B. I and III only C. II and III only D. I, II and III

162. Which of the following best describes the term electrolysis?
A. a process that uses electrical energy to cause a spontaneous reaction
B. a process that generates electrical energy using a spontaneous reaction
C. a process that uses electrical energy to cause a non-spontaneous reaction
D. a process that generates electrical energy using a non-spontaneous reaction

W2: Design and label the parts of an electrolytic cell capable of electrolyzing an aqueous salt

163. Which of the following aqueous solution should not be used as an electrolyte in an electrolytic cell?
A. 1.0 M KOH B. 1.0 M H_2SO_4 C. 1.0 M $CuSO_4$ D. 1.0 M $C_6H_{12}O_6$

164. On the diagram below, label the following:



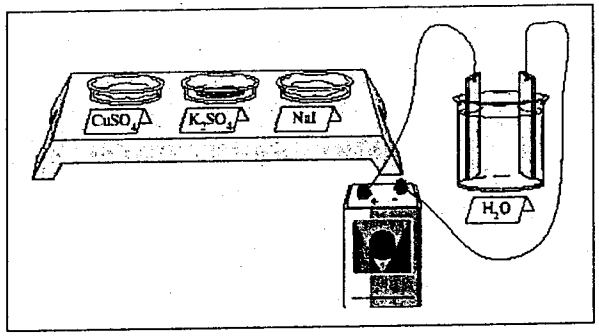
- anode and cathode

b. Write out the half-reaction that occurs at the anode

c. Write out the half-reaction that occurs at the cathode.

d. Calculate the E^o_{cell}.

165. Consider the following diagram:



Students are asked to produce hydrogen and oxygen gas by the electrolysis of water. They are given three substances ($CuSO_4$, K_2SO_4 and NaI) to choose from to prepare an electrolytic solution that will only produce hydrogen and oxygen gases.

a. Which substance should be selected. Explain why.

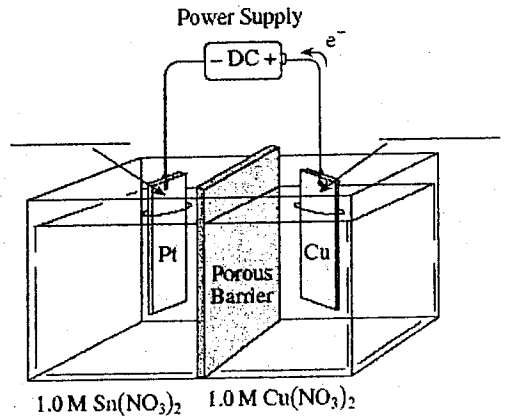
Substance _____ Explanation:

b. Write the equation for the half-reaction that occurs at the anode in this electrolytic cell.

c. Explain why it would not be acceptable to use a copper anode in this cell.

166. Sodium metal is produced commercially by the electrolysis of molten $NaCl_{(l)}$. Explain why sodium metal $Na_{(s)}$ cannot be produced by electrolysis of aqueous $NaCl_{(aq)}$.

167. Consider the following electrolytic cell which contains a porous barrier to prevent general mixing of solutions.



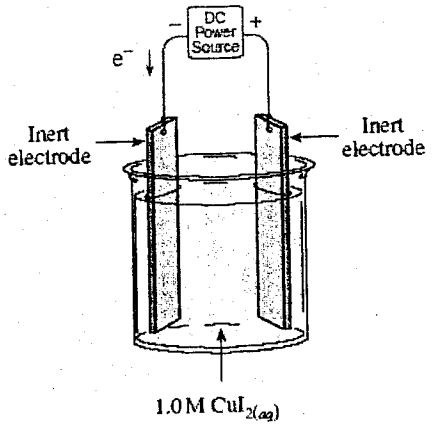
a. Label the anode and cathode in the space provided on the diagram above.

b. Write an equation for the overall cell reaction.

c. Calculate the minimum theoretical voltage required for this reaction under standard conditions.

