5) If a saturated sodium nitrate solution at 30°C is evaporated to dryness, how many grams will crystallize out?

6) Which solid salt has the greatest increase in solubility from 20°C to 70°C?

7) You have a potassium chlorate solution containing 10 g of solute in 100 g of water at 50°C. What mass of solute do you have to add to make this solution saturated?

8) You have 80 g ammonium chloride in 100 g of water at 80°C. How many grams of solute must crystallize out of the solution for it to become saturated at the same temperature?

9) You have 100 g ammonium chloride in 100 g of water at 10°C. What temperature do you have to heat this to in order for the solution to become saturated?

9) How much ammonia gas escapes out as a saturated solution originally held at 40°C is warmed to 90°C?

10) What are the steps needed to make a saturated solution of potassium chloride in 300 g of water at 50°C?

6.6 Review + Hwk Answers

Lesson 6.6: Molarity and Dilution

The **concentration** of a solution is called its **molarity**. It is, simply, the number of solute particles dissolved (expressed as moles) per liter of solution. The solution includes both the solute and the solvent.

Practically speaking, you can increase the molarity of a solution (or make it more **concentrated**) by:

- Adding more solute to the solution and dissolving it all – if the temperature is high enough
- Decreasing the volume of the solution – not by pouring out some of the sample (that will do nothing to the concentration) but by removing some of the solvent. This is best done by evaporating it.

To make a solution less concentrated (or **dilute**), it is easiest to just add more solvent to the sample in order to increase the volume of the solution.

Relevant formulas:

Percent by Mass $\% = \frac{mass\ solute}{mass\ solute + mass\ solvent} x100$

Molarity $M = \frac{mol\ solute}{liters\ solution}$ ** changes w/ temp

Dilution $M_1V_1 = M_2V_2$ **# moles solute** # moles = $M \times V$ in L

Density of solution If given the volume and density of the solution, **mass of solute** = volume × density

Review: Calculate the molarity of each solution.

a) 3.0 mol sugar dissolved in 2.0 L of solution. ___ $\frac{3.0\ mol}{2.0\ L} = 1.5\ M$ or $1.5\ mol/L$

b) 0.030 moles KNO_3 dissolved in 50.0 mL of soln. ____ $\frac{0.030 \text{ moles } KNO_3}{0.050 \text{ L}} = .60 \text{ M}$

c) 6.45 g of sodium sulfate dissolved in 250 mL of solution. ___ $\frac{\left(6.45 \text{ g } Na_2SO_4 \mid \frac{1 \text{ mol}}{142.042 \text{ g}}\right)}{.250 \text{ L}} = .18 \text{ M}$

d) 465 mg potassium fluoride of dissolved in 0.054 L of soln. ____ $\frac{465 \text{ mg} \mid \frac{1 \text{ g}}{1000 \text{ mg}}}{} = .465 \text{ g}$ $\frac{\left(.465 \text{ g KF} \mid \frac{1 \text{ mol}}{58.096 \text{ g}}\right)}{.054 \text{ L}} = .15 \text{ M}$

Review: Calculate the number of moles, mass of solute, or volume of solution.

a) How many moles of NaBr are needed to make 150 mL of 3.0 M NaBr solution? Ans: _____

$\frac{.150 \text{ L} \mid 3.0 \text{ moles}}{1 \text{ L}} = .45 \text{ moles}$

b) How many grams of $NaNO_2$ are needed to make 3.5 L of 0.50 M $NaNO_2$ solution? Ans: _____

$\frac{3.5 \text{ L} \mid .50 \text{ moles}}{1 \text{ L}} = 1.75 \text{ moles}$; $\frac{1.75 \text{ moles} \mid 68.995 \text{ g}}{1 \text{ mole}} = 121 \text{ g}$

c) How many grams of K_2CO_3 are needed to make 300.0 mL of 1.25 M K_2CO_3 solution? Ans: _____

$\frac{.3000 \text{ L} \mid 1.25 \text{ moles} \mid 138.284 \text{ g}}{1 \text{ L} \mid 1 \text{ mole}} = 51.8 \text{ g}$

d) How many mL of 2.50 M Na_3PO_4 solution can be made using 1.8 g of Na_3PO_4? Ans: _____

$\frac{1.8 \text{ g } Na_3PO_4 \mid 1 \text{ mole} \mid 1 \text{ L} \mid 1000 \text{ mL}}{163.94 \text{ g} \mid 2.50 \text{ moles} \mid 1 \text{ L}} = 4.4 \text{ mL}$

Review: Determine the concentrations for each of the following mixtures.

