Redox Review

1. What is the oxidation state of nitrogen in the compound NH_4Br?

   A) −1   B) +2   **C) −3**   D) +4

2. Given the balanced equation representing a reaction:

   $$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

   The oxidation state of chlorine in this reaction changes from

   A) −1 to +1   B) −1 to +5
   C) +1 to −1   **D) +5 to −1**

3. During which process does an atom gain one or more electrons?

   A) transmutation   **B) reduction**
   C) oxidation   D) neutralization

4. Which half-reaction correctly represents reduction?

   A) $Mn^{4+} \rightarrow Mn^{3+} + e^-$
   B) $Mn^{4+} \rightarrow Mn^{7+} + 3e^-$
   C) $Mn^{4+} + e^- \rightarrow Mn^{3+}$
   D) $Mn^{4+} + 3e^- \rightarrow Mn^{7+}$

5. In a redox reaction, the total number of electrons lost is

   A) less than the total number of electrons gained
   B) greater than the total number of electrons gained
   C) equal to the total number of electrons gained
   D) equal to the total number of protons gained

6. Half-reactions can be written to represent all

   A) double-replacement reactions
   B) neutralization reactions
   C) fission and fusion reactions
   D) oxidation and reduction reactions

7. Which half-reaction equation represents the reduction of an iron(II) ion?

   A) $Fe^{2+} \rightarrow Fe^{3+} + e^-$
   B) $Fe^{2+} + 2e^- \rightarrow Fe$
   C) $Fe^{3+} + e^- \rightarrow Fe^{2+}$
   D) $Fe \rightarrow Fe^{2+} + 2e^-$

8. Given the balanced equation representing a reaction:

   $$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$
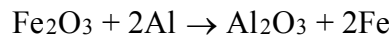
   During this reaction, the oxidation number of Fe changes from

   A) +2 to 0 as electrons are transferred
   B) +2 to 0 as protons are transferred
   C) +3 to 0 as electrons are transferred
   D) +3 to 0 as protons are transferred

9. Given the balanced equation representing a redox reaction:

   $$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$$
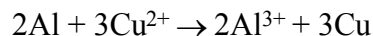
   Which statement is true about this reaction?

   A) Each Al loses $2e^-$ and each Cu^{2+} gains $3e^-$.
   B) Each Al loses $3e^-$ and each Cu^{2+} gains $2e^-$.
   C) Each Al^{3+} gains $2e^-$ and each Cu loses $3e^-$.
   D) Each Al^{3+} gains $3e^-$ and each Cu loses $2e^-$.

10. Which half-reaction correctly represents reduction?

    A) $Ag \rightarrow Ag^+ + e^-$
    B) $F_2 \rightarrow 2 F^- + 2e^-$
    C) $Au^{3+} + 3e^- \rightarrow Au$
    D) $Fe^{2+} + e^- \rightarrow Fe^{3+}$

11. Which balanced equation represents a redox reaction?

    A) $AgNO_3(aq) + NaCI(aq) \rightarrow AgCI(s) + NaNO_3(aq)$
    B) $H_2CO_3(aq) \rightarrow H_2O(\ell) + CO_2(g)$
    C) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(\ell)$
    D) $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

12. Which equation represents an oxidation-reduction reaction?

A) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
B) $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$
C) $MgCrO_4 + BaCl_2 ® MgCl_2 + BaCrO_4$
D) $Zn(NO_3)_2 + Na_2CO_3 \rightarrow 2NaNO_3 + ZnCO_3$
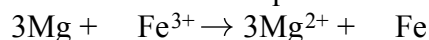
13. Which metal is more active than H_2?

