Chemistry 103, Dr. Hamers
Practice Problems that may help you prepare for Exam I
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CHAPTER 1

1. a. Is color an intrinsic property or an extrinsic property?
b. Is the boiling point of water a chemical or physical property?
c. Is a solution made of sodium chloride and water a homogeneous or heterogeneous solution?
d. The name of the family Group IA is what?
e. A metal with 11 protons is _____?
f. List 1 noble gas compound _____.

2. The density of aluminum is 2.70 g/ml. How much volume in ml is occupied by 0.0550 kg of aluminum?
a. 0.0204 b. 0.149 c. 14.9 d. 20.4 e. 0.0490

CHAPTER 2

3. Answer the following short-answer questions.
a. Name an element in the 4^{th} period that is an alkaline earth metal.
b. What family in the periodic table contains elements that are solids, liquids, and gases?
c. Identify a metal that is found in Group IVA.
d. List 2 physical properties of the element you wrote in part c) above.
e. Identify the lightest elemental gas.
f. Identify a metal that is found as a liquid.
g. What two other compounds (there are many) would have similar chemical properties to $CaCl_2$?
h. The correct charge on the sulfate ion is what?
i. The noble gases are in what group of the periodic table?
j. What is the formula of a compound containing ammonium and sulfur?
k. Which of the following are metals? Al Se Sc S
l. Carbon is found naturally as diamond, graphite, and Bucky balls. These forms of carbon are called what?

4. Answer the following short questions.
a. What is the name for As? _____
b. What is the name for Hg? _____
c. What is the symbol for potassium? _____
d. What is the formula for copper(I) hydrogen carbonate? _____
e. What is the formula for dinitrogen monoxide? _____
f. What is the name for $Mg(ClO_3)_2$? _____
g. What is the name for $Cr(SO_4)_3$? _____
h. Define the chemical word compound. _____
i What is the formula of a compound made from oxygen and calcium? _____
j. What is the formula for a compound made from nitrogen and potassium? _____

5. Draw a separate picture to represent each of the following: $H_2O(s)$, $H_2O(l)$, and $H_2O(g)$.

6. Answer the following short-answer questions.
a. Give an example of a halogen. _____
b. A column of elements in the periodic table is called a _____.
c. A row of elements in the periodic table is called a _____.
d. Most elements are found as (monoatomic, diatomic, polyatomic-choose one) elements in nature. _____
e. Si can be classified as a (metal, nonmetal, metalloid) _____.
(take a nap)

7. How many protons (p^+), neutrons (n), and electrons (e^-) are there in one atom of $^{119}_{50}Sn^{+2}$?

a. 50 p^+, 50 n, 52 e^- b. 50 p^+, 69 n, 50 e^- c. 50 p^+, 69 n, 48 e^-

d. 50 p^+, 119 n, 52 e^- e. 50 p^+, 119 n, 169 e^-

8. a. What is the isotopic symbol of a neutral atom that has 40 neutrons and 33 protons in its nucleus?
b. What is the isotopic symbol and charge of an ion having 12 protons, mass number of 25, and 10 electrons?
c. How many protons, neutrons, and electrons are in $(^{14}N^{16}O^{16}O)^-$?

9. An element has isotopes with the following masses and abundances. Calculate the average atomic mass of this element.

Atomic Mass	Fractional Abundance
27.977 g/mol	0.9221
28.976 g/mol	0.0470
29.974 g/mol	0.0309

a. 28.09 g/mol b. 28.98 g/mol c. 86.94 g/mol d. 87.94 g/mol e. None of the above.

10. Chlorine exists as two isotopes: $^{35}_{17}Cl$ and $^{37}_{17}Cl$. If the average atomic weight of chlorine is 35.45, what do you expect the approximate abundance of $^{37}_{17}Cl$ to be?
a. <5% b. 25% c. 50% d. 75% e. 95%

11. An element, D, is found as 2 isotopes: ^{18}D and ^{21}D. If the average atomic mass of D is 20.0, what are the abundances of the two isotopes of D?

12. There are 2 isotopes of B: ^{10}B (mass = 10.0129) and ^{11}B (mass = 11.0093). If the average atomic weight of B is 10.811, what are the natural abundances of the B isotopes?

13. Given 1.0mol of each substance, NO, NO_2, N_2O_3, N_2O_4, answer the following questions.

a. Which has the greatest mass?	NO	NO_2	N_2O_3	N_2O_4	have the same
b. Which has the greatest #molecules?	NO	NO_2	N_2O_3	N_2O_4	have the same
b. Which has the greatest #atoms?	NO	NO_2	N_2O_3	N_2O_4	have the same

14. A sample of gold (density = 19.31 g/cm^3) occupies a volume of 1.25 cm^3. How many gold atoms are contained within this sample?

