Solutions Manual to accompany

Chemistry

Abrash · Hardcastle

SOLUTIONS MANUAL

TO ACCOMPANY

CHEMISTRY

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TO THE STUDENT

Chemistry, like any other skill, requires practice. The most effective way to prepare for a chemistry test is to work problems until you are sure of your mastery of the subject. The successful completion of these problems requires that you learn the material, know how to manipulate the necessary mathematical equations, and, most importantly, recognize which equation (or equations) is appropriate to a particular problem.

This manual provides worked-out solutions to all the numerical problems in *Chemistry* by Henry I. Abrash and Kenneth I. Hardcastle (Encino, CA: Glencoe, 1980). In addition, it provides brief discussions of many of the essay questions. The only problems that are not answered are those that merely involve a simple restatement of fundamental definitions.

The information in this solutions manual will help you only if you show some self-control in using it. If you look up each problem's solution immediately without first trying to solve the problems on your own, the best you can achieve is rote learning of the procedures for working the specific problems in the textbook. This rote learning will probably be of little help when you try to answer slightly different problems, such as those your instructor will present on your tests. Furthermore, you will get no practice in deciding for yourself the appropriate way to solve the problems.

The best procedure is to refer to a solution in this manual only after you are reasonably confident that you have solved the problem. If you cannot reach a solution, even after a great deal of effort (including rereading the necessary principles in the text and referring to the sample problems), you may benefit from studying the worked-out solution in this manual. If, however, you must constantly refer to this manual for solutions, you should seek immediate help from your instructor, because this is a sure sign that you are not mastering the course material.

There are often many ways, differing in style rather than substance, to present the solution to a particular problem. We do not have the space to present all of them, but they are all correct. If you have already learned a problem-solving method different from the ones presented here, there is no reason to change your style to conform with ours. The best method for treating a problem is the one that you find the most comfortable and efficient. If you are using a valid method, you will obtain a correct answer.

We will present most solutions in the *factor-unit form*. For a problem requiring the conversion of a pressure of 680 torr to atmosphere units, for example, we will write:

$$P = (680\ \cancel{\text{torr}})\left(\frac{1\ \text{atm}}{760\ \cancel{\text{torr}}}\right)$$

rather than:

$$P = \frac{680\ \cancel{\text{torr}}}{760\ \dfrac{\cancel{\text{torr}}}{\text{atm}}}$$

The purpose of the factor-unit method is to make the manipulation of units clearer.

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CHAPTER 1

1-7. momentum = $(9.1 \times 10^{-31}\text{ kg})(4.5 \times 10^{5}\text{ m/sec})$
$= 4.1 \times 10^{-25}$ kg-m/sec

1-8. $K.E. = \frac{1}{2}(6.1 \times 10^{-26}\text{ kg})(5.00 \times 10^{2}\text{ m/sec})^{2} = 7.6 \times 10^{-21}$ J

1-9. a. $E = (2.5 \times 10^{-19}\text{ newtons})(2.5\text{ m}) = 6.3 \times 10^{-19}$ J

b. change in energy = energy expended = 6.3×10^{-19} J

1-10. 0.0800 J = (3.00 newtons)(distance); distance = 2.67×10^{-2} m

1-11. work = (0.200 newtons)(0.350 m) = 7.00×10^{-2} J

1-12. a. $5.0 \times 10^{3}\ \cancel{\text{mm}}\left(\frac{1\text{ m}}{10^{3}\ \cancel{\text{mm}}}\right) = 5.0\text{ m}$

$3.5 \times 10^{-3}\ \cancel{\text{km}}\left(\frac{10^{3}\text{ m}}{1\ \cancel{\text{km}}}\right) = 3.5\text{ m}$

$2.0 \times 10^{6}\ \cancel{\text{Å}}\left(\frac{1\text{ m}}{10^{10}\ \cancel{\text{Å}}}\right) = 2.0 \times 10^{-4}\text{ m}$

b. $430\ \cancel{\text{mg}}\left(\frac{1\ \cancel{\text{g}}}{10^{3}\ \cancel{\text{mg}}}\right)\left(\frac{1\text{ kg}}{10^{3}\ \cancel{\text{g}}}\right) = 4.30 \times 10^{-4}\text{ kg}$

$5893\ \cancel{\text{hg}}\left(\frac{100\ \cancel{\text{g}}}{1\ \cancel{\text{hg}}}\right)\left(\frac{1\text{ kg}}{10^{3}\ \cancel{\text{g}}}\right) = 589.3\text{ kg}$

$85\ \cancel{\text{pg}}\left(\frac{1\ \cancel{\text{g}}}{10^{12}\ \cancel{\text{pg}}}\right)\left(\frac{1\text{ kg}}{10^{3}\ \cancel{\text{g}}}\right) = 8.5 \times 10^{-14}\text{ kg}$

c. $1200\ \cancel{p\text{ sec}}\left(\frac{1\text{ sec}}{10^{12}\ \cancel{p\text{ sec}}}\right) = 1.2 \times 10^{-9}\text{ sec}$