As long as volumes are equal, molarities will average

a) equal volumes of 3.0 M KCl & water:

1.5 M

b) equal volumes of 3.0 M KCl & 7.0 M KCl:

5.0 M

Review: Use the dilution equation to determine the concentrations of the following mixtures. $M_1V_1 = M_2V_2$

a) 45 L of 3.6 M KCl and 71 L of water:

$V_2 = 45 + 71 = 116 \text{ L}$

$M_2 = \frac{M_1V_1}{V_2}$

$= \frac{(3.6 \text{ M})(45 \text{ L})}{116 \text{ L}}$ Ans: _____

$= 1.4 \text{ M}$

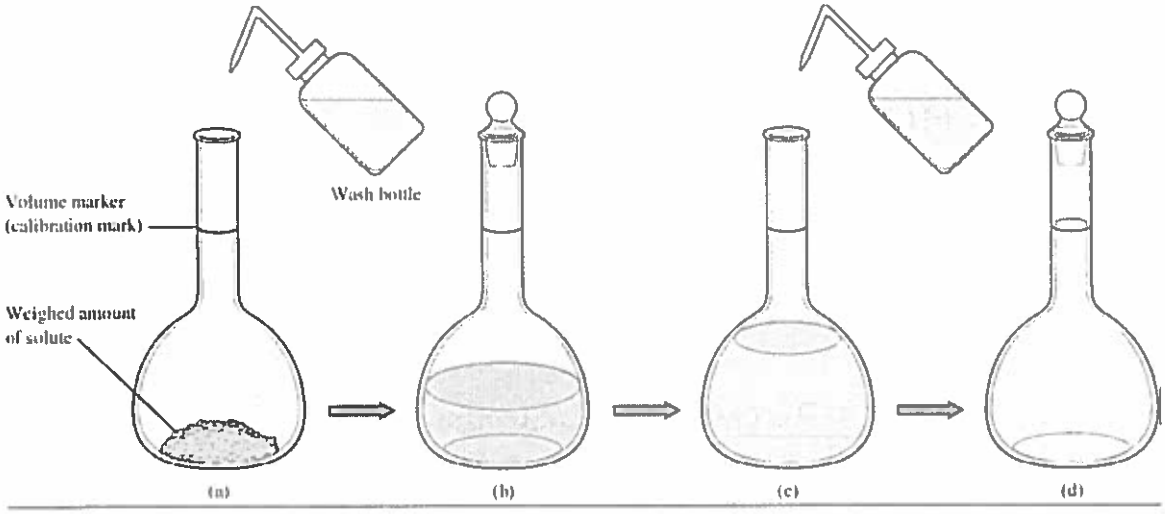
b) 215 mL of 2.8 M KCl and 47 mL water:

$V_2 = 215 + 47 = 262 \text{ mL}$

$M_2 = \frac{M_1V_1}{V_2}$

$= \frac{(2.8 \text{ M})(215 \text{ mL})}{262 \text{ mL}}$ Ans: _____

$= 2.3 \text{ M}$



↗ MM = 158.032 g/mol

Review: Describe each step of the preparation of a **standard solution** of 500. mL of 0.150 *M* $KMnO_4$, and include the necessary calculations in detail. (A "standard solution" is a solution that you precisely know the concentration of.)

How many grams to add? $\frac{(.500\,L \times .150\,M)}{1\,mol} \left| \frac{158.032\,g}{} \right. = 11.9\,g$

1) weigh out 11.9 g of solid $KMnO_4$
2) to a 500 mL flask, add a small amount of H_2O (distilled)
3) add the 11.9 g to the water in the flask
4) swirl to mix / dissolve
5) use a wash bottle to add H_2O to the flask
6) near the mark, add drops of H_2O up to the line 7) add stopper

Diluting a solution (Pipets/burets are accurate, but take more time to use)

1) calculate V_1, given M_2 (required molarity), V_2 (required volume), and M_1 original molarity). V_1 is the volume of original solution you need to use.
2) measure out V_1 using **volumetric pipet, buret** or graduated cylinder
3) add V_1 to beaker or volumetric flask that matches V_2
4) add distilled water to beaker or flask containing V_1 to just before the mark
5) use dropper to add drops of water up to the mark; add stopper

** Caution: if the solute is a strong acid, switch steps 3 and 4. Always add acid to water, not in reverse!

Review: What volume of 12*M* hydrochloric acid must be used to prepare 600 mL of a 0.30 *M* HCl solution? Describe the steps and equipment necessary to make this solution.

What volume is needed? $V_1 = \frac{M_2V_2}{M_1} = \frac{.30\,M \cdot .600\,L}{12\,M} = .180\,L = 180\,mL$

1) measure 180 mL of 12M acid in a volumetric pepet, buret, etc.
2) add some distilled H_2O to a 600 mL volumetric flask
3) add the 180 mL of 12 M acid to the flask; swirl to dissolve
4) add more H_2O to the flask to just before the mark
5) add drops of water to the mark, add stopper

$\#mol = .045L \cdot 3.6M = .162\,mol$ $\quad .071L \cdot 6.2M = .4402\,mol$

c) 45 mL of 3.6 M KCl and 71 mL of 6.2 M KCl:

$V_2 = 45mL + 71mL = 116\,mL$

total #moles = $.162 + .4402 = .6022$ mol

molarity = $\frac{.6022\,mol}{.116L} = 5.2M$

Ans: _____

d) 38 mL of 6.0 M KCl diluted to a total volume of 100 mL: (V_2)

