

Chapter 3: 22, 30, 32, 36, 38, 40, 44, 46, 48, 52, 58, 66, 68, 70, 74, 80, 82, 84, 90, 102, 104, 112, 116, 118, 128, 130

22. $(283.4 \text{ amu} \times 0.3460) + (284.7 \text{ amu} \times 0.2120) + (287.8 \text{ amu} \times 0.4420) = \mathbf{285.6 \text{ amu}}$

30. $500.0 \text{ g Fe} \times \frac{1 \text{ mole Fe}}{55.85 \text{ g Fe}} = \mathbf{8.953 \text{ mole Fe}}$

$$8.953 \text{ mole Fe} \times \frac{6.022 \times 10^{23} \text{ atoms Fe}}{1 \text{ mole Fe}} = \mathbf{5.391 \times 10^{24} \text{ atoms Fe}}$$

32. $5.0 \times 10^{21} \text{ atoms C} \times \frac{1 \text{ mole C}}{6.022 \times 10^{23} \text{ atoms C}} = \mathbf{8.3 \times 10^{-3} \text{ mole C}}$

$$8.0 \times 10^{-3} \text{ mole C} \times \frac{12.01 \text{ g C}}{1 \text{ mole C}} = \mathbf{0.10 \text{ g C}}$$

36. a. $4(30.97 \text{ g/mole}) + 6(16.00 \text{ g/mole}) = \mathbf{219.88 \text{ g/mole}}$

b. $3(40.08 \text{ g/mole}) + 2(30.97 \text{ g/mole}) + 8(16.00 \text{ g/mole}) = \mathbf{310.18 \text{ g/mole}}$

c. $2(22.99 \text{ g/mole}) + 1(1.008 \text{ g/mole}) + 1(30.97 \text{ g/mole}) + 4(16.00 \text{ g/mole}) = \mathbf{141.96 \text{ g/mole}}$

38. a. $1.00 \text{ g P}_4\text{O}_6 \times \frac{1 \text{ mole P}_4\text{O}_6}{219.88 \text{ g P}_4\text{O}_6} = \mathbf{4.55 \times 10^{-3} \text{ mole P}_4\text{O}_6}$

b. $1.00 \text{ g Ca}_3(\text{PO}_4)_2 \times \frac{1 \text{ mole Ca}_3(\text{PO}_4)_2}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} = \mathbf{3.22 \times 10^{-3} \text{ mole Ca}_3(\text{PO}_4)_2}$

c. $1.00 \text{ g Na}_2\text{HPO}_4 \times \frac{1 \text{ mole Na}_2\text{HPO}_4}{141.96 \text{ g Na}_2\text{HPO}_4} = \mathbf{7.04 \times 10^{-3} \text{ mole Na}_2\text{HPO}_4}$

40. a. $5.00 \text{ mole P}_4\text{O}_6 \times \frac{219.88 \text{ g P}_4\text{O}_6}{1 \text{ mole P}_4\text{O}_6} = \mathbf{1.10 \times 10^3 \text{ g P}_4\text{O}_6}$

b. $5.00 \text{ mole Ca}_3(\text{PO}_4)_2 \times \frac{310.18 \text{ g Ca}_3(\text{PO}_4)_2}{1 \text{ mole Ca}_3(\text{PO}_4)_2} = \mathbf{1.55 \times 10^3 \text{ g Ca}_3(\text{PO}_4)_2}$

c. $5.00 \text{ mole Na}_2\text{HPO}_4 \times \frac{141.96 \text{ g Na}_2\text{HPO}_4}{1 \text{ mole Na}_2\text{HPO}_4} = \mathbf{7.10 \times 10^2 \text{ g Na}_2\text{HPO}_4}$

44. a.

$$4.55 \times 10^{-3} \text{ mole P}_4\text{O}_6 \times \frac{6.022 \times 10^{23} \text{ molecules P}_4\text{O}_6}{1 \text{ mole P}_4\text{O}_6} = \mathbf{2.74 \times 10^{21} \text{ molecules P}_4\text{O}_6}$$

b.