$38.25\ \cancel{n\text{ sec}}\left(\frac{1\text{ sec}}{10^{9}\ \cancel{n\text{ sec}}}\right) = 3.825 \times 10^{-8}\text{ sec}$

$53.5 \times 10^{-2}\ \cancel{M\text{ sec}}\left(\frac{10^{6}\text{ sec}}{1\ \cancel{M\text{ sec}}}\right) = 5.35 \times 10^{5}\text{ sec}$

1-13. a. $454\ \cancel{\text{g}}\left(\frac{1\text{ kg}}{1000\ \cancel{\text{g}}}\right) = 0.454\text{ kg}$

b. $1\ \cancel{\text{y}}\left(\frac{365\ \cancel{\text{d}}}{1\ \cancel{\text{y}}}\right)\left(\frac{24\ \cancel{\text{hr}}}{1\ \cancel{\text{d}}}\right)\left(\frac{3600\ \cancel{\text{sec}}}{1\ \cancel{\text{hr}}}\right)\left(\frac{1\ G\text{ sec}}{10^{9}\ \cancel{\text{sec}}}\right) = 0.032\ G\text{ sec}$

$(0.032\ \cancel{G\text{ sec}})\left(\frac{10^{15}\ \mu\text{sec}}{1\ \cancel{G\text{ sec}}}\right) = 3.2 \times 10^{13}\ \mu\text{sec}$

c. $450\ \cancel{MJ}\left(\frac{10^6\ \cancel{J}}{1\ \cancel{MJ}}\right)\left(\frac{10^{12}\ pJ}{1\ \cancel{J}}\right) = 4.5 \times 10^{20}\ pJ$

d. $5.2\ \cancel{mmol}\left(\frac{1\ mol}{10^3\ \cancel{mmol}}\right) = 5.2 \times 10^{-3}\ mol$

1-14. $\frac{1.00\ g\ X}{11.8\ g\ Y}$ to form XY_4; therefore $\frac{1.00\ g\ X}{\frac{11.8}{4}\ g\ Y} = 0.339$ to 1

1-15. $\frac{1.00\ g\ M}{0.272\ g\ oxygen} = 3.68\ g\,M/g$ oxygen

since oxide formed is MO, atomic masses are in same ratio: 3.68 to 1

1-16. $\frac{5.79\ g\ Z}{1.00\ \cancel{g\ O}}\left(\frac{16.0\ \cancel{g\ O}}{1\ \cancel{mol\ O}}\right)\left(\frac{3\ \cancel{mol\ O}}{2\ mol\ Z}\right) = 139$ amu

1-17. $\left(\frac{44.0\ \cancel{g\ O}}{100.0\ g\ X_2O_5}\right)\left(\frac{1\ \cancel{mol\ O}}{16.0\ \cancel{g\ O}}\right)\left(\frac{2\ mol\ X}{5\ \cancel{mol\ O}}\right) = 1.10\ mol\ X/100.0\ g\ X_2O_5$

or $\left(\frac{56.0\ g\ X}{100.0\ \cancel{g\ X_2O_5}}\right)\left(\frac{100.0\ \cancel{g\ X_2O_5}}{1.10\ mol\ X}\right) = 50.9\ g\ X/mol\ X$

1-18. $\frac{1.00\ g\ X}{1.42\ g\ Y} \cdot \frac{3\ atoms\ Y}{1\ atom\ X} = 1.00\ g\ X$ for $0.473\ g\ Y$; 1:1 ratio

$\frac{1.00\ g\ X}{0.473\ g\ Y} \cdot \frac{5\ atoms\ Y}{1\ atom\ X}$ (in XY_5) = 1.00 g X combines with 2.37 g Y

1-19. SO_2: $\frac{m_S}{2m_O}$ but $m_S = 2m_O$; therefore $\frac{(2 \times m_O)}{2m_O} = 1$

1-20. conservation of mass

g oxygen = (108 g H_2O + 264 g CO_2) - 180 g glucose = 192 g

1-21. mass sodium nitrate = mass silver nitrate + mass sodium chloride - mass silver chloride

= 85.0 g + 29.2 g - 71.7 g = 42.5 g

1-22. $\frac{1.000\ g\ oxygen}{2.505\ g\ calcium}$ and 2.00 g oxygen requires 5.010 g calcium

therefore, calcium is the limiting reagent

$\frac{1.000\ g\ oxygen}{2.505\ \cancel{g\ calcium}}(4.008\ \cancel{g\ calcium}) = 1.600$ g oxygen consumed

therefore, 2.000 g oxygen initially - 1.600 g oxygen consumed = 0.400 g oxygen remain

