1. What is the oxidati on number of chromium in the chrom ate ion, CrO_4^{2-} ?
   - A. +6
   - C. +3
   - B. +2
   - D. +8

2. What is the oxidation number assigned to manganese in $KMnO_4$?
   - A. +7
   - C. +3
   - B. +2
   - D. +4

3. Which changes occur when Pt^{2+} is reduced?
   - A. The Pt^{2+} gains electrons and its oxidation number increases.
   - B. The Pt^{2+} gains electrons and its oxidation number decreases.
   - C. The Pt^{2+} loses electrons and its oxidation number increases.
   - D. The Pt^{2+} loses electrons and its oxidation number decreases.

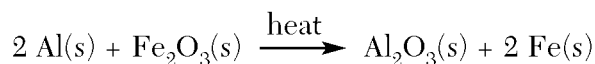4. Given the balanced ionic equation representing a reaction:

   $$2Al^{3+}(aq) + 3Mg(s) \rightarrow 3Mg^{2+}(aq) + 2Al(s)$$
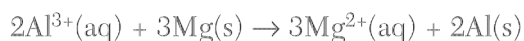
   In this reaction, electrons are transferred from
   - A. Al to Mg^{2+}
   - C. Mg to Al^{3+}
   - B. Al^{3+} to Mg
   - D. Mg^{2+} to Al

5. Half-reactions can be w ritten to rep resent all
   - A. double-replacement reactions
   - B. neutralization reactions
   - C. fission and fusion reactions
   - D. oxidation and reduction reactions

6. In an oxidation-reduction reaction, reduction is defined as the
   - A. loss of protons
   - C. loss of electrons
   - B. gain of protons
   - D. gain of electrons

7. In which reaction are electrons transferred from one reactant to another reactant?
   - A. $2Ca(s) + O_2 (g) \rightarrow 2CaO(s)$
   - B. $AgNO_3 (aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3 (aq)$
   - C. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(\ell)$
   - D. $H_3O^+ (aq) + OH^- (aq) \rightarrow 2H_2O(\ell)$

8. Which balanced equation represents a redox reaction?
   - A. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
   - B. $BaCl_2 + K_2CO_3 \rightarrow BaCO_3 + 2KCl$
   - C. $CuO + CO \rightarrow Cu + CO_2$
   - D. $HCl + KOH \rightarrow KCl + H_2O$

9. Which metal reacts spontaneously with a solution containing zinc ions?
   - A. magnesium
   - C. copper
   - B. nickel
   - D. silver

10. Which reaction is an example of an oxidation-reduction reaction?
    - A. $AgNO_3 + KI \rightarrow AgI + KNO_3$
    - B. $Cu + 2 AgNO_3 \rightarrow Cu(NO_3)_2 + 2 Ag$
    - C. $2 KOH + H_2SO_4 \rightarrow K_2SO_4 + 2 H_2O$
    - D. $Ba(OH)_2 + 2 HCl \rightarrow BaCl_2 + 2 H_2O$

11. Given the reaction:

    $$2\ Al(s)\ +\ Fe_2O_3(s)\ \xrightarrow{\text{heat}}\ Al_2O_3(s)\ +\ 2\ Fe(s)$$

    Which species undergoes reduction?
    - A. Al
    - C. Al^{+3}
    - B. Fe
    - D. Fe^{+3}

12. According to Reference Ta ble J, which of these metals will react most readily with 1.0 M HCl to produce $H_2(g)$?
    - A. Ca
    - C. Mg
    - B. K
    - D. Zn

13. Given the balanced equation representing a redox reaction:

    $$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$$
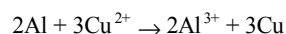
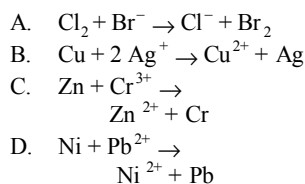   Which statement is true about this reaction?
    - A. Each Al loses $2e^-$ and each Cu^{2+} gains $3e^-$.
    - B. Each Al loses $3e^-$ and each Cu^{2+} gains $2e^-$.
    - C. Each Al^{3+} gains $2e^-$ and each Cu loses $3e^-$.
    - D. Each Al^{3+} gains $3e^-$ and each Cu loses $2e^-$.

