Given values in RED
wanted units in DK GREEN

proof of units after dimensional analysis in LT. GREEN

Problems including concepts from Chapter 13/14 as well as 15:

1. The LD_{50} of caffeine is 192 mg/kg.
   a. If the average shot of espresso contains 64 mg of caffeine, how many shots would a 135 lb person have to consume to ingest a lethal dose of caffeine? (2.2 lb = 1 kg)

$$\frac{135\,\cancel{lb}}{1} \times \frac{1\,kg}{2.2\,\cancel{lb}} = 61.36\,kg$$

$$\frac{192\,mg}{\cancel{kg}} \times \frac{61.36\,\cancel{kg}}{1} = \frac{11781.8\,\cancel{mg}}{1} \times \frac{1\,shot}{64\,\cancel{mg}} = \boxed{184\text{ shots of espresso}}$$

   b. The molecular formula for caffeine is $C_8H_{10}N_4O_2$. How many **moles** of caffeine are in a lethal dose for that person? molar mass = 194.2 g/mol

$$\frac{11781.8\,\cancel{mg}}{1} \times \frac{1\,\cancel{g}}{1000\,\cancel{mg}} \times \frac{1\,mol}{194.2\,\cancel{g}} = \boxed{0.061\,mol}$$

   c. How many **molecules of caffeine** are in the lethal dose for that person?

$$\frac{0.061\,\cancel{mol}}{1} \times \frac{6.02\times10^{23}\,molecules}{\cancel{mol}} = \boxed{3.6722\times10^{22}\,molecules}$$

   d. How many **nitrogen atoms** are in the lethal dose for that person?

1 mol caffeine has 4 mol N atoms

$$\frac{3.6722\times10^{22}\,\cancel{molecules}}{1} \times \frac{4\,N\,atoms}{\cancel{molecule}} = \boxed{1.46888\times10^{23}\,N\,atoms}$$

2. If a beaker contains 1.25 L of a 6M Na_2SO_4 solution, how many **moles of Na_2SO_4** are in the beaker?

$$\frac{1.25\,\cancel{L}}{1} \times \frac{6\,mol}{\cancel{L}} = \boxed{7.5\,mol\,Na_2SO_4}$$

   a. How many **grams of sulfur** are in the beaker? molar mass S = 32.07 g/mol

7.5 mol Na_2SO_4 has 7.5 mol S

$$\frac{7.5\,\cancel{mol}}{1} \times \frac{32.07\,g}{\cancel{mol}} = \boxed{240.525\,g\,S}$$

   b. How many **sulfur atoms** are in the beaker?

$$\frac{7.5\,\cancel{mol}}{1} \times \frac{6.02\times10^{23}\,atoms}{\cancel{mol}} = \boxed{4.515\times10^{24}\,S\,atoms}$$

   c. How many **sodium atoms** are in the beaker?

7.5 mol Na_2SO_4 has 15 mol Na atoms

$$\frac{15\,\cancel{mol}}{1} \times \frac{6.02\times10^{23}\,atoms}{\cancel{mol}} = \boxed{9.03\times10^{24}\,Na\,atoms}$$

WANTED GIVEN

Problem Set #1:

1. Sea water contains roughly 28.0 g of NaCl per liter. What is the molarity of sodium chloride in sea water? $=1L$ $=M=\frac{mol}{L}$

molar mass NaCl $= 22.99 + 35.45 = \boxed{58.44\ g/mol}$

$$\frac{28\cancel{g}}{1} \times \frac{1\ mol}{58.44\cancel{g}} \times \frac{1}{1\ L} = 0.479\ \frac{mol}{L} = \boxed{0.479\ M}$$

2. How many moles of Na_2CO_3 are in 10.0 mL of a 2.0 M solution? $1000\ mL = 1L$

$$\frac{10\ \cancel{mL}}{1} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{2.0\ mol}{\cancel{L}} = \boxed{0.02\ mol}$$