A) Ag   B) Au   C) Cu   **D) Pb**

14. Which reaction occurs spontaneously?

A) $Cl_2(g) + 2NaBr(aq) \rightarrow Br_2(\ell) + 2NaCl(aq)$
B) $Cl_2(g) + 2NaF(aq) \rightarrow F_2(g) + 2NaCl(aq)$
C) $I_2(s) + 2NaBr(aq) \rightarrow Br_2(\ell) + 2NaI(aq)$
D) $I_2(s) + 2NaF(aq) \rightarrow F_2(g) + 2NaI(aq)$

15. Given the unbalanced ionic equation:
$$3Mg + \underline{\quad}Fe^{3+} \rightarrow 3Mg^{2+} + \underline{\quad}Fe$$
When this equation is balanced, both Fe^{3+} and Fe have a coefficient of

A) 1, because a total of 6 electrons is transferred
B) 2, because a total of 6 electrons is transferred
C) 1, because a total of 3 electrons is transferred
D) 2, because a total of 3 electrons is transferred

16. Which half-reaction shows conservation of charge?

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

17. Given the balanced equation representing a reaction:

$$2Fe + 3Cu^{2+} \rightarrow 2Fe^{3+} + 3Cu$$
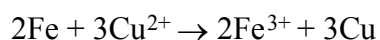
When the iron atoms lose six moles of electrons, how many moles of electrons are gained by the copper ions?

A) 12 moles   B) 2 moles
C) 3 moles   **D) 6 moles**

18. A voltaic cell spontaneously converts chemical energy to

A) electrical energy
B) geothermal energy
C) mechanical energy
D) nuclear energy

19. In a voltaic cell, chemical energy is converted to

A) electrical energy, spontaneously
B) electrical energy, non-spontaneously
C) nuclear energy, spontaneously
D) nuclear energy, non-spontaneously

20. Which half-reaction can occur at the anode in a voltaic cell?

A) $Ni^{2+} + 2e^- \rightarrow Ni$
B) $Sn + 2e^- \rightarrow Sn^{2+}$
C) $Zn \rightarrow Zn^{2+} + 2e^-$
D) $Fe^{3+} \rightarrow Fe^{2+} + e^-$

21. Given the balanced ionic equation representing the reaction in an operating voltaic cell:
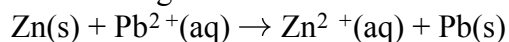
$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$
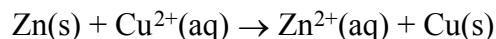
The flow of electrons through the external circuit in this cell is from the

A) Cu anode to the Zn cathode
B) Cu cathode to the Zn anode
C) Zn anode to the Cu cathode
D) Zn cathode to the Cu anode

22. Reduction occurs at the cathode in

A) electrolytic cells, only
B) voltaic cells, only
C) both electrolytic cells and voltaic cells
D) neither electrolytic cells nor voltaic cells

23. Given the balanced equation representing the reaction occurring in a voltaic cell:
$$Zn(s) + Pb^{2+}(aq) \rightarrow Zn^{2+}(aq) + Pb(s)$$
In the completed external circuit, the electrons flow from

A) Pb(s) to Zn(s)
B) $Pb^{2+}(aq)$ to $Zn^{2+}(aq)$
C) Zn(s) to Pb(s)
D) $Zn^{2+}(aq)$ to $Pb^{2+}(aq)$

24. Which statement is true about oxidation and reduction in an electrochemical cell?

A) Both occur at the anode.
B) Both occur at the cathode.
C) Oxidation occurs at the anode and reduction occurs at the cathode.
D) Oxidation occurs at the cathode and reduction occurs at the anode.

25. Which statement describes one characteristic of an operating electrolytic cell?

A) It produces electrical energy.
B) It requires an external energy source.
C) It uses radioactive nuclides.
D) It undergoes a spontaneous redox reaction.