W3: Predict the direction of flow of all ions in the cell

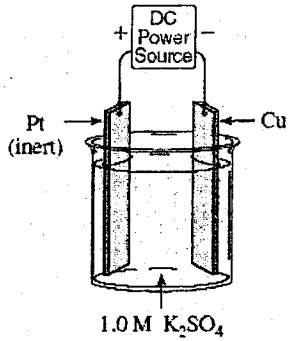
168. Consider the following cell:



What happens to the $[I^-]$ and the pH in the operating cell?

	$[I^-]$	pH
A.	increases	decreases
B.	decreases	stays constant
C.	stays constant	increases
D.	stays constant	decreases

169. Consider the following diagram:



Which of the following best describes the mass of the copper electrode and the direction of the cation movement as the cell operates?

	Mass of copper electrode	Cation movement
A.	increases	to the left
B.	stays the same	to the left
C.	stays the same	to the right
D.	decreases	to the right

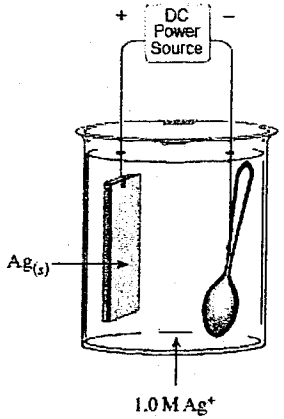
W4: Write the half-reaction occuring at each electrode

170. The products of the electrolysis of molten $MgCl_2$ using inert electrodes are
- A. hydrogen and oxygen
- B. hydrogen and chlorine
- C. magnesium and oxygen
- D. magnesium and chlorine

171. When 1.0 M Na_2SO_4 is electrolyzed, the solution near the anode becomes
- A. basic and bubbles form
- B. acidic and bubbles form
- C. basic and no bubbles form
- D. acidic and no bubbles form

172. Which of the following is formed at the anode during the electrolysis of 1.0 M KF?

A. K B. F_2 C. H_2 D. O_2



173.

What is the reaction at the anode?

A. $Ag \rightarrow Ag^+ + e^-$
B. $Ag^+ + e^- \rightarrow Ag$
C. $Cu \rightarrow Cu^{+2} + 2e^-$
D. $Cu^{+2} + 2e^- \rightarrow Cu$

174. An aqueous solution of $CuSO_4$ is electrolyzed using copper electrodes. Which of the following would correctly describe the changes in the mass of each electrode and the $[Cu^{+2}]$ in solution?

	Mass of anode	Mass of cathode	$[Cu^{+2}]$
A.	stays the same	increases	decreases
B.	stays the same	stays the same	stays the same
C.	decreases	increases	stays the same
D.	decreases	stays the same	increases

175. Which of the following are produced at the anode and cathode in the electrolysis of aqueous potassium sulfate using carbon electrodes?

	Anode	Cathode
A.	potassium	oxygen
B.	hydrogen	oxygen
C.	oxygen	hydrogen
D.	sulfur	potassium

176. The electrolysis of aqueous Rb_2SO_4 using carbon electrodes produces changes in the solution around the electrodes. How will the pH change around the anode and cathode?

	pH around the anode	pH around the cathode
A.	increase	increase
B.	decrease	decrease
C.	increase	decrease
D.	decrease	increase

177. The same amount of electricity (same number of moles of electrons) is used to carry out the electrolysis of $PdCl_{2\,(aq)}$ and $AgNO_{3\,(aq)}$ solutions in separate cells. The masses of Pd and Ag produced were measured and compared. Which of the following is true about the mass of Pd produced?

A. The mass of Pd produced is not related to the mass of Ag.
B. The mass of Pd produced is approximately half that of Ag.
C. The mass of Pd produced is approximately twice that of Ag.
D. The mass of Pd produced is approximately the same as that of Ag.

178. Which of the following are produced at the anode and cathode during the electrolysis of aqueous calcium iodide using carbon electrodes?

