

**9.1 (12, 103 and 107) Electrolytes****9.2 (15, 21, 23, 25, 93 and 97)****9.3 (27, 31, 33, 35, 101, 105 and 111)****9.4 (45,47,49 and 51)****8.2 (17, 19, 21 and 65)**

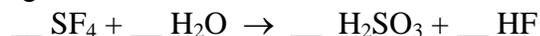
More Stoichiometry practice

1. A laboratory method of preparing O<sub>2</sub> involves the decomposition of KClO<sub>3</sub> as seen by the following reaction. If a 12.8 g sample of KClO<sub>3</sub> is decomposed. How many grams of KCl can be produced?

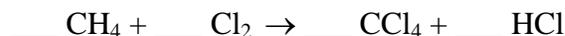


2. Refer to the (unbalanced) equation  $\text{CS}_2 + \text{CaO} \rightarrow \text{CO}_2 + \text{CaS}$
- Balance this equation.
  - How many moles of CO<sub>2</sub> can be obtained from the reaction of 4 moles of CS<sub>2</sub>?
  - How many moles of CaO are consumed if 0.3 mole CS<sub>2</sub> reacts?
  - How many grams of CaS are produced if 53 g of CO<sub>2</sub> are produced?
  - How many grams of CaO are required to react completely with 38 g of CS<sub>2</sub>?
3. Using the (unbalanced) equation shown below, how many grams of ammonia will be formed if 75 grams of nitrogen reacts with excess hydrogen?
- $$\text{H}_2 + \text{N}_2 \rightarrow \text{NH}_3$$

4. Balance the following equation using the smallest set of whole numbers, then add together the coefficients. Don't forget to count coefficients of one. The sum of the coefficients is



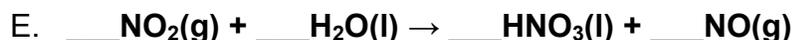
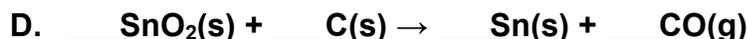
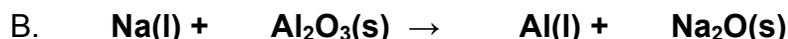
5. Balance the following equation using the smallest set of whole numbers, then add together the coefficients. Don't forget to count coefficients of one. The sum of the coefficients is



6. What is the coefficient of O<sub>2</sub> when the following equation is properly balanced with the smallest set of whole numbers?



7. Balance the following reactions



8. When a chemist mixed 0.334 L of 0.112 M sodium chloride with 2.12 L of 0.0343 M lead(II) nitrate, 4.98 g of lead(II) chloride was isolated. Calculate the % yield.

1. What is the difference between a nonelectrolyte and an electrolyte?

- A nonelectrolyte is ionic in nature, while an electrolyte is molecular
- An aqueous solution of an electrolyte will conduct electricity, while a solution of a nonelectrolyte will not.
- An electrolyte is basic in aqueous solution, while a nonelectrolyte is acidic.
- An electrolyte contains chloride atoms, while a nonelectrolyte contains carbon atoms.

