Name:

Unit Review: Red-Ox

Base your answers to questions 1 and 2 on the information below.

Litharge, PbO, is an ore that can be roasted (heated) in the presence of carbon monoxide, CO, to produce elemental lead. The reaction that takes place during this roasting process is represented by the balanced equation below.

$$PbO(s) + CO(g) \rightarrow Pb(\ell) + CO_2(g)$$

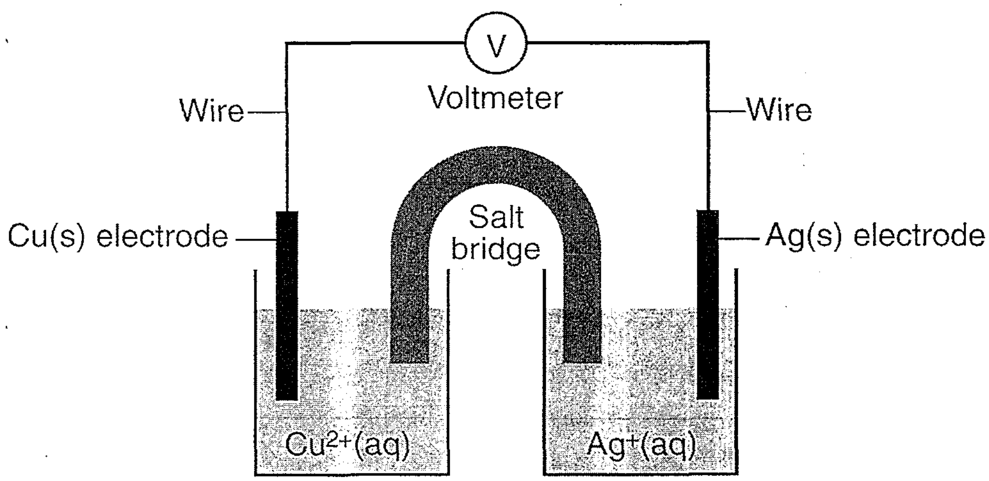
1. Determine the oxidation number of carbon in carbon monoxide.

2. Write the balanced equation for the reduction half-reaction that occurs during this roasting process.

Base your answers to questions 3 and 4 on the information below.

The diagram and balanced ionic equation below represent a voltaic cell with copper and silver electrodes and the reaction that occurs when the cell is operating.

Voltaic Cell



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

3. State the purpose of the salt bridge in this voltaic cell.

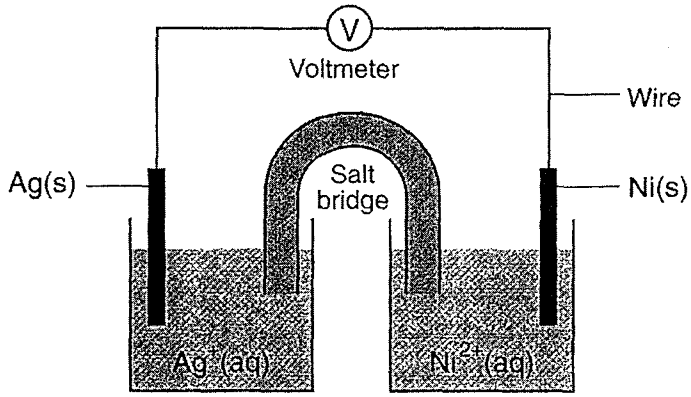
4. Describe the direction of electron flow in the external circuit in this operating cell.

---

5. Explain, in terms of activity, why HCl(aq) reacts with Zn(s), but HCl(aq) does *not* react with Cu(s).

Base your answers to questions 6 through 8 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.



$$2Ag^+(aq) + Ni(s) \longrightarrow 2Ag(s) + Ni^{2+}(aq)$$

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

7. 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

8. Identify the anode in this cell.

---

40. Na: +1
Al: +3
F: -1

39. $Al^{3+} + 3e^- \rightarrow Al$

38. *Examples:* - A voltaic cell produces electrical energy and an electrolytic cell used in the Hall process requires electrical energy - Electrolysis uses electrical energy. Voltaic cells produce electrical energy.

37. __Mg(s) + 2HCl(aq) __$MgCl_2$(aq) + __H_2(g).

