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Molarity and dilutions worksheet answers

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Molarity & Dilution Practice Problems Answers

- Determine the molarity of a solution containing 2.4 mol of KI in 140 mL total volume of solution **ANS: 17.1 M KI**
- What is the concentration of a solution of NaCl if 40 mL of a 2.5 M NaCl solution is diluted to a total volume of 500 mL? **ANS: 0.2 M NaCl**
- What is the concentration of a solution of KOH if 75 mL of a 2.25 M KOH solution is diluted to a total volume of 250 mL? **ANS: 0.68 M KOH**
- Determine the number of moles of NaOH in 500 mL of a 0.6 M NaOH solution. **ANS: 0.3 mol NaOH**
- How many mL of 6.0 M HCl is needed to make 250 mL of a 1.5 M HCl solution? **ANS: 62.5 mL of 6.0 M HCl**
- Determine the molarity of the solution containing 1.5 mol of KNO₃ in 250 mL total volume of solution. **ANS: 6 M KNO₃**
- What is the volume of 0.5 M NaI needed to have 0.25 mol NaI? **ANS: 0.5 L of 0.5 M NaI**
- How many mL of 2.0 M CrCl₃ is needed to make 400 mL of a 0.25 M CrCl₃ solution? **ANS: 50 mL of 2.0 M CrCl₃**
- How many mL of 4.0 M NaCl is needed to make 50 mL of a 0.5 M NaCl solution? **ANS: 6.25 mL of 4.0 M NaCl**
- How many grams of LiOH is needed to make 250 mL of a 0.33 M LiOH solution? **ANS: 1.98 g LiOH**
- What is the concentration of a solution of CaSO₄ if 8.0 mL of a 1.0 M CaSO₄ solution is diluted to a total volume of 100 mL? **ANS: 0.08 M CaSO₄**
- How many grams of Ca(NO₃)₂ is needed to make 800 mL of a 2.0 M Ca(NO₃)₂ solution? **ANS: 211.36 g Ca(NO₃)₂**

Learning Objectives Describe the fundamental properties of solutions Calculate solution concentrations using molarity Perform dilution calculations using the dilution equation In preceding sections, we focused on the composition of substances: samples of matter that contain only one type of element or compound. However, mixtures—samples of matter containing two or more substances physically combined—are more commonly encountered in nature than are pure substances. Similar to a pure substance, the relative composition of a mixture plays an important role in determining its properties. The relative amount of oxygen in a planet's atmosphere determines its ability to sustain aerobic life. The relative amounts of iron, carbon, nickel, and other elements in steel (a mixture known as an "alloy") determine its physical strength and resistance to corrosion. The relative amount of the active ingredient in a medicine determines its effectiveness in achieving the desired pharmacological effect. The relative amount of sugar in a beverage determines its sweetness (Figure 1). In this section, we will describe one of the most common ways in which the relative compositions of mixtures may be quantified. Figure 1: Sugar is one of many components in the complex mixture known as coffee.

The amount of sugar in a given amount of coffee is an important determinant of the beverage's sweetness.



