Solutions Manual to Accompany *Chemistry for Accelerated Students*

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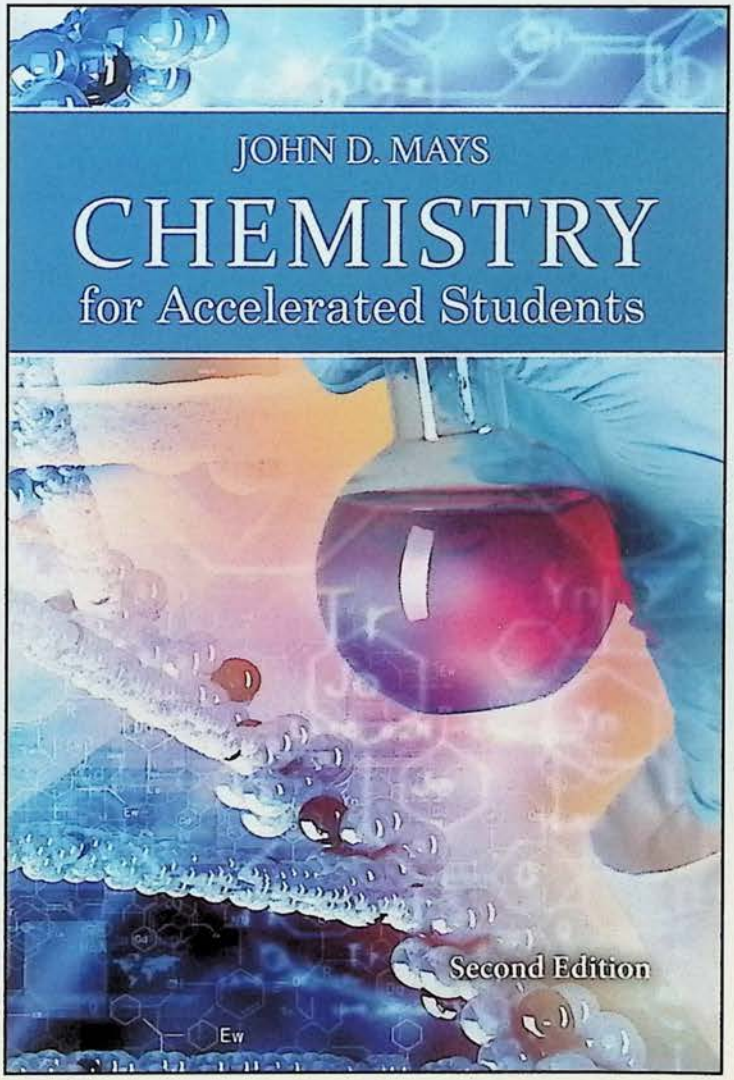

Contents

Chapter 1

1.

$$\lambda = 543\ \text{nm} \cdot \frac{1\ \text{m}}{1\times10^{9}\ \text{nm}} = 5.43\times10^{-7}\ \text{m}$$

$$E = \frac{hv}{\lambda} = \frac{6.626\times10^{-34}\ \text{J}\cdot\text{s}\cdot 2.9979\times10^{8}\ \frac{\text{m}}{\text{s}}}{5.43\times10^{-7}\ \text{m}} = 3.66\times10^{-19}\ \text{J}$$

2.

$E = 2.2718\times10^{-19}$ J

With 5 sig digs, we need to use constants from Appendix B with at least 5 sig digs:

$$E = \frac{hv}{\lambda} \rightarrow \lambda = \frac{hv}{E} = \frac{6.626\times10^{-34}\ \text{J}\cdot\text{s}\cdot 2.9979\times10^{8}\ \frac{\text{m}}{\text{s}}}{2.2718\times10^{-19}\ \text{J}} = 8.7439\times10^{-7}\ \text{m}\cdot\frac{10^{9}\ \text{nm}}{\text{m}} = 874.39\ \text{nm}$$

The result has 5 sig digs because the given value has 5.

3.

From Figure 1.6, $E = 2.18 \times 10^{-18}$ J

$$E = \frac{hv}{\lambda} \rightarrow \lambda = \frac{hv}{E} = \frac{6.626\times10^{-34}\ \text{J}\cdot\text{s}\cdot 2.9979\times10^{8}\ \frac{\text{m}}{\text{s}}}{2.18\times10^{-18}\ \text{J}} = 9.11\times10^{-8}\ \text{m}\cdot\frac{10^{9}\ \text{nm}}{1\ \text{m}} = 91.1\ \text{nm}$$

The result has 3 sig digs because the given value has 3.

4.

The visible spectrum is the Balmer series. From Figure 1.8,

$$\lambda_1 = 410\text{ nm}\cdot\frac{1\text{ m}}{1\times10^9\text{ nm}} = 4.1\times10^{-7}\text{ m}$$

$$\lambda_2 = 434\text{ nm}\cdot\frac{1\text{ m}}{1\times10^9\text{ nm}} = 4.34\times10^{-7}\text{ m}$$

$$\lambda_3 = 486\text{ nm}\cdot\frac{1\text{ m}}{1\times10^9\text{ nm}} = 4.86\times10^{-7}\text{ m}$$

$$\lambda_4 = 656\text{ nm}\cdot\frac{1\text{ m}}{1\times10^9\text{ nm}} = 6.56\times10^{-7}\text{ m}$$

$$E_1 = \frac{hv}{\lambda} = \frac{6.626\times10^{-34}\text{ J}\cdot\text{s}\cdot 2.9979\times10^8\ \frac{\text{m}}{\text{s}}}{4.1\times10^{-7}\text{ m}} = 4.8\times10^{-19}\text{ J (2 sig digs because 410 has 2)}$$

$$E_2 = \frac{hv}{\lambda} = \frac{6.626\times10^{-34}\text{ J}\cdot\text{s}\cdot 2.9979\times10^8\ \frac{\text{m}}{\text{s}}}{4.34\times10^{-7}\text{ m}} = 4.58\times10^{-19}\text{ J (3 sig digs because 434 has 3)}$$

$$E_3 = \frac{hv}{\lambda} = \frac{6.626\times10^{-34}\text{ J}\cdot\text{s}\cdot 2.9979\times10^8\ \frac{\text{m}}{\text{s}}}{4.86\times10^{-7}\text{ m}} = 4.09\times10^{-19}\text{ J (3 sig digs because 486 has 3)}$$

$$E_4 = \frac{hv}{\lambda} = \frac{6.626\times10^{-34}\text{ J}\cdot\text{s}\cdot 2.9979\times10^8\ \frac{\text{m}}{\text{s}}}{6.56\times10^{-7}\text{ m}} = 3.03\times10^{-19}\text{ J (3 sig digs because 656 has 3)}$$

18.

In Table 1.5, the heaviest nuclide listed is U-238.

238 nucleons – 92 protons = 146 neutrons

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19. a.

$$73.2\text{ g Cu}\cdot\frac{1\text{ mol}}{63.55\text{ g}}\cdot\frac{6.022\times10^{23}\text{ particles}}{\text{mol}} = 6.94\times10^{23}\text{ particles (atoms)}$$

---

19. b.

$$1.35\text{ mol Na}\cdot\frac{6.022\times10^{23}\text{ particles}}{\text{mol}} = 8.13\times10^{23}\text{ particles (atoms)}$$

---

19. c.

$$1.5000\text{ kg W}\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{183.85\text{ g}}\cdot\frac{6.0221\times10^{23}\text{ particles}}{\text{mol}} = 4.9133\times10^{24}\text{ particles (atoms)}$$

---

20. a

$$6.022\times10^{23}\text{ atoms K}\cdot\frac{\text{mol}}{6.022\times10^{23}\text{ atoms}}\cdot\frac{39.098\text{ g}}{\text{mol}} = 39.10\text{ g}$$

(4 sig digs because the given value has 4)

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20. b.

$$100 \text{ atoms Au} \cdot \frac{\text{mol}}{6.022 \times 10^{23} \text{ atoms}} \cdot \frac{196.9665 \text{ g}}{\text{mol}} = 3 \times 10^{-20} \text{ g}$$

(1 sig dig because the given value has 1)

---

20. c.

$$0.00100 \text{ mol Xe} \cdot \frac{131.29 \text{ g}}{\text{mol}} = 0.131 \text{ g}$$

(3 sig digs because the given value has 3)

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20. d.

$$2.0 \text{ mol Li} \cdot \frac{6.941 \text{ g}}{\text{mol}} = 14 \text{ g}$$

(2 sig digs because the given value has 2)

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20. e.

$$4.2120 \text{ mol Br} \cdot \frac{79.904 \text{ g}}{\text{mol}} = 336.56 \text{ g}$$

(5 sig digs because the given value has 5)

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20. f.

$$7.422 \times 10^{22} \text{ atoms Pt} \cdot \frac{\text{mol}}{6.022 \times 10^{23} \text{ atoms}} \cdot \frac{195.08 \text{ g}}{\text{mol}} = 24.04 \text{ g}$$

(4 sig digs because the given value has 4)

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21. a.

$$25 \text{ g } Ca(OH)_2 \cdot \frac{\text{mol}}{74.09 \text{ g}} = 0.34 \text{ mol}$$

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21. b.

$$286.25 \text{ g } Al_2(CrO_4)_3 \cdot \frac{\text{mol}}{401.944 \text{ g}} = 0.71216 \text{ mol}$$

---

21. c

$$2.111 \text{ kg KCl} \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{\text{mol}}{74.551 \text{ g}} = 28.32 \text{ mol}$$

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21. d.

$$47.50 \text{ g } LiClO_3 \cdot \frac{\text{mol}}{90.39 \text{ g}} = 0.5255 \text{ mol}$$

---

21. e.

$$10.0\text{ g }O_2\cdot\frac{\text{mol}}{32.0\text{ g}}=0.313\text{ mol}$$

---

21. f.

$$1.00\text{ mg }C_{14}H_{18}N_2O_5\cdot\frac{1\text{ g}}{1000\text{ mg}}\cdot\frac{\text{mol}}{294.307\text{ g}}=3.40\times10^{-6}\text{ mol}$$

22.