$$3.22 \times 10^{-3} \text{ mole Ca}_3(\text{PO}_4)_2 \times \frac{6.022 \times 10^{23} \text{ form. units Ca}_3(\text{PO}_4)_2}{1 \text{ mole Ca}_3(\text{PO}_4)_2} = \mathbf{1.94 \times 10^{21} \text{ form. units Ca}_3(\text{PO}_4)_2}$$

c.

$$7.04 \times 10^{-3} \text{ mole Na}_2\text{HPO}_4 \times \frac{6.022 \times 10^{23} \text{ form. units Na}_2\text{HPO}_4}{1 \text{ mole Na}_2\text{HPO}_4} = \mathbf{4.24 \times 10^{21} \text{ form. units Na}_2\text{HPO}_4}$$

46. a.

$$2.74 \times 10^{21} \text{ molecules P}_4\text{O}_6 \times \frac{4 \text{ atoms P}}{1 \text{ molecule P}_4\text{O}_6} = \mathbf{1.10 \times 10^{22} \text{ atoms P}}$$

b.

$$1.94 \times 10^{21} \text{ formula units Ca}_3(\text{PO}_4)_2 \times \frac{2 \text{ atoms P}}{1 \text{ formula unit Ca}_3(\text{PO}_4)_2} = \mathbf{3.88 \times 10^{22} \text{ atoms P}}$$

c.

$$4.24 \times 10^{21} \text{ formula units Na}_2\text{HPO}_4 \times \frac{1 \text{ atom P}}{1 \text{ formula unit Na}_2\text{HPO}_4} = \mathbf{4.24 \times 10^{21} \text{ atoms P}}$$

48. a. C₉H₈O₄ 180.15 g/mole

b.

$$5.00 \times 10^2 \text{ mg C}_9\text{H}_8\text{O}_4 \times \frac{1 \text{ g C}_9\text{H}_8\text{O}_4}{10^3 \text{ mg C}_9\text{H}_8\text{O}_4} \times \frac{1 \text{ mole C}_9\text{H}_8\text{O}_4}{180.15 \text{ g C}_9\text{H}_8\text{O}_4} = \mathbf{2.78 \times 10^{-3} \text{ mole C}_9\text{H}_8\text{O}_4}$$

c.

$$2.78 \times 10^{-3} \text{ mole C}_9\text{H}_8\text{O}_4 \times \frac{6.022 \times 10^{23} \text{ molecules C}_9\text{H}_8\text{O}_4}{1 \text{ mole C}_9\text{H}_8\text{O}_4} = \mathbf{1.67 \times 10^{21} \text{ molecules C}_9\text{H}_8\text{O}_4}$$

52. a.

$$5.00 \text{ g C}_2\text{H}_5\text{O}_2\text{N} \times \frac{1 \text{ mole C}_2\text{H}_5\text{O}_2\text{N}}{75.07 \text{ g C}_2\text{H}_5\text{O}_2\text{N}} \times \frac{6.022 \times 10^{23} \text{ molecules C}_2\text{H}_5\text{O}_2\text{N}}{1 \text{ mole C}_2\text{H}_5\text{O}_2\text{N}} \times \frac{1 \text{ atom N}}{1 \text{ molecule C}_2\text{H}_5\text{O}_2\text{N}}$$
$$= \mathbf{4.01 \times 10^{22} \text{ atoms N}}$$

b.

$$5.00 \text{ g Mg}_3\text{N}_2 \times \frac{1 \text{ mole Mg}_3\text{N}_2}{100.95 \text{ g Mg}_3\text{N}_2} \times \frac{6.022 \times 10^{23} \text{ formula units Mg}_3\text{N}_2}{1 \text{ mole Mg}_3\text{N}_2} \times \frac{2 \text{ atom N}}{1 \text{ formula unit Mg}_3\text{N}_2}$$
$$= \mathbf{5.97 \times 10^{22} \text{ atoms N}}$$

c.

