

Solutions Manual to accompany

# Chemistry

Abrash • Hardcastle



# SOLUTIONS MANUAL

TO ACCOMPANY

# CHEMISTRY

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# TO THE STUDENT

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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:

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

rather than:

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

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

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

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

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

$$b. \text{ change in energy} = \text{energy expended} = 6.3 \times 10^{-19} \text{ J}$$

$$1-10. 0.0800 \text{ J} = (3.00 \text{ newtons})(\text{distance}); \text{ distance} = 2.67 \times 10^{-2} \text{ m}$$

$$1-11. \text{ work} = (0.200 \text{ newtons}) (0.350 \text{ m}) = 7.00 \times 10^{-2} \text{ J}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1-20. conservation of mass

$$\text{g oxygen} = (108 \text{ g H}_2\text{O} + 264 \text{ g CO}_2) - 180 \text{ g glucose} = 192 \text{ g}$$

$$\begin{aligned} 1-21. \quad \text{mass sodium nitrate} &= \text{mass silver nitrate} + \text{mass sodium chloride} \\ &\quad - \text{mass silver chloride} \\ &= 85.0 \text{ g} + 29.2 \text{ g} - 71.7 \text{ g} = 42.5 \text{ g} \end{aligned}$$

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

therefore, calcium is the limiting reagent

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

$$\begin{aligned} \text{therefore, } 2.000 \text{ g oxygen initially} &- 1.600 \text{ g oxygen consumed} \\ &= 0.400 \text{ g oxygen remain} \end{aligned}$$

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,  $\text{PH}_3$

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.  $1.50 \times 10^{20} \text{ atoms H}$  requires  $0.5 \times 10^{20} \text{ atoms P}$ ,  
therefore,  $1.0 \times 10^{20} \text{ atoms P}$  extra

1-26.  $98.6^\circ\text{F} = 1.8^\circ\text{C} + 32 \quad ^\circ\text{C} = 37.0$

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

1-28.  $12.0 \text{ kJ} = \left( \frac{1.00 \text{ cal}}{\text{g H}_2\text{O} - ^\circ\text{C}} \right) \left( \frac{4.184 \text{ J}}{1.000 \text{ cal}} \right) \left( \frac{1 \text{ kJ}}{10^3 \text{ J}} \right) (500 \text{ g H}_2\text{O}) (t_F - 25.0)$   
 $t_F = 30.7^\circ\text{C}$

1-29. a.  $250 \text{ g H}_2\text{O} \left( \frac{1.00 \text{ cal}}{\text{g H}_2\text{O} - ^\circ\text{C}} \right) (35 - 20^\circ\text{C}) \left( \frac{4.184 \text{ J}}{1.000 \text{ cal}} \right) = 15.7 \text{ kJ}$

b. the same amount, 15.7 kJ

1-30.  $3.50 \times 10^3 \text{ J} = (2.75 \text{ kg Fe}) (t_F - 27^\circ\text{C}) \left( \frac{0.452 \text{ J}}{\text{g Fe} - ^\circ\text{C}} \right) \left( \frac{10^3 \text{ g}}{1 \text{ kg}} \right)$   
 $(t_F - 27^\circ\text{C}) = 2.8^\circ\text{C}$

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

1-32. ethyl alcohol  $2.42 \text{ J/}^\circ\text{C}$   
mercury  $0.104 \text{ J/}^\circ\text{C}$

More heat is required to change the temperature of ethyl alcohol  $1^\circ\text{C}$  than for mercury.

1-33. zero, no energy lost

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

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

$$\text{energy change per ball} = 175 \text{ J}$$

therefore,  $2 \times 175 \text{ J} = 350 \text{ J}$  heat generated

1-35. per 100 grams,  $\frac{63.6 \text{ g N}_A}{36.4 \text{ g O}_A} = 1.75$        $\frac{46.7 \text{ g N}_B}{53.3 \text{ g O}_B} = 0.876$

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

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

therefore, 24.00% of the heavier isotope

1-37.  $\frac{\text{g Cl}}{\text{g M}} = 2.22$        $\frac{\text{g Cl}}{\text{g M}} = 2.95$        $\frac{2.95}{2.22} = 1.33$  or 4:3 is the ratio  
of chlorine atoms in compound 2 to compound 1.  
Possible formulas:  $\text{MCl}_3$  and  $\text{MCl}_4$ .

