

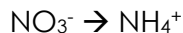
# Chemistry 12

## Electrochemistry Review Package

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### I. Multiple Choice

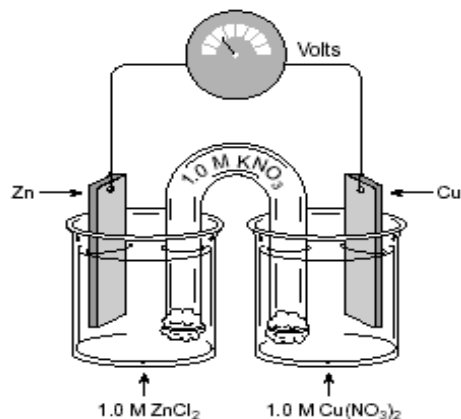
1. Consider the following:



The balanced half-reaction is

- A.  $\text{NO}_3^- + 10 \text{H}^+ + 8\text{e}^- \rightarrow \text{NH}_4^+ + 2\text{H}_2\text{O}$
- B.  $\text{NO}_3^- + 7 \text{H}^+ + 9\text{e}^- \rightarrow \text{NH}_4^+ + 3\text{OH}^-$
- C.  $\text{NO}_3^- + 6 \text{H}^+ + 4\text{e}^- \rightarrow \text{NH}_4^+ + 3\text{H}_2\text{O}$
- D.  $\text{NO}_3^- + 10 \text{H}^+ + 8\text{e}^- \rightarrow \text{NH}_4^+ + 3\text{H}_2\text{O}$

Use the following cell diagram for questions 2 and 3.



2. In the above electrochemical cell,

- A. the mass of the anode increases and the mass of the cathode increases.
- B. the mass of the anode decreases and the mass of the cathode decreases.
- C. the mass of the anode decreases and the mass of the cathode increases.
- D. the mass of the anode increases and the mass of the cathode decreases.

3. In the operating electrochemical cell above, the initial voltage is:

- A. -1.10 V
- B. -0.42 V
- C. 0.00 V
- D. +1.10 V

4. The substance formed at the anode during the electrolysis of 1.0 M molten NaI is:

- A. iodine.
- B. oxygen.
- C. sodium.
- D. hydrogen.

5. When molten aluminum oxide is electrolyzed, the cathode reaction is:

- A.  $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$
- B.  $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$
- C.  $\text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-}$
- D.  $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$

6. 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.  $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

7. 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.  $+2^{1/3}$
- B.  $+2/3$
- C.  $-3^{1/3}$
- D.  $-10$

8. A product of the oxidation of  $MnO_2$  is:

- A. Mn
- B.  $Mn^{2+}$
- C.  $MnO_4^-$
- D.  $Mn_2O_3$

9. Consider the following:



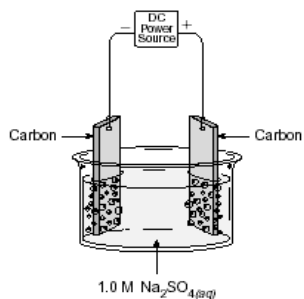
In the redox reaction above,

- A. hydrogen is both reduced and oxidized.
- B. manganese is both reduced and oxidized.
- C. manganese is reduced and hydrogen is oxidized.
- D. manganese is oxidized and hydrogen is reduced.

10. The oxidation number of phosphorus in  $Na_4P_2O_7$  is:

- A. -10
- B. -5
- C. +5
- D. +10

11. Consider the following electrolytic cell:



The gas produced at the anode is:

- A. oxygen.
- B. hydrogen.
- C. water vapour.
- D. sulphur dioxide.

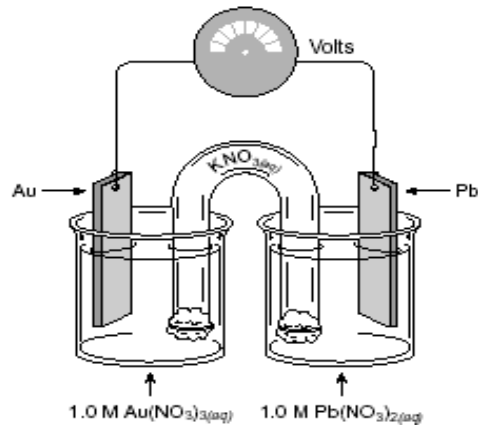
12. The reaction that occurs spontaneously when pieces of lead, zinc, copper and silver are placed in a solution of  $\text{Ni}(\text{NO}_3)_2$  is:

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

13. In a redox reaction,  $\text{ClO}^-$  was converted to  $\text{Cl}^-$  in a basic solution. The balanced half-reaction for this process is

- A.  $\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Cl}^- + 2\text{OH}^-$
- B.  $\text{ClO}^- + 2\text{OH}^- \rightarrow \text{Cl}^- + 2\text{e}^- + \text{H}_2\text{O}$
- C.  $\text{ClO}^- + \text{H}_2\text{O} \rightarrow \text{Cl}^- + 2\text{e}^- + 2\text{OH}^-$
- D.  $\text{ClO}^- + 2\text{OH}^- + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$

Use the following diagram to answer questions 14, 15 and 16.