$$5.00 \text{ g Ca(NO}_3)_2 \times \frac{1 \text{ mole Ca(NO}_3)_2}{164.10 \text{ g Ca(NO}_3)_2} \times \frac{6.022 \times 10^{23} \text{ form. units Ca(NO}_3)_2}{1 \text{ mole Ca(NO}_3)_2} \times \frac{2 \text{ atom N}}{1 \text{ form. units Ca(NO}_3)_2}$$
$$= \mathbf{3.67 \times 10^{22} \text{ atoms N}}$$

d.

$$5.00 \text{ g N}_2\text{O}_4 \times \frac{1 \text{ mole N}_2\text{O}_4}{92.02 \text{ g N}_2\text{O}_4} \times \frac{6.022 \times 10^{23} \text{ molecules N}_2\text{O}_4}{1 \text{ mole N}_2\text{O}_4} \times \frac{2 \text{ atoms N}}{1 \text{ molecule N}_2\text{O}_4}$$
$$= \mathbf{6.54 \times 10^{22} \text{ atoms N}}$$

58. a. NO $\frac{14.01}{(14.01+16.00)} \times 100 = \mathbf{46.68\%N}$

b. NO₂ $\frac{14.01}{(14.01+2(16.00))} \times 100 = \mathbf{30.45\%N}$

c. N₂O₄ $\frac{2(14.01)}{(2(14.01)+4(16.00))} \times 100 = \mathbf{30.45\%N}$

d. N₂O $\frac{2(14.01)}{(2(14.01)+16.00)} \times 100 = \mathbf{63.65\%N}$

66. a. SNH = 47.09 g/mole

$$\frac{188.35 \text{ g/mole}}{47.09 \text{ g/mole}} = 4.0 \quad \mathbf{S_4N_4H_4}$$

b. NPCl₂ = 115.88 g/mole

$$\frac{347.64 \text{ g/mole}}{115.88 \text{ g/mole}} = 3.0 \quad \mathbf{N_3P_3Cl_6}$$

c. CoC₄O₄ = 170.97 g/mole

$$\frac{341.94 \text{ g/mole}}{170.97 \text{ g/mole}} = 2.0 \quad \mathbf{Co_2C_8O_8}$$

d. SN = 46.08 g/mole

$$\frac{184.32 \text{ g/mole}}{46.08 \text{ g/mole}} = 4.0 \quad \mathbf{S_4N_4}$$

68. Assume 100 g of compound:

$$56.79 \text{ g C} \times \frac{1 \text{ mole C}}{12.01 \text{ g C}} = 4.729 \text{ mole C}/0.5910 = 8.000 \approx 8$$

$$6.56 \text{ g H} \times \frac{1 \text{ mole H}}{1.008 \text{ g H}} = 6.508 \text{ mole H}/0.5910 = 11.01 \approx 11$$

$$28.37 \text{ g O} \times \frac{1 \text{ mole O}}{16.00 \text{ g O}} = 1.773 \text{ mole O} / 0.5910 = 3.000 \approx 3$$

$$8.28 \text{ g N} \times \frac{1 \text{ mole N}}{14.01 \text{ g N}} = 0.5910 \text{ mole O} / 0.5910 = 1$$

Therefore: Empirical formula = **C₈H₁₁O₃N**

70. $0.480 \text{ g C} \times \frac{1 \text{ mole C}}{12.01 \text{ g C}} = 0.0400 \text{ mole C} / 0.0400 = 1$

$$0.161 \text{ g H} \times \frac{1 \text{ mole H}}{1.008 \text{ g H}} = 0.160 \text{ mole H} / 0.0400 = 4.000 \approx 4$$

$$0.640 \text{ g O} \times \frac{1 \text{ mole O}}{16.00 \text{ g O}} = 0.0400 \text{ mole O} / 0.0400 = 1$$

$$1.121 \text{ g N} \times \frac{1 \text{ mole N}}{14.01 \text{ g N}} = 0.08001 \text{ mole O} / 0.0400 = 2.00 \approx 2$$