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.  $\frac{15.9994 \text{ g O}}{18.015 \text{ g H}_2\text{O}} \times 100 = 88.81\% \text{ O}$

b.  $\frac{17.999 \text{ g O}}{20.015 \text{ g H}_2\text{O}} \times 100 = 89.93\% \text{ O}$

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

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

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

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

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

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

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

$$M_B = m_B v_B \quad \text{or} \quad M_A > M_B$$

## CHAPTER 2

---

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

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

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

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

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

$$2-6. \quad 0.0300 \cancel{\text{mol O}_2} \left( \frac{2 \text{ atoms O}}{1 \cancel{\text{molecule O}_2}} \right) \left( \frac{6.02 \times 10^{23} \cancel{\text{molecules O}_2}}{\cancel{\text{mol O}_2}} \right) \\ = 3.61 \times 10^{22} \text{ atoms}$$

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

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

$$2-9. \quad \frac{13.8 \text{ g N}}{14.007} = 0.985 \div 0.330 \approx 3$$

therefore 3N : 1Cl

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

$$2-10. \quad \text{C}_5\text{H}_{11}\text{NSO}_2 : 5\text{C}, 11\text{H}, 1\text{N}, 1\text{S}, 2\text{O's}$$

$$2-11. \quad (\text{NH}_4)_2\text{Cr}_2\text{O}_7 : 2\text{N}, 8\text{H}, 2\text{Cr}, 7\text{O's}$$

$$2-12. \quad \text{K}_4\text{Fe}(\text{CN})_6 \cdot 3\text{H}_2\text{O} : 4\text{K}, 1\text{Fe}, 6\text{C}, 6\text{N}, 6\text{H}, 3\text{O's}, \text{ and } 3 \text{ waters of hydration}$$

$$2-13. \quad \text{CsAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O} : 1\text{Cs}, 1\text{Al}, 2\text{S}, 20\text{O's}, 24\text{H}, \text{ and } 12 \text{ waters of hydration}$$

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

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

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

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

$$(c) \quad \frac{2 \text{ atoms C} \left( \frac{12.0 \text{ g}}{1 \text{ atom C}} \right) + 6 \text{ atoms H} \left( \frac{1.008 \text{ g}}{1 \text{ atom H}} \right) + 1 \text{ atom O} \left( \frac{16.0 \text{ g}}{1 \text{ atom O}} \right)}{\text{molecule C}_2\text{H}_6\text{O}} = 46.0 \text{ g}$$

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

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

$$(c) \quad \frac{3 \text{ atoms H} \left( \frac{1.008 \text{ g}}{1 \text{ atom H}} \right) + 1 \text{ atom N} \left( \frac{14.0 \text{ g}}{1 \text{ atom N}} \right) + 1 \text{ atom O} \left( \frac{16.0 \text{ g}}{1 \text{ atom O}} \right)}{\text{molecule H}_2\text{NOH}} = 33.0 \text{ g}$$

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

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

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

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

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

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

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

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

$$2-21. \quad (a) \quad 3.50 \text{ g H}_2\text{S} \left( \frac{1 \text{ mol}}{34.1 \text{ g H}_2\text{S}} \right) = 0.103 \text{ mol}$$

$$(b) \quad 0.175 \text{ mg glycine} \left( \frac{1 \text{ g glycine}}{1000 \text{ mg glycine}} \right) \left( \frac{1 \text{ mol}}{75.0 \text{ g glycine}} \right) \\ = 2.33 \times 10^{-6} \text{ mol}$$

$$2-22. \quad 9.5 \text{ g F}_2 \left( \frac{1 \text{ mol F}_2}{38.0 \text{ g F}_2} \right) \left( \frac{2 \text{ mol F}}{1 \text{ mol F}_2} \right) = 0.50 \text{ mol F}$$

$$2-23. \quad 21.0 \text{ g N}_2 \left( \frac{1 \text{ mol N}_2}{28.0 \text{ g N}_2} \right) \left( \frac{2 \text{ mol N}}{1 \text{ mol N}_2} \right) = 1.50 \text{ mol N}$$

$$2-24. \quad 0.200 \text{ mol C}_6\text{H}_{12}\text{O}_6 \left( \frac{6 \text{ mol C}}{1 \text{ mol C}_6\text{H}_{12}\text{O}_6} \right) = 1.20 \text{ mol C}$$

$$2-25. \quad 5.0 \times 10^{-3} \text{ mol Ba(H}_2\text{PO}_2)_2 \cdot \text{H}_2\text{O} \left( \frac{6 \text{ mol H}}{1 \text{ mol Ba(H}_2\text{PO}_2)_2 \cdot \text{H}_2\text{O}} \right) \\ = 0.030 \text{ mol H}$$