1-23. a. $\frac{0.16 \text{ g hydrogen}}{2.50 \text{ g sulfur}} \times 20.00 \text{ g sulfur} = 1.28 \text{ g hydrogen}$

b. $1.00 \text{ g hydrogen} \times \frac{2.50 \text{ g sulfur}}{0.16 \text{ g hydrogen}} = 15.6 \text{ g sulfur}$

c. $\frac{2.50 \text{ g sulfur}}{2.66 \text{ g hydrogen sulfide}} \times 100 = 94.0\%$

1-24. a. $\frac{4.64 \text{ g N}}{1.00 \text{ g H}}$; therefore, $\frac{1.00 \text{ g H}}{5.64 \text{ g ammonia}} \times 100 = 17.7\% \text{ H}$

b. $20.0 \text{ g N}\left(\frac{1.00 \text{ g H}}{4.64 \text{ g N}}\right) = 4.31 \text{ g H}$

1-25. a. $\frac{6.00 \times 10^{23} \text{ atoms H}}{2.00 \times 10^{23} \text{ atoms P}} = \frac{3\text{H}}{1\text{P}}$; therefore, PH_3

b. $\frac{1.50 \times 10^{20} \text{ atoms H}}{1.50 \times 10^{20} \text{ atoms P}}$ but combining ratio expected is $\frac{3\text{H}}{1\text{P}}$,

therefore, H is the limiting reactant

c. 1.50×10^{20} atoms H requires 0.5×10^{20} atoms P, therefore, 1.0×10^{20} atoms P extra

1-26. $98.6°\text{F} = 1.8°\text{C} + 32 \qquad °\text{C} = 37.0$

1-27. $°\text{F} = 1.8°\text{C} + 32 = 1.8(75) + 32 = 167$

1-28. $12.0 \text{ kJ} = \left(\frac{1.00 \text{ cal}}{\text{g } H_2O - °\text{C}}\right)\left(\frac{4.184 \text{ J}}{1.000 \text{ cal}}\right)\left(\frac{1 \text{ kJ}}{10^3 \text{ J}}\right)(500 \text{ g } H_2O)(t_F - 25.0)$

$t_F = 30.7°\text{C}$

1-29. a. $250 \text{ g } H_2O\left(\frac{1.00 \text{ cal}}{\text{g } H_2O - °\text{C}}\right)(35 - 20°\text{C})\left(\frac{4.184 \text{ J}}{1.000 \text{ cal}}\right) = 15.7 \text{ kJ}$

b. the same amount, 15.7 kJ

1-30. $3.50 \times 10^3 \text{ J} = (2.75 \text{ kg Fe})(t_F - 27°\text{C})\left(\frac{0.452 \text{ J}}{\text{g Fe} - °\text{C}}\right)\left(\frac{10^3 \text{ g}}{1 \text{ kg}}\right)$

$(t_F - 27°\text{C}) = 2.8°\text{C}$

1-31. $454 \text{ g Cu}(72 - 23°\text{C})\left(\frac{0.385 \text{ J}}{\text{g Cu} - °\text{C}}\right) = 8.6 \text{ kJ}$

1-32. ethyl alcohol 2.42 J/°C
mercury 0.104 J/°C

More heat is required to change the temperature of ethyl alcohol 1 °C than for mercury.

1-33. zero, no energy lost

1-34. for each ball: $KE_i = \frac{1}{2}(2.00 \text{ kg})(20.0 \text{ m/sec})^2 = 400 \text{ J}$

$KE_f = \frac{1}{2}(2.00 \text{ kg})(15.0 \text{ m/sec})^2 = \underline{225 \text{ J}}$

energy change per ball = 175 J

therefore, 2 x 175 J = 350 J heat generated

1-35. per 100 grams, $\frac{63.6 \text{ g } N_A}{36.4 \text{ g } O_A} = 1.75 \qquad \frac{46.7 \text{ g } N_B}{53.3 \text{ g } O_B} = 0.876$

or ratio of N:O in A = 2 ratio of N:O in B

1-36. $(34.97x) + 36.97(1 - x) = 35.45 \qquad 1 - x = 0.2400$

therefore, 24.00% of the heavier isotope

1-37. $\frac{\text{g Cl}}{\text{g M}} = 2.22 \qquad \frac{\text{g Cl}}{\text{g M}} = 2.95 \qquad \frac{2.95}{2.22} = 1.33$ or 4:3 is the ratio of chlorine atoms in compound 2 to compound 1.
Possible formulas: MCl_3 and MCl_4.