Therefore: Empirical formula = **CH₄ON₂**

74. Assume 100 g of compound:

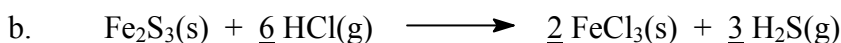
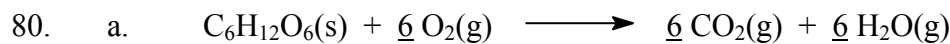
$$49.31 \text{ g C} \times \frac{1 \text{ mole C}}{12.01 \text{ g C}} = 4.106 \text{ mole C} / 2.737 = 1.500 \times 2 \approx 3$$

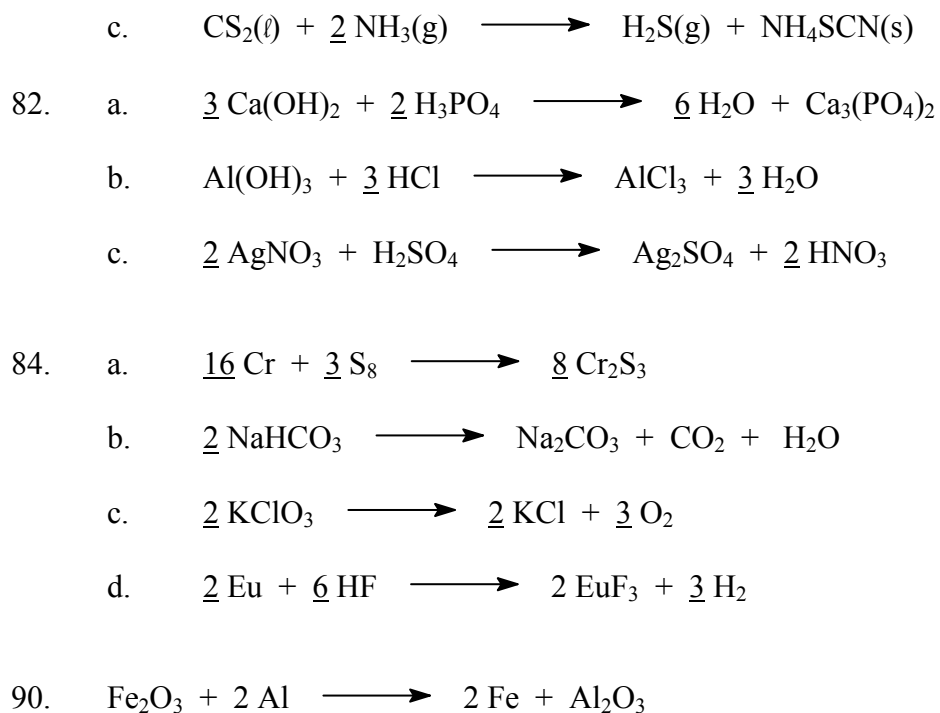
$$6.90 \text{ g H} \times \frac{1 \text{ mole H}}{1.008 \text{ g H}} = 6.84 \text{ mole H} / 2.737 = 2.501 \times 2 \approx 5$$

$$43.79 \text{ g O} \times \frac{1 \text{ mole O}}{16.00 \text{ g O}} = 2.737 \text{ mole O} / 2.737 = 1 \times 2 = 2$$

Therefore: Empirical formula = C₃H₅O₂ FW = 73.07 g/mole

$$\frac{146.1 \text{ g/mole}}{73.07 \text{ g/mole}} = 1.999 \approx 2 ; \text{ Molecular formula} = \text{C}_6\text{H}_{10}\text{O}_4$$

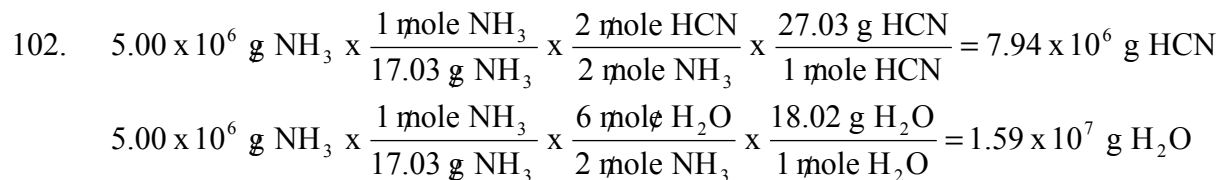




$$15.0 \text{ g Fe} \times \frac{1 \text{ mole Fe}}{55.85 \text{ g Fe}} \times \frac{1 \text{ mole Fe}_2\text{O}_3}{2 \text{ mole Fe}} \times \frac{159.70 \text{ g Fe}_2\text{O}_3}{1 \text{ mole Fe}_2\text{O}_3} = \mathbf{21.4 \text{ g Fe}_2\text{O}_3}$$