3. What weight (in grams) of H_2SO_4 would be needed to make 750.0 mL of 2.00 M solution? $1000mL = 1L$

molar mass $H_2SO_4 = 2(1.008) + 32.07 + 4(16) = \boxed{98.086\ g/mol}$

$$\frac{750\ \cancel{mL}}{1} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{2\ \cancel{mol}}{\cancel{L}} \times \frac{98.086\ g}{\cancel{mol}} = \boxed{147.129\ g}$$

4. What is the molarity of 245.0 g of H_2SO_4 dissolved in 1.000 L of solution?

$$\frac{245\cancel{g}}{1} \times \frac{1\ mol}{98.086\cancel{g}} \times \frac{1}{1\ L} = \boxed{2.497\ M}$$

5. How many moles of NaCl are contained in 100.0 mL of a 0.200 M solution?

$$\frac{100\ \cancel{mL}}{1} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{0.2\ mol}{\cancel{L}} = \boxed{0.02\ mol}$$

6. What weight (in grams) of NaCl would be contained in problem #5?

$$\frac{0.02\ \cancel{mol}}{1} \times \frac{58.44\ g}{1\ \cancel{mol}} = \boxed{1.17\ g}$$

7. What is the molarity of 5.30 g of Na_2CO_3 dissolved in 400.0 mL solution?

molar mass $Na_2CO_3 = 2(22.99) + 12.01 + 3(16) = \boxed{105.99\ g/mol}$

$$\frac{5.3\cancel{g}}{1} \times \frac{1\ mol}{105.99\cancel{g}} \times \frac{1}{400\ \cancel{mL}} \times \frac{1000\ \cancel{mL}}{1\ L} = 0.125\ \frac{mol}{L} = \boxed{0.125\ M}$$

8. What is the molarity of 5.00 g of NaOH in 750.0 mL of solution? molar mass NaOH $= 22.99 + 1.008 + 16 = 39.998\ g/mol$

$$\frac{5\cancel{g}}{1} \times \frac{1\ mol}{39.998\cancel{g}} \times \frac{1}{750\ \cancel{mL}} \times \frac{1000\ \cancel{mL}}{1\ L} = 0.167\ \frac{mol}{L} = \boxed{0.167\ M}$$

9. How many moles of Na_2CO_3 are there in 10.0 L of 2.00 M solution?

$$\frac{10.0\ \cancel{L}}{1} \times \frac{2.00\ mol}{\cancel{L}} = \boxed{20.0\ mol}$$

10. What volume (in mL) of 18.0 M H_2SO_4 is needed to contain 2.45 g H_2SO_4? *molar mass $= 98.086\ \frac{g}{mol}$

$$\frac{2.45\cancel{g}}{1} \times \frac{1\ \cancel{mol}}{98.086\cancel{g}} \times \frac{1\ \cancel{L}}{18.0\ \cancel{mol}} \times \frac{1000\ mL}{\cancel{L}} = \boxed{1.39\ mL}$$

Problem Set #2:

11. What volume (in mL) of 12.0 M HCl is needed to contain 3.00 moles of HCl?

$$\frac{1000\,\text{mL}}{\cancel{\text{L}}} \times \frac{1\,\cancel{\text{L}}}{12\,\cancel{\text{mol}}} \times \frac{3.00\,\cancel{\text{mol}}}{1} = \boxed{250\,\text{mL}}$$

12. How many grams of $Ca(OH)_2$ are needed to make 100.0 mL of 0.250 M solution?

molar mass $Ca(OH)_2$ = 74.096 g/mol

$$\frac{100\,\cancel{\text{mL}}}{1} \times \frac{1\,\cancel{\text{L}}}{1000\,\cancel{\text{mL}}} \times \frac{0.250\,\cancel{\text{mol}}}{1\,\cancel{\text{L}}} \times \frac{74.096\,\text{g}}{1\,\cancel{\text{mol}}} = \boxed{1.85\,\text{g}}$$

13. What is the molarity of a solution made by dissolving 20.0 g of H_3PO_4 in 50.0 mL of solution?

molar mass H_3PO_4 = 97.994 g/mol

$$\frac{20.0\,\cancel{\text{g}}}{1} \times \frac{1\,\text{mol}}{97.994\,\cancel{\text{g}}} \times \frac{1000\,\cancel{\text{mL}}}{1\,\text{L}} \times \frac{1}{50\,\cancel{\text{mL}}} = 4.08\,\frac{\text{mol}}{\text{L}} = \boxed{4.08\,M}$$

