Chapter 4: Reactions in Aqueous Solution

1. Which of the following compounds is a *strong electrolyte*?
   A) H₂O  B) CH₃OH  C) CH₃CH₂OH  D) HF  E) NaF  
   Ans: E  Category: Easy  Section: 4.1

2. Which of the following compounds is a *weak electrolyte*?
   A) HNO₃  B) NaNO₃  C) HNO₂  D) NaNO₂  E) NaOH  
   Ans: C  Category: Easy  Section: 4.1

3. Which of the following compounds is a *strong electrolyte*?
   A) H₂O  B) N₂  C) CH₃COOH (acetic acid)  D) CH₃CH₂OH (ethanol)  E) KOH  
   Ans: E  Category: Easy  Section: 4.1

4. Which of the following compounds is a *weak electrolyte*?
   A) HCl  B) CH₃COOH (acetic acid)  C) C₆H₁₂O₆ (glucose)  D) O₂  E) NaCl  
   Ans: B  Category: Easy  Section: 4.1

5. Which of the following compounds is a *weak electrolyte*?
   A) HCl  B) NH₃  C) C₆H₁₂O₆ (glucose)  D) N₂  E) KCl  
   Ans: B  Category: Easy  Section: 4.1

6. Which of the following compounds is a *nonelectrolyte*?
   A) NaF  B) HNO₃  C) CH₃COOH (acetic acid)  D) NaOH  E) C₆H₁₂O₆ (glucose)  
   Ans: E  Category: Easy  Section: 4.1

7. Which of the following compounds is a *nonelectrolyte*?
   A) NaOH  B) HNO₃  C) C₂H₆O (ethanol)  D) KF  E) CH₃COOH (acetic acid)  
   Ans: C  Category: Easy  Section: 4.1

8. Identify the *major* ionic species present in an aqueous solution of Na₂CO₃.
   A) Na⁺, CO₃²⁻  B) Na⁺, C²⁻, O₃⁻  C) Na⁺, C⁴⁺, O₃²⁻  D) Na⁺, C²⁺, O²⁻  E) Na⁺, CO₃²⁻  
   Ans: E  Category: Easy  Section: 4.1
9. Identify the major ionic species present in an aqueous solution of K$_2$SO$_4$.
   A) K$^{2+}$, S$^{6+}$, O$_4$$^{8-}$
   B) K$^{2+}$, S$^{6+}$, 4O$_2$$^{-}$
   C) 2K$^+$, S$^{6+}$, O$_4$$^{8-}$
   Ans: E Category: Easy Section: 4.1

10. The distinguishing characteristic of all electrolyte solutions is that they
    A) contain molecules. D) always contain acids.
    B) conduct electricity. E) conduct heat.
    C) react with other solutions.
    Ans: B Category: Easy Section: 4.1

11. Based on the solubility rules, which one of the following compounds should be insoluble in water?
    A) NaCl  B) MgBr$_2$  C) FeCl$_3$  D) AgBr  E) ZnCl$_2$
    Ans: D Category: Easy Section: 4.2

12. Based on the solubility rules, which one of the following compounds should be insoluble in water?
    A) Na$_2$SO$_4$  B) BaSO$_4$  C) CuSO$_4$  D) MgSO$_4$  E) Rb$_2$SO$_4$
    Ans: B Category: Easy Section: 4.2

13. Based on the solubility rules, which one of the following compounds should be insoluble in water?
    A) CaCO$_3$  B) (NH$_4$)$_2$CO$_3$  C) Na$_2$CO$_3$  D) K$_2$CO$_3$  E) KNO$_3$
    Ans: A Category: Easy Section: 4.2

14. Based on the solubility rules, which one of the following should be soluble in water?
    A) Hg$_2$Cl$_2$  B) Na$_2$S  C) Ag$_2$CO$_3$  D) Ag$_2$S  E) BaSO$_4$
    Ans: B Category: Easy Section: 4.2

15. Based on the solubility rules, which one of the following should be soluble in water?
    A) AgBr  B) AgCl  C) Ag$_2$CO$_3$  D) AgNO$_3$  E) Ag$_2$S
    Ans: D Category: Easy Section: 4.2

16. Based on the solubility rules, which one of the following should be soluble in water?
    A) (NH$_4$)$_3$PO$_4$  B) Ca$_3$(PO$_4$)$_2$  C) AlPO$_4$  D) Ag$_3$PO$_4$  E) Mg$_3$(PO$_4$)$_2$
    Ans: A Category: Easy Section: 4.2

17. Based on the solubility rules, which one of the following should be soluble in water?
    A) CaSO$_4$  B) BaSO$_4$  C) PbSO$_4$  D) K$_2$SO$_4$  E) AgCl
    Ans: D Category: Easy Section: 4.2
18. Based on the solubility rules, which of the following will occur when a solution containing about 0.1 g of Pb(NO$_3$)$_2$(aq) is mixed with a solution containing 0.1 g of KI(aq)/100 mL?

A) KNO$_3$ will precipitate; Pb$^{2+}$ and I$^-$ are spectator ions.
B) No precipitate will form.
C) Pb(NO$_3$)$_2$ will precipitate; K$^+$ and I$^-$ are spectator ions.
D) Pbl$_2$ will precipitate; K$^+$ and NO$_3^-$ are spectator ions.
E) Pb$^{2+}$ and I$^-$ are spectator ions, and Pbl$_2$ will precipitate.

Ans: D

19. Based on the solubility rules, which of the following will occur if solutions of CuSO$_4$(aq) and BaCl$_2$(aq) are mixed?

A) CuCl$_2$ will precipitate; Ba$^{2+}$ and SO$_4^{2-}$ are spectator ions.
B) CuSO$_4$ will precipitate; Ba$^{2+}$ and Cl$^-$ are spectator ions.
C) BaSO$_4$ will precipitate; Cu$^{2+}$ and Cl$^-$ are spectator ions.
D) BaCl$_2$ will precipitate; Cu$^{2+}$ and SO$_4^{2-}$ are spectator ions.
E) No precipitate will form.

Ans: C

20. Based on the solubility rules, which of the following will occur when solutions of ZnSO$_4$(aq) and MgCl$_2$(aq) are mixed?

A) ZnCl$_2$ will precipitate; Mg$^{2+}$ and SO$_4^{2-}$ will be spectator ions.
B) ZnSO$_4$ will precipitate; Mg$^{2+}$ and Cl$^-$ will be spectator ions.
C) MgSO$_4$ will precipitate; Zn$^{2+}$ and Cl$^-$ will be spectator ions.
D) MgCl$_2$ will precipitate; Zn$^{2+}$ and SO$_4^{2-}$ will be spectator ions.
E) No precipitate will form.

Ans: E

21. Which of the following is the correct net ionic equation for the reaction that occurs when solutions of Pb(NO$_3$)$_2$ and NH$_4$Cl are mixed?

