APPENDIX A

GENERAL RULES FOR SOLVING SOLUTION PROBLEMS

1. Read the problem carefully. What is the problem asking for? Be sure the entire problem has been read and understood. This may require you to read the problem two or three times. YOU CANNOT ANSWER THE PROBLEM IF YOU DO NOT KNOW WHAT IT IS ASKING!!!!

2. Determine what principles and relationships are involved.

3. Determine exactly what results are to be produced by the calculations.

4. Think about possible methods to use in solving the problem.

5. What information are you given in the problem? This may help in determining how to solve the problem.

6. Based on definition, determine which expression allows you to solve for the unknown quantity.

7. Once you have selected an expression suitable for that specific problem type, write it down on your paper.

8. Place your given information directly under its corresponding place in the expression. Be sure to include the units.

9. Make sure your units are suitable. For example, if your formula requires your unit of volume to be in liters and the problem provides the number in milliliters, did you remember to convert?

10. Write the intermediate stages of the calculations clearly. Avoid writing one number on top of another as a method of correction. Make each digit legible. This will allow you to go back and check your work later.

11. Mentally estimate an answer before working the problem.

12. Do the mathematics involved and check your work. Be extremely careful in positioning the decimal point.

13. Cancel your units. The units you have left should be an appropriate unit for what the problem asked for. Example: If the problem asked for "How many grams," your final answer should be in grams. If it is not, go back and check your work. Often, all that is required is a simple metric conversion.

14. Compare the calculated result with your estimated answer. If the two figures disagree drastically, determine which result is wrong.

15. Finally, go back and read the problem again. Did you answer the question correctly and does your answer make sense?

APPENDIX B

TABLE OF FOUR-PLACE LOGARITHMS

	0	1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0756
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3684
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522

APPENDIX B

TABLE OF FOUR-PLACE LOGARITHMS

	0	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9026

APPENDIX B

TABLE OF FOUR-PLACE LOGARITHMS

	0	1	2	3	4	5	6	7	8	9
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680
93	9685	9689	9694	9699	9703	9708	9713	9417	9722	9727
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996

APPENDIX C

TABLE OF COMMON ELEMENTS AND RADICALS

NAME	SYMBOL	APPROX. ATOMIC WEIGHT	COMMON VALENCE
Aluminum	Al	27.0	+3
Antimony	Sb	121.8	+3
Arsenic	As	74.9	+3
Barium	Ba	137.3	+2
Bismuth	Bi	209.0	+3
Bromine	Br	79.9	-1
Calcium	Ca	40.1	+2
Carbon	C	12.0	+4
Chlorine	Cl	35.5	-1
Chromium	Cr	52.0	+3, +6
Copper	Cu	63.5	+1, +2
Fluorine	F	19.0	-1
Gold	Au	197.0	+3
Hydrogen	H	1.0	+1
Iodine	I	126.9	-1
Iron	Fe	55.8	+2, +3
Lead	Pb	207.2	+2, +4
Lithium	Li	6.9	+1
Magnesium	Mg	24.3	+2
Manganese	Mn	54.9	+2
Molybdenum	Mo	95.9	+6
Mercury	Hg	200.6	+1, +2
Nickel	Ni	58.7	+2, +3
Nitrogen	N	14.0	+3, -3
Oxygen	O	16.0	-2
Phosphorus	P	31.0	+5
Potassium	K	39.1	+1
Silicon	Si	28.1	+4
Silver	Ag	107.9	+1
Sodium	Na	23.0	+1
Strontium	Sr	87.6	+2
Sulfur	S	32.1	-2, +6
Tin	Sn	118.7	+2, +4
Tungsten	W	183.9	+6
Zinc	Zn	65.4	+2
Ammonium	NH_4		+1
Acetate	$C_2H_3O_2$		-1
Bicarbonate	HCO_3		-1
Bisulfate	HSO_4		-1
Carbonate	CO_3		-2
Chlorate	ClO_3		-1
Dichromate	Cr_2O_7		-2
Hydroxide	OH		-1
Hypochlorite	ClO		-1
Nitrate	NO_3		-1
Nitrite	NO_2		-1
Oxalate	C_2O_4		-2
Permanganate	MnO_4		-1
Phosphate	PO_4		-3
Monohydrogen phosphate	HPO_4		-2
Dihydrogen phosphate	H_2PO_4		-1
Sulfate	SO_4		-2
Sulfite	SO_3		-2
Tungstate	WO_4		-2