15. a. How many atoms of S are there in 10.0grams of $Fe_2(SO_4)_3$?
b. If there are 1.7 x 10^{23} molecules of water, how many grams of water are there?
c. How much does one atom of sulfur weigh in grams?
d. If a single atom has a mass of 9.123 x 10^{-23} g, which element is it?
e. How many moles of carbon are present in 1.0 g of $C_6H_{12}O_6$?
f. The number of moles of nitrogen in a mixture of 2.0mol N_2O and 3.0mol NO_2 is _____?
g. What is the mass percent of N in $(NH_4)_2CO_3$?

16. If the empirical formula is CH_2O with a molar mass of 120.1g/mol, what is the molecular formula?
a. $C_2H_4O_2$ b. CH_2O c. CHO d. $C_{120}H_{240}O_{120}$ e. $C_4H_8O_4$

(watch some TV)

17. a. A compound is 21.2% by mass N and contains 2 N atoms per molecule. What is the molar mass?
b. A compound is 13.64% by mass hydrogen and has a molar mass of 88g/mol. How many atoms of hydrogen are there in each molecule of this compound?
c. A compound contains 32.84% by mass of an unknown element. If this compound contains 2 atoms of this element per molecule and has a molar mass of 316.70g/mol, what is the unknown element?

18. A compound contains 41.68% by mass Mg, 54.86% O and 3.46% H. What is its empirical formula?

19. When 0.1257g of the hydrated compound $Al_2O_3 \cdot xH_2O$ was heated to 250°C, all the water was removed and the mass dropped to 0.08215g. How many waters of hydration were in the original compound?

20. When 5.000g of $CuSO_4 \cdot xH_2O$ is heated all of the water is removed and the mass remaining in the crucible is 3.196g. How many waters of hydration are attached to the copper(II) sulfate (i.e., what is x)?

21. 5.50g of MBr_3 is electrolyzed (broken into its elements) and produces 4.46g of Br_2. What is the metal, M?

22. A metal oxide, M_2O, is 83.01% by mass metal, M. Determine the atomic mass and identity of the metal.

23. 15.0 grams of a metal carbonate, $M_2(CO_3)_3$ is heated and converted into MO and CO_2 producing 6.787 grams of CO_2. $M_2(CO_3)_3 \rightarrow M_2O_3 + 3CO_2$ The metal, M, is
a. Ba b. S c. Fe d. As e. Na

CHAPTER 3

24. Answer the following short answer questions.
a. Write a balanced reaction of nitrogen dioxide and hydrogen gas reacting to produce ammonia and water.
b. Write the balanced reaction of carbon dioxide with lithium hydroxide to yield lithium carbonate and water.
c. Which of the following will dissolve in water? FeS $FeCl_3$ NaCl NH_4Cl $Cu(NO_3)_2$
d. When CO_2 is dissolved in water, the resulting solution is acidic/basic/neutral (choose one).

25. Classify each of the chemicals below as a strong, weak, or non-electrolyte when dissolved in water.
NaCl HCl $HC_2H_3O_2$ Sugar ($C_{12}H_{22}O_{11}$) C_2H_6O NH_4NO_3 Fe NH_3 NaOH $PbCl_2$ H_3PO_4
Strong electrolyte: _____

Weak electrolyte: _____

Non-electrolyte: _____

26. A white compound is found and is either $Pb(NO_3)_2$ or $Ba(NO_3)_2$. Which one of the following compounds could be used with the unknown compound to determine the identity of the unknown compound?
a. HNO_3 b. HCl c. $AgNO_3$ d. $KClO_4$ e. none

27. Which reaction or reactions do **not** proceed readily to products (i.e., which is/are reactant-favored)?
I. $HCl + H_2O \rightarrow H_3O^+ + Cl^-$
II. $CH_3OH + H_2O \rightarrow CH_3O^- + H_3O^+$
III. $HC_2H_3O_2 + H_2O \rightarrow C_2H_3O_2^- + H_3O^+$
IV. $HF + NaOH \rightarrow NaF + H_2O$
V. $CH_4 + H_2O \rightarrow CH_3^- + H_3O^+$
(eat some pizza)

Writing Reactions

28. For each reaction, identify the type of reaction [combustion, acid-base, gas-forming, or precipitation].

a. $2KI(aq) + Pb(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + PbI_2(s)$

b. $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$

c. $AgNO_3(aq) + NaCl \rightarrow AgCl(s) + NaNO_3(aq)$

d. $HNO_3(aq) + LiOH(aq) \rightarrow LiNO_3(aq) + H_2O(l)$

e. $Na_2CO_3(aq) + 2HCl(aq) \rightarrow CO_2(g) + H_2O(l) + 2NaCl(aq)$

f. $HF(aq) + NaOH(aq) \rightarrow NaF(aq) + H_2O(l)$

g. $K_2CO_3(aq) + 2HC_2H_3O_2 \rightarrow 2KC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$

29. a. Write a balanced molecular reaction for the combustion of pentane (C_5H_{12}).

b. Write a balance molecular reaction for the combustion of heptene (C_7H_{14}).