	Anode	Cathode
A.	iodine	calcium
B.	hydrogen	oxygen
C.	oxygen	hydrogen
D.	iodine	hydrogen

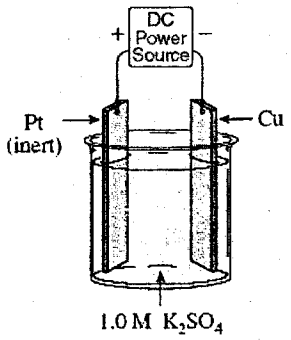
179. Which of the following are produced at the anode and the cathode in the electrolysis of molten lithium chloride using platinum inert electrodes?

	Anode	Cathode
A.	oxygen	hydrogen
B.	hydrogen	oxygen
C.	chlorine	lithium
D.	lithium	chloride

180. What are the most likely products of the electrolysis of 1.0 M MgI_2 using inert electrodes?

A. H_2 and I_2 B. Mg and I_2 C. H_2 and O_2 D. Mg and O_2

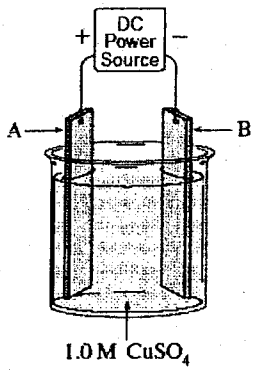
181. Consider the following diagram:



What is the equation for the anode reaction?

A. $K \rightarrow K^+ + e^-$
B. $Cu \rightarrow Cu^{+2} + 2e^-$
C. $2SO_4^{-2} \rightarrow S_2O_8^{-2} + 2e^-$
D. $H_2O \rightarrow {}^1/_2O_2 + 2H^+(10^{-7}\,M) + 2e^-$

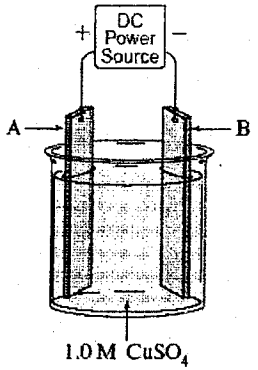
182. Consider the following diagram:



A student tries to use the above apparatus to copper plate a zinc object. What will happen if the student places the zinc object at A and the copper electrode at B?

	Electrode A	Electrode B
A.	Cu (s) forms	Cu dissolves
B.	Zn dissolves	Zn (s) forms
C.	Zn dissolves	Cu (s) forms
D.	bubbles form	bubbles form

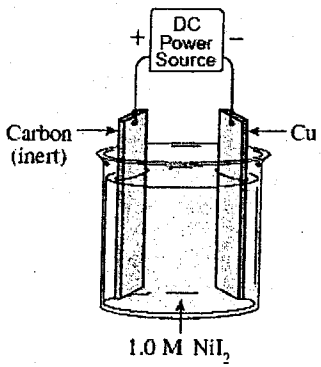
183. Consider the following diagram:



A student tries to use the above apparatus to copper plate a zinc object. What will happen if the student places the zinc object at B and the copper electrode at A?

	Electrode A	Electrode B
A.	Cu (s) dissolves	Cu forms
B.	Zn dissolves	bubbles form
C.	Zn dissolves	Cu (s) forms
D.	Cu (s) forms	Zn (s) dissolves

184. Consider the following:



What products would form at the anode and cathode as this cell operates?

	Anode	Cathode
A.	I_2	Ni
B.	Ni	I_2
C.	O_2	H_2
D.	Cu^{+2}	Ni

185. A 1.0 M HCl solution is electrolyzed using a copper anode and an inert carbon cathode. Predict the half reactions that will occur and describe what you would observe at each electrode.