APPENDIX C

APPROXIMATE CONCENTRATIONS OF COMMERCIAL ACIDS AND BASES

ACID OR BASE	FORMULA	PERCENT (w/v)	S.G.	MOLARITY	NORMALITY
Acetic Acid	$HC_2H_3O_2$	99.6	1.05	17	17
Hydrochloric Acid	HCl	36	1.19	12	12
Lactic Acid	$HC_3H_5O_3$	85	1.20	11	11
Nitric Acid	HNO_3	70	1.42	16	16
Phosphoric Acid	H_3PO_4	85	1.71	15	45
Sulfuric Acid	H_2SO_4	97	1.84	18	36
Ammonium Hydroxide	NH_4OH	28 (NH_3)	0.90	15	15

APPENDIX D

METRIC PREFIXES

PREFIX	ABBREVIATION	SCIENTIFIC NOTATION	DECIMAL VALUE
Giga-	G	10^{9}	1,000,000,000
Mega-	M	10^{6}	1,000,000
Kilo-	k	10^{3}	1,000
Hecto-	h	10^{2}	100
Deka-	dk	10^{1}	10
(Base unit) (m, L, or g)		10^{0}	1
Deci-	d	10^{-1}	0.1
Centi-	c	10^{-2}	0.01
Milli-	m	10^{-3}	0.001
Micro-	u	10^{-6}	0.000001
Nano-	n	10^{-9}	0.000000001
Pico-	p	10^{-12}	0.000000000001
Femto-	f	10^{-15}	0.000000000000001

APPENDIX E

REVIEW OF DIMENSIONAL ANALYSIS

1. Most quantities used in chemistry consist of both a numerical value and a dimensional value. The comment that a flask contains 315 ml. of a liquid conveys two important ideas - the numerical value 315 and the dimensional value milliliters, both of which are necessary in order to express correctly the volume of liquid. The dimensional values commonly used in chemistry are discussed in the math section on metric system. In the solution of a problem both the numerical and the dimensional values may be treated mathematically. When this is done the answer represents the correct numerical and dimensional values. The process of treating dimensions mathematically is called dimensional analysis.

2. Treatment of dimensions in addition and subtraction

   Numbers which are added or subtracted must have the same dimensions. It is obvious that there is no significance to the sum obtained by adding quantities such as 25 in. and 37 cm. without first converting to like units. This is discussed in the math section on addition and subtraction using significant digits.

3. Treatment of dimensions in multiplication and division.

   Quantities expressed either in like or unlike units may be multiplied or divided. The dimensions of the numbers may be treated mathematically in the same manner as the numbers.

   a. Example: What is the area of a rectangular board 4.0 ft long and 3.0 ft. wide?

      Solution:

      $$4.0 \text{ ft.} \times 3.0 \text{ ft.} = (4.0 \times 3.0)(\text{ft.} \times \text{ft.}) = 12.0 \text{ ft.}^2$$

      Note that both the numerical and the dimensional values have been multiplied.

   b. Example: A car traveled 260 miles in 5.0 hours. Calculate the speed of the car in miles per hour (mi./hr.).

      Solution:

      $$\frac{260 \text{ mi.}}{5.0 \text{ hr.}} = \frac{260}{5.0} \frac{\text{mi.}}{\text{hr.}} = 52 \frac{\text{mi.}}{\text{hr.}}$$

      In this example the dimensional value can not by simplified.

c. Example: How many centimeters are there in 15.0 in.?

Solution:

There are 2.54 cm/in. Therefore:

$$2.54 \frac{\text{cm.}}{\text{in.}} \times 15.0 \text{ in.} = 38.1 \text{ cm}$$

Cancellation of like units (in.) gives the desired dimensions, centimeters.

d. Example: How many feet are there in 200 cm.?

Solution:

There are 30.5 cm./ft. Therefore:

$$\frac{200 \text{ cm.}}{30.5 \frac{\text{cm.}}{\text{ft.}}} = \frac{200}{30.5}\text{cm} \times \frac{\text{ft.}}{\text{cm.}} = 6.56 \text{ ft.}$$

Cancellation of like units (cm.) gives the desired dimensions, feet.

e. Example: Given that there are 2.54 cm./in. Determine the number of inches per centimeter (in./cm.)

Solution:

Dimensionally cm./in. and in./cm. are reciprocals. Therefore:

$$\frac{1}{2.54 \frac{\text{cm.}}{\text{in.}}} = \frac{1 \text{ in.}}{2.54 \text{ cm.}} = 0.394 \frac{\text{in.}}{\text{cm.}}$$

f. Example: Convert 2.36 kilograms to milligrams.