26. The diagram below represents an operating electrochemical cell and the balanced ionic equation for the reaction occurring in the cell.


$$Zn(s) + Ni^{2+}(aq) \rightarrow Zn^{2+}(aq) + Ni(s)$$
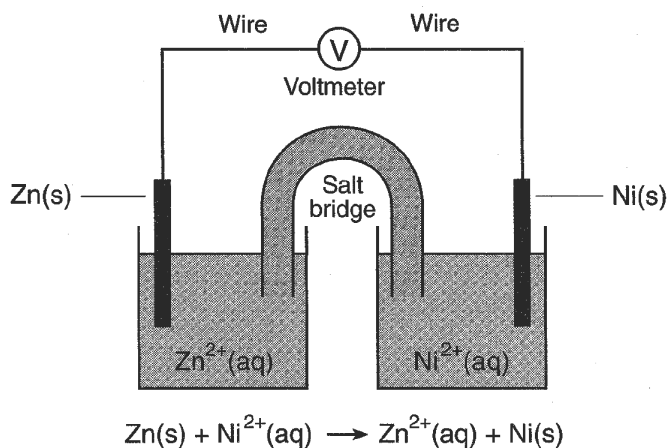
Which statement identifies the part of the cell that conducts electrons and describes the direction of electron flow as the cell operates?

A) Electrons flow through the salt bridge from the Ni(s) to the Zn(s).
B) Electrons flow through the salt bridge from the Zn(s) to the Ni(s).
C) Electrons flow through the wire from the Ni(s) to the Zn(s).
D) Electrons flow through the wire from the Zn(s) to the Ni(s).

27. Which statement describes electrolysis?

A) Chemical energy is used to produce an electrical change.
B) Chemical energy is used to produce a thermal change.
C) Electrical energy is used to produce a chemical change.
D) Thermal energy is used to produce a chemical change.

28. Given the balanced equation representing a reaction occurring in an electrolytic cell:

$$2NaCl(\ell) \rightarrow 2Na(\ell) + Cl_2(g)$$

Where is $Na(\ell)$ produced in the cell?

A) at the anode, where oxidation occurs
B) at the anode, where reduction occurs
C) at the cathode, where oxidation occurs
D) at the cathode, where reduction occurs

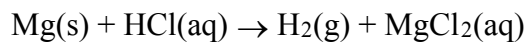Base your answers to questions **29** through **31** on the information below.

The diagram below represents an operating voltaic cell at 298 K and 1.0 atmosphere in a laboratory investigation. The reaction occurring in the cell is represented by the balanced ionic equation below.

$$2Ag^+(aq) + Ni(s) \longrightarrow 2Ag(s) + Ni^{2+}(aq)$$
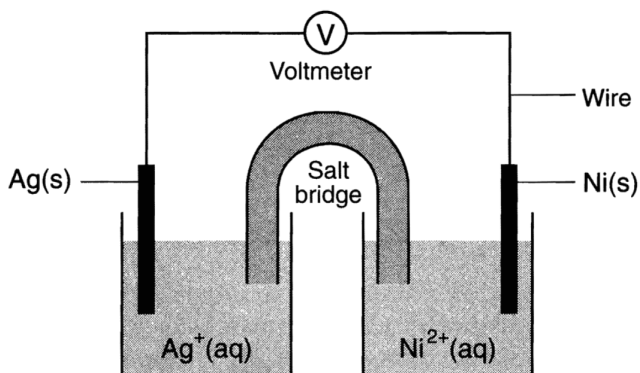
29. Determine the total number of moles of $Ni^{2+}(aq)$ ions produced when 4.0 moles of $Ag^+(aq)$ ions completely react in this cell