Anode half reaction: _____

Anode observation: _____

_____

Cathode half reaction: _____

Cathode observation: _____

_____

186. A 1.0 M solution of $CoSO_4$ is electrolyzed using inert electrodes.

a. Write the anode and cathode half-reactions that would occur.
Anode : _____

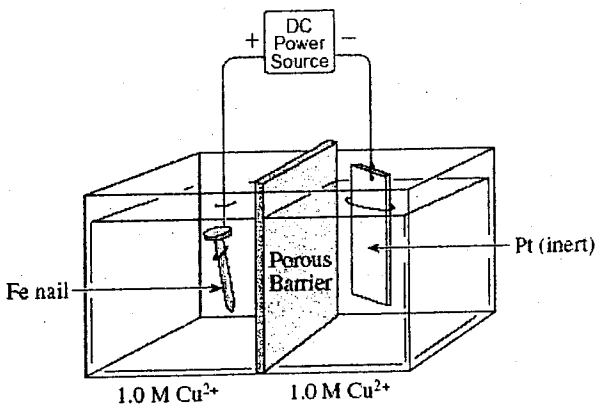
Cathode: _____

b. What is observed when bromthymol blue is added to the solution?
Color of the bromthymol blue: _____
Explanation:

W5: Demonstrate the principles involved in simple electroplating

187. A copper spoon was electroplated with silver. Which of the following reactions occured at the cathode during electroplating?
A. $Ag \rightarrow Ag^+ + e^-$ B. $Ag^+ + e^- \rightarrow Ag$ C. $Cu \rightarrow Cu^{+2} + 2e^-$ D. $Cu^{+2} + 2e^- \rightarrow Cu$

188. Consider the following:



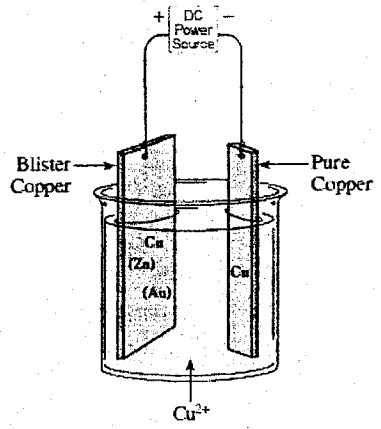
Why would this cell fail to electroplate the Fe nail with copper?
A. The Pt is inert.
B. The Fe nail is the anode.
C. The Fe nail is the cathode.
D. The porous barrier prevents reaction.

189. Draw and label the apparatus needed to electroplate a zinc statue with copper. The statue is suspended in a $Cu(NO_3)_2$ solution.

b. Explain why it is a good idea to turn on the power supply before immersing the electrodes in the solution.

W6: Construct an electrolytic cell capable of electroplating an object

190. Consider the following electrolytic cell used to electrorefine metals from impure (blister) sources. Sufficient electricity is supplied that the cell will operate under standard conditions.



0.20 M H_2SO_4

a. Is the blister electrode the anode or the cathode? _____
Explain your answer.

b. Which metal will be the first metal to corrode from the blister electrode? _____
Explain your answer.

c. Will the gold (Au) oxidize and go into the solution? _____
Explain.

191. Draw an electrolytic cell that could be used to plate an iron ring with gold. Besure to include all of the necessary parts. In addition, label the anode, solution used and composition of the electrodes.

W7: Describe the electrolysis aspects of metal refining processes

192. In the electro-refining of an ore, the ore is dissolved and the solution placed in an electrolytic cell. A specific or produces a solution which contains Na^+, Cu^{+2}, Pb^{+2} and Ag^+. Which of these metals can be plated out from the solution by electrolysis?
A. all four metals
B. Cu and Pb only
C. Na, Cu and Pb only
D. Cu, Pb and Ag only

193. In the electro-refining of an ore, the ore is dissolved and the solution placed in an electrolytic cell. A specific or produces a solution which contains Au^{+3}, Mn^{+2}, Mg^{+2} and Ag^+. Which of these metals can be plated out from the solution by electrolysis?
A. all four metals
B. Au and Ag only
C. Mn and Mg only
D. Ag, Mn and Mg only

194. Draw a diagram on an operating electrolytic cell used to extract pure lead from an impure lead sample. Identify the electrolyte and the material used for the anode.

W8: Draw and label the parts of an electrolytic cell used for electrolysis of a molten binary salt

195. Which of the following occurs during the electrolysis of molten KCl?
A. Oxygen forms at the anode
B. Potassium forms at the anode
C. Chlorine forms at the cathode
D. Potassium forms at the cathode

196. Which of the following would be produced at the cathode and anode of an electrolytic cell that contains molten $AlCl_3$?

