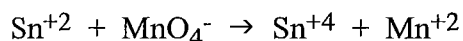


Show all work in booklet

1. When  $\text{SO}_4^{2-}$  reacts to form  $\text{S}_2\text{O}_6^{2-}$ , the sulphur atoms

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

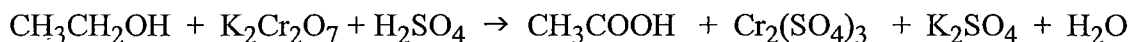
2. Consider the following unbalanced redox reaction:



Which of the following describes the change in manganese in the  $\text{MnO}_4^-$ ?

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

3. Consider the following equation for the breathalyzer reaction:



The change in oxidation number for each carbon is equivalent to

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

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

- |                                     | $\text{N}_2$ | $\text{Li}_3\text{N}$ | $\text{NO}_2^-$ |
|-------------------------------------|--------------|-----------------------|-----------------|
| A.                                  | -3           | -3                    | -3              |
| <input checked="" type="radio"/> B. | 0            | -3                    | +3              |
| C.                                  | -3           | -3                    | +3              |
| D.                                  | 0            | <del>-3</del>         | -3              |

5. The oxidation number of manganese changes as  $\text{MnO}_4^-$  is converted to  $\text{MnO}_2$ . How many electrons are gained or lost by the manganese during the change?

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

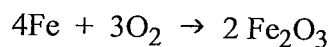
A reducing agent

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

7. Which of the following describes a strong oxidizing agent?

- A. a substance which loses electrons easily
- B. a substance which has a large increase in oxidation numbers
- C. a substance which has a small increase in oxidation numbers
- D. a substance which gains electrons easily

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



Which of the following is **false**?

- A.  $\text{O}_2$  is the oxidizing agent.
- B. Metallic iron is reduced to  $\text{Fe}^{+3}$ .
- C. Metallic iron is the reducing agent.
- D. This is a redox reaction.

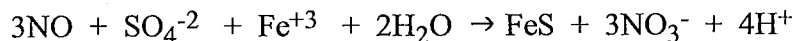
9. Two separate reactions involved in the refining of copper ore are:

Reaction I	$2\text{Cu}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2$
Reaction II	$\text{Cu}_2\text{S} + 2\text{Cu}_2\text{O} \rightarrow 6\text{Cu} + \text{SO}_2$

What happens to the copper ions during this process?

- A. Copper ions are oxidized in Reaction II.
  - B. Copper ions are oxidized in Reaction I.
  - C. Copper ions are reduced in Reaction II.
  - D. Copper ions are reduced in Reaction I.
10. Which of the following could be produced by the reduction of  $\text{NO}_2$ ?
- A. NO
  - B.  $\text{N}_2\text{O}_5$
  - C.  $\text{HNO}_3$
  - D.  $\text{N}_2\text{O}_4$

11. Consider the following redox reaction:



Which of the following is being oxidized?

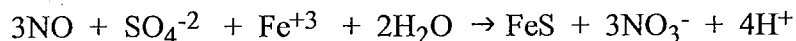
A. NO

B. H<sub>2</sub>O

C. SO<sub>4</sub><sup>-2</sup>

D. Fe<sup>+3</sup>

12. Consider the following redox reaction:



The oxidation number for nitrogen in this reaction has

A. increased by 3

B. decreased by 2

C. increased by 2

D. decreased by 1

13. What is the oxidation number for chromium in Cr<sub>2</sub>O<sub>7</sub><sup>-2</sup>?

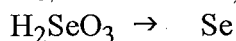
A. +7

B. +6

C. +14

D. +12

14. Consider the following unbalanced half-reaction:



The oxidation number of Se

A. increases as it undergoes reduction

B. decreases as it undergoes oxidation

C. decreases as it undergoes reduction

D. increases as it undergoes oxidation

15. What is the oxidation number for sulfur in S<sub>2</sub>O<sub>8</sub><sup>-2</sup>?

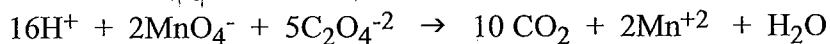
A. +9

B. -2

C. +7

D. +8

16. Consider the following equation:



Identify the chemical species which is reduced.

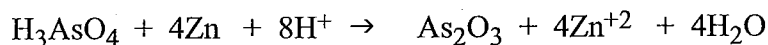
A. Mn<sup>+2</sup>

B. H<sup>+</sup>

C. C<sub>2</sub>O<sub>4</sub><sup>-2</sup>

D. MnO<sub>4</sub><sup>-</sup>

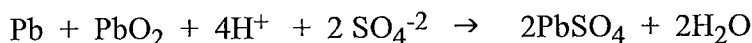
17. Consider the following :



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

- A. The oxidation of hydrogen decreases by 1.
  - B. The  $\text{H}_3\text{AsO}_4$  is the reducing agent.
  - C. The oxidation number of arsenic decreases by 2.
  - D. The oxidation number of arsenic increases by 2.
18. What is the oxidation number of iron in  $\text{Fe}_3\text{O}_4$ ?
- A. +2
  - B. +3
  - C. +8/3
  - D. +4/3
19. What is the oxidation number of iron in  $\text{FeO}_2$ ?
- A. +3
  - B. +4
  - C. +2
  - D. +1/2
20. In which of the following chemical changes will there be an oxidation number change of +3?
- A.  $\text{ClO}^- \rightarrow \text{ClO}_2^-$
  - B.  $\text{Cr}^{+3} \rightarrow \text{Cr}_2\text{O}_7^{-2}$
  - C.  $\text{Mn}^{+2} \rightarrow \text{MnO}_4^-$
  - D.  $\text{Cr}^{+3} \rightarrow \text{Cr}^{+2}$
21. Which of the following represents an oxidation?
- A.  $\text{SO}_2 + \text{H}_2\text{O} \rightarrow 2\text{H}^+ + \text{SO}_3^{-2}$
  - B.  $\text{Na}^+ + \text{Cl}^- \rightarrow \text{NaCl}$
  - C.  $2\text{SO}_4^{-2} \rightarrow \text{S}_2\text{O}_8^{-2}$
  - D.  $2\text{H}^+ + \text{S} \rightarrow \text{H}_2\text{S}$
22. Which equation represents a redox reaction?
- A.  $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}$
  - B.  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
  - C.  $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
  - D.  $2\text{CrO}_4^{-2} + 2\text{H}^+ \rightarrow \text{Cr}_2\text{O}_7^{-2} + \text{H}_2\text{O}$

23. Identify the oxidizing agent in the following equation:



- A. Pb                      B.  $\text{H}^+$                       C.  $\text{SO}_4^{-2}$                       D.  $\text{PbO}_2$

24. Which of the following is a redox equation?

- A.  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$   
B.  $\text{Ag}(\text{NH}_3)_2^+ + 2\text{H}^+ + \text{Cl}^- \rightarrow \text{AgCl} + 2\text{NH}_4^+$   
C.  $\text{Mn}(\text{OH})_2 + 2\text{HC}_2\text{H}_3\text{O}_2 \rightarrow \text{Mn}^{+2} + 2\text{H}_2\text{O} + 2\text{C}_2\text{H}_3\text{O}_2^-$   
D.  $\text{Ag}_2\text{CrO}_4 \rightarrow 2\text{Ag}^+ + \text{CrO}_4^{-2}$

