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V.6. MOLAR CONCENTRATION

This section is concerned with the idea of "concentration" and how to work with solutions of different concentrations. Everything in this section involves a simple idea: **knowing the concentration of a solution provides a way to find how much of a particular substance exists in a given volume of the solution.**

Definitions: The **CONCENTRATION** of a substance in solution is the amount of the substance which exists in a given volume of the solution.

A **CONCENTRATED** solution has a relatively high concentration. (There is a large amount of substance dissolved in the solution.)

A **DILUTE** solution has a relatively low concentration. (Very little substance is dissolved in the solution.)

NOTE: The terms "concentrated" and "dilute" are comparative and do not have precise meanings. Frequently, concentrated solutions are SATURATED solutions, or solutions with the "maximum possible concentration". Dilute solutions can be formed when large amounts of some solvent (normally water) are added to a concentrated solution in order to produce a lower concentration.

Chemists frequently use the "mole" to describe the amount of a substance in a solution.

Definition: The **MOLAR CONCENTRATION** or **MOLARITY** of a substance in solution is the number of moles of the substance contained in 1 L of ***solution***.

Note: This definition refers to "1 L of SOLUTION", not "1 L of SOLVENT". For example, 1 L of a concentrated solution of KBr(aq) may contain 550 g of KBr and 825 mL of water.

EXAMPLE: **If 2.0 L of solution contain 5.0 mol of NaCl, what is the molarity of the NaCl?**

$$\text{molar concentration} = \frac{5.0\ \text{mol}}{2.0\ \text{L}} = \mathbf{2.5\ \frac{mol}{L}}$$

NOTES:
1. The unit symbol for "**mol/L**" is "**M**".
2. When expressed in words, the unit symbol "**M**" is written as "**molar**".
3. The short–hand symbol for "**molar concentration of ...**" is a set of brackets: **[...]**

EXAMPLES: If a 1.0 L of solution contains 2.5 mol of NaCl, the molar concentration can be expressed in several equivalent ways (shown below).

$$\text{molar concentration of NaCl} = 2.5\ \frac{\text{mol}}{\text{L}} = 2.5\ \text{M}$$

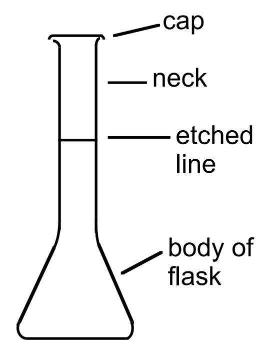
[NaCl] = 2.5 M

The molarity of the sodium chloride is 2.5 molar.

MAKING UP SOLUTIONS

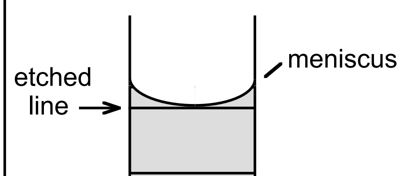
VOLUMETRIC FLASKS are used to obtain accurate volumes of solutions (see Figure 1, at right). Volumetric flasks are manufactured in specific volumes: 10 mL, 25 mL, 50 mL, 100 mL, 250 mL, 500 mL, 1000 mL, 2000 mL, etc. Generally, the volumes are accurate to about ± 0.1%. The following procedure is used for making up an aqueous solution.

Add the required amount of chemical to a flask having an appropriate volume. Then add distilled water until the flask is about one–half to two–thirds full. Cap the flask and shake it until the chemical has completely dissolved. Then add distilled water until the bottom of the meniscus (curved separation between water and air) just touches the etched line on the flask's neck (Figure 2). In order to get the last bit of water in accurately, it is advisable to use a small dropper. Finally, re–cap the flask and shake thoroughly until no wavy lines (resembling the heated air seen above a hot road) can be seen in the solution.



Typical volumetric flask

Figure 1



Aligning the meniscus

Figure 2

EXERCISES:

56. You have been asked to make 1.000 L of 1.000 M NaCl solution. Why shouldn't you add 1.000 L of water first and then add the NaCl to be dissolved?
57. You are making up a solution and accidentally add a bit too much liquid, so that the liquid level is about 2 mm above the etched line on the neck of the volumetric flask. What should you do at this point?
58. What practical problems arise if a solution is not thoroughly mixed?

The definition of molar concentration leads directly to the equations below.

molar concentration = $\dfrac{\textbf{moles}}{\textbf{volume}}$	where:	$\boldsymbol{c}$ = molar concentration, in mol/L
		$\boldsymbol{n}$ = number of moles
or: $\boldsymbol{c} = \dfrac{\boldsymbol{n}}{\boldsymbol{V}}$		$\boldsymbol{V}$ = volume, in litres

EXAMPLE: **What is the [NaCl] in a solution containing 5.12 g of NaCl in 250.0 mL of solution?**

Plan: In order to find molarity (c), the moles (n) and volume (V) are needed. A volume is given and the mass given can be converted to moles.

$$\text{moles of NaCl} = 5.12\text{ g} \times \frac{1\text{ mol}}{58.5\text{ g}} = 0.0875\text{ mol}$$

and: $$[\text{NaCl}] = c = \frac{n}{V} = \frac{0.0875\text{ mol}}{0.2500\text{ L}} = \mathbf{0.350\ M}$$

EXAMPLE: **What mass of NaOH is contained in 3.50 L of 0.200 M NaOH?**

Plan: The molarity (*c*) and volume (*V*) are given so moles (*n*) can be found. Moles can then be converted to mass.

Solving $c = \frac{n}{V}$ for *n* gives $n = c \cdot V$

then: $\text{moles NaOH} = 0.200\ \frac{\text{mol}}{\text{L}} \times 3.50\ \text{L} = 0.700\ \text{mol}$

and: $\text{mass NaOH} = 0.700\ \text{mol} \times \frac{40.0\ \text{g}}{1\ \text{mol}} = \mathbf{28.0\ g}$

EXAMPLE: **What is the molarity of pure sulphuric acid, H_2SO_4, having a density of 1.839 g/mL?**

Notice that density and molarity both have units of amount/volume

where: $\text{density} = \frac{\text{amount (as mass)}}{\text{volume}}$ and $\text{molarity} = \frac{\text{amount (as moles)}}{\text{volume}}$.