1-38. a. if the ratio of H/C is 1:1, then the mass of a carbon atom is 3 times the mass of a hydrogen atom

b. if the ratio of H/C is 4:1, then the mass of a carbon atom is 12 times the mass of a hydrogen atom

1-39. $\frac{16.0000}{15.9994} = 1.000038:1$

1-40. a. $\frac{15.9994 \text{ g O}}{18.015 \text{ g } H_2O} \times 100 = 88.81\% \text{ O}$

b. $\frac{17.999 \text{ g O}}{20.015 \text{ g } H_2O} \times 100 = 89.93\% \text{ O}$

1-41. a. $\frac{3.024 \text{ g H}}{17.031 \text{ g } NH_3} \times 100 = 17.76\% \text{ H}$

b. $\frac{6.042}{20.049} \times 100 = 30.14\% \text{ D}$

1-42. $a = \frac{\Delta v}{t} = \frac{7.50 \times 10^5 \text{ m/sec} - 2.50 \times 10^5 \text{ m/sec}}{2.00 \times 10^{-3} \text{ sec}} = 2.50 \times 10^8 \text{ m/sec}$

1-43. $a = \frac{\Delta v}{t} = \frac{(+400 \text{ m/sec}) - (-400 \text{ m/sec})}{3.00 \times 10^{-6} \text{ sec}} = 2.67 \times 10^8 \text{ m/sec}^2$ downward

1-44. $F = (6.4 \times 10^{-27} \text{ kg})(3.50 \times 10^{10} \text{ m/sec}^2) = 2.24 \times 10^{-16}$ newtons

1-45. $a = \frac{2.5 \times 10^{-16}\ \cancel{\text{newtons}}}{1.67 \times 10^{-27}\ \cancel{\text{kg}}}\left(\frac{1\ \cancel{\text{kg}}\text{-m/sec}^2}{1\ \cancel{\text{newton}}}\right) = 1.5 \times 10^{11}\ \text{m/sec}^2$

1-46. $m = \frac{5.0 \times 10^{-17}\ \text{kg-}\cancel{\text{m/sec}^2}}{2.2 \times 10^{9}\ \cancel{\text{m/sec}^2}} = 2.27 \times 10^{-26}\ \text{kg}$

1-47. $3.0 \times 10^{-26}\ \text{kg}\left(\frac{700\ \text{m/sec}}{2.50 \times 10^{-6}\ \text{sec}}\right) = 8.4 \times 10^{-18}\ \text{newtons}$

1-48. $K.E. = \frac{1}{2}mv^2 \qquad \frac{1}{2}m_A v_A^2 = \frac{1}{2}\cancel{m_B}v_B^2 = \frac{1}{\cancel{2}}(\cancel{2}\cancel{m_B})v_A^2$

therefore, $\frac{v_B}{v_A} = \sqrt{2}$

$M_A = m_A v_A = (2m_B)v_A = (2m_B)\left(\frac{v_B}{\sqrt{2}}\right) = \frac{2}{\sqrt{2}}m_B v_B = 1.4 M_B$

$M_B = m_B v_B$ or $M_A > M_B$

CHAPTER 2

2-1. $0.030\ \cancel{\text{mol NH}_3}\left(\dfrac{6.02 \times 10^{23}\ \text{molecules}}{\cancel{\text{mol NH}_3}}\right) = 1.8 \times 10^{22}$

2-2. $0.48\ \cancel{\text{g SO}_2}\left(\dfrac{6.02 \times 10^{23}\ \text{molecules}}{64.06\ \cancel{\text{g SO}_2}}\right) = 4.5 \times 10^{21}$

2-3. $2.00 \times 10^{21}\ \cancel{\text{molecules}}\left(\dfrac{18.0\ \text{g water}}{6.02 \times 10^{23}\ \cancel{\text{molecules}}}\right) = 5.98 \times 10^{-2}\ \text{g}$

2-4. $3.25\ \cancel{\text{mol Sn}}\left(\dfrac{118.7\ \text{g Sn}}{\cancel{\text{mol Sn}}}\right) = 386\ \text{g}$

2-5. $0.58\ \cancel{\text{mol P}_4}\left(\dfrac{31\ \text{g}}{\cancel{\text{mol P}}}\right)\left(\dfrac{4\ \cancel{\text{mol P}}}{1\ \cancel{\text{mol P}_4}}\right) = 72\ \text{g}$

2-6. $0.0300\ \cancel{\text{mol O}_2}\left(\dfrac{2\ \text{atoms O}}{1\ \cancel{\text{molecule O}_2}}\right)\left(\dfrac{6.02 \times 10^{23}\ \cancel{\text{molecules O}_2}}{\cancel{\text{mol O}_2}}\right)$

$= 3.61 \times 10^{22}\ \text{atoms}$

2-7. $0.500\ \cancel{\text{mol O}}\ \text{atoms}\left(\dfrac{1\ \text{mol O}_3}{3\ \cancel{\text{mol O}}\ \text{atoms}}\right) = 0.167\ \text{mol}$