$$15.0 \text{ g Fe} \times \frac{1 \text{ mole Fe}}{55.85 \text{ g Fe}} \times \frac{2 \text{ mole Al}}{2 \text{ mole Fe}} \times \frac{26.98 \text{ g Al}}{1 \text{ mole Al}} = \mathbf{7.25 \text{ g Al}}$$

$$15.0 \text{ g Fe} \times \frac{1 \text{ mole Fe}}{55.85 \text{ g Fe}} \times \frac{1 \text{ mole Al}_2\text{O}_3}{2 \text{ mole Fe}} \times \frac{101.96 \text{ g Al}_2\text{O}_3}{1 \text{ mole Al}_2\text{O}_3} = \mathbf{13.7 \text{ g Al}_2\text{O}_3}$$



or

$$5.00 \times 10^6 \text{ g O}_2 \times \frac{1 \text{ mole O}_2}{32.00 \text{ g O}_2} \times \frac{2 \text{ mole HCN}}{3 \text{ mole O}_2} \times \frac{27.03 \text{ g HCN}}{1 \text{ mole HCN}} = \mathbf{2.82 \times 10^6 \text{ g HCN}}$$

$$5.00 \times 10^6 \text{ g O}_2 \times \frac{1 \text{ mole O}_2}{32.00 \text{ g O}_2} \times \frac{6 \text{ mole H}_2\text{O}}{3 \text{ mole O}_2} \times \frac{18.02 \text{ g H}_2\text{O}}{1 \text{ mole H}_2\text{O}} = \mathbf{5.63 \times 10^6 \text{ g H}_2\text{O}}$$

or

$$5.00 \times 10^6 \text{ g CH}_4 \times \frac{1 \text{ mole CH}_4}{16.04 \text{ g CH}_4} \times \frac{2 \text{ mole HCN}}{2 \text{ mole CH}_4} \times \frac{27.03 \text{ g HCN}}{1 \text{ mole HCN}} = 8.43 \times 10^6 \text{ g HCN}$$

$$5.00 \times 10^6 \text{ g CH}_4 \times \frac{1 \text{ mole CH}_4}{16.04 \text{ g CH}_4} \times \frac{6 \text{ mole H}_2\text{O}}{2 \text{ mole CH}_4} \times \frac{18.02 \text{ g H}_2\text{O}}{1 \text{ mole H}_2\text{O}} = 1.69 \times 10^7 \text{ g H}_2\text{O}$$

O₂ is the limiting reagent.

$$104. \quad 1.50 \text{ g SA} \times \frac{1 \text{ mole SA}}{138.12 \text{ g SA}} \times \frac{1 \text{ mole Aspirin}}{1 \text{ mole SA}} \times \frac{180.15 \text{ g Aspirin}}{1 \text{ mole Aspirin}} = \mathbf{1.97 \text{ g Aspirin}}$$

or

$$2.00 \text{ g AA} \times \frac{1 \text{ mole AA}}{102.09 \text{ g AA}} \times \frac{1 \text{ mole Aspirin}}{1 \text{ mole SA}} \times \frac{180.15 \text{ g Aspirin}}{1 \text{ mole Aspirin}} = 3.53 \text{ g Aspirin}$$

