1.9.6: Dilution

Muriatic acid (another name for HCl) is widely used for cleaning concrete and masonry surfaces. The acid must be diluted before use to get it down to a safer strength. Commercially available at concentrations of about 18%, muriatic acid can be used to remove scales and deposits (usually composed of basic materials).

Dilutions

When additional water is added to an aqueous solution, the concentration of that solution decreases. This is because the number of moles of the solute does not change, while the volume of the solution increases. We can set up an equality between the moles of the solute before the dilution (1) and the moles of the solute after the dilution (2).

$$\mathrm{mol}_1 = \mathrm{mol}_2$$

Since the moles of solute in a solution is equal to the molarity multiplied by the liters, we can set those equal.

$$M_1 \times L_1 = M_2 \times L_2$$

Finally, because the two sides of the equation are set equal to one another, the volume can be described in any unit that we choose, as long as that unit is the same on both sides. Our equation for calculating the molarity of a diluted solution becomes:

$$M_1 \times V_1 = M_2 \times V_2 \tag{1.9.6.1}$$

Suppose that you have $100.\ \mathrm{mL}$ of a $2.0\ \mathrm{M}$ solution of HCl. You dilute the solution by adding enough water to make the solution volume $500.\ \mathrm{mL}$. The new molarity can easily be calculated by using the above equation and solving for M_2:

$$M_2 = \frac{M_1 \times V_1}{V_2} = \frac{2.0\ \mathrm{M} \times 100.\ \mathrm{mL}}{500.\ \mathrm{mL}} = 0.40\ \mathrm{M\ HCl}$$

The solution has been diluted by one-fifth since the new volume is five times as great as the original volume. Consequently, the molarity is one-fifth of its original value.

Another common dilution problem involves deciding how much of a highly concentrated solution is required to make a desired quantity of solution of lesser concentration. The highly concentrated solution is typically referred to as the stock solution.

Example 1.9.6.1

Nitric acid $\left(HNO_3\right)$ is a powerful and corrosive acid. When ordered from a chemical supply company, its molarity is $16\ \mathrm{M}$. How much of the stock solution of nitric acid needs to be used to make $8.00\ \mathrm{L}$ of a $0.50\ \mathrm{M}$ solution?

Solution

Step 1: List the known quantities and plan the problem.

Known

- Stock $HNO_3 = 16\ \mathrm{M}$
- $V_2 = 8.00\ \mathrm{L}$
- $M_2 = 0.50\ \mathrm{M}$

Unknown

The unknown in the equation is V_1, the volume of the concentrated stock solution.

Step 2: Solve

Using Equation 1.9.6.1 we can solve for V_1:

$$V_1 = \frac{M_2 \times V_2}{M_1} = \frac{0.50\ \mathrm{M} \times 8.00\ \mathrm{L}}{16\ \mathrm{M}} = 0.25\ \mathrm{L} = 250\ \mathrm{mL}$$

Step 3: Think about your result

$250\ \mathrm{mL}$ of the stock HNO_3 needs to be diluted with water to a final volume of $8.00\ \mathrm{L}$. The dilution is by a factor of 32 to go from $16\ \mathrm{M}$ to $0.5\ \mathrm{M}$.

Dilutions can be performed in the laboratory with various tools, depending on the volumes required and the desired accuracy. The images below illustrate the use of two different types of pipettes. In the first figure, a glass **pipette** is being used to transfer a portion of a solution to a graduated cylinder. Use of a pipette rather than a graduated cylinder for the transfer improves accuracy. The second figure shows a **micropipette**, which is designed to quickly and accurately dispense small volumes. Micropipettes are adjustable and come in a variety of sizes.

Figure 1.9.6.1: Volumetric pipette and micropipette.

Summary

- A process is described to calculate dilutions.
- Pipettes and micropipettes are used to transfer and dispense solution.