Therefore, a unit conversion can be used to convert from an amount expressed in "grams" to an amount expressed in "moles" (and vice versa).

$$[H_2SO_4] = \frac{1.839\ \text{g}}{0.001\ \text{L}} \times \frac{1\ \text{mol}}{98.1\ \text{g}} = \mathbf{18.7\ M}$$

EXAMPLE: **What is the molarity of the $CaCl_2$ in a solution made by dissolving and diluting 15.00 g of $CaCl_2 \bullet 6H_2O$ to 500.0 mL?**

When $CaCl_2 \bullet 6H_2O$ dissolves in water $CaCl_2 \bullet 6H_2O(s) \longrightarrow CaCl_2(aq) + 6\ H_2O(l)$

the moles of $CaCl_2$ produced equals the moles of $CaCl_2 \bullet 6H_2O(s)$ dissolved.

$$[CaCl_2] = [CaCl_2 \bullet 6H_2O] = \frac{15.00\ \text{g}}{0.5000\ \text{L}} \times \frac{1\ \text{mol}}{219.1\ \text{g}} = \mathbf{0.1369\ M}$$

EXERCISES:

59. Calculate the molar concentration of the following solutions.
    (a) 0.26 mol of HCl in 1.0 L of solution
    (b) 2.8 mol of HNO_3 in 4.0 L of solution
    (c) 0.0700 mol of NH_4Cl in 50.0 mL of solution
    (d) 25.0 g of NaCl in 250.0 mL of solution
    (e) 1.50 g of $CoBr_2 \bullet 6H_2O$ in 600.0 mL of solution
    (f) 10.0 g of $Cr(NO_3)_3 \bullet 9H_2O$ in 325 mL of solution

60. What is the actual experimental procedure you would use to prepare the following solutions?
    (a) 1.00 L of 3.00 M NH_4Cl
    (b) 500.0 mL of 0.250 M $Hg(NO_3)_2$
    (c) 125 mL of 0.500 M $Ba(NO_3)_2$
    (d) 250.0 mL of 0.100 M $SbCl_3$
    (e) 2.75 L of 0.0120 M NaOH
    (f) 2.00 L of 0.0300 M $CuSO_4$, starting with $CuSO_4 \bullet 5H_2O(s)$
    (g) 50.0 mL of 0.225 M BaI_2, starting with $BaI_2 \bullet 2H_2O(s)$

61. How many moles of $AlCl_3$ are contained in 350.0 mL of 0.250 M $AlCl_3$?

62. What volume of 2.40 M HCl can be made from 100.0 g of HCl?

63. How many moles of $Sr(NO_3)_2$ are contained in 55.0 mL of 1.30×10^{-3} M $Sr(NO_3)_2$?

64. What volume of 2.8×10^{-2} M NaF contains 0.15 g of NaF?

65. The density of water at 4°C is 1.000 kg/L. What is the molar concentration of H_2O in pure water at 4°C? (Hint: how many moles of H_2O are contained in 1 L?)

66 The density of acetic acid, $CH_3COOH(l)$, is 1049 g/L. What is the molarity of pure acetic acid?

67. The molar concentration of pure $HClO_4$(l) is 17.6 M. What is the density of pure $HClO_4$?
68. The molarity of CS_2(l) is 16.6 M. What is the density of CS_2(l)?
69. How many grams of $CaCl_2$ are contained in 225 mL of 0.0350 M $CaCl_2$ solution?
70. How many grams of Na_3PO_4 are contained in 3.45 L of 0.175 M $Na_3PO_4 \cdot 12H_2O$?
71. Acetone has a density of 0.790 g/mL. What mass of acetone and benzoic acid, C_6H_5COOH, is required to make 350.0 mL of a 0.0100 M solution of benzoic acid dissolved in acetone? Ignore the contribution which the benzoic acid makes to the volume. Based on your answer, why does it seem appropriate that you can ignore the contribution made by benzoic acid to the total volume?

DILUTION CALCULATIONS

The following set of exercises is designed to help you develop an intuitive approach to working with molarity calculations involving dilution and mixing of solutions. To make sure you don't get on the "wrong track", you should check each answer before proceeding to the next question or part of a question.

EXERCISES:

72. Assume you have been given a can of orange juice concentrate. Let:

    concentration of juice in can = 1 OJ (1 orange juice unit) .

    You are probably aware of the fact that mixing one can of concentrated orange juice with one can of water produces orange juice that is "one half of full strength", so that:

    diluted concentration = $\frac{1}{2}$ full strength = $\mathbf{\frac{1}{2}}$ **OJ** (1 Orange Juice unit)

    What diluted concentration, in OJ's, will you have if you mix

    (a) one can of orange juice with two cans of water?
    (b) one can of orange juice with three cans of water?
    (c) one can of orange juice with nine cans of water?
    (d) two cans of orange juice with two cans of water?
    (e) two cans of orange juice with eight cans of water?
    (f) three cans of orange juice with five cans of water?

73. Summarize the results of exercise 72 by writing a general equation for the diluted concentration of orange juice produced by mixing **C** cans of concentrated orange juice and **W** cans of water.

74. Now let's pretend that you are not mixing concentrated orange juice with water, but instead are mixing concentrated orange juice with concentrated apple juice.

    Let: concentration of apple juice = 1 AJ.

    (a) Does the fact that you are now adding apple juice instead of water to the orange juice change the AMOUNT of orange juice already present? Is the total volume different when one can of orange juice is mixed into one can of apple juice instead of one can of water? Is the orange juice diluted more (or less) if apple juice is added instead of water?
    (b) Let's change our viewpoint for a moment. Pretend we are now interested in how much the apple juice is being diluted, rather than how much the orange juice is diluted. Remembering that the concentration of the apple juice is 1 AJ, what is the diluted concentration of the apple juice when one can of apple juice is mixed with one can of orange juice?
    (c) Separately calculate the diluted concentration of orange juice, in OJ's, and the diluted concentration of apple juice, in AJ's, when the following are mixed.
        i) One can of orange juice is mixed with one can of apple juice.
        ii) One can of orange juice is mixed with two cans of apple juice.

iii) One can of orange juice is mixed with three cans of apple juice.
iv) Two cans of orange juice is mixed with three cans of apple juice.
v) Five cans of orange juice is mixed with five cans of apple juice.
vi) Four cans of orange juice is mixed with six cans of apple juice.

75. Summarize the results of exercise 74 by writing two general equations: one for the diluted concentration of orange juice and one for the diluted concentration of apple juice. Assume that **O** cans of orange juice and **A** cans of apple juice are mixed together.

76. How would you modify your equations in exercise 75 if the original concentrations were 0.8 OJ and 0.7 AJ instead of 1 OJ and 1 AJ?