Solution:

Dimensional analysis shows that the following operations must be carried out in order to obtain the value in milligrams.

$$\text{kg.} \times \frac{\text{g.}}{\text{kg.}} \times \frac{\text{mg.}}{\text{g.}} = \text{mg.}$$

Since there are 1000 $\frac{g.}{kg.}$ and 1000 $\frac{mg.}{g.}$, then:

$$2.36 \text{ kg.} \times 1000 \frac{g.}{kg.} \times 1000 \frac{mg.}{g.} = 2.36 \times 10^6 \text{ mg.}$$

Cancellation of like units (kg. and g.) gives the desired dimensions, mg.

g. Example: Convert 2 7/16 in. to millimeters.

Solution:

There are 2.54 cm./in. and 10 mm./cm. Therefore:

$$\frac{39}{16} \text{ in.} \times 2.54 \frac{cm.}{in.} \times 10 \frac{mm.}{cm.} = 61.9 \text{ mm.}$$

Cancellation of like units (cm. and in.) gives the desired dimensions, mm.

h. Example: A car is traveling 60 mi./hr. What is the speed of the car in ft./sec.?

Solution:

To solve the problem it is necessary to convert mi. to ft and hr. to sec., and simplify. Since there are 5280 ft./mi., 60 min./hr., and 60 sec./min., then

$$\frac{60 \text{ mi.} \times 5280 \frac{ft.}{mi.}}{1.0 \text{ hr.} \times 60 \frac{min.}{hr.} \times 60 \frac{sec.}{min.}} = \frac{60 \times 5280 \text{ ft.}}{60 \times 60 \text{ sec.}} = 88 \frac{ft.}{sec}$$

Cancellation of like units (mi., hr. and min.) gives the desired dimensions, ft, and sec.

i. What is the weight in grams of 2.50 gallons of water, given that there are 231 $in.^3$/gal, 2.543 cm./in., and that water weighs 1.00 $g./cm.^3$?

Solution:

$$2.50 \text{ gal.} \times 231 \frac{in.^3}{gal.} \times (2.54 \frac{cm.}{in.})^3 \times 1.00 \frac{g.}{cm.^3} = 9.46 \times 10^3 \text{ g.}$$

$$\text{gal.} \times \frac{\text{in.}^3}{\text{gal.}} = \text{in.}^3$$

$$\text{in.}^3 \times \frac{\text{cm.}^3}{\text{in.}^3} = \text{cm.}^3$$

$$\text{cm.}^3 \times \frac{\text{g.}}{\text{cm.}^3} = \text{g.}$$

4. Nondimensional numbers

Although most quantities are dimensional, there are a few nondimensional quantities. These are called pure numbers.

a. Example: Two iron rods are 65 ft. and 10 ft. respectively in length. The longer rod is how many times the length of the shorter rod?

Solution:

$$\frac{65 \text{ ft.}}{10 \text{ ft.}} = 6.5$$

The dimensions cancel, giving the pure number 6.5. That is, the longer rod is 6.5 times the length of the shorter rod.

b. Example: What is the circumference of a circle having a diameter of 12.0 cm.? That is:

$$C \propto d.$$

The proportionality constant is 3.1416, commonly designated by the Greek letter pi, π. Or:

$$C = 3.1416 \times d.$$ Therefore:
$$C = 3.1416 \times 12.0 \text{ cm.} = 37.7 \text{ cm.}$$

Proportionality constants, such as pi, are pure numbers.

APPENDIX F

ROUNDING OFF NUMBERS, AND SIGNIFICANT FIGURES

ROUNDING OFF NUMBERS

1. DISCUSSION

Rounding off of numbers is the dropping of one or more digits of a number to obtain the desired number of significant figures.

2. RULES

a. When the digit dropped is less than five (5), the last digit retained remains unchanged; e.g., 6.582 becomes 6.58.

b. When the digit dropped is greater than 5, the last digit retained is increased by one (1); e.g., 6.586 becomes 6.59.

c. When the digit dropped is five (5) alone or a 5 followed by only a zero or only zeros, the digit remaining is rounded to the nearest even number; e.g., 2.585 becomes 2.58. Since the remaining digit was already an even number it was not changed. However, the number 2.575 when rounded off becomes 2.58, since the remaining digit was seven (7).