	Cathode	Anode
A.	aluminum	chlorine gas
B.	hydrogen	chlorine gas
C.	chlorine gas	oxygen gas
D.	chlorine gas	aluminum

Review

197. What is a typical characteristic of a strong oxidizing agent?
A. It is readily oxidized.
B. It easily loses electrons.
C. It has a negative oxidation number.
D. It has a positive reduction potential.

198. Consider the following redox equation:

$$MnO_4^- + 5Fe^{+2} + 8H^+ \rightarrow Mn^{+2} + 5Fe^{+3} + 4H_2O$$

Which of the following statements is **true**?
A. The Fe^{+3} is oxidized.
B. The H^+ is reduced.
C. The oxidation number of manganese is raised by +3.
D. The equation is balanced.

199. Identify the reactant being reduced in the following equation:

$$Zn + 2MnO_2 + 2H_2O \rightarrow Zn(OH)_2 + 2MnO(OH)$$

A. Zn B. H_2O C. MnO_2 D. $Zn(OH)_2$

200. Consider the following equation:

$$16H^+ + 2MnO_4^- + 5C_2O_4^{-2} \rightarrow 10\,CO_2 + 2Mn^{+2} + H_2O$$

Identify the chemical species which is oxidized.
A. H^+ B. CO_2 C. MnO_4^- D. $C_2O_4^{-2}$

201. When U_3O_8 (Pitchblende) is dissolved in nitric acid, it changes into $UO_2(NO_3)_2$ (uranyl nitrate. What is the change in oxidation number for uranium?
A. $+3\,^2/_3$ B. $+^2/_3$ C. $-3\,^1/_3$ D. -10

202. Consider the following unbalanced redox equation:

$$Pt + NO_3^- + Cl^- \rightarrow PtCl_6^{-2} + NO + H_2O$$

Which chemical species is neither oxidized nor reduced?
A. Pt B. Cl^- C. H_2O D. NO_3^-

203. In an experiment Ag^+ reacts spontaneously with Ru but not with Pd. The relative strength of the metal ions from strongest to weakest oxidizing agent is
A. $Ag^+ > Ru^+ > Pd^+$ B. $Pd^+ > Ag^+ > Ru^+$ C. $Ru^+ > Ag^+ > Pd^+$ D. $Ru^+ > Pd^+ > Ag^+$

204. Consider the following spontaneous reactions:

$$3Cd^{+2} + 2Np \rightarrow 3\,Cd + 2Np^{+3}$$
$$Cd + Pd^{+2} \rightarrow Pd + Cd^{+2}$$
$$Np^{+3} + Ce \rightarrow Np + Ce^{+3}$$

Which is the weakest reducing agent?
A. Cd B. Ce C. Np D. Pd

205. The metals Hg, Cd, and Pd reacts as follows:

$$Hg^{+2} + Pd \rightarrow Pd^{+2} + Hg$$
$$Pd^{+2} + Cd \rightarrow Cd^{+2} + Pd$$
$$Hg^{+2} + Cd \rightarrow Cd^{+2} + Hg$$

Put the metal ions in order from weakest oxidizing agents to strongest:

A. $Pd^{+2} < Hg^{+2} < Cd^{+2}$ B. $Cd^{+2} < Pd^{+2} < Hg^{+2}$ C. $Hg^{+2} < Pd^{+2} < Cd^{+2}$ D. $Cd^{+2} < Hg^{+2} < Pd^{+2}$

206. A piece of Ag does not react spontaneously with 1.0 M Ti^{+2} because

A. Ag is a weaker reducing agent than Ti
B. Ag is a weaker oxiding agent than Ti
C. Ag is a stronger reducing agent than Ti
D. Ag is a stronger oxidizing agent than Ti

207. Which of the following can act as an oxidizing agent, but **not** as a reducing agent?

A. Sn^{+2} B. Br^- C. Fe^{+2} D. Ca^{+2}

208. Solid copper forms spontaneously in the following reaction:

$$V + Cu^{+2} \rightarrow Cu + V^{+2}$$

Based on these observations, Cu is a

A. weaker reducing agent than V
B. weaker oxidizing agent than V
C. stronger reducing agent than V
D. stronger oxidizing agent than V

209. Which of the following is the strongest reducing agent?

A. Fe^{+2} B. H_2O C. Sn^{+2} D. I_2

210. Which of the following is the weakest oxidizing agent?

A. Cl_2 B. Al^{+3} C. Sn^{+2} D. acidified $Cr_2O_7^{-2}$

211. A solution of $AuCl_4^-$ is mixed with a solution Sn^{+2} under standard conditions. Which of the following best describes the result?