77. OK, now we investigate the results of mixing two different brands of orange juice. El Cheapo Orange Drink Concentrate has a concentration which is 0.50 OJ. The other brand, Expensive Orange Juice Concentrate, has a concentration which is 1.0 OJ. ***The mixing of the two different brands means the addition of the cans of one brand will DILUTE the concentration of the other brand, similar to the way that the apple juice and orange juice diluted each other.***

Assume you mix TWO cans of El Cheapo (having a concentration of 0.50 OJ) with THREE cans of Expensive (having a concentration of 1.0 OJ).

a) What is the concentration of the El Cheapo orange juice, after mixing?
b) What is the concentration of the Expensive orange juice, after mixing?
c) What is the total concentration of orange juice, expressed in OJ's, in the mixture?
d) What is the total concentration of orange juice produced when five cans of Expensive Concentrate is mixed with three cans of El Cheapo Concentrate?
e) What is the total concentration of orange juice produced when four cans of Expensive Concentrate is mixed with seven cans of El Cheapo Concentrate?

Now that you have explored the deep mysteries of orange and apple juice, let's apply this knowledge to chemical solutions having concentrations measured in moles / litre.

When two solutions are mixed, the resulting mixture has a total volume and total number of moles equal to the sum of the individual volumes and individual numbers of moles of chemical found in the separate solutions.

In other words –

$$\textbf{molarity of mixture} = \frac{\textbf{total moles of chemical in which we are interested}}{\textbf{total volume of mixture}}$$

A. SIMPLE DILUTION OF A CHEMICAL IN SOLUTION

Assume: **initial concentration of solution** (in more concentrated form) = c_{CONC}
initial volume of solution (in more concentrated form) = V_{CONC}
diluted concentration (after water is added) = c_{DIL}
diluted volume (after water is added) = V_{DIL}

The "diluted volume" can also be thought of as the "total volume after dilution".

Since $c = \dfrac{n}{V}$ then $n = c \cdot V$

which means moles of chemical in concentrated solution = $n_{CONC} = c_{CONC} \times V_{CONC}$
and moles of chemical in diluted solution = $n_{DIL} = c_{DIL} \times V_{DIL}$.

But the amount of the chemical is not changed when the solution is diluted, only the concentration of the chemical is changed. Therefore moles of concentrated chemical = moles of diluted chemical

or: $n_{CONC} = n_{DIL}$

so that: $c_{CONC} \times V_{CONC} = n_{CONC} = n_{DIL} = c_{DIL} \times V_{DIL}$.

FINAL EQUATION:

$$c_{CONC} \times V_{CONC} = c_{DIL} \times V_{DIL}$$

or

$$c_{DIL} = c_{CONC} \times \frac{V_{CONC}}{V_{DIL}}$$

Aha! Look at the second equation in the box, above. It is our "orange juice dilution equation"!

EXAMPLE: **If 200.0 mL of 0.500 M NaCl is added to 300.0 mL of water, what is the resulting [NaCl] in the mixture?**

Since $[NaCl]_{DIL}$ and c_{DIL} have the same meaning, then

$$[NaCl]_{DIL} = [NaCl]_{CONC} \times \frac{V_{CONC}}{V_{DIL}} = 0.500\text{ M} \times \frac{200.0\text{ mL}}{(200.0+300.0)\text{ mL}} = \mathbf{0.200\text{ M}}$$.

B. MIXING TWO SOLUTIONS HAVING DIFFERENT CONCENTRATIONS OF THE SAME CHEMICAL

This is the equivalent problem to mixing El Cheapo orange juice and Expensive orange juice. One solution dilutes the other solution, and vice versa. In the calculations below, one solution is arbitrarily "#1" and the other "#2". In order to get an accurate answer you must keep extra digits in the intermediate answers, rounding only the final answer to the correct number of significant digits.

Treat mixtures of two solutions as two separate "single dilutions" and then add the results of the individual single dilutions to get the overall concentration of the mixture as was done when mixing El Cheapo and Expensive brands of orange juice in exercise 77.

EXAMPLE: **If 300.0 mL of 0.250 M NaCl is added to 500.0 mL of 0.100 M NaCl, what is the resulting [NaCl] in the mixture?**

Arbitrarily, let solution #1 be 0.250 M NaCl and solution #2 be 0.100 M NaCl.

$$[NaCl]_{DIL}\ (\#1) = [NaCl]_{CONC}\ (\#1) \times \frac{V_{CONC}\ (\#1)}{V_{DIL}} = 0.250\text{ M} \times \frac{300.0\text{ mL}}{800.0\text{ mL}} = 0.09375\text{ M}$$

$$[NaCl]_{DIL}\ (\#2) = 0.100\text{ M} \times \frac{500.0\text{ mL}}{800.0\text{ mL}} = 0.06250\text{ M}$$

$$[NaCl]\ (\text{total}) = [NaCl]_{DIL}\ (\#1) + [NaCl]_{DIL}\ (\#2) = 0.09375 + 0.06250 = \mathbf{0.156\text{ M}}$$

Note: The final concentration lies between the original concentrations of the two NaCl solutions: 0.100 M < **0.156 M** < 0.250 M. Obviously the mixture's concentration cannot be greater than the most concentrated solution involved or less than the least concentrated solution used.

C. MAKING DILUTE SOLUTIONS FROM CONCENTRATED SOLUTIONS

Again, this calculation is based on the fact that the moles of chemical in the diluted solution equals the moles of chemical poured from the concentrated solution. That is, $n_{CONC} = n_{DIL}$.

$$c_{CONC} \times V_{CONC} = c_{DIL} \times V_{DIL}$$

EXAMPLE: **What volume of 6.00 M HCl is used in making up 2.00 L of 0.125 M HCl?**

The equation: $c_{CONC} \times V_{CONC} = c_{DIL} \times V_{DIL}$

is rearranged to solve for the volume of concentrated solution required.

$$V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.125\ M \times 2.00\ L}{6.00\ M} = \mathbf{0.0417\ L}$$

EXAMPLE: **A student mixes 100.0 mL of water with 25.0 mL of a sodium chloride solution having an unknown concentration. If the student finds the molarity of the sodium chloride in the diluted solution is 0.0876 M, what is the molarity of the original sodium chloride solution?**

The diluted volume is 100.0 mL + 25.0 mL = 125.0 mL

Therefore $$c_{CONC} = c_{DIL} \times \frac{V_{DIL}}{V_{CONC}} = 0.0876\ M \times \frac{125.0\ mL}{25.0\ mL} = \mathbf{0.438\ M}$$

EXERCISES:

