1. Which energy conversion occurs during the operation of an electrolytic cell?

   A) chemical energy to electrical energy
   B) electrical energy to chemical energy
   C) nuclear energy to electrical energy
   D) electrical energy to nuclear energy

2. 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) $MgCrO_4 + BaCl_2 \rightarrow MgCl_2 + BaCrO_4$
   D) $Zn(NO_3)_2 + Na_2CO_3 \rightarrow 2NaNO_3 + ZnCO_3$

3. What is the oxidation number of chromium in the chromate ion, $CrO_4^{2-}$ ?

   A) +6 B) +2 C) +3 D) +8

4. In which compound does carbon have an oxidation state of –4?

   A) CO B) $CO_2$ C) $CCl_4$ D) $CH_4$

5. In an oxidation-reduction reaction, the oxidation number of the oxidizing agent

   A) decreases B) increases
   C) remains the same

6. A student wishes to set up an electrochemical cell. The following list of materials and equipment will be used:
   - two 250-ml beakers
   - wire
   - one piece of Zn metal
   - 125 ml of 0.10 M $Zn(NO_3)_2$
   - voltmeter
   - switch
   - one piece of Pb metal
   - 125 ml of 0.10 M $Pb(NO_3)_2$

   For the cell to operate properly, the student will also need

   A) an anode
   B) a cathode
   C) an external path for electrons
   D) a salt bridge

7. According to Reference Table J, which is the strongest reducing agent?

   A) Li(s) B) Na(s)
   C) $F_2(g)$ D) $Br_2(\ell)$

8. A redox reaction always involves

   A) a change in oxidation number
   B) a change of phase
   C) the transfer of protons
   D) the formation of ions

9. In the half-reaction

   $Pb^0 \rightarrow Pb^{2+} + 2e^-$, the $Pb^0$

   A) gains protons B) loses protons
   C) is oxidized D) is reduced

10. When the redox equation

$$\_\_\_\ Cr^{3}(aq) + 3\,Mn(s) \rightarrow \_\_\_\ Mn^{2+}(aq) + \_\_\_\ Cr(s)$$

is completely balanced, the coefficient of $Cr^{3+}(aq)$ will be

A) 1 B) 2 C) 3 D) 4

11. In an electrolytic cell, which ion would migrate through the solution to the positive electrode?

A) a hydrogen ion B) a chloride ion
C) an ammonium ion D) a hydronium ion

12. What is the sum of the oxidation numbers of the atoms in the compound $CO_2$?

A) 0 B) –2 C) –4 D) +4

13. Given the reaction:

$$Ca(s) + Cu_{2+}(aq) \rightarrow Ca_{2+}(aq) + Cu(s)$$

What is the correct reduction half-reaction?

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

14. According to Reference Table J, which ion will oxidize Fe?

A) $Zn^{2+}$ B) $Ca^{2+}$ C) $Mg^{2+}$ D) $Cu^{2+}$

15. According to Reference Table *J*, which metal will react spontaneously with hydrochloric acid?

A) gold B) silver
C) copper D) zinc

16. Which equation represents a redox reaction?

A) $2\,Na^+ + S^{2-} \rightarrow Na_2S$
B) $H^+ + C_2H_3O_2^- \rightarrow HC_2H_3O_2$
C) $NH_3 + H^+ + Cl^- \rightarrow NH_4^+ + Cl$
D) $Cu + 2\,Ag^+ + 2\,NO_3^- \rightarrow 2\,Ag + Cu^{2+} + 2\,NO_3^-$

17. Based on Reference Table J, which reaction will take place spontaneously?

A) $Cu + 2\,H^+ \rightarrow Cu^{2+} + H_2$
B) $2\,Au + 6\,H^+ \rightarrow 2\,Au^{3+} + 3\,H_2$
C) $Pb + 2\,H^+ \rightarrow Pb^{2+} + H_2$
D) $2\,Ag + 2\,H^+ \rightarrow 2\,Ag^+ + H_2$

18. 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

19. Given the reaction that occurs in an electrochemical cell:

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

During this reaction, the oxidation number of Zn changes from

A) 0 to +2 B) 0 to –2
C) +2 to 0 D) –2 to 0

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

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

21. 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) $Mn^{4+} + 3e^- \rightarrow Mn^{7+}$

22. 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

23. In a redox reaction, the species reduced

A) gains electrons and is the oxidizing agent
B) gains electrons and is the reducing agent
C) loses electrons and is the oxidizing agent
D) loses electrons and is the reducing agent

24. In the reaction

$$2\ Mg + O_2 \rightarrow 2\ MgO,$$

the magnesium is the

A) oxidizing agent and is reduced
B) oxidizing agent and is oxidized
C) reducing agent and is reduced
D) reducing agent and is oxidized

25. 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

26. 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 $2e^-$.

27. Given the reaction for the corrosion of aluminum:

$4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$

Which half-reaction correctly represents the oxidation that occurs?

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

28. Given the reaction:

$$Mg + CuSO_4 \rightarrow MgSO_4 + Cu$$

Which equation represents the oxidation that takes place?

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