30. Write the balanced molecular and net ionic reaction for each of the following.

a. $AgNO_3(aq) + Na_2S(aq) \rightarrow$

b. $HF(aq) + NaOH(aq) \rightarrow$

c. $HCl(aq) + Ba(OH)_2(aq) \rightarrow$

d. $Pb(NO_3)_2(aq) + (NH_4)_2CrO_4(aq) \rightarrow$ (hint: a solid forms)

e. $NaHCO_3(aq) + HC_2H_3O_2(aq) \rightarrow$

31. a. When a nonmetal oxide reacts with water, what is produced? _____

b. When a metal oxide reacts with water, what is produced? _____

32. Write the balanced molecular and net ionic reaction for the following. If no reaction occurs, write NR.

a. An insoluble precipitate forms when aqueous silver(I) nitrate and sodium sulfide are mixed.

b. The reaction between aqueous acetic acid and aqueous barium hydroxide.

c. The reaction between aqueous sodium nitrate and aqueous potassium chloride.

33. a. Write the molecular reaction of a calcium oxide reacting with water.

b. Write the molecular reaction of a magnesium oxide reacting with water.

c. Write the molecular reaction of a sulfur trioxide reacting with water.

Redox

34. a. The oxidation number of chromium in sodium dichromate, $Na_2Cr_2O_7$ is _____ ?

b. The oxidation number of sulfur in aluminum thiosulfate, $Al_2(S_2O_3)_3$ is _____ ?

c. The oxidation number of uranium $(UO_2)_3(PO_4)_2$ is _____ ?

d. The oxidation number of carbon in $(NH_4)_2C_2O_4$ is _____ ?

35. Which of the following reactions are oxidation-reduction reactions?

I. $3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$

II. $Fe(s) + Cu(NO_3)_2(aq) \rightarrow Cu(s) + Fe(NO_3)_2(aq)$

III. $CO_2(g) + 2LiOH(aq) \rightarrow Li_2CO_3(aq) + H_2O(l)$

IV. $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

a. II b. III c. I and II d. I, IV e. II, III

(take another nap)

36. For each reaction, identify what chemical is oxidized and reduced, and is the oxidizing and reducing agents.

a. $MnO_4^- + 5Fe^{+2} + 8H^+ \rightarrow Mn^{+2} + 5Fe^{+3} + 4H_2O$

b. $3C_2H_5OH + 2Cr_2O_7^{-2} + 16H^+ \rightarrow 4Cr^{+3} + 3HC_2H_3O_2 + 11H_2O$

CHAPTER 4

Stoichiometry

37. If you want to produce 37 grams of ammonia, how many grams of H_2 would be needed?

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

(watch some TV)

38. Use the following reaction to answer the following questions

$CO_2(g) + 2LiOH(aq) \rightarrow Li_2CO_3(aq) + H_2O(l)$

15.0g of CO_2 and 10.0g of LiOH are combined.

a. How many grams of Li_2CO_3 can theoretically be produced in this reaction?

b. Which reactant is the limiting reagent?

c. Which reactant is the excess reagent?

d. How many grams of the excess reagent is **unused**?

e. If 5.2g of Li_2CO_3 were recovered, what is the percent yield?

39. Use the following reaction to answer the following questions

$Mg_3N_2(aq) + 6H_2O(l) \rightarrow 3Mg(OH)_2(aq) + 2NH_3(aq)$

25g of Mg_3N_2 and 15g of H_2O are combined.

a. How many moles of Mg_3N_2 are there?

b. How many moles of H_2O are there?

c. Which reactant is the limiting reagent?

d. How many grams of NH_3 can theoretically be produced in this reaction?

e. If 4.0g of NH_3 were recovered, what is the percent yield?

Empirical Formulas

40. Cyclohexane is used as a solvent for many reactions and contains only *carbon* and *hydrogen*. When a sample of cyclohexane is burned 15.71g CO_2 and 6.429g H_2O are recovered. What is the empirical formula of cyclohexane?

41. When 1.00g of a compound containing *carbon*, *hydrogen*, and *oxygen* is combusted, 1.91g CO_2 and 1.17g H_2O are recovered. a. What is the empirical formula? b. The molar mass of the compound is 46g/mol. What is the molecular formula?

42. When 2.50g of a compound containing *carbon*, *hydrogen*, and *oxygen* is combusted, 5.49g CO_2 and 3.00g H_2O are recovered. a. What is the empirical formula? b. The molar mass of the compound is 120.2g/mol. What is the molecular formula?

43. A 4.575g sample of a compound, B_xH_y, is reacted in pure oxygen to form 12.177g of B_2O_3. What is the empirical formula for B_xH_y?

(almost done)

Molarity

44. What volume in mL of a 0.35M CaF_2 solution contains 12.5g CaF_2?

45. Determine the Na^+ concentration that results when 2.75g of Na_2SO_4 is dissolved in 700ml of H_2O?

46. How much 5.0M KOH stock solution is needed to make a 250ml/0.60M KOH solution?

47. What mass of $Ca(OH)_2(s)$ is required to react exactly with 25.0 ml of a 0.500M HCl solution?
$Ca(OH)_2(s) + 2HCl(aq) \rightarrow 2H_2O(l) + CaCl_2(aq)$

48. If it takes 12.5 ml of a 0.400M HCl solution to completely react with 25.0ml of a $Ca(OH)_2$ solution, what was the concentration of the $Ca(OH)_2$ solution?