78. If 20.0 mL of 0.75 M HBr is diluted to a total volume of 90.0 mL, what is the molar concentration of the HBr in the resulting solution?
79. What is the molar concentration of the KOH solution resulting from mixing 55 mL of 0.15 M KOH and 75 mL of 0.25 M KOH?
80. If 1 drop (0.050 mL) of 0.20 M NaBr is added to 100.00 mL of water, what is the molarity of the NaBr in the resulting solution?
81. What is the molar concentration of the HNO_3 solution resulting from mixing 5.0 mL of 3.5 M HNO_3 and 95 mL of 0.20 M HNO_3?
82. Concentrated HNO_3 is 15.4 M. How would you prepare 2.50 L of 0.375 M HNO_3?
83. Concentrated H_3PO_4 is 14.6 M. How would you prepare 45.0 L of 0.0600 M H_3PO_4?
84. If 300.0 mL of solution A contains 25.0 g of KCl and 250.0 mL of solution B contains 60.0 g of KCl, what is the molarity of the KCl in the solution resulting from mixing solutions A and B?
85. If 500.0 mL of 0.750 M NaCl is boiled down until the final volume is reduced to 300.0 mL, what is the final molarity of the NaCl? (Assume no salt is lost during the boiling process.)
86. How would you prepare 250.0 mL of 0.350 M HCl, starting with 6.00 M HCl?
87. What mass of NaCl is needed to prepare 500.0 mL of 0.400 M NaCl?
88. What is the concentration of the NaOH solution produced by mixing 125.0 mL of 0.250 M NaOH with 200.0 mL of 0.175 M NaOH?
89. What volume of 12.0 M NaOH is required in order to prepare 3.00 L of 0.750 M NaOH?
90. What is the concentration of $CaCl_2$ produced when 55.0 mL of 0.300 M HCl is mixed with 80.0 mL of 0.550 M $CaCl_2$?

91. When 350.0 mL of 0.250 M $MgCl_2$ is boiled down to a final volume of 275.0 mL, what is the molarity of the $MgCl_2$ in the resulting solution?

92. If 20.0 mL of 0.350 M NaCl and 75.0 mL of 0.875 M NaCl are mixed and the resulting solution is boiled down to a volume of 60.0 mL, what is the molarity of the NaCl in the final solution?

93. A solution is made by mixing 100.0 mL of 0.200 M $BaCl_2$ and 150.0 mL of 0.400 M NaCl. What is the concentration of sodium chloride in the final solution?

94. If 75.0 mL of 0.200 M Na_3PO_4 is added to 25.0 mL of 0.800 M K_3PO_4, what is the concentration of Na_3PO_4 in the mixture?

AN OVERVIEW OF MOLARITY PROBLEMS

The 5 basic types of molarity problems and the equations relevant to the problems are shown below.

A. Making a solution with a given concentration

$$c = \frac{n}{V}, \quad \text{where} \quad n = \text{mass (g)} \times \frac{1\ \text{mol}}{\text{molar mass (g)}}$$

You may also be given moles (or mass) and concentration, and be asked to find the volume, or some variation of this problem.

B. Dilution of a single solution

$$c_{\text{DIL}} = c_{\text{CONC}} \times \frac{V_{CONC}}{V_{DIL}}$$

C. Mixing two solutions

$$c_{\text{DIL}}\ (\#1) = c_{\text{CONC}}\ (\#1) \times \frac{V_{\text{CONC}}\ (\#1)}{V_{\text{DIL}}} \quad \text{and} \quad c_{\text{DIL}}\ (\#2) = c_{\text{CONC}}\ (\#2) \times \frac{V_{\text{CONC}}\ (\#2)}{V_{\text{DIL}}}$$

$$c\ (\text{total}) = c_{\text{DIL}}\ (\#1) + c_{\text{DIL}}\ (\#2)$$

D. Converting a density to a molarity and vice versa

$$c = d\ \frac{\text{(g)}}{\text{(L)}} \times \frac{1\ \text{mol}}{\text{molar mass (g)}} \quad \text{and} \quad d = c\ \frac{\text{(mol)}}{\text{(L)}} \times \frac{\text{molar mass (g)}}{1\ \text{mol}}$$

E. Making a dilute solution from a concentrated solution

$$c_{\text{CONC}} \times V_{\text{CONC}} = c_{\text{DIL}} \times V_{\text{DIL}}$$

(Note that this is essentially the same as type B, above.)

MOLARITY REVIEW PROBLEMS

95. What is the molarity of each of the following solutions?
(a) 5.62 g of $NaHCO_3$ is dissolved in enough water to make 250.0 mL
(b) 184.6 mg of K_2CrO_4 is dissolved in enough water to make 500.0 mL
(c) 0.584 g of oxalic acid ($H_2C_2O_4$) is diluted to 100.0 mL

96. What is the actual experimental procedure you would use to make
(a) 1.00 L of 0.100 M NaCl, starting with solid NaCl?
(b) 250.0 mL of 0.09000 M KBr, starting with solid KBr?
(c) 500.0 mL of 0.125 M $Ca(NO_3)_2$, starting with solid $Ca(NO_3)_2{\cdot}3H_2O$?

97. What is the concentration of the solution produced when
    (a) 125 mL of 3.55 M LiOH is mixed with 475 mL of 2.42 M LiOH?
    (b) 150.0 mL of water is added to 200.0 mL of 0.250 M NaCl?
    (c) 100.0 mL of 12.0 M KBr is mixed with 950.0 mL of 0.200 M KBr?
    (d) 75 mL of water is mixed with 5.0 mL of 2.50 M KBr?
    (e) 50.0 mL of water is mixed with 850.0 mL of 0.1105 M HCl?
    (f) 50.0 mL of 0.125 M HCl is mixed with 75.0 mL of 0.350 M HCl?

98. What is the molarity of the solution produced when
    (a) 250.0 mL of 0.750 M KBr is boiled down to a volume of 175.0 mL?
    (b) 350.0 mL of water and 75.0 mL of 0.125 M $NaNO_3$ are mixed and boiled down to 325.0 mL?
    (c) 150.0 mL of 0.325 M LiBr and 225.0 mL of 0.500 M LiBr are mixed and boiled to 275.0 mL?

99. What mass of solid solute is present in
    (a) 5.0 L of 2.5 M KBr? (b) 225 mL of 0.135 M MgI_2? (c) 350.0 mL of 0.250 M NaCl?