Using data from Tables 1.5 and 1.6:

92 protons $92\cdot1.007276\text{ u}=92.66939\text{ u}$

146 neutrons $146\cdot1.008665\text{ u}=147.2651\text{ u}$

92 electrons $92\cdot0.0005486\text{ u}=0.05047\text{ u}$

$$\begin{array}{r} 92.66939\text{ u}\\ 147.2651\text{ u}\\ +\ \underline{0.05047\text{ u}}\\ 239.9850\text{ u}\end{array}$$

$$\begin{array}{r} 239.9850\text{ u}\\ -\ \underline{238.0508\text{ u}}\\ 1.9342\text{ u}\end{array}$$

$$1.9342\text{ u}=1.9342\ \frac{\text{g}}{\text{mol}}\cdot\frac{\text{mol}}{6.022142\times10^{23}\text{ atoms}}=3.2118\times10^{-24}\ \frac{\text{g}}{\text{atom}}$$

23.

Sig digs in all products are determined by the factor with the lowest precision. Sig digs in all sums are determined according to the addition rule.

silicon

$27.9769\text{ u}\cdot0.92223=25.801\text{ u}$

$28.9765\text{ u}\cdot0.04685=1.358\text{ u}$

$29.9738\text{ u}\cdot0.03092=0.9268\text{ u}$

$$\begin{array}{r} 25.801\text{ u}\\ 1.358\text{ u}\\ +\ \underline{0.9268\text{ u}}\\ 28.086\text{ u}\end{array}$$

calcium

$39.9626\text{ u}\cdot0.96941=38.740\text{ u}$

$41.9856\text{ u}\cdot0.00647=2.72\text{ u}$

$$\begin{array}{r} 38.740\text{ u}\\ +\ \underline{0.272\text{ u}}\\ 39.012\text{ u}\end{array}$$

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iron

$53.9396\ u \cdot 0.05845 = 3.153\ u$

$55.9349\ u \cdot 0.91754 = 51.323\ u$

$56.9354\ u \cdot 0.02119 = 1.206\ u$

$57.9333\ u \cdot 0.00282 = 0.163\ u$

$$\begin{array}{r} 3.153\ u \\ 51.323\ u \\ 1.206\ u \\ +\ 0.163\ u \\ \hline 55.822\ u \end{array}$$

uranium

$235.0439\ u \cdot 0.007204 = 1.693\ u$

$238.0508\ u \cdot 0.992742 = 236.323\ u$

$$\begin{array}{r} 1.693\ u \\ +\ 236.323\ u \\ \hline 238.016\ u \end{array}$$

---

24. a. For all items in problem 24, sig digs are determined as in problem 23.

$1 \cdot 14.0067\ \frac{g}{mol} = 14.0067\ \frac{g}{mol}$

$3 \cdot 1.0079\ \frac{g}{mol} = 3.0237\ \frac{g}{mol}$

$$\begin{array}{r} 14.0067\ g/mol \\ +\ 3.0237\ g/mol \\ \hline 17.0304\ g/mol \end{array}$$

---

24. b.

$1 \cdot 12.011\ \frac{g}{mol} = 12.011\ \frac{g}{mol}$

$2 \cdot 15.9994\ \frac{g}{mol} = 31.9988\ \frac{g}{mol}$

$$\begin{array}{r} 12.011\ g/mol \\ +\ 31.9988\ g/mol \\ \hline 44.010\ g/mol \end{array}$$

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24. c.

$2 \cdot 35.4527\ \frac{g}{mol} = 70.9054\ \frac{g}{mol}$

---

24. d.

$1 \cdot 63.546\ \frac{g}{mol} = 63.546\ \frac{g}{mol}$

$1 \cdot 32.066\ \frac{g}{mol} = 32.066\ \frac{g}{mol}$

$4 \cdot 15.9994\ \frac{g}{mol} = 63.9976\ \frac{g}{mol}$

$$\begin{array}{r} 63.546\ g/mol \\ 32.066\ g/mol \\ +\ 63.9976\ g/mol \\ \hline 159.610\ g/mol \end{array}$$

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24. e.

$1 \cdot 40.078\ \frac{g}{mol} = 40.078\ \frac{g}{mol}$

$2 \cdot 14.0067\ \frac{g}{mol} = 28.0134\ \frac{g}{mol}$

$4 \cdot 15.9994\ \frac{g}{mol} = 63.9976\ \frac{g}{mol}$

$$\begin{array}{r} 40.078\ g/mol \\ 28.0134\ g/mol \\ +\ 63.9976\ g/mol \\ \hline 132.089\ g/mol \end{array}$$

---

24. f.

$$12 \cdot 12.011\ \frac{g}{mol} = 144.13\ \frac{g}{mol}$$
$$22 \cdot 1.0079\ \frac{g}{mol} = 22.174\ \frac{g}{mol}$$
$$11 \cdot 15.9994\ \frac{g}{mol} = 175.993\ \frac{g}{mol}$$

144.13 g/mol
22.174 g/mol
+ 175.993 g/mol
342.29 g/mol

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24. g.

$$2 \cdot 12.011\ \frac{g}{mol} = 24.022\ \frac{g}{mol}$$
$$6 \cdot 1.0079\ \frac{g}{mol} = 6.0474\ \frac{g}{mol}$$
$$1 \cdot 15.9994\ \frac{g}{mol} = 15.9994\ \frac{g}{mol}$$

24.022 g/mol
6.0474 g/mol
+ 15.9994 g/mol
46.068 g/mol

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24. h.

$$3 \cdot 12.011\ \frac{g}{mol} = 36.033\ \frac{g}{mol}$$
$$8 \cdot 1.0079\ \frac{g}{mol} = 8.0632\ \frac{g}{mol}$$

36.033 g/mol
+ 8.0632 g/mol
44.096 g/mol

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24. i.

$$1 \cdot 28.0855\ \frac{g}{mol} = 28.0855\ \frac{g}{mol}$$
$$2 \cdot 15.9994\ \frac{g}{mol} = 31.9988\ \frac{g}{mol}$$

28.0855 g/mol
+ 31.9988 g/mol
60.0843 g/mol

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25. a. For all items in problem 25, sig digs are determined as in problem 23.

$1 \cdot 24.3050\ u = 24.3050\ u$
$2 \cdot 35.4527\ u = 70.9054\ u$

24.3050 u
+ 70.9054 u
95.2104 u

---

25. b.

$1 \cdot 40.078\ u = 40.078\ u$
$2 \cdot 14.0067\ u = 28.0134\ u$
$6 \cdot 15.9994\ u = 95.9964\ u$

40.078 u
28.0134 u
+ 95.9964 u
164.087 u

---

25. c.

$1 \cdot 32.066\ u = 32.066\ u$
$4 \cdot 15.9994\ u = 63.9976\ u$

32.066 u
+ 63.9976 u
96.064 u

---

25. d.

$$1 \cdot 63.546\ u = 63.546\ u$$
$$1 \cdot 32.066\ u = 32.066\ u$$
$$4 \cdot 15.9994\ u = 63.9976\ u$$

$$\begin{array}{r} 63.546\ u \\ 32.066\ u \\ \underline{+\ 63.9976\ u} \\ 159.610\ u \end{array}$$

25. e.

$$1 \cdot 10.811\ u = 10.811\ u$$
$$3 \cdot 18.9984\ u = 56.9952\ u$$

$$\begin{array}{r} 10.811\ u \\ \underline{+\ 56.9952\ u} \\ 67.806\ u \end{array}$$

25. f.

$$1 \cdot 12.011\ u = 12.011\ u$$
$$4 \cdot 35.4527\ u = 141.811\ u$$

$$\begin{array}{r} 12.011\ u \\ \underline{+\ 141.811\ u} \\ 153.822\ u \end{array}$$

26.

$$2.25\ \text{mol}\ AgNO_3 \cdot \frac{169.8731\ \text{g}}{\text{mol}} = 382\ \text{g}$$

(3 sig digs because the given value has 3)

27. a.

$$2.25\ \text{kg}\ CCl_4 \cdot \frac{1000\ \text{g}}{\text{kg}} \cdot \frac{\text{mol}}{153.822\ \text{g}} = 14.6\ \text{mol}$$

(3 sig digs because the given value has 3)

27. b.

$$14.63\ \text{mol} \cdot \frac{6.022 \times 10^{23}\ \text{particles}}{\text{mol}} = 8.81 \times 10^{24}\ \text{particles}$$

For CCl_4, particles = molecules, and each molecule contains 1 carbon atom, giving 8.81×10^{24} carbon atoms. (Computing moles in step 1 was an intermediate calculation for this one, thus an extra digit was retained to get 14.63.)