36. Examples: - The reaction is single replacement. - single displacement -redox

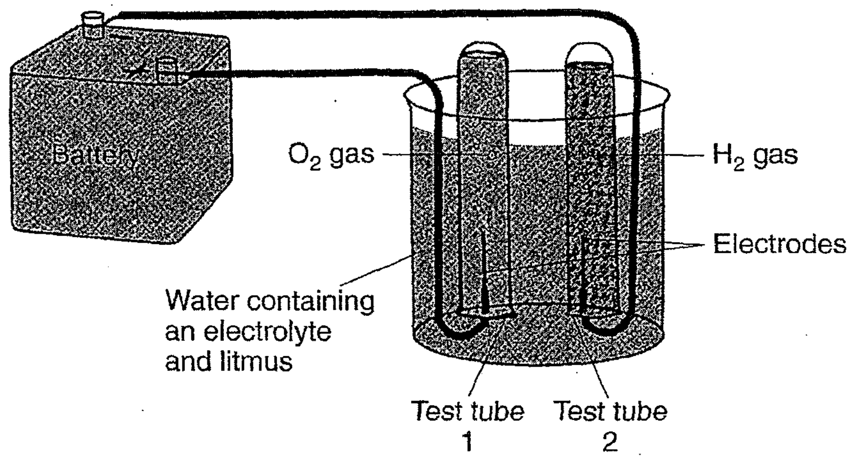
35. Examples: 2.50g × 1 mol/24.3 g *or* 2.50/24

34. Examples: - Ag is below H_2 in the activity series. - Ag is more difficult to oxidize.

33. --Aluminum atoms are losing electrons and becoming aluminum ions that are entering the solution.

Base your answers to questions 9 and 10 on the information below.

The diagram below shows a system in which water is being decomposed into oxygen gas and hydrogen gas. Litmus is used as an indicator in the water. The litmus turns red in test tube 1 and blue in test tube 2.



The oxidation and reduction occurring in the test tubes are represented by the balanced equations below.

Test tube 1: $2H_2O(\ell) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

Test tube 2: $4H_2O(\ell) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$

9. Determine the change in oxidation number of oxygen during the reaction in test tube 1.

10. Identify the information in the diagram that indicates this system is an electrolytic cell.

11. Identify *one* ion from Table *F* that can combine with $Pb^{2+}(aq)$ to produce an insoluble compound.

12. What is the oxidation number of nitrogen in NO(g)?

13. Base your answer to the following question on the information below.

    During a laboratory activity, a student reacted a piece of zinc with 0.1 M HCl(aq).

    Based on Reference Table *J*, identify *one* metal that does *not* react spontaneously with HCl(aq).

14. Because tap water is slightly acidic, water pipes made of iron corrode over time, as shown by the balanced ionic equation below:

    $$2Fe + 6H^+ \rightarrow 2Fe^{3+} + 3H_2$$

    Explain, in terms of chemical reactivity, why copper pipes are *less* likely to corrode than iron pipes.

Base your answers to questions **15** and **16** 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.

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

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

16. Balance the equation below, using the smallest whole-number coefficients.

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

Base your answers to questions **17** through **20** on the information below.

In a laboratory investigation, a student constructs a voltaic cell with iron and copper electrodes. Another student constructs a voltaic cell with zinc and iron electrodes. Testing the cells during operation enables the students to write the balanced ionic equations below.

Cell with iron and copper electrodes: $Cu^{2+}(aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+}(aq)$

Cell with zinc and iron electrodes: $Fe^{2+}(aq) + Zn(s) \rightarrow Fe(s) + Zn^{2+}(aq)$

17. State the relative activity of the three metals used in these two voltaic cells.

18. Write a balanced half-reaction equation for the reduction that takes place in the cell with zinc and iron electrodes.

19. Identify the particles transferred between Fe^{2+} and Zn during the reaction in the cell with zinc and iron electrodes.

20. State evidence from the balanced equation for the cell with iron and copper electrodes that indicates the reaction in the cell is an oxidation-reduction reaction.

---

41. Examples: – ions – charged particles – H_3O^+ - SO_4^{2-}

42. electrolytic or electrolysis

43. • $Na^+ + e^- \rightarrow Na$ or $2Na^+ + 2e^- \rightarrow 2Na$

44. • Electrolytic cells require energy. • The battery forces the non-spontaneous reaction to occur.

