Chemistry – Chapter 9: The Mole Concept

Homework Problem Answers:

Text Problems: 3, 9, 15, 17, 19, 25, 33, 37, 43, 49, 51, 57, 61, 65, 77, 79, 81

3.

	Element	Mass		Element	Mass
(a)	Be	9.01 g	(b)	Br	79.90 g
(c)	Sc	44.96 g	(d)	Se	78.96 g

9. (a) $0.125 \cancel{\text{mol Zn}} \times \dfrac{6.02 \times 10^{23} \text{ atoms Zn}}{1 \cancel{\text{mol Zn}}} = 7.52 \times 10^{22} \text{ atoms Zn}$

(b) $0.250 \cancel{\text{mol Cl}_2} \times \dfrac{6.02 \times 10^{23} \text{ molecules Cl}_2}{1 \cancel{\text{mol Cl}_2}} = 1.51 \times 10^{23} \text{ molecules Cl}_2$

(c) $0.675 \cancel{\text{mol ZnCl}_2} \times \dfrac{6.02 \times 10^{23} \text{ formula units ZnCl}_2}{1 \cancel{\text{mol ZnCl}_2}}$

$= 4.06 \times 10^{23} \text{ formula units ZnCl}_2$

15.

	Compound	Molar Mass
(a)	CaS	40.08 g Ca + 32.07 g S = 72.15 g/mol
(b)	$CaSO_4$	40.08 g Ca + 32.07 g S + 4(16.00 g O) = 136.15 g/mol
(c)	$Fe(C_2H_3O_2)_2$	55.85 g + 2(12.01 g + 12.01 g + 1.01 g + 1.01 g + 1.01 g + 16.00 g + 16.00 g) = 173.95 g/mol
(d)	$Fe_3(PO_4)_2$	3(55.85 g) + 2(30.97 g + 16.00 g + 16.00 g + 16.00 g + 16.00 g) = 357.49 g/mol

17. (a) MM of Hg = 200.59 g/mol

$$2.95 \times 10^{23} \cancel{\text{atoms Hg}} \times \frac{1 \cancel{\text{mol Hg}}}{6.02 \times 10^{23} \cancel{\text{atoms Hg}}} \times \frac{200.59 \text{ g Hg}}{1 \cancel{\text{mol Hg}}}$$

$$= 98.3 \text{ g Hg}$$

(b) MM of N_2 = 2(14.01 g N) = 28.02 g/mol

$$1.16 \times 10^{22} \cancel{\text{molecules N}_2} \times \frac{1 \cancel{\text{mol N}_2}}{6.02 \times 10^{23} \cancel{\text{molecules N}_2}} \times \frac{28.02 \text{ g N}_2}{1 \cancel{\text{mol N}_2}}$$

$$= 0.540 \text{ g N}_2$$

(c) MM of $BaCl_2$ = 137.33 g Ba + 2(35.45 g Cl) = 208.23 g/mol

$$5.05 \times 10^{21} \text{ formula units } BaCl_2 \times \frac{1 \text{ mol } BaCl_2}{6.02 \times 10^{23} \text{ formula units } BaCl_2} \times \frac{208.23 \text{ g } BaCl_2}{1 \text{ mol } BaCl_2} = 1.75 \text{ g } BaCl_2$$

19. (a) MM of K = 39.10 g/mol

$$1.50 \text{ g K} \times \frac{1 \text{ mol K}}{39.10 \text{ g K}} \times \frac{6.02 \times 10^{23} \text{ atoms K}}{1 \text{ mol K}} = 2.31 \times 10^{22} \text{ atoms K}$$

(b) MM of O_2 = 2(16.00 g O) = 32.00 g/mol

$$0.470 \text{ g } O_2 \times \frac{1 \text{ mol } O_2}{32.00 \text{ g } O_2} \times \frac{6.02 \times 10^{23} \text{ molecules } O_2}{1 \text{ mol } O_2} = 8.84 \times 10^{21} \text{ molecules } O_2$$

(c) MM of $AgClO_3$ = 107.87 g Ag + 35.45 g Cl + 3(16.00 g O) = 191.32 g/mol

$$0.555 \text{ g } AgClO_3 \times \frac{1 \text{ mol } AgClO_3}{191.32 \text{ g } AgClO_3} \times \frac{6.02 \times 10^{23} \text{ formula units } AgClO_3}{1 \text{ mol } AgClO_3} = 1.75 \times 10^{21} \text{ formula units } AgClO_3$$

25. (a) MM of Ar = 39.95 g/mol

Density of Ar (at STP): $\frac{39.95 \text{ g}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 1.78 \text{ g/L}$