2-8. $\dfrac{\left(\dfrac{1\ \text{mol S}}{1\ \text{mol}\ \cancel{\text{C}_6\text{H}_8\text{N}_2\text{SO}_2}}\right)}{\left(\dfrac{2\ \text{mol N}}{1\ \text{mol}\ \cancel{\text{C}_6\text{H}_8\text{N}_2\text{SO}_2}}\right)} = 1 : 2$

2-9. $\dfrac{13.8\ \text{g N}}{14.007} = 0.985 \div 0.330 \cong 3$

$\dfrac{11.7}{35.45} = 0.330 \div 0.330 = 1$

therefore 3N : 1Cl

2-10. $C_5H_{11}NSO_2$: 5C, 11H, 1N, 1S, 2O's

2-11. $(NH_4)_2Cr_2O_7$: 2N, 8H, 2Cr, 7O's

2-12. $K_4Fe(CN)_6 \cdot 3H_2O$: 4K, 1Fe, 6C, 6N, 6H, 3O's, and 3 waters of hydration

2-13. $CsAl(SO_4)_2 \cdot 12H_2O$: 1Cs, 1Al, 2S, 20O's, 24H, and 12 waters of hydration

2-14. $5\ \text{molecules CCl}_4\left(\dfrac{4\ \text{atoms Cl}}{1\ \text{molecule CCl}_4}\right) = 20\ \text{atoms Cl}$

2-15. $15\ \text{SO}_3\ \text{molecules}\left(\dfrac{3\ \text{O atoms}}{1\ \text{molecule SO}_3}\right) = 45\ \text{atoms O}$

2-16. (a) $\left(\dfrac{6\ \text{atoms S}}{\text{molecule S}}\right)\left(\dfrac{32\ \text{g}}{1\ \text{atom S}}\right) = 192\ \text{g}$

(b) $$\frac{2\ \text{atoms N}\left(\dfrac{14.0\ \text{g}}{1\ \text{atom N}}\right) + 4\ \text{atoms O}\left(\dfrac{16.0\ \text{g}}{1\ \text{atom O}}\right)}{\text{molecule N}_2\text{O}_4} = 92.0\ \text{g}$$

(c) $$\frac{2\ \text{atoms C}\left(\dfrac{12.0\ \text{g}}{1\ \text{atom C}}\right) + 6\ \text{atoms H}\left(\dfrac{1.008\ \text{g}}{1\ \text{atom H}}\right) + 1\ \text{atom O}\left(\dfrac{16.0\ \text{g}}{1\ \text{atom O}}\right)}{\text{molecule C}_2\text{H}_6\text{O}}$$

$= 46.0\ \text{g}$

2-17. (a) $\left(\dfrac{4\ \text{atoms P}}{\text{molecule P}_4}\right)\left(\dfrac{31.0\ \text{g}}{1\ \text{atom P}}\right) = 124\ \text{g}$

(b) $$\frac{1\ \text{atom Xe}\left(\dfrac{131\ \text{g}}{1\ \text{atom Xe}}\right) + 4\ \text{atoms F}\left(\dfrac{19.0\ \text{g}}{1\ \text{atom F}}\right)}{\text{molecule XeF}_4} = 207\ \text{g}$$

(c) $$\frac{3\ \text{atoms H}\left(\dfrac{1.008\ \text{g}}{1\ \text{atom H}}\right) + 1\ \text{atom N}\left(\dfrac{14.0\ \text{g}}{1\ \text{atom N}}\right) + 1\ \text{atom O}\left(\dfrac{16.0\ \text{g}}{1\ \text{atom O}}\right)}{\text{molecule H}_2\text{NOH}}$$

$= 33.0\ \text{g}$

2-18. (a) $1\ \text{mol P}_4\left(\dfrac{124\ \text{g}}{1\ \text{mol P}_4}\right) = 124\ \text{g}$

(b) $0.350\ \text{mol CH}_4\left(\dfrac{16.0\ \text{g}}{1\ \text{mol CH}_4}\right) = 5.60\ \text{g}$

(c) $7.0 \times 10^{-4}\ \text{mol C}_2\text{H}_5\text{OH}\left(\dfrac{46.0\ \text{g}}{1\ \text{mol C}_2\text{H}_5\text{OH}}\right) = 3.2 \times 10^{-2}\ \text{g}$

2-19. (a) $2.50\ \text{mol N}_2\text{H}_4\left(\dfrac{32.0\ \text{g}}{\text{mol N}_2\text{H}_4}\right) = 80.0\ \text{g}$

(b) $4.3 \times 10^{-5}\ \text{mol (NH}_4)_2\text{SO}_4\left(\dfrac{132\ \text{g}}{\text{mol (NH}_4)_2\text{SO}_4}\right) = 5.7 \times 10^{-3}\ \text{g}$

(c) $0.035\ \text{mol SOCl}_2\left(\dfrac{119\ \text{g}}{\text{mol SOCl}_2}\right) = 4.2\ \text{g}$