45. • negative electrode • cathode • the one on the right

46. The salt bridge allows ions to flow between the half-cells.

47. 12 mol

48. from anode to cathode *or* Zn electrode to Pb electrode *or* to the left *or* from half-cell 2 to half-cell 1 *or* – to +

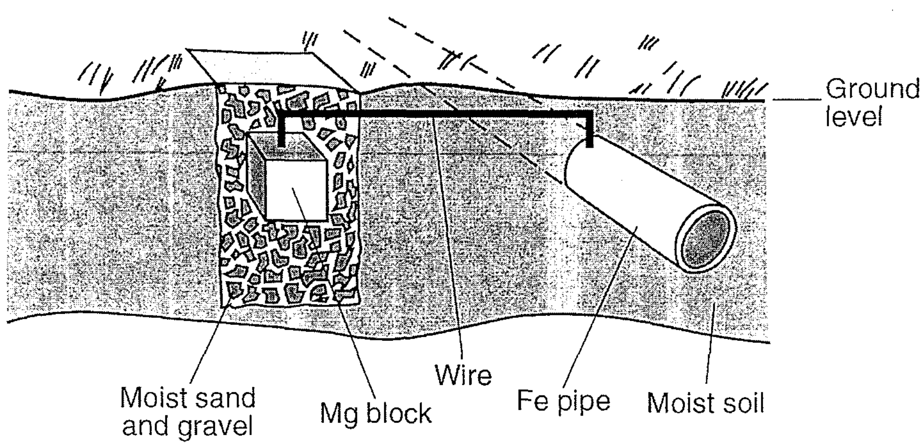
49. $Pb^{2+} + 2e^- \rightarrow Pb$

50. 2 *or* Zn *or* anode *or* right

Base your answers to questions 21 and 22 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



21. Explain, in terms of reactivity, why magnesium is preferred over zinc to protect underground iron pipes. Your response must include *both* magnesium and zinc.

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

Base your answers to questions 23 and 24 on the following information.

A flashlight can be powered by a rechargeable nickel-cadmium battery. In the battery, the anode is Cd(s) and the cathode is NiO_2(s). The unbalanced equation below represents the reaction that occurs as the battery produces electricity When a nickel-cadmium battery is recharged, the reverse reaction occurs.

$$Cd(s) + NiO_2(s) + H_2O(\ell) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$$

23. Explain why Cd would be above Ni if placed on Table J.

24. Determine the change in oxidation number for the element that makes up the anode in the reaction that produces electricity

---

25. Base your answer to the following question on the information below.

"Hand Blasters" is a toy that consists of a set of two ceramic balls, each coated with a mixture of sulfur and potassium chlorate, $KClO_3$. When the two balls are struck together, a loud popping noise is produced as sulfur and potassium chlorate react with each other.

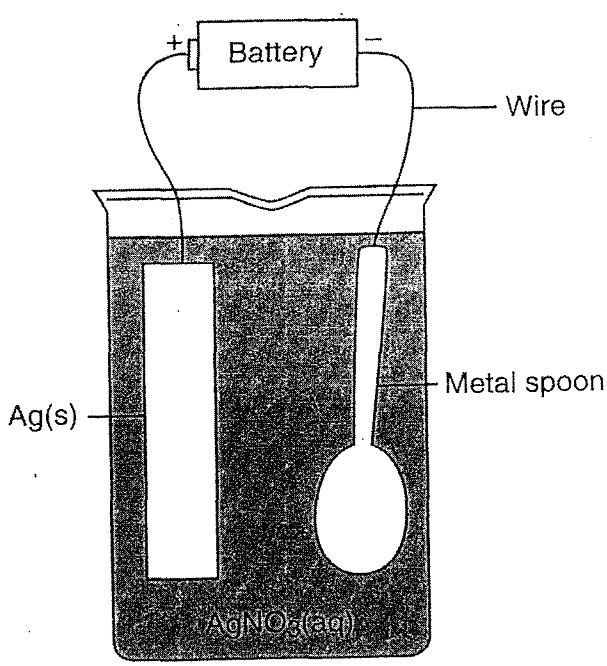
Balance the equation below for the "Hand Blaster" reaction, using the smallest whole-number coefficients.