100. What is the molarity of the following pure liquids?
    (a) C_8H_{18}, d = 0.7025 g/mL (b) CH_3COCH_3, d = 789.9 g/L (c) $POCl_3$, d = 1.675 g/mL

101. What is the density of the following pure liquids?
    (a) SbF_5, molarity = 13.8 M (b) S_2Cl_2, molarity = 12.73 M (c) C_6H_5CHO, molarity = 9.825 M

102. (a) What volume of 3.00 M HCl is required to make up 5.00 L of 0.250 M HCl?
    (b) What volume of 15.4 M HNO_3 is needed to make up 500.0 mL of 0.100 M HNO_3?
    (c) What volume of 0.150 M HCl can be made from 250.0 mL of 5.00 M HCl?
    (d) What concentration of NaCl solution is made by diluting 3.00 L of 0.850 M NaCl to 12.5 L?
    (e) A solution is made in such a way that when 100.0 mL of the solution is diluted to 5.00 L, the resulting mixture has a concentration of 0.100 M. What is the molarity of the original solution?
    (f) What mass of KBr is contained in 500.0 mL of 0.235 M KBr?
    (g) What volume of 0.550 M HCl contains 50.0 g of HCl?
    (h) How many moles of LiCl are contained in 5.50 L of 0.850 M LiCl?
    (i) What is the concentration of $CaCl_2$ produced when 75.0 g of $CaCl_2$ is diluted to 950.0 mL?
    (j) What is the density of pure liquid $CHBr_3$ (molarity = 11.4 M)?
    (k) What volume of 0.0675 M $Ba(NO_3)_2$ contains 2.55 g of $Ba(NO_3)_2$?
    (l) How many moles of $FeCl_3$ are contained in 1.50 L of 0.368 M $FeCl_3$?
    (m) What is the molarity of $SnCl_2$ produced when 25.00 g of $SnCl_2$•$2H_2O$ is diluted to 750.0 mL?
    (n) What volume of 0.995 M HCl is required to make 3.50 L of 0.0450 M HCl?
    (o) What is the molarity of NaCl made by mixing 185.0 mL of water with 55.0 mL of 0.543 M NaCl?
    (p) What mass of $BaCl_2$•$2H_2O$ is required to make up 1.35 L of 0.250 M $BaCl_2$?
    (q) What is the concentration of $CaCl_2$ produced by mixing 145 mL of 0.550 M $CaCl_2$ with 55 mL of 0.135 M $CaCl_2$?
    (r) What is the molarity of pure liquid C_6H_6 (d = 0.8787 g/mL)?

54. empirical mass = 14.0 g

density = $\frac{0.938 \text{ g}}{0.500 \text{ L}}$ = 1.876 g/L and mass of 1 mol = 1.876 $\frac{\text{g}}{\text{L}}$ x 22.4 L = 42.0 g

N = $\frac{42.0 \text{ g}}{14.0 \text{ g}}$ = 3.0 and molecular formula = 3 x (CH_2) = $\mathbf{C_3H_6}$

55. empirical mass = 16.0 g ; molar mass = 3 x 16.0 g = 48.0 g

N = $\frac{48.0 \text{ g}}{16.0 \text{ g}}$ = 3.0 and molecular formula = 3 x (O) = $\mathbf{O_3}$

56. The total volume of water plus dissolved salt would be greater than 1.000 L.

57. Ask for instructions regarding disposal of the solution. There is no quick way to "save" the solution and be sure of the concentration.

58. When pouring samples from the volumetric flask, some of the samples will have different concentrations from other samples. The samples taken from the top of the flask will be less concentrated than those taken from the bottom.

59. (a) [HCl] = $\frac{0.26 \text{ mol}}{1.0 \text{ L}}$ = **0.26 M**

(b) [HNO_3] = $\frac{2.8 \text{ mol}}{4.0 \text{ L}}$ = **0.70 M**

(c) [NH_4Cl] = $\frac{0.0700 \text{ mol}}{0.0500 \text{ L}}$ = **1.40 M**

(d) [NaCl] = $\frac{25.0 \text{ g}}{0.2500 \text{ L}}$ x $\frac{1 \text{ mol}}{58.5 \text{ g}}$ = **1.71 M**

(e) [$CoBr_2 \cdot 6H_2O$] = $\frac{1.50 \text{ g}}{0.6000 \text{ L}}$ x $\frac{1 \text{ mol}}{326.7 \text{ g}}$ = **0.00765 M**

(f) [$Cr(NO_3)_3 \cdot 9H_2O$] = $\frac{10.0 \text{ g}}{0.325 \text{ L}}$ x $\frac{1 \text{ mol}}{400.0 \text{ g}}$ = **0.0769 M**

60. (a) moles NH_4Cl = 3.00 $\frac{\text{mol}}{\text{L}}$ x 1.00 L = 3.00 mol

mass NH_4Cl = 3.00 mol x $\frac{53.5 \text{ g}}{1 \text{ mol}}$ = 161 g

Dissolve 161 g of NH_4Cl in less than 1.00 L of water and dilute to 1.00 L.

(b) moles $Hg(NO_3)_2$ = 0.250 $\frac{\text{mol}}{\text{L}}$ x 0.5000 L = 0.125 mol

mass $Hg(NO_3)_2$ = 0.125 mol x $\frac{324.6 \text{ g}}{1 \text{ mol}}$ = 40.6 g

Dissolve 40.6 g of $Hg(NO_3)_2$ in less than 500 mL of water and dilute to 500.0 mL.

(c) moles $Ba(NO_3)_2$ = 0.500 $\frac{\text{mol}}{\text{L}}$ x 0.125 L = 0.0625 mol

mass $Ba(NO_3)_2$ = 0.0625 mol x $\frac{261.3 \text{ g}}{1 \text{ mol}}$ = 16.3 g

Dissolve 16.3 g of $Ba(NO_3)_2$ in less than 125 mL of water and dilute to 125 mL.

(d) moles $SbCl_3 = 0.100\ \frac{mol}{L} \times 0.2500\ L = 0.0250\ mol$

mass $SbCl_3 = 0.0250\ mol \times \frac{228.3\ g}{1\ mol} = 5.71\ g$

Dissolve 5.71 g of $SbCl_3$ in less than 250 mL of water and then dilute to 250 mL.

(e) moles NaOH $= 0.0120\ \frac{mol}{L} \times 2.75\ L = 0.0330\ mol$

mass NaOH $= 0.0330\ mol \times \frac{40.0\ g}{1\ mol} = 1.32\ g$

Dissolve 1.32 g of NaOH in less than 2.75 L of water and then dilute to 2.75 L.

(f) moles $CuSO_4{\bullet}5H_2O$ = moles $CuSO_4 = 0.0300\ \frac{mol}{L} \times 2.00\ L = 0.0600\ mol$

mass $CuSO_4{\bullet}5H_2O = 0.0600\ mol \times \frac{249.6\ g}{1\ mol} = 15.0\ g$

Dissolve 15.0 g of $CuSO_4{\bullet}5H_2O$ in less than 2.00 L of water and then dilute to 2.00 L.

