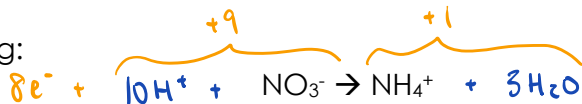


Chemistry 12 Electrochemistry Review Package

Name: *Key*
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I. Multiple Choice

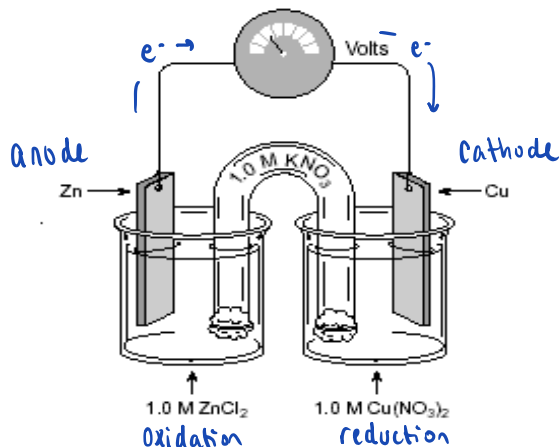
1. Consider the following:



The balanced half-reaction is

- A. $NO_3^- + 10 H^+ + 8e^- \rightarrow NH_4^+ + 2H_2O$
- B. $NO_3^- + 7 H^+ + 9e^- \rightarrow NH_4^+ + 3OH^-$
- C. $NO_3^- + 6 H^+ + 4e^- \rightarrow NH_4^+ + 3H_2O$
- D. $NO_3^- + 10 H^+ + 8e^- \rightarrow NH_4^+ + 3H_2O$

Use the following cell diagram for questions 2 and 3.



*e⁻ flow from
anode to cathode*

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

$$E^{\circ}_{total} = 0.34V + 0.76V = +1.10V$$

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.

*no
H₂O*

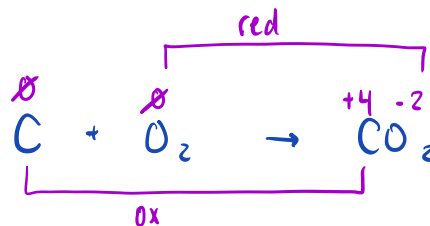
5. When molten aluminum oxide is electrolyzed, the cathode reaction is:

- A. $Al \rightarrow Al^{3+} + 3e^-$
- B. $Al^{3+} + 3e^- \rightarrow Al$
- C. $O_2 + 4e^- \rightarrow 2O^{2-}$
- D. $2O^{2-} \rightarrow O_2 + 4e^-$



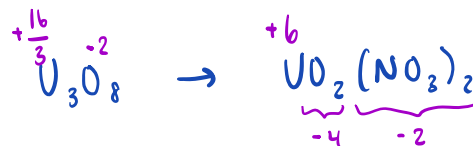
6. Which equation represents a redox reaction?

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



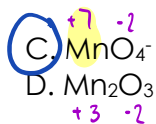
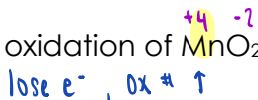
7. When U₃O₈ (pitchblende) is dissolved in nitric acid, it changes into UO₂(NO₃)₂ (uranyl nitrate). What is the change in oxidation number for uranium?

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



8. A product of the oxidation of MnO₂ is:

- A. Mn
- B. Mn²⁺
- C. MnO₄⁻
- D. Mn₂O₃



9. Consider the following:

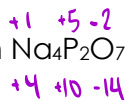


In the redox reaction above,

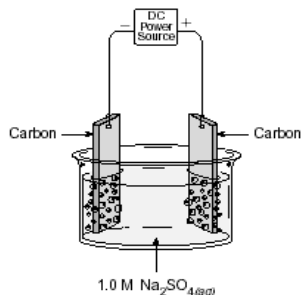
- A. hydrogen is both reduced and oxidized.
- B. manganese is both reduced and oxidized.
- C. manganese is reduced and hydrogen is oxidized.
- D. manganese is oxidized and hydrogen is reduced.