$$2-26. \quad 20.0 \text{ g C}_4\text{H}_4\text{N}_2 \left( \frac{1 \text{ mol C}_4\text{H}_4\text{N}_2}{80.0 \text{ g C}_4\text{H}_4\text{N}_2} \right) \left( \frac{2 \text{ mol N}}{1 \text{ mol C}_4\text{H}_4\text{N}_2} \right) = 0.500 \text{ mol N}$$

$$2-27. \quad 15.0 \text{ g SF}_6 \left( \frac{1 \text{ mol SF}_6}{146.1 \text{ g SF}_6} \right) \left( \frac{6 \text{ mol F}}{1 \text{ mol SF}_6} \right) = 0.616 \text{ mol F}$$

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

therefore



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

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

$$2-29. \quad \left. \begin{array}{l} \frac{42.1}{12.0} = 3.51 \div 3.21 = 1.1 \\ \frac{6.5}{1.0} = 6.5 \div 3.21 = 2.0 \\ \frac{51.4}{16.0} = 3.21 \div 3.21 = 1.0 \end{array} \right\} \begin{array}{l} \text{C}_{11}\text{H}_{20}\text{O}_{10} \text{ gives a formula mass of} \\ 31.2 \text{ but the actual mass is } 342; \\ \text{therefore the molecular formula} \\ \text{must be a multiple: } 342 \div 31.2 \approx 11. \end{array}$$

or molecular formula is  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ .

2-30. mass of  $\text{BH}_3$  unit is  $10.8 + 3(1.008) = 13.8$  amu

$$\frac{28}{13.8} \approx 2; \text{ therefore } \text{B}_2\text{H}_6 \text{ is its molecular formula.}$$

2-31. mass of  $\text{C}_3\text{H}_3\text{O}$  unit is  $(3 \times 12.0) + (3 \times 1.008) + 16.0 = 55.0$  amu

$$\frac{110 \text{ amu}}{55 \text{ amu}} = 2; \text{ therefore } \text{C}_6\text{H}_6\text{O}_2 \text{ is its molecular formula}$$

2-32. Na:  $\frac{29.1}{23.0} = 1.27 \div 1.27 = 1.0$  times 2 to give integer values  
yields  $\text{Na}_2\text{S}_2\text{O}_3$

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

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

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

$$\text{N: } \frac{19.14}{14.007} = 1.366 \div 0.2277 \approx 6.00 \quad \text{therefore } \text{PtN}_6\text{H}_{18}\text{Cl}_4,$$

$$\text{H: } \frac{4.13}{1.008} = 4.097 \div 0.2277 = 18.0 \quad \text{commonly written } \text{Pt}(\text{NH}_3)_6\text{Cl}_4$$

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

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:

$$\text{H: } \frac{4.0}{1.0} = 4.0 \div 2.67 = 1.5 \quad \text{C}_2\text{H}_3\text{O}_3$$

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

(b)  $(2 \times 12.0) + (3 \times 1.008) + (3 \times 16.0) = 75.0$  amu

$$\frac{150 \text{ amu}}{75.0 \text{ amu}} = 2; \text{ therefore its molecular formula is } \text{C}_4\text{H}_6\text{O}_6.$$

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

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

(b)  $\frac{52 \text{ amu}}{26.0 \text{ amu}} = 2; \text{ therefore its molecular formula is } \text{C}_2\text{N}_2.$

$$2-36. \quad \frac{2 \cancel{\text{mol B}}}{1 \cancel{\text{mol C}_{10}\text{H}_{22}\text{B}_2}} \left( \frac{10.8 \text{ g B}}{1 \cancel{\text{mol B}}} \right) \left( \frac{1 \cancel{\text{mol C}_{10}\text{H}_{22}\text{B}_2}}{163.6 \text{ g C}_{10}\text{H}_{22}\text{B}_2} \right) = 13.2\%$$

$$2-37. \frac{1 \text{ mol Ni}}{\text{mol Ni}(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_2} \left( \frac{\text{mol Ni}(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_2}{288.7 \text{ g Ni}(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_2} \right) \left( \frac{58.7 \text{ g Ni}}{\text{mol Ni}} \right) = 20.3\%$$

2-38. sodalite: 484.7 amu  $\approx$  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

