Foundations of Chemistry – Unit Practice Problems – Solutions

Naming Compounds

1. Name the following ionic compounds:
   a. ammonium chloride
   b. iron(III) nitride
   c. titanium(III) bromide
   d. magnesium oxide
   e. copper(I) phosphide
   f. tin(IV) selenide
   g. gallium arsenide
   h. lead(IV) sulfate
   i. manganese(III) sulfite
   j. aluminum cyanide
   k. sodium bromide
   l. scandium hydroxide
   m. vanadium(III) carbonate
   n. calcium bicarbonate
   o. nickel(III) phosphate
   p. zinc phosphide
   q. strontium acetate
   r. copper(I) oxide
   s. silver phosphate
   t. potassium permanganate
   u. lead(II) nitride
   v. cobalt(II) carbonate
   w. cadmium sulfide
   x. copper(II) nitrite
   y. lithium nitrate

2. Write the formula for the following ionic compounds:
   a. NaF
   b. LiI
   c. Ag_2O
   d. Pb_3N_2
   e. $Cr(PO_4)_2$
   f. $MgCO_3$
   g. $Sn(NO_3)_2$
   h. Co_2O_3
   i. $Ti(C_2H_3O_2)_2$
   j. $Zn(OH)_2$
   k. $Fe_3(PO_4)_2$ iron(II) phosphate
   l. CaSe
   m. Mn_3As_7
   n. $(NH_4)_2SO_4$
   o. Sr_3P_2
   p. $AlCl_3$
   q. $CuNO_3$
   r. PbO_2
   s. $CaBr_2$
   t. $Al_2(Cr_2O_7)_3$
   u. AgCN
   v. $(NH_4)_2S$

3. Name the following covalent compounds:
   a. Carbon monoxide
   b. diphosphorus pentoxide
   c. ammonia
   d. silicon dioxide
   e. nitrogen gas
   f. dicarbon hexabromide
   g. iodine dioxide
   h. carbon tetrachloride
   i. dinitrogen trioxide

4. Write the formula for the following covalent compounds:
   a. P_4Se_3
   b. Si_2Br_6
   c. Se_2I_2
   d. S_4N_2
   e. H_2
   f. SiO2
   g. B_2Br_4
   h. XeF_6
   i. N_2O_3
   j. CH_4

5. Name the following compounds:
   a. cobalt(II) fluoride
   b. phosphorus trichloride
   c. strontium nitride
   d. sodium sulfide
   e. silver chloride
   f. aluminum bromide
   g. diphosphorus pentoxide
   h. potassium nitride
   i. aluminum sulfate
   j. iron(II) oxide
   k. dinitrogen trioxide
   l. copper(I) sulfide
   m. ammonium fluoride
   n. iron(III) oxide
   o. barium nitrate
   p. copper(I) nitrate
   q. zinc acetate
   r. lead(II) chromate
   s. iron(III) dichromate

6. Write the formula for the following compounds:
   a. $BaBr_2$
   b. FeO
   c. Na_3PO_4
   d. $Ni(ClO_3)_2$
   e. N_2Cl_4
   f. CaS
   g. CuF_2
   h. $SrSO_4$
   i. $Co(NO_3)_2$
   j. LiI
   k. CoS
   l. $Ca(C_2H_3O_2)_2$
   m. CO_2
   n. $Cr_2(SO_4)_3$
   o. PCl_3
   p. Mg_3N_2
   q. Cl_2O
   r. PCl_5
   s. $Mn_3(PO_4)_7$

Writing and Balancing Equations

7. Use the following equation to answer the questions:

$$Mg\ (s) + 2\ HNO_3\ (aq) \rightarrow Mg(NO_3)_2\ (aq) + H_2\ (g)$$

   a. Hydrogen (H_2) is a gas.
   b. magnesium nitrate and hydrogen gas
   c. 2
   d. 6

8. Something that is aqueous means it is dissolved in water. The individual particles have broken apart (into ions or molecules) and are dispersed throughout the water to make a solution. A liquid substance does not contain water. It is just the original substance in liquid form, and the particles do not break apart.
   For example, aqueous sodium chloride is sodium and chloride ions dissolved into a solution (salt water) and liquid sodium chloride is salt that has been heated so hot that it melts.