25. Which of the following contains molybdenum with its highest oxidation number?

- A.  $\text{Mo}_2\text{S}_3$   
B.  $\text{MoCl}_5$   
C.  $\text{Mo}_6\text{Cl}_{12}$   
D.  $\text{MoO}_4^{-2}$

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

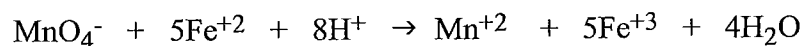
- I.  $\text{ClO}^- \rightarrow \text{ClO}_3^-$   
II.  $\text{C}_2\text{H}_5\text{OH} \rightarrow \text{C}_2\text{H}_4\text{O}_2$   
III.  $\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$

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

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

- A.  $\text{Cl}_2 + 2\text{NaI} \rightarrow 2\text{NaCl} + \text{I}_2$   
B.  $\text{Sn}^{+4} + 2\text{Fe}^{+2} \rightarrow 2\text{Fe}^{+3} + \text{Sn}^{+2}$   
C.  $\text{Zn} + \text{S} \rightarrow \text{ZnS}$   
D.  $\text{K}_3\text{PO}_4 + 3\text{AgNO}_3 \rightarrow \text{Ag}_3\text{PO}_4 + 3\text{KNO}_3$

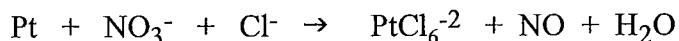
28. Consider the following redox equation:



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

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

29. Consider the following unbalanced redox equation:



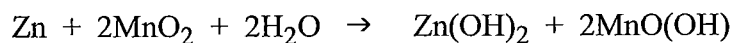
Which chemical species is reduced?

- A.  $\text{NO}_3^-$                       B. Pt                              C.  $\text{Cl}^-$                               D.  $\text{H}_2\text{O}$

30. What is the oxidation number of carbon in  $\text{Mn}(\text{CH}_3\text{COO})_3$  ?

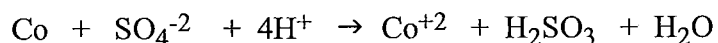
- A. +1  
B. -1  
C. +1/2  
D. 0

31. Identify the reducing agent in the following equation:



- A.  $\text{H}_2\text{O}$                               B.  $\text{MnO}_2$                               C. Zn                                      D.  $\text{Zn}(\text{OH})_2$

32. Consider the following equation:



Which statement is correct?

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

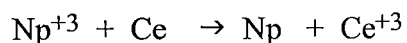
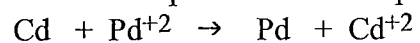
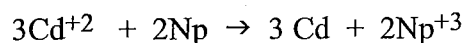
33. In an experiment  $\text{Ag}^+$  reacts spontaneously with Ru but not with Pd. The relative strength of the metals from strongest to weakest reducing agent is

- A.  $\text{Ru} > \text{Ag} > \text{Pd}$   
B.  $\text{Pd} > \text{Ag} > \text{Ru}$   
C.  $\text{Ru} > \text{Pd} > \text{Ag}$   
D.  $\text{Ag} > \text{Ru} > \text{Pd}$

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

- A.  $\text{Pt} < \text{Ga} < \text{Pd}$   
B.  $\text{Ga} < \text{Pt} < \text{Pd}$   
C.  $\text{Ga} < \text{Pd} < \text{Pt}$   
D.  $\text{Pt} < \text{Pd} < \text{Ga}$

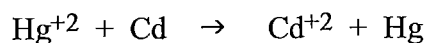
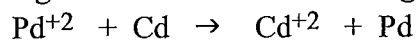
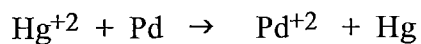
35. Consider the following spontaneous reactions:



Which is the strongest oxidizing agent?

- A.  $\text{Pd}^{+2}$
- B.  $\text{Np}^{+3}$
- C.  $\text{Ce}^{+3}$
- D.  $\text{Cd}^{+2}$

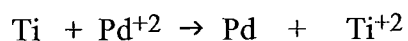
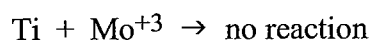
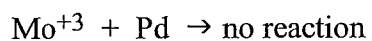
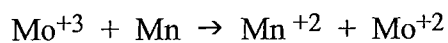
36. The metals Hg, Cd, and Pd reacts as follows:



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

- A.  $\text{Hg} < \text{Pd} < \text{Cd}$
- B.  $\text{Cd} < \text{Pd} < \text{Hg}$
- C.  $\text{Hg} < \text{Cd} < \text{Pd}$
- D.  $\text{Pd} < \text{Hg} < \text{Cd}$

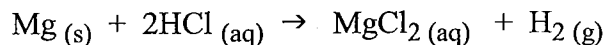
37. Consider the following experimental results:



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

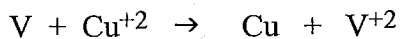
	Oxidizing Agents	Reducing Agents	
↑ STRONGEST  WEAKEST		n	WEAKEST  ↓ STRONGEST
		n	
		n	
		n	

38. Consider the following spontaneous reaction:



Which of the following statements is correct?

- A. Mg is a weaker reducing agent than  $\text{H}^+$
  - B. Mg is a stronger reducing agent than  $\text{H}^+$
  - C. Mg is a stronger reducing agent than  $\text{H}_2$
  - D. Mg is a weaker reducing agent than  $\text{H}_2$
39. A piece of Ag does not react spontaneously with 1.0 M  $\text{Ti}^{+2}$  because
- A.  $\text{Ag}^+$  is a weaker oxidizing agent than  $\text{Ti}^{+2}$
  - B.  $\text{Ag}^+$  is a stronger reducing agent than  $\text{Ti}^{+2}$
  - C.  $\text{Ag}^+$  is a stronger oxidizing agent than  $\text{Ti}^{+2}$
  - D.  $\text{Ag}^+$  is a weaker reducing agent than  $\text{Ti}^{+2}$
40. Which of the following can act as an oxidizing agent, but **not** as a reducing agent?
- A.  $\text{Cl}^-$
  - B.  $\text{Na}^+$
  - C.  $\text{Cu}^+$
  - D. Cr
41. Which of the following can act as a reducing agent, but **not** as an oxidizing agent?
- A. Sn
  - B.  $\text{Ca}^{+2}$
  - C.  $\text{Br}_2$
  - D.  $\text{Fe}^{+2}$
42. Solid copper forms spontaneously in the following reaction:



Based on these observations,  $\text{V}^{+2}$  is a

- A. stronger reducing agent than  $\text{Cu}^{+2}$
  - B. weaker oxidizing agent than  $\text{Cu}^{+2}$
  - C. stronger oxidizing agent than  $\text{Cu}^{+2}$
  - D. weaker reducing agent than  $\text{Cu}^{+2}$
43. Which of the following is the strongest reducing agent?
- A.  $\text{H}_2\text{Te}$
  - B.  $\text{H}_2\text{Se}$
  - C.  $\text{H}_2\text{O}$
  - D.  $\text{H}_2\text{S}$