(g) moles $BaI_2{\bullet}2H_2O$ = moles $BaI_2 = 0.225\ \frac{mol}{L} \times 0.0500\ L = 0.01125\ mol$

mass $BaI_2{\bullet}2H_2O = 0.01125\ mol \times \frac{427.1\ g}{1\ mol} = 4.80\ g$

Dissolve 4.80 g of $BaI_2{\bullet}2H_2O$ in less than 50.0 mL of water and then dilute to 50.0 mL.

61. moles $AlCl_3 = 0.250\ \frac{mol}{L} \times 0.3500\ L = \mathbf{0.0875\ M}$

62. moles HCl $= 100.0\ g \times \frac{1\ mol}{36.5\ g} = 2.74\ mol$

$c = \frac{n}{V}$, so $V = \frac{n}{c} = \frac{2.74\ mol}{2.40\ mol/L} = \mathbf{1.14\ L}$

63. moles $Sr(NO_3)_2 = 1.30 \times 10^{-3}\ \frac{mol}{L} \times 0.0550\ L = \mathbf{7.15 \times 10^{-5}\ mol}$

64. moles NaF $= 0.15\ g \times \frac{1\ mol}{42.0\ g} = 3.57 \times 10^{-3}\ mol$

$c = \frac{n}{V}$, so $V = \frac{n}{c} = \frac{3.57 \times 10^{-3}\ mol}{2.8 \times 10^{-2}\ mol/L} = \mathbf{0.13\ L}$

65. $[H_2O] = 1000\ \frac{g}{L} \times \frac{1\ mol}{18.0\ g} = \mathbf{55.6\ M}$

66. $[CH_3COOH] = 1049\ \frac{g}{L} \times \frac{1\ mol}{60.0\ g} = \mathbf{17.5\ M}$

67. $d = 17.6\ \frac{mol}{L} \times \frac{100.5\ g}{1\ mol} = \mathbf{1.77 \times 10^3\ \frac{g}{L}}$

68. $d = 16.6\ \frac{mol}{L} \times \frac{76.2\ g}{1\ mol} = \mathbf{1.26 \times 10^3\ \frac{g}{L}}$

69. moles $CaCl_2 = 0.0350\ \frac{mol}{L} \times 0.225\ L = 7.88 \times 10^{-3}$ mol

mass $= 7.88 \times 10^{-3}\ mol \times \frac{111.1\ g}{1\ mol} =$ **0.875 g**

70. moles Na_3PO_4 = moles $Na_3PO_4{\cdot}12H_2O = 0.175\ \frac{mol}{L} \times 3.45\ L = 0.604$ mol

mass $Na_3PO_4 = 0.604\ mol \times \frac{164.0\ g}{1\ mol} =$ **99.0 g**

71. moles $C_6H_5COOH = 0.0100\ \frac{mol}{L} \times 0.3500\ L = 3.50 \times 10^{-3}$ mol

mass $C_6H_5COOH = 3.50 \times 10^{-3}\ mol \times \frac{122.0\ g}{1\ mol} =$ **0.427 g**

Now to find the mass of the acetone. Since $d = \frac{m}{V}$, then $m = d{\cdot}V$

and mass acetone $= 0.790\ \frac{g}{mL} \times 350.0\ mL =$ **277 g.**

Since the volume of solvent used was 350 mL (about a "pop-can-full"), the addition of less than half a gram of solid (about a "pinch") would not appreciably change the volume.

72. (a) $\frac{1}{3}$ OJ (b) $\frac{1}{4}$ OJ (c) $\frac{1}{10}$ OJ (d) $\frac{2}{4}$ OJ = $\frac{1}{2}$ OJ (e) $\frac{1}{5}$ OJ (f) $\frac{3}{8}$ OJ

73. diluted concentration = $\frac{\mathbf{C}}{\mathbf{C} + \mathbf{W}}$ OJ

74. (a) The amount of orange juice is not changed and the total volume is unchanged from that produced when water is used instead of apple juice. Therefore the orange juice is diluted to the same extent, regardless of whether apple juice or water is added.

(b) diluted concentration of apple juice = $\frac{1}{2}$ AJ

(c) i) diluted orange = $\frac{1}{2}$ OJ ; diluted apple = $\frac{1}{2}$ AJ

ii) diluted orange = $\frac{1}{3}$ OJ ; diluted apple = $\frac{2}{3}$ AJ

iii) diluted orange = $\frac{1}{4}$ OJ ; diluted apple = $\frac{3}{4}$ AJ

iv) diluted orange = $\frac{2}{5}$ OJ ; diluted apple = $\frac{3}{5}$ AJ

v) diluted orange = $\frac{1}{2}$ OJ ; diluted apple = $\frac{1}{2}$ AJ

vi) diluted orange = $\frac{2}{5}$ OJ ; diluted apple = $\frac{3}{5}$ AJ

75. diluted orange = $\frac{\mathbf{O}}{\mathbf{O} + \mathbf{A}}$ OJ ; diluted apple = $\frac{\mathbf{A}}{\mathbf{O} + \mathbf{A}}$ AJ

76. diluted orange = $\frac{\mathbf{O}}{\mathbf{O} + \mathbf{A}} \times 0.8$ OJ ; diluted apple = $\frac{\mathbf{A}}{\mathbf{O} + \mathbf{A}} \times 0.7$ AJ

77. (a) diluted El Cheapo = $\frac{2}{5}$ x 0.5 OJ = 0.20 OJ

(b) diluted Expensive = $\frac{3}{5}$ X 1.0 OJ = 0.60 OJ

(c) total concentration = 0.20 OJ + 0.60 OJ = 0.80 OJ

(d) total concentration = $\frac{5}{8}$ x 1.0 OJ + $\frac{3}{8}$ x 0.50 OJ = 0.81 OJ

(e) total concentration = $\frac{4}{11}$ x 1.0 OJ + $\frac{7}{11}$ x 0.50 OJ = 0.68 OJ

78. [HBr] = 0.75 M x $\frac{20.0 \text{ mL}}{90.0 \text{ mL}}$ = **0.17 M**

79. $[KOH]_{DIL}$ (#1) = 0.15 M x $\frac{55 \text{ mL}}{130 \text{ mL}}$ = 0.063 M

$[KOH]_{DIL}$ (#2) = 0.25 M x $\frac{75 \text{ mL}}{130 \text{ mL}}$ = 0.14 M

[KOH] (total) = 0.063 + 0.14 = **0.21 M**

80. [NaBr] = 0.20 M x $\frac{0.050 \text{ mL}}{100.05 \text{ mL}}$ = **1.0 x 10^{-4} M**

81. $[HNO_3]_{DIL}$ (#1) = 3.5 M x $\frac{5.0 \text{ mL}}{100 \text{ mL}}$ = 0.18 M

$[HNO_3]_{DIL}$ (#2) = 0.20 M x $\frac{95 \text{ mL}}{100 \text{ mL}}$ = 0.19 M

$[HNO_3]$ (total) = 0.18 + 0.19 = **0.37 M**

82. $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.375 \text{ M X } 2.50 \text{ L}}{15.4 \text{ M}}$ = 0.0609 L

Dilute 0.0609 L of concentrated HNO_3 to a total volume of 2.50 L.