(b) MM of Cl_2 = 2(35.45 g Cl) = 70.90 g/mol

Density of Cl_2 (at STP): $\frac{70.90 \text{ g}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 3.17 \text{ g/L}$

(c) MM of CH_4 = 12.01 g C + 4(1.01 g H) = 16.05 g/mol

Density of CH_4 (at STP): $\frac{16.05 \text{ g}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 0.717 \text{ g/L}$

(d) MM of C_2H_6 = 2(12.01 g C) + 6(1.01 g H) = 30.08 g/mol

Density of C_2H_6 (at STP): $\frac{30.08 \text{ g}}{1 \text{ mol}} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = 1.34 \text{ g/L}$

33. (a) MM of H_2S = 2(1.01 g H) + 32.07 g S = 34.09 g/mol

$$1.05\ \cancel{\text{L } H_2S} \times \frac{1\ \cancel{\text{mol } H_2S}}{22.4\ \cancel{\text{L } H_2S}} \times \frac{34.09\ \text{g } H_2S}{1\ \cancel{\text{mol } H_2S}} = 1.60\ \text{g } H_2S$$

(b) MM of N_2O_3 = 2(14.01 g N) + 3(16.00 g O) = 76.02 g/mol

$$5.33\ \cancel{\text{L } N_2O_3} \times \frac{1\ \cancel{\text{mol } N_2O_3}}{22.4\ \cancel{\text{L } N_2O_3}} \times \frac{76.02\ \text{g } N_2O_3}{1\ \cancel{\text{mol } N_2O_3}} = 18.1\ \text{g } N_2O_3$$

37.

Gas	Molecules	Mass	Volume at STP
hydrogen, H_2	**1.50×10^{23}**	0.503 g	5.58 L
ammonia, NH_3	1.50×10^{23}	**4.25 g**	5.58 L
methane, CH_4	1.50×10^{23}	4.00 g	**5.58 L**

43. MM of $C_5H_{11}NSO_2$

= 5(12.01 g C) + 11(1.01 g H) + 14.01 g N + 32.07 g S + 2(16.00 g O)

= 60.05 g C + 11.11 g H + 14.01 g N + 32.07 g S + 32.00 g O

= 149.24 g/mol

$$\frac{60.05\ \text{g C}}{149.24\ \text{g } C_5H_{11}NSO_2} \times 100\% = 40.24\%\ \text{C}$$

$$\frac{11.11\ \text{g H}}{149.24\ \text{g } C_5H_{11}NSO_2} \times 100\% = 7.444\%\ \text{H}$$

$$\frac{14.01\ \text{g N}}{149.24\ \text{g } C_5H_{11}NSO_2} \times 100\% = 9.388\%\ \text{N}$$

$$\frac{32.07\ \text{g S}}{149.24\ \text{g } C_5H_{11}NSO_2} \times 100\% = 21.49\%\ \text{S}$$

$$\frac{32.00\ \text{g O}}{149.24\ \text{g } C_5H_{11}NSO_2} \times 100\% = 21.44\%\ \text{O}$$

49. $1.925\ \text{g Cu} \times \frac{1\ \text{mol Cu}}{63.55\ \text{g Cu}} = 0.03029\ \text{mol Cu}$

$2.410\ \text{g Cu}_x\text{O}_y - 1.925\ \text{g Cu} = 0.485\ \text{g O}$

$0.485\ \text{g O} \times \frac{1\ \text{mol O}}{16.00\ \text{g O}} = 0.0303\ \text{mol O}$

$\frac{\text{Cu } 0.03029}{0.0303}\ \frac{\text{O } 0.0303}{0.0303} = \text{Cu}_{1.00}\text{O}_{1.00}$ The empirical formula is CuO.

51. $1.115\ \text{g Co} \times \frac{1\ \text{mol Co}}{58.93\ \text{g Co}} = 0.0189\ \text{mol Co}$

$2.025\ \text{g Co}_x\text{S}_y - 1.115\ \text{g Co} = 0.910\ \text{g S}$

$0.910\ \text{g S} \times \frac{1\ \text{mol S}}{32.07\ \text{g S}} = 0.0284\ \text{mol S}$

$\frac{\text{Co } 0.0189}{0.0189}\ \frac{\text{S } 0.0284}{0.0189} = \text{Co}_{1.00}\text{S}_{1.50}$ The empirical formula is Co_2S_3.