27. c.

From Table 1.5, 1.078% of carbon atoms are carbon-13. This gives $8.81 \times 10^{24} \cdot 0.01078 = 9.50 \times 10^{22}$ atoms of carbon-13.

28. a.

$$1.00\text{ gal}\cdot\frac{3.785\text{ L}}{1\text{ gal}}\cdot\frac{1000\text{ mL}}{1\text{ L}}=3785\text{ mL}$$

$$\rho=\frac{m}{V}\rightarrow m=\rho V=1.000\ \frac{\text{g}}{\text{mL}}\cdot 3785\text{ mL}=3785\text{ g}$$

$$3785\text{ g}\cdot\frac{\text{mol}}{18.02\text{ g}}=2.10\times10^{2}\text{ mol}$$

(Result written in scientific notation in order to show 3 sig digs.)

28. b.

$$210.0\text{ mol}\cdot\frac{6.022\times10^{23}\text{ particles}}{\text{mol}}=1.264\times10^{26}\text{ particles}$$

Particles = molecules, and there are 2 H atoms in each molecule. Doubling and rounding to 3 sig digs gives 2.53×10^{26} H atoms.

28. c.

From Table 1.5, H-2 is 0.0115% of all hydrogen. $2.53\times10^{26}\cdot 0.000115 = 2.91\times10^{22}$ atoms of H-2.

29.

Assuming a 100-gram sample:

$$38.7\text{ g C}\cdot\frac{\text{mol}}{12.011\text{ g}}=3.222\text{ mol C}\quad(3.222/3.222=1)$$

$$9.7\text{ g H}\cdot\frac{\text{mol}}{1.0079\text{ g}}=9.62\text{ mol H}\quad(9.62/3.222=2.99\approx3)$$

$$51.6\text{ g O}\cdot\frac{\text{mol}}{15.9994\text{ g}}=3.225\text{ mol O}\quad(3.225/3.222\approx1)$$

These ratios give an empirical formula of CH_3O.

$$1\cdot12.011\text{ u}+3\cdot1.0079\text{ u}+1\cdot15.9994\text{ u}=31.0\text{ u}$$

$$62.1\text{ u}/31.0\text{ u}\approx2$$

Applying the factor of 2 to the empirical formula gives a molecular formula of $C_2H_6O_2$.

30. a.

$$\text{C: }\frac{43.910\text{ g}}{47.593\text{ g}}=0.92261=92.261\%\text{ C}$$

$$\text{H: }\frac{3.683\text{ g}}{47.593\text{ g}}=0.07739=7.739\%\text{ H}$$

30. b.

Assuming a 100-gram sample:

$$92.261\text{ g C}\cdot\frac{\text{mol}}{12.011\text{ g}}=7.68\text{ mol}\quad(7.68/7.68=1)$$

$$7.739\text{ g H}\cdot\frac{\text{mol}}{1.0079\text{ g}}=7.68\text{ mol}\quad(7.68/7.68=1)$$

These ratios give an empirical formula of CH.

---

30. c.

$$1\cdot12.011\text{ u}+1\cdot1.0079\text{ u}=13.019\text{ u}$$

$$78.11\text{ u}/13.019\text{ u}=6$$

Applying the factor of 6 to the empirical formula gives a molecular formula of C_6H_6.

31.

$$125.0\text{ g HClO}_3\cdot\frac{\text{mol}}{84.459\text{ g}}\cdot\frac{6.022\times10^{23}\text{ particles}}{\text{mol}}=8.913\times10^{23}\text{ particles}$$

(molecules)

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32. a.

$$1\cdot22.9898\text{ u}+1\cdot1.0079\text{ u}+1\cdot12.011\text{ u}+3\cdot15.9994\text{ u}=84.007\text{ u}$$

$$22.9898/84.007=0.27367\rightarrow27.367\%\text{ Na}$$

$$1.0079/84.007=0.011998\rightarrow1.1998\%\text{ H}$$

$$12.011/84.007=0.14298\rightarrow14.298\%\text{ C}$$

$$(3\cdot15.9994)/84.007=0.57136\rightarrow57.136\%\text{ O}$$

The sig digs in the formula mass are limited by the decimals in the mass of carbon. When this value came out with 5 sig digs, all percentages after that had 5 sig digs.

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32. b.

$$2\cdot22.9898\text{ u}+1\cdot15.9994\text{ u}=61.9790\text{ u}$$

$$(2\cdot22.9898)/61.9790=0.741858\rightarrow74.1858\%\text{ Na}$$

$$(1\cdot15.9994)/61.9790=0.258142\rightarrow25.8142\%\text{ O}$$

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32. c.

$$2\cdot55.847\text{ u}+3\cdot15.9994\text{ u}=159.692\text{ u}$$

$$(2\cdot55.847)/159.692=0.69943\rightarrow69.943\%\text{ Fe}$$

$$(3\cdot15.9994)/159.692=0.300567\rightarrow30.0567\%\text{ O}$$

The sig digs in the formula mass are limited by the decimals in the mass of iron. The atomic mass of iron also limits the iron percentage to 5 sig digs.

32. d.

$1 \cdot 107.8682\ u + 1 \cdot 14.0067\ u + 3 \cdot 15.9994\ u = 169.8731\ u$

$(1 \cdot 107.8682)/169.8731 = 0.6349928 \rightarrow 63.49928\%\ Ag$

$(1 \cdot 14.0067)/169.8731 = 0.0824539 \rightarrow 8.24539\%\ N$

$(3 \cdot 15.9994)/169.8731 = 0.282553 \rightarrow 28.2553\%\ O$

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32. e.

$1 \cdot 40.078\ u + 4 \cdot 12.011\ u + 6 \cdot 1.0079\ u + 4 \cdot 15.9994\ u = 158.167\ u$

$(1 \cdot 40.078)/158.167 = 0.25339 \rightarrow 25.339\%\ Ca$

$(4 \cdot 12.011)/158.167 = 0.30375 \rightarrow 30.375\%\ C$

$(6 \cdot 1.0079)/158.167 = 0.038234 \rightarrow 3.8234\%\ H$

$(4 \cdot 15.9994)/158.167 = 0.404620 \rightarrow 40.4620\%\ O$

The sig digs in the formula mass are limited to the third decimal by Ca and C. In the results, the sig digs for Ca, C, and H are limited by the atomic masses to 5. O has 6 sig digs in the mass, thus 6 in the result.

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32. f.

$9 \cdot 12.011\ u + 8 \cdot 1.0079\ u + 4 \cdot 15.9994\ u = 180.160\ u$

$(9 \cdot 12.011)/180.160 = 0.60002 \rightarrow 60.002\%\ C$

$(8 \cdot 1.0079)/180.160 = 0.044756 \rightarrow 4.4756\%\ H$

$(4 \cdot 15.9994)/180.160 = 0.355226 \rightarrow 35.5226\%\ O$

33.

$1 \cdot 65.39\ u + 1 \cdot 32.066\ u + 4 \cdot 15.9994\ u + 14 \cdot 1.0079\ u + 7 \cdot 15.9994\ u = 287.56\ u$

$14 \cdot 1.0079\ u + 7 \cdot 15.9994\ u = 126.1064\ u$

$126.1064 / 287.56 = 0.43854\ (43.854\%)$

34.

Assuming a 100-gram sample:

$$22.65\ g\ S \cdot \frac{mol}{32.066\ g} = 0.7064\ mol \quad (0.7064/0.7064 = 1)$$

$$32.38\ g\ Na \cdot \frac{mol}{22.9898\ g} = 1.408\ mol \quad (1.408/0.7064 \approx 2)$$

$$44.99\ g\ O \cdot \frac{mol}{15.9994\ g} = 2.812\ mol \quad (2.812/0.7064 \approx 4)$$

These ratios give an empirical formula of SNa_2O_4. As we see later, this is actually Na_2SO_4.

35.

$1 \cdot 12.011\text{ u} + 2 \cdot 1.0079\text{ u} + 1 \cdot 15.9994\text{ u} = 30.026\text{ u}$

$120.12 / 30.026 \approx 4$

Applying the factor of 4 to the empirical formula gives a molecular formula of $C_4H_8O_4$.

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36. a.

Assuming a 100-gram sample:

$$49.5\text{ g C} \cdot \frac{\text{mol}}{12.011} = 4.12\text{ mol} \quad (4.12/1.03 = 4)$$

$$5.15\text{ g H} \cdot \frac{\text{mol}}{1.0079} = 5.11\text{ mol} \quad (5.11/1.03 \approx 5)$$

$$28.9\text{ g N} \cdot \frac{\text{mol}}{14.0067} = 2.06\text{ mol} \quad (2.06/1.03 = 2)$$

$$16.5\text{ g O} \cdot \frac{\text{mol}}{15.9994} = 1.03\text{ mol} \quad (1.03/1.03 = 1)$$

These ratios give an empirical formula of $C_4H_5N_2O$. We get the multiplier factor from the empirical formula mass:

$4 \cdot 12.011\text{ u} + 5 \cdot 1.0079\text{ u} + 2 \cdot 14.0067\text{ u} + 1 \cdot 15.9994\text{ u} = 97.096\text{ u}$

$195 / 97.096 \approx 2$

This factor gives a molecular formula of $C_8H_{10}N_4O_2$.