_____ S(s) + _____ $KClO_3$(s) → _____ SO_2(g) + _____ KCl(s) + energy

Base your answers to questions 26 and 27 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



26. Explain the purpose of the battery in this cell.

27. Explain why $AgNO_3$ is a better choice than AgCl for use in this electrolytic process.

____

Base your answers to questions 28 and 29 on the information below.

The outer structure of the Statue of Liberty is made of copper metal. The framework is made of iron. Over time, a thin green layer (patina) forms on the copper surface.

28. Where the iron framework came in contact with the copper surface, a reaction occurred in which iron was oxidized. Using information from Reference Table *J*, explain why the iron was oxidized.

29. When copper oxidized to form this patina layer, the copper atoms became copper(II) ions (Cu^{2+}). Write a balanced half-reaction for this oxidation of copper.

____

Base your answers to questions 30 and 31 on the information below

The unbalanced equation below represents the decomposition of potassium chlorate.

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

30. Determine the oxidation number of chlorine in the reactant.

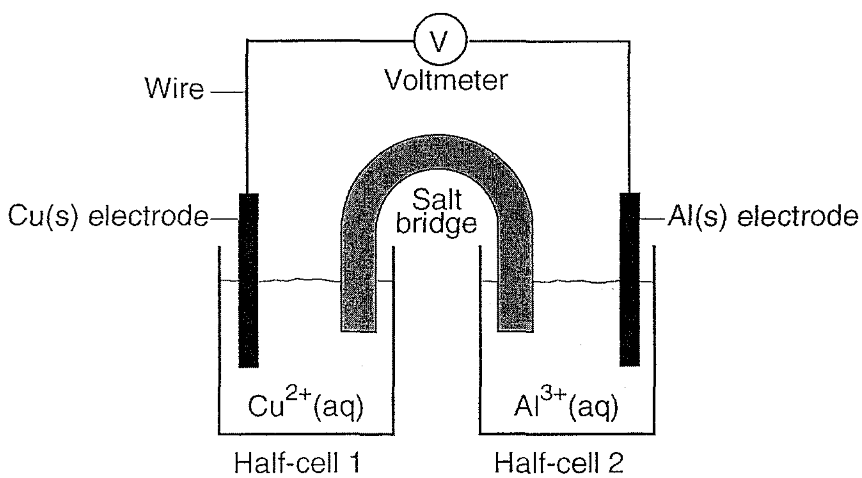
31. Balance the equation *below*, using the smallest whole-number coefficients.

__________$KClO_3(s) \rightarrow$ __________$KCl(s) +$ __________$O_2(g)$

Base your answers to questions 32 and 33 on the diagram below.

The diagram shows a voltaic cell with copper and aluminum electrodes immediately after the external circuit is completed.

Voltaic Cell

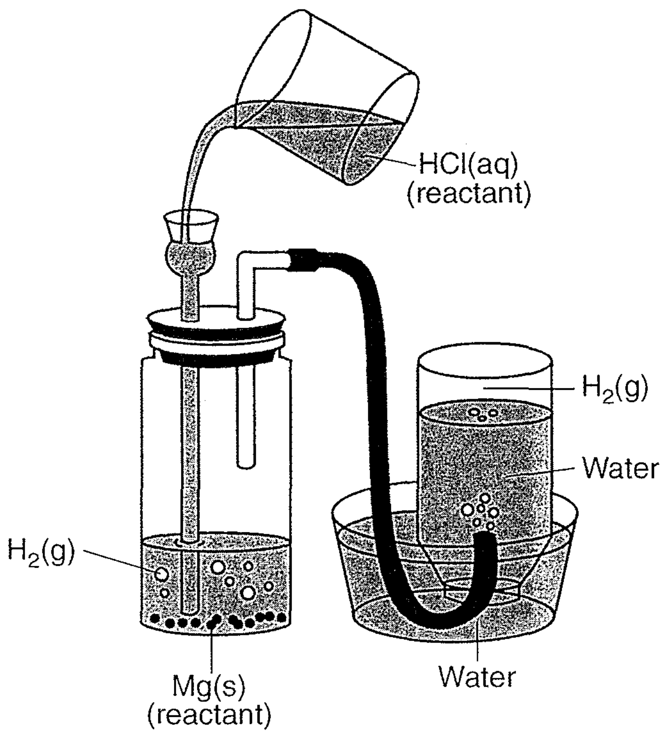


32. Explain the function of the salt bridge.

33. As this voltaic cell operates, the mass of the Al(s) electrode decreases. Explain, in terms of particles, why this decrease in mass occurs.