We have previously defined solutions as homogeneous mixtures, meaning that the composition of the mixture (and therefore its properties) is uniform throughout its entire volume. Solutions occur frequently in nature and have also been implemented in many forms of manmade technology. We will explore a more thorough treatment of solution properties in the chapter on solutions and colloids, but here we will introduce some of the basic properties of solutions. The relative amount of a given solution component is known as its concentration. Often, though not always, a solution contains one component with a concentration that is significantly greater than that of all other components. This component is called the solvent and may be viewed as the medium in which the other components are dispersed, or dissolved. Solutions in which water is the solvent are, of course, very common on our planet. A solution in which water is the solvent is called an aqueous solution. A solute is a component of a solution that is typically present at a much lower concentration than the solvent. Solute concentrations are often described with qualitative terms such as dilute (of relatively low concentration) and concentrated (of relatively high concentration). Concentrations may be quantitatively assessed using a wide variety of measurement units, each convenient for particular applications. Molarity (M) is a useful concentration unit for many applications in chemistry. Molarity is defined as the number of moles of solute in exactly 1 liter (1 L) of the solution: $M = \frac{\text{moles of solute}}{\text{L of solution}}$. What is the molar concentration of sucrose in the beverage? Since the molar amount of solute and the volume of solution are both given, the molarity can be calculated using the definition of molarity. Per this definition, the solution volume must be converted from mL to L: $M = \frac{0.133 \text{ mol}}{0.133 \text{ L}} = 1.0 \text{ M}$. How much sugar (mol) is contained in a modest sip (~10 mL) of the soft drink from Example 1? In this case, we can rearrange the definition of molarity to isolate the quantity sought, moles of sugar. We then substitute the value for molarity that we derived in Example 3.4.2: $M = \frac{\text{moles of solute}}{\text{L of solution}}$. What volume (mL) of the sweetened tea described in Example 1 contains the same amount of sugar (mol) as 10 mL of the soft drink in this example? Answer 80 mL. Distilled white vinegar (Figure 2) is a solution of acetic acid, $\text{CH}_3\text{CO}_2\text{H}$, in water. A 0.500-L vinegar solution contains 25.2 g of acetic acid. What is the concentration of the acetic acid solution in units of molarity? Figure 3: Distilled white vinegar is a solution of acetic acid in water. A label on a container is shown. The label has a picture of a salad with the words "Distilled White Vinegar," and, "Reduced with water to 5% acidity," written above it. As in previous examples, the definition of molarity is the primary equation used to calculate the quantity sought. In this case, the mass of solute is provided instead of its molar amount, so we must use the solute's molar mass to obtain the amount of solute in moles: $M = \frac{\text{moles of solute}}{\text{L of solution}}$. Then, use the molarity of the solution to calculate the volume of solution containing this molar amount of solute: $V = \frac{\text{moles of solute}}{M}$. Combining these two steps into one yields: $V = \frac{\text{mass of solute}}{M \times \text{molar mass}}$. Finally, this molar amount is used to derive the mass of NaCl: $M = \frac{\text{moles of NaCl}}{\text{L of solution}}$. How many grams of CaCl_2 (110.98 g/mol) are contained in 250.0 mL of a 0.200-M solution of calcium chloride? Answer 5.55 g CaCl_2 . When performing calculations stepwise, as in Example 1, it is important to refrain from rounding any intermediate calculation results, which can lead to rounding errors in the final result. In Example 4, the molar amount of NaCl computed in the first step, 1.325 mol, would be properly rounded to 1.32 mol if it were to be reported; however, although the last digit (5) is not significant, it must be retained as a guard digit in the intermediate calculation. If we had not retained this guard digit, the final calculation for the mass of NaCl would have been 77.1 g, a difference of 0.3 g. In addition to retaining a guard digit for intermediate calculations, we can also avoid rounding errors by performing computations in a single step (Example 5). This eliminates intermediate steps so that only the final result is rounded. In Example 6, we found the typical concentration of vinegar to be 0.839 M. What volume of vinegar contains 75.6 g of acetic acid? First, use the molar mass to calculate moles of acetic acid from the given mass: $n = \frac{m}{M}$. Then, use the molarity of the solution to calculate the volume of solution containing this molar amount of solute: $V = \frac{n}{M}$. Combining these two steps into one yields: $V = \frac{m}{M \times \text{molar mass}}$. According to the definition of molarity, the molar amount of solute in a solution is equal to the product of the solution's molarity and its volume in liters: $n = M \times V$. Expressions like these may be written for a solution before and after it is diluted: $n_1 = M_1 \times V_1 = n_2 = M_2 \times V_2$. What volume (mL) of 0.45 M HBr can be prepared from 11 mL (0.011 L) of 0.12 M HBr? We are given the volume and concentration of a stock solution, V_1 and C_1 , and the concentration of the resultant diluted solution, C_2 . We need to find the volume of the diluted solution, V_2 . We thus rearrange the dilution equation in order to isolate V_2 : $V_2 = \frac{C_1 \times V_1}{C_2}$. Since the diluted concentration (0.12 M) is slightly more than one-fourth the original concentration (0.45 M), we would expect the volume of the diluted solution to be roughly four times the original volume, or around 44 mL. Substituting the given values and solving for the unknown volume yields: $V_2 = \frac{0.45 \text{ M} \times 11 \text{ mL}}{0.12 \text{ M}} = 41.25 \text{ mL}$. The result is reasonable and compares well with our rough estimate. A laboratory experiment calls for 0.125 M HNO_3 . What volume of 0.125 M HNO_3 can be prepared from 0.250 L of 1.88 M HNO_3 ? Answer 3.76 L. What volume of 1.59 M KOH is required to prepare 5.00 L of 0.100 M KOH?