9. For each statement:
   a. Write a word equation.
   b. Write a chemical equation, including states.
   c. Balance the equation.

   i. $Pb(NO_3)_2\ (aq) + 2\ NaI\ (aq) \longrightarrow PbI_2\ (s) + 2\ NaNO_3\ (aq)$ ii. $2\ H_2O_2\ (l) \longrightarrow 2\ H_2O\ (l) + O_2\ (g)$ iii. $C_4H_{10}\ (l) + 13/2\ O_2\ (g) \longrightarrow 4\ CO_2\ (g) + 5\ H_2O\ (l)$

   OR

   $2\ C_4H_{10}\ (l) + 13\ O_2\ (g) \longrightarrow 8\ CO_2\ (g) + 10\ H_2O\ (l)$

10. Balance the following equations:
    a. $1\ Na_3PO_4 + 3\ KOH \rightarrow 3\ NaOH + 1\ K_3PO_4$

b. $1\ CF_4 + 2\ Br_2 \rightarrow 1\ CBr_4 + 2\ F_2$
c. $2\ HCN + 1\ CuSO_4 \rightarrow 1\ H_2SO_4 + 1\ Cu(CN)_2$
d. $1\ P_4 + 3\ O_2 \rightarrow 2\ P_2O_3$
e. $1\ CH_4 + 2\ O_2 \rightarrow 1\ CO_2 + 2\ H_2O$
f. $2\ Al + 6\ HCl \rightarrow 3\ H_2 + 2\ AlCl_3$
g. $1\ N_2 + 3\ F_2 \rightarrow 2\ NF_3$
h. $1\ SO_2 + 2\ Li_2Se \rightarrow 1\ SSe_2 + 2\ Li_2O$
i. $2\ NH_3 + 1\ H_2SO_4 \rightarrow 1\ (NH_4)_2SO_4$

Types of Reactions

11. For each of the following reactions:
    i. $1\ N_2 + 3\ F_2 \rightarrow 2\ NF_3$ (synthesis) nitrogen gas + fluorine gas ⟶ nitrogen trifluoride
    ii. $1\ C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12\ CO_2 + 11\ H_2O$ (combustion) sucrose + oxygen ⟶ carbon dioxide + water
    iii. $1\ MgF_2 + 1\ Li_2CO_3 \rightarrow 1\ MgCO_3 + 2\ LiF$ (double displacement) magnesium fluoride + lithium carbonate ⟶ magnesium carbonate + lithium fluoride
    iv. $3\ CuSO_4 + 2\ Fe \rightarrow 1\ Fe_2(SO_4)_3 + 3\ Cu$ (single displacement) copper(II) sulfate + iron ⟶ iron(II) sulfate + copper
    v. $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$ (decomposition) potassium chlorate ⟶ potassium chloride + oxygen gas

12. For each of the following reactions:
    i. magnesium + silver nitrate → silver + magnesium nitrate
    $Mg + 2\ AgNO_3 \longrightarrow 2\ Ag + Mg(NO_3)_2$ (single displacement)
    ii. lead(II) oxide → lead + oxygen
    $2\ PbO \longrightarrow 2\ Pb + O_2$ (decomposition) iii. aluminum chloride + sodium hydroxide → aluminum hydroxide + sodium chloride
    $AlCl_3 + 3\ NaOH \longrightarrow Al(OH)_3 + 3\ NaCl$ (double displacement)
    iv. sodium + oxygen → sodium oxide
    $4\ Na + O_2 \longrightarrow 2\ Na_2O$ (decomposition)
    v. ethane + oxygen → carbon dioxide + water
    $C_2H_6 + 7/2\ O_2 \longrightarrow 2\ CO_2 + 3\ H_2O$ (combustion) OR
    $2\ C_2H_6 + 7\ O_2 \longrightarrow 4\ CO_2 + 6\ H_2O$

13. A + BC → B + AC – if the element alone is more reactive than the element in the compound
14. For each reaction, determine if it will occur. If it will, write the correct products. If not, write "NR".

a. NR
b. $Zn + AgNO_3 \rightarrow Ag + Zn(NO_3)_2$
c. $2\ Al + 3\ H_2SO_4 \rightarrow 3\ H_2 + 2\ Al_2(SO_4)_3$
d. $Cl_2 + 2\ KI \rightarrow I_2 + 2\ KCl$
e. $2\ Li + 2\ H_2O \rightarrow H_2 + 2\ LiOH$
f. NR
g. $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$
h. $Fe + Pb(NO_3)_2 \rightarrow Fe(NO_3)_2 + Pb$
i. NR
j. NR
k. $2\ Al + 3\ Pb(NO_3)_2 \rightarrow 2\ Al(NO_3)_3 + 3\ Pb$
l. $Cl_2 + 2\ NaI \rightarrow I_2 + 2\ NaCl$
m. $Fe + AgC_2H_3O_2 \rightarrow Fe(C_2H_3O_2)_2 + Ag$
n. $2\ Al + 3\ CuCl_2 \rightarrow 2\ AlCl_3 + 3\ Cu$

o. $Br_2 + CaI_2 \rightarrow CaBr_2 + I_2$
p. $2\ Al + 6\ HCl \rightarrow 2\ AlCl_3 + 3\ H_2$
q. $Mg + 2\ HCl \rightarrow MgCl_2 + H_2$
r. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
s. $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
t. $Cl_2 + MgI_2 \rightarrow MgCl_2 + I_2$