44. Which of the following is the strongest oxidizing agent?
- A.  $\text{H}_2\text{O}$
  - B.  $\text{Sn}^{+2}$
  - C.  $\text{I}_2$
  - D.  $\text{Fe}^{+2}$
45. Which of the following ions can be reduced by  $\text{Pb (s)}$  under standard conditions?
- A.  $\text{Cu}^+$
  - B.  $\text{Sn}^{+2}$
  - C.  $\text{Ca}^{+2}$
  - D.  $\text{Cr}^{+3}$
46. Which of the following is more difficult to reduce than the  $\text{H}^+_{(\text{aq})}$  ion?
- A.  $\text{Zn}^{+2}$
  - B.  $\text{Ag}^+$
  - C.  $\text{Cu}^{+2}$
  - D.  $\text{I}_2$
47. A piece of  $\text{Cu}$  reacts spontaneously with  $1.0 \text{ M Pd}^{+2}$  because
- A.  $\text{Cu}$  is a stronger reducing agent than  $\text{Pd}$  and  $E^\circ > 0$
  - B.  $\text{Cu}$  is a weaker reducing agent than  $\text{Pd}$  and  $E^\circ < 0$
  - C.  $\text{Cu}$  is a stronger reducing agent than  $\text{Pd}$  and  $E^\circ < 0$
  - D.  $\text{Cu}$  is a weaker reducing agent than  $\text{Pd}$  and  $E^\circ > 0$
48. Which two species will **not** react spontaneously at standard conditions?
- A.  $\text{Cu}$  with  $\text{Ag}^+$
  - B.  $\text{Mg}$  with  $\text{Cr}^{+3}$
  - C.  $\text{Ag}$  with  $\text{Zn}^{+2}$
  - D.  $\text{Co}$  with  $\text{Cl}_2$
49. Which of the following will not react spontaneously with  $\text{H}_2\text{O}$  at standard conditions?
- A.  $\text{Sn}$
  - B.  $\text{Na}$
  - C.  $\text{Ca}$
  - D.  $\text{F}_2$
50. Which of the following will react spontaneously with  $\text{Ag}_2\text{S}$  at standard conditions?
- A.  $\text{Au}$
  - B.  $\text{Co}$
  - C.  $\text{Pb}$
  - D.  $\text{Al}$

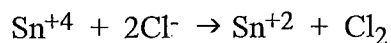
51. Which of the following represents a spontaneous redox reaction?

- A.  $\text{AuCl}_4^- + 3\text{Ag} \rightarrow \text{Au} + 4\text{Cl}^- + 3\text{Ag}^+$
- B.  $2\text{Br}^- + \text{Mg}^{+2} \rightarrow \text{MgBr}_2$
- C.  $\text{Cu} + \text{Sn}^{+4} \rightarrow \text{Cu}^{+2} + \text{Sn}^{+2}$
- D.  $\text{Ag}_2\text{S} + 2\text{Fe}^{+2} \rightarrow 2\text{Fe}^{+3} + 2\text{Ag} + \text{S}^{-2}$

52. Which of the following will react spontaneously with  $\text{Br}_2$  but not with  $\text{I}_2$ ?

- A.  $\text{Cr}^{+2}$
- B.  $\text{Fe}^{+2}$
- C.  $\text{Mn}^{+2}$
- D.  $\text{F}^-$

53. Consider the following:



What is true for this reaction?

- A.  $E^\circ_{\text{cell}} = +1.21 \text{ V}$  and it is spontaneous
- B.  $E^\circ_{\text{cell}} = -1.51 \text{ V}$  and it is not spontaneous
- C.  $E^\circ_{\text{cell}} = -1.21 \text{ V}$  and it is not spontaneous
- D.  $E^\circ_{\text{cell}} = +1.51 \text{ V}$  and it is spontaneous

54. Which of the following could react spontaneously with Ag metal?

- A.  $\text{Fe}^{+2}$
- B. acidified  $\text{NO}_3^-$
- C. acidified  $\text{SO}_4^{-2}$
- D.  $\text{Cl}^-$

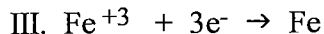
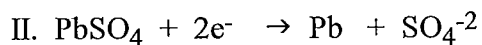
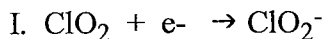
55. Which of the following could react spontaneously with  $\text{Fe}^{+2}$ ?

- A.  $\text{MnO}_4^-$  in base
- B.  $\text{Cl}^-$
- C. acidified  $\text{SO}_4^{-2}$
- D.  $\text{Ag}^+$

56. Which of the following metals can be oxidized by 1.0 M  $\text{Fe}^{+2}$ ?

- A. Co
- B. Ag
- C. Cr
- D. Sn

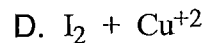
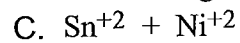
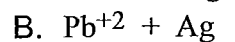
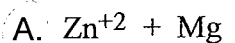
57. Consider the following half-reactions under standard conditions:



In an experiment when  $\text{ClO}_2$  and Fe were combined, they reacted. In a second experiment when  $\text{PbSO}_4$  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  $E^\circ$ ?

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

58. Which of the following combinations will react spontaneously?



59. A sample of copper is placed in  $\text{HNO}_3(\text{aq})$  and another sample of copper is placed in  $\text{HCl}(\text{aq})$ .

a. In which acid does a spontaneous redox reaction occur with the copper? 1

b. Calculate the  $E^\circ$  for the reaction that occurs. 4

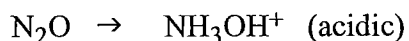
60. An excess of copper solid is dropped into a solution which contains  $\text{AgNO}_3$ ,  $\text{Fe}(\text{NO}_3)_3$  and  $\text{Zn}(\text{NO}_3)_2$ . Write the equations for any reduction half-reactions that occur over time under standard conditions.

61. 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: Cu + 2AgNO<sub>3</sub> → Cu(NO<sub>3</sub>)<sub>2</sub> + 2Ag

Net ionic equation: Cu + 2Ag<sup>+</sup> → Cu<sup>2+</sup> + 2Ag

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



- A.  $\text{N}_2\text{O} + 2\text{H}^+ + \text{H}_2\text{O} + \text{e}^- \rightarrow \text{NH}_3\text{OH}^+$
- B.  $\text{N}_2\text{O} + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NH}_3\text{OH}^+$
- C.  $\text{N}_2\text{O} + 6\text{H}^+ + \text{H}_2\text{O} + 4\text{e}^- \rightarrow 2\text{NH}_3\text{OH}^+$
- D.  $\text{N}_2\text{O} + 6\text{H}^+ + \text{H}_2\text{O} \rightarrow 2\text{NH}_3\text{OH}^+ + 4\text{e}^-$

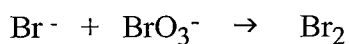
63. When the skeletal equation  $\text{S}_2\text{O}_3^{2-} \rightarrow \text{HSO}_3^-$  is balanced in acidic solution  $\text{H}^+$  and  $\text{e}^-$  will appear. Which of the following best describes the  $\text{H}^+$  and  $\text{e}^-$  for the balanced half-reaction?