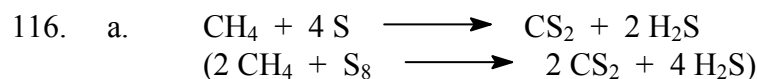
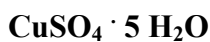
$$\% \text{ Yield} = \frac{1.50 \text{ g actual yield}}{1.97 \text{ g theoretical}} \times 100 = \mathbf{76.1 \% \text{ Aspirin}}$$

$$112. \quad 0.755 \text{ g hydrate} - 0.483 \text{ g anhydrous} = 0.272 \text{ g H}_2\text{O}$$

$$0.272 \text{ g H}_2\text{O} \times \frac{1 \text{ mole H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} = 0.0151 \text{ mole H}_2\text{O}$$

$$0.483 \text{ g CuSO}_4 \times \frac{1 \text{ mole CuSO}_4}{159.62 \text{ g CuSO}_4} = 0.00303 \text{ mole CuSO}_4$$

$$\frac{0.0151 \text{ mole H}_2\text{O}}{0.00303 \text{ mole CuSO}_4} = 4.988 \approx 5$$



b.

$$1.20 \times 10^2 \text{ g CH}_4 \times \frac{1 \text{ mole CH}_4}{16.043 \text{ g CH}_4} \times \frac{1 \text{ mole CS}_2}{1 \text{ mole CH}_4} \times \frac{76.15 \text{ g CS}_2}{1 \text{ mole CS}_2} = 5.70 \times 10^2 \text{ g CS}_2$$

$$1.20 \times 10^2 \text{ g S} \times \frac{1 \text{ mole S}}{32.07 \text{ g S}} \times \frac{1 \text{ mole CS}_2}{4 \text{ mole S}} \times \frac{76.15 \text{ g CS}_2}{1 \text{ mole CS}_2} = \mathbf{71.2 \text{ g CS}_2}$$

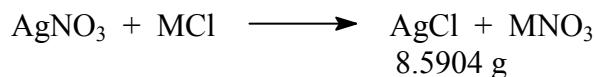
$$118. \quad 0.0985 \text{ g ZnCl}_2 \times \frac{1 \text{ mole ZnCl}_2}{136.28 \text{ g ZnCl}_2} \times \frac{1 \text{ mole Zn}}{1 \text{ mole ZnCl}_2} \times \frac{65.38 \text{ g Zn}}{1 \text{ mole Zn}} = 0.0473 \text{ g Zn}$$

$$\text{a.} \quad \frac{0.0473 \text{ g Zn}}{0.5065 \text{ g brass alloy}} \times 100 = \mathbf{9.33 \%Zn}$$

$$\frac{0.5065 \text{ g brass alloy} - 0.0473 \text{ g Zn}}{0.5065 \text{ g brass alloy}} = \frac{0.4592 \text{ g Cu}}{0.5065 \text{ g brass alloy}} \times 100 = \mathbf{90.7 \%Cu}$$

- b. 1. Weigh what is left.
2. Collect and measure the H₂.

128. Let x = mass of NaCl
 y = mass of KCl



$$x \text{ g NaCl} \times \frac{1 \text{ mole NaCl}}{58.44 \text{ g NaCl}} \times \frac{1 \text{ mole AgCl}}{1 \text{ mole NaCl}} \times \frac{143.4 \text{ g AgCl}}{1 \text{ mole AgCl}} +$$

$$y \text{ g KCl} \times \frac{1 \text{ mole KCl}}{74.55 \text{ g KCl}} \times \frac{1 \text{ mole AgCl}}{1 \text{ mole KCl}} \times \frac{143.4 \text{ g AgCl}}{1 \text{ mole AgCl}} = 8.5904 \text{ g AgCl}$$

Simplified, this is:

$$2.453x + 1.923y = 8.5904 \quad (1)$$

It is also know that since the 4.000 g of mixture just contains NaCl and KCl:

$$x + y = 4.000; \quad y = 4.000 - x \quad (2)$$

Plugging equation 2 into equation 1 gives:

$$2.453x + 1.923(4.000 - x) = 8.5904$$

$$x = 1.696 \text{ g NaCl}$$

$$y = 4.000 - 1.696 = 2.304 \text{ g KCl}$$

$$\frac{1.696 \text{ g NaCl}}{4.000 \text{ g sample}} \times 100 = \mathbf{42.40 \%NaCl}$$

$$\frac{2.304 \text{ g KCl}}{4.000 \text{ g sample}} \times 100 = \mathbf{57.60 \%KCl}$$