14. What weight (in grams) of KCl is there in 2.50 liters of 0.500 M KCl solution?

molar mass KCl = 74.55 g/mol

$$\frac{2.5\,\cancel{\text{L}}}{1} \times \frac{0.5\,\cancel{\text{mol}}}{\cancel{\text{L}}} \times \frac{74.55\,\text{g}}{1\,\cancel{\text{mol}}} = \boxed{93.19\,\text{g}}$$

15. What is the molarity of a solution containing 12.0 g of NaOH in 250.0 mL of solution?

molar mass NaOH = 39.998 g/mol

$$\frac{12.0\,\cancel{\text{g}}}{1} \times \frac{1\,\text{mol}}{39.998\,\cancel{\text{g}}} \times \frac{1}{250\,\cancel{\text{mL}}} \times \frac{1000\,\cancel{\text{mL}}}{1\,\text{L}} = 1.2\,\frac{\text{mol}}{\text{L}} = \boxed{1.2\,M}$$

16. Determine the molarity of these solutions:
   a. 4.67 moles of Li_2SO_3 dissolved to make 2.04 liters of solution

$$\frac{4.67\,\text{mol}}{2.04\,\text{L}} = \boxed{2.29\,M}$$

b. $\boxed{0.629\text{ moles}}$ of Al_2O_3 to make $\boxed{1.500\text{ liters}}$ of solution.

$$\frac{0.629\,mol}{1.5\,L} = \boxed{0.419\,M}$$

c. $\boxed{4.783\text{ grams}}$ of $\boxed{Na_2CO_3}$ to make $\boxed{10.00\text{ liters}}$ of solution.

molar mass Na_2CO_3 = 105.99 g/mol

$$\frac{4.783\,\cancel{g}}{1} \times \frac{1\,mol}{105.99\,\cancel{g}} \times \frac{1}{10.0\,L} = 0.0045\,\frac{mol}{L} = \boxed{0.0045\,M}$$

d. $\boxed{0.897\text{ grams}}$ of $\boxed{(NH_4)_2CO_3}$ to make $\boxed{250\text{ mL}}$ of solution.

1000 mL = 1 L

molar mass $(NH_4)_2CO_3$ = 96.094 g/mol

$$\frac{0.897\,\cancel{g}}{1} \times \frac{1\,mol}{96.094\,\cancel{g}} \times \frac{1}{250\,\cancel{mL}} \times \frac{1000\,\cancel{mL}}{1\,L}$$

$$= 0.037\,\frac{mol}{L} = \boxed{0.037\,M}$$

e. $\boxed{0.0348\text{ grams}}$ of $\boxed{PbCl_2}$ to form $\boxed{45.0\text{ mL}}$ of solution.

molar mass $PbCl_2$ = 278.1 g/mol

$$\frac{0.0348\,\cancel{g}}{1} \times \frac{1\,mol}{278.1\,\cancel{g}} \times \frac{1}{45\,\cancel{mL}} \times \frac{1000\,\cancel{mL}}{L} = 0.0028\,\frac{mol}{L} = \boxed{0.0028\,M}$$

17. Determine the $\boxed{\text{number of moles}}$ of solute to prepare these solutions

a. $\boxed{2.35\text{ liters}}$ of a $\boxed{2.00\text{ M}}$ $Cu(NO_3)_2$ solution

$$\frac{2.00\,mol}{\cancel{L}} \times \frac{2.35\,\cancel{L}}{1} = \boxed{4.7\,mol}$$

b. $\boxed{16.00\text{ mL}}$ of a $\boxed{0.415\text{-molar}}$ $Pb(NO_3)_2$ solution.