14. As the cell operates:

- A.  $\text{NO}_3^-$  and  $\text{K}^+$  will migrate toward the Pb half-cell.
- B.  $\text{NO}_3^-$  and  $\text{K}^+$  will migrate toward the Au half-cell.
- C.  $\text{NO}_3^-$  will migrate toward the Pb half-cell and  $\text{K}^+$  will migrate toward the Au half-cell.
- D.  $\text{NO}_3^-$  will migrate toward the Au half-cell and  $\text{K}^+$  will migrate toward the Pb half-cell.

15. The initial voltage is:

- A.  $-1.37 \text{ V}$
- B.  $0.00 \text{ V}$
- C.  $1.37 \text{ V}$
- D.  $1.63 \text{ V}$

16. The direction of the electron flow is:

- A. from Au to Pb through the wire.
- B. from Pb to Au through the wire.
- C. from Au to Pb through the salt bridge.
- D. from Pb to Au through the salt bridge.

17. A student attempted to determine the  $E^\circ$ (volts) of the following half-reaction:



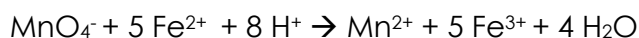
She observed the following:

1.  $\text{Pd}^{2+} + \text{Cu} \rightarrow \text{Pd} + \text{Cu}^{2+}$
2.  $\text{Pd}^{2+} + \text{Au} \rightarrow$  no reaction
3.  $\text{Pd}^{2+} + \text{Hg} \rightarrow$  no reaction

Based on the above, the  $E^\circ$ (volts) of a Pd half-cell is:

- |                         |  |
|-------------------------|--|
| A. less than 0.34 V.    | C. greater than 0.85 V but less than 1.50 V. |
| B. greater than 1.50 V. | D. greater than 0.34 V but less than 0.85 V. |

**Use the following redox reaction to answer questions 18 and 19.**



18. During the reaction, electrons transfer from:

- |   |   |
|---|---|
| A. $\text{Fe}^{3+}$ to $\text{Fe}^{2+}$ | C. $\text{MnO}_4^-$ to $\text{Fe}^{2+}$ |
| B. $\text{Fe}^{2+}$ to $\text{MnO}_4^-$ | D. $\text{MnO}_4^-$ to $\text{Mn}^{2+}$ |

19. The oxidizing agent in the above reaction is:

- |                     |                     |
|---------------------|---------------------|
| A. $\text{Fe}^{2+}$ | C. $\text{Mn}^{2+}$ |
| B. $\text{Fe}^{3+}$ | D. $\text{MnO}_4^-$ |

20. Electroplating **always** involves the:

- |                                     |   |
|-------------------------------------|---|
| <del>A. oxidation of anions.</del>  | <del>C. reduction at the anode.</del>   |
| <del>B. reduction of cations.</del> | <del>D. oxidation at the cathode.</del> |

21. An iron spoon is electroplated with copper. The equation representing the reduction reaction is:

- $\text{Cu}^{2+}_{(\text{aq})} + 2\text{e}^- \rightarrow \text{Cu}_{(\text{s})}$
- $\text{Cu}_{(\text{s})} \rightarrow \text{Cu}^{2+}_{(\text{aq})} + 2\text{e}^-$
- $\text{Fe}^{2+}_{(\text{aq})} + 2\text{e}^- \rightarrow \text{Fe}_{(\text{s})}$
- $\text{Fe}_{(\text{s})} \rightarrow \text{Fe}^{2+}_{(\text{aq})} + 2\text{e}^-$

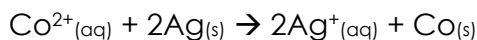
22. If a piece of nickel is to be gold-plated, which half-reaction occurs at the cathode?

- $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^-$
- $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$
- $\text{Au} \rightarrow \text{Au}^{3+} + 3\text{e}^-$
- $\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$

23. To plate a nickel coin with copper:

- |   |   |
|---|---|
| A. the nickel coin must be the cathode. | C. the electrons must flow to the anode.  |
| B. the cathode must be made of copper.  | D. the solution must contain nickel ions. |

24. Consider the following redox reaction:



The reaction is

- A. spontaneous and  $E^\circ$  is positive.                      C. non-spontaneous and  $E^\circ$  is positive.  
B. spontaneous and  $E^\circ$  is negative.                      D. non-spontaneous and  $E^\circ$  is negative.

25. Which of the following metals could be used to cathodically protect a sample of lead (ie. be used as a cathode in a spontaneous reaction)?