83. $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.0600 \text{ M X } 45.0 \text{ L}}{14.6 \text{ M}}$ = 0.185 L

Dilute 0.185 L of concentrated H_3PO_4 to a total volume of 45.0 L.

84. [KCl] = $\frac{\text{total moles}}{\text{total volume}}$, total mass KCl = 25.0 + 60.0 = 85.0 g

[KCl] = $\frac{85.0 \text{ g}}{0.5500 \text{ L}}$ x $\frac{1 \text{ mol}}{74.6 \text{ g}}$ = **2.07 M**

85. [NaCl] = 0.750 M x $\frac{500.0 \text{ mL}}{300.0 \text{ mL}}$ = **1.25 M**

86. $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.350\text{M x } 0.2500 \text{ L}}{6.00 \text{ M}}$ = 0.0146 L = 14.6 mL

Dilute 14.6 mL of concentrated HCl to a total volume of 250.0 mL.

87. moles NaCl needed = 0.400 $\frac{\text{mol}}{\text{L}}$ x 0.5000 L = 0.200 mol

mass NaCl = 0.200 mol x $\frac{58.5 \text{ g}}{1 \text{ mol}}$ = **11.7 g**

88. $[NaOH]_{DIL}$ (#1) = $0.250\text{ M} \times \frac{125.0\text{ mL}}{325.0\text{ mL}} = 0.0962\text{ M}$

$[NaOH]_{DIL}$ (#2) = $0.175\text{ M} \times \frac{200.0\text{ mL}}{325.0\text{ mL}} = 0.108\text{ M}$

[NaOH] (total) = 0.0962 + 0.108 = **0.204 M**

89. $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.750\text{ M} \times 3.00\text{ L}}{12.0\text{ M}} = \mathbf{0.188\text{ L}}$

90. $[CaCl_2] = 0.550\text{ M} \times \frac{80.0\text{ mL}}{135.0\text{ mL}} = \mathbf{0.326\text{ M}}$

91. $[MgCl_2] = 0.250\text{ M} \times \frac{350.0\text{ mL}}{275.0\text{ mL}} = \mathbf{0.318\text{ M}}$

92. $[NaCl]_{DIL}$ (#1) = $0.350\text{ M} \times \frac{20.0\text{ mL}}{60.0\text{ mL}} = 0.117\text{ M}$

$[NaCl]_{DIL}$ (#2) = $0.875\text{ M} \times \frac{75.0\text{ mL}}{60.0\text{ mL}} = 1.09\text{ M}$

[NaCl] (total) = 0.117 M + 1.09 M = **1.21 M**

93. $[NaCl] = 0.400\text{ M} \times \frac{150.0\text{ mL}}{250.0\text{ mL}} = \mathbf{0.240\text{ M}}$

94. $[Na_3PO_4] = 0.200\text{ M} \times \frac{75.0\text{ mL}}{100.0\text{ mL}} = \mathbf{0.150\text{ M}}$

95. (a) $[NaHCO_3] = \frac{5.62\text{ g}}{0.2500\text{ L}} \times \frac{1\text{ mol}}{84.0\text{ g}} = \mathbf{0.268\text{ M}}$

(b) $[K_2CrO_4] = \frac{0.1846\text{ g}}{0.5000\text{ L}} \times \frac{1\text{ mol}}{194.2\text{ g}} = \mathbf{1.901 \times 10^{-3}\text{ M}}$

(c) $[H_2C_2O_4] = \frac{0.584\text{ g}}{0.1000\text{ L}} \times \frac{1\text{ mol}}{90.0\text{ g}} = \mathbf{0.0649\text{ M}}$

96. (a) moles NaCl = $0.100\ \frac{\text{mol}}{\text{L}} \times 1.00\text{ L} = 0.100\text{ mol}$

mass NaCl = $0.100\text{ mol} \times \frac{58.5\text{ g}}{1\text{ mol}} = 5.85\text{ g}$

Dissolve 5.85 g of NaCl in less than 1 L and then dilute to 1.00 L.

(b) moles KBr = $0.09000\ \frac{\text{mol}}{\text{L}} \times 0.2500\text{ L} = 0.02250\text{ mol}$

mass KBr = $0.02250\text{ mol} \times \frac{119.0\text{ g}}{1\text{ mol}} = 2.678\text{ g}$

Dissolve 2.678 g of KBr in less than 250 mL and then dilute to 250.0 mL.

(c) moles $Ca(NO_3)_2 = 0.125\ \frac{\text{mol}}{\text{L}} \times 0.5000\text{ L} = 0.0625\text{ mol}$ = moles $Ca(NO_3)_2{\bullet}3H_2O$

mass $Ca(NO_3)_2{\bullet}3H_2O = 0.0625\text{ mol} \times \frac{218.1\text{ g}}{1\text{ mol}} = 13.6\text{ g}$

Dissolve 13.6 g of $Ca(NO_3)_2{\bullet}3H_2O$ in less than 500 mL and dilute to 500.0 mL.