14. Given the redox reaction:

    $$Cr^{3+} + Al \rightarrow Cr + Al^{3+}$$
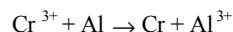
    As the reaction takes place, there is a transfer of
    - A. electrons from Al to Cr^{3+}
    - C. protons from Al to Cr^{3+}
    - B. electrons from Cr^{3+} to Al
    - D. protons from Cr^{3+} to Al

15. Which half-reaction correctly represent s reduction?
    - A. $Ag \rightarrow Ag^+ + e^-$
    - B. $F_2 \rightarrow 2 F^- + 2e^-$
    - C. $Au^{3+} + 3e^- \rightarrow Au$
    - D. $Fe^{2+} + e^- \rightarrow Fe^{3+}$

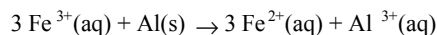16. Which equation shows conservation of both mass and charge?
    - A. $Cl_2 + Br^- \rightarrow Cl^- + Br_2$
    - B. $Cu + 2 Ag^+ \rightarrow Cu^{2+} + Ag$
    - C. $Zn + Cr^{3+} \rightarrow Zn^{2+} + Cr$
    - D. $Ni + Pb^{2+} \rightarrow Ni^{2+} + Pb$

17. Which half-reaction can occ ur at th e anode in a voltaic cell?
    - A. $Ni^{2+} + 2e^- \rightarrow Ni$
    - C. $Zn \rightarrow Zn^{2+} + 2e^-$
    - B. $Sn + 2e^- \rightarrow Sn^{2+}$
    - D. $Fe^{3+} \rightarrow Fe^{2+} + e^-$

18. Given the balanced equation:

    $3 Fe^{3+}(aq) + Al(s) \rightarrow 3 Fe^{2+}(aq) + Al^{3+}(aq)$

    What is the total number of moles of electrons lost by 2 moles of Al(s)?

    A. 1 mole   C. 3 moles

    B. 6 moles   D. 9 moles

19. Given the unbalanced ionic equation:
      $3Mg + \_\_Fe^{3+} \rightarrow 3Mg^{2+} + \_\_Fe$

    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

20. Which energy conversion occurs during the operation of a voltaic cell?

    A. Chemical energy is spontaneously converted to electrical energy.
    B. Chemical energy is converted to electrical energy only when an external power source is provided.
    C. Electrical energy is spontaneously converted to chemical energy.
    D. Electrical energy is converted to chemical energy only when an external power source is provided.

21. A student collects the materials and equipment below to construct a voltaic cell:

    • two 250-mL beakers
    • wire and a switch
    • one strip of magnesium
    • one strip of copper
    • 125 mL of 0.20 M $Mg(NO_3)_2(aq)$
    • 125 mL of 0.20 M $Cu(NO_3)_2(aq)$

    Which additional item is required for the construction of the voltaic cell?

    A. an anode   C. a cathode

    B. a battery   D. a salt bridge

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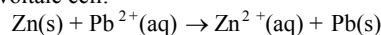
    In the completed external circuit, the electrons flow from

    A. Pb(s) to Zn(s)   C. Zn(s) to Pb(s)

    B. $Pb^{2+}(aq)$ to $Zn^{2+}(aq)$ D. $Zn^{2+}(aq)$ to $Pb^{2+}(aq)$

23. 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.