49. If it takes 20ml of a 0.1M H_3PO_4 solution to completely neutralize 50ml of a $Ba(OH)_2$ solution, what was the concentration of the $Ba(OH)_2$ solution?

50. Given the following balanced reaction
$Pb(NO_3)_2(aq) + 2NaI(aq) \rightarrow PbI_2(s) + 2NaNO_3(aq)$
When 200.0ml of a 0.100M solution of $Pb(NO_3)_2$ (molar mass = 331.2g/mol) is mixed with 100.0ml of a 0.100M NaI (molar mass = 149.9g/mol), how many grams of PbI_2 (molar mass = 461g/mol) can precipitate? (yea done!)

ANSWERS

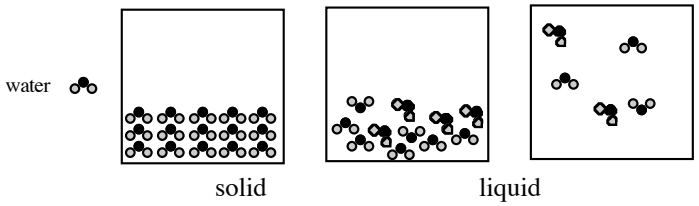
1. a. intrinsic property b. physical property c. homogeneous d. alkali metals e. sodium f. XeF_2 (XeF_4, XeF_6)

2. d {D = m/V → V = m/D = [0.055kg x (1000g/1kg)]/(2.7g/ml) = 20.37ml}

3. a. Ca b. halogens c. Sn or Pb d. shiny, electrical conductor, thermal conductor, malleable e. hydrogen f. mercury g. $MgCl_2$, CaF_2, MgI_2, etc. {replace the Ca with another Group IIA element and/or replace Cl with another Group VIIA element} h. –2 i. VIIIA j. $(NH_4)_2S$ k. Al, Sc l. allotropes

4. a. arsenic b. mercury c. K d. $CuHCO_3$ e. N_2O f. magnesium chlorate g. chromium(VI) sulfate h. A compound is a material made up of 2 different elements, e.g., H_2O or NaCl. i. CaO j. K_3N

5.



6. a. F_2 (or any element in the same column) b. a family or group c. period d. monatomic e. metalloid

7. c {$^{\text{protons+neutrons}}_{\text{protons}}Z$; Sn has 50 protons; 119 - 50 = 69 neutrons; +2 = 50(+1) + x(-1) → x = 48 electrons}

8. a. $^{73}_{33}As$ {33 protons → As; mass number = n+p^+ = 40+33=73; $^{\text{protons+neutrons}}_{\text{protons}}Z = {}^{73}_{33}As$} b. $^{25}_{12}Mg^{+2}$
c. 23 protons, 23 neutrons, 24 electrons {can do each isotope separately: ^{14}N: 7p, 7n; ^{16}O: 8p, 8n; #p = 7 + 8 + 8 = 23; #n = 7 + 8 + 8 = 23; #e = 24 since there is a charge of –1 on the entire ion}

9. a {AAW = (27.977)(0.9221) + (28.976)(0.0470) + (29.974)(0.0309)}

10. 25% {If the 2 isotopes were 50/50, the average weight would be 36. Since the weight is closer to 35, ^{35}Cl must dominate. Since the average weight is between 35 and 36, then choosing 25% for ^{37}Cl and 75% for ^{35}Cl would be the best choice.}

11. ^{18}D abundance = 33%; ^{21}D abundance = 67% {AAW = (M1)(RA1) + (M2)(RA2); 20 = (18)(x) + (21)(1-x); 20 = -3x + 21; 3x = 1; x = 0.33; ^{18}D abundance = 33%; ^{21}D abundance = 67%}

12. ^{10}B = 19.90%; ^{11}B = 80.10% {from AAW = (M1 x FA1) + (M2 x FA2) where M's are masses, FA's are fractional abundances, and AAW is average atomic weight, AAW = 10.811, M1 = 10.0129, M2 = 11.0093, RA1 = x, and RA2 = y → plugging in yields: 10.811 = 10.0129x + 11.0093y; since there are 2 variables, we need a 2nd equation; sum of all FA = 1 → FA1 + FA2 = 1 → x + y = 1 → y = 1 - x; subbing this in → 10.811 = 10.0129x + 11.0093(1-x) → solve for x → x = 0.1990 = 19.90%; y = 1-x = 1-0.1990 = 0.8010 = 80.10% → relative abundance of ^{10}B = x = 19.90% and relative abundance of ^{11}B = y = 80.10%}

13. a. N_2O_4 {since they are all 1.0mol, the one with the greatest molar mass will have the greatest mass → N_2O_4}

    b. all have the same number {same #mol means same #molecules; namely, 6.022 x 10^{23}}

    c. N_2O_4 {since 1 molecule of N_2O_4 has the most atoms at 6, and since there are the same #molecules → N_2O_4}