97. (a) $[LiOH]_{DIL}$ (#1) = 3.55 M x $\frac{125\ mL}{600\ mL}$ = 0.740 M

$[LiOH]_{DIL}$ (#2) = 2.42 M x $\frac{475\ mL}{600\ mL}$ = 1.92 M

[LiOH] (total) = 0.740 M + 1.92 M = **2.66 M**

(b) [NaCl] = 0.250 M x $\frac{200.0\ mL}{350.0\ mL}$ = **0.143 M**

(c) $[KBr]_{DIL}$ (#1) = 12.0 M x $\frac{100.0\ mL}{1050.0\ mL}$ = 1.14 M

$[KBr]_{DIL}$ (#2) = 0.200 M x $\frac{950.0\ mL}{1050.0\ mL}$ = 0.181 M

[KBr] (total) = 1.14 M + 0.181 M = **1.32 M**

(d) [KBr] = 2.50 M x $\frac{5.0\ mL}{80\ mL}$ = **0.16 M**

(e) [HCl] = 0.1105 M x $\frac{850.0\ mL}{900.0\ mL}$ = **0.1044 M**

(f) $[HCl]_{DIL}$ (#1) = 0.125 M x $\frac{50.0\ mL}{125.0\ mL}$ = 0.0500 M

$[HCl]_{DIL}$ (#2) = 0.350 M x $\frac{75.0\ mL}{125.0\ mL}$ = 0.210 M

[HCl] (total) = 0.0500 M + 0.210 M = **0.260 M**

98. (a) [KBr] = 0.750 M x $\frac{250.0\ mL}{175.0\ mL}$ = **1.07 M**

(b) $[NaNO_3]$ = 0.125 M x $\frac{75.0\ mL}{325.0\ mL}$ = **0.0288 M**

(c) $[LiBr]_{DIL}$ (#1) = 0.325 M x $\frac{150.0\ mL}{275.0\ mL}$ = 0.177 M

$[LiBr]_{DIL}$ (#2) = 0.500 M x $\frac{225.0\ mL}{275.0\ mL}$ = 0.409 M

[LiBr] (total) = 0.177 M + 0.409 M = **0.586 M**

99. (a) moles KBr = 2.5 $\frac{mol}{L}$ x 5.0 L = 12.5 mol

mass KBr = 12.5 mol x $\frac{119.0\ g}{1\ mol}$ = **1.5 x 10^3 g**

(b) moles MgI_2 = 0.135 $\frac{mol}{L}$ x 0.225 L = 0.0304 mol

mass MgI_2 = 0.0304 mol x $\frac{278.1\ g}{1\ mol}$ = **8.45 g**

(c) moles NaCl = 0.250 $\frac{mol}{L}$ x 0.3500 L = 0.0875 mol

mass NaCl = 0.0875 mol x $\frac{58.5\ g}{1\ mol}$ = **5.12 g**

100. (a) $[C_8H_{18}] = 702.5\ \frac{g}{L} \times \frac{1\ mol}{114.0\ g} = \mathbf{6.162\ M}$

(b) $[CH_3COCH_3] = 789.9\ \frac{g}{L} \times \frac{1\ mol}{58.0\ g} = \mathbf{13.6\ M}$

(c) $[POCl_3] = 1675\ \frac{g}{L} \times \frac{1\ mol}{153.5\ g} = \mathbf{10.91\ M}$

101. (a) $d = 13.8\ \frac{mol}{L} \times \frac{216.8\ g}{1\ mol} = \mathbf{2.99 \times 10^3\ g/L}$ or $\mathbf{2.99\ g/mL}$

(b) $d = 12.73\ \frac{mol}{L} \times \frac{135.2\ g}{1\ mol} = \mathbf{1721\ g/L}$ or $\mathbf{1.721\ g/mL}$

(c) $d = 9.825\ \frac{mol}{L} \times \frac{106.0\ g}{1\ mol} = \mathbf{1041\ g/L}$ or $\mathbf{1.041\ g/mL}$

102. (a) $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.250\ M \times 5.00\ L}{3.00\ M} = \mathbf{0.417\ L}$

(b) $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.100\ M \times 0.5000\ L}{15.4\ M} = 0.00325\ L = \mathbf{3.25\ mL}$

(c) $V_{DIL} = \frac{c_{CONC} \times V_{CONC}}{c_{DIL}} = \frac{5.00\ M \times 0.2500\ L}{0.150\ M} = \mathbf{8.33\ L}$

(d) $c_{DIL} = \frac{c_{CONC} \times V_{CONC}}{V_{DIL}} = \frac{0.850\ M \times 3.00\ L}{12.5\ L} = \mathbf{0.204\ M}$

(e) $c_{CONC} = \frac{c_{DIL} \times V_{DIL}}{V_{CONC}} = \frac{0.100\ M \times 5.00\ L}{0.1000\ L} = \mathbf{5.00\ M}$

(f) moles KBr $= 0.235\ \frac{mol}{L} \times 0.5000\ L = 0.118\ mol$

mass KBr $= 0.118\ mol \times \frac{119.0\ g}{1\ mol} = \mathbf{14.0\ g}$

(g) moles HCl $= 50.0\ g \times \frac{1\ mol}{36.5\ g} = 1.37\ mol$

volume $= \frac{1.37\ mol}{0.550\ mol/L} = \mathbf{2.49\ L}$

(h) moles LiCl $= 0.850\ \frac{mol}{L} \times 5.50\ L = \mathbf{4.68\ mol}$

(i) $[CaCl_2] = \frac{75.0\ g}{0.9500\ L} \times \frac{1\ mol}{111.1\ g} = \mathbf{0.710\ M}$

(j) density $= 11.4\ \frac{mol}{L} \times \frac{252.7\ g}{1\ mol} = \mathbf{2.88 \times 10^3\ g/L}$ or $\mathbf{2.88\ g/mL}$

(k) moles $Ba(NO_3)_2 = 2.55\ g \times \frac{1\ mol}{261.3\ g} = 9.76 \times 10^{-3}\ mol$

volume $= \frac{9.76 \times 10^{-3}\ mol}{0.0675\ mol/L} = \mathbf{0.144\ L}$

(l) moles $FeCl_3 = 0.368 \ \frac{mol}{L} \times 1.50 \ L =$ **0.552 mol**

(m) $[SnCl_2] = \frac{25.00 \ g}{0.7500 \ L} \times \frac{1 \ mol}{225.7 \ g} =$ **0.1477 M**

(n) $V_{CONC} = \frac{c_{DIL} \times V_{DIL}}{c_{CONC}} = \frac{0.0450 \ M \times 3.50 \ L}{0.995 \ M} =$ **0.158 M**

(o) $[NaCl] = 0.543 \ M \times \frac{55.0 \ mL}{240.0 \ mL} =$ **0.124 M**

(p) moles $BaCl_2{\bullet}2H_2O$ = moles $BaCl_2 = 0.250 \ \frac{mol}{L} \times 1.35 \ L = 0.338$ mol

mass $BaCl_2{\bullet}2H_2O = 0.338 \ mol \times \frac{244.3 \ g}{1 \ mol} =$ **82.4 g**

(q) $[CaCl_2]_{DIL}$ (#1) $= 0.550 \ M \times \frac{145 \ mL}{200 \ mL} = 0.399$ M

$[CaCl_2]_{DIL}$ (#2) $= 0.135 \ M \times \frac{55 \ mL}{200 \ mL} = 0.0371$ M

$[CaCl_2]$ (total) = 0.399 M + 0.0371 M = **0.436 M**

(r) $[C_6H_6] = 878.7 \ \frac{g}{L} \times \frac{1 \ mol}{78.0 \ g} =$ **11.3 M**