A) Pb(NO$_3$)$_2$(aq) + 2NH$_4$Cl(aq) $\rightarrow$ NH$_4$NO$_3$(aq) + PbCl$_2$(s)
B) Pb$^{2+}$(aq) + 2Cl$^-$(aq) $\rightarrow$ PbCl$_2$(s)
C) Pb$^{2+}$(aq) + 2NO$_3^-$ (aq) + 2NH$_4^+$ (aq) + 2Cl$^-$(aq) $\rightarrow$ 2NH$_4^+$ (aq) + 2NO$_3^-$ (aq) + PbCl$_2$(s)
D) NH$_4^+$(aq)+ NO$_3^-$ (aq) $\rightarrow$ 2NH$_4$NO$_3$(s)
E) No reaction occurs when the solutions are mixed.

Ans: B

22. The common constituent in all acid solutions is

A) H$_2$  B) H$^+$  C) OH$^-$  D) H$_2$SO$_4$  E) Cl$^-$

Ans: B

23. Which of the following compounds is a weak acid?

A) HF  B) HCl  C) HBr  D) HI  E) HClO$_4$

Ans: A
24. Identify the major ions present in an aqueous LiOH solution.
   A) Li^2+, O^-, H^- B) Li^+, OH^- C) LiO^-, H^+ D) Li^+, O^2-, H^+ E) Li^-, OH^+
   Ans: B Category: Easy Section: 4.3

25. Identify the major ions present in an aqueous HNO_3 solution.
   A) HN^+, O^2- B) OH^-, NO_3^- C) OH^-, NO D) H^+, N^3-, O^2- E) H^+, NO_3^-
   Ans: E Category: Easy Section: 4.3

26. Identify the major ionic species present in an aqueous solution of H_2SO_4.
   A) S^6+, O_3^- (plus H_2O as a neutral species) B) H^+, OH^-, S^6+, 3O^2- C) 2H^+, S^6+, 4O^2- D) H^+, HSO_4^- E) 2H^+, SO_4^{2-}
   Ans: D Category: Medium Section: 4.3

27. What is the correct formula of the salt formed in the neutralization reaction of hydrochloric acid with calcium hydroxide?
   A) CaO B) CaCl_2 C) CaH_2 D) CaCl E) CaClH
   Ans: B Category: Medium Section: 4.3

28. What is the chemical formula of the salt produced by the neutralization of hydrobromic acid with magnesium hydroxide?
   A) MgBr B) Mg_3Br_2 C) Mg_3Br_2 D) Mg_2Br E) MgBr_2
   Ans: E Category: Medium Section: 4.3

29. What is the chemical formula of the salt produced by the neutralization of nitric acid with calcium hydroxide?
   A) Ca(NO_3)_3 B) Ca_2(NO_3)_3 C) Ca_3(NO_3)_2 D) Ca_2NO_3 E) Ca(NO_3)_2
   Ans: E Category: Medium Section: 4.3

30. What is the chemical formula of the salt produced by the complete neutralization of sodium hydroxide with sulfuric acid?
   A) Na_2SO_4 B) Na_2(SO_4)_3 C) Na(SO_4)_2 D) NaSO_3 E) Na_3SO_4
   Ans: A Category: Medium Section: 4.3

31. What is the chemical formula of the salt produced by the neutralization of potassium hydroxide with sulfuric acid?
   A) KSO_3 B) K_2(SO_4)_3 C) K_2SO_4 D) K(SO_4)_2 E) KSO_4
   Ans: C Category: Medium Section: 4.3

32. The oxidation number of N in NaNO_3 is
   A) +6 B) +5 C) +3 D) –3 E) None of the above.
   Ans: B Category: Medium Section: 4.4
33. The oxidation number of S in K$_2$SO$_4$ is
A) +6  B) +4  C) +2  D) –1  E) None of the above.
Ans: A  Category: Medium  Section: 4.4

34. The oxidation number of Mn in KMnO$_4$ is
A) +8  B) +7  C) +5  D) –7  E) –8
Ans: B  Category: Medium  Section: 4.4

35. The oxidation number of Fe in K$_3$Fe(CN)$_6$ is
A) +3  B) +2  C) +1  D) –3  E) –4
Ans: A  Category: Medium  Section: 4.4

36. The oxidation number of Cr in Cr$_2$O$_7^{2–}$ is
A) –12  B) –7  C) –2  D) +6  E) +7
Ans: D  Category: Medium  Section: 4.4

37. The oxidation number of Cl in ClO$_3^–$ is
A) –1  B) +7  C) +5  D) +3  E) None of the above.
Ans: C  Category: Medium  Section: 4.4

38. The oxidation number of Cl in ClO$_4^–$ is
A) –1  B) +1  C) +3  D) +5  E) None of the above.
Ans: E  Category: Medium  Section: 4.4

39. The highest possible oxidation number of nitrogen is
A) +8  B) +5  C) +3  D) +1  E) –3
Ans: B  Category: Medium  Section: 4.4

40. For which one of the following acids is chlorine in the +5 oxidation state?
A) HCl  B) HClO  C) HClO$_2$  D) HClO$_3$  E) HClO$_4$
Ans: D  Category: Medium  Section: 4.4

41. The highest possible oxidation number of carbon is
A) +8  B) +6  C) +4  D) +2  E) –4
Ans: C  Category: Medium  Section: 4.4

42. Select the compound in which sulfur has its highest possible oxidation number.
A) H$_2$S  B) SO$_2$  C) SC$_2$  D) H$_2$SO$_3$  E) Na$_2$SO$_4$
Ans: E  Category: Medium  Section: 4.4

43. The oxidation number of N in N$_2$H$_4$ is
A) +4  B) –4  C) +2  D) –2  E) 0
Ans: D  Category: Medium  Section: 4.4
44. Which choice gives the correct oxidation numbers for all three elements in Rb$_2$SO$_3$ in the order that the elements are shown in the formula?
   A) −2, +6, −2   B) −1, +4, −3   C) +2, +4, −2   D) +1, +4, −2   E) +1, +6, −6
   Ans: D   Category: Medium   Section: 4.4

45. Which choice gives the correct oxidation numbers for all three elements in Ca(ClO)$_2$ in the order that the elements are shown in the formula?
   A) +2, +1, −2   B) +2, −2, +1   C) +2, −3, +2   D) −2, +2, −1   E) −2, +3, −2
   Ans: A   Category: Medium   Section: 4.4

46. In the following redox reaction
   4NH$_3$ + 3Ca(ClO)$_2$ → 2N$_2$ + 6H$_2$O + 3CaCl$_2$
   which element is oxidized and which is reduced?
   A) H is oxidized and N is reduced   D) Cl is oxidized and O is reduced
   B) N is oxidized and Cl is reduced   E) Cl is oxidized and N is reduced
   C) N is oxidized and O is reduced
   Ans: B   Category: Medium   Section: 4.4

47. Which one of the following is a redox reaction?
   A) 2Al(s) + 3H$_2$SO$_4$(aq) → Al$_2$(SO$_4$)$_3$(aq) + 3H$_2$(g)
   B) 2H$_2$O → 2H$_2$ + O$_2$
   C) 2NaCl + Pb(NO$_3$)$_2$ → PbCl$_2$ + 3NaNO$_3$
   D) 2NaI + Br$_2$ → 2NaBr + I$_2$
   E) Cu(NO$_3$)$_2$ + Zn → Zn(NO$_3$)$_2$ + Cu
   Ans: A   Category: Medium   Section: 4.4

48. Which of the following equations does not represent an oxidation-reduction reaction?
   A) 3Al + 6HCl → 3H$_2$ + AlCl$_3$
   B) 2H$_2$O → 2H$_2$ + O$_2$
   C) 2NaCl + Pb(NO$_3$)$_2$ → PbCl$_2$ + 3NaNO$_3$
   D) 2NaI + Br$_2$ → 2NaBr + I$_2$
   E) Cu(NO$_3$)$_2$ + Zn → Zn(NO$_3$)$_2$ + Cu
   Ans: C   Category: Medium   Section: 4.4

49. In the following chemical reaction the oxidizing agent is
   5H$_2$O$_2$ + 2MnO$_4^-$ + 6H$^+$ → 2Mn$^{2+}$ + 8H$_2$O + 5O$_2$
   A) H$_2$O$_2$   B) MnO$_4^-$   C) H$^+$   D) Mn$^{2+}$   E) O$_2$
   Ans: B   Category: Difficult   Section: 4.4

50. In the following chemical reaction the oxidizing agent is
   5S + 6KNO$_3$ + 2CaCO$_3$ → 3K$_2$SO$_4$ + 2CaSO$_4$ + CO$_2$ + 3N$_2$
   A) S   B) N$_2$   C) KNO$_3$   D) CaSO$_4$   E) CaCO$_3$
   Ans: C   Category: Difficult   Section: 4.4
51. Identify the oxidizing agent in the following chemical reaction.

\[ 2\text{MnO}_4^- + 5\text{H}_2\text{SO}_3 \rightarrow 2\text{Mn}^{2+} + 5\text{SO}_4^{2-} + 4\text{H}^+ + 3\text{H}_2\text{O} \]

A) \text{MnO}_4^-  B) \text{H}_2\text{SO}_3  C) \text{Mn}^{2+}  D) \text{SO}_4^{2-}  E) \text{H}^+

Ans: A  Category: Difficult  Section: 4.4

52. Identify the reducing agent in the following chemical reaction.

\[ 5\text{Fe}^{2+}(\text{aq}) + \text{MnO}_4^- (\text{aq}) + 8\text{H}^+(\text{aq}) \rightarrow 5\text{Fe}^{3+}(\text{aq}) + \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O(l)} \]

A) \text{Fe}^{2+}  B) \text{MnO}_4^-  C) \text{H}^+  D) \text{Mn}^{2+}  E) \text{Fe}^{3+}

Ans: A  Category: Difficult  Section: 4.4

53. Identify the reducing agent in the following chemical reaction.

\[ \text{Cd} + \text{NiO}_2 + 2\text{H}_2\text{O} \rightarrow \text{Cd(OH)}_2 + \text{Ni(OH)}_2 \]

A) \text{Cd}  B) \text{NiO}_2  C) \text{H}_2\text{O}  D) \text{Cd(OH)}_2  E) \text{Ni(OH)}_2

Ans: A  Category: Difficult  Section: 4.4

54. What element is oxidized in the following chemical reaction?

\[ 3\text{Cu} + 8\text{HNO}_3 \rightarrow 3\text{Cu(NO}_3)_2 + 2\text{NO} + 4\text{H}_2\text{O} \]

A) \text{Cu}  B) \text{H}  C) \text{N}  D) \text{O}  E) \text{H}_2\text{O}

Ans: A  Category: Medium  Section: 4.4

55. What element is oxidized in the following chemical reaction?

\[ \text{NiO}_2 + \text{Cd} + 2\text{H}_2\text{O} \rightarrow \text{Ni(OH)}_2 + \text{Cd(OH)}_2 \]

A) \text{Ni}  B) \text{Cd}  C) \text{O}  D) \text{H}  E) \text{This is not a redox reaction.}

Ans: B  Category: Medium  Section: 4.4

56. What element is oxidized in the following chemical reaction?

\[ \text{H}_2\text{SO}_4 + \text{Cd(OH)}_2 \rightarrow 2\text{H}_2\text{O} + \text{CdSO}_4 \]

A) \text{H}  B) \text{S}  C) \text{O}  D) \text{Cd}  E) \text{this is not a redox reaction}

Ans: E  Category: Medium  Section: 4.4

57. What element is reduced in the following chemical reaction?

\[ \text{Cu} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O} \]

A) \text{Cu}  B) \text{H}  C) \text{S}  D) \text{O}  E) \text{H}_2\text{O}

Ans: C  Category: Medium  Section: 4.4

58. Identify the elements that are oxidized and reduced in the following reaction.

\[ \text{KClO}_3(\text{aq}) + 6\text{HBr(aq)} \rightarrow \text{KCl(aq)} + 3\text{Br}_2(\text{l}) + 3\text{H}_2\text{O(l)} \]

A) \text{Br} is oxidized and \text{Cl} is reduced  D) \text{O} is oxidized and \text{Cl} is reduced
B) \text{Cl} is oxidized and \text{H} is reduced  E) \text{Cl} is oxidized and \text{Br} is reduced
C) \text{H} is oxidized and \text{O} is reduced

Ans: A  Category: Medium  Section: 4.4
59. Predict the products of the following single replacement reaction.
Fe(s) + CuSO\(_4\)(aq) →
A) Cu(s) + FeSO\(_4\)(aq)  
B) Fe(s) + Cu(s) + SO\(_4\)(aq)  
C) CuS(s) + Fe\(_2\)SO\(_4\)(aq)

Ans: A  Category: Medium  Section: 4.4

60. Which of the following is an example of a disproportionation reaction?
A) 2C\(_2\)H\(_6\)(g) + 7O\(_2\)(g) → 4CO\(_2\)(g) + 6H\(_2\)O(l)  
B) 2KBr(aq) + Cl\(_2\)(g) → 2KCl(aq) + Br\(_2\)(l)  
C) 2H\(_2\)O\(_2\)(aq) → 2H\(_2\)O(l) + O\(_2\)(g)  
D) CaBr\(_2\)(aq) + H\(_2\)SO\(_4\)(aq) → CaSO\(_4\)(s) + 2HBr(g)  
E) 2Al(s) + 3H\(_2\)SO\(_4\)(aq) → Al\(_2\)(SO\(_4\))\(_3\)(aq) + 3H\(_2\)(g)

Ans: C  Category: Medium  Section: 4.4

61. Which of the following represents a metal displacement reaction?
A) 2NaN\(_3\)(s) → 2Na(s) + 3N\(_2\)(g)  
B) Fe\(_2\)O\(_3\)(s) + 2Al(s) → 2Fe(s) + Al\(_2\)O\(_3\)(s)  
C) 3NO\(_2\)(g) + H\(_2\)O(l) → 2HNO\(_3\)(aq) + NO(g)  
D) 2P(s) + 3Cl\(_2\)(g) → 2PCl\(_3\)(g)  
E) 2ZnS(s) + 3O\(_2\)(g) → 2ZnO(s) + 2SO\(_2\)(g)

Ans: B  Category: Easy  Section: 4.4

62. Which of the following represents a halogen displacement reaction?
A) 2KBr(aq) + Cl\(_2\)(g) → 2KCl(aq) + Br\(_2\)(l)  
B) 2Na(s) + 2H\(_2\)O(l) → 2NaOH(aq) + H\(_2\)(g)  
C) CaBr\(_2\)(aq) + H\(_2\)SO\(_4\)(aq) → CaSO\(_4\)(s) + 2HBr(g)  
D) 2KNO\(_3\)(s) → 2KNO\(_2\)(s) + O\(_2\)(g)  
E) 2LiOH(aq) + H\(_2\)SO\(_4\)(aq) → Li\(_2\)SO\(_4\)(aq) + 2H\(_2\)O(l)

Ans: A  Category: Easy  Section: 4.4

63. Which of the following represents a precipitation reaction?
A) 2H\(_2\)(g) + O\(_2\)(g) → 2H\(_2\)O(l)  
B) CaBr\(_2\)(aq) + H\(_2\)SO\(_4\)(aq) → CaSO\(_4\)(s) + 2HBr(g)  
C) 2KNO\(_3\)(s) → 2KNO\(_2\)(s) + O\(_2\)(g)  
D) 2KBr(aq) + Cl\(_2\)(g) → 2KCl(aq) + Br\(_2\)(l)  
E) 2Al(s) + 3H\(_2\)SO\(_4\)(aq) → Al\(_2\)(SO\(_4\))\(_3\)(aq) + 3H\(_2\)(g)

Ans: B  Category: Easy  Section: 4.2
64. Which of the following represents an *acid-base neutralization reaction*?

A) \(2\text{Al(s) + 3H}_2\text{SO}_4(aq) \rightarrow \text{Al}_2(\text{SO}_4)_3(aq) + 3\text{H}_2(g)\)
B) \(\text{SO}_2(g) + \text{H}_2\text{O(l) \rightarrow H}_2\text{SO}_3(g)\)
C) \(\text{LiOH(aq) + HNO}_3(aq) \rightarrow \text{LiNO}_3(aq) + \text{H}_2\text{O(l)}\)
D) \(2\text{KBr(aq) + Cl}_2(g) \rightarrow 2\text{KCl(aq) + Br}_2(l)\)
E) \(\text{CaBr}_2(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{CaSO}_4(s) + 2\text{HBr(g)}\)

Ans: C Category: Medium Section: 4.4

65. Which of the following represents a *hydrogen displacement reaction*?

A) \(2\text{C}_2\text{H}_6(g) + 7\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 6\text{H}_2\text{O(l)}\)
B) \(2\text{KBr(aq) + Cl}_2(g) \rightarrow 2\text{KCl(aq) + Br}_2(l)\)
C) \(\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)\)
D) \(\text{CaBr}_2(aq) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{CaSO}_4(s) + 2\text{HBr(g)}\)
E) \(2\text{Al(s) + 3H}_2\text{SO}_4(aq) \rightarrow \text{Al}_2(\text{SO}_4)_3(aq) + 3\text{H}_2(g)\)

Ans: E Category: Medium Section: 4.4

66. Which of the following represents a *combustion reaction*?

A) \(2\text{C}_2\text{H}_6(g) + 7\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 6\text{H}_2\text{O(l)}\)
B) \(\text{LiOH(aq) + HNO}_3(aq) \rightarrow \text{LiNO}_3(aq) + \text{H}_2\text{O(l)}\)
C) \(\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)\)
D) \(2\text{Na(s) + 2H}_2\text{O(l) \rightarrow 2NaOH(aq) + H}_2(g)\)
E) \(2\text{Al(s) + 3H}_2\text{SO}_4(aq) \rightarrow \text{Al}_2(\text{SO}_4)_3(aq) + 3\text{H}_2(g)\)

Ans: A Category: Easy Section: 4.4

67. What mass of K\(_2\text{CO}_3\) is needed to prepare 200. mL of a solution having a potassium ion concentration of 0.150 M?

A) 4.15 g  B) 10.4 g  C) 13.8 g  D) 2.07 g  E) 1.49 g

Ans: D Category: Medium Section: 4.5

68. What mass of Na\(_2\text{SO}_4\) is needed to prepare 350. mL of a solution having a sodium ion concentration of 0.125 M?

A) 3.11 g  B) 24.9 g  C) 12.4 g  D) 6.21 g  E) 8.88 g

Ans: A Category: Medium Section: 4.5

69. What mass of Li\(_3\text{PO}_4\) is needed to prepare 500. mL of a solution having a lithium ion concentration of 0.175 M?

A) 6.75 g  B) 10.1 g  C) 19.3 g  D) 30.4 g  E) 3.38 g

Ans: E Category: Medium Section: 4.5

70. A 50.0 mL sample of 0.436 M \(\text{NH}_4\text{NO}_3\) is diluted with water to a total volume of 250.0 mL. What is the ammonium nitrate concentration in the resulting solution?

A) 21.8 M  B) 0.459 M  C) \(2.18 \times 10^{-2}\) M  D) \(8.72 \times 10^{-2}\) M  E) 0.109 M

Ans: D Category: Medium Section: 4.5
71. A 20.00 mL sample of 0.1015 M nitric acid is introduced into a flask, and water is added until the volume of the solution reaches 250. mL. What is the concentration of nitric acid in the final solution?
A) 1.27 M  
B) 8.12 \times 10^{-3} M  
C) 0.406 M  
D) 3.25 \times 10^{-2} M  
E) 5.08 \times 10^{-4} M  
Ans: B  
Category: Medium  
Section: 4.5

72. A 3.682 g sample of KClO₃ is dissolved in enough water to give 375. mL of solution. What is the chlorate ion concentration in this solution?
A) 3.00 \times 10^{-2} M  
B) 4.41 \times 10^{-2} M  
C) 0.118 M  
D) 1.65 \times 10^{-2} M  
E) 8.01 \times 10^{-2} M  
Ans: E  
Category: Medium  
Section: 4.5

73. A 4.691 g sample of MgCl₂ is dissolved in enough water to give 750. mL of solution. What is the magnesium ion concentration in this solution?
A) 3.70 \times 10^{-2} M  
B) 1.05 \times 10^{-2} M  
C) 6.57 \times 10^{-2} M  
D) 4.93 \times 10^{-2} M  
E) 0.131 M  
Ans: C  
Category: Medium  
Section: 4.5

74. A 0.9182 g sample of CaBr₂ is dissolved in enough water to give 500. mL of solution. What is the calcium ion concentration in this solution?
A) 9.19 \times 10^{-3} M  
B) 2.30 \times 10^{-3} M  
C) 2.72 \times 10^{-3} M  
D) 4.59 \times 10^{-3} M  
E) 1.25 \times 10^{-3} M  
Ans: A  
Category: Medium  
Section: 4.5

75. 35.0 mL of 0.255 M nitric acid is added to 45.0 mL of 0.328 M Mg(NO₃)₂. What is the concentration of nitrate ion in the final solution?
A) 0.481 M  
B) 0.296 M  
C) 0.854 M  
D) 1.10 M  
E) 0.0295 M  
Ans: A  
Category: Difficult  
Section: 4.5

76. 17.5 mL of a 0.1050 M Na₂CO₃ solution is added to 46.0 mL of 0.1250 M NaCl. What is the concentration of sodium ion in the final solution?
A) 0.205 M  
B) 0.119 M  
C) 0.539 M  
D) 0.148 M  
E) 0.165 M  
Ans: D  
Category: Difficult  
Section: 4.5

77. 25.0 mL of a 0.2450 M NH₄Cl solution is added to 55.5 mL of 0.1655 M FeCl₃. What is the concentration of chloride ion in the final solution?
A) 0.607 M  
B) 0.418 M  
C) 1.35 M  
D) 0.190 M  
E) 0.276 M  
Ans: B  
Category: Difficult  
Section: 4.5
78. When 38.0 mL of 0.1250 M H₂SO₄ is added to 100. mL of a solution of PbI₂, a precipitate of PbSO₄ forms. The PbSO₄ is then filtered from the solution, dried, and weighed. If the recovered PbSO₄ is found to have a mass of 0.0471 g, what was the concentration of iodide ions in the original solution?

A) 3.10 \times 10^{-4} \text{ M}  
B) 1.55 \times 10^{-4} \text{ M}  
C) 6.20 \times 10^{-3} \text{ M}

D) 3.11 \times 10^{-3} \text{ M}  
E) 1.55 \times 10^{-3} \text{ M}

Ans: D  
Category: Difficult  
Section: 4.6

79. When 50.0 mL of a 0.3000 M AgNO₃ solution is added to 50.0 mL of a solution of MgCl₂, an AgCl precipitate forms immediately. The precipitate is then filtered from the solution, dried, and weighed. If the recovered AgCl is found to have a mass of 0.1183 g, what as the concentration of magnesium ions in the original MgCl₂ solution?

A) 0.300 M  
B) 8.25 \times 10^{-3} \text{ M}  
C) 1.65 \times 10^{-2} \text{ M}

D) 2.06 \times 10^{-5} \text{ M}  
E) 4.13 \times 10^{-3} \text{ M}

Ans: B  
Category: Difficult  
Section: 4.6

80. When 20.0 mL of a 0.250 M (NH₄)₂S solution is added to 150.0 mL of a solution of Cu(NO₃)₂, a CuS precipitate forms. The precipitate is then filtered from the solution, dried, and weighed. If the recovered CuS is found to have a mass of 0.3491 g, what was the concentration of copper ions in the original Cu(NO₃)₂ solution?

A) 3.65 \times 10^{-3} \text{ M}  
B) 1.22 \times 10^{-2} \text{ M}  
C) 3.33 \times 10^{-2} \text{ M}

D) 4.87 \times 10^{-2} \text{ M}  
E) 2.43 \times 10^{-2} \text{ M}

Ans: E  
Category: Difficult  
Section: 4.6

81. 34.62 mL of 0.1510 M NaOH was needed to neutralize 50.0 mL of an H₂SO₄ solution. What is the concentration of the original sulfuric acid solution?

A) 0.0229 M  
B) 0.218 M  
C) 0.0523 M  
D) 0.209 M  
E) 0.105 M

Ans: C  
Category: Medium  
Section: 4.7

82. The concentration of oxalate ion (C₂O₄²⁻) in a sample can be determined by titration with a solution of permanganate ion (MnO₄⁻) of known concentration. The net ionic equation for this reaction is

2MnO₄⁻ + 5C₂O₄²⁻ + 16H⁺ \rightarrow 2Mn^{2+} + 8H₂O + 10CO₂

A 30.00 mL sample of an oxalate solution is found to react completely with 21.93 mL of a 0.1725 M solution of MnO₄⁻. What is the oxalate ion concentration in the sample?

A) 0.02914 M  
B) 0.4312 M  
C) 0.1821 M  
D) 0.3152 M  
E) 0.05044 M

Ans: D  
Category: Medium  
Section: 4.8
83. One method of determining the concentration of hydrogen peroxide (H₂O₂) in a solution is through titration with iodide ion. The net ionic equation for this reaction is

\[ \text{H}_2\text{O}_2 + 2\text{I}^- + 2\text{H}^+ \rightarrow \text{I}_2 + 2\text{H}_2\text{O} \]

A 50.00 mL sample of a hydrogen peroxide solution is found to react completely with 37.12 mL of a 0.1500 M KI solution. What is the concentration of hydrogen peroxide in the sample?

A) 5.568 × 10⁻² M  
B) 0.2227 M  
C) 0.1010 M  
D) 0.4041 M  
E) 0.1114 M

Ans: A  
Category: Medium  
Section: 4.8

84. Zinc dissolves in hydrochloric acid to yield hydrogen gas:

\[ \text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]

What mass of hydrogen gas is produced when a 7.35 g chunk of zinc dissolves in 500. mL of 1.200M HCl?

A) 0.605 g  
B) 0.113 g  
C) 0.302 g  
D) 0.453 g  
E) 0.227 g

Ans: E  
Category: Medium  
Section: 4.8

85. Zinc dissolves in hydrochloric acid to yield hydrogen gas:

\[ \text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]

When a 12.7 g chunk of zinc dissolves in 500. mL of 1.450M HCl, what is the concentration of hydrogen ions remaining in the final solution?

A) 0.776 M  
B) 0.388 M  
C) 0.674 M  
D) 1.06 M  
E) 0 M

Ans: C  
Category: Medium  
Section: 4.8

86. Lithium metal dissolves in water to yield hydrogen gas and aqueous lithium hydroxide. What is the final concentration of hydroxide ions when 5.500 g of lithium metal is dropped into 750. mL of water?

A) 1.06 M  
B) 0.528 M  
C) 2.11 M  
D) 0.792 M  
E) 0.943 M

Ans: A  
Category: Medium  
Section: 4.8

87. When solid iron(II) hydroxide is added to water, the resulting solution contains 1.4×10⁻³ g of dissolved iron(II) hydroxide per liter of solution. What is the hydroxide ion concentration in this solution?

A) 7.8×10⁻⁶ M  
B) 1.6×10⁻⁵ M  
C) 2.5×10⁻¹⁰ M  
D) 3.1×10⁻⁵ M  
E) 4.0×10⁻³ M

Ans: D  
Category: Difficult  
Section: 4.5

88. A 250. mL sample of 0.0328M HCl is partially neutralized by the addition of 100. mL of 0.0245M NaOH. Find the concentration of hydrochloric acid in the resulting solution.

A) 0.00700 M  
B) 0.0164 M  
C) 0.0383 M  
D) 0.0230 M  
E) 0.0575 M

Ans: B  
Category: Difficult  
Section: 4.7
89. A 350. mL sample of 0.276M HNO₃ is partially neutralized by 125 mL of 0.0120M Ca(OH)₂. Find the concentration of nitric acid in the resulting solution.
A) 0.210 M  B) 0.00632 M  C) 0.203 M  D) 0.0240 M  E) 0.197 M
Ans: E  Category: Difficult  Section: 4.7

90. 158 mL of a 0.148M NaCl solution is added to 228 mL of a 0.369M NH₄NO₃ solution. The concentration of ammonium ions in the resulting mixture is
A) 0.157 M  B) 0.218 M  C) 0.625 M  D) 0.369 M  E) 0 M
Ans: B  Category: Medium  Section: 4.5

91. 1.40 g of silver nitrate is dissolved in 125 mL of water. To this solution is added 5.00 mL of 1.50M hydrochloric acid, and a precipitate forms. Find the concentration of silver ions remaining in solution.
A) 5.7×10⁻³ M  D) 0.121M
B) 6.34×10⁻² M  E) 5.9×10⁻³ M
C) 5.77×10⁻² M
Ans: A  Category: Difficult  Section: 4.6

92. Calcium sulfate dihydrate (commonly known as gypsum) dissolves in cold water to the extent of 0.241 g per 100. cm³. What is the concentration of calcium ions in this solution?
A) 1.77×10⁻² M  D) 3.54×10⁻² M
B) 2.80×10⁻² M  E) 1.40×10⁻² M
C) 1.77×10⁻³ M
Ans: E  Category: Difficult  Section: 4.5

93. Calcium nitrate tetrahydrate dissolves in cold water to the extent of 266 g per 100. cm³. What is the concentration of nitrate ions in this solution?
A) 32.4M  B) 22.5M  C) 11.3M  D) 16.2M  E) 8.10M
Ans: B  Category: Difficult  Section: 4.5

94. Define solution, solute, and solvent.
Ans: A solution is a homogeneous mixture of two or more substances. The substance present in a smaller amount is called the solute, while the substance present in the larger amount is called the solvent.
Category: Easy  Section: 4.1

95. Identify the following compound as an electrolyte or nonelectrolyte: NaOH.
Ans: electrolyte
Category: Easy  Section: 4.1

96. Identify the following compound as an electrolyte or nonelectrolyte: H₂SO₄.
Ans: electrolyte
Category: Easy  Section: 4.1
97. Identify the following compound as an electrolyte or nonelectrolyte: Methanol (CH₃OH).
   Ans: nonelectrolyte
   Category: Easy   Section: 4.1

98. Identify the following compound as an electrolyte or nonelectrolyte: C₁₂H₂₂O₁₁(sucrose).
   Ans: nonelectrolyte
   Category: Easy   Section: 4.1

99. Identify the following compound as an electrolyte or nonelectrolyte: MgCl₂.
   Ans: electrolyte
   Category: Easy   Section: 4.1

100. Identify the following compound as a strong electrolyte, weak electrolyte, or nonelectrolyte: CH₃OH (methanol).
    Ans: nonelectrolyte
    Category: Easy   Section: 4.1

101. Identify the following compound as a strong electrolyte, weak electrolyte, or nonelectrolyte: CH₃COOH.
    Ans: weak electrolyte
    Category: Easy   Section: 4.1

102. Identify the following compounds as a strong electrolytes, weak electrolytes, or nonelectrolytes: KNO₃, KNO₂, HNO₃, HNO₂,
    Ans: KNO₃, KNO₂, and HNO₃ are strong electrolytes; HNO₂ is a weak electrolyte.
    Category: Medium   Section: 4.3

103. Identify the following compound as a strong electrolyte, weak electrolyte, or nonelectrolyte: NH₃.
    Ans: weak electrolyte
    Category: Medium   Section: 4.1

104. Identify the following compound as a strong electrolyte, weak electrolyte, or nonelectrolyte: NH₄Cl.
    Ans: strong electrolyte
    Category: Easy   Section: 4.1

105. Define and illustrate with an example the difference between an electrolyte and a nonelectrolyte.
    Ans: (Answers will vary.) An electrolyte is a substance that, when dissolved in water, results in a solution that can conduct electricity. An example is sodium hydrogen carbonate. A nonelectrolyte does not conduct electricity when dissolved in water. An example would be sugar.
    Category: Medium   Section: 4.1
106. Define **precipitate** and illustrate with an example.
   Ans: (Answers will vary.) A precipitate is an insoluble solid that separates from a solution.
   \[
   \text{CoCl}_2 \text{(aq)} + \text{Na}_2\text{CO}_3 \text{(aq)} \rightarrow \text{CoCO}_3 \text{(s)} + 2\text{NaCl} \text{(aq)}
   \]
   In this reaction, CoCO$_3$ is a precipitate.
   Category: Medium   Section: 4.2

107. Give an example of a **monoprotic acid**.
   Ans: HNO$_3$ (for example)
   Category: Easy   Section: 4.3

108. Give an example of a **diprotic acid**.
   Ans: H$_2$CO$_3$ (for example)
   Category: Easy   Section: 4.3

109. Name and give the formulas for six **strong acids**.
   Ans: hydrochloric acid, HCl; hydrobromic acid, HBr; hydroiodic acid, HI; nitric acid, HNO$_3$; sulfuric acid, H$_2$SO$_4$; perchloric acid, HClO$_4$
   Category: Easy   Section: 4.3

110. Give an example of a **triprotic acid**.
    Ans: H$_3$PO$_4$
    Category: Easy   Section: 4.3

111. Write the **net ionic equation** for the following reaction. Aqueous iron(III) sulfate is added to aqueous sodium sulfide to produce solid iron(III) sulfide and aqueous sodium sulfate.
    Ans: 2Fe$^{3+}$(aq) + 3S$^{2-}$(aq) $\rightarrow$ Fe$_2$S$_3$(s)
    Category: Medium   Section: 4.2

112. Determine the oxidation number of each of the elements in Cs$_2$Cr$_2$O$_7$?
    Ans: the oxidation number of Cs is +1; the oxidation number of Cr is +6; the oxidation number of O is –2
    Category: Easy   Section: 4.4

113. Identify the element being oxidized in the following reaction.
    4Al + 3O$_2$ $\rightarrow$ 2Al$_2$O$_3$
    Ans: Al
    Category: Medium   Section: 4.4

114. Identify the element being reduced in the following reaction.
    4Al + 3O$_2$ $\rightarrow$ 2Al$_2$O$_3$
    Ans: O
    Category: Medium   Section: 4.4
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115. Identify the oxidizing agent in the following reaction.
   \[ 4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 \]
   Ans: \(\text{O}_2\)
   Category: Medium    Section: 4.4

116. Identify the reducing agent in the following reaction.
   \[ 4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 \]
   Ans: Al
   Category: Medium    Section: 4.4

117. Identify the element being oxidized in the following reaction.
   \[ 2\text{KBr} + \text{F}_2 \rightarrow \text{Br}_2 + 2\text{KF} \]
   Ans: Br
   Category: Medium    Section: 4.4

118. Identify the element being reduced in the following reaction.
   \[ 2\text{KBr} + \text{F}_2 \rightarrow \text{Br}_2 + 2\text{KF} \]
   Ans: F
   Category: Medium    Section: 4.4

119. Identify the oxidizing agent in the following reaction.
   \[ 2\text{KBr} + \text{F}_2 \rightarrow \text{Br}_2 + 2\text{KF} \]
   Ans: F\(_2\)
   Category: Medium    Section: 4.4

120. Identify the reducing agent in the following reaction.
   \[ 2\text{KBr} + \text{F}_2 \rightarrow \text{Br}_2 + 2\text{KF} \]
   Ans: Br\(^-\) (or KBr)
   Category: Medium    Section: 4.4

121. Determine the oxidation number of each of the elements BaNaPO\(_4\)?
   Ans: the oxidation number of Ba is +2; the oxidation number of Na is +1; the oxidation number of P is +5; the oxidation number of O is –2
   Category: Easy    Section: 4.4

122. Determine the oxidation number of each of the elements in K\(_2\)TaF\(_7\)?
   Ans: the oxidation number of K is +1; the oxidation number of Ta is +5; the oxidation number of F is –1
   Category: Easy    Section: 4.4

123. Thorium metal is prepared by reacting thorium oxide with calcium.
   \[ \text{ThO}_2 + 2\text{Ca} \rightarrow \text{Th} + 2\text{CaO} \]
   Which substance is reduced in this process?
   Ans: Th\(^{1+}\) is reduced
   Category: Medium    Section: 4.4
124. Thorium metal is prepared by reacting thorium oxide with calcium.
\[ \text{ThO}_2 + 2\text{Ca} \rightarrow \text{Th} + 2\text{CaO} \]
What is the reducing agent in this process?
Ans: Ca
Category: Medium     Section: 4.4

125. Thorium metal is prepared by reacting thorium oxide with calcium.
\[ \text{ThO}_2 + 2\text{Ca} \rightarrow \text{Th} + 2\text{CaO} \]
Which substance is oxidized in this process?
Ans: Ca
Category: Medium     Section: 4.4

126. Thorium metal is prepared by reacting thorium oxide with calcium.
\[ \text{ThO}_2 + 2\text{Ca} \rightarrow \text{Th} + 2\text{CaO} \]
What is the oxidizing agent in this process?
Ans: ThO$_4$
Category: Medium     Section: 4.4

127. Batteries in our cars generate electricity by the following chemical reaction.
\[ \text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O} \]
Which substance is reduced in this process?
Ans: Pb$^{4+}$
Category: Medium     Section: 4.4

128. Batteries in our cars generate electricity by the following chemical reaction.
\[ \text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O} \]
What is the reducing agent in this process?
Ans: Pb
Category: Medium

129. Batteries in our cars generate electricity by the following chemical reaction.
\[ \text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O} \]
Which substance is oxidized in this process?
Ans: Pb
Category: Medium     Section: 4.4

130. Batteries in our cars generate electricity by the following chemical reaction.
\[ \text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O} \]
What is the oxidizing agent in this process?
Ans: PbO$_2$
Category: Medium     Section: 4.4
131. Describe the procedure used to make 3.0 liters of a 2.0 M KCl solution, starting with solid KCl and water.
   Ans: Determine the molar mass of KCl, which is 74.55 g/mol; weigh out 447.3 grams (6 mol) of KCl; dissolve the KCl in enough water to form exactly 3 liters of solution.
   Category: Medium     Section: 4.5

132. What is the molarity of a solution that contains 5.0 moles of solute in 2.00 liters of solution?
   Ans: 2.5 M
   Category: Easy     Section: 4.5

133. The solubility of Ba(NO$_3$)$_2$ is 130.5 grams per liter at 0°C. How many moles of dissolved salt are present in 4.0 liters of a saturated solution of Ba(NO$_3$)$_2$ at 0°C?
   Ans: 2.0 moles
   Category: Medium     Section: 4.5

134. What is the molar concentration of chloride ions in a solution prepared by mixing 100. mL of 2.0 M KCl with 50. mL of a 1.5 M CaCl$_2$ solution?
   Ans: 2.3 M
   Category: Difficult

135. What volume of concentrated nitric acid (15.0 M) is required to make 100. mL of a 3.0 M nitric acid solution?
   Ans: 20. mL
   Category: Medium     Section: 4.5

136. During a titration the following data were collected. A 10. mL portion of an unknown monoprotic acid solution was titrated with 1.0 M NaOH; 40. mL of the base were required to neutralize the sample. What is the molarity of the acid solution?
   Ans: 4.0 M
   Category: Medium     Section: 4.7

137. During a titration the following data were collected. A 10. mL portion of an unknown monoprotic acid solution was titrated with 1.0 M NaOH; 40. mL of the base were required to neutralize the sample. How many moles of acid are present in 2.0 liters of this unknown solution?
   Ans: 8.0 moles
   Category: Medium     Section: 4.7

138. If 145 grams of potassium nitrate were added to water to make 1,500 mL of solution, what would be the molarity of the resulting solution?
   Ans: 0.956 M
   Category: Medium     Section: 4.5
139. During a titration the following data were collected. A 50.0 mL portion of an HCl solution was titrated with 0.500 M NaOH; 200. mL of the base was required to neutralize the sample. How many grams of HCl are present in 500. mL of this acid solution?
   Ans: 36.5 g
   Category: Medium   Section: 4.7

140. Identify the following as either a good or poor conductor of electricity: a crystal of Na₂SO₄.
   Ans: poor
   Category: Easy   Section: 4.1

141. Identify the following as either a good or poor conductor of electricity: an aqueous solution of Na₂SO₄.
   Ans: good
   Category: Easy   Section: 4.1

142. Identify the following as either a good or poor conductor of electricity: gasoline (C₈H₁₈).
   Ans: poor
   Category: Easy   Section: 4.1

143. Which substance is acting as a Brønsted acid in the following reaction?
   HSO₄⁻ + NH₄⁺ → H₂SO₄ + NH₃
   Ans: NH₄⁺
   Category: Medium   Section: 4.3

144. Identify the Brønsted acid in the following reaction.
   NH₃ + H₂O → NH₄⁺ + OH⁻
   Ans: H₂O
   Category: Medium   Section: 4.3

145. Write balanced molecular and net ionic equations for the reaction that would occur between CaCl₂(aq) and Na₂CO₃(aq). Be sure to include the correct states in your final equations. If no reaction is expected, write “no reaction.”
   Ans: Molecular equation: CaCl₂(aq) + Na₂CO₃(aq) → CaCO₃(s) + 2NaCl(aq)
        Net ionic equation: Ca²⁺(aq) + CO₃²⁻(aq) → CaCO₃(s)
   Category: Medium   Section: 4.2