2. What property of water enables its molecules to interact with ions in solution?
- Water is a polarized compound and can hydrate both positive and negative ions.
  - The low molecular weight of water enables it to interact with ions in solution.
  - Water is ionic and therefore interacts with ions in solution.
  - Water's high boiling point enables it to interact with ions in solution.
3. Lithium fluoride (LiF) is a strong electrolyte. What species are present in LiF(aq)?
4. Explain why a solution of HCl in benzene does not conduct electricity but in water it does.
5. What is the difference between an ionic equation and a molecular equation?
- An ionic equation is not balanced, while a molecular equation is balanced.
  - A molecular equation represents only molecular compounds, while an ionic equation represents only ionic compounds.
  - A molecular equation shows spectator ions while an ionic equation does not.
  - An ionic equation shows all compounds dissociated as ions, while a molecular equation represents all compounds as associated.
6. Using solubility rules, which of the following methods would separate  $K^+$  from  $Ag^+$ ? All cations are assumed to be in aqueous solution, and the common anion is the nitrate ion.
- Add chlorate ions.
  - Add nitrate ions
  - Add sugar
  - Add Chloride ions
7. Which of the following compounds is soluble in water?
- $CaCO_3$
  - $Mn(OH)_2$
  - $AgClO_3$
  - $Ba(OH)_2$
8. Which of the following compounds is soluble in water?
- $Ca_3(PO_4)_2$
  - $BaSO_4$
  - $CaCO_3$
  - $K_2S$
9. Which of the following compounds is not soluble in water?
- $NH_4ClO_4$
  - $Mn(OH)_2$
  - $K_2S$
  - $AgClO_3$
10. Which of the following processes will likely result in a precipitation reaction?
- Mixing a  $NaNO_3$  solution with a  $CuSO_4$  solution.
  - Mixing a  $BaCl_2$  solution with a  $K_2SO_4$  solution.
  - Mixing a  $NaCl$  solution with a  $K_2SO_4$  solution.
  - Mixing a  $KF$  solution with a  $KCl$  solution.
11. With reference to the solubility table, which of the following methods would separate  $Ag^+$  from  $Pb^{2+}$ ? All cations are assumed to be in aqueous solution, and the common anion is the nitrate ion.
- Add iodide ions.
  - Add sulfate ions
  - Add sugar
  - Add nitrate ions
12. Calculate the mass of the precipitate formed when 2.27 L of 0.0820 M  $Ba(OH)_2$  are mixed with 3.06 L of 0.0664 M  $Na_2SO_4$ .
13. Which of the following is the correct *net ionic equation* for the reaction that occurs when solutions of  $Pb(NO_3)_2$  and  $NH_4Cl$  are mixed?
- $Pb(NO_3)_2(aq) + 2NH_4Cl(aq) \rightarrow NH_4NO_3(aq) + PbCl_2(s)$
  - $Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$
  - $Pb^{2+}(aq) + 2NO_3^-(aq) + 2NH_4^+(aq) + 2Cl^-(aq) \rightarrow 2NH_4^+(aq) + 2NO_3^-(aq) + PbCl_2(s)$
  - $NH_4^+(aq) + NO_3^-(aq) \rightarrow 2NH_4NO_3(s)$
  - No reaction occurs when the solutions are mixed.

14. 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.
15. What mass of  $\text{Li}_3\text{PO}_4$  is needed to prepare 500.0 mL of a solution having a lithium ion concentration of 0.175 M?
16. 17.5 mL of a 0.1050 M  $\text{Na}_2\text{CO}_3$  solution is added to 46.0 mL of 0.1250 M  $\text{NaCl}$ . What is the concentration of sodium ion in the final solution?
17. 25.0 mL of a 0.2450 M  $\text{NH}_4\text{Cl}$  solution is added to 55.5 mL of 0.1655 M  $\text{FeCl}_3$ . What is the concentration of chloride ion in the final solution?
18. When 38.0 mL of 0.1250 M  $\text{H}_2\text{SO}_4$  is added to 100. mL of a solution of  $\text{PbI}_2$ , a precipitate of  $\text{PbSO}_4$  forms. The  $\text{PbSO}_4$  is then filtered from the solution, dried, and weighed. If the recovered  $\text{PbSO}_4$  is found to have a mass of 0.0471 g, what was the concentration of iodide ions in the original solution?
19. When 50.0 mL of a 0.3000 M  $\text{AgNO}_3$  solution is added to 50.0 mL of a solution of  $\text{MgCl}_2$ , an  $\text{AgCl}$  precipitate forms immediately. The precipitate is then filtered from the solution, dried, and weighed. If the recovered  $\text{AgCl}$  is found to have a mass of 0.1183 g, what was the concentration of magnesium ions in the original  $\text{MgCl}_2$  solution?
20. When 20.0 mL of a 0.250 M  $(\text{NH}_4)_2\text{S}$  solution is added to 150.0 mL of a solution of  $\text{Cu}(\text{NO}_3)_2$ , a  $\text{CuS}$  precipitate forms. The precipitate is then filtered from the solution, dried, and weighed. If the recovered  $\text{CuS}$  is found to have a mass of 0.3491 g, what was the concentration of copper ions in the original  $\text{Cu}(\text{NO}_3)_2$  solution?
21. If 30.0 mL of 0.150 M  $\text{CaCl}_2$  is added to 15.0 mL of 0.100 M  $\text{AgNO}_3$ , what is the mass in grams of  $\text{AgCl}$  precipitate?
22. A sample of 0.6760 g of an unknown compound containing barium ions ( $\text{Ba}^{2+}$ ) is dissolved in water and treated with an excess of  $\text{Na}_2\text{SO}_4$ . If the mass of the  $\text{BaSO}_4$  precipitate formed is 0.4105 g, what is the percent by mass of Ba in the original unknown compound?
23. How many grams of  $\text{NaCl}$  are required to precipitate most of the  $\text{Ag}^+$  ions from  $2.50 \times 10^2$  mL of 0.0113 M  $\text{AgNO}_3$  solution?
24. The concentration of  $\text{Cu}^{2+}$  ions in the water (which also contains sulfate ions) discharged from a certain industrial plant is determined by adding excess sodium sulfide ( $\text{Na}_2\text{S}$ ) solution to 0.800 L of the water. The molecular equation is:  **$\text{Na}_2\text{S}(\text{aq}) + \text{CuSO}_4(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{CuS}(\text{s})$**   
Calculate the molar concentration of  $\text{Cu}^{2+}$  in the water sample if 0.0177 g of solid  $\text{CuS}$  is formed.
25. The concentration of lead ions ( $\text{Pb}^{2+}$ ) in a sample of polluted water that also contains nitrate ions ( $\text{NO}_3^-$ ) is determined by adding solid sodium sulfate ( $\text{Na}_2\text{SO}_4$ ) to exactly 500 mL of the water. Calculate the molar concentration of  $\text{Pb}^{2+}$  if 0.00450 g of  $\text{Na}_2\text{SO}_4$  was needed for the complete precipitation of  $\text{Pb}^{2+}$  ions as  $\text{PbSO}_4$ .
27. A 0.8870-g sample of a mixture of  $\text{NaCl}$  and  $\text{NaNO}_3$  is dissolved in water, and the solution is then treated with an excess of  $\text{AgNO}_3$  to yield 1.913 g of  $\text{AgCl}$ . Calculate the percent by mass of the  $\text{NaCl}$  in the mixture.

28. A useful application of oxalic acid is the removal of rust ( $\text{Fe}_2\text{O}_3$ ) from, say, bathtub rings according to the reaction:  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{H}_2\text{C}_2\text{O}_4(\text{aq}) \rightarrow 2\text{Fe}(\text{C}_2\text{O}_4)_3^{3-}(\text{aq}) + 3\text{H}_2\text{O} + 6\text{H}^+(\text{aq})$

Calculate the number of grams of rust that can be removed by  $5.00 \times 10^2$  mL of a 0.100 M solution of oxalic acid.

29. Which of the following is a weak acid?

A.  $\text{HNO}_3$

B.  $\text{HCOOH}$

C.  $\text{NH}_3$

D.  $\text{HBr}$

30. Which of the following is not both – a Brønsted acid and a Brønsted base (amphoteric)?

A.  $\text{HCO}_3^-$

B.  $\text{PO}_4^{2-}$

C.  $\text{HPO}_4^{2-}$

D.  $\text{HSO}_4^-$

31. Calculate the volume in mL of a 1.420 M NaOH solution required to titrate 25.00 mL of a 2.430 M HCl solution.

32. Calculate the volume in mL of a 1.420 M NaOH solution required to titrate 25.00 mL of a 4.500 M  $\text{H}_2\text{SO}_4$  solution.

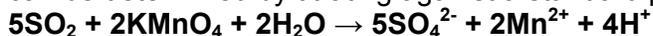
33. Calculate the concentration of the acid (or base) remaining in solution when 10.7 mL of 0.211 M  $\text{HNO}_3$  are added to 16.3 mL of 0.258 M NaOH.

34. Calculate the volume in mL of a 1.420 M NaOH solution required to titrate 25.00 mL of a 1.500 M  $\text{H}_3\text{PO}_4$  solution.

35. What volume of a 0.500 M HCl solution is needed to completely neutralize 10.0 mL of a 0.300 M NaOH solution?

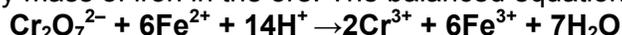
36. What volume of a 0.500 M HCl solution is needed to completely neutralize 10.0 mL of a 0.200 M  $\text{Ba}(\text{OH})_2$  solution?

37. The  $\text{SO}_2$  present in air is mainly responsible for the acid rain phenomenon. Its concentration can be determined by titrating against a standard permanganate solution as follows:

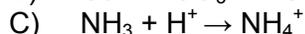
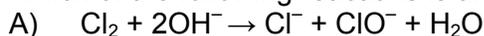


Calculate the number of grams of  $\text{SO}_2$  in a sample of air if 7.37 mL of 0.00800 M  $\text{KMnO}_4$  solution are required for the titration.

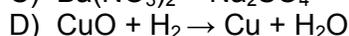
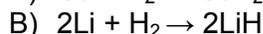
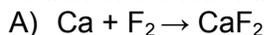
38. A sample of iron ore weighing 0.2792 g was dissolved in dilute acid solution, and all the Fe(II) was converted to Fe(III) ions. The solution required 23.30 mL of 0.0194 M  $\text{K}_2\text{Cr}_2\text{O}_7$  for titration. Calculate the percent by mass of iron in the ore. The balanced equation is:



39. Which of the following reactions is an acid/base reaction?



40. Which of the following reactions is a precipitation reaction?



41. Which of the following aqueous solutions would you expect to be the best conductor of electricity at 258° C?
- A. 0.20 M NaCl                      B. 0.60 M CH<sub>3</sub>COOH                      C. 0.25 M HCl                      D. 0.20 M Mg(NO<sub>3</sub>)<sub>2</sub>
42. A 5.00 x 10<sup>2</sup>-mL sample of 2.00 M HCl solution is treated with 4.47 g of magnesium. Calculate the concentration of the acid solution after all the metal has reacted. Assume that the volume remains unchanged.
43. Sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>) is available in very pure form and can be used to standardize acid solutions. What is the molarity of a HCl solution if 28.3 mL of the solution are required to react with 0.256 g of Na<sub>2</sub>CO<sub>3</sub>?
44. A 3.664-g sample of a monoprotic acid was dissolved in water. It took 20.27 mL of a 0.1578 M NaOH solution to neutralize the acid. Calculate the molar mass of the acid.
45. Acetic acid (CH<sub>3</sub>COOH) is an important ingredient of vinegar. A sample of 50.0 mL of commercial vinegar is titrated against a 1.00 M NaOH solution. What is the concentration (in M) of acetic acid present in the vinegar if 5.75 mL of the base are needed for the titration?
46. Milk of magnesia is an aqueous suspension of magnesium hydroxide [Mg(OH)<sub>2</sub>] used to treat acid indigestion. Calculate the volume of a 0.035 M HCl solution (a typical acid concentration in an upset stomach) needed to react with two spoonfuls (approximately 10 mL) of milk of magnesia [at 0.080 g Mg(OH)<sub>2</sub>/mL].
47. Ammonium nitrate (NH<sub>4</sub>NO<sub>3</sub>) is one of the most important nitrogen-containing fertilizers. Its purity can be analyzed by titrating a solution of NH<sub>4</sub>NO<sub>3</sub> with a standard NaOH solution. In one experiment a 0.2041-g sample of industrially prepared NH<sub>4</sub>NO<sub>3</sub> required 24.42 mL of 0.1023 M NaOH for neutralization. What is the percent purity of the sample?
48. What is the oxidation number for each of the elements in Cs<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> ?
49. Identify the element being oxidized, the element being reduced, the oxidizing agent, and the reducing agent in the following reactions: **4Al + 3 O<sub>2</sub> → 2 Al<sub>2</sub>O<sub>3</sub>**
50. Identify the element being oxidized, the element being reduced, the oxidizing agent, and the reducing agent in the following reaction: **2KBr + F<sub>2</sub> → Br<sub>2</sub> + 2KF**
51. What is the oxidation number of each of the elements in BaNaPO<sub>4</sub>?
52. For the following reaction: 4Na(s) + O<sub>2</sub>(g) → 2Na<sub>2</sub>O(s), which species is the oxidizing agent?
- A. Na                      B. O<sub>2</sub>                      C. Na<sub>2</sub>O                      D. This is not a redox reaction
53. Each of the following species, H<sub>2</sub>, Se<sub>8</sub>, P<sub>4</sub>, O, U, As<sub>4</sub>, B<sub>12</sub>, has the same oxidation number. What is it?

54. Arrange the following species in order of increasing oxidation number of the sulfur atom:  
 (a) H<sub>2</sub>S, (b) S<sub>8</sub>, (c) H<sub>2</sub>SO<sub>4</sub>, (d) S<sup>2-</sup>.

55. 2.386 g of a compound containing only Carbon, Hydrogen and Oxygen undergoes combustion analysis to produce 5.77 g CO<sub>2</sub> and 2.14 g H<sub>2</sub>O. What is the empirical formula of this compound?

56. Vitamin C is essential for the prevention of scurvy. Combustion of a 2.00 gram sample of this Carbon, Hydrogen and Oxygen containing compound yields 2.998 g CO<sub>2</sub> and 0.819 g H<sub>2</sub>O. What is the empirical formula and percent composition of Vitamin C?