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36. b.

Assuming a 100-gram sample:

$$75.69\text{ g C} \cdot \frac{\text{mol}}{12.011} = 6.302\text{ mol} \quad (6.302/0.9694 \approx 6.5) \rightarrow (6.5 \cdot 2 = 13)$$

$$8.80\text{ g H} \cdot \frac{\text{mol}}{1.0079} = 8.73\text{ mol} \quad (8.73/0.9694 \approx 9) \rightarrow (9 \cdot 2 = 18)$$

$$15.51\text{ g O} \cdot \frac{\text{mol}}{15.9994} = 0.9694\text{ mol} \quad (0.9694/0.9694 = 1) \rightarrow (1 \cdot 2 = 2)$$

The values are all doubled to obtain whole number ratios. These ratios give an empirical formula of $C_{13}H_{18}O_2$. We get the multiplier factor from the empirical formula mass:

$13 \cdot 12.011\text{ u} + 18 \cdot 1.0079\text{ u} + 2 \cdot 15.9994\text{ u} = 206.284\text{ u}$

$206 / 206.284 \approx 1$

The factor of 1 indicates that the empirical and molecular formulas are the same.

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36. c.

Assuming a 100-gram sample:

$$81.71\text{ g C}\cdot\frac{\text{mol}}{12.011}=6.803\text{ mol}\quad(6.803/6.803=1)\rightarrow(1\cdot3=3)$$

$$18.29\text{ g H}\cdot\frac{\text{mol}}{1.0079}=18.15\text{ mol}\quad(18.15/6.803\approx2.668)\rightarrow(2.668\cdot3\approx8)$$

The values are all tripled to obtain whole number ratios. These ratios give an empirical formula of C_3H_8. We get the multiplier factor from the empirical formula mass:

$3\cdot12.011\text{ u}+8\cdot1.0079\text{ u}=44.096\text{ u}$

$44.096/44.096=1$

The factor of 1 indicates that the empirical and molecular formulas are the same.

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36. d.

Assuming a 100-gram sample:

$$57.14\text{ g C}\cdot\frac{\text{mol}}{12.011}=4.757\text{ mol}\quad(4.757/0.680\approx7)\rightarrow(7\cdot2=14)$$

$$6.16\text{ g H}\cdot\frac{\text{mol}}{1.0079}=6.11\text{ mol}\quad(6.11/0.680\approx9)\rightarrow(9\cdot2=18)$$

$$9.52\text{ g N}\cdot\frac{\text{mol}}{14.0067}=0.680\text{ mol}\quad(0.680/0.680=1)\rightarrow(1\cdot2=2)$$

$$27.18\text{ g O}\cdot\frac{\text{mol}}{15.9994}=1.699\text{ mol}\quad(1.699/0.680=2.5)\rightarrow(2.5\cdot2=5)$$

The values are all doubled to obtain whole number ratios. These ratios give an empirical formula of $C_{14}H_{18}N_2O_5$. We get the multiplier factor from the empirical formula mass:

$14\cdot12.011\text{ u}+18\cdot1.0079\text{ u}+2\cdot14.0067\text{ u}+5\cdot15.9994\text{ u}=294.31\text{ u}$

$294.302/294.31\approx1$

The factor of 1 indicates that the empirical and molecular formulas are the same.

---

36. e.

Assuming a 100-gram sample:

$$92.26\text{ g C}\cdot\frac{\text{mol}}{12.011}=7.681\text{ mol}\quad(7.681/7.68\approx1)$$

$$7.74\text{ g H}\cdot\frac{\text{mol}}{1.0079}=7.68\text{ mol}\quad(7.68/7.68=1)$$

These ratios give an empirical formula of CH. We get the multiplier factor from the empirical formula mass:

$1\cdot12.011\text{ u}+1\cdot1.0079\text{ u}=13.019\text{ u}$

$26.038/13.019=2$

This factor gives a molecular formula of C_2H_2.

37.

$9.581/10.5 = 0.912 \rightarrow 91.2\%$ C

$0.919/10.5 = 0.0875 \rightarrow 8.75\%$ H

Assuming a 100-gram sample:

$$91.2 \text{ g C} \cdot \frac{\text{mol}}{12.011 \text{ g}} = 7.59 \text{ mol} \quad (7.59/7.59 = 1) \rightarrow (1 \cdot 7 = 7)$$

$$8.75 \text{ g H} \cdot \frac{\text{mol}}{1.0079 \text{ g}} = 8.68 \text{ mol} \quad (8.68/7.59 \approx 1.14) \rightarrow (1.14 \cdot 7 = 8)$$

The values are multiplied by 7 to obtain whole number ratios. These ratios give an empirical formula of C_7H_8. We get the multiplier factor from the empirical formula mass:

$7 \cdot 12.011 \text{ u} + 8 \cdot 1.0079 \text{ u} = 92.140 \text{ u}$

$92.140/92.140 = 1$

The factor of 1 indicates that the empirical and molecular formulas are the same.

Chapter 2

6. a.

$$\frac{1.098\ \text{Å}}{2}+\frac{0.741\ \text{Å}}{2}=0.920\ \text{Å} \qquad \frac{|1.012\ \text{Å}-0.920\ \text{Å}|}{1.012\ \text{Å}}\times 100\%=9.09\%$$

6. b.

$$\frac{1.242\ \text{Å}}{2}+\frac{1.208\ \text{Å}}{2}=1.225\ \text{Å} \qquad \frac{|1.128\ \text{Å}-1.225\ \text{Å}|}{1.128\ \text{Å}}\times 100\%=8.60\%$$

6. c.

$$\frac{1.242\ \text{Å}}{2}+\frac{1.208\ \text{Å}}{2}=1.225\ \text{Å} \qquad \frac{|1.160\ \text{Å}-1.225\ \text{Å}|}{1.160\ \text{Å}}\times 100\%=5.60\%$$

6. d.

$$\frac{1.893\ \text{Å}}{2}+\frac{1.413\ \text{Å}}{2}=1.653\ \text{Å} \qquad \frac{|1.570\ \text{Å}-1.653\ \text{Å}|}{1.570\ \text{Å}}\times 100\%=5.29\%$$

33.

$$\lambda=94\ \text{nm}\cdot\frac{1\ \text{m}}{1\times 10^{9}\ \text{nm}}=9.4\times 10^{-8}\ \text{m}$$

$$E=\frac{hv}{\lambda}=\frac{6.626\times 10^{-34}\ \text{J}\cdot\text{s}\cdot 2.9979\times 10^{8}\ \frac{\text{m}}{\text{s}}}{9.4\times 10^{-8}\ \text{m}}=2.11\times 10^{-18}\ \text{J}\cdot\frac{1\ \text{eV}}{1.60\times 10^{-19}\ \text{J}}=13\ \text{eV}$$

34.

$$E=5.09\times 10^{-19}\ \text{J}$$

$$E=\frac{hv}{\lambda}\rightarrow\lambda=\frac{hv}{E}=\frac{6.626\times 10^{-34}\ \text{J}\cdot\text{s}\cdot 2.9979\times 10^{8}\ \frac{\text{m}}{\text{s}}}{5.09\times 10^{-19}\ \text{J}}=3.903\times 10^{-7}\ \text{m}\cdot\frac{1\times 10^{9}\ \text{nm}}{1\ \text{m}}=390\ \text{nm}$$

The result is stated with only 2 sig digs instead of three so we can see it in nanometers and compare it to the visible band of 700–400 nm. Doing so, the light is in the ultraviolet band and would thus not be visible.

37.

$$112\ \text{g}\ CO_2\cdot\frac{\text{mol}}{44.01\ \text{g}}\cdot\frac{6.022\times 10^{23}\ \text{particles}}{\text{mol}}=1.53\times 10^{24}\ \text{particles}$$

For CO_2, the particles are molecules and there is one atom of C in each molecule. Thus, this value is the number of carbon atoms.

38.

$$2 \cdot 1.0079\ \text{u} + 1 \cdot 32.066\ \text{u} + 4 \cdot 15.9994\ \text{u} = 98.079\ \text{u}$$

$$2 \cdot 1.0079\ \text{u} / 98.079\ \text{u} = 0.020553 \rightarrow 2.0553\%\ \text{H}$$

$$1 \cdot 32.066\ \text{u} / 98.079\ \text{u} = 0.32694 \rightarrow 32.694\%\ \text{S}$$

$$4 \cdot 15.9994\ \text{u} / 98.079\ \text{u} = 0.65251 \rightarrow 65.251\%\ \text{O}$$

$$35.0\ \text{g}\ H_2SO_4 \cdot \frac{\text{mol}}{98.079\ \text{g}} \cdot \frac{6.022 \times 10^{23}\ \text{particles}}{\text{mol}} = 2.15 \times 10^{23}\ \text{particles}$$

Each particle is a molecule, and each molecule contains 2 H atoms, 1 S atom, and 4 O atoms. Thus, the numbers of atoms are 4.30×10^{23} H atoms, 2.15×10^{23} S atoms, and 8.60×10^{23} O atoms.