2-20. (a) $1.00\ \cancel{\text{g HCl}}\left(\frac{1\text{ mol}}{36.5\ \cancel{\text{g HCl}}}\right) = 2.74 \times 10^{-2}\text{ mol}$

(b) $2.70\ \cancel{\text{kg glucose}}\left(\frac{1000\text{ g glucose}}{1\ \cancel{\text{kg glucose}}}\right)\left(\frac{1\text{ mol glucose}}{180\text{ g glucose}}\right) = 15.0\text{ mol}$

2-21. (a) $3.50\ \cancel{\text{g }H_2S}\left(\frac{1\text{ mol}}{34.1\ \cancel{\text{g }H_2S}}\right) = 0.103\text{ mol}$

(b) $0.175\ \cancel{\text{mg glycine}}\left(\frac{1\ \cancel{\text{g glycine}}}{1000\ \cancel{\text{mg glycine}}}\right)\left(\frac{1\text{ mol}}{75.0\ \cancel{\text{g glycine}}}\right)$

$= 2.33 \times 10^{-6}\text{ mol}$

2-22. $9.5\ \cancel{\text{g }F_2}\left(\frac{1\ \cancel{\text{mol }F_2}}{38.0\ \cancel{\text{g }F_2}}\right)\left(\frac{2\text{ mol F}}{1\ \cancel{\text{mol }F_2}}\right) = 0.50\text{ mol F}$

2-23. $21.0\ \cancel{\text{g }N_2}\left(\frac{1\ \cancel{\text{mol }N_2}}{28.0\ \cancel{\text{g }N_2}}\right)\left(\frac{2\text{ mol N}}{1\ \cancel{\text{mol }N_2}}\right) = 1.50\text{ mol N}$

2-24. $0.200\text{ mol }\cancel{C_6H_{12}O_6}\left(\frac{6\text{ mol C}}{1\text{ mol }\cancel{C_6H_{12}O_6}}\right) = 1.20\text{ mol C}$

2-25. $5.0 \times 10^{-3}\ \cancel{\text{mol }Ba(H_2PO_2)_2} \cdot H_2O\left(\frac{6\text{ mol H}}{1\ \cancel{\text{mol }Ba(H_2PO_2)_2} \cdot H_2O}\right)$

$= 0.030\text{ mol H}$

2-26. $20.0\ \cancel{\text{g }C_4H_4N_2}\left(\frac{1\ \cancel{\text{mol }C_4H_4N_2}}{80.0\ \cancel{\text{g }C_4H_4N_2}}\right)\left(\frac{2\text{ mol N}}{1\ \cancel{\text{mol }C_4H_4N_2}}\right) = 0.500\text{ mol N}$

2-27. $15.0\ \cancel{\text{g }SF_6}\left(\frac{1\ \cancel{\text{mol }SF_6}}{146.1\ \cancel{\text{g }SF_6}}\right)\left(\frac{6\text{ mol F}}{1\ \cancel{\text{mol }SF_6}}\right) = 0.616\text{ mol F}$

2-28. $\frac{85.8}{10.8} = 7.94 \div 7.94 = 1.00 \times 5 = 5.00$

therefore $\boxed{B_5H_9}$

$\frac{14.2}{1.008} = 14.1 \div 7.94 = 1.78 \times 5 = 8.90 \approx 9.0$

$5(10.8) + 9(1.008) = 63.1\text{ amu}$

2-29. $\frac{42.1}{12.0} = 3.51 \div 3.21 = 1.1$

$\frac{6.5}{1.0} = 6.5 \div 3.21 = 2.0$

$\frac{51.4}{16.0} = 3.21 \div 3.21 = 1.0$

$C_{1.1}H_{2.0}O_{1.0}$ gives a formula mass of 31.2 but the actual mass is 342; therefore the molecular formula must be a multiple: $342 \div 31.2 \cong 11$.

or molecular formula is $\boxed{C_{12}H_{22}O_{11}}$.

2-30. mass of BH_3 unit is 10.8 + 3(1.008) = 13.8 amu

$\frac{28}{13.8} \cong 2$; therefore B_2H_6 is its molecular formula.