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

64. When the skeletal equation  $\text{Br}_2 \rightarrow \text{BrO}_3^-$  is balanced in acidic solution,  $\text{H}_2\text{O}$ ,  $\text{H}^+$  and  $\text{e}^-$  will appear. Which of the following are the correct balancing coefficients?

- |    | $\text{H}_2\text{O}$ | $\text{H}^+$ | $\text{e}^-$ |
|----|----------------------|--------------|--------------|
| A. | 6                    | 12           | 10           |
| B. | 3                    | 3            | 2            |
| C. | 3                    | 6            | 4            |
| D. | 6                    | 12           | 5            |

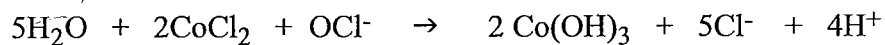
65. Consider the following skeletal equation for a redox reaction in acidic solution:



What is the equation for the balanced reduction half-reaction

- A.  $2\text{Br}^- + 2\text{e}^- \rightarrow \text{Br}_2$
- B.  $5\text{e}^- + 6\text{H}^+ + \text{BrO}_3^- \rightarrow \text{Br}_2 + 3\text{H}_2\text{O}$
- C.  $10\text{e}^- + 12\text{H}^+ + 2\text{BrO}_3^- \rightarrow \text{Br}_2 + 6\text{H}_2\text{O}$
- D.  $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$

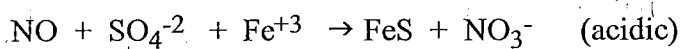
66. Consider the following balanced redox equation in acidic solution:



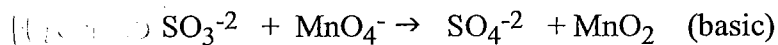
Which of the following describes the amounts and locations of  $\text{OH}^-$  and  $\text{H}_2\text{O}$  if the equation is balanced in basic solution?

- (A)  $1\text{H}_2\text{O}$  on the left and  $4\text{OH}^-$  on the left
- B.  $5\text{H}_2\text{O}$  on the left and  $4\text{OH}^-$  on the left
- C.  $1\text{H}_2\text{O}$  on the left and  $4\text{OH}^-$  on the right
- D.  $1\text{H}_2\text{O}$  on the left and no  $\text{OH}^-$

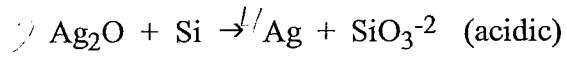
67. Balance the following redox reaction:



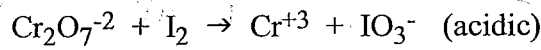
68. Balance the following redox equation:



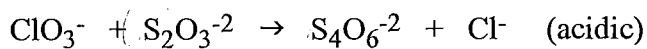
69. Balance the following redox reaction: (acidic)



70. Balance the following redox reaction: (acidic)



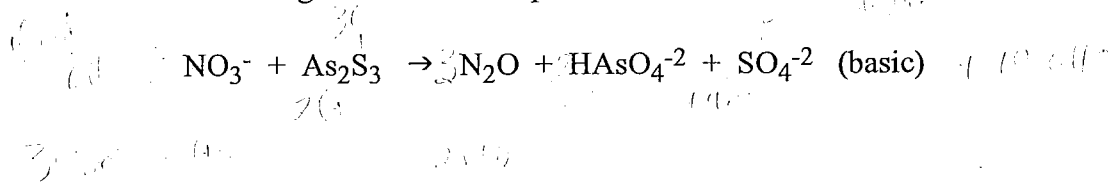
71. Balance the following redox equation:



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

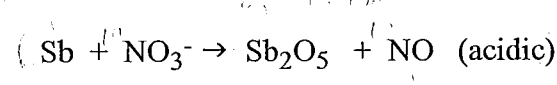


73. Balance the following skeletal redox equation in basic solution:



*[Handwritten notes and calculations for problem 73, including oxidation state assignments and balancing steps.]*

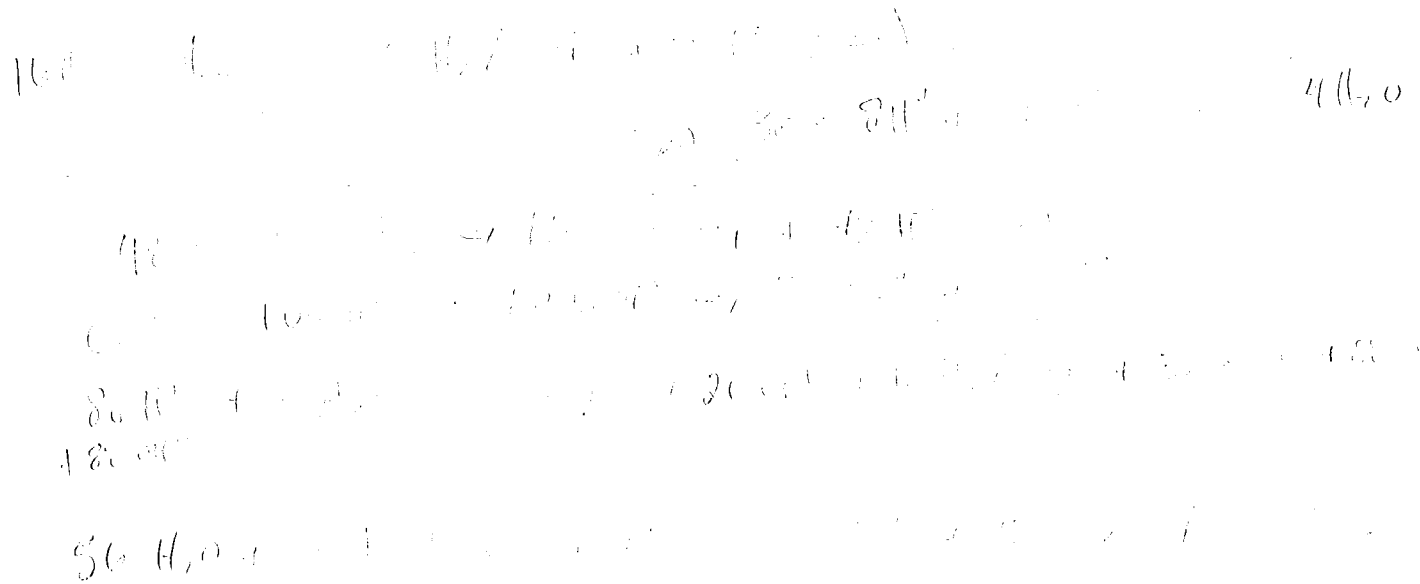
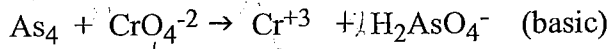
74. Balance the following redox reaction:



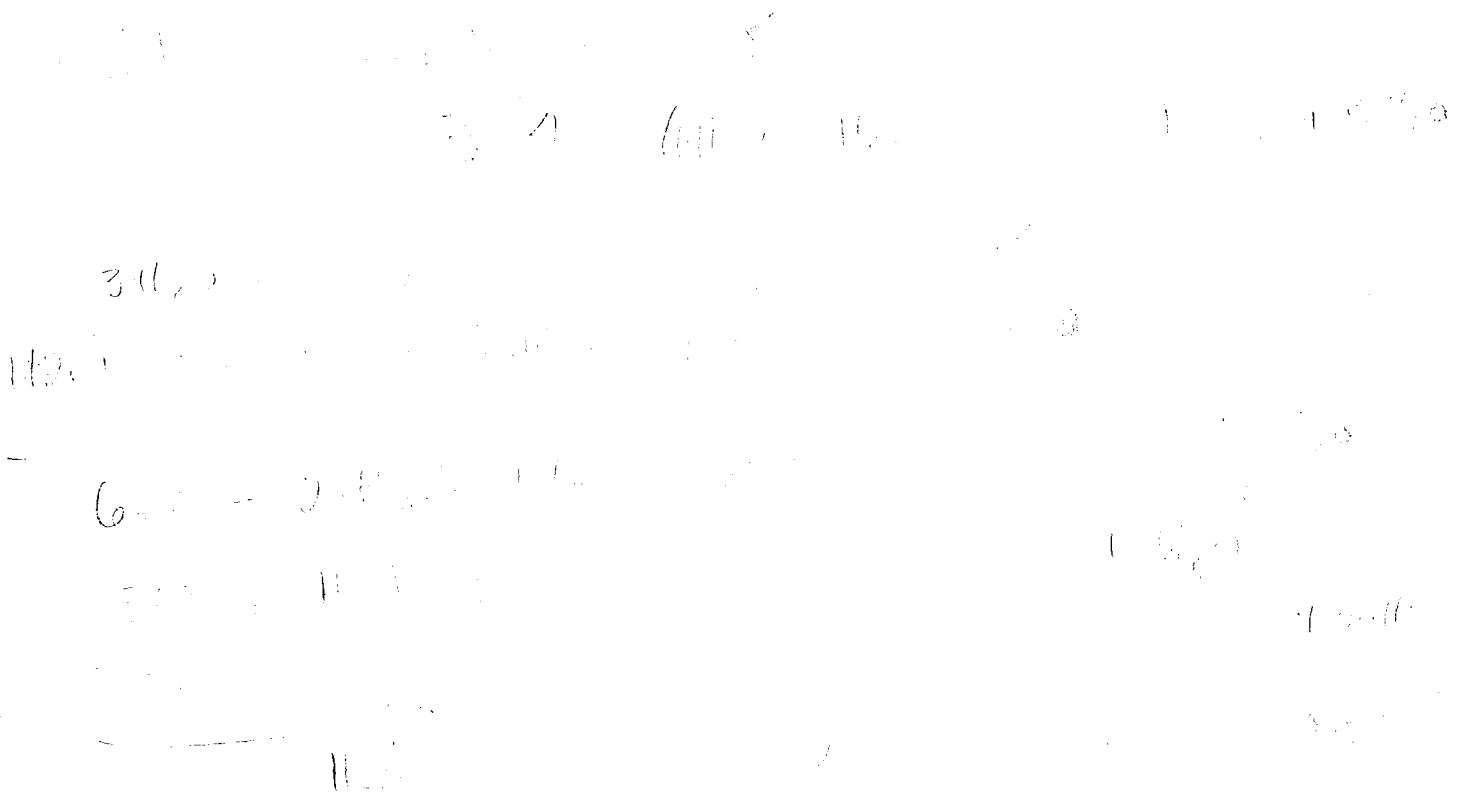
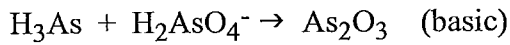
*[Handwritten notes and calculations for problem 74, including oxidation state assignments and balancing steps.]*



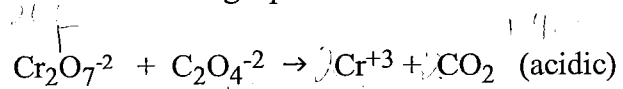
75. Balance the following redox reaction:



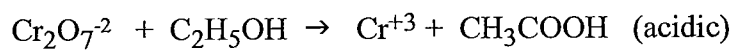
76. Balance the following redox reaction:



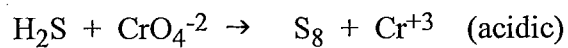
77. Balance the following equation.



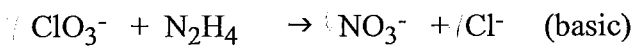
78. Balance the following equation.



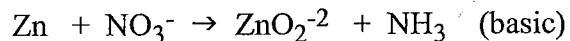
79. Balance the following redox reaction:



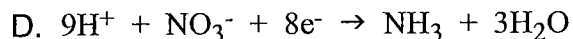
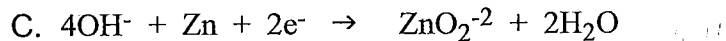
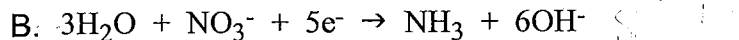
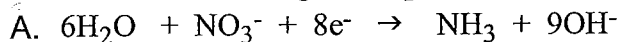
80. Balance the following redox reaction in basic solution:



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



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



82. When a piece of Ag is placed in 1.0 M  $\text{NiCl}_2$

A. the  $[\text{Ag}^+]$  decreases

B. no changes occur

C. the  $[\text{Ni}^{2+}]$  decreases

D. the  $[\text{Cl}^-]$  increases

83. When a piece of Cu is placed in 1.0 M  $\text{AgNO}_3$

A. the  $[\text{Cu}^{2+}]$  increases

B. the  $[\text{NO}_3^-]$  decreases

C. no change occurs

D. the  $[\text{Ag}^+]$  increases

84. When a piece of Cu is placed in 1.0 M  $\text{HNO}_3$

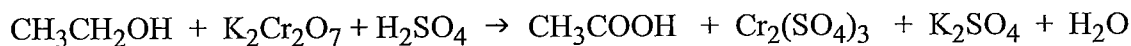
A. the  $[\text{NO}_3^-]$  decreases

B. the  $[\text{Cu}^{2+}]$  decreases

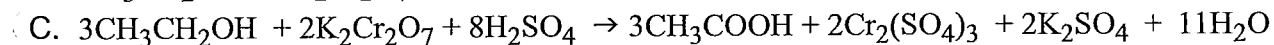
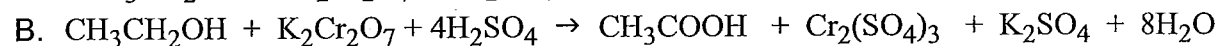
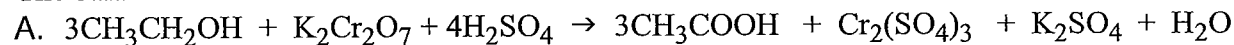
C. no change occurs

D. the  $[\text{H}^+]$  increases

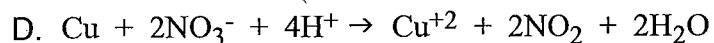
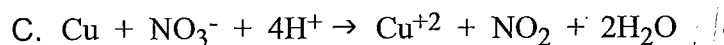
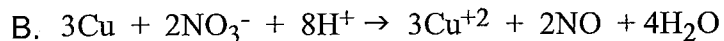
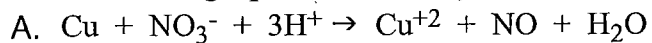
85. Consider the following equation for the breathalyzer reaction:



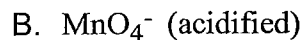
The balanced redox reaction would be:



86. Nitric oxide (NO) can be prepared by the oxidation of Cu with  $\text{NO}_3^-$  in acidic solution. Which of the following equations correctly describes this process?