40.

The difference in mass between Br-79 and Br-81 is 2 u. The difference between the average mass 79.904 and 79 is 0.904. 0.904/2 = 0.452. If the average were 80, the proportion of each isotope would be 0.5. Instead the proportions are 0.452 and 0.548. Since the average mass of 79.904 is closer to 79 than it is to 81, the proportion of Br-79 is greater, and is 0.548. Thus, the closest of the choices given is 52%.

41.

$$3.00\ \text{mol}\ CaBr_2 \cdot \frac{199.89\ \text{g}}{\text{mol}} = 599.7\ \text{g}$$

$$40.078\ \text{u} / 199.89\ \text{u} = 0.2005\ \text{(proportion of calcium)}$$

$$0.2005 \cdot 599.7\ \text{g} = 1.20 \times 10^2\ \text{g}$$

The result is stated in scientific notation in order to show 3 sig digs.

42.

Assuming a 100-gram sample:

$$53.64\ \text{g Cl} \cdot \frac{\text{mol}}{35.4527\ \text{g}} = 1.513\ \text{mol} \quad (1.513 / 0.2522 = 6)$$

$$46.36\ \text{g W} \cdot \frac{\text{mol}}{183.85\ \text{g}} = 0.2522\ \text{mol} \quad (0.2522 / 0.2522 = 1)$$

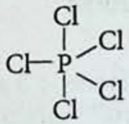
The 6:1 ratio gives an empirical formula of WCl_6.

Chapter 3

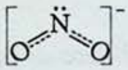
20. a.

The Lewis structure is: S=C=S Each bond is a double bond, so bond number is 2.

20. b.

The Lewis structure is:  Each bond is a single bond, so bond number is 1.

20. c.

The Lewis structure is:  Each bond is composed of one part single bond and one part that is its share of the resonance structure bond. There is one resonance structure bond to be shared by two bonds, so the share of each is 0.5. Adding this to the single bond we get a bond number of 1.5.

22. a.

Be—F: 2.41, O—F: 0.54, C—F: 1.43

22. b.

F—F: 0, B—F: 1.94, S—O: 0.86

22. c.

O—Cl: 0.28, S—Cl: 0.58, C—P: 0.36

24.

$$100.00\ \text{g CaCO}_3 \cdot \frac{\text{mol}}{100.057\ \text{g}} \cdot \frac{6.02214 \times 10^{23}\ \text{particles}}{\text{mol}} = 6.0187 \times 10^{23}\ \text{particles}$$

In this ionic compound, the particles are formula units. There are 3 O atoms in each formula unit, so the number of O atoms is 1.8056×10^{24}.

25.

$$1 \cdot 32.066\ \text{u} + 6 \cdot 18.9984\ \text{u} = 146.056\ \text{u}$$

$$1 \cdot 32.066\ \text{u} / 146.056\ \text{u} = 0.21955 \rightarrow 21.955\%\ \text{S}$$

$$6 \cdot 18.9984\ \text{u} / 146.056\ \text{u} = 0.780457 \rightarrow 78.0457\%\ \text{F}$$

28.

$$12.00\ \text{u} \cdot 0.9893 + 13.0034\ \text{u} \cdot 0.01078 = 12.01\ \text{u}$$

$$\text{percent difference} = \frac{|12.01\ \text{u} - 12.01\ \text{u}|}{12.01\ \text{u}} \times 100\% = 0.00\%$$

29.

$$\rho=\frac{m}{V}\rightarrow m=\rho V=2.33\ \frac{\text{g}}{\text{cm}^3}\cdot 1.000\ \text{cm}^3=2.33\ \text{g}$$

$$2.33\ \text{g MgCl}_2\cdot\frac{\text{mol}}{95.2104\ \text{g}}\cdot\frac{6.022\times10^{23}\ \text{particles}}{\text{mol}}=1.47\times10^{22}\ \text{particles}$$

In this ionic compound, the particles are formula units. There are 2 Cl atoms in each formula unit, so the number of Cl atoms is 2.94×10^{22}.

32.

Assuming a 100-gram sample:

$$12.84\ \text{g S}\cdot\frac{\text{mol}}{32.066\ \text{g}}=0.4044\ \text{mol}\quad(0.4044/0.4011\approx1)$$

$$25.45\ \text{g Cu}\cdot\frac{\text{mol}}{63.546\ \text{g}}=0.4011\ \text{mol}\quad(0.4011/0.4011=1)$$

$$25.63\ \text{g O}\cdot\frac{\text{mol}}{15.9994\ \text{g}}=1.602\ \text{mol}\quad(1.602/0.4011\approx4)$$

$$36.07\ \text{g H}_2\text{O}\cdot\frac{\text{mol}}{18.0152\ \text{g}}=2.002\ \text{mol}\quad(2.002/0.4011\approx5)$$

These ratios give an empirical formula of $CuSO_4{\cdot}5H_2O$. This is copper sulfate pentahydrate.

33.

$$E=3.73\times10^{-19}\ \text{J}$$

$$E=\frac{hv}{\lambda}\rightarrow\lambda=\frac{hv}{E}=\frac{6.626\times10^{-34}\ \text{J}\cdot\text{s}\cdot2.9979\times10^{8}\ \frac{\text{m}}{\text{s}}}{3.73\times10^{-19}\ \text{J}}=5.33\times10^{-7}\ \text{m}$$

$$5.33\times10^{-7}\ \text{m}\cdot\frac{10^{9}\ \text{nm}}{1\ \text{m}}=533\ \text{nm}$$

Chapter 4

23.

Formula: $C_3NO_2H_7$

$3 \cdot 12.011\ u / 89.094\ u = 0.40444 \rightarrow 40.444\%\ C$

$1 \cdot 14.0067\ u / 89.094\ u = 0.15721 \rightarrow 15.721\%\ N$

$2 \cdot 15.9994\ u / 89.094\ u = 0.35916 \rightarrow 35.916\%\ O$

$7 \cdot 1.0079\ u / 89.094\ u = 0.079189 \rightarrow 7.9189\%\ H$

24.

$$\lambda = 601\ nm \cdot \frac{1\ m}{1 \times 10^9\ nm} = 6.01 \times 10^{-7}\ m$$

$$E = \frac{hv}{\lambda} = \frac{6.626 \times 10^{-34}\ J \cdot s \cdot 2.9979 \times 10^8\ \frac{m}{s}}{6.01 \times 10^{-7}\ m} = 3.305 \times 10^{-19}\ J \cdot \frac{1\ eV}{1.602 \times 10^{-19}\ J} = 2.06\ eV$$

33. a.

$$65.6\ g\ H_2O \cdot \frac{mol}{18.02\ g} = 3.64\ mol$$

33. b.

$$1250\ mg\ C_6H_6O_6 \cdot \frac{g}{1000\ mg} \cdot \frac{mol}{174.110\ g} = 0.00718\ mol$$

33. c.

$$400\ mg\ C_9H_8O_4 \cdot \frac{g}{1000\ mg} \cdot \frac{mol}{180.160\ g} = 0.002\ mol$$

This result has been rounded to 1 sig dig since the given quantity (400 mg) has only 1 sig dig.

33. d.

$$14.0\ kg\ KNO_3 \cdot \frac{1000\ g}{1\ kg} \cdot \frac{mol}{101.103\ g} = 138\ mol$$

This result has been rounded to 3 sig digs since the given quantity (14.0 kg) has 3 sig digs.

33. e.

$$1050\ g\ HClO_4 \cdot \frac{mol}{100.4582\ g} = 10.5\ mol$$

This result has been rounded to 3 sig digs since the given quantity (1050 g) has 3 sig digs.

33. f.

$$953.00 \text{ g HF} \cdot \frac{\text{mol}}{20.0063 \text{ g}} = 47.635 \text{ mol}$$

This result has been rounded to 5 sig digs since the given quantity (953.00 g) has 5 sig digs.

---

34. a.

$$55 \text{ g HgS} \cdot \frac{\text{mol}}{232.66 \text{ g}} \cdot \frac{6.022 \times 10^{23} \text{ particles}}{\text{mol}} = 1.4 \times 10^{23} \text{ particles}$$

In this ionic compound, a particle is a formula unit. Each formula unit contains one Hg atom, so the number of Hg atoms is equal to the number of particles.

---

34. b.

$$3.00 \text{ kg } Fe_2O_3 \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{\text{mol}}{159.692 \text{ g}} \cdot \frac{6.022 \times 10^{23} \text{ particles}}{\text{mol}} = 1.13 \times 10^{25} \text{ particles}$$

In this ionic compound, a particle is a formula unit. Each formula unit contains two Fe atoms, so the number of Fe atoms is twice the number of particles, or 2.26×10^{25}.

---

34. c.

$$1.0000 \text{ mol } CaCO_3 \cdot \frac{6.0221 \times 10^{23} \text{ particles}}{\text{mol}} = 6.0221 \times 10^{23} \text{ particles}$$

In this ionic compound, a particle is a formula unit. Each formula unit contains one Ca atom, so the number of Ca atoms is equal to the number of particles. The Avogadro constant was written with 5 sig digs because the given quantity (1.0000 mol) contains 5 sig digs.