14. 7.38 x 10^{22} {mass = D x V = 19.31g Au/cm^3 x 1.25 cm^3 = 24.14g Au; 24.14g Au x [1mol Au/197g Au] x [6.022 x 10^{23} atoms Au/1mol Au]}

15. a. 4.52 x 10^{22} {10.0 g $Fe_2(SO_4)_3$ x [1mol $Fe_2(SO_4)_3$/399.9g ($Fe_2(SO_4)_3$] x [3mol S/1mol $Fe_2(SO_4)_3$] x [6.022 x 10^{23}atoms S/1mol S] = 4.5176 x 10^{22}}

    b. 5.1g H_2O {1.7 x 10^{23}molecules H_2O x (1mol H_2O/6.022 x 10^{23}molecules H_2O) x (18.016g H_2O/1mol H_2O) = 5.09g H_2O}

    c. 5.324 x 10^{-23} g {1 atom S x [1molS/6.022 x 10^{23} atoms S] x [32.06g S/1mol S] = 5.324 x 10^{-23}g}

    d. manganese {9.123 x 10^{-23}g/1atom x [6.022 x 10^{23} atoms/1mol] = 54.94g/mol → Mn}

    e. 0.033 mol C {1.0g $C_6H_{12}O_6$ x (1mol $C_6H_{12}O_6$/180.2g $C_6H_{12}O_6$) x (6mol C/1mol $C_6H_{12}O_6$) = 0.0333mol C}

    f. 7mol N {2mol N_2O x (2mol N/1mol N_2O) + 3mol NO_2 x (1mol N/1mol NO_2) = 7mol N}

    g. 29.2% {mass% N = (mass N/total mass) x 100%; assume 1 mole; total mass = 2(N) + 8(H) + 1(C) + 3(O) = 2(14) + 8(1) + 1(12) + 3(16) = 96 g; mass of N = 2(N) = 2(14) = 28 g; mass% N = (28/96) x 100% = 29%}

16. e {MW_{EF} = 30.03g/mol; MW_{MF}/MW_{EF} = 120.1/30.03 = 3.999 = 4; EF x 4 = CH_2O x 4 = $C_4H_8O_4$}

17. a. 132g/mol {mass% = (#atoms x AW/molar mass) x 100%; 21.2 = [(2)(14)/x](100); x = 132g/mol}

    b. 12 {mass% = (#atoms x AW/molar mass) x 100%; 13.64 = [(x)(1.01)/88](100); x = 11.9 which is about 12}

    c. Cr {mass% = (#atoms x AW/molar mass) x 100%; 32.84 = [(2)(x)/316.70] x 100; x = 52.00g/mol → Cr}

18. MgO_2H_2 {assume 100g; 41.68g Mg x (1mol Mg/24.31g Mg) = 1.715mol Mg; 54.86g O x (1mol O/16.0g O) = 3.429mol O; 3.46g H x (1mol H/1.008g H) = 3.433mol H; $Mg_{1.715}O_{3.429}H_{3.433}$; ÷1.715 → $MgO_{1.999}H_{2.002}$ = MgO_2H_2}

19. 3 {mass H_2O = 0.1257-0.08215 = 0.04355g; convert to mol H_2O: 0.04355g H_2O x (1mol H_2O/18.02g H_2O) = 0.002417mol H_2O; 0.08215g Al_2O_3 x (1mol Al_2O_3/101.96g Al_2O_3) = 0.0008057mol Al_2O_3; mol H_2O/mol Al_2O_3 = 0.002417mol H_2O/0.0008057mol Al_2O_3 = 2.9998 mol H_2O/mol Al_2O_3; x = 3; $Al_2O_3 \cdot 3H_2O$}

20. 5 {5.000-3.196 = 1.804g H_2O; 1.804g H_2O x (1mol H_2O/18.02g H_2O) = 0.100mol H_2O; 3.196g $CuSO_4$ x (1mol $CuSO_4$/159.62g $CuSO_4$) = 0.02002mol $CuSO_4$; $(CuSO_4)_{0.02002}(H_2O)_{0.100}$; divide by 0.02002 → $(CuSO_4)_1(H_2O)_{4.99}$ → $CuSO_4 \cdot 5H_2O$}

21. Fe {Need to determine AW of M; to do this you need gM and molM; g_{total} = gM + gBr → gM = 5.5 – 4.46 = 1.04g M; mol M: 4.46g Br_2 x (1mol Br_2/159.8g Br_2) x (2mol Br/1mol Br_2) x (1mol M/3mol Br) = 0.0186mol M; AW_M = 1.04g M/0.0186mol M = 55.89g/mol → Fe}

22. 39.10g/mol; K {16.99g O x [1mol O/16g O] x [2mol M/1mol O] = 2.123mol M; 83.01g M/2.123mol M = 39.10g/mol}