130. a. $40 \times 10^6 \times 10^{12} = 4.0 \times 10^{19}$ formula units

$$4.0 \times 10^{19} \text{ formula units A} \times \frac{1 \text{ mole A}}{6.022 \times 10^{23} \text{ formula units A}} = \underline{6.6 \times 10^{-5} \text{ mole A}}$$

$$\text{Formula Weight A} = \frac{4.26 \text{ mg A} \times \frac{10^{-3} \text{ g A}}{1 \text{ mg A}}}{6.6 \times 10^{-5} \text{ mole A}} = 64 \text{ g/mole}$$

Since the formula weight is 64 g/mole, the alkaline earth metal cannot be Sr, Ba, or Ra.

Assume 100 g of sample:

$$37.5 \text{ g C} \times \frac{1 \text{ mole C}}{12.01 \text{ g C}} = 3.122 \text{ mole C}$$

There are $100.0 - 37.5 = 62.5$ g of M, where M is Be, Mg or Ca. Try each.

$$62.5 \text{ g Be} \times \frac{1 \text{ mole Be}}{9.012 \text{ g Be}} = 6.935 \text{ mole Be}; \quad \frac{6.935 \text{ mole Be}}{3.122 \text{ mole C}} = 2.22$$

$$62.5 \text{ g Mg} \times \frac{1 \text{ mole Mg}}{24.31 \text{ g Mg}} = 2.571 \text{ mole Mg}; \quad \frac{3.122 \text{ mole C}}{2.571 \text{ mole Mg}} = 1.21$$

$$62.5 \text{ g Ca} \times \frac{1 \text{ mole Ca}}{40.08 \text{ g Ca}} = 1.559 \text{ mole Ca}; \quad \frac{3.122 \text{ mole C}}{1.559 \text{ mole Mg}} = 2.00$$

The best fit is for CaC_2 which has FW of 64.10 g/mole. **A is CaC_2 .**

b. $5.36 \text{ g H} \times \frac{1 \text{ mole H}}{1.008 \text{ g H}} = 5.32 \text{ mole H} / 2.66 = 2.00 = 2$

$$42.5 \text{ g O} \times \frac{1 \text{ mole O}}{16.00 \text{ g O}} = 2.66 \text{ mole H} / 2.66 = 1$$

B is H_2O .

c. $33.8 \text{ g CO}_2 \times \frac{1 \text{ mole CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mole C}}{1 \text{ mole CO}_2} = 0.768 \text{ mole C} / 0.768 = 1$

$$6.92 \text{ g H}_2\text{O} \times \frac{1 \text{ mole H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mole H}}{1 \text{ mole H}_2\text{O}} = 0.768 \text{ mole H} / 0.768 = 1$$

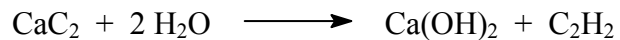
Empirical formula is CH FW = 13.02 g/mole

$$\frac{26}{13.02} = 2.0 = 2; \quad \text{Molecular formula is } \text{C}_2\text{H}_2$$

C is C_2H_2 (acetylene).

d. **D is $\text{Ca}(\text{OH})_2$.**

The reaction is:



$$45.0 \text{ g CaC}_2 \times \frac{1 \text{ mole CaC}_2}{64.10 \text{ g CaC}_2} \times \frac{1 \text{ mole C}_2\text{H}_2}{1 \text{ mole CaC}_2} \times \frac{26.04 \text{ g C}_2\text{H}_2}{1 \text{ mole C}_2\text{H}_2} = 18.3 \text{ g C}_2\text{H}_2$$

$$23.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mole H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{1 \text{ mole C}_2\text{H}_2}{2 \text{ mole H}_2\text{O}} \times \frac{26.04 \text{ g C}_2\text{H}_2}{1 \text{ mole C}_2\text{H}_2} = \mathbf{16.6 \text{ g C}_2\text{H}_2}$$