Dilutions Worksheet

- 1) If I add 25 mL of water to 125 mL of a 0.15 M NaOH solution, what will the molarity of the diluted solution be?
- 2) If I add water to 100 mL of a 0.15 M NaOH solution until the final volume is 150 mL, what will the molarity of the diluted solution be?
- 3) How much 0.05 M HCl solution can be made by diluting 250 mL of 10 M HCl?
- 4) I have 345 mL of a 1.5 M NaCl solution. If I boil the water until the volume of the solution is 250 mL, what will the molarity of the solution be?
- 5) How much water would I need to add to 500 mL of a 2.4 M KCl solution to make a 1.0 M solution?

We are given the concentration of a stock solution, C_1 , and the volume and concentration of the resultant diluted solution, V_2 and C_2 . We need to find the volume of the stock solution, V_1 . We thus rearrange the dilution equation in order to isolate V_1 : $[C_1 V_1 = C_2 V_2]$ $[V_1 = \frac{C_2 V_2}{C_1}]$ Since the concentration of the diluted solution 0.100 M is roughly one-sixteenth that of the stock solution (1.59 M), we would expect the volume of the stock solution to be about one-sixteenth that of the diluted solution, or around 0.3 liters. Substituting the given values and solving for the unknown volume yields: $[V_1 = \frac{(0.100\text{M})(150\text{ mL})}{1.59\text{M}}]$ $[V_1 = 0.314\text{ L}]$ Thus, we would need 0.314 L of the 1.59-M solution to prepare the desired solution. This result is consistent with our rough estimate. What volume of a 0.575-M solution of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, can be prepared from 50.00 mL of a 3.00-M glucose solution? Answer 0.261 Solutions are homogeneous mixtures. Many solutions contain one component, called the solvent, in which other components, called solutes, are dissolved. An aqueous solution is one for which the solvent is water. The concentration of a solution is a measure of the relative amount of solute in a given amount of solution. Concentrations may be measured using various units, with one very useful unit being molarity, defined as the number of moles of solute per liter of solution. The solute concentration of a solution may be decreased by adding solvent, a process referred to as dilution.

Dilutions Worksheet - Solutions

- 1) If I add 25 mL of water to 125 mL of a 0.15 M NaOH solution, what will the molarity of the diluted solution be?
 $M_1 V_1 = M_2 V_2$
 $(0.15\text{ M})(125\text{ mL}) = M_2 (150\text{ mL})$
 $x = 0.125\text{ M}$
- 2) If I add water to 100 mL of a 0.15 M NaOH solution until the final volume is 150 mL, what will the molarity of the diluted solution be?
 $M_1 V_1 = M_2 V_2$
 $(0.15\text{ M})(100\text{ mL}) = M_2 (150\text{ mL})$
 $x = 0.100\text{ M}$
- 3) How much 0.05 M HCl solution can be made by diluting 250 mL of 10 M HCl?
 $M_1 V_1 = M_2 V_2$
 $(10\text{ M})(250\text{ mL}) = (0.05\text{ M}) x$
 $x = 50,000\text{ mL}$
- 4) I have 345 mL of a 1.5 M NaCl solution. If I boil the water until the volume of the solution is 250 mL, what will the molarity of the solution be?
 $M_1 V_1 = M_2 V_2$
 $(1.5\text{ M})(345\text{ mL}) = M_2 (250\text{ mL})$
 $x = 2.57\text{ M}$
- 5) How much water would I need to add to 500 mL of a 2.4 M KCl solution to make a 1.0 M solution?
 $M_1 V_1 = M_2 V_2$
 $(2.4\text{ M})(500\text{ mL}) = (1.0\text{ M}) x$
 $x = 1200\text{ mL}$
1200 mL will be the final volume of the solution. However, since there's already 500 mL of solution present, you only need to add 700 mL of water to get 1200 mL as your final volume. The answer: 700 mL.

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The dilution equation is a simple relation between concentrations and volumes of a solution before and after dilution. Key Equations $[M = \frac{\text{mol solute}}{\text{L solution}}]$ $[C_1 V_1 = C_2 V_2]$ aqueous solution solution for which water is the solvent concentrated qualitative term for a solution containing solute at a relatively high concentration concentration quantitative measure of the relative amounts of solute and solvent present in a solution dilute qualitative term for a solution containing solute at a relatively low concentration dilution process of adding solvent to a solution in order to lower the concentration of solutes dissolved describes the process by which solute components are dispersed in a solvent molarity (M) unit of concentration, defined as the number of moles of solute dissolved in 1 liter of solution solute solution component present in a concentration less than that of the solvent solvent solution component present in a concentration that is higher relative to other components