30. Identify the anode in this cell.

31. Write a balanced half-reaction equation for the reduction that occurs in this cell.

32. Base your answer to the following question on the information below.
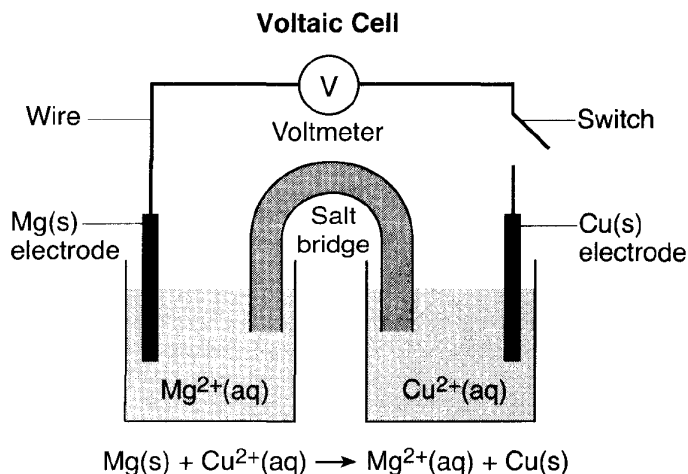
In a laboratory investigation, magnesium reacts with hydrochloric acid to produce hydrogen gas and magnesium chloride. This reaction is represented by the unbalanced equation below.

$$Mg(s) + HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$$

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

Base your answers to questions **33** through **35** on the information below.

A voltaic cell with magnesium and copper electrodes is shown in the diagram below. The copper electrode has a mass of 15.0 grams.

Voltaic Cell

Wire — Voltmeter V — Switch

Mg(s) electrode — Salt bridge — Cu(s) electrode

$Mg^{2+}(aq)$ $Cu^{2+}(aq)$

$Mg(s) + Cu^{2+}(aq) \longrightarrow Mg^{2+}(aq) + Cu(s)$

When the switch is closed, the reaction in the cell begins. The balanced ionic equation for the reaction in the cell is shown below the cell diagram. After several hours, the copper electrode is removed, rinsed with water, and dried. At this time, the mass of the copper electrode is greater than 15.0 grams.

33. State the purpose of the salt bridge in this cell.

34. State the directions of electron flow through the wire between the electrodes when the switch is closed.

35. Explain, in terms of copper ions and copper atoms, why the mass of the copper electrode increases as the cell operates. Your response must include information about *both* copper ions and copper atoms.

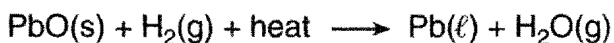36. Base your answer to the following question on the information below.
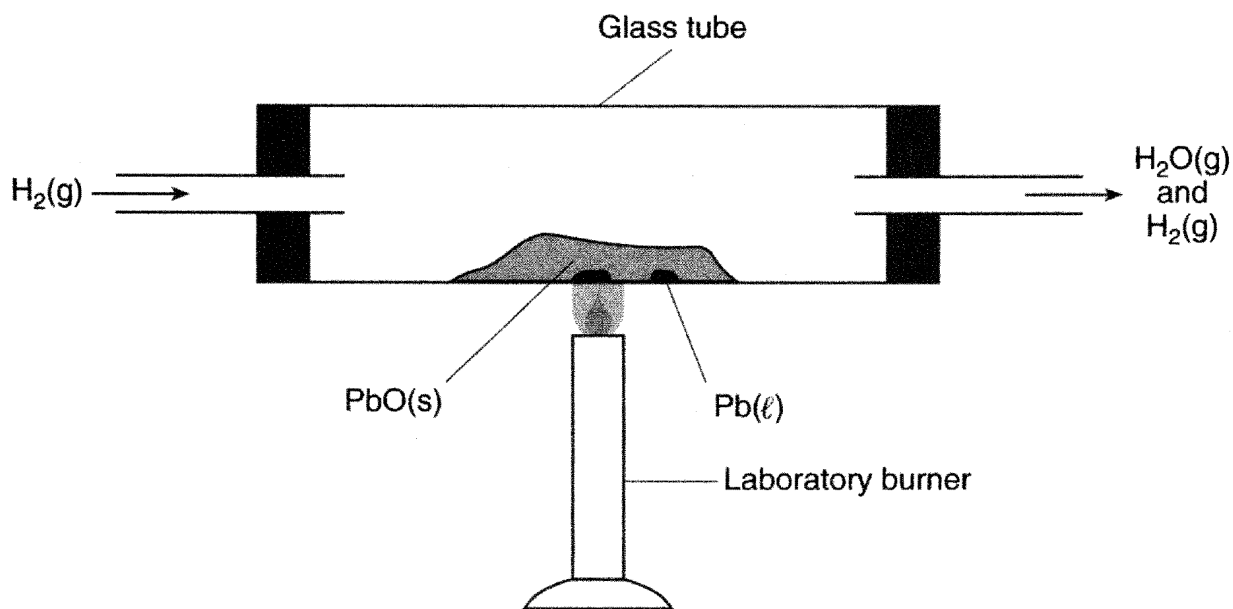
Electroplating is an electrolytic process used to coat metal objects with a more expensive and less reactive metal. The diagram below shows an electroplating cell that includes a battery connected to a silver bar and a metal spoon. The bar and spoon are submerged in $AgNO_3(aq)$.