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



88. A 2.000 g strip of cobalt metal is suspended in 100.0 mL of 0.20 M  $\text{AgNO}_3$  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  $\text{Ag}^+$  reacting, and show how these values support the balanced equation.

89. Which of the following could be used to determine the acidified  $[\text{BrO}_3^-]$  by a redox reaction?

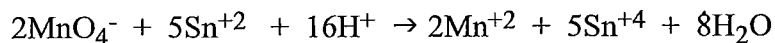
- A.  $\text{MnO}_4^-$  (acidified)
- B.  $\text{NO}_3^-$  (acidified)
- C.  $\text{Cu}^{+2}$
- D.  $\text{I}^-$

90. Which of the following could be titrated using acidified  $\text{MnO}_4^-$  ions?

- A.  $\text{IO}_3^-$
- B.  $\text{SO}_4^{-2}$
- C.  $\text{Na}^+$
- D.  $\text{H}_2\text{O}_2$

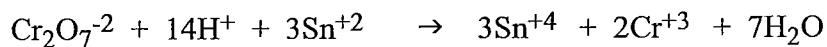
91. Acidified potassium permanganate ( $\text{KMnO}_4$ ) solution is often used in redox titrations.

Permanganate reacts with  $\text{Sn}^{+2}$  as follows:



A 10.0 mL solution containing  $\text{Sn}^{+2}$  is titrated with 19.3 mL of 0.10 M  $\text{KMnO}_4$ . What is the  $[\text{Sn}^{+2}]$ ?

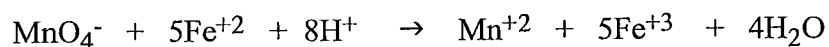
92. The titration of a 25.0 mL  $\text{SnCl}_2$  sample, in acidic solution, requires 14.4 mL of 0.030 M  $\text{K}_2\text{Cr}_2\text{O}_7$ . The balanced equation for the reaction is shown below:



What is the number of moles of  $\text{SnCl}_2$  in the original sample?

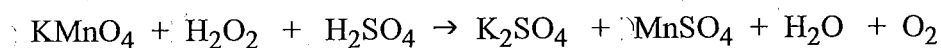
- A.  $4.3 \times 10^{-4}$  moles
- B.  $1.3 \times 10^{-3}$  moles
- C.  $5.2 \times 10^{-2}$  moles
- D.  $1.4 \times 10^{-4}$  moles

93. A 10.0 mL water sample was analyzed for  $[\text{Fe}^{+2}]$  using a redox titration with acidified  $\text{KMnO}_4$ . The equation for the reaction is:



A 10.0 mL sample was titrated with 12.5 mL of 0.10 M  $\text{KMnO}_4$  solution. What is the  $[\text{Fe}^{+2}]$  in the water sample?

- A. 0.13 M  
B. 0.28 M  
C. 0.63 M  
D. 0.025 M
94. Consider the following redox reaction in acidic solution:



- a. Balance the above redox reaction.

- b. The above reaction was used for a redox titration. At the equivalence point  $5.684 \times 10^{-4}$  mol  $\text{KMnO}_4$  was required to titrate 5.00 mL of  $\text{H}_2\text{O}_2$  solution. Calculate  $[\text{H}_2\text{O}_2]$

95. A titration is performed to determine the  $[\text{Fe}^{+2}]$  in 25.00 mL of an  $\text{FeSO}_4$  solution. It requires 22.52 mL of 0.015 M  $\text{KMnO}_4$  to reach the equivalence point in which  $\text{Mn}^{+2}$  and  $\text{Fe}^{+3}$  are produced.

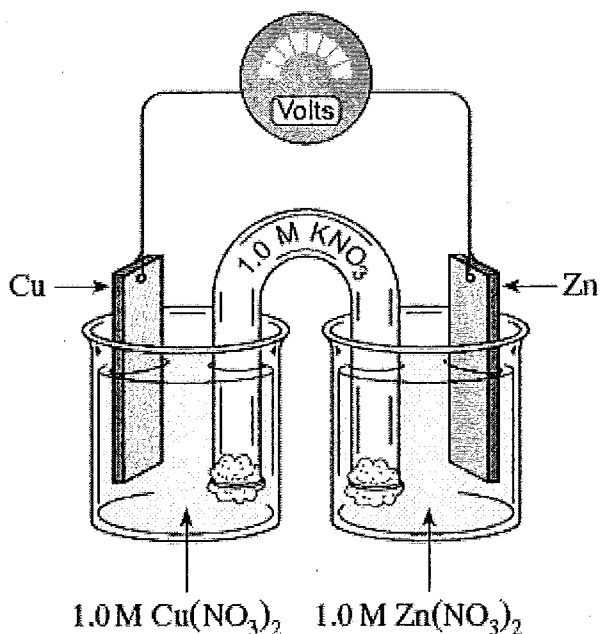
a. balance the redox reaction:



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



96. Consider the following cell for the next three questions:



The  $[\text{Cu}^{+2}]$  in the copper half-cell will

- A. decrease as  $\text{Cu}^{+2}$  gains electrons and is reduced.
- B. increase as Cu loses electrons and is oxidized.
- C. decrease as  $\text{Cu}^{+2}$  gains electrons and is oxidized.
- D. increase as Cu loses electrons and is reduced.

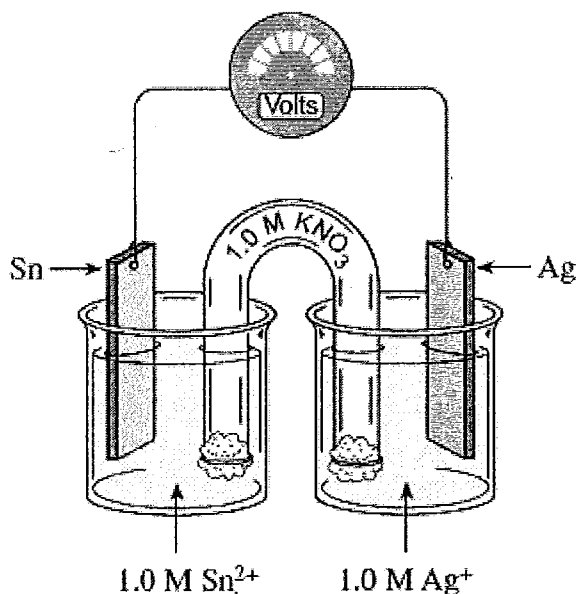
97. The  $[\text{Zn}^{+2}]$  in the zinc half-cell will