24. The diagram below shows a key being plated with copper in an electrolytic cell
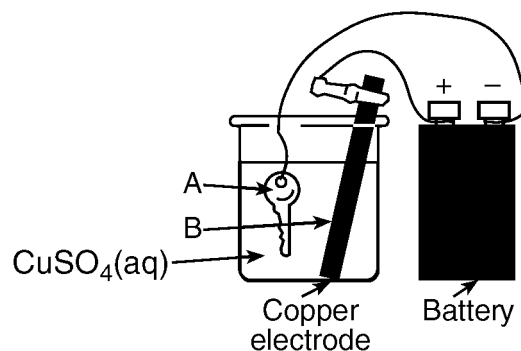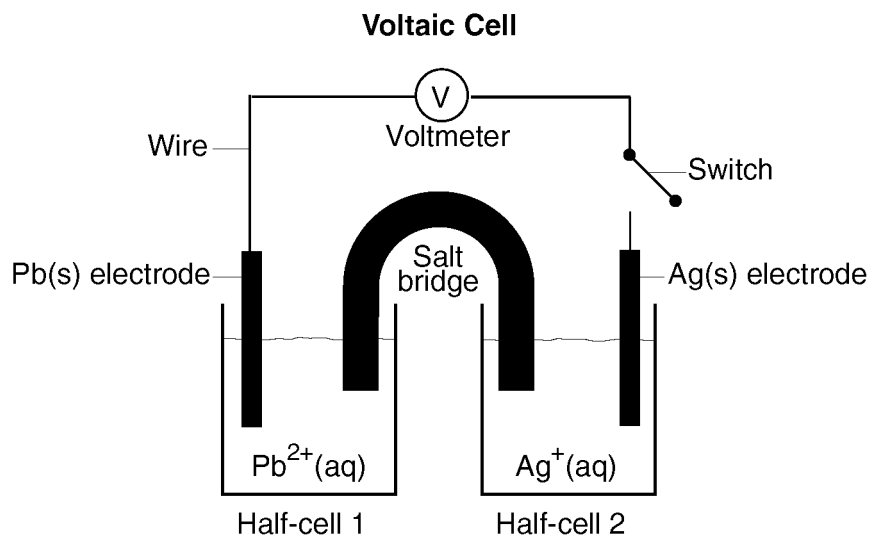

    Given the reduction reaction for this cell:

    $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
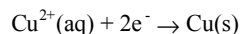
    This reduction occurs at

    A. *A*, which is the anode C. *B*, which is the anode

    B. *A*, which is the cathode D. *B*, which is the cathode

Base your answers to questions **25** through **27** on the diagram of the voltaic cell below.

Voltaic Cell

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

25. When the switch is closed, in which half-cell does oxidation occur?

26. When the switch is closed, state the direction that electrons will flow through the wire.

27. *Based on the given equation,* write the balanced half-reaction that occurs in half-cell 1.

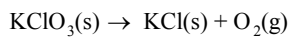Base your answers to questions **28** and **29** on the information below.

Electroplating is an el ectrolytic process us ed to coat metal objects with a more expensive and less reactive metal. The di agram 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
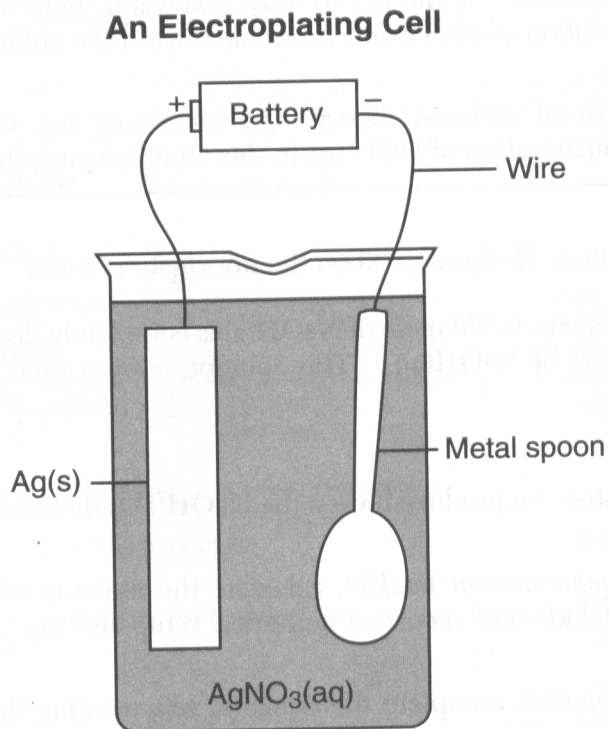
28. Explain the purpose of the battery in this cell.