2-31. mass of C_3H_3O unit is (3 x 12.0) + (3 x 1.008) + 16.0 = 55.0 amu

$\frac{110 \text{ amu}}{55 \text{ amu}} = 2$; therefore $C_6H_6O_2$ is its molecular formula

2-32. Na: $\frac{29.1}{23.0} = 1.27 \div 1.27 = 1.0$ times 2 to give integer values yields $Na_2S_2O_3$

S: $\frac{40.6}{32.0} = 1.27 \div 1.27 = 1.0$

O: $\frac{30.4}{16.0} = 1.90 \div 1.27 = 1.5$

2-33. Pt: $\frac{44.43}{195.09} = 0.2277 \div 0.2277 = 1.00$

N: $\frac{19.14}{14.007} = 1.366 \div 0.2277 \cong 6.00$ therefore $PtN_6H_{18}Cl_4$,

H: $\frac{4.13}{1.008} = 4.097 \div 0.2277 = 18.0$ commonly written $Pt(NH_3)_6Cl_4$

Cl: $\frac{32.30}{35.45} = 0.9111 \div 0.2277 = 4.00$

2-34. (a) C: $\frac{32.0}{12.0} = 2.67 \div 2.67 = 1.0$ times 2 to give integer values yields a simplest formula: $C_2H_3O_3$

H: $\frac{4.0}{1.0} = 4.0 \div 2.67 = 1.5$

O: $\frac{64.0}{16.0} = 4.00 \div 2.67 = 1.5$

(b) (2 x 12.0) + (3 x 1.008) + (3 x 16.0) = 75.0 amu

$\frac{150 \text{ amu}}{75.0 \text{ amu}} = 2$; therefore its molecular formula is $C_4H_6O_6$.

2-35. (a) C: $\frac{46.2}{12.0} = 3.85 \div 3.84 = 1.0$ therefore its simplest formula is CN

N: $\frac{53.8}{14.0} = 3.84 \div 3.84 = 1.0$ 12.0 + 14.0 = 26.0 amu

(b) $\frac{52 \text{ amu}}{26.0 \text{ amu}} = 2$; therefore its molecular formula is C_2N_2.

2-36. $$\frac{2 \cancel{\text{mol B}}}{1 \text{ mol } \cancel{C_{10}H_{22}B_2}}\left(\frac{10.8 \text{ g B}}{1 \cancel{\text{mol B}}}\right)\left(\frac{1 \text{ mol } \cancel{C_{10}H_{22}B_2}}{163.6 \text{ g } C_{10}H_{22}B_2}\right) = 13.2\%$$

2-37. $$\frac{1\ \cancel{\text{mol Ni}}}{\text{mol}\ \cancel{Ni(C_4H_7N_2O_2)_2}}\left(\frac{\text{mol}\ \cancel{Ni(C_4H_7N_2O_2)_2}}{288.7\ \text{g}\ Ni(C_4H_7N_2O_2)_2}\right)\left(\frac{58.7\ \text{g Ni}}{\cancel{\text{mol Ni}}}\right) = 20.3\%$$

2-38. sodalite: 484.7 amu ≈ 485 amu

$$\frac{4(23.0\ \text{amu Na/molecule})}{485\ \text{amu}} = 19.0\%\ \text{Na}$$

$$\frac{3(27.0\ \text{amu Al/molecule})}{485\ \text{amu}} = 16.7\%\ \text{Al}$$

$$\frac{3(28.1\ \text{amu Si/molecule})}{485\ \text{amu}} = 17.4\%\ \text{Si}$$

$$\frac{12(16.0\ \text{amu O/molecule})}{485\ \text{amu}} = 39.6\%\ \text{O}$$

$$\frac{1(35.45\ \text{amu Cl/molecule})}{485\ \text{amu}} = 7.3\%\ \text{Cl}$$

2-39. Mohr's salt: 392 amu

(a) $$\frac{2(14.007\ \text{amu N/molecule})}{392\ \text{amu}} = 7.15\%\ \text{N}$$

$$\frac{20(1.008\ \text{amu H/molecule})}{392\ \text{amu}} = 5.14\%\ \text{H}$$

$$\frac{2(32.06\ \text{amu S/molecule})}{392\ \text{amu}} = 16.4\%\ \text{S}$$

$$\frac{14(16.00\ \text{amu O/molecule})}{392\ \text{amu}} = 57.1\%\ \text{O}$$

$$\frac{1(55.85\ \text{amu Fe/molecule})}{392\ \text{amu}} = 14.2\%\ \text{Fe}$$

2-40. (a) $P_{4\,(g)} + 1O_{2\,(g)} \rightarrow P_2O_{5\,(s)}$

(b) $2C_2H_{6\,(g)} + 7O_{2\,(g)} \rightarrow 4CO_{2\,(g)} + 6H_2O_{(g)}$

(c) $3CaCl_{2\,(aq)} + 2Na_2HPO_{4\,(aq)} \rightarrow Ca_3(PO_4)_{2\,(s)} + 4NaCl_{(aq)} + 2HCl_{(aq)}$

(d) $H_2O + 2AgNO_{3\,(aq)} + Na_2SO_{3\,(aq)} \rightarrow 2Ag_{(s)} + Na_2SO_{4\,(aq)} + 2HNO_{3\,(aq)}$

(e) $2CrO_{3\,(aq)} + 12HCl_{(aq)} \rightarrow 2CrCl_{3\,(aq)} + 6H_2O + 3Cl_{2\,(g)}$