1000 mL = 1 L

$$\frac{0.415\,mol}{\cancel{L}} \times \frac{1\,\cancel{L}}{1000\,\cancel{mL}} \times \frac{16\,\cancel{mL}}{1} = \boxed{0.0067\,mol}$$

c. 3.00 L of a 0.500 M $MgCO_3$ solution.

$$\frac{0.50\ \text{mol}}{\cancel{L}} \times \frac{3.0\ \cancel{L}}{1} = \boxed{1.5\ \text{mol}}$$

d. 6.20 L of a 3.76-molar Na_2O solution.

$$\frac{3.76\ \text{mol}}{\cancel{L}} \times \frac{6.20\ \cancel{L}}{1} = \boxed{23.31\ \text{mol}}$$

18. Determine the grams of solute to prepare these solutions: molar mass $Cu(NO_3)_2$ = 187.57 g/mol

a. 0.289 liters of a 0.00300 M $Cu(NO_3)_2$ solution

$$\frac{0.003\ \cancel{\text{mol}}}{\cancel{L}} \times \frac{0.289\ \cancel{L}}{1} \times \frac{187.57\ g}{1\ \cancel{\text{mol}}} = \boxed{0.16\ g}$$

molar mass $Pb(NO_3)_2$ = 331.22 g/mol

b. 16.00 milliliters of a 5.90-molar $Pb(NO_3)_2$ solution

$$\frac{5.9\ \cancel{\text{mol}}}{\cancel{L}} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{16\ \cancel{mL}}{1} \times \frac{331.22\ g}{\cancel{\text{mol}}} = \boxed{31.27\ g}$$

c. 508 mL of a 2.75-molar NaF solution. molar mass NaF = 26.993 g/mol

$$\frac{2.75\ \cancel{\text{mol}}}{\cancel{L}} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{508\ \cancel{mL}}{1} \times \frac{26.993\ g}{\cancel{\text{mol}}} = \boxed{37.71\ g}$$

d. 6.20 L of a 3.76-molar Na_2O solution. molar mass Na_2O = 61.98 g/mol

$$\frac{3.76\ \cancel{\text{mol}}}{\cancel{L}} \times \frac{6.2\ \cancel{L}}{1} \times \frac{61.98\ g}{\cancel{\text{mol}}} = \boxed{1444.88\ g}$$

e. 0.500 L of a 1.00 M KCl solution. molar mass KCl = 74.55 g/mol

$$\frac{1.0\ \cancel{\text{mol}}}{\cancel{L}} \times \frac{0.5\ \cancel{L}}{1} \times \frac{74.55\ g}{\cancel{\text{mol}}} = \boxed{37.275\ g}$$

f. 4.35 L of a 3.50 M $CaCl_2$ solution.

molar mass $CaCl_2$ = 110.98 g/mol

$$\frac{3.5\,\cancel{mol}}{\cancel{L}} \times \frac{4.35\,\cancel{L}}{1} \times \frac{110.98\,g}{\cancel{mol}} = \boxed{1689.67\,g}$$

19. Determine the final volume of these solutions:

a. 4.67 moles of Li_2SO_3 dissolved to make a 3.89 M solution.

$$\frac{1\,L}{3.89\,\cancel{mol}} \times \frac{4.67\,\cancel{mol}}{1} = \boxed{1.2\,L}$$

b. 4.907 moles of Al_2O_3 to make a 0.500 M solution.

$$\frac{1\,L}{0.50\,\cancel{mol}} \times \frac{4.907\,\cancel{mol}}{1} = \boxed{9.81\,L}$$

c. 0.783 grams of Na_2CO_3 to make a 0.348 M solution.

molar mass Na_2CO_3 = 105.99 g/mol

$$\frac{1\,L}{0.348\,\cancel{mol}} \times \frac{0.783\,\cancel{g}}{1} \times \frac{1\,\cancel{mol}}{105.99\,\cancel{g}} = \boxed{0.021\,L}$$

d. 8.97 grams of $(NH_4)_2CO_3$ to make a 0.250-molar solution.

molar mass $(NH_4)_2CO_3$ = 96.094 g/mol

$$\frac{1\,L}{0.250\,\cancel{mol}} \times \frac{8.97\,\cancel{g}}{1} \times \frac{1\,\cancel{mol}}{96.094\,\cancel{g}} = \boxed{0.37\,L}$$

e. 48.00 grams of $PbCl_2$ to form a 5.0-molar solution.

