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| **Student Objectives** | | |
| * Describe the parts of a solution. * Use molarity to describe solution concentration. * Use factor-label to calculate molarity. * Use calculations to determine solution dilutions. * Express solution concentration is terms other than molarity. |  |  |

**Solutions:   
homogeneous mixtures of solute and solvent.**

**Solvent - the most abundant substance in a solution.**

**Solute - the other substance in a solution.**

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|  | It is possible for a solution to have more than one solute. Air is an example. |

**Concentration - comparison of the amounts of solute and solvent.**

Describing a solution as "stong" or "weak" does give you some comparison of the amounts of solute and solvent, but it is only a general idea. Even the terms "dilute" and "concentrated" do not give enough information to make quantitative calculations. To be able to compare solutions quantitatively, we must know "how much" solute and solvent are present. **Moles** can be used to compare solutions, giving us the most common units of concentration.

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| |  | | --- | | **Molarity (M) = moles of solute per dm3 of solution.** | |

**Remember the following:**

The volume is the volume of the **total solution**, not the volume of the solvent.   
One cubic decimeter (dm3) = 1000 cm3 = 1 liter = 1000 ml



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| |  | | --- | | **Molarity Practice Problems:**   1. Calculate the M of 200cm3 of a solution containing 50g NaOH. 2. How much calcium sulfate is needed to make 100cm3 of 0.25M CaSO4? 3. How many grams of HCl are in 100ml of a 0.5M hydrochloric acid solution? | |

Making dilutions:

A solution can be made less concentrated by dilution with solvent. The number of moles of solute does not change when more solvent is added to the solution. If a solution is diluted from V1 to V2, the molarity of that solution changes according to the equation:

**M1 V1 = M2 V2**   
original solution 1 = diluted solution 2

The volume units must be the same for both volumes in this equation.

**Dilution calculation example:**

**How do you prepare 100ml of 0.40M MgSO4 from a stock solution of 2.0M MgSO4?**

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| There are two solutions involved in this problem. Notice that you are given two concentrations, but only one volume. **Solution #1** is the one for which you have **only** concentration - the solution that is already sitting on the shelf. **Solution #2** is the one for which you have **both** concentration and volume - the solution that you are going to prepare.  At least until you are comfortable with this type of problem, it may be helpful to write out what numbers go with what letters in our equation.  M1 = 2.0M MgSO4         V1 = unknown  M2 = 0.40M MgSO4         V2 = 100ml |

**Step 1 - write the equation:** M1 V1 = M2 V2   
**Step 2 - manipulate the equation:** V1 = M2 V2 /M1   
**Step 3 - put numbers into the equation:** V1 = (0.40M) (100ml) /2.0M   
**Step 4 - do the calculation:** V1 = 20ml   
**Step 5 - describe preparing the solution:** Add 80ml of distilled water to 20ml of the 0.40M MgSO4 solution.

Although molatiry is the most common type of solution concentration used in general chemistry, there are several situations when a different comparison between solute and solvent is needed. Some of these have specialized uses, but you should be familiar with the following:

**Other solution concentrations:**

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| * **molality (m) = moles solute / Kg solvent**   Colligative properties depend on the number of particles of a substance involved. Chemists do calculations dealing with changing vapor pressure, boiling point elevation, and freezing point depression in solutions. A solution concentration that compares moles of solute and kilograms of solvent is most useful in these calculations. |

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| * **normality (N) = equivalents of solute / dm3 solution**   Normality is a useful concentration unit to use during neutralization reactions (titrations). One mole of hydrogen ions reacts with one mole of hydroxide ions to produce water. But that doesn't mean that one mole of any acid will neutralize one mole of any base. Chemists need a unit for the amount of acid (or base) that will give one mole of hydrogen (or hydroxide) ions.  One **equivalent** is the amount of an acid (or base) that will give one mole of hydrogen (or hydroxide) ions.  The numerical values of normality and molarity are equal for acids and bases that give 1 equivalent of H + or OH - per mole. For example, a solution containing 1 mole of NaOH per dm3 is 1M and also 1N. A solution containing 1 mole of H2SO4 per dm3 is 1M, but it is 2N because it contains 2 equivalents of H + per mole. |