Base your answers to questions 34 through 37 on the information below.

A student places a 2.50-gram sample of magnesium metal in a bottle and fits the bottle with a 2-hole stopper as shown in the diagram. Hydrochloric acid is added to the bottle, causing a reaction. As the reaction proceeds, hydrogen gas travels through the tubing to an inverted bottle filled with water, displacing some of the water in the bottle.



34. Based on Reference Table *J*, explain why Ag(s) will *not* react with HCl (aq) to generate H_2(g).

35. Show a correct numerical setup for calculating the number of moles of magnesium used in the experiment.

36. Identify the type of chemical reaction that occurs when magnesium reacts with hydrochloric acid.

37. Balance the equation for the reaction of magnesium and hydrochloric acid, using the smallest whole-number coefficients.

Base your answers to questions **38** through **40** on the information below.

Aluminum is one of the most abundant metals in Earth's crust. The aluminum compound found in bauxite ore is Al_2O_3. Over one hundred years ago, it was difficult and expensive to isolate aluminum from bauxite ore. In 1886, a brother and sister team, Charles and Julia Hall, found that molten (melted) cryolite, Na_3AlF_6, would dissolve bauxite ore. Electrolysis pf the resulting mixture caused the aluminum ions in the Al_2O_3 to be reduced to molten aluminum metal. This less expensive process is known as the Hall process.

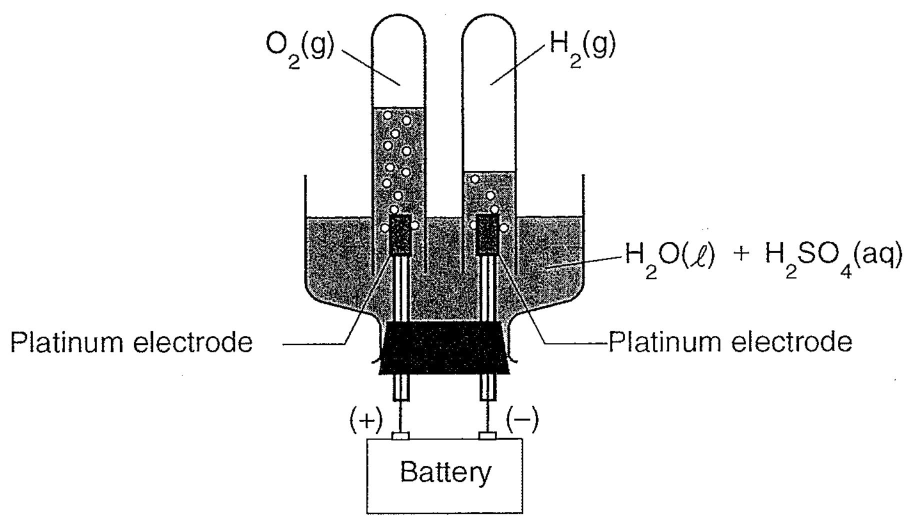
38. Explain, in terms of electrical energy, how the operation of a voltaic cell differs from the operation of an electrolytic cell used in the Hall process. Include *both* the voltaic cell and the electrolytic cell in your answer