$M_2 = \frac{M_1V_1}{V_2} = \frac{(6.0M)(38mL)}{100mL} \simeq 2\,M$

Ans: _____

To what total volume must 26.0 mL of 4.80 M KCl be diluted to reduce its concentration to... (V_2?)

e) ... 2.10 M

$V_2 = \frac{M_1V_1}{M_2} = \frac{(4.80M)(26.0mL)}{(2.10M)}$

Ans: 59.4 mL

f) ... 0.480 M

$V_2 = \frac{M_1V_1}{M_2} = \frac{(4.80M)(26.0mL)}{0.480M} = 260mL$

(or - understand 4.80 M → 0.480 M is a tenfold dilution, so the volume increases by 10)

Ans: 260 mL

What volume of water must be added to 35 mL of 2.6 M KCl to reduce its concentration to...

a) ... 1.2 M $\quad V_2 = \frac{M_1V_1}{M_2} = \frac{(2.6M)(35mL)}{1.2M} = 76\,mL$

vol. H_2O to add = $76mL - 35mL = 41\,mL$

Ans: 41 mL

b) ... 0.26 M $\quad V_2 = \frac{M_1V_1}{M_2} = \frac{(2.6M)(35mL)}{0.26M} = 350mL$

vol. H_2O to add = $350mL - 35mL = 315\,mL = 3.2 \times 10^2\,mL$

Ans: _____

What volume of 2.5 M KCl must be added to 37 mL of 6.0 M KCl to make the total concentration of:

a) ... 1.5 M The molarity of the mixture cannot be less than either of the two original solutions used

Ans: ⁄ (no answer)

b) ... 4.2 M $\quad .037L \times 6.0M = .222$ moles KCl

Let x be the # L of 2.5M KCl required

$4.2M = \frac{.222 + 2.5x}{.037 + x}$

$4.2(.037 + x) = .222 + 2.5x$

$x = .039 = 39\,mL$

Ans: 39 mL

Steps in making a solution

1) calculate and weigh out mass of solute required
   (given molarity, calculate **# moles solute** # moles = $M \times V$ in L)
2) add small amount of distilled H_2O to appropriate **volumetric flask**
3) add solute to H_2O in flask
4) swirl/swish to dissolve, or use a glass stirring rod
5) add distilled water to just before the mark/line
6) use dropper to add drops of water up to the mark; add stopper

6.6 HWK

Lesson 6.6

1. 65.0 mL of a 1.30 M K_3PO_4 solution is evaporated. How many grams of solid should be recovered after all the water boils away?

$.0650\,L\ K_3PO_4 \times \frac{1.30\ moles}{1\,L} = .0845\ moles$

$.0845\ moles\ K_3PO_4 \mid \frac{212.264\,g}{1\ mol} = 17.9\,g$

2. Fill in the blank: To make orange juice from frozen concentrate, one usually mixes the can of concentrate with three cans of water. This dilutes the concentrate to 1/4th (what fraction?) its original concentration.

3. Describe each step of the preparation of a standard solution of 750. mL of 0.250 *M* $CuSO_4$, and include the necessary calculations in detail.

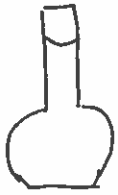
$.750\,L \times \frac{0.250\,mol}{1\,L} = .188\ moles \times \frac{159.608\,g}{1\,mol}$

$= 30.0\,g$

1) weigh 30.0g $CuSO_4$ solid
2) add some distilled H_2O to a 750mL volumetric flask
3) add the 30.0g $CuSO_4$
4) swirl to mix
5) add more H_2O up to the mark; near the mark, add drops with a pipette
6) add stopper

4. Sketch a volumetric flask and explain precisely how you would use a 500.0 mL volumetric flask to make some 1.500 M $NaNO_3$ solution. (You have available some 2.000 M $NaNO_3$ solution and whatever other lab equipment you need) How much 2.000 M solution is needed?

$V_1 = \frac{M_2V_2}{M_1} = \frac{(1.500\ M)(.5000\,L)}{2.000\,M} = .375\,L$



500.0mL flask

1) measure 375mL of 2.000M $NaNO_3$ solution using graduated cylinder
2) add this to the flask
3) add distilled H_2O up to the mark - use a dropper when you get close. Add stopper.

5. You need to make up some 5.0 M KCl solution but all you have is 125 mL of 3.0 M KCl. Explain what to do to make up the 5.0 M solution. How much 5.0 M KCl will you get? Show calculations: (hint - calculate how much water to evaporate)

$M_1V_1 = M_2V_2$

$V_2 = \frac{M_1V_1}{M_2} = \frac{(.125\,L)(3.0\,M)}{5.0\,M} = .075\,L = 75mL$

You must evaporate $125\,mL - 75\,mL = 50.\,mL\ H_2O$ from the solution

Lesson 6.8

1. Write an equation for the ionization of the following acids in water.

a) HNO_2

b) HCO_3^-

c) $H_2PO_4^-$ (complete ionization)