23. c {Need to determine AW of M; to do this you need g M and mol M; mol M: 6.787g CO_2 x (1mol CO_2/44g CO_2) x (1mol $M_2(CO_3)_3$/3mol CO_2) x (2mol M/1mol $M_2(CO_3)_3$) = 0.103mol M; g_{total} = g M + g CO_3; find g CO_3; 6.787g CO_2 x (1mol CO_2/44g CO_2) x (3mol CO_3/3mol CO_2) x (60.01g CO_3/1mol CO_3) = 9.257g CO_3; gM = 15.0 – 9.257 = 5.74g M; AW_M = 5.74g M/0.103mol M = 55.76g/mol → Fe}

24. a. $2NO_2 + 7H_2 \rightarrow 2NH_3 + 4H_2O$ b. $CO_2 + 2LiOH \rightarrow Li_2CO_3 + H_2O$

    c. $FeCl_3$, NaCl, NH_4Cl, $Cu(NO_3)_2$ d. acidic

25. strong: NaCl, HCl, NH_4NO_3, NaOH weak: $HC_2H_3O_2$, NH_3, H_3PO_4 non: Sugar, C_2H_6O, Fe, $PbCl_2$

26. b {HCl: $Pb^{+2} + 2Cl^- \rightarrow PbCl_2$(s) forms a precipitate; all the rest yield no reaction}

27. II, III, V

28. a. precipitation b. combustion c. precipitation d. acid-base e. gas-forming f. acid-base g. gas-forming

29. a. $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ b. $2C_7H_{14} + 21O_2 \rightarrow 14CO_2 + 14H_2O$

30. a. molecular: $2AgNO_3(aq) + Na_2S(aq) \rightarrow 2NaNO_3(aq) + Ag_2S(s)$; net: $2Ag^+(aq) + S^{-2}(aq) \rightarrow Ag_2S(s)$;

b. molecular: $HF(aq) + NaOH(aq) \rightarrow NaF(aq) + H_2O(l)$; net: $HF(aq) + OH^-(aq) \rightarrow F^-(aq) + H_2O(l)$

c. molecular: $2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$; net: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

d. molecular: $Pb(NO_3)_2(aq) + (NH_4)_2CrO_4(aq) \rightarrow PbCrO_4(s) + 2NH_4NO_3(aq)$; net: $Pb^{+2}(aq) + CrO_4^{-2}(aq) \rightarrow PbCrO_4(s)$

e. molecular: $NaHCO_3(aq) + HC_2H_3O_2(aq) \rightarrow NaC_2H_3O_2(aq) + CO_2(g) + H_2O(l)$;

net: $HCO_3^-(aq) + HC_2H_3O_2(aq) \rightarrow C_2H_3O_2^-(aq) + CO_2(g) + H_2O(l)$

31. a. acid b. base

32. a. molecular: $2AgNO_3(aq) + Na_2S(aq) \rightarrow 2NaNO_3(aq) + Ag_2S(s)$; net: $2Ag^+(aq) + S^{-2}(aq) \rightarrow Ag_2S(s)$;

b. molecular: $2HC_2H_3O_2(aq) + Ba(OH)_2(aq) \rightarrow Ba(C_2H_3O_2)_2(aq) + 2H_2O(l)$;

net: $HC_2H_3O_2\,(aq) + OH^-(aq) \rightarrow C_2H_3O_2^-(aq) + H_2O(l)$

c. molecular: $NaNO_3(aq) + KCl(aq) \rightarrow KNO_3(aq) + NaCl(aq)$; net: No Reaction

33. a. $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ b. $2MgO + 2H_2O(l) \rightarrow 2Mg(OH)_2$ c. $SO_3 + H_2O \rightarrow H_2SO_4$

34. a. +6 {assign O = -2 and Na = +1; sum rule: sum of the oxidation numbers equals the charge; in this case, the charge = 0 → 0 = 2(Na) + 2(Cr) + 7(O) = 2(+1) + 2(Cr) + 7(-2); solve for Cr → +6}

b. +2 {Al has a charge of +3; so S_2O_3 has a charge of –2 → $S_2O_3^{-2}$; assign O = -2 and from sum rule S = +2; -2 = 3(O) + 2(S) = 3(-2) + 2(S); solve for S → +2}

c. +6 {separate into ions: UO_2^{+2} and PO_4^{-3}; using UO_2^{+2} assign O as –2, therefore, U = +6}

d. +3 {separate into ions: NH_4^+ and $C_2O_4^{-2}$; using $C_2O_4^{-2}$ assign O as –2, therefore, C = +3}

35. a {Fe: 0 → +2, Cu: +2 → 0}

36. a. MnO_4^- is reduced, Fe^{+2} is oxidized, MnO_4^- is oxidizing agent, Fe^{+2} is reducing agent,
{Mn: +7 → +2 → reduction; Fe: +2 → +3 → oxidation}

b. C_2H_5OH is oxidized, $Cr_2O_7^{-2}$ is reduced, C_2H_5OH is reducing agent, $Cr_2O_7^{-2}$ is oxidizing agent
{C: -2 → 0 → oxidation; Cr: +6 → +3 → reduction}

37. 6.53g H_2 {37g NH_3 x (1mol NH_3/17.0g NH_3) x (3mol H_2/2mol NH_3) x (2.0g H_2/1mol H_2) = 6.53g H_2}