57. $18.25\ \text{g C} \times \frac{1\ \text{mol C}}{12.01\ \text{g C}} = 1.52\ \text{mol C}$

$0.77\ \text{g H} \times \frac{1\ \text{mol H}}{1.01\ \text{g H}} = 0.76\ \text{mol H}$

$80.99\ \text{g Cl} \times \frac{1\ \text{mol Cl}}{35.45\ \text{g Cl}} = 2.28\ \text{mol Cl}$

$\frac{\text{C } 1.52}{0.76}\ \frac{\text{H } 0.76}{0.76}\ \frac{\text{Cl } 2.28}{0.76} = \text{C}_{2.0}\text{H}_{1.0}\text{Cl}_{3.0}$ The empirical formula is C_2HCl_3.

61. MM of $\text{C}_3\text{H}_8\text{N}$ $= 3(12.01\ \text{g C}) + 8(1.01\ \text{g H}) + 14.01\text{g N}$
$= 36.03\ \text{g C} + 8.08\ \text{g H} + 14.01\ \text{g N} = 58.12\ \text{g/mol}$

Hexamethylene diamine: $\frac{(\text{C}_3\text{H}_8\text{N})_n}{\text{C}_3\text{H}_8\text{N}} = \frac{115\ \text{g/mol}}{58.12\ \text{g/mol}}$ $n \approx 2$

The molecular formula of the compound is $(\text{C}_3\text{H}_8\text{N})_2$ or $\text{C}_6\text{H}_{16}\text{N}_2$.

65. Empirical Formula

$$24.8\ \cancel{\text{g C}} \times \frac{1\ \text{mol C}}{12.01\ \cancel{\text{g C}}} = 2.06\ \text{mol C}$$

$$2.08\ \cancel{\text{g H}} \times \frac{1\ \text{mol H}}{1.01\ \cancel{\text{g H}}} = 2.06\ \text{mol H}$$

$$73.1\ \cancel{\text{g Cl}} \times \frac{1\ \text{mol Cl}}{35.45\ \cancel{\text{g Cl}}} = 2.06\ \text{mol Cl}$$

$$\frac{\text{C } 2.06}{2.06}\ \frac{\text{H } 2.06}{2.06}\ \frac{\text{Cl } 2.06}{2.06} = C_{1.00}H_{1.00}Cl_{1.00}$$ The empirical formula is CHCl.

Molecular Formula

MM of CHCl = 12.01 g C + 1.01 g H + 35.45 g Cl
= 48.47 g/mol

Lindane: $\frac{(CHCl)_n}{CHCl} = \frac{290\ \text{g/mol}}{48.47\ \text{g/mol}}$ $n \approx 6$

The molecular formula of lindane is $(CHCl)_6$ or $C_6H_6Cl_6$.

77. $$1\ \cancel{\text{molecule } H_2O} \times \frac{1\ \cancel{\text{mol } H_2O}}{6.02 \times 10^{23}\ \cancel{\text{molecules } H_2O}} \times \frac{18.02\ \cancel{\text{g } H_2O}}{1\ \cancel{\text{mol } H_2O}} \times \frac{1\ \text{cm}^3\ H_2O}{1.00\ \cancel{\text{g } H_2O}}$$

$$= 2.99 \times 10^{-23}\ \text{cm}^3\ H_2O$$

79. MM of $C_{12}H_{22}O_{11}$ = 12(12.01 g C) + 22(1.01 g H) + 11(16.00 g O)
= 144.12 g C + 22.22 g H + 176.00 g O
= 342.34 g/mol

$$1.00\ \cancel{\text{g}}\ \cancel{C_{12}H_{22}O_{11}} \times \frac{1\ \cancel{\text{mol}}}{342.34\ \cancel{\text{g}}} \times \frac{12\ \cancel{\text{mol C}}}{1\ \cancel{\text{mol}}\ \cancel{C_{12}H_{22}O_{11}}} \times \frac{6.02 \times 10^{23}\ \text{atoms C}}{1\ \cancel{\text{mol C}}}$$

$$= 2.11 \times 10^{22}\ \text{atoms C}$$

81. $$1\ \cancel{\text{molecule vitamin K}} \times \frac{1\ \cancel{\text{mol vitamin K}}}{6.02 \times 10^{23}\ \cancel{\text{molecules vitamin K}}} \times \frac{173\ \cancel{\text{g vitamin K}}}{1\ \cancel{\text{mol vitamin K}}}$$

$$\times \frac{76.3\ \cancel{\text{g C}}}{100\ \cancel{\text{g vitamin K}}} \times \frac{1\ \cancel{\text{mol C}}}{12.01\ \cancel{\text{g C}}} \times \frac{6.02 \times 10^{23}\ \text{atoms C}}{1\ \cancel{\text{mol C}}} = 11\ \text{atoms C}$$

(Note: Since the number of atoms must be a whole number, the answer is 11 atoms, not 11.0 atoms.)