An Electroplating Cell
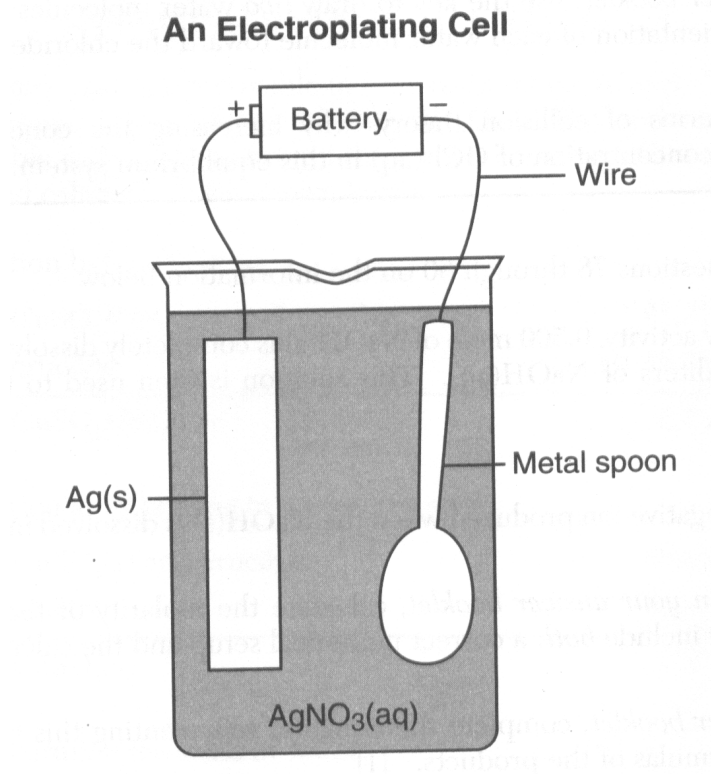
Explain the purpose of the battery in this cell.

Base your answers to questions **37** through **40** on
the information below and on your knowledge of chemistry.

In a laboratory apparatus, a sample of lead(II) oxide reacts with hydrogen gas at high
temperature. The products of t his reaction are liquid lead and water vapor. As the reaction
proceeds, water vapor and excess hydrogen gas leave the glass tube. The diagram and balanced
equation below represent this reaction.

Glass tube

$H_2(g) \longrightarrow$

$H_2O(g)$
and
$H_2(g)$

PbO(s)

Pb(ℓ)

Laboratory burner

$$PbO(s) + H_2(g) + heat \longrightarrow Pb(\ell) + H_2O(g)$$

37. State *one* change in reaction conditions, other than adding a catalyst, that would cause the rate of this
reaction to increase.

38. E xplain why the reaction that occurs in this glass tube can *not* reach equilibrium.

39. Write a balanced half-reaction equation for the reduction of the Pb^{2+} ions in this reaction.

40. Determine the change in oxidation number for the hydrogen that reacts.

Base your answers to questions **41** and **42** on the information below.