38. a. 15.5g Li_2CO_3 {Calculate Li_2CO_3 from each reactant:
15g CO_2 x (1mol CO_2/44g CO_2) x (1mol Li_2CO_3/1mol CO_2) x (73.9g Li_2CO_3/1mol Li_2CO_3) = 25.2g Li_2CO_3;
10g LiOH x (1mol LiOH/23.9g LiOH) x (1mol Li_2CO_3/2mol LiOH) x (73.9g Li_2CO_3/1mol Li_2CO_3) = 15.5g Li_2CO_3;
the smaller amount is the actual amount that can be produced; so 15.5g Li_2CO_3 can be produced. Since LiOH was the reactant that created the smaller amount, it's the limiting reagent.}

b. LiOH is the limiting reagent {Used answer in part a to determine this; LiOH produced the smaller amount of Li_2CO_3}

c. CO_2 is the excess reagent {Used answer to part a to determine this; LiOH produced the smaller amount of Li_2CO_3}

d. 5.79g CO_2 {10g LiOH x (1mol LiOH/23.9g LiOH) x (1mol CO_2/2mol LiOH) x (44g CO_2/1mol CO_2) = 9.21g CO_2 used; left over = starting amount – amount used = 15g CO_2 – 9.21g CO_2 = 5.79g CO_2}

e. 33.5% {%yield = (actual yield/theoretical yield) x 100% = (5.2/15.5) x 100% = 33.5%}

39. a. 0.25mol Mg_3N_2 {25g Mg_3N_2 x (1mol Mg_3N_2/100.9g Mg_3N_2) = 0.25mol Mg_3N_2}

b. 0.83mol H_2O {15g H_2O x (1mol H_2O/18g H_2O) = 0.83mol H_2O}

c. H_2O is the limiting reagent {I used the answer to part d to determine this; H_2O produced the smaller amount of NH_3}

d. 4.7g NH_3 {Calculate NH_3 from each of the reactants:
25g Mg_3N_2 x (1mol Mg_3N_2/100.9g Mg_3N_2) x (2mol NH_3/1mol Mg_3N_2) x (17g NH_3/1mol NH_3) = 8.42g NH_3;
15g H_2O x (1mol H_2O/18g H_2O) x (2mol NH_3/6mol H_2O) x (17g NH_3/1mol NH_3) = 4.72g NH_3
The smaller amount is the actual amount that can be produced; so 4.72 g NH_3 can be produced. Since H_2O was the one that created the smaller amount, it's the limiting reagent.}

e. 85% {%yield = (actual yield/theoretical yield) x 100% = (4.00/4.72) x 100% = 84.7%}

40. CH_2 {15.71g CO_2 x (1mol CO_2/44g CO_2) x (1mol C/1mol CO_2) = 0.357mol C; 6.429g H_2O x (1mol H_2O/18g H_2O) x (2mol H/1mol H_2O) = 0.714mol H; write formula: $C_{0.357}H_{0.714}$ → divide by 0.357 → $C_1H_{2.0}$ → CH_2}

41. a. C_2H_6O {1.91g CO_2 x (1mol CO_2/44.011g CO_2) x (1mol C/1mol CO_2) = 0.0434mol C; 1.17g H_2O x (1mol H_2O/18.016g H_2O) x (2mol H/1mol H_2O) = 0.1300mol H; g_{sample} = gO + gC + gH → solve for gC and gH → gH = 0.1300mol H x (1.0079g H/1mol H) = 0.1310g H; gC = 0.0434mol C x (12.011g C/1mol C) = 0.5213g C; solve for gO: gO = g_{sample} – gC – gH = 1.00 – 0.5213 – 0.1310 = 0.3477g O x (1mol O/16.0g O) = 0.0217mol O; $C_{0.0434}H_{0.1300}O_{0.0217} = C_2H_{5.99}O_1 = C_2H_6O$}

b. C_2H_6O {MW_{MF}/MW_{EF} = 46/46 = 1; C_2H_6O x 1 = C_2H_6O}

42. a. C_3H_8O {5.49g CO_2 x (1mol CO_2/44.011g CO_2) x (1mol C/1mol CO_2) = 0.1247mol C; gC = 0.1247mol C x (12.011g C/1mol C) = 1.498g C; 3.00g H_2O x (1mol H_2O/18.016g H_2O) x (2mol H/1mol H_2O) = 0.333mol H; gH = 0.333mol H x (1.0079g H/1mol H) = 0.336g H; g_{sample} = gO + gC + gH; solve for gO: gO = g_{sample} – gC – gH = 2.50 – 1.498 – 0.336 = 0.666g O x (1mol O/16.0g O) = 0.0416mol O; $C_{0.1247}H_{0.333}O_{0.0416} = C_2H_{5.99}O_1 = C_{2.998}H_{8.005}O = C_3H_8O$}

b. C_3H_8O {MW_{MF}/MW_{EF} = 120.2/60.03 = 2; C_3H_8O x 2 = $C_6H_{16}O_2$}

43. B_4H_9 {find mol B: 12.177g B_2O_3 x (1mol B_2O_3/69.62g B_2O_3) x (2mol B/1mol B_2O_3) = 0.3498mol B; find grams B: 0.3498mol B x (10.81g B/1mol B) = 3.781g B; find grams H: $g_{sample} = g_B + g_H$; g_H = 4.575 – 3.781 = 0.7935g H; find mol H: 0.7935g H x (1mol H/1.008g H) = 0.7872mol H; write formula: $B_{0.3498}H_{0.7872}$ and divide by smallest number of moles: $B_1H_{2.25}$; multiply by 4 to get rid of fraction: $B_1H_{2.25\ x\ 4} = B_4H_9$}