15. Predict the products for each reaction. If the reaction will occur, write the formulas and balance each reaction. Otherwise, write "NR".
a. zinc + hydrogen chloride $Zn + 2\ HCl \rightarrow H_2 + ZnCl_2$
b. magnesium + hydrogen sulfate $Mg + H_2SO_4 \rightarrow H_2 + MgSO_4$
c. copper(II) chloride + fluorine $CuCl_2 + F_2 \rightarrow CuF_2 + Cl_2$
d. silver + sodium hydroxide NR
e. potassium iodide + bromine $2\ KI + Br_2 \rightarrow 2\ KBr + I_2$
f. calcium + hydrogen hydroxide $Ca + 2\ H_2O \rightarrow Ca(OH)_2 + H_2$
g. iron(III) oxide + hydrogen NR

Double Displacement Reactions

16. $AC + BD \rightarrow AD + BC$ – use solubility rules

17. If a solid is produced, or a gas is produced

18. Indicate whether each substance is soluble. If it is, write the dissociation equation.
a. insoluble
b. $KOH \rightarrow K^+ + OH^-$
c. $Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$
d. insolube
e. insoluble
f. $Ba(NO_3)_2 \rightarrow Ba^{2+} + 2\ NO_3^-$
g. $(NH_4)_3PO_4 \rightarrow 3\ NH_4^+ + PO_4^{3-}$
h. $MgBr_2 \rightarrow Mg^{2+} + 2\ Br^-$
i. $Sn(NO_3)_4 \rightarrow Sn^{4+} + 4\ NO_3^-$
j. insoluble

19. For each, write the molecular, total ionic and net ionic equations for the reaction. Remember that a complete equation includes coefficients, ion charges and states. Be sure to balance each reaction.
a. $SrBr_2\ (aq) + K_2SO_4\ (aq) \rightarrow SrSO_4\ (s) + 2KBr\ (aq)$
$Sr^{2+} + 2Br^- + 2K^+ + SO_4^{2-} \rightarrow SrSO_4\ (s) + 2K^+ + 2Br^-$
$Sr^{2+}\ (aq) + SO_4^{2-}\ (aq) \rightarrow SrSO_4\ (s)$
b. $AgNO_3\ (aq) + KCl\ (aq) \rightarrow AgCl\ (s) + KNO_3\ (aq)$
$Ag^+ + NO^{3-} + K^+ + Cl^- \rightarrow AgCl\ (s) + K^+ + 2\ NO_3^-$
$Ag^+\ (aq) + Cl^-\ (aq) \rightarrow AgCl\ (s)$
c. $Mg(NO_3)_2\ (aq) + Na_2CO_3\ (aq) \rightarrow MgCO_3\ (s) + 2NaNO_3\ (aq)$
$Mg^{2+} + 2NO_3^- + 2Na^+ + CO_3^{2-} \rightarrow MgCO_3\ (s) + 2Na^+ + 2NO_3^-$
$Mg^{2+}\ (aq) + CO_3^{2-}\ (aq) \rightarrow MgCO_3\ (s)$
d. $MnCl_2\ (aq) + (NH_4)_2CO_3\ (aq) \rightarrow MnCO_3\ (s) + 2NH_4Cl\ (aq)$
$Mn^{2+} + 2Cl^- + 2NH_4^+ + CO_3^{2-} \rightarrow MnCO_3\ (s) + 2NH_4^+ + 2Cl^-$
$Mn^{2+}\ (aq) + CO_3^{2-}\ (aq) \rightarrow MnCO_3\ (s)$