39. Write the balanced half-reaction equation for the reduction of Al^{3+} to Al.

40. Write the oxidation state for *each* of the elements in cryolite.

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

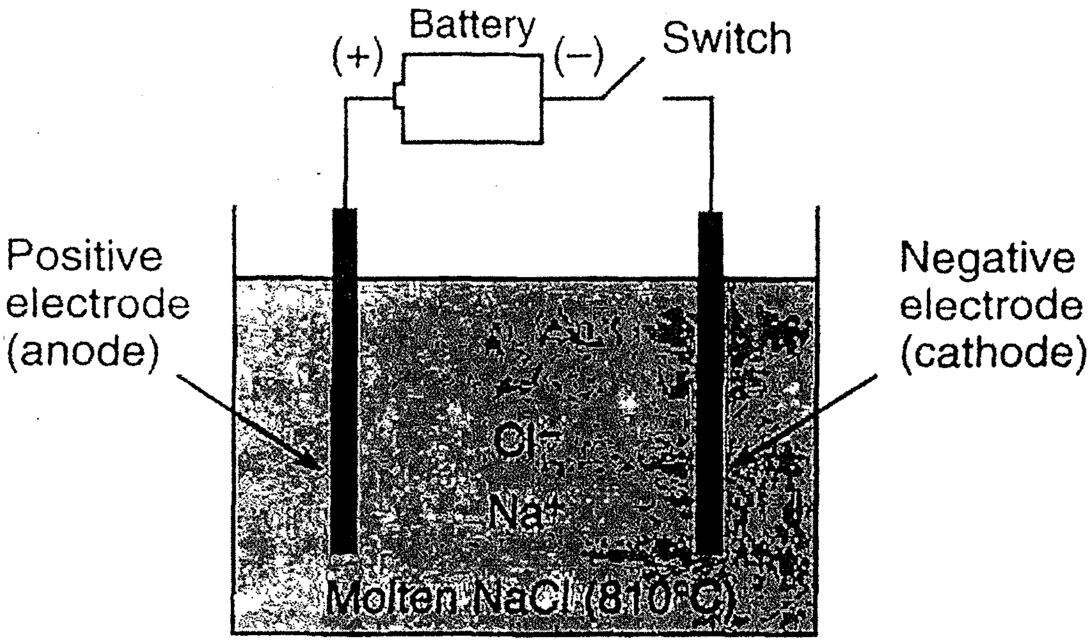
The apparatus shown in the diagram consists of two inert platinum electrodes immersed in water. A small amount of an electrolyte, H_2SO_4, must be added to the water for the reaction to take place. The electrodes are connected to a source that supplies electricity.



41. What particles are provided by the electrolyte that allow an electric current to flow?

42. What type of electrochemical cell is shown?

Base your answers to questions 43 through 45 on the diagram and balanced equation below, which represent the electrolysis of molten NaCl.



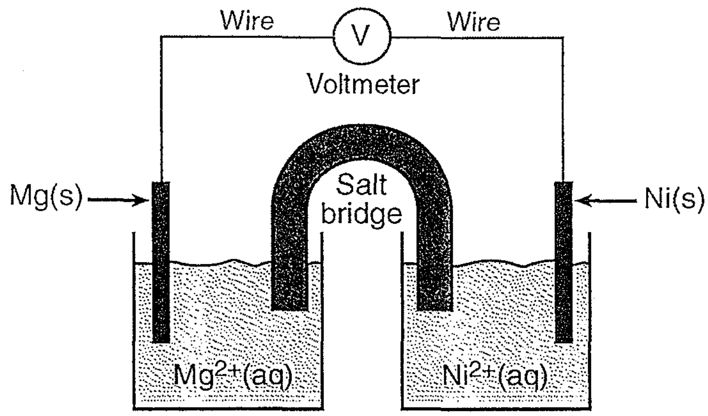
$$2NaCl \rightarrow Cl_2 + 2Na$$

43. Write the balanced half-reaction for the reduction that occurs in this electrolytic cell.

44. What is the purpose of the battery in this electrolytic cell?

45. When the switch is closed, which electrode will attract the sodium ions?

Base your answers to questions 46 and 47 on the diagram of a voltaic cell and the balanced ionic equation below.