molar mass $PbCl_2$ = 278.1 g/mol

$$\frac{1\,L}{5.0\,\cancel{mol}} \times \frac{48\,\cancel{g}}{1} \times \frac{1\,\cancel{mol}}{278.1\,\cancel{g}} = \boxed{0.035\,L}$$

20. Challenge - A student placed 11.0 g of glucose ($C_6H_{12}O_6$) in a volumetric flask, added enough water to dissolve the glucose by swirling, then carefully added additional water until the 100. mL mark on the neck of the flask was reached. The flask was then shaken until the solution was uniform. A 20.0 mL sample of this glucose solution was diluted to 0.500L. How many grams of glucose are in 100 mL of the final solution?

molar mass $C_6H_{12}O_6$ = 180.156 g/mol

$$\frac{11\,g}{1} \times \frac{1\,mol}{180.156\,g} \times \frac{1}{0.10\,L} = \boxed{0.61\,M}$$ initial molarity

$$\frac{0.61\,mol}{\cancel{L}} \times \frac{0.02\,\cancel{L}}{1} = \boxed{.012\,mol}$$ glucose in 20 mL sample

$$\frac{.012\,mol}{0.5\,L} = \boxed{.024\,M}$$ new molarity

$$\frac{.024\,mol}{\cancel{L}} \times \frac{.1\,\cancel{L}}{1} = \boxed{.0024\,mol}$$ new moles in 100 mL

$$\frac{.0024\,mol}{1} \times \frac{180.156\,g}{1\,mol} = \boxed{0.44\,g}$$ glucose

Problem Set #3:

1. What is the molarity of a solution in which 0.360 moles of NaCl are dissolved in enough water to make 150.0 ml of solution?

$\frac{0.360\,mol}{1} \times \frac{1000\,\cancel{mL}}{1\,L} \times \frac{1}{150\,\cancel{mL}} = 2.4\,\frac{mol}{L} = \boxed{2.4\,M}$

2. When 4.56 grams of aluminum nitrate are added to enough water to make 1.00 liter of solution, what is the resulting molarity? $Al(NO_3)_3$ molar mass = 213.01 g/mol

$\frac{4.56\,\cancel{g}}{1} \times \frac{1\,mol}{213.01\,\cancel{g}} \times \frac{1}{1\,L} = 0.021\,\frac{mol}{L} = \boxed{0.021\,M}$

3. How many grams of silver acetate need to be used to make 750.0 ml of a 0.100 M solution? $AgC_2H_3O_2$ molar mass = 166.94 g/mol

$\frac{750\,\cancel{mL}}{1} \times \frac{1\,\cancel{L}}{1000\,\cancel{mL}} \times \frac{0.10\,\cancel{mol}}{\cancel{L}} \times \frac{166.94\,g}{1\,\cancel{mol}} = \boxed{12.52\,g}$

4. A) What volume of a 2.00 M solution can be prepared if you start with 6.05 moles of sodium sulfide?

$\frac{1\,L}{2.0\,\cancel{mol}} \times \frac{6.05\,\cancel{mol}}{1} = \boxed{3.025\,L}$

B) What is the molarity of the sodium ion in this solution? sodium sulfide = Na_2S

6.05 mol Na_2S, means $\boxed{12.1\,mol\ Na^+}$

$\frac{12.01\,mol}{3.025\,L} = \boxed{4\,M}$

C) What is the molarity of the sulfide ion in this solution?

6.05 mol Na_2S means $\boxed{6.05\,mol\ S^{2-}}$

$\frac{6.05\,mol}{3.025\,L} = \boxed{2\,M}$ see molarity in part A

5. How many milliliters of a 0.400 M CsCl solution do you need initially if you wish to have 16.0 grams of cesium?

$\frac{1\,\cancel{L}}{0.40\,\cancel{mol}} \times \frac{1\,\cancel{mol}}{132.9\,\cancel{g}} \times \frac{16\,\cancel{g}}{1} \times \frac{1000\,mL}{1\,\cancel{L}}$

$= \boxed{300.98\,mL}$