44. 458ml {12.5g CaF_2 x 1molCaF_2/78g CaF_2) = 0.160mol CaF_2; L = mol/M = 0.16/0.35 = 0.458L x 1000ml/L = 458ml}

45. 5.53×10^{-2} M {[Na^+] = mol Na^+/L; 2.75g Na_2SO_4 x [1mol Na_2SO_4/142g Na_2SO_4] x [2mol Na^+/1mol Na_2SO_4] = 3.87×10^{-2} mol Na^+; [Na^+] = 3.87×10^{-2} mol Na^+/0.7L}

46. 30ml of 5.0M stock solution; dilute to 250ml with water. {dilution problem: $M_1V_1 = M_2V_2$ where M_1 = 5.0, V_1 = ?, M_2 = 0.60M, V_2 = 250ml; (5)(x) = (0.60)(250) → solve for x: x = 30ml}

47. 0.463g {need to find mol of $Ca(OH)_2$ needed to neutralize HCl; write reaction: $Ca(OH)_2 + 2HCl \rightarrow 2H_2O + CaCl_2$; find mol HCl: M = mol/L → mol HCl = M_{HCl} x L_{HCl} = 0.5M x [25ml x (1L/1000ml)] = 0.0125 mol HCl; find mol $Ca(OH)_2$: 0.0125 mol HCl x (1 mol $Ca(OH)_2$/2 mol HCl) = 0.00625 mol $Ca(OH)_2$; convert to grams: 0.00625 mol $Ca(OH)_2$ x (74g $Ca(OH)_2$ /1mol $Ca(OH)_2$) = 0.4625g $Ca(OH)_2$ are required to neutralize the HCl solution}

48. 0.100 M {[$Ca(OH)_2$] = mol $Ca(OH)_2$/L $Ca(OH)_2$ solution; L $Ca(OH)_2$ solution = 25ml x (1L/1000ml) = 0.025L; need to find mol $Ca(OH)_2$; first write balanced reaction: $Ca(OH)_2 + 2HCl \rightarrow 2H_2O + CaCl_2$; reach equivalence point means $Ca(OH)_2$ was just used up; find mol HCl: M = mol/L → mol HCl = M_{HCl} x L_{HCl} = 0.4M x [12.5ml x (1L/1000ml)] = 0.005 mol HCl → 0.005 mol HCl x (1 mol $Ca(OH)_2$/2 mol HCl) = 0.0025 mol $Ca(OH)_2$; $M_{Ca(OH)2}$ = 0.0025mol $Ca(OH)_2$/0.025L = 0.1M}

49. 0.06 M {first write reaction: $3Ba(OH)_2 + 2H_3PO_4 \rightarrow 6H_2O + Ba_3(PO_4)_2$; [$Ba(OH)_2$] = mol $Ba(OH)_2$/L $Ba(OH)_2$; L $Ba(OH)_2$ = 50ml x (1L/1000ml) = 0.050L; completely neutralize means $Ba(OH)_2$ was just used up; to find mol $Ba(OH)_2$ first find mol H_3PO_4: M = mol/L → mol H_3PO_4 = $M_{H_3PO_4}$ x $L_{H_3PO_4}$ = 0.1M x [20ml x (1L/1000ml)] = 0.002 mol H_3PO_4; 0.002mol H_3PO_4 x 3mol mol $Ba(OH)_2$/2mol H_3PO_4 = 0.003mol $Ba(OH)_2$; [$Ba(OH)_2$] = 0.003mol $Ba(OH)_2$/0.050L = 0.06M}

50. 2.31g {Limiting reagent problem since 2 quantities were given. Go from M and L to grams PbI_2 for each and choose smaller amount. For $Pb(NO_3)_2$: from M = mol/L solve for mol: (0.2L x 0.1M) = 0.02 mol $Pb(NO_3)_2$; 0.02 mol $Pb(NO_3)_2$ x [1mol PbI_2/1mol $Pb(NO_3)_2$] x [461g PbI_2/1mol PbI_2] = 9.22 g PbI_2; repeat with NaI: from M = mol/L solve for mol: (0.1L x 0.1M) = 0.01 mol NaI; 0.01 mol NaI x [1mol PbI_2/2mol NaI] x [461g PbI_2/1mol PbI_2] = 2.31 g PbI_2; smaller amount is 2.31 g of PbI_2 and NaI is limiting reagent}