A. $AuCl_4^- + Sn^{+2} \rightarrow Sn^{+4} + Au_{(s)} + 4Cl^-$
B. $2AuCl_4^- + 3Sn^{+2} \rightarrow 3Sn^{+4} + 2Au_{(s)} + 8Cl^-$
C. $AuCl_4^- + e^- + Sn^{+2} \rightarrow Sn^{+4} + Au_{(s)} + 4Cl^-$
D. $2AuCl_4^- + 3Sn^{+2} \rightarrow 3Sn + 2Au_{(s)} + 8Cl^-$

212. Which of the following could be used to determine the acidified $[IO_3^-]$ by a redox reaction?

A. Cr^{+3} B. I^- C. Cu^{+2} D. $Cr_2O_7^{-2}$ (acidified)

213. When the skeletal equation $HPO_4^{-2} \rightarrow H_3P_2O_7$ is balanced in acidic solution H^+ and e^- will appear. Which of the following best describes the H^+ and e^- for the balanced half-reaction?

A. $3H^+$ on the left and $1e^-$ on the right
B. $3H^+$ on the left and $1e^-$ on the left
C. $4H^+$ on the right and $6e^-$ on the left
D. $4H^+$ on the left and $6e^-$ on the left

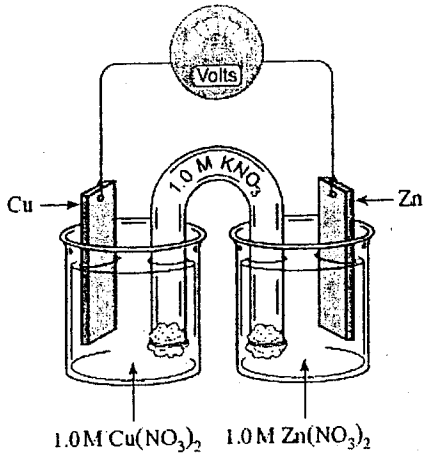
214. Consider the following redox reaction in acidic solution:

$$H_2Cr_2O_7 + Fe^{+2} + HClO_4 \rightarrow Cr(ClO_4)_3 + Fe^{+3}$$

a. Balance the above redox reaction.

b. The above reaction was used for a redox titration. At the equivilence point 15.42 mL of a 0.0200M $H_2Cr_2O_7$ solution was required to titrate 25.00 mL of Fe^{+2} solution. Calculate $[Fe^{+2}]$

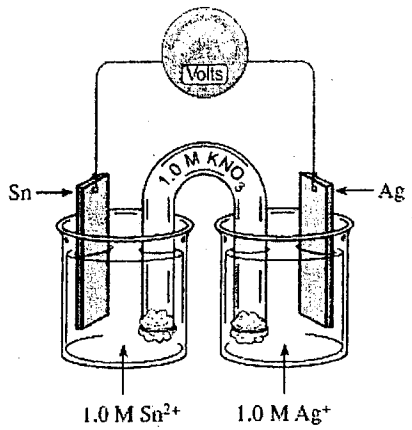
215. Consider the following cell:



In what directions do the electrons and cations move?