10. The oxidation number of phosphorus in Na₄P₂O₇ 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:

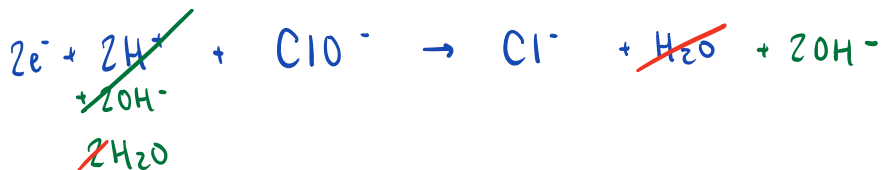
- A. $\text{Pb} + \text{Ni}^{2+} \rightarrow \text{Pb}^{2+} + \text{Ni}$
- B. $\text{Zn} + \text{Ni}^{2+} \rightarrow \text{Zn}^{2+} + \text{Ni}$
- C. $\text{Cu} + \text{Ni}^{2+} \rightarrow \text{Cu}^{2+} + \text{Ni}$
- D. $2\text{Ag} + \text{Ni}^{2+} \rightarrow 2\text{Ag}^+ + \text{Ni}$



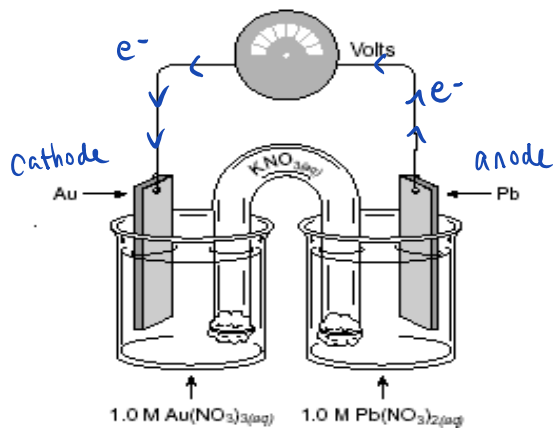
↳ RA must be lower than OA

13. In a redox reaction, ClO^- was converted to 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.



Cations (K^+) → Cathode (Au)
 Anions (NO_3^-) → anion (Pb)

14. As the cell operates:

$E^\circ = 1.50\text{V}$ $E^\circ = +0.13\text{V}$

- A. NO_3^- and K^+ will migrate toward the Pb half-cell.
- B. NO_3^- and K^+ will migrate toward the Au half-cell.
- C. NO_3^- will migrate toward the Pb half-cell and K^+ will migrate toward the Au half-cell.
- D. NO_3^- will migrate toward the Au half-cell and K^+ will migrate toward the Pb half-cell.

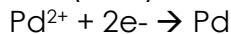
15. The initial voltage is:

- A. -1.37 V
- B. 0.00 V
- C. 1.37 V
- D. 1.63 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° (volts) of the following half-reaction:



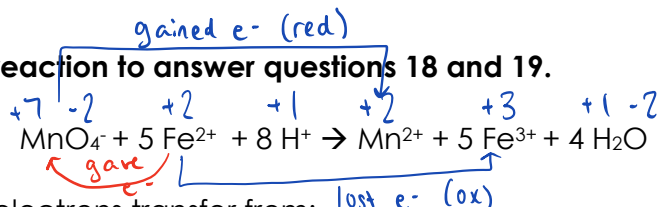
She observed the following:

1. $\text{Pd}^{2+} + \text{Cu} \rightarrow \text{Pd} + \text{Cu}^{2+}$ $E^\circ = 0.34\text{V}$
2. $\text{Pd}^{2+} + \text{Au} \rightarrow \text{no reaction}$ $E^\circ = 1.50\text{V}$
3. $\text{Pd}^{2+} + \text{Hg} \rightarrow \text{no reaction}$ $E^\circ = 0.85\text{V}$

Based on the above, the E° (volts) of a Pd half-cell is:

- A. less than 0.34 V.
- B. greater than 1.50 V.
- C. greater than 0.85 V but less 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. Fe^{3+} to Fe^{2+}
- B. Fe^{2+} to MnO_4^-
- C. MnO_4^- to Fe^{2+}
- D. MnO_4^- to Mn^{2+}