146. Write balanced molecular and net ionic equations for the acid-base neutralization reaction between H₃PO₄(aq) and Ba(OH)₂(aq). Be sure to include the correct states in your final equations. If no reaction is expected, write “no reaction.”
   Ans: Molecular equation: 2H₃PO₄(aq) + 3Ba(OH)₂(aq) → Ba₃(PO₄)₂(s) + 6H₂O(l)
        Net ionic equation: 2H₃PO₄(aq) + 3Ba²⁺(aq) + 6OH⁻(aq) → Ba₃(PO₄)₂(s) + 6H₂O(l)
   Category: Difficult   Section: 4.3
147. Write balanced molecular and net ionic equations for the reaction that would occur between Al(s) and Co(NO₃)₂(aq). Be sure to include the correct states in your final equations. If no reaction is expected, write “no reaction.”
   Ans: Molecular equation: 2Al(s) + 3Co(NO₃)₂(aq) → 2Al(NO₃)₃(aq) + 3Co(s)
       Net ionic equation: 2Al(s) + 3Co²⁺(aq) → 2Al³⁺(aq) + 3Co(s)
   Category: Medium   Section: 4.4

148. Write balanced molecular and net ionic equations for the reaction that would occur between CuCl₂(aq) and Pb(s). Be sure to include the correct states in your final equations. If no reaction is expected, write “no reaction.”
   Ans: Molecular equation: CuCl₂(aq) + Pb(s) → Cu(s) + PbCl₂(s)
       Net ionic equation: Cu²⁺(aq) + 2Cl⁻(aq) + Pb(s) → Cu(s) + PbCl₂(s)
   Category: Difficult   Section: 4.4

149. A piece of copper metal was added to an aqueous solution of silver nitrate, and within a few minutes it was observed that a grey crystalline solid formed on surface of the copper and the solution turned a blue color characteristic of copper(II) ions. Write the balanced chemical equation for this reaction.
   Ans: Cu(s) + 2AgNO₃(aq) → 2Ag(s) + Cu(NO₃)₂(aq)
   Category: Medium   Section: 4.4

150. A piece of copper metal was added to an aqueous solution of silver nitrate, and within a few minutes it was observed that a grey crystalline solid formed on surface of the copper and the solution turned a blue color characteristic of copper(II) ions. Write the net ionic equation for this reaction.
   Ans: Cu(s) + 2Ag⁺(aq) → Cu²⁺(aq) + 2Ag(s)
   Category: Medium   Section: 4.4

151. A piece of lead metal was added to an aqueous solution of copper(II) nitrate, and within a few minutes it was observed that the lead turned black and crumbled, and the blue solution characteristic of copper(II) ions faded. (NOTE: Lead forms a 2+ ion when it reacts.) Write the balanced chemical equation for this reaction.
   Ans: Pb(s) + Cu(NO₃)₂(aq) → Cu(s) + Pb(NO₃)₂(aq)
   Category: Medium   Section: 4.4

152. A piece of lead metal was added to an aqueous solution of copper(II) nitrate, and within a few minutes it was observed that the lead turned black and crumbled, and the blue solution characteristic of copper(II) ions faded. (NOTE: Lead forms a 2+ ion when it reacts.) Write the net ionic equation for this reaction.
   Ans: Pb(s) + Cu²⁺(aq) → Pb²⁺(aq) + Cu(s)
   Category: Medium   Section: 4.4
153. A piece of zinc metal was added to an aqueous solution of lead(II) nitrate. After some time it was observed that the zinc metal had appeared to fall apart and a solid had accumulated at the bottom of the reaction vessel.
Write the balanced chemical equation for this reaction.
Ans: Zn(s) + Pb(NO\textsubscript{3})\textsubscript{2}(aq) → Pb(s) + Zn(NO\textsubscript{3})\textsubscript{2}(aq)
Category: Difficult Section: 4.4

154. A piece of zinc metal was added to an aqueous solution of lead(II) nitrate. After some time it was observed that the zinc metal had appeared to fall apart and a solid had accumulated at the bottom of the reaction vessel.
Write the net ionic equation for this reaction.
Ans: Zn(s) + Pb\textsuperscript{2+}(aq) → Zn\textsuperscript{2+}(aq) + Pb(s)
Category: Difficult Section: 4.4

155. The following experiments were carried out and observations recorded.

Expt. #1: copper metal was added to an aqueous solution of silver nitrate
Observation: The copper become coated with a substance.
Expt. #2: lead metal was added to an aqueous solution of copper(II) nitrate
Observation: The lead turned black and crumbled.
Expt. #3: zinc metal was added to an aqueous solution of lead(II) nitrate
Observation: The zinc appeared to fall apart.

Rank the metals from most active to least active.
Ans: most active Zn, next most active Pb, next most active Cu, least active Ag
Category: Difficult Section: 4.4

156. Write a balanced molecular equation for the reaction that occurs when aqueous solutions of potassium iodide and lead(II) nitrate are combined.
Ans: 2KI(aq) + Pb(NO\textsubscript{3})\textsubscript{2}(aq) → PbI\textsubscript{2}(s) + 2KNO\textsubscript{3}(aq)
Category: Medium Section: 4.2

157. If 73.5 mL of 0.200 M KI(aq) was required to precipitate all of the lead(II) ion from an aqueous solution of lead(II) nitrate, how many moles of Pb\textsuperscript{2+} were originally in the solution?
Ans: 7.35 \times 10^{-3} moles of Pb\textsuperscript{2+}
Category: Medium Section: 4.6

158. Sugar dissolves in water, therefore it is a strong electrolyte.
Ans: False Category: Medium Section: 4.1

159. Silver chloride (AgCl) has an extremely low solubility in water; therefore, it is a weak electrolyte.
Ans: False Category: Medium Section: 4.1
160. Most compounds containing chlorides, bromides, and iodides are soluble except those containing Ag\(^+\), Hg\(2^+\), and Pb\(^2+\).
   Ans: True     Category: Easy     Section: 4.2

161. The following reaction is an acid-base neutralization reaction.
   \[ \text{H}_2\text{SO}_4(aq) + \text{CaBr}_2(aq) \rightarrow \text{CaSO}_4(s) + 2\text{HBr}(g) \]
   Ans: False     Category: Easy     Section: 4.3

162. The oxidation number of N in NO is +7.
   Ans: False     Category: Easy     Section: 4.4

163. Hydrogen is oxidized in the following chemical reaction.
   \[ \text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl} \]
   Ans: True     Category: Medium     Section: 4.4

164. The following equation is an example of a net ionic equation.
   \[ \text{Na}^+(aq) + \text{Br}^–(aq) + \text{Ag}^+(aq) + \text{NO}_3^–(aq) \rightarrow \text{AgBr}(s) + \text{Na}^+(aq) + \text{NO}_3^–(aq) \]
   Ans: False     Category: Medium     Section: 4.2

165. The oxidation number of iodine increases by 6 in the following reaction.
   \[ 2\text{MnO}_4^– + \Gamma + \text{H}_2\text{O} \rightarrow 2\text{MnO}_2 + \text{IO}_3^– + 2\text{OH}^– \]
   Ans: True     Category: Medium     Section: 4.4

166. A weak acid or a weak base ionizes completely.
   Ans: False     Category: Medium     Section: 4.4

167. The following reaction is a redox reaction.
   \[ \text{CaC}_2(s) + \text{H}_2\text{O}(l) \rightarrow \text{HCCH}(g) + \text{CaO}(s) \]
   Ans: False     Category: Medium     Section: 4.4