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

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

The unbalanced equation below repre sents the decomposition of po tassium chlorate.

$KClO_3$(s) → KCl(s) + O_2(g)

Balance the equation *below*, using the s mallest whole-number coeffic ients.

_____$KClO_3$(s) → _____KCl(s) + _____O_2(g)
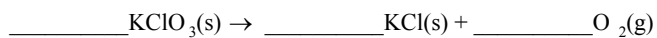
Base your answers to questions **31** through **33** on the diagram below. The diagram shows a voltaic cell with copper and aluminum electrodes immediately after the external circuit is completed.
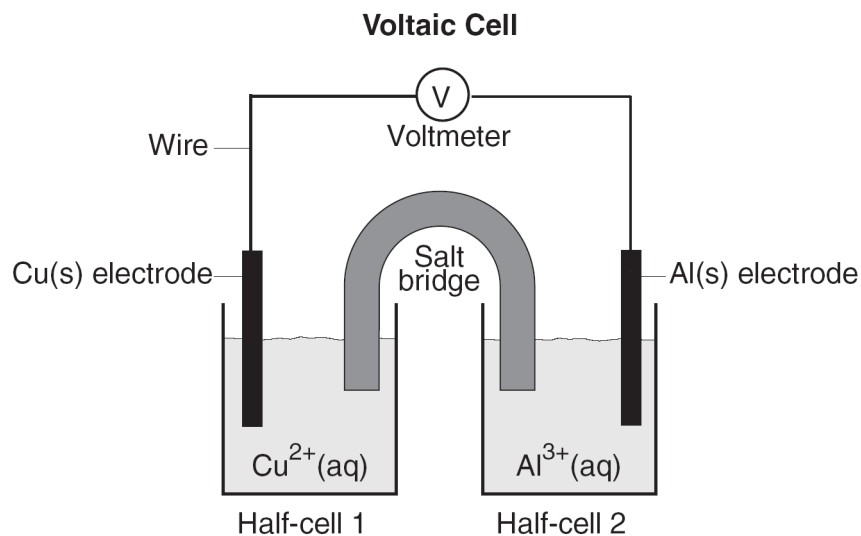
Voltaic Cell

31. Explain the function of the salt bridge.

32. Balance the redox equation below, using the small est whole-number coefficients.

_____Cu^{2+}(aq) + _____Al(s) → _____Cu(s) + _____Al^{3+}(aq)
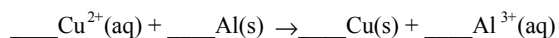
33. As this voltaic cell operates, the mass of the Al(s) electrode decreases. Explain, i n terms of particles, why this decrease in mass occurs.

1. ___A___

2. ___A___

3. ___B___

4. ___C___
—prevents polarization

5. ___D___

6. ___D___

7. ___A___

8. ___C___

9. ___A___

10. ___B___

11. ___D___

12. ___B___

13. ___B___

14. ___A___

15. ___C___

16. ___D___

17. ___C___

18. ___B___

19. ___B___

20. ___A___

21. ___D___

22. ___C___

23. ___C___

24. ___B___

25. Acceptable responses: half-cell 1, Pb, left, lead.

26. Acceptable responses: from Pb electrode to Ag electrode, left to right, cell 1 → cell 2, Do not allow credit for a response that indicates that electrons flow through the salt bridge.

27. Allow credit for **Pb(s)** → **Pb^{2+}(aq) + 2e^{-}** even if the labels (s) and (aq) are not included.

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

29. *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.

30. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

31. *Examples:* —It allows migration of ions. —maintains neutrality

32. $3\ Cu^{2+}(aq) + 2\ Al(s) \rightarrow 3\ Cu(s) + 2\ Al^{3+}(aq)$.

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