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

98. What will happen to the electrodes as the cell operates?

- |    | Copper electrode | Zinc electrode |
|----|------------------|----------------|
| A. | decreases        | increases      |
| B. | increases        | increases      |
| C. | increases        | decreases      |
| D. | decreases        | decreases      |

99. Consider the following cell for the next three questions:



What is the overall reaction:

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

100. Calculate the cell's voltage

- A.  $E^\circ = +0.94 \text{ V}$
- B.  $E^\circ = -0.76 \text{ V}$
- C.  $E^\circ = +0.76 \text{ V}$
- D.  $E^\circ = +1.74 \text{ V}$

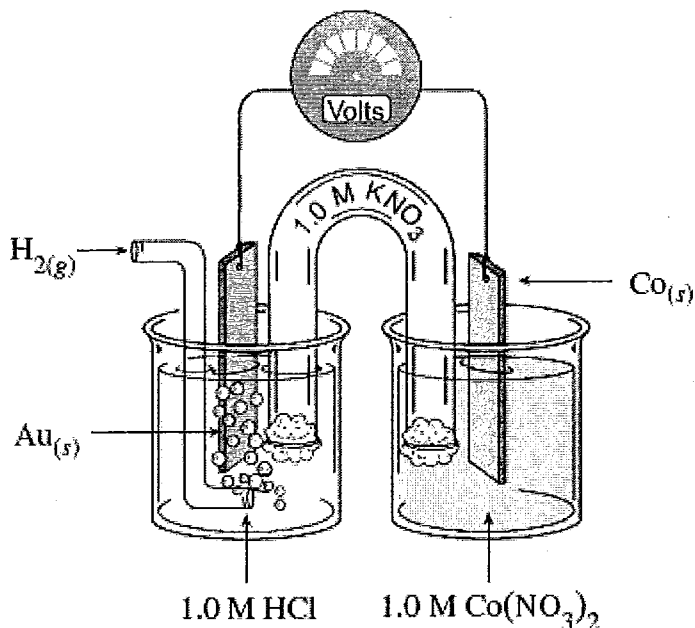
101. Calculate the cell's voltage

- A.  $E^\circ = +0.76 \text{ V}$
- B.  $E^\circ = -0.76 \text{ V}$
- C.  $E^\circ = +1.74 \text{ V}$
- D.  $E^\circ = +0.94 \text{ V}$

102. Which way will the electrons flow, and why will the electrons go in that direction

- A. Electrons will travel from the Sn to the Ag electrodes because Ag is the anode.
- B. Electrons will travel from the Ag to the Sn electrodes because Sn is the anode.
- C. Electrons will travel from the Ag to the Sn electrodes because Ag is the anode.
- D. Electrons will travel from the Sn to the Ag electrodes because Sn is the anode.

103. Consider the diagram below for the next three questions:



Identify the overall cell reaction

- A.  $\text{Au}^{+3} + \text{Co}^{+2} \rightarrow \text{Au} + \text{Co}$
- B.  $\text{Co}^{+2} + \text{H}_2 \rightarrow 2\text{H}^+ + \text{Co}$
- C.  $2\text{Au}^{+3} + 3\text{Co} \rightarrow 2\text{Au} + 3\text{Co}^{+2}$
- D.  $2\text{H}^+ + \text{Co} \rightarrow \text{Co}^{+2} + \text{H}_2$

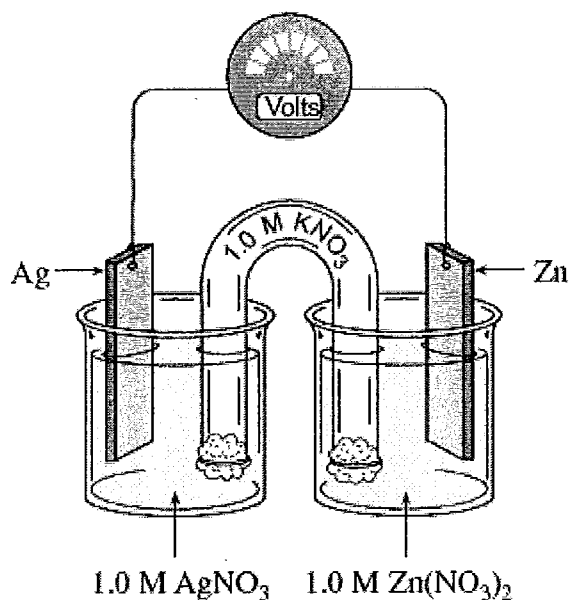
104. Which direction will the anions and cations travel?

- |    | Anions         | Cations        |
|----|----------------|----------------|
| A. | to the Co cell | to the Co cell |
| B. | to the Au cell | to the Au cell |
| C. | to the Co cell | to the Au cell |
| D. | to the Au cell | to the Co cell |

105. What will happen to the mass of the Co in the Co cell and what will happen to the  $[\text{Cl}^-]$  in the Au cell?

- |    | Mass of Co | $[\text{Cl}^-]$ |
|----|------------|-----------------|
| A. | decreases  | decreases       |
| B. | increases  | increases       |
| C. | increases  | decreases       |
| D. | decreases  | increases       |

106. Consider the following cell for the next three questions



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

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

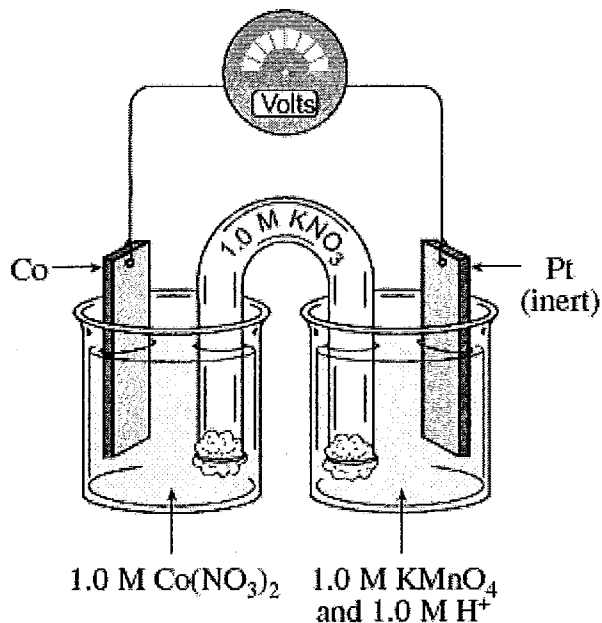
107. What will happen to the  $[\text{Ag}^+]$  and the  $[\text{Zn}^{+2}]$  as the cell operates?