---

34. d

$$45 \text{ g } Sr(NO_2)_2 \cdot \frac{\text{mol}}{179.63 \text{ g}} \cdot \frac{6.022 \times 10^{23} \text{ particles}}{\text{mol}} = 1.5 \times 10^{23} \text{ particles}$$

In this ionic compound, a particle is a formula unit. Each formula unit contains one Sr atom, so the number of Sr atoms is equal to the number of particles.

---

34. e.

$$2.000 \text{ mol } Na_2CrO_4 \cdot \frac{6.022 \times 10^{23} \text{ particles}}{\text{mol}} = 1.2044 \times 10^{24} \text{ particles}$$

This result has one extra sig dig. In this ionic compound, a particle is a formula unit. Each formula unit contains two Na atoms, so the number of Na atoms is twice the number of particles, or 2.4088×10^{24}. Rounding to 4 sig digs gives 2.409×10^{24} Na atoms.

---

34. f.

$$5.05 \text{ kg } Ca(CH_3COO)_2 \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{\text{mol}}{158.167 \text{ g}} \cdot \frac{6.022 \times 10^{23} \text{ particles}}{\text{mol}} = 1.92 \times 10^{25} \text{ particles}$$

In this ionic compound, a particle is a formula unit. Each formula unit contains one Ca atom, so the number of Ca atoms is equal to the number of particles.

36.

$$53.9396\ \text{u} \cdot 0.05845 + 55.9349\ \text{u} \cdot 0.91754 + 56.9354\ \text{u} \cdot 0.02119 + 57.9333\ \text{u} \cdot 0.00282 =$$
$$3.1528\ \text{u} + 51.323\ \text{u} + 1.206\ \text{u} + 0.163\ \text{u} = 55.845\ \text{u}$$

The number of sig digs is driven by the addition rule, the result being limited to three decimal places.

40.

$4.62\ \text{g} + 0.776\ \text{g} + 6.154\ \text{g} = 11.55\ \text{g}$ (sample mass)

$4.62\ \text{g} / 11.55\ \text{g} = 0.400 \rightarrow 40.0\%\ \text{C}$

$0.776\ \text{g} / 11.55\ \text{g} = 0.0672 \rightarrow 6.72\%\ \text{H}$

$6.154\ \text{g} / 11.55\ \text{g} = 0.5328 \rightarrow 53.28\%\ \text{O}$

The sig digs shown here result from the given quantities. (To add these percentages, decimals are limited by the addition rule to 1 decimal place, so the quantities would have to be rounded to 40.0%, 6.7%, and 53.3%. Arguably, this is also a legitimate way of expressing the result.)

Assuming a 100-gram sample:

$$40.0\ \text{g C} \cdot \frac{\text{mol}}{12.011\ \text{g}} = 3.33\ \text{mol} \quad (3.33/3.33 = 1)$$

$$6.72\ \text{g H} \cdot \frac{\text{mol}}{1.0079\ \text{g}} = 6.67\ \text{mol} \quad (6.67/3.33 = 2)$$

$$53.28\ \text{g O} \cdot \frac{\text{mol}}{15.9994\ \text{g}} = 3.330\ \text{mol} \quad (3.330/3.33 = 1)$$

These ratios give an empirical formula of CH_2O.

$1 \cdot 12.011\ \text{u} + 2 \cdot 1.0079\ \text{u} + 1 \cdot 15.9994\ \text{u} = 30.026\ \text{u}$

$180.157\ \text{u} / 30.026\ \text{u} \approx 6$

Applying this multiplier to the empirical formula gives a molecular formula of $C_6H_{12}O_2$.

Chapter 5

16.

$AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$

$$3.5 \text{ mol } AgNO_3 \cdot \frac{1 \text{ mol } AgBr}{1 \text{ mol } AgNO_3} = 3.5 \text{ mol } AgBr$$

$$3.5 \text{ mol } AgBr \cdot \frac{187.772 \text{ g}}{\text{mol}} = 657 \text{ g}$$

Rounded to 2 sig digs, the answer is 660 g.

17.

$2H_2 + O_2 \rightarrow 2H_2O$

$$1575 \text{ mol } H_2 \cdot \frac{2 \text{ mol } H_2O}{2 \text{ mol } H_2} = 1575 \text{ mol } H_2O$$

$$1575 \text{ mol } H_2 \cdot \frac{1 \text{ mol } O_2}{2 \text{ mol } H_2} = 787.5 \text{ mol } O_2$$

18.

$Al_2S_3 + 6H_2O \rightarrow 3H_2S + 2Al(OH)_3$

$$2.290 \text{ kg } Al_2S_3 \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{\text{mol}}{150.161 \text{ g}} = 15.250 \text{ mol } Al_2S_3$$

$$15.250 \text{ mol } Al_2S_3 \cdot \frac{2 \text{ mol } Al(OH)_3}{1 \text{ mol } Al_2S_3} = 30.500 \text{ mol } Al(OH)_3$$

$$30.50 \text{ mol } Al(OH)_3 \cdot \frac{78.0034 \text{ g}}{\text{mol}} = 2379 \text{ g } Al(OH)_3$$

19.

$Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$

19. a.

$$750 \text{ mg } Al(OH)_3 \cdot \frac{1 \text{ g}}{1000 \text{ mg}} \cdot \frac{\text{mol}}{78.0034 \text{ g}} = 0.00961 \text{ mol } Al(OH)_3$$

$$0.00961 \text{ mol } Al(OH)_3 \cdot \frac{3 \text{ mol } HCl}{1 \text{ mol } Al(OH)_3} = 0.0288 \text{ mol } HCl$$

Rounding this result to 2 sig digs gives 0.029 mol HCl.

19. b.

$$750 \text{ mg Al(OH)}_3 \cdot \frac{1 \text{ g}}{1000 \text{ mg}} \cdot \frac{\text{mol}}{78.0034 \text{ g}} = 0.00961 \text{ mol Al(OH)}_3$$

$$0.00961 \text{ mol Al(OH)}_3 \cdot \frac{3 \text{ mol H}_2\text{O}}{1 \text{ mol Al(OH)}_3} = 0.0288 \text{ mol H}_2\text{O}$$

$$0.0288 \text{ mol H}_2\text{O} \cdot \frac{18.02 \text{ g}}{\text{mol}} = 0.5198 \text{ g H}_2\text{O}$$

Rounding this result to 2 sig digs gives 0.52 g H_2O.

20.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

$$2.50\times10^4 \text{ kg Fe}_2\text{O}_3 \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{\text{mol}}{159.692 \text{ g}} = 156{,}600 \text{ mol Fe}_2\text{O}_3$$

$$156{,}600 \text{ mol Fe}_2\text{O}_3 \cdot \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} = 313{,}100 \text{ mol Fe}$$

$$313{,}100 \text{ mol Fe} \cdot \frac{55.847 \text{ g}}{\text{mol}} = 1.75\times10^7 \text{ g Fe} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} = 1.75\times10^4 \text{ kg Fe}$$

21.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

21. a.

$$29.55 \text{ g NaOH} \cdot \frac{\text{mol}}{39.9971 \text{ g}} = 0.7388 \text{ mol NaOH}$$

$$44.11 \text{ g H}_2\text{SO}_4 \cdot \frac{\text{mol}}{98.079 \text{ g}} = 0.4497 \text{ mol H}_2\text{SO}_4$$

$$0.4497 \text{ mol H}_2\text{SO}_4 \cdot \frac{2 \text{ mol NaOH}}{1 \text{ mol H}_2\text{SO}_4} = 0.8994 \text{ mol NaOH required}$$

This much NaOH is not available, so NaOH is the limiting reactant.

---

21. b.

$$0.73880 \text{ mol NaOH} \cdot \frac{1 \text{ mol Na}_2\text{SO}_4}{2 \text{ mol NaOH}} = 0.36940 \text{ mol Na}_2\text{SO}_4$$

$$0.36940 \text{ mol Na}_2\text{SO}_4 \cdot \frac{142.043 \text{ g}}{\text{mol}} = 52.47 \text{ g Na}_2\text{SO}_4$$

---

21. c.

$$0.73880 \text{ mol NaOH} \cdot \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol NaOH}} = 0.73880 \text{ mol H}_2\text{O}$$

$$0.73880 \text{ mol H}_2\text{O} \cdot \frac{18.015 \text{ g}}{\text{mol}} = 13.31 \text{ g H}_2\text{O}$$

---

22. a.

$$350.0\text{ mol }C_8H_{18}\cdot\frac{25\text{ mol }O_2}{2\text{ mol }C_8H_{18}}=4375\text{ mol }O_2$$

The result has been rounded to 4 sig digs as required by the given information.

22. b.

$$3.5\text{ kg }O_2\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{32.00\text{ g}}=109.4\text{ mol }O_2$$

$$109.4\text{ mol }O_2\cdot\frac{18\text{ mol }H_2O}{25\text{ mol }O_2}=78.77\text{ mol }H_2O$$

$$78.77\text{ mol }H_2O\cdot\frac{18.02\text{ g}}{\text{mol}}\cdot\frac{1\text{ kg}}{1000\text{ g}}=1.4\text{ kg }H_2O$$

The result has been rounded to 2 sig digs as required by the given information.

