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 $CaCl_2 \cdot 6H_2O$ to 500.0 mL?**

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

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

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

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 $CoBr_2 \cdot 6H_2O$ in 600.0 mL of solution
    (f) 10.0 g of $Cr(NO_3)_3 \cdot 9H_2O$ 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 $CuSO_4 \cdot 5H_2O(s)$
    (g) 50.0 mL of 0.225 M BaI_2, starting with $BaI_2 \cdot 2H_2O(s)$

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:

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

    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.