NOTE: Although we will follow the above rule concerning the dropping of the number five (5), be aware that it is not always observed. It is quite common to round up if the digit dropped is five (5) or greater and to leave the last digit retained unchanged if the digit dropped is four (4) or less.

ROUNDING OFF NUMBERS EXERCISE

After you have completed these exercises, turn to the end of the lesson, and check your answers with the review solutions.

FIRST REQUIREMENT: Round to the nearest tenths place (one digit to the right of the decimal point).

a. 78.99

_____

b. 13.6

_____

c. 56.019

_____

d. 639.138

_____

e. 1.27

_____

f. 99.999

_____

g. 24.451

k. 5.098

SECOND REQUIREMENT: Round to the nearest hundredths place (two digits to the right of the decimal point).

h. 844.556

l. 9.999

i. 6.7755

m. 8.8151

n. 8.6555

j. 100.999

THIRD REQUIREMENT: Round to the nearest thousandths place (three digits to the right of the decimal point).

o. 6.9895

r. 1.3375

p. 333.0003

s. 4.8525

q. 21.7666

t. 2.1999

SIGNIFICANT FIGURES

1. DISCUSSION

The validity of a number depends upon the precision to which the number was determined.

a. For example, an individual counted the number of ants that were in an ant hill and reported that there were 246,337 ants. This number is obviously inaccurate, since during the period of the count ants died and others hatched. A more realistic number of ants would have been 246,000, or 2.46×10^5.

b. A common pitfall is the manner in which laboratory values are reported. The specialist can use a calculator to determine the value of an unknown specimen and report a value to the physician that is inaccurate. For example, in using the photometric equation, the value for glucose in a clinical specimen was determined to be 99.1825734 using the calculator. It would be absurd to report this value since the limits of accuracy of the measuring device used to obtain the calculation data (accuracy of the test) allows, at best, only a value of 99.

c. In most cases, the number of significant figures in your least accurate piece of data used in your calculations determines the accuracy of reported results.

2. DETERMINING THE NUMBER OF SIGNIFICANT FIGURES IN A NUMBER

a. **Non-Zero Integers.** All non-zero integers are significant figures.

b. **Use of Zero (0).** A zero in a number may or may not be significant, depending upon the manner in which it is used.

(1) Zeros used to locate decimal points: If one or more zeros are used to locate a decimal point (place holder) they are not significant. For example, the numbers 0.025, 0.0025, and 0.00025 each have only two significant figures, the two (2) and the five (5).

(2) Zeros appearing between numbers: When a zero appears between numbers it is significant. For example, 1.095 has four (4) significant figures.

(3) Zeros appearing at the end of a number:

(a) If a number contains a decimal point and the last number (digit) is a zero, the zero is a significant figure. For example, 15.60 has four (4) significant figures.

(b) If the last digit in the number is a zero and the number does not contain a decimal point, the zero may or may not be significant. For example, the number 1670 has four significant figures if the accuracy of the measurement included the zero as a significant digit. If the digit seven (7) was estimated, then the zero is not significant and hence the number contains only three (3) significant figures.

NOTE: For all course work that follows, any trailing zeros will be considered significant. For example, the number 1000 has four significant figures.

c. **Examples.**

Number	Number of significant figures
18	2
18.0	3
108	3
0.0018	2
0.0108	3
180	3 (for this subcourse)

3. IMPLIED LIMITS

If a laboratory result is reported as 3.6, it indicates that this value is accurate to the nearest tenth and that the exact value lies between 3.55 and 3.65.

4. LABORATORY APPLICATION

The real importance of significant figures lies in their application to fundamental laboratory calculations.

a. **Addition and Subtraction.** When adding or subtracting, the last digit retained in the sum or difference should correspond to the first doubtful decimal place of the addends (least accurate number).

b. **Example.** Add 5.683 plus 0.0052.

Solution. In the number 5.683, the three (3) is the doubtful decimal place; i.e., the value of this measurement could vary from 5.6825 to 5.6835. Since the fourth digit after the decimal point is unknown, the answer is limited to four (4) digits. Thus,

$$\begin{array}{r} 5.683 \\ +\ 0.0052 \\ \hline 5.6882 \end{array} \quad \text{----> } 5.688$$

c. **Multiplication and Division.** When multiplying or dividing, the product or quotient can contain no more significant digits than the least number of significant figures in the numbers involved in the calculation.

d. **Example.** Multiply 0.5823 by 8.2.

Solution. The number 0.5823 contains four (4) significant figures whereas the number 8.2 contains only two (2) significant figures. Thus, the product can contain only two (2) significant figures.