22. c.

$$11.5\text{ gal }C_8H_{18}\cdot\frac{3.785\text{ L}}{1\text{ gal}}\cdot\frac{1000\text{ mL}}{1\text{ L}}\cdot\frac{0.692\text{ g}}{\text{mL}}=30{,}120\text{ g }C_8H_{18}$$

$$30{,}120\text{ g }C_8H_{18}\cdot\frac{\text{mol}}{114.230\text{ g}}=263.7\text{ mol }C_8H_{18}$$

$$263.7\text{ mol }C_8H_{18}\cdot\frac{25\text{ mol }O_2}{2\text{ mol }C_8H_{18}}=3296\text{ mol }O_2$$

$$3296\text{ mol }O_2\cdot\frac{32.00\text{ g}}{\text{mol}}\cdot\frac{1\text{ kg}}{1000\text{ g}}=105\text{ kg }O_2$$

The result has been rounded to 3 sig digs as required by the given information.

23. a.

$$855\text{ g }NH_3\cdot\frac{\text{mol}}{17.0304\text{ g}}=50.20\text{ mol }NH_3$$

$$1750\text{ g }O_2\cdot\frac{\text{mol}}{32.00\text{ g}}=54.69\text{ mol }O_2$$

$$50.20\text{ mol }NH_3\cdot\frac{5\text{ mol }O_2}{4\text{ mol }NH_3}=62.75\text{ mol }O_2\text{ required.}$$

This much O_2 is not available, so O_2 is the limiting reactant.

23. b.

$$1750\text{ g O}_2 \cdot \frac{\text{mol}}{32.00\text{ g}} = 54.69\text{ mol O}_2$$

$$54.69\text{ mol O}_2 \cdot \frac{4\text{ mol NO}}{5\text{ mol O}_2} = 43.75\text{ mol NO}$$

$$43.75\text{ mol NO} \cdot \frac{30.006\text{ g}}{\text{mol}} = 1313\text{ g NO}$$

Rounding to 3 sig digs as required by the given information, we have 1310 g NO.

---

23. c.

$$\frac{1272\text{ g}}{1313\text{ g}} \cdot 100\% = 96.9\%$$

24.

$$2\text{Al(OH)}_3 + 3\text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 6\text{H}_2\text{O}$$

24. a.

$$31.8\text{ g H}_2\text{SO}_4 \cdot \frac{\text{mol}}{98.079\text{ g}} = 0.3242\text{ mol H}_2\text{SO}_4$$

$$25.4\text{ g Al(OH)}_3 \cdot \frac{\text{mol}}{78.0034\text{ g}} = 0.3256\text{ mol Al(OH)}_3$$

$$0.3256\text{ mol Al(OH)}_3 \cdot \frac{3\text{ mol H}_2\text{SO}_4}{2\text{ mol Al(OH)}_3} = 0.4884\text{ mol H}_2\text{SO}_4\text{ required.}$$

This much H_2SO_4 is not available, so H_2SO_4 is the limiting reactant.

---

24. b.

$$0.3242\text{ mol H}_2\text{SO}_4 \cdot \frac{2\text{ mol Al(OH)}_3}{3\text{ mol H}_2\text{SO}_4} = 0.2161\text{ mol Al(OH)}_3$$

$$0.2161\text{ mol Al(OH)}_3 \cdot \frac{78.0034\text{ g}}{\text{mol}} = 16.86\text{ g Al(OH)}_3\text{ are consumed}$$

$$25.4\text{ g} - 16.9\text{ g} = 8.5\text{ g Al(OH)}_3\text{ remaining}$$

---

24. c.

$$0.3242\text{ mol H}_2\text{SO}_4 \cdot \frac{1\text{ mol Al}_2(\text{SO}_4)_3}{3\text{ mol H}_2\text{SO}_4} = 0.1081\text{ mol Al}_2(\text{SO}_4)_3$$

$$0.1081\text{ mol Al}_2(\text{SO}_4)_3 \cdot \frac{342.154\text{ g}}{\text{mol}} = 37.0\text{ g Al}_2(\text{SO}_4)_3\text{ produced}$$

$$0.3242\text{ mol H}_2\text{SO}_4 \cdot \frac{6\text{ mol H}_2\text{O}}{3\text{ mol H}_2\text{SO}_4} = 0.6484\text{ mol H}_2\text{O}$$

$$0.6484\text{ mol H}_2\text{O} \cdot \frac{18.02\text{ g}}{\text{mol}} = 11.7\text{ g H}_2\text{O produced}$$

---

25. a.

$$1.200\times10^{3}\text{ kg }N_2H_4\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{32.0368\text{ g }N_2H_4}=37{,}457\text{ mol }N_2H_4$$

$$1.000\times10^{3}\text{ kg }(CH_3)_2N_2H_2\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{60.099\text{ g }N_2H_4}=16{,}639\text{ mol }(CH_3)_2N_2H_2$$

$$4.500\times10^{3}\text{ kg }N_2O_4\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{92.0110\text{ g }N_2O_4}=48{,}907\text{ mol }N_2O_4$$

$$37{,}457\text{ mol }N_2H_4\cdot\frac{1\text{ mol }(CH_3)_2N_2H_2}{2\text{ mol }N_2H_4}=18{,}729\text{ mol }(CH_3)_2N_2H_2$$

This much $(CH_3)_2N_2H_2$ is not available, so $(CH_3)_2N_2H_2$ is the limiting reactant between these two reactants. Next, we compare this with N_2O_4:

$$16{,}639\text{ mol }(CH_3)_2N_2H_2\cdot\frac{3\text{ mol }N_2O_4}{1\text{ mol }(CH_3)_2N_2H_2}=49{,}917\text{ mol }N_2O_4$$

This much N_2O_4 is not available, so N_2O_4 is the limiting reactant for the reaction, and was thus consumed first.

---

25. b.

$$48{,}907\text{ mol }N_2O_4\cdot\frac{8\text{ mol }H_2O}{3\text{ mol }N_2O_4}=130{,}491\text{ mol }H_2O$$

$$130{,}491\text{ mol }H_2O\cdot\frac{18.015\text{ g}}{\text{mol}}\cdot\frac{1\text{ kg}}{1000\text{ g}}=2349\text{ kg }H_2O$$

---

25. c.

$$48{,}907\text{ mol }N_2O_4\cdot\frac{6\text{ mol }N_2}{3\text{ mol }N_2O_4}=97{,}814\text{ mol }N_2$$

$$97{,}814\text{ mol }N_2\cdot\frac{6.0221\times10^{23}\text{ particles}}{\text{mol}}=5.890\times10^{28}\text{ particles }N_2$$

Since there are 2 N atoms per molecule, this gives 1.178×10^{29} N atoms.

---

26. a.

$$542\text{ g }SiO_2\cdot\frac{\text{mol}}{60.0843\text{ g}}=9.021\text{ mol}$$

$$9.021\text{ mol }SiO_2\cdot\frac{6\text{ mol HF}}{1\text{ mol }SiO_2}=54.1\text{ mol HF}$$

---

26. b.

$$4.25\text{ mol HF}\cdot\frac{1\text{ mol }H_2SiF_6}{6\text{ mol HF}}=0.7083\text{ mol }H_2SiF_6$$

$$0.7083\text{ mol }H_2SiF_6\cdot\frac{144.0917\text{ g}}{\text{mol}}=102\text{ g }H_2SiF_6$$

---

26. c.

$$2.0\text{ gal}\cdot\frac{3.785\text{ L}}{1\text{ gal}}\cdot\frac{1000\text{ mL}}{1\text{ L}}\cdot\frac{0.998\text{ g}}{\text{mL}}=7555\text{ g H}_2\text{O}$$

$$7555\text{ g H}_2\text{O}\cdot\frac{\text{mol}}{18.015\text{ g}}=419\text{ mol H}_2\text{O}$$

$$419\text{ mol H}_2\text{O}\cdot\frac{6\text{ mol HF}}{2\text{ mol H}_2\text{O}}=1300\text{ mol HF}$$

The result has been rounded to 2 sig digs as required.

---

26. d.

$$2.50\text{ kg HF}\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{20.0063\text{ g}}=125.0\text{ mol HF}$$

$$1.205\text{ kg SiO}_2\cdot\frac{1000\text{ g}}{1\text{ kg}}\cdot\frac{\text{mol}}{60.0843\text{ g}}=20.06\text{ mol SiO}_2$$

$$20.06\text{ mol SiO}_2\cdot\frac{6\text{ mol HF}}{1\text{ mol SiO}_2}=120.3\text{ mol HF}$$

More HF than this is available, so the limiting reactant is SiO_2.