- A. iron \_\_\_\_\_ C. silver  
B. gold \_\_\_\_\_ D. copper

26. Consider the following overall reaction:



The  $E^\circ$  for the half reaction  $\text{Rh}^{+}_{(\text{aq})} + \text{e}^- \rightarrow \text{Rh}$  is:

- A. -0.86 V                      C. +0.60 V  
B. -0.60 V                      D. +0.86 V

27. The oxidation of iron metal can be prevented by attaching a piece of zinc to the iron because

- A. zinc oxidizes more readily than iron                      C. electrons flow from the zinc to the iron.  
B. zinc reduces more readily than iron.                      D. iron ions form more readily than zinc ions.

28. When a metal undergoes corrosion, it:

- A. loses electrons                      C. acts as an oxidizing agent  
B. becomes reduced                      D. decreases in oxidation number

29. At standard conditions,  $\text{Fe}^{2+}$  reacts spontaneously with

- A.  $\text{I}_2$                       C.  $\text{Br}^-$   
B.  $\text{Co}$                       D.  $\text{Ag}^+$

30. Which of the following half-reactions is balanced?

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

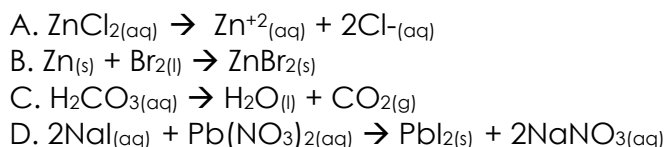
31. During a redox reaction, the oxidizing agent:

- A. reduces other species                      C. increases in oxidation number  
B. gains electrons                      D. becomes oxidized

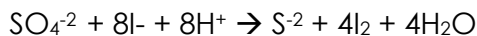
32. For a given redox reaction the oxidation # of tin changed from +2 to +4. As a result, tin:
- A. lost 2 electrons and was reduced
  - B. gained 2 electrons and was reduced
  - C. lost 2 electrons and was oxidized
  - D. gained 2 electrons and was oxidized

33. In which of the following compounds does carbon have an oxidation number of -2?
- A. CO
  - B. CO<sub>2</sub>
  - C. CH<sub>2</sub>O
  - D. CH<sub>3</sub>OH

34. Which of the following equations represents a redox reaction?



35. Consider the following reaction:



The reducing agent is

- A. I<sup>-</sup>
- B. H<sup>+</sup>
- C. S in SO<sub>4</sub><sup>2-</sup>
- D. O in SO<sub>4</sub><sup>2-</sup>

36. When MnO<sub>4</sub><sup>2-</sup> undergoes oxidation, it may form:

- A. MnO
- B. MnO<sub>4</sub><sup>-</sup>
- C. MnO<sub>3</sub>
- D. Mn<sub>2</sub>O<sub>3</sub>

37. Consider the following reaction:



In this reaction, the I<sub>2</sub> atoms undergo:

- A. oxidation only
- B. reduction only
- C. both oxidation and reduction
- D. neither oxidation nor reduction

38. In an electrochemical cell, electrons flow from the

- A. anode to the cathode through the salt bridge
- B. cathode to the anode through the salt bridge
- C. anode to cathode through the external circuit
- D. cathode to anode through the external circuit

39. In an electrochemical cell, the anode

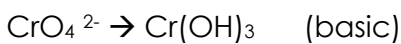
- A. is oxidized
- B. gains mass
- C. is reduced
- D. is the oxidizing agent

40. Gold is found in nature in its pure form because:

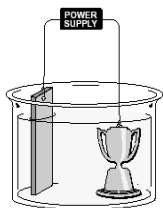
- A. It is a strong reducing agent
- B. It is a strong oxidizing agent
- C. It is a weak oxidizing agent
- D. It cannot easily bond with other elements

## II. Problems

1) Balance the following half-reaction:



2) A trophy manufacturer electroplates an iron trophy with gold.



a) Write the equation for the half-reaction that occurs at the iron trophy.

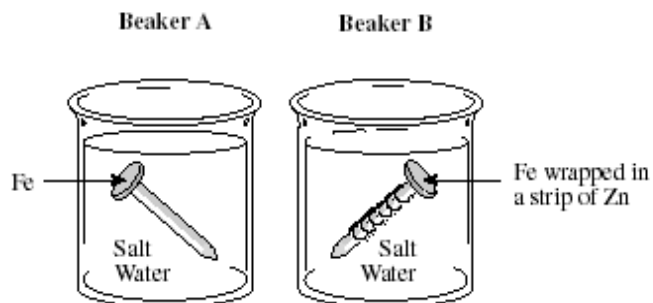
b) Identify an appropriate electrolyte.

c) Identify the cathode.

3) Balance the following redox equation:  $\text{H}_2\text{S} + \text{CrO}_4^{2-} \rightarrow \text{S}_8 + \text{Cr}^{3+}$

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

5) Consider the following diagrams:



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

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

6) In an electrochemical cell, why is it necessary to separate the anode reaction from the cathode reaction? Explain.