Solution Concentration

Name: _____

In these problems, assume "concentration" refers to **molarity** unless stated otherwise.

1) A student dissolves 5.00 g of copper(II) nitrate trihydrate in water to make 100.0 mL solution. Calculate the **concentration** of the solution.

2) A student dissolved 20.0 g of calcium chloride, $CaCl_2$, to make 500.0 mL solution. What is the solution's **concentration**?

3) What is the **molarity** of a sucrose solution, ($C_{12}H_{22}O_{11}$), if 10.0 g of sucrose is dissolved to make 50.0 mL of solution?

4) The lab technician dissolved 12.8 g of naphthalene, $C_{10}H_8$, in ethanol to prepare 2.00 L of solution.

   a) What is the solute and what is the solvent in this solution?

   b) What is the solution's concentration?

5) What **mass** of $Mg(NO_3)_2$ is needed to prepare 250.0 mL of 0.120-M solution?

6) A chemist has pipetted 10.00 mL of 0.0500-M $CaCl_2$ into a test tube. How many **moles** of $CaCl_2$ is this?

7) A student used a graduated cylinder to obtain 25.0 mL of ethanol. She poured the ethanol into a 200.0-mL volumetric flask and added distilled water to prepare a solution. Pure ethanol (C_2H_5OH) has a density of 0.789 g/mL.

   a) How many **moles** of ethanol were used?

   b) Calculate the **molarity** of the solution.

   c) How many **molecules** of ethanol are in the solution?

8) You need to prepare 100.0 mL of 0.200-M $CuSO_4$ by dissolving $CuSO_4 \cdot 5H_2O$.

a) How many **moles** of $CuSO_4 \cdot 5H_2O$ are needed?

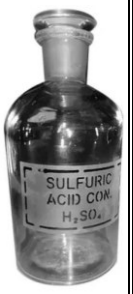
b) What **mass** of $CuSO_4 \cdot 5H_2O$ should you use?

9) You dissolved 50.0 g of sodium hydroxide in enough water to make 2.00-L of solution. What is the **concentration** (molarity) of the solution?

10) You are asked to prepare 50.0 mL of 0.600-M iron(III) chloride by dissolving $FeCl_3 \cdot 6H_2O$. What **mass** of salt should you use?

11) You need to prepare 500.0 mL of 40.0% (by volume) isopropyl alcohol in water. In point form, and with specific volumes, describe how to make the solution. Refer to two different types of appropriate lab glassware also.

12) **Concentrated sulfuric acid**, H_2SO_4, is labeled as 96.2% by mass with a density of 1.84 g/mL.



a) Assume you have 1000. g of the acid. What **mass** of sulfuric acid is in the solution?

b) How many **moles** of sulfuric acid are there?

c) We assumed we had 1000. g solution. Use two unit multipliers to find its **volume**, in L.

d) What is the **molarity** of the acid solution?

13) A lab tech needs to prepare 500.0 mL of 0.0400-M ammonium sulfate, $(NH_4)_2SO_4$. What mass should of the salt she use?

14) List steps to prepare the solution.

1.	
2.	
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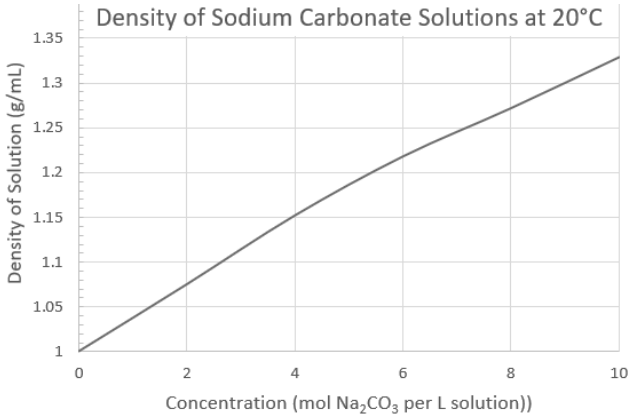


15) Examine the graph for these questions.

a) Identify the solute and solvent.

Solute	Solvent

b) What type of concentration is being used for the solutions in the graph?

c) A student prepared a solution by dissolving 21.2 g of sodium carbonate in enough water to make 100.0 mL of solution. What is the **concentration** of the solution?

d) What should be the **density** of the solution?

e) Both density and molarity change slightly based on temperature changes. Explain why.

16) You **pipet** 25.00 mL of 0.300-M NaCl solution into a petri dish and allow it to completely evaporate. What **mass** of salt will remain in the dish?

17) An experiment calls for 0.25 mol of sodium hydroxide, NaOH. What **volume** of a 0.10-M solution should be used?

18) What **volume** (in mL) of 6.00-M hydrochloric acid, HCl, will contain 10.0 g of the acid?

19) Explain what it means to **dilute** an aqueous solution. Mention both the <u>volume</u> and the <u>concentration</u> of the solution.

20) A student dilutes a 200.0 mL solution of 0.150-M sucrose solution to a new volume of 250.0 mL. Calculate the new **concentration**.

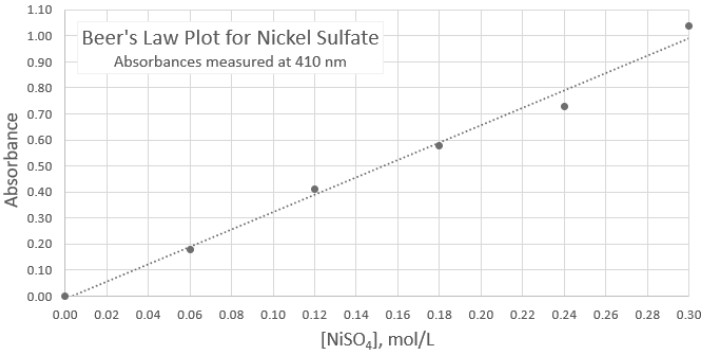
21) A student mixes 6.00 mL of distilled water with 4.00 mL of 0.400-M $CuSO_4$. What is the **concentration** after dilution?

22) You plan to dilute a 2.0-M stock solution to prepare 250.0 mL of 0.050-M solution? What **volume** of stock solution should you use?

23) A student pipets 8.00 mL of 0.160-M sodium sulfate into a test tube and then adds 4.00 mL of distilled water. What is the **concentration** of the solution after mixing?

24) You are given 20.0 mL of 0.500-M KOH and asked to use all of it to create a 0.200-M. What **volume** of water should you **add** to do this?

25) You decide to combine 50.0 mL of 0.240-M sucrose solution with 100.0 mL of 0.600-M sucrose. What will be the **concentration** of the new solution?



26) Solