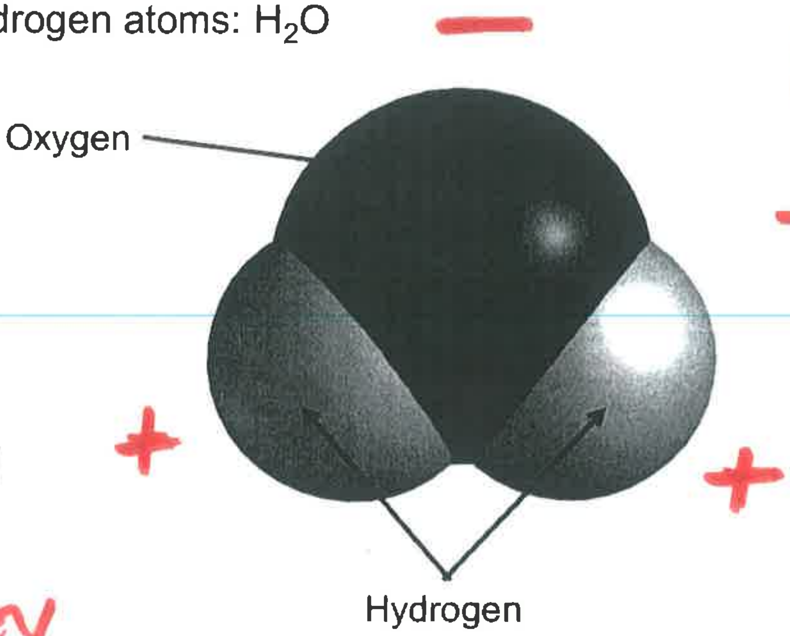
What Is Water?

A water molecule is made of one oxygen atom and two hydrogen atoms: H_2O



POLAR
MOLECULE

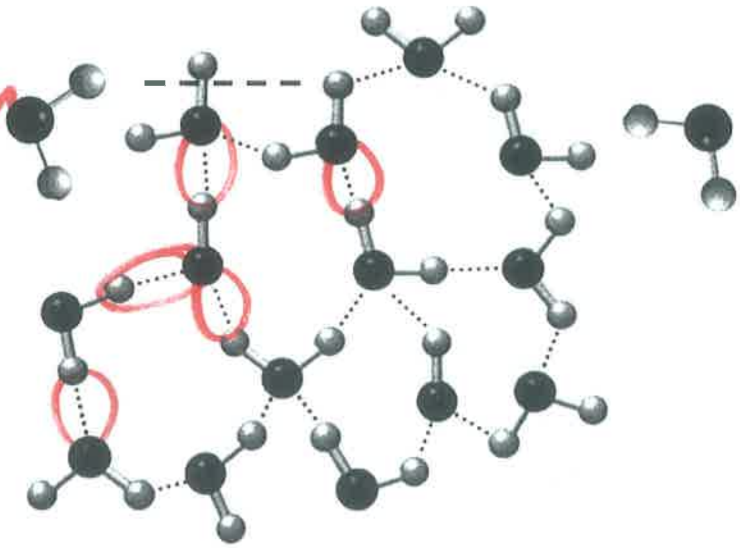
+ AND −
CHARGES

MICKEY
MOUSE

Hydrogen Bonds

Many unique and important properties of water result from hydrogen bonding.

between H atom on one H_2O and O atom on ANOTHER H_2O



bugs, lizards walk on water

Due to HYDROGEN BONDING

1. **High Surface Tension** paperclip floats on surface
    - -ability to resist external force
    - -inward force or pull causes drops
2. **Low Vapor Pressure**
    - -slow evaporation prevents lakes and oceans from evaporating
3. **High Boiling Point** absorbs ALOT of HEAT, sweating
    - -no boiling, so lakes and oceans remain in liquid state
4. **Ice Floats on Water**
    - -ice less dense than water

ICEBERGS and ICE at TOP not BOTTOM

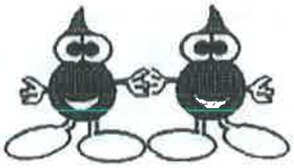
if not, would kill/freeze aquatic life

Water is **UNIVERSAL SOLVENT**

-ability to dissolve many substances

-dissolves sugar, salt, other solutions to be diluted

- **COHESION** – water is attracted to water



Cohesion

- **ADHESION** – water is attracted to other substances

Adhesion

Name________________________Period____Date____/____/____

Lab 10.1 Crystals in Saturated Solutions

Prelab Questions

1. In your own words define solution:

2. In your own words define *solute:*

3. Best describe the meaning of the word *saturated.* Use an example to help support your description.

Analysis

1. What material used in this lab was the solute? What material was the solution?

   Water

   BORAX (laundry detergent salt)

2. What happens to liquid molecules as they increase in temperature?

   Kinetic
   gain energy → more movement
   ↓
   more collisions

3. Analyze the solubility chart for Borax shown on the lab handout.
   a. What is the trend in solubility for Borax in water as the temperature increases?

   ~~mor~~ increasing temperature
   ↓
   increase amount of borax dissolve

Solubility in water

Temperature °C (°F)	Borax Decahydrate % by weight in saturated solution
0 (32)	1.99
5 (41)	2.46
10 (50)	3.09
15 (59)	3.79
20 (68)	4.71
25 (77)	5.80
30 (86)	7.20
35 (95)	9.02
40 (104)	11.22
45 (113)	14.22
50 (122)	17.91
55 (131)	23.22
60 (140)	30.33
65 (149)	33.89
70 (158)	36.94
75 (167)	40.18
80 (176)	44.31
85 (185)	48.52
90 (194)	53.18
95 (203)	58.95
100 (212)	65.84

ROOM TEMP →

BOILING ↑

b. What is the approximate value for the percentage of Borax by weight in the solution you created in procedure step 9? How did you determine this?

100°C → 65.64%

c. What is the approximate value for the percentage of Borax by weight in the final solution you have now, a day or more later? How did you determine this?

25°C → 5.80%

4. Often when a solution is heated it increases its capacity for dissolving solutes, this is how a *supersaturated solution* is created. The borax and water solution that you created was a supersaturated solution, what happened to your snowflake after the solution cooled overnight? **Why do you think this happened**? Be thoughtful in your response, use the chart shown in question 3 to help you.

   the borax becomes solid (crystallizes)

   hot

   $\text{borax}(aq) \xrightarrow{\text{COOL}} \text{borax}(s)$

Chapter 16 Solutions
Turn to page 544 and read Chapter 16.1 and 16.2
Answer the following questions and define the following terms.

Background In a solution, the dissolving medium is the **solvent**. The dissolved particles in a solution are the **solute**. A solvent dissolves the solute, and the solute becomes dispersed in the solvent. Solvents and solutes may be gases, liquids or solids.

1. What are the three factors that affect how fast a substance dissolves?

a.
b.
c.

2. Define saturated solution

3. Define solubility

4. Define unsaturated solution

5. Define supersaturated solution

Chapter 16.2 on page 551

6. Define concentration

7. Define molarity (M)

8. What is the formula for molarity?

9. Define dilution.

10. Fill in the blanks for the statement
Diluting a solution ____________ the number of moles of ___________ per unit volume, but the total number of moles of solute in solution does not change.

11. What the formula for the moles of solute in a solution?

12. What is the formula for the percent by volume of a solution?

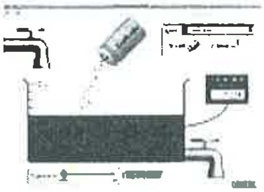
13. What is the formula for the percent by mass of a solution?

Name________________________________Period____Date____/____/____

Virtual Lab 10.2 Concentration and Molarity

Go to Simulations at http://phet.colorado.edu/ >Search for concentration>Click on concentration simulation. Click play.

Introduction: Everyone likes candy. Have you ever wondered how that candy is produced? How do they get all that delicious sugar into those tiny packages? Could you make hard candy like those you can buy? It's easier than you think. Web searching for "rock candy" will yield a number of delicious recipes you can try at home.



Concentration

Some handy vocabulary for you to define:

Solute ______________________________ Solvent ______________________________

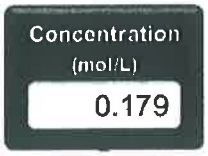
Moles ____

Molarity ____

Saturated (not fats)____

Unsaturated (not fats)____

Supersaturated____



Concentration
(mol/L)
0.179

Procedure: *PhET→Play with the Sims → Chemistry → Concentration* Run Now!

Part 1: Dissolution and Saturation

Take some time to play and familiarize yourself with the simulation. Click on everything. Move all the sliders. Notice what happens to the concentration as solid solute  is added and when evaporation occurs.

How does the concentration change as solid solute is added? INCREASE

How does the concentration change as additional water is added? DECREASE

How does the concentration change as evaporation occurs? INCREASE

How do you know when a solution is ***saturated***? MAXIMUM AMOUNT OF SOLUTE

When a solution *is* saturated, and additional solid solute is added, what happens? NO CHANGE IN CONCENTRATION

Why do you think this is? NOT ENOUGH SOLVENT

How does adding this additional solute change the concentration of this saturated solution? NO CHANGE

How does evaporation change the concentration of a saturated solution? NO CHANGE

Part 2: Concentrated Solutions ◉ Solution ***– Click on solution***

Adding a concentrated solution… describe a way to determine the concentration of the solution in the spigot. Write your plan here: ____

____

Using your plan…how might you get that concentrated solution to become saturated? ____________

____

Does your plan work for all the other solutions too? __________ Why? / Why Not?______________________

____

Part 3 – Saturation Concentration

Molarity is **moles per Liter**, that is, how many moles of solute (entire salt) is dissolved per Liter of solution.

First, determine the **saturation concentration of** each of the solutions, that is, how concentrated can you get each solution before the solution is saturated. You do this by adding the specific solute to the water (don't forget to move the sensor over the water first). Once you add the maximum amount of solute, your saturation concentration would be the concentration shown on the display. The first one has been done for you.

■ Cobalt (II) nitrate	5.640 mol/L	Potassium chromate	3.350 mol/L
■ Cobalt chloride	4.330 mol/L	■ Nickel (II) chloride	5.210 mol/L
■ Potassium dichromate	0.510 mol/L	■ Copper sulfate	1.380 mol/L
		■ Potassium permanganate	0.480 mol/L

Part 4: Calculating Molarity

Use the formula for Molarity to solve for all the variables (M, Moles and Liters)

$$\text{Concentration=Molarity (M)} = \frac{moles\ of\ solute\ (mols)}{volume\ of\ solvent\ (liters)} = \frac{n}{L}$$

Moles of Compound (mol)	Liters of Solution (L)	Molarity of Solution (M)	Moles of Compound (mol)	Liters of Solution (L)	Molarity of Solution (M)
.53	.79	0.67	0.46	.78	.59
.86	.34	2.5[illegible]	.88	0.49	1.8
1.0	.20	5.0	3.5	8.4	0.42
.67	.67	1.0		6.4	8.5

Conclusion Questions and Calculations, Concentration and Molarity Post-Lab Exercises

(please staple to your lab page)

The Sims: *Google: "Phet" PhET→Play with the Sims → Chemistry → "Concentration"* or *"Molarity"*

1. Adding pure water to a saturated solution (**with no solids**) would cause the concentration of that solution to *increase / decrease / remain the same.* (circle)
2. Adding pure water to a saturated solution **(with some solids)** would cause the concentration of that solution to initially *increase / decrease / remain the same.* (circle)
3. Adding a solid salt to a saturated solution causes the concentration of that solution to *increase / decrease / remain the same.*

4. Evaporation acting on an unsaturated solution causes the solution's concentration [✓ *to increase*] / *decrease* / *remain the same.*

5. Evaporation acting on a saturated solution causes the solution's concentration to *increase* / *decrease* / [✓ *remain the same.*]

6. Using your notes, your text, or the internet discover what happens to the saturation concentration when a solution's temperature is increased. What happens as a solution is heated? SUPERSATURATED

7. Why does this happen? (hint…think about the molecules) more solute dissolve with increase in heat

8. Can you dissolve .35 moles of Potassium Permanganate ($KMnO_4$) into 500 mL of water? NO Why? / Why not?
Hint: Go back to saturation concentration of this lab (please show work)

Maximum is 0.480 M

$$M = \frac{n}{L} \qquad M = \frac{.35}{.500} = 0.70\ M$$

9. Can 1750 mL of water dissolve 4.6 moles of Copper Sulfate $CuSO_4$? NO Why? / Why not? (show work)

$$M = \frac{4.6\ mol}{1.750\ L} = 2.6\ M$$

MAXIMUM 1.380 M

10. What is the solution concentration formed from 3.6 moles NaCl dissolved into 1.3 L of water? (show work)

$$M = \frac{n}{L} \qquad M = \frac{3.6}{1.3} = 2.8\ M$$

11. What is the solution concentration formed from 2.1 moles $BaCl_2$ dissolved into 1.9 L of water? (show work)

$$M = \frac{n}{L} \qquad M = \frac{2.1}{1.9} = 1.1\ M$$

12. How many moles of solute are present in .75 L of a .89 M (molar) solution? (show work)

$$M = \frac{n}{L} \qquad n = (M)(L) \qquad n = (.89)(.75)$$
$$= 0.67\ mol$$

13. How many moles of solute are present in 1.4 L of a 1.9 M (molar) solution? (show work)

$$M = \frac{n}{L} \qquad n = (M)(L) \qquad n = (1.9)(1.4)$$
$$= 2.7\ mol$$

14. What volume of water would be required to dissolve .46 moles of solute to produce a .22 M solution? (show work)

$$L\ M = \frac{n}{\cancel{L}}\cancel{L} \qquad \frac{L\cancel{M}}{\cancel{M}} = \frac{n}{M} \qquad L = \frac{n}{M}$$

$$L = \frac{0.46\ mol}{0.22\ M}$$

$$= 2.1\ L$$

Overview of Molarity and Concentration

A **solution** is a homogeneous mixture composted of two or more substances. In a solution, a solute is dissolved in another substance called a solvent.

How to make a Kool-Aid solution…

Solute – dissolving substance or particle
-in this case it is

Solvent – substance that dissolves another
-in this case it is

Which is solvent and solute? Depends!
More moles of the "substance" = **solvent**
Less moles of the "substance" = **solute**

Molarity (M) is a fancy word in chemistry that means CONCENTRATION in Chemistry. The molarity of a solution is determined by the **amount of moles (n) of solute** dissolved in the **amount of volume (L) of the solvent**.

The formula to calculate the concentration or molarity (M) is given below;

$$\textbf{Molarity (M)} = \frac{\textit{moles of solute (n)}}{\textit{volume of solvent (L)}}$$

Example 1: Calculate the molarity of a solution when 2.00 mol of glucose are dissolved in 5.00 L of water. **(0.400 M)**

$M = ?$ n V

$$M = \frac{n}{L} \qquad M = \frac{2.00\text{ mol}}{5.00\text{ L}} = 0.400\text{ M}$$

Example 2: How many moles of NaCl are in 5.40 L of 1.25 M NaCl ? **(6.90 mol)** 6.75 mol

$n = ?$ V M MOLARITY

$$M = \frac{n}{L}\ (5.40)1.25 = \frac{n}{\cancel{5.40}\text{ L}}(\cancel{5.40}) \qquad n = 6.96\text{ mol} \qquad 6.75\text{ mol}$$

Example 3: What volume of solvent is needed to dissolve 0.673 mol of $CaCl_2$ to prepare a 0.298 M $CaCl_2$ solution? **(2.26 L)**

$V = ?$ n M MOLARITY

$$M = \frac{n}{L} \qquad \frac{L\ 0.298\text{ M}}{.\cancel{298}\text{ M}} = \frac{.673\text{ mol }\cancel{L}}{\cancel{L}\ .298\text{M}} = 2.26$$

$$\cancel{L}\ \frac{0.298}{1} = \frac{.673}{L}$$

$$\frac{L(.2\cancel{9}8)}{.2\cancel{9}8} = \frac{1(.673)}{.298}$$

Factors Affecting Solubility (ability to dissolve)

- AGITATION
  - Stirring, shaking
    example) **STIRRING** coffee mixture with sugar, cream, etc.
- TEMPERATURE
  - Add heat, increase temperature to dissolve solute
    example) making **HOT** tea, cooking
- SURFACE AREA
  - Break particles into smaller pieces to increase surface
    example) **BREAKING** sugar cubes in lemonade/coffee to make them smaller

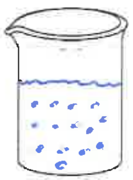
Types of Solution (hand warmer demo)

- UNSATURATED – contains less solute than a saturated solution at a given temperature and pressure
- SATURATED –contains maximum amount of solute for a given quantity of solvent at a constant temperature pressure
- SUPERSATURATED - contains more solute than it can theoretically hold at a given temperature

Name KEY

Notes 10.1 Solutions Lab & Virtual Molarity Discussion And Dilutions

Types of Solutions



UNSATURATED

more solute can be dissolved

SATURATED

maximum amount solute

SUPERSATURATED

more solute that THEORETICALLY Be dissolved

Factors that Affect Solubility

1. Agitation –

2. Increase temperature –

3. Increase surface area –

Borax Salt Crystalizing

1. Boil 400 mL of water.
2. Dissolve 40 grams of borax in boiling water.
3. Allow borax solution with ornament to cool.

Solving for M, n, or L using the Molarity formula

$$\textbf{Molarity (M)} = \frac{\textit{moles of solute (mol)}}{\textit{volume of solvent (L)}}$$

$$\mathbf{M} = \frac{n}{L}$$

M = molarity
n = moles of solute
L = volume of solvent

1. Isolate mol (n) in the molarity formula.

$(L)M = \frac{n}{\cancel{L}} \swarrow \qquad n = (L)(M)$

2. Isolate liters (L) in the molarity formula.

$\frac{L\cancel{M}}{\cancel{M}} = \frac{n}{\cancel{L}M} \swarrow \qquad L = \frac{n}{M}$

Example 1 Calculate the molarity of a solution when 2.00 mol of glucose are dissolved in 5.00 L of water (0.400 M)

$M = \frac{n}{L} \qquad M = \frac{2.00\ mol}{5.00\ L} = 0.400\ M$

Example 2 How many moles of NaCl are in 5.40 L of 1.25 M NaCl ? (~~6.90~~ mol)

6.75 mol $\quad M = \frac{n}{L} \quad n = (L)(M)$

$n = (5.40L)(1.25M) = 6.75\ mol$

Example 3 What volume of solvent is needed to dissolve 0.673 mol of CaCl2 to prepare a 0.298 M CaCl2 solution? (2.26 L)

$L = \frac{n}{M} = \frac{0.673\ mol}{0.298\ M} = 2.26\ L$

For practice problems and review, go over the Virtual Lab 10.2

*Example problems involving **mass of solute instead of moles of solute** dissolve in solvent.*

m = ? V M

Example 4 Calculate the mass of solute of a 1.00 liter of a 1.00 M mercury (II) chloride ($HgCl_2$) solution. **(272 g $HgCl_2$)**

1. solve for n
2. convert n to m

$M = \frac{n}{L}$

$n = (M)(L)$

$n = (1.00)(1.00)$

$n = 1.00$ mol $HgCl_2$

201+(35.5)2

1.00 mol $HgCl_2$ × $\frac{272 \text{ g } HgCl_2}{1 \text{ mol } HgCl_2}$

272 g $HgCl_2$

1. What mass of the following chemicals is needed to make the solutions indicated?

a) 2.00 liters of a 1.50 M sodium nitrate ($NaNO_3$) solution **(255 g $NaNO_3$)**

$n = ML$

$= (1.50 M)(2.00 L)$

$= 3.00$ mol

3.00 mol $NaNO_3$ × $\frac{85 \text{ g } NaNO_3}{1 \text{ mol } NaNO_3}$ = 255 g $NaNO_3$

b) 5.00 liters of a 0.100 M $Ca(OH)_2$ solution **(37.0 g $Ca(OH)_2$)**

$n = ML$

$= (0.100 M)(5.00 L)$

$= 0.500$ mol

0.500 mol $Ca(OH)_2$ × $\frac{74 \text{ g } Ca(OH)_2}{1 \text{ mol } Ca(OH)_2}$ = 37.0 g $Ca(OH)_2$

M

2. Calculate the molarity of the following solutions.

a) 12.0 g of lithium hydroxide (LiOH) in 1.00 L of solution **(0.500 M)**

mass V

1. convert mass to mol (n)
2. divide n by V

12.0 g × $\frac{1 \text{ mol LiOH}}{24 \text{ g LiOH}}$ = 0.500 mol

$M = \frac{n}{L} = \frac{0.500 \text{ mol}}{1.00 \text{ L}} = 0.500$ M

b) 198 g of barium bromide ($BaBr_2$) in 2.00 L of solution **(0.333 M)**

198 g $BaBr_2$ × $\frac{1 \text{ mol } BaBr_2}{297 \text{ g } BaBr_2}$ = 0.667 mol

$M = \frac{n}{L} = \frac{0.667 \text{ mol}}{2.00 \text{ L}} = 0.334$ M

V

3. Calculate the volume of each solution, in liters.

a) 1.00 M solution containing 85.0 g of silver nitrate ($AgNO_3$) **(0.500 L)**

M mass

1. convert mass to mol (n)
2. divide n by M

85.0 g $AgNO_3$ × $\frac{1 \text{ mol } AgNO_3}{170 \text{ g } AgNO_3}$

= 0.500 mol

$L = \frac{n}{M} = \frac{0.500 \text{ mol}}{1.00 \text{ M}} = 0.500$ L

b) 0.500 M solution containing 252 g of manganese (II) chloride ($MnCl_2$)**(4.00 L)**

252 g $MnCl_2$ × $\frac{1 \text{ mol } MnCl_2}{126 \text{ g } MnCl_2}$ = 2.00 mol

$L = \frac{n}{M} = \frac{2.00 \text{ mol}}{0.500 \text{ M}} = 4.00$ L

Name____ Date_____/_____/_____Period____

Worksheet 10.2 Dilutions

Dilution – process of preparing a less-concentrated solution from a more concentrated one by adding more volume solvent. The number of moles of solute is the same, only the volume of the solvent is increasing.

There is a formula to express the proportion between the two concentrations in the dilution process.

$M_1 > M_2$

$V_2 > V_1$

$M_1V_1 = M_2V_2$ less volume less concentrated **n (moles) is constant** more volume

more concentrated **(initial concentration) (initial volume) = (final concentration) (final volume)**

Example 1A How much concentrated 18.0 M sulfuric acid is needed to prepare 0.250 L of a 6.00 M solution?

M_1 M_2

$M_1 =$ 18.0 M

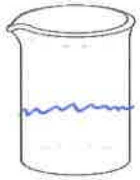
$V_1 =$?

$M_2 =$ 6.00 M

$V_2 =$ .250 L

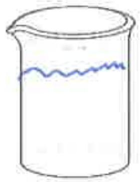
$M_1V_1 = M_2V_2$

$$\frac{(18.\cancel{0}\text{ M})V_1}{18.\cancel{0}\text{ M}} = \frac{(6.00\text{ M})(0.250\text{ L})}{18.0\text{ M}} = 0.0833\text{ L}$$



18.0M

V = ?



6.00 M

.250 L

$V_1 = 0.0833$ L

In the lab, you would take 0.083 liter of the 18 M solution and added enough solvent (usually water) to be 0.250 L which will change the solution to have a 6.0 molar concentration.

Example 1B How much solvent did you need to add to $V_1 = 0.083$ L to get it to $V_2 = 0.250$ L.

Answer: 0.250 L – 0.0833 L = 0.1667 L

M_1 V_2 M_2

Example 2A How much concentrated 12.0 M hydrochloric acid is needed to prepare 0.100 L of a 2.00 M solution?

$M_1 =$ 12.0 M

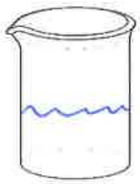
$V_1 =$?

$M_2 =$ 2.00 M

$V_2 =$ 0.100 L

$M_1V_1 = M_2V_2$

$$\frac{(12.\cancel{0}\text{ M})\ V_1}{12.\cancel{0}\text{ M}} = \frac{(2.00\text{ M})(0.100\text{ L})}{12.0\text{ M}}$$



12.0 M

V = ?

2.00 M

0.100 L

$V_1 = 0.0167$ L

Example 2B How much water do you need to add to V_1 to get to V_2?

$V_2 - V_1 = 0.100 - 0.0167 = 0.0833$ L

$M_1 = ?$ M_2 V_1 V_2

1. What is the molarity of a NaCl solution that becomes 0.15 M NaCl when 2.0 L is diluted to 6.50 L? **(0.490 M)**

$M_1V_1 = M_2V_2$

$\frac{M_1(\cancel{2.0})}{\cancel{2.0}} = \frac{(0.15)(6.50)}{2.0}$ $M_1 = 0.490\ M$

$V_2 = ?$ V_1 M_1 M_2

2. How many liters of solution will be produced when diluting 1.65 L of a 0.432 M KI solution to 0.21 M KI? **(~~3.36~~ L)**

3.39 L

$M_1V_1 = M_2V_2$

$\frac{(0.432)(1.65)}{0.21} = \frac{(\cancel{0.21})V_2}{\cancel{0.21}}$ $V_2 = 3.39\ L$

$V_1 = ?$ M_1 V_2 M_2

3. How many liters of a 6.00 M stock solution of NH_3 would you need to prepare 100.0 mL of 0.30 M NH_3? **(5.00 x 10^{-3} L)**

$\downarrow$ .100 L

$M_1V_1 = M_2V_2$

$\frac{(\cancel{6.00})V_1}{\cancel{6.00}} = \frac{(0.30)(0.100)}{6.00}$ $V_1 = 0.005\ L$

M_1 V_2 M_2

4. How much concentrated 18 M sulfuric acid is needed to prepare .250 L of a 6.0 M solution? **(0.083 L)**

$M_1V_1 = M_2V_2$

$\frac{(\cancel{18})(V_1)}{\cancel{18}} = \frac{(6.0)(0.250)}{18}$ $V_1 = 0.083L$

V_1 M_1 M_2

5. To what volume should 0.025 L of 15 M nitric acid be diluted to prepare a 3.0 M solution? **(0.13 L)**

$M_1V_1 = M_2V_2$

$\frac{(15)(0.025)}{3.0} = \frac{(\cancel{3.0})V_2}{\cancel{3.0}}$ $V_2 = 0.125\ L$

0.13 L

V_1 M_1 M_2

6. How much water should be added 50 L of 12 M hydrochloric acid be added to produce a 4.0 M solution? **(100 L should be added, 150 L total solution)**

$M_1V_1 = M_2V_2$

$\frac{(12)(50)}{4.0} = \frac{(\cancel{4.0})V_2}{\cancel{4.0}}$ $V_2 = 150$

How much H_2O added?

$V_2 - V_1 = 150L - 50L = 100L$ added

V_1 M_1 M_2

7. How much water should be added to 100 L of an 18 M sulfuric acid be added to prepare a 1.5 M solution? **(1100 L should be added, 1200 L total solution)**

$M_1V_1 = M_2V_2$

$\frac{(18)(100)}{1.5} = \frac{(1.5)V_2}{1.5}$

$V_2 = 1200\ L$

How much H_2O added?

$V_2 - V_1 = 1200L - 100L$

$= 1100\ L$ added