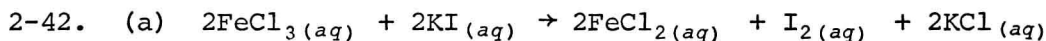
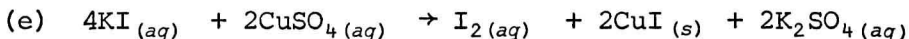
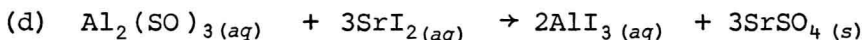
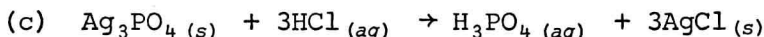
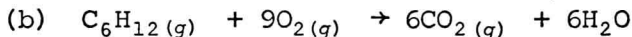
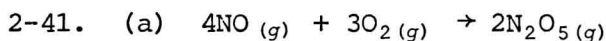
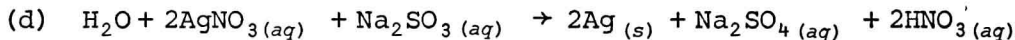
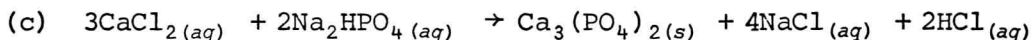
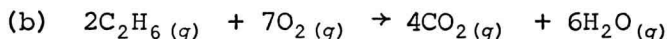
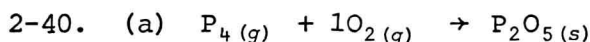
$$(a) \frac{2(14.007 \text{ amu N/molecule})}{392 \text{ amu}} = 7.15\% \text{ N}$$

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

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

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

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



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

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

therefore KI is the limiting reagent.

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

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

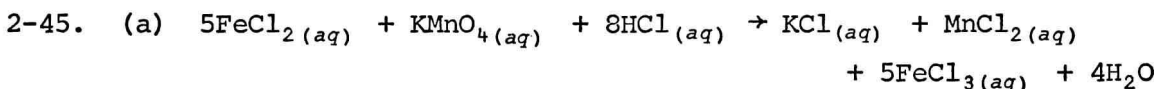
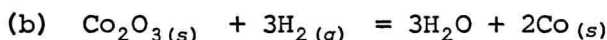
$$7.00 \text{ g } \cancel{\text{KH}_2\text{PO}_4} \left( \frac{1 \text{ mol } \text{KH}_2\text{PO}_4}{136.1 \text{ g } \cancel{\text{KH}_2\text{PO}_4}} \right) = 0.0514 \text{ mol}$$

Stoichiometry is 1 mol  $\text{Ba}(\text{NO}_3)_2$  to  $2/3$  mol  $\text{KH}_2\text{PO}_4$ ; therefore  $\text{Ba}(\text{NO}_3)_2$  is the limiting reagent.

$$1.91 \times 10^{-2} \text{ mol } \cancel{\text{Ba}(\text{NO}_3)_2} \left( \frac{1 \text{ mol } \text{Ba}_3(\text{PO}_4)_2}{3 \text{ mol } \cancel{\text{Ba}(\text{NO}_3)_2}} \right) \left( \frac{602.0 \text{ g } \text{Ba}_3(\text{PO}_4)_2}{1 \text{ mol } \text{Ba}_3(\text{PO}_4)_2} \right) \\ = 3.83 \text{ g}$$

$$2-44. \quad (a) \quad \begin{array}{rcl} 2.075 \text{ g oxide} & \text{Co:} & \frac{1.472}{58.93} = 0.0250 \div 0.0250 = 1 \\ - 1.472 \text{ g Co} & & \\ \hline 0.603 \text{ g O} & \text{O:} & \frac{0.603}{16.0} = 0.0377 \div 0.0250 = 1.5 \end{array}$$

or times 2 to give integer values yields  $\text{Co}_2\text{O}_3$ .



$$(b) \quad 0.381 \text{ g } \cancel{\text{FeCl}_2} \left( \frac{1 \text{ mol } \cancel{\text{FeCl}_2}}{126.75 \text{ g } \cancel{\text{FeCl}_2}} \right) \left( \frac{1 \text{ mol } \cancel{\text{KMnO}_4}}{5 \text{ mol } \cancel{\text{FeCl}_2}} \right) \left( \frac{158.0 \text{ g } \text{KMnO}_4}{1 \text{ mol } \cancel{\text{KMnO}_4}} \right) \\ = 9.50 \times 10^{-2} \text{ g}$$

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

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

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

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