57. An 0.1888-g sample of a hydrocarbon produces 0.6270 g of CO<sub>2</sub> and 0.1602 g H<sub>2</sub>O in combustion analysis. Its molar mass is found to be 106 g/mol. For this hydrocarbon, determine  
 A) Its percent composition; B) Its empirical formula and C) its molecular formula

58. Para-cresol is used as a disinfectant and in the manufacture of herbicides and artificial food flavors. A 0.4039-g sample of this carbon-hydrogen-oxygen containing compound yields 1.1518 g CO<sub>2</sub> and 0.2694 g H<sub>2</sub>O. What is the empirical formula of para-cresol?

**Answers:**

1. 7.79g KCl      2. a.  $\text{CS}_2 + 2\text{CaO} \rightarrow \text{CO}_2 + 2\text{CaS}$       b. 4 moles  
 c. 0.6 mole      d. 170 g      e. 56 g      3. 91 g  
 4. 9      5. 10      6. 3  
 7. A.  $5\text{NaN}_3(\text{s}) + \text{NaNO}_3(\text{aq}) \rightarrow 3\text{Na}_2\text{O}(\text{s}) + 8\text{N}_2(\text{g})$   
 B.  $6\text{Na}(\text{l}) + \text{Al}_2\text{O}_3(\text{s}) \rightarrow 2\text{Al}(\text{l}) + 3\text{Na}_2\text{O}(\text{s})$   
 C.  $3\text{H}_2(\text{g}) + \text{WO}_3(\text{s}) \rightarrow 3\text{H}_2\text{O}(\text{g}) + \text{W}(\text{s})$   
 D.  $\text{SnO}_2(\text{s}) + 2\text{C}(\text{s}) \rightarrow \text{Sn}(\text{s}) + 2\text{CO}(\text{g})$   
 E.  $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{l}) + \text{NO}(\text{g})$   
 8. 37. 95.8%  
 1. B      2. A      3. Li<sup>+</sup> and F<sup>-</sup>      4. HCl is dissociated to H<sup>+</sup> and Cl<sup>-</sup> ions in water; it does not dissociate in benzene.      5. D      6. D  
 7. C      8. D      9. B      10. B      11. B  
 12. 43.4 g      13. B      14.  $2\text{Fe}^{3+}(\text{aq}) + 3\text{S}^{2-}(\text{aq}) \rightarrow \text{Fe}_2\text{S}_3(\text{s})$       15. 3.38 g  
 16. 0.148 M      17. 0.418 M      18.  $3.11 \times 10^{-3}$  M      19.  $8.25 \times 10^{-3}$  M      20.  $2.43 \times 10^{-2}$  M  
 21. 0.215 g      22. 35.72 %      23. 0.165 g      24.  $2.31 \times 10^{-4}$  M      25.  $6.34 \times 10^{-5}$  M  
 26. 0.231 mg/mL      27. 87.87 %      28. 2.66 g  
 29. B      30. B      31. 42.78 mL  
 32. 158.5 mL      33. 0.0722 M NaOH      34. 79.23 mL  
 35. 6.00 mL      36. 8.00 mL      37.  $9.43 \times 10^{-3}$  g  
 38. 54.1%      39. C      40. C  
 41. D      42. 1.26 M      43. 0.171 M  
 44. 1145 g/mol      45. 0.115 M      46. 0.80 L  
 47. 97.99 %      48. Cs,+1; Cr,+6; O, -2  
 49. Al is oxidized, O<sub>2</sub> is reduced, Al is the reducing agent, O<sub>2</sub> is the oxidizing agent  
 50. Br is oxidized, F is reduced, Br<sup>-</sup> is the reducing agent, F<sub>2</sub> is the oxidizing agent  
 51. Ba,+2; Na, +1; P, +5; O, -2      52. B      53. 0  
 54. (a) = (d) < (b) < (c)  
 55. C<sub>11</sub>H<sub>20</sub>O<sub>3</sub>      56. C<sub>3</sub>H<sub>4</sub>O<sub>3</sub>/      40.91% C 4.58% H and 54.51% O  
 57. A) 90.56% C 9.44% H      b) C<sub>4</sub>H<sub>5</sub>      C) C<sub>8</sub>H<sub>10</sub>      58. C<sub>7</sub>H<sub>8</sub>O