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| * **mole fraction = the ratio of the number of moles of one substance to the total number of moles of all substances in the solution.**   Mole fraction is a dimensionless quantity, like a ratio. The sum of the mole fractions of all the components in a solution must equal to ONE.  In a solution containing nA moles of solute and nB moles of solvent, the mole fraction of solute, XA, and the mole fraction of the solvent, XB, can be expressed as follows:   |  |  | | --- | --- | | XA = nA / nA + nB | XB = nB / nA + nB | |

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| * **mass percent = the percent of a solution's total mass that is solute.**   Many commercial solutions are labeled with mass percent. This solution concentration compares the mass of the solute to the total mass of the solution. For example, a 10% salt solution contains 10 grams of salt in each 100 grams of solution. |

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| |  | | --- | | **Concept Understanding:**  Work these practice problems:   1. What is the molality of a solution consisting of 45g of MgCl2 dissolved in 620g of H2O? 2. What is the mole fraction of ethanol in a solution made of 92g of C2H5OH and 144g of H2O? 3. What is the mole fraction of H2O in question #2? 4. What is the mass percent of ethanol in question #2? 5. What is the normality of a 2M solution of H3PO4? | |

  answers:

1. 0.93m MgCl2
2. 0.2
3. 0.8
4. 39% ethanol
5. 6N H3PO4

**Molarity Practice Problems**

**Calculate the molarity of these solutions:**

1. **89.7g (NH4)2C4H4O6 in 500cm3 of solution**
2. **9.94g CoSO4 in 250cm3 of solution**
3. **5.23g Fe(NO3)2 in 0.1dm3 of solution**

**Describe these preparations:**

1. **How much nickel (II) chloride is needed to make a liter of 3M solution?**
2. **How much silver fluoride is needed to prepare 500ml of 1.5M solution?**
3. **You need 250cm3 of 0.20M NaCl, but the only salt you have is in a 1.0M solution. Describe how you prepare the required solution?**

**Describe these dilutions:**

1. **How do you prepare 100cm3 of 0.1M CoCl2 from a 0.52M solution of CoCl2?**
2. **How many cubic centimeters of 0.69M Ba(NO3)2 are needed to prepare 200ml of 0.25M solution?**
3. **Given a standard solution of 2M NH4Br, describe the preparation of 500ml of 0.15M ammonium bromide solution.**

**Practice problem answers:**

**Molarity Calculations:**

1. **0.975M (NH4)2C4H4O6**
2. **0.257M CoSO4**
3. **0.291M Fe(NO3)2**

**Preparations:**

1. **390g NiCl2**
2. **95.3g AgF**
3. **Use 50cm3 of the 1.0M NaCl solution. Add 200cm3 of distilled water to make the total volume 250cm3.**

**Dilutions:**

1. **Add 19.2cm3 of 0.52M CoCl2 solution to a graduate. Add distilled water to make the total volume 100cm3.**
2. **Add 72.5cm3 of 0.69M Ba(NO3)2 solution to a graduate. Add distilled water to make the total volume 200cm3.**
3. **Add 37.5ml of 2M NH4Br solution to a graduate. Add distilled water to make the total volume 500ml.**

**The first person to CORRECTLY demonstrate this to the class  
will get bonus points on the Solutions Quiz.**When you are ready to try it, let me know .... if you ask **any** questions, you are disqualified!   
You only have one shot at doing it correctly. If you make a mistake, you're done!   
(I will provide the materials, but **no** help!)

**The Problem:**

* **Prepare half a liter of 0.15M ammonium sulfate solution using only the following:** 
  + **500 ml volumetric flask**
  + **triple-beam balance**
  + **one sheet of weighing paper**
  + **magnetic stirrer**
  + **bottle of ammonium sulfate solid**
  + **chemical spoon**

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