2-41. (a) $4NO_{(g)} + 3O_{2\,(g)} \rightarrow 2N_2O_{5\,(g)}$

(b) $C_6H_{12\,(g)} + 9O_{2\,(g)} \rightarrow 6CO_{2\,(g)} + 6H_2O$

(c) $Ag_3PO_{4\,(s)} + 3HCl_{(aq)} \rightarrow H_3PO_{4\,(aq)} + 3AgCl_{(s)}$

(d) $Al_2(SO)_{3\,(aq)} + 3SrI_{2\,(aq)} \rightarrow 2AlI_{3\,(aq)} + 3SrSO_{4\,(s)}$

(e) $4KI_{(aq)} + 2CuSO_{4\,(aq)} \rightarrow I_{2\,(aq)} + 2CuI_{(s)} + 2K_2SO_{4\,(aq)}$

2-42. (a) $2FeCl_{3\,(aq)} + 2KI_{(aq)} \rightarrow 2FeCl_{2\,(aq)} + I_{2\,(aq)} + 2KCl_{(aq)}$

(b) $1.00\ \text{g FeCl}_3\left(\frac{1\ \text{mol FeCl}_3}{162.2\ \text{g FeCl}_3}\right) = 6.17 \times 10^{-3}\ \text{mol FeCl}_3$

$$1.00\ \text{g KI}\left(\frac{1\ \text{mol KI}}{166\ \text{g KI}}\right) = 6.02 \times 10^{-3}\ \text{mol KI}$$

therefore KI is the limiting reagent.

(c) $6.02 \times 10^{-3}\ \text{mol KI}\left(\frac{1\ \text{mol I}_2}{2\ \text{mol KI}}\right)\left(\frac{253.8\ \text{g I}_2}{1\ \text{mol I}_2}\right) = 0.764\ \text{g I}_2$

2-43. $5.00\ \text{g Ba(NO}_3)_2\left(\frac{1\ \text{mol Ba(NO}_3)_2}{261.3\ \text{g Ba(NO}_3)_2}\right) = 0.0191\ \text{mol}$

$$7.00\ \text{g KH}_2\text{PO}_4\left(\frac{1\ \text{mol KH}_2\text{PO}_4}{136.1\ \text{g KH}_2\text{PO}_4}\right) = 0.0514\ \text{mol}$$

Stoichiometry is 1 mol $Ba(NO_3)_2$ to 2/3 mol KH_2PO_4; therefore $Ba(NO_3)_2$ is the limiting reagent.

$$1.91 \times 10^{-2}\ \text{mol Ba(NO}_3)_2\left(\frac{1\ \text{mol Ba}_3(\text{PO}_4)_2}{3\ \text{mol Ba(NO}_3)_2}\right)\left(\frac{602.0\ \text{g Ba}_3(\text{PO}_4)_2}{1\ \text{mol Ba}_3(\text{PO}_4)_2}\right)$$

$= 3.83$ g

2-44. (a)

2.075 g oxide	Co: $\frac{1.472}{58.93} = 0.0250 \div 0.0250 = 1$
− 1.472 g Co	
0.603 g O	O: $\frac{0.603}{16.0} = 0.0377 \div 0.0250 = 1.5$

or times 2 to give integer values yields Co_2O_3.

(b) $Co_2O_{3(s)} + 3H_{2(g)} = 3H_2O + 2Co_{(s)}$

2-45. (a) $5FeCl_{2(aq)} + KMnO_{4(aq)} + 8HCl_{(aq)} \rightarrow KCl_{(aq)} + MnCl_{2(aq)} + 5FeCl_{3(aq)} + 4H_2O$

(b) $0.381\ \text{g FeCl}_2\left(\frac{1\ \text{mol FeCl}_2}{126.75\ \text{g FeCl}_2}\right)\left(\frac{1\ \text{mol KMnO}_4}{5\ \text{mol FeCl}_2}\right)\left(\frac{158.0\ \text{g KMnO}_4}{1\ \text{mol KMnO}_4}\right)$

$= 9.50 \times 10^{-2}$ g

2-46. (a) $15\ \text{g Br}_2\left(\frac{1\ \text{mol Br}_2}{160\ \text{g Br}_2}\right) = 0.0938\ \text{mol}$; limiting reagent

$$45\ \text{g CHCl}_3\left(\frac{1\ \text{mol CHCl}_3}{119.4\ \text{g CHCl}_3}\right) = 0.377\ \text{mol}$$

$$0.0938\ \text{mol Br}_2\left(\frac{1\ \text{mol CBrCl}_3}{1\ \text{mol Br}_2}\right)\left(\frac{198.3\ \text{g CBrCl}_3}{1\ \text{mol CBrCl}_3}\right) = \boxed{18.6\ \text{g}}$$

(b) $\frac{6.0\ \text{g}}{18.6\ \text{g}} \times 100 = \boxed{32.2\%}$