---

26. e.

$$20.06\text{ mol SiO}_2\cdot\frac{1\text{ mol H}_2\text{SiF}_6}{1\text{ mol SiO}_2}=20.06\text{ mol H}_2\text{SiF}_6$$

$$20.06\text{ mol H}_2\text{SiF}_6\cdot\frac{144.0917\text{ g}}{\text{mol}}=2890\text{ g}\cdot\frac{1\text{ kg}}{1000\text{ g}}=2.89\text{ kg H}_2\text{SiF}_6$$

---

26. f.

$$\frac{2.657\text{ kg}}{2.890\text{ kg}}\cdot 100\%=91.9\%$$

27.

$$C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$$

27. a.

$$45.0\text{ g C}_6\text{H}_6\cdot\frac{\text{mol}}{78.113\text{ g}}=0.5761\text{ mol C}_6\text{H}_6$$

$$97.5\text{ g Br}_2\cdot\frac{\text{mol}}{159.808\text{ g}}=0.6101\text{ mol Br}_2$$

$$0.5761\text{ mol C}_6\text{H}_6\cdot\frac{1\text{ mol Br}_2}{1\text{ mol C}_6\text{H}_6}=0.5761\text{ mol Br}_2$$

More Br_2 than this is available, so C_6H_6 is the limiting reactant.

$$0.5761 \text{ mol } C_6H_6 \cdot \frac{1 \text{ mol } C_6H_5Br}{1 \text{ mol } C_6H_6} = 0.5761 \text{ mol } C_6H_5Br$$

$$0.5761 \text{ mol } C_6H_5Br \cdot \frac{157.010 \text{ g}}{\text{mol}} = 90.5 \text{ g } C_6H_5Br$$

---

27. b.

$$\frac{63.25 \text{ g}}{90.5 \text{ g}} \cdot 100\% = 69.9\%$$

---

28. a.

$$2.85 \times 10^{-6} \text{ mol } O_3 \cdot \frac{2 \text{ mol NaI}}{1 \text{ mol } O_3} = 5.70 \times 10^{-6} \text{ mol NaI}$$

---

28. b.

$$3.00 \text{ g } O_3 \cdot \frac{\text{mol}}{48.00 \text{ g}} = 0.06250 \text{ mol } O_3$$

$$0.06250 \text{ mol } O_3 \cdot \frac{2 \text{ mol NaI}}{1 \text{ mol } O_3} = 0.1250 \text{ mol NaI}$$

$$0.1250 \text{ mol NaI} \cdot \frac{149.08 \text{ g}}{\text{mol}} = 18.6 \text{ g NaI}$$

---

28. c.

$$1455 \text{ g NaI} \cdot \frac{\text{mol}}{149.8943 \text{ g}} = 9.7068 \text{ mol NaI}$$

$$250.0 \text{ g } O_3 \cdot \frac{\text{mol}}{47.998 \text{ g}} = 5.2085 \text{ mol } O_3$$

$$5.2086 \text{ mol } O_3 \cdot \frac{2 \text{ mol NaI}}{1 \text{ mol } O_3} = 10.417 \text{ mol NaI}$$

This much NaI is not available, so NaI is the limiting reactant.

$$9.7068 \text{ mol NaI} \cdot \frac{1 \text{ mol } I_2}{2 \text{ mol NaI}} = 4.8534 \text{ mol } I_2$$

$$4.8534 \text{ mol } I_2 \cdot \frac{253.809 \text{ g}}{\text{mol}} = 1232 \text{ g } I_2$$

---

28. d.

$$4.8534 \text{ mol } I_2 \cdot \frac{6.0221 \times 10^{23} \text{ particles}}{\text{mol}} = 2.923 \times 10^{24} \text{ particles}$$

Each particle is a molecules containing two I atoms, so there are 5.846×10^{24} I atoms.

---

29. a.

$16.81\ \text{mg} / 25.0\ \text{mg} = 0.672 \rightarrow 67.2\%\ \text{C}$

$1.736\ \text{mg} / 25.0\ \text{g} = 0.0694 \rightarrow 6.94\%\ \text{H}$

$3.015\ \text{mg} / 25.0\ \text{g} = 0.121 \rightarrow 12.1\%\ \text{N}$

$3.445\ \text{mg} / 25.0\ \text{g} = 0.138 \rightarrow 13.8\%\ \text{O}$

---

29. b.

Assuming a 100-gram sample:

$$67.2\ \text{g C} \cdot \frac{\text{mol}}{12.011\ \text{g}} = 5.59\ \text{mol} \quad (5.59 / 0.863 \approx 6.5) \rightarrow 6.5 \cdot 2 = 13$$

$$6.94\ \text{g H} \cdot \frac{\text{mol}}{1.0079\ \text{g}} = 6.89\ \text{mol} \quad (6.89 / 0.863 \approx 8) \rightarrow 8 \cdot 2 = 16$$

$$12.1\ \text{g N} \cdot \frac{\text{mol}}{14.0067\ \text{g}} = 0.864\ \text{mol} \quad (0.864 / 0.863 \approx 1) \rightarrow 1 \cdot 2 = 2$$

$$13.8\ \text{g O} \cdot \frac{\text{mol}}{15.9994\ \text{g}} = 0.863\ \text{mol} \quad (0.863 / 0.863 = 1) \rightarrow 1 \cdot 2 = 2$$

Proportions are doubled to give whole numbers. These ratios give an empirical formula of $C_{13}H_{16}N_2O_2$. The formula mass of this formula is 232.82 u, the same as the given molar mass. Thus, this is the molecular formula.

---

29. c.

$$3.0\ \text{mg}\ C_{13}H_{16}N_2O_2 \cdot \frac{1\ \text{g}}{1000\ \text{mg}} \cdot \frac{\text{mol}}{232\ \text{g}} \cdot \frac{6.022 \times 10^{23}\ \text{particles}}{\text{mol}} = 7.79 \times 10^{18}\ \text{particles}$$

Each particle (molecule) contains 13 C atoms, giving 1.0×10^{20} C atoms.

30.

$$E = 2.271\ \text{eV} \cdot \frac{1.60218 \times 10^{-19}\ \text{J}}{1\ \text{eV}} = 3.6386 \times 10^{-19}\ \text{J}$$

$$E = \frac{hv}{\lambda} \rightarrow \lambda = \frac{hv}{E} = \frac{6.626 \times 10^{-34}\ \text{J} \cdot \text{s} \cdot 2.9979 \times 10^{8}\ \frac{\text{m}}{\text{s}}}{3.6386 \times 10^{-19}\ \text{J}} = 5.459 \times 10^{-7}\ \text{m} \cdot \frac{1 \times 10^{9}\ \text{nm}}{1\ \text{m}} = 545.9\ \text{nm}$$

33.

$$27.9769\ \text{u} \cdot 0.92223 + 28.9765\ \text{u} \cdot 0.04685 + 29.9738\ \text{u} \cdot 0.03092 =$$
$$25.801\ \text{u} + 1.358\ \text{u} + 0.9268\ \text{u} = 28.085\ \text{u}$$

Chapter 6

5.

Since we are using the density in a calculation with the acceleration of gravity and pressure, we must use MKS units.

$$\rho = 0.998\ \frac{\text{g}}{\text{mL}} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} \cdot \frac{1000\ \text{mL}}{1\ \text{L}} \cdot \frac{1000\ \text{L}}{\text{m}^3} = 998\ \frac{\text{kg}}{\text{m}^3}$$

$$g = 9.80\ \frac{\text{m}}{\text{s}^2}$$

$$P = 101{,}325\ \text{Pa}$$

$$P = \rho g h \rightarrow h = \frac{P}{\rho g} = \frac{101{,}325\ \text{Pa}}{998\ \frac{\text{kg}}{\text{m}^3} \cdot 9.80\ \frac{\text{m}}{\text{s}^2}} = 10.4\ \text{m}$$

6.

$$1850\ \text{psi} \cdot \frac{6894.8\ \text{Pa}}{1\ \text{psi}} = 12{,}755{,}000\ \text{Pa}$$

Rounding to 3 sig digs, we have 12,800,000 Pa.

$$12{,}800{,}000\ \text{Pa} \cdot \frac{1\ \text{kPa}}{1000\ \text{Pa}} = 12{,}800\ \text{kPa}$$

$$12{,}755{,}000\ \text{Pa} \cdot \frac{1\ \text{atm}}{101{,}325\ \text{Pa}} = 125.89\ \text{atm}$$

Rounding to 3 sig digs, we have 126 atm.

$$125.89\ \text{atm} \cdot \frac{760\ \text{Torr}}{1\ \text{atm}} = 95{,}700\ \text{Torr}$$

$$12{,}800{,}000\ \text{Pa} \cdot \frac{1\ \text{bar}}{100{,}000\ \text{Pa}} = 128\ \text{bar}$$

7.

Using the symbol F_w to represent the skater's weight:

$$l = 2.9\ \text{mm} \cdot \frac{1\ \text{m}}{1000\ \text{mm}} = 0.0029\ \text{m}$$

$$w = 57\ \text{mm} \cdot \frac{1\ \text{m}}{1000\ \text{mm}} = 0.057\ \text{m}$$

$$F_w = 200.0\ \text{lb} \cdot \frac{4.448\ \text{N}}{1\ \text{lb}} = 889.6\ \text{N}$$

$$A = l \cdot w = 0.0029\ \text{m} \cdot 0.0057\ \text{m} = 0.0001653\ \text{m}^2$$

$$P = \frac{F}{A} = \frac{889.6\ \text{N}}{0.0001653\ \text{m}^2} = 5{,}382{,}000\ \text{Pa}$$

$$5{,}382{,}000\ \text{Pa} \cdot \frac{1\ \text{atm}}{101{,}325\ \text{Pa}} = 53\ \text{atm}$$

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