Therefore,

$$\begin{array}{r} 0.5823 \\ \times\ 8.2 \\ \hline 4.77486 \end{array} \text{ -----> } 4.8$$

SIGNIFICANT FIGURES EXERCISE

After you have completed these exercises, turn to the end of the lesson, and check your answers with the review solutions.

FIRST REQUIREMENT: Indicate the number of significant figures in the following:

a. 8400	k. 0.004300
b. 4370	l. 0.0085
c. 2.045	m. 370
d. 10.360	n. 999
e. 0.8400	o. 110.0
f. 209	p. 0018
g. 482.000	q. 49.0611
h. 80	r. 101.0
i. 1.95001	s. 0.0850100
j. 101	t. 0.00001

SECOND REQUIREMENT: Solve the following problems and report the answers using the appropriate number of significant figures:

u. 6012.14 + 305.2	z. 18.9 X 21
_____	_____
v. 310.221 - 6.1	aa. 0.269 - 3
_____	_____
w. 0.01154 + 0.23	ab. 662 - 18.0
_____	_____
x. 100.2 + 85	ac. 75 X 801
_____	_____
y. 66 - 2	ad. 0.21 X 3.0233
_____	_____

SOLUTIONS TO EXERCISES

SOLUTIONS TO ROUNDING OFF EXERCISE

The reference for these exercises is paragraphs 1 - 2.

a. 79.0

b. 13.6

c. 56.0

d. 639.1

e. 1.3

f. 100.0

g. 24.4

h. 844.6

i. 6.78

j. 101.00

k. 5.10

l. 10.00

m. 8.82

n. 8.66

o. 6.990

p. 333.000

q. 21.767

r. 1.338

s. 4.852 (para 1-16c)

t. 2.200

SOLUTIONS TO SIGNIFICANT FIGURES EXERCISE

The reference for these exercises is paragraphs 1 - 4:

a. 4

b. 4

c. 4

d. 5

e. 4

f. 3

g. 6

h. 2

i. 6

j. 3

k. 4

l. 2

m. 3

n. 3

o. 4

p. 2

q. 6

r. 4

s. 6

t. 1

u. 6317.3

v. 304.1

w. 0.24

x. 185

y. 64

z. 4.0×10^2 (only 2 significant figures)

aa. -2.731 = -3 (only 1 significant figure)

ab. 644

ac. 6.0×10^4 (only 2 significant figures)

ad. 0.63

APPENDIX G

PROPORTIONALITY

The Concept of proportionality

1. Ratio and proportion

A proportion is statement of equality between two ratios. In the most general form a proportion may be expressed as $\frac{a}{b} = \frac{c}{d}$

where any one of the four quantities may be the unknown. One solution of the proportion gives ad = bc. In this form the unknown may be expressed in terms of the other three.

Example: Solve for x.

$$\frac{122}{11.2} = \frac{24}{x}$$

Solution.

$$122x = (11.2)(24)$$

$$x = 2.2$$

2. Proportionality and proportionality constants.

a. In chemical reactions the rate of the reaction is <u>proportional</u> to the product of the concentrations of the reactants, each raised to the power of its coefficient in the balanced equation. For example, in the reaction nA + mB -----> C the rate is

$$\text{rate} \propto [A]^n[B]^m; \propto = \text{proportionality sign.}$$

This expression shows a proportionality between the rate of a chemical reaction and the concentration of the reactants.

By using a proportionality constant k, the rate relationship can be written as an equality

$$\text{rate} = k[A]^n[B]^m$$

The proportionality constant is a function of the nature of the reactants and the temperature of the reaction mixture. This proportionality constant is called the specific rate constant.

b. There are many mathematical relationships in which proportionalities may be made equalities by using a proportionality constant.

For example the circumference of a circle, C, is directly proportional to the diameter, d.

$$C \propto d.$$

This expression of proportionality can be made an equality by multiplying the diameter by a proportionality constant, commonly designated by the Greek letter pi, π.

$$C = \pi d.$$

If the circumference, C, of a circle is 37.7 cm and the diameter, d, is 12.0 cm the proportionality constant can be calculated from the following relationship.

$$\pi = \frac{C}{d} = \frac{37.7}{12.0} = 3.1416$$

NOTE: Remember that proportionality constants, such as π, are pure numbers

c. Gas Laws

1) When describing gas laws, a topic discussed in general chemistry, defining a law by name and then memorizing equations related to each gas law is usually the first step in working gas law problems. By looking at some relationships involving the properties of gases one can figure out the laws regardless of how they are named. In dealing with laws that govern the nature of gaseous systems there are four properties that generally characterize these gaseous system. They are temperature (T), pressure (P), volume (V), and mass (n, for number of molecules). If any two of these factors are kept constant, and the third is varied, the question is what will happen to the fourth. This is exactly what happens in many of the gas laws. In order to understand the effect one variable will have on another, the concept of proportionality and proportionality constants is necessary.