- |    | $[\text{Ag}^+]$ | $[\text{Zn}^{+2}]$ |
|----|-----------------|--------------------|
| A. | increases       | decreases          |
| B. | decreases       | increases          |
| C. | increases       | increases          |
| D. | decreases       | decreases          |

108. At equilibrium, what will be the voltage?

- A.  $E^\circ = -1.56 \text{ V}$       B.  $E^\circ = +0.04 \text{ V}$       C.  $E^\circ = 0.0 \text{ V}$       D.  $E^\circ = +1.56 \text{ V}$

109. Consider the following cell for the next three questions



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

- A.  $\text{Co}^{+2} + 2\text{e}^- \rightarrow \text{Co}$
- B.  $\text{Co} \rightarrow \text{Co}^{+2} + 2\text{e}^-$
- C.  $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{+2} + 4\text{H}_2\text{O}$
- D.  $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$

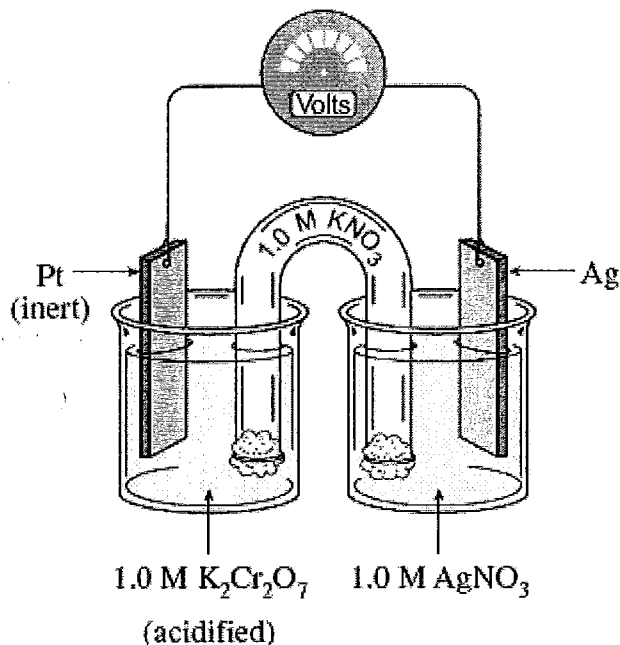
110. What is the function of the salt bridge in this electrochemical cell?

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

111. What will happen to the mass of the electrodes in this cell?

- | Anode electrode   | Cathode electrode |
|-------------------|-------------------|
| A. stays the same | stays the same    |
| B. decreases      | stays the same    |
| C. decreases      | increases         |
| D. stays the same | increases         |

112. Consider the following electrochemical cell for the next three questions



Which of the following represents the overall cell reaction?

- A.  $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 9\text{Ag} \rightarrow 9\text{Ag}^+ + \text{Cr}^{3+} + 7\text{H}_2\text{O}$
- B.  $\text{Cr}_2\text{O}_7^{2-} + \text{H}^+ + \text{Ag} \rightarrow \text{Ag}^+ + \text{Cr}^{3+} + \text{H}_2\text{O}$
- C.  $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Ag}^+ \rightarrow 6\text{Ag} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
- D.  $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Ag} \rightarrow 6\text{Ag}^+ + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$

113. What would be the voltage for the above cell?

- A.  $E^\circ = 0.0 \text{ V}$
- B.  $E^\circ = +2.03 \text{ V}$
- C.  $E^\circ = +0.43 \text{ V}$
- D.  $E^\circ = -1.17 \text{ V}$

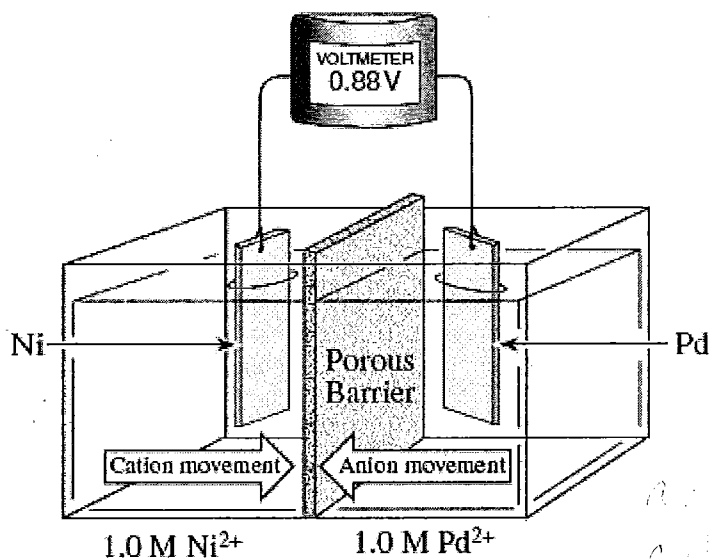
114. What will happen to the  $[\text{Cr}_2\text{O}_7^{2-}]$  and  $[\text{Ag}^+]$  as the cell operates?

- |    | $[\text{Cr}_2\text{O}_7^{2-}]$ | $[\text{Ag}^+]$ |
|----|--------------------------------|-----------------|
| A. | decreases                      | decreases       |
| B. | increases                      | increases       |
| C. | increases                      | decreases       |
| D. | decreases                      | increases       |

115. What happens to the pH at each electrode?

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

116. Consider the following diagram:



What is the half-cell reaction at the anode?

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

117. Calculate the  $E^\circ$  value for the following half-reaction:  $\text{Pd}^{2+} + 2\text{e}^- \rightarrow \text{Pd}$

- A.  $E^\circ = -0.62 \text{ V}$       B.  $E^\circ = +1.14 \text{ V}$       C.  $E^\circ = -1.14 \text{ V}$       (D.  $E^\circ = +0.62 \text{ V}$

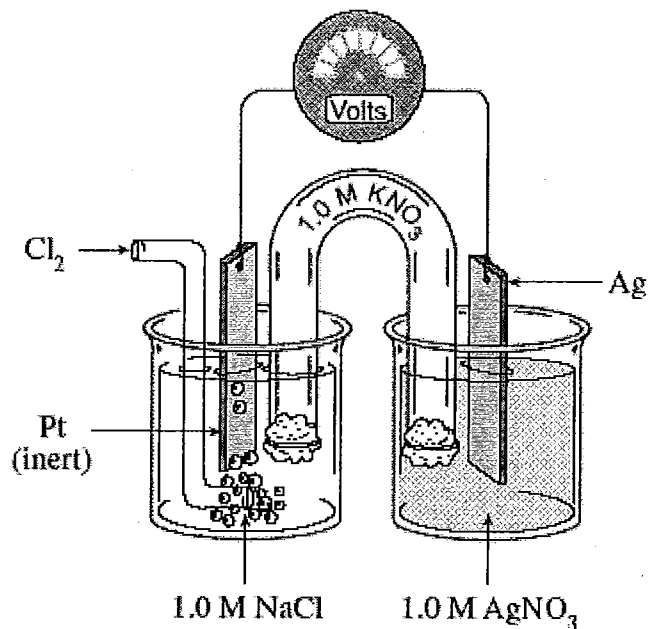
118. What will happen to the  $[\text{Ni}^{2+}]$  and in what direction will the electrons travel?

- |    | $[\text{Ni}^{2+}]$ | direction      |
|----|--------------------|----------------|
| A. | increases          | to the cathode |
| B. | decreases          | to the anode   |
| C. | decreases          | to the cathode |
| D. | increases          | to the anode   |

119. What is the half-cell reaction at the cathode?

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

120. Consider the following cell:



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

- A.  $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$
- B.  $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$
- C.  $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
- D.  $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$

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

- A.  $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
- B.  $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$
- C.  $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$
- D.  $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$