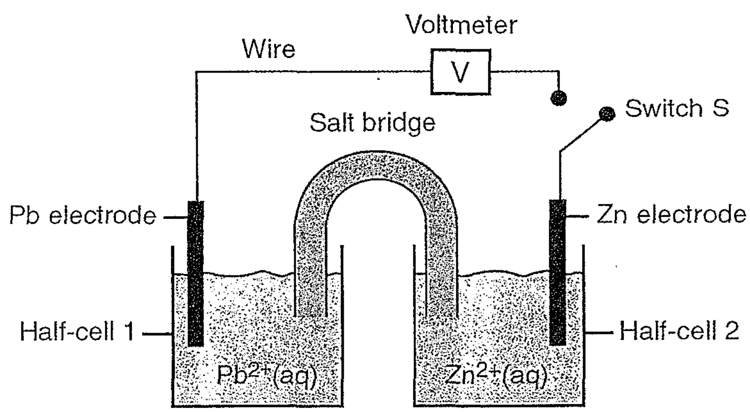


$$Mg(s) + Ni^{2+}(aq) \rightarrow Mg^{2+}(aq) + Ni(s)$$

46. Explain the function of the salt bridge in the voltaic cell.

47. What is the total number of moles of electrons needed to completely reduce 6.0 moles of $Ni^{2+}(aq)$ ions?

Base your answers to questions 48 through 50 on the diagram below, which represents a voltaic cell at 298 K and 1 atm.



$$Pb^{2+}(aq) + Zn \rightarrow Pb + Zn^{2+}(aq)$$

48. Describe the direction of electron flow between the electrodes when switch *S* is closed.

49. Write the balanced half-reaction equation that will occur in half-cell 1 when switch *S* is closed.

50. In which half-cell will oxidation occur when switch *S* is closed?

Answer Key
[New Exam]

1. +2.

2. Acceptable responses include, but are not limited to: • $Pb^{2+} + 2e^{-} \rightarrow Pb$

3. Acceptable responses include, but are not limited to: • The salt bridge allows for the migration of ions between the half-cells. • The salt bridge prevents polarization of the half-cells maintains electrical neutrality

4. Acceptable responses include, but are not limited to: • Electrons flow from the copper electrode to the silver electrode through the wires and voltmeter. • The e^{-} flow is from Cu to Ag in the external circuit from anode to cathode

5. Acceptable responses include, but are not limited to: • Zinc is more active than hydrogen, but copper is less active than hydrogen. • On Table *J*, Zn is above H_2, and Cu is below H_2.

6. $Ag^{+} + e^{-} \rightarrow Ag$ Cd is more reactive than Ni $2Ag^{+} + 2e^{-} \rightarrow 2Ag$

7. 2.0 mol.

8. –Ni(s) *or* –the nickle electrode

9. –2 to 0

10. • A battery is part of the cell and is providing energy that causes the reaction. • Electricity is used to operate the cell.

11. *Examples:* Cl^{-}, sulfate,carbonate ion, any halide, sulfide, OH^{-}, CrO_4^{2-}, PO_4^{3-}

12. +2

13. *Examples:* -Cu -Ag -gold

14. Examples: – Copper is less reactive than iron – Cu below H_2 on Table *J*

15. $Mg \rightarrow Mg^{2+} + 2e^{-}$

16. ____ Mg(s) + __2__ HCl(aq) → ____ H_2(g) + ____ $MgCl_2$(aq).

17. Examples: Zinc is more reactive than iron, and iron is more reactive than copper.; The order of decreasing activity is Zn, Fe, Cu.; Copper is least active and zinc is most active.

18. Example: $Fe^{2+} + 2e^{-} \rightarrow Fe$

19. Examples: electrons; e^{-}

20. Examples: The oxidation number of Cu^{2+} changes to 0.; Iron's oxidation state changes from zero to +2.; Oxidation numbers change during the reaction because electrons are transferred.

21. *Examples:* – Magnesium atoms lose electrons more easily than zinc atoms. – Mg oxidizes more readily than Zn. – Mg is more active than Zn.

22. *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

23. *Examples:* – Cadmium oxidizes in the presence of Ni

24. 0 to +2

25. __3__ S(s) + __2__ $KClO_3$(s) → __3__ SO_2(g) + __2__ KCl(

26. *Examples:* – The battery provides the electrical energy necessary for the reaction to occur.

27. *Examples:* – Silver nitrate produces more ions than silver chloride in water. – $AgNO_3$ readily dissolves in H_2O; AgCl dissolves only slightly in H_2O.

28. Responses include, but are not limited to, these examples: Iron is a more active metal • Fe above Cu • Iron metal loses electrons more easily than copper metal • copper less active

29. Responses include, but are not limited to, these examples: $Cu \rightarrow Cu^{2+} + 2e^{-}$ • $Cu - 2e^{-} \rightarrow Cu^{2+}$

30. +5

31. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

32. *Examples:* --It allows migration of ions. --maintains neutrality --prevents polarization