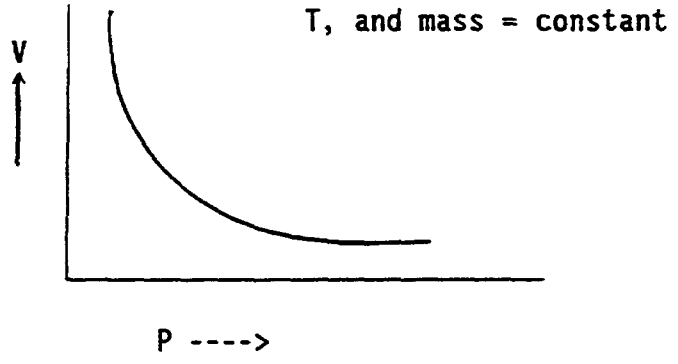
2) In the expression AB = k, all values of the factor A when multiplied by factor B must equal the same product k. Therefore, if k is specified as 12, and we know that A = 4, then B must equal 3 so that 4 X 3 = 12. If the factor A is increased to 6, we must reduce B to 2. These factors are called variables and are said to be inversely related to each other; in order for their product to remain constant, if one varies (for example, increases), the other must be changed proportionately in the opposite direction (for example, decreases). In summary, the general rule is that when two variables are factors whose product is a constant, these variables are inversely related.

3) In contrast, if two variables are expressed as a ratio with a constant quotient, A/B = k, we see that a change in one will necessitate a proportionate change in the other in the same direction. Therefore is k is specified as 2, and we know that A = 8, then B must be 4 so that 8/4 = 2. If factor A is increased to 16, we must increase B to 8. If factor A is decreased to 4, we must decrease B to 2. These variables are thus directly related.

4) Both inversely and directly related variables can easily be combined to show their dependency on one another. It is evident from the previous discussion that AB/CD = k means that A and B are inversely related, C and D are inversely related, but both A and B are directly related to C and D. Remember that the product-quotient must remain fixed at its original value.

5) A look at two gas variables (P vs V, or V vs T) will demonstrate how direct and inverse proportionalities can be used to derive mathematical equations for two gas laws.

a) Boyles Law



The graphical representation of the V vs P data shows that there is in inverse relationship between the pressure of the gas and the volume of the gas. For example, when the pressure goes up the volume of the gas goes down.

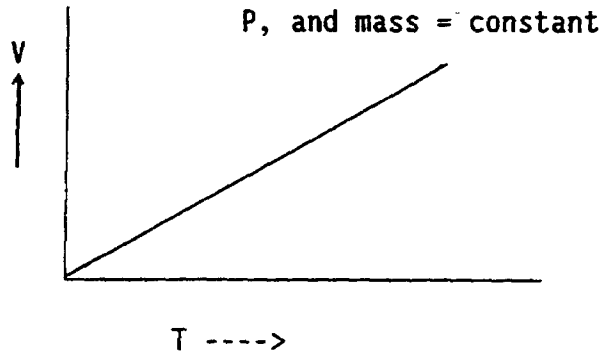
This tells us, therefore, that PV = k. This means that some initial pressure(P_1)-volume(V_1) product is a constant and if the proportionality is to hold true then some final pressure(P_2)-volume(P_2) product is also the same constant.

Thus, since $P_1V_1 = k = P_2V_2$ then;

$P_1V_1 = P_2V_2$

This is the mathematical expression for Boyle's Law

b) Charles' law



This tells us, therefore, that $V/T = k$. This means that some initial volume(V_1)-temperature(T_1) quotient is a constant and if the proportionality is to hold true then some final volume(V_2)-temperature(T_2) quotient is also the same constant.

Thus, since $V_1/T_1 = k = V_2/T_2$ then;

$V_1/T_1 = V_2/T_2$

This is the mathematical expression for Charles'law.

c) Combined gas law

Since volume in inversely related to pressure and directly related to temperature, we see that the following relationship is true.

$$\frac{PV}{T} = k \quad \text{Therefore;} \quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$