	Direction of electrons	Direction of cations
A.	towards the Cu electrode	towards the Zn electrode
B.	towards the Cu electrode	towards the Cu electrode
C.	towards the Zn electrode	towards the Zn electrode
D.	towards the Zn electrode	towards the Cu electrode

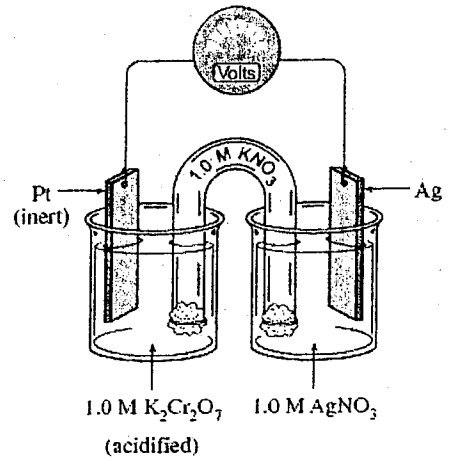
216. Consider the following cell:



What is the value for E^{o}_{cell}?

A. -0.94 V B. -0.66 V C. +0.66 V D. +0.94 V

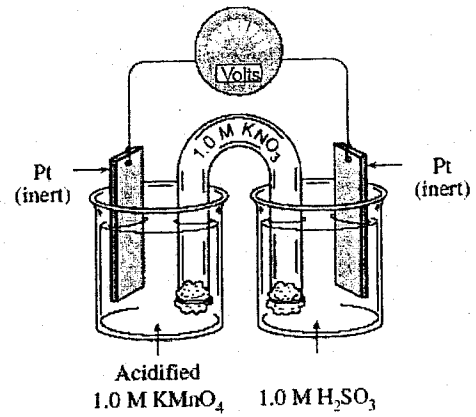
217. Consider the following electrochemical cell:



Calculate the E^{o} for this cell at equilibrium.

A. 0.00V B. +0.43 V C. +2.03 V D. -0.43 V

218. Consider the following:



In the above cell, what reactions occurs at the anode?

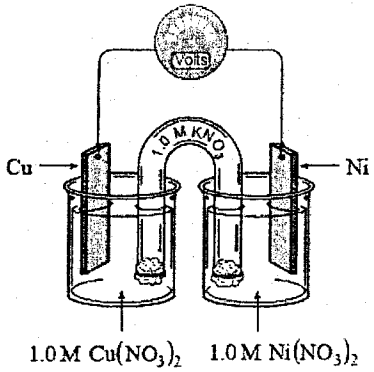
A. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O$

B. $Mn^{+2} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e^-$

C. $H_2SO_3 + H_2O \rightarrow SO_4^{-2} + 4H^+ + 2e^-$

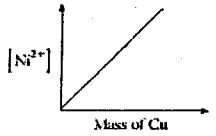
D. $SO_4^{-2} + 4H^+ + 2e^- \rightarrow H_2SO_3 + H_2O$

219. Consider the following cell:

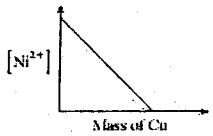


Which of the following diagrams represents the relationship between the $[Ni^{+2}]$ and the mass of the Cu electrode as the cell above is in operation?

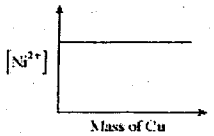
A.



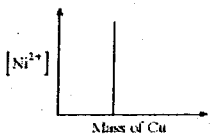
B.



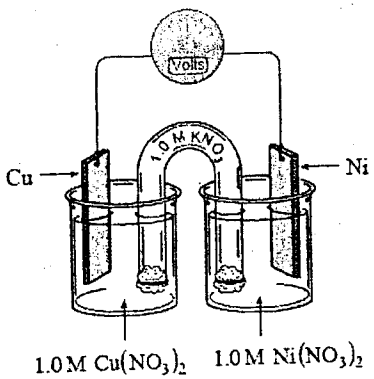
C.



D.



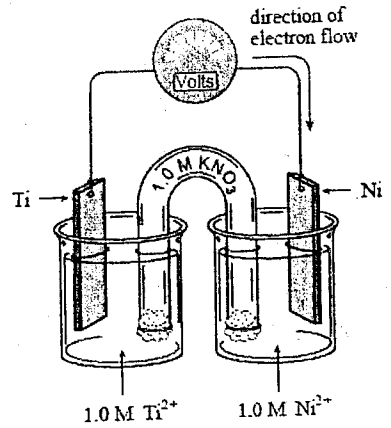
220. Consider the following cell:



As the cell operates, what happens to the ions in the salt bridge?