20. For each pair of reactants, write the two possible products, then use the solubility rules to determine if a precipitate will form. If a reaction will occur, write the balanced molecular
a. aluminum chloride (aq) + mercury(II) iodide (s)
$2\ AlI_3\ (aq) + 3\ HgCl_2\ (aq) \rightarrow 2\ AlCl_3\ (aq) + 3\ HgI_2\ (s)$
b. potassium nitrate (aq) + silver phosphate (s)
$3\ AgNO_3\ (aq) + K_3PO_4\ (aq) \rightarrow Ag_3PO_4\ (s) + 3KNO_3\ (aq)$
c. copper(II) chloride (aq) + aluminum bromide (aq)

d. calcium carbonate (s) + sodium acetate (aq)
$Ca(C_2H_3O_2)_2\,(aq) + Na_2CO_3\,(aq) \rightarrow CaCO_3\,(s) + 2NaC_2H_3O_2\,(aq)$
e. ammonium acetate (aq) + mercury(I) chloride (s)
$NH_4Cl\,(aq) + HgC_2H_3O_2\,(aq) \rightarrow NH_4C_2H_3O_2\,(aq) + HgCl\,(s)$
f. calcium chloride (aq) + hydrogen nitrate (aq)
g. iron(II) chloride (aq) + hydrogen sulfide (aq)
h. copper(II) acetate (aq) + water (l)
i. magnesium phosphate (s) + water (l)
$3Mg(OH)_2\,(aq) + 2H_3PO_4\,(aq) \rightarrow Mg_3(PO_4)_2\,(s) + 6H_2O\,(l)$
j. zinc hydroxide (s) + potassium bromide (aq)
$ZnBr_2\,(aq) + 2KOH\,(aq) \rightarrow Zn(OH)_2\,(s) + 2KBr\,(aq)$

Sources of Error in Measurement

21. Suppose you wanted to find the density of a solid chunk of metal. First, you find the mass of a metal on an electronic balance. Then, you fill a graduated cylinder half full and record the volume. You drop the piece of metal in and determine the volume by measuring the change in the water level. Density is then calculated by dividing mass by volume.
    a. Calibration of the scale, rounding on scale, metal must be pure, reading measurement on graduated cylinder (parallax error, error inherent in measurement, quality of glassware), possible splashing, metal must be solid (no air bubbles)
    b. Perform same calculation multiple times, repeat with multiple pieces of the same metal, use most accurate equipment possible, make volume readings multiple times

22. Write down the measurement, including units and uncertainty, for each device.
12.34 kg ± 0.005 kg 67°C ± 2.5°C 20.45°C ± 0.25°C

Molar Mass

23. Find the molar mass of each of the following compounds:
    a. 38.00 g/mol
    b. 56.11 g/mol
    c. 162.20 g/mol
    d. 132.17 g/mol
    e. 40.31 g/mol
    f. 169.88 g/mol
    g. 16.05 g/mol
    h. 17.04 g/mol
    i. 108.02 g/mol
    j. 102.89 g/mol

24. The name is Avogadro's number. It is 6.02×10^{23} particles/mol.

25. Compounds X, Y and Z have the following molar masses: $M_X = 50.00$ g/mol, $M_Y = 100.00$ g/mol, $M_z = 150.00$ g/mol. Assume they are covalent compounds.
    a. You have one mole of each compound.
    b. You have more molecules of X, since each molecule of X weighs less than one of Y, so it takes more of them to make up 100 g.
    c. 3 times

Molar Mass Conversions

26. Determine the molar mass of each of the following:

a. 22.99 g/mol b. 63.55 g/mol c. 28.09 g/mol

27. Determine the number of moles in each of the following:
    a. 0.399 mol b. 2.00 mol
28. Determine the mass of each of the following:
    a. 4.92 g b. 4.52 g

29. Determine the molar mass of the following compounds:
    a. 58.10 g/mol c. 148.26 g/mol e. 74.10 g/mol
    b. 40.00 g/mol d. 89.11 g/mol f. 342.17 g/mol

30. Determine the number of moles in each of the following:
    a. 8.71 mol b. 0.000242 mol

31. Determine the mass of each of the following.
    a. 593 g b. 363 g

32. 171 g

33. 1.54 mol/L

34. 195 g

35. One molecule of ammonia has a much lower mass, so more of them are needed to equal the same mass.

Concentration

36. 2.60 mol/L
37. 3.23 g
38. 15.11 g
39. 2.00 L
40. 2.33 mol/L
41. 0.0400 mol/L
42. 0.043 g
43. 4.67 g

Mole Ratios and Mole Conversions

44. Given the chemical reaction: $3\ MgCl_2 + 2\ Al \rightarrow 3\ Mg + 2\ AlCl_3$
    a. Write the mole ratio for:
        i. $3\ mol\ MgCl_2 : 2\ mol\ Al$
        ii. $3\ mol\ MgCl_2 : 2\ mol\ AlCl_3$
    b. 5.33 mol
    c. 15 mol