Underground iron pipes in contact with moist soil are likely to corrode. This corrosion can be prevented by applying the principles of electrochemistry. Connecting an iron pipe to a magnesium block with a wire creates an electrochemical cell. The magnesium block acts as the anode and the iron pipe acts as the cathode. A diagram of this system is shown below.

**Cross-Sectional View of
Underground Pipe Protection System**
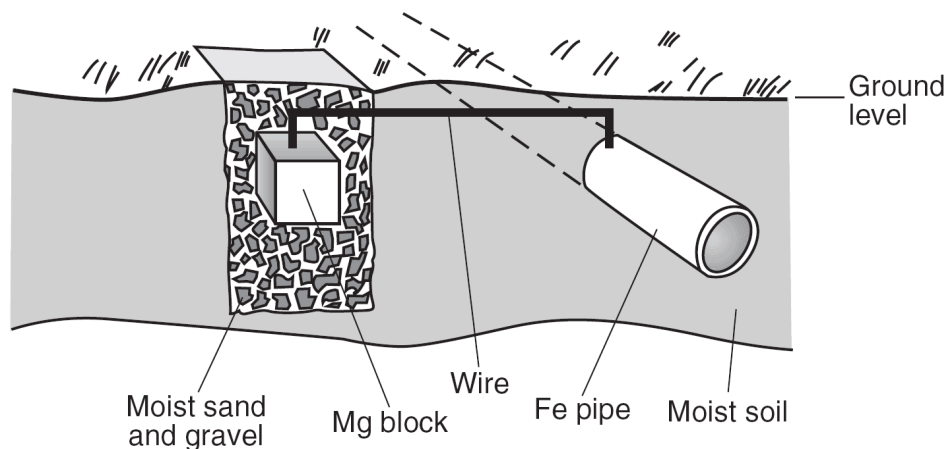
41. Explain, in terms of reactivity, why magnesium is preferred over zinc to protect underground iron pipes. Your response must include *both* magnesium and zinc.

42. State the direction of the flow of electrons between the electrodes in this cell.

Answer Key
Redox Review

1. __C__
2. __D__
3. __B__
4. __C__
5. __C__
6. __D__
7. __B__
8. __C__
9. __B__
10. __C__
11. __D__
12. __A__
13. __D__
14. __A__
15. __B__
16. __B__
17. __D__
18. __A__
19. __A__
20. __C__
21. __C__
22. __C__
23. __C__
24. __C__
25. __B__
26. __D__
27. __C__
28. __D__
29. 2.0 mol.
30. –Ni(s) *or* –the nickle electrode
31. $Ag^+ + e^- \rightarrow Ag$ *or* $2Ag^+ + 2e^- \rightarrow 2Ag$

32. $Mg \rightarrow Mg^{2+} + 2e^-$
33. The salt bridge allows ions to flow between the half-cells; Preventing polarization.
34. The electrons flow from the Mg electrode to the Cu electrode; From anode to cathode.
35. copper ions from the solution are reduced to copper atoms at the electrode, increasing the mass of the electrode; Copper ions become copper atoms; The number of copper ions decreases, and the number of copper atoms increases.
36. A battery is part of the cell and is providing energy that causes the reaction. • Electricity is used to operate the cell.

37. –Increase the temperature. –Increase the concentration of the hydrogen gas in the tube. –Grind the metal oxide to increase its surface area.
38. – The glass tube is not a closed system. –Gases are entering and leaving the system. –The reaction is *not* reversible under these conditions.
39. $Pb^{2+} + 2e^- \rightarrow Pb$
40. – From 0 to +1 –From zero to one
41. *Examples:* – Magnesium atoms lose electrons more easily than zinc atoms. – Mg oxidizes more readily than Zn. – Mg is more active than Zn.
42. *Examples:* – Electrons flow from the magnesium block to the iron pipe. – Electrons flow from the Mg to the Fe through the wire. – Electrons flow from the anode to the cathode in a voltaic cell. – from the block to the pipe