A. K^+ and NO_3^- will both migrate to the nickel half-cell.
B. K^+ and NO_3^- will both migrate to the nickel half-cell.
C. K^+ will migrate to the nickel half-cell while the NO_3^- will migrate to the copper half-cell.
D. K^+ will migrate to the copper half-cell while the NO_3^- will migrate to the nickel half-cell.

221. Consider the following electrochemical cell:



E° cell = 1.37 V

a. Identify which electrode is the anode and which electrode is the cathode:

Anode _____ Cathode _____

b. Write out the half-reaction that takes place at the cathode:

Cathode half-reaction _____

c. Calculate the E^o value for the reduction of the Ti^{+2} ion.

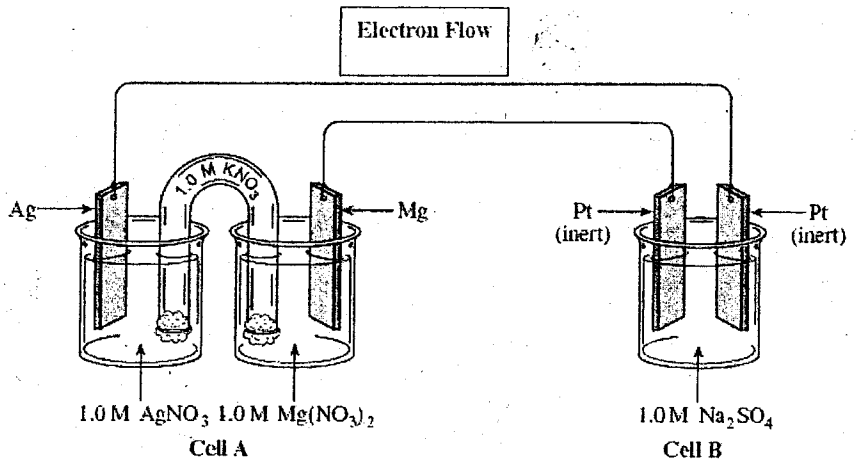
$Ti^{+2} + 2e^- \rightarrow Ti$ $\quad E^o =$ _____

222. Which of the following would protect an iron pipeline from rusting?

A. connecting it to a solution of silver nitrate
B. connecting it to the positive terminal of a direct current power supply
C. connecting it to the negative terminal of a direct current power supply
D. connecting it to electrodes made of copper which are buried beside the pipeline

223. Consider the following apparatus consisting of an electrochemical cell joined to an electrolytic

223. cell:



a. On the diagram above, indicate the direction of electron flow in the top wire.

b. Write the anode and cathode half-reactions for cell A and calculate the standard reduction potential for this cell.

Anode _____

Cathode _____

E^o = _____

c. Write the anode and cathode half-reactions for cell B and calculate the standard reduction potential for this cell.

Anode _____

Cathode _____

E^o = _____

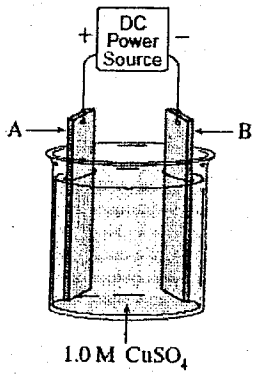
224. Which of the following is formed at the cathode during the electrolysis of 1.0 M KF?

A. K B. F_2 C. H_2 D. O_2

225. The electrolysis of aqueous Rb_2SO_4 using carbon electrodes produces changes in the solution around the electrodes. How will the mass of the electrodes change?

	mass of anode	mass of cathode
A.	stays the same	increase
B.	decrease	stays the same
C.	stays the same	stays the same
D.	decrease	increase

226. Consider the following diagram:



The above cell is constructed in order to copper plate an object. For the best results, which of the following should be used for electrodes A and B?

	Electrode A	Electrode B
A.	object	pure copper
B.	pure copper	object
C.	object	any conductor
D.	any conductor	object