45. Given the chemical reaction: $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$
    a. Write the mole ratio for:

i. 4 mol Fe : 3 mol O_2
ii. 2 mol Fe_2O_3 : 3 mol O_2

b. 4.875 mol O_2
c. 0.050 mol Fe_2O_3

46. 1.15 mol

47. 3.95 mol

48. Methanol reacts with oxygen in a combustion reaction to produce water and carbon dioxide.
    a. $2\ CH_3OH + 3\ O_2 \rightarrow 4\ H_2O + 2\ CO_2$
    b. 6.35 mol

49. Solid sodium reacts with water to produce sodium hydroxide and hydrogen gas.
    a. $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$
    b. 0.0256 mol
    c. 0.0128 mol

50. 0.0146 mol

Mass-to-Mass Conversions

51. 55.7 g

52. Balance: $2\ HCl + Na_2SO_4 \rightarrow 2\ NaCl + H_2SO_4$
    30.0 g

53. Calcium hydroxide reacts with hydrogen bromide to produce calcium bromide and water.
    a. $Ca(OH)_2 + 2\ HBr \rightarrow CaBr_2 + 2\ H_2O$
    b. 24.98 g

54. $C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$
    141.5 g

Percent Yield

55. A test is out of 65 marks. You got 58 marks on the test.
    a. 65
    b. 58
    c. 89%

56. In a chemical reaction, 4.3 g of precipitate is supposed to be produced. However, only 3.8 g was produced.
    d. 4.3 g

e. 88%

57. Given the equation: $CaCO_3 + 2\ HCl \rightarrow CaCl_2 + H_2O + CO_2$
    f. 0.295 g
    g. 86.1%

58. Given the equation: $2\ NH_3 \rightarrow N_2 + 3\ H_2$
    h. 0.0845 g
    i. 0.0540 g

59. A reaction occurs between propane (C_3H_8) and oxygen.
    j. combustion
    k. $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
    l. 8.82 g
    m. theoretical = 16.2 g, actual = 13.3 g

60. A reaction occurs between iron(III) sulfate and sodium phosphate.
    n. Double displacement
    o. $Fe_2(SO_4)_3 + 2\ Na_3PO_4 \rightarrow 3\ Na_2SO_4 + 2\ FePO_4$
    p. 18.9 g
    q. 97.9%
    r. Yes, since the percent yield is below 100%. The percent yield should always be below 100%, unless there are errors in the procedure.
    s. Theoretical = 19.5 g, actual = 12.7 g

Limiting Reactants

61. Given the equation: $Al_2(SO_3)_3 + 6\ NaOH \longrightarrow 3\ Na_2SO_3 + 2\ Al(OH)_3$
    a. n(AS) = 0.0340 mol ÷ 1 = 0.0340 n(SH) = 0.250 mol ÷ 6 = 0.0417
    Aluminum sulfite ($Al_2(SO_3)_3$) is limiting
    b. 0.0680 mol
    c. 1.84 g of NaOH

62. Given the equation: $Mg + \underline{\mathbf{2}}\ HCl \longrightarrow H_2 + MgCl_2$
    a. n(HCl) = 0.165 mol ÷ 2 = 0.0823 n(Mg) = 0.206 mol ÷ 1 = 0.206
    Hydrogen chloride (HCl) is limiting
    b. 0.167 g
    c. 3.00 g

63. Given the reaction: $H_2CO_3 + 2\ LiOH \longrightarrow Li_2CO_3 + 2\ H_2O$ n(CA) = 0.717 mol ÷ 1 = 0.717 n(LH) = 1.35 mol ÷ 2 = 0.674
    Lithium hydroxide (LiOH) is limiting
    49.9 g produced

64. 2.33 grams of chlorine gas reacts with 43.0 grams of sodium bromide to produce bromine gas and sodium chloride.
    a. $Cl_2 + 2\ NaBr \rightarrow Br_2 + 2\ NaCl$
    b. $n(Cl_2) = 0.0329\ mol \div 1 = 0.0329$ $n(NaBr) = 0.418\ mol \div 2 = 0.209$
       Chlorine gas is limiting
       5.26 g produced
65. A double displacement reaction occurs when 45.3 moles of sodium iodide react with 34.8 grams of lead (II) nitrate. How many grams of solid product are produced?
    $2\ NaI + Pb(NO_3)_2 \rightarrow 2\ NaNO_3 + PbI_2\ (s)$
    $n(SI) = 0.302\ mol \div 2 = 0.151$ $n(LN) = 0.105\ mol \div 1 = 0.105$
    Lead nitrate ($Pb(NO_3)_2$) is limiting
    48.4 g produced