19. The oxidizing agent in the above reaction is:

- A. Fe^{2+}
- B. Fe^{3+}
- C. Mn^{2+}
- D. MnO_4^-

20. Electroplating **always** involves the:

- ~~A. oxidation of anions.~~
- ~~B. reduction of cations.~~
- ~~C. reduction at the anode.~~
- ~~D. oxidation at the cathode.~~

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

- A. $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$
- B. $\text{Cu}(\text{s}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$
- C. $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$
- D. $\text{Fe}(\text{s}) \rightarrow \text{Fe}^{2+}(\text{aq}) + 2\text{e}^-$

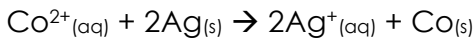
22. If a piece of nickel is to be gold-plated, which half-reaction occurs at the cathode?

- A. $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^-$
 - B. $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$
 - C. $\text{Au} \rightarrow \text{Au}^{3+} + 3\text{e}^-$
 - D. $\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$
- ↳ site of reduction

23. To plate a nickel coin with copper:

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

24. Consider the following redox reaction:



The reaction is

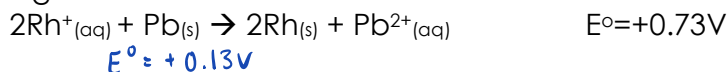
$$E^{\circ} = -0.28\text{V} \quad E^{\circ} = -0.80\text{V}$$

- A. spontaneous and E° is positive. C. non-spontaneous and E° is positive.
 B. spontaneous and E° is negative. **D. non-spontaneous and E° is negative.**

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

- A. iron _____ C. silver
 B. gold _____ D. copper

26. Consider the following overall reaction:



$$E^{\circ} = +0.13\text{V}$$

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

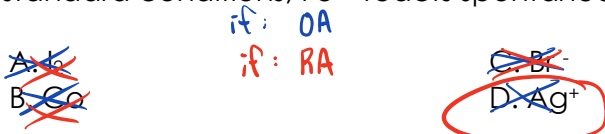
- A. zinc oxidizes more readily than iron** C. electrons flow from the zinc to the iron.
 B. zinc reduces more readily than iron. D. iron ions form more readily than zinc ions.

→ aka. oxidation

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, Fe^{2+} reacts spontaneously with



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

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

31. During a redox reaction, the oxidizing agent:

gets reduced (gains e^{-})

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

lost 2 e⁻ (oxidized)

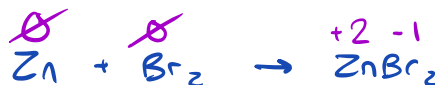
32. For a given redox reaction the oxidation # of tin changed from +2 to +4. As a result, tin:
- A. lost 2 electrons and was reduced
 - C. lost 2 electrons and was oxidized
 - B. gained 2 electrons and was reduced
 - D. gained 2 electrons and was oxidized

33. In which of the following compounds does carbon have an oxidation number of -2?

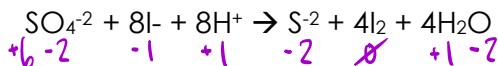
- A. CO
- B. CO₂
- C. CH₂O
- D. CH₃OH

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

- A. $\text{ZnCl}_{2(aq)} \rightarrow \text{Zn}^{2+}_{(aq)} + 2\text{Cl}^{-}_{(aq)}$
- B. $\text{Zn}_{(s)} + \text{Br}_{2(l)} \rightarrow \text{ZnBr}_{2(s)}$
- C. $\text{H}_2\text{CO}_{3(aq)} \rightarrow \text{H}_2\text{O}_{(l)} + \text{CO}_{2(g)}$
- D. $2\text{NaI}_{(aq)} + \text{Pb}(\text{NO}_3)_{2(aq)} \rightarrow \text{PbI}_{2(s)} + 2\text{NaNO}_{3(aq)}$



35. Consider the following reaction:



The reducing agent is

- A. I⁻
- B. H⁺
- C. S in SO₄²⁻
- D. O in SO₄²⁻

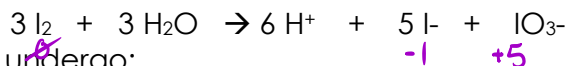
↳ gets oxidized (loses e⁻ becomes more ⊕)

36. When MnO₄²⁻ undergoes oxidation, it may form:

- A. MnO
- B. MnO₄⁻
- C. MnO₃
- D. Mn₂O₃

↳ becomes more ⊕ by losing e⁻

37. Consider the following reaction:



In this reaction, the I₂ 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

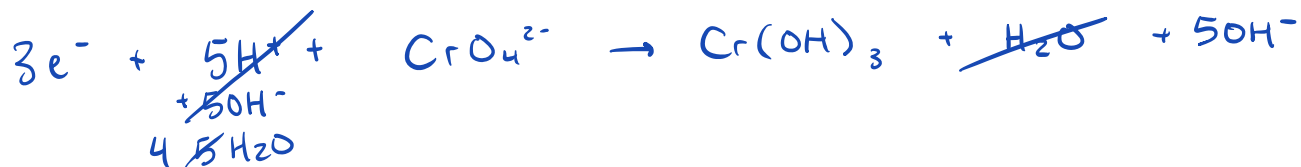
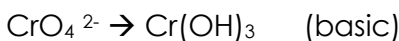
- A. is oxidized
- B. gains mass
- C. is reduced
- D. is the oxidizing agent

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

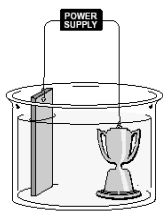
- A. It is a strong reducing agent
- B. It is a strong oxidizing agent
- C. It is a weak oxidizing agent
- D. It cannot easily bond with other elements

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.



* need Au^{3+} ions in electrolyte

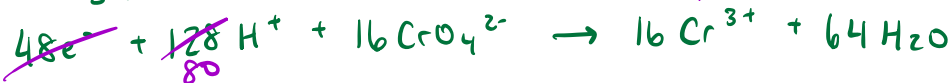
c) Identify the cathode.

Fe trophy

d) Explain how to maintain a constant metal ion concentration in the electrolyte.



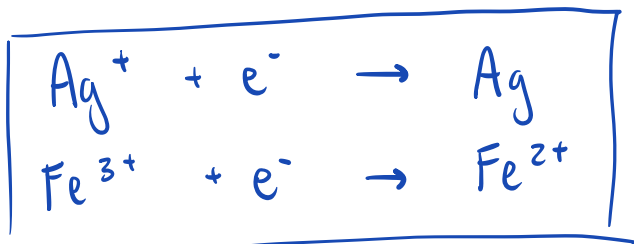
3) Balance the following redox equation: $\text{H}_2\text{S} + \text{CrO}_4^{2-} \rightarrow \text{S}_8 + \text{Cr}^{3+}$



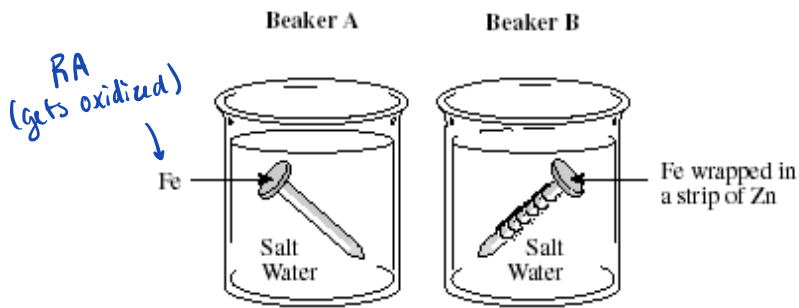
4) An excess of copper solid is dropped into a solution which contains AgNO_3 , $\text{Fe(NO}_3)_3$, and $\text{Zn(NO}_3)_2$. Write the equations for any reduction half-reactions that occur over time under standard conditions.



• OA must be higher than RA



5) Consider the following diagrams:



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

Fe will oxidize b/c it is a reducing agent (RA)

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

Zn is a stronger RA than Fe, so it will oxidize more readily.
This protects Fe from oxidizing

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

The reaction is spontaneous in an electrochemical cell. If the anode and cathode aren't separated, the electrons won't be able to travel through the wire and produce a voltage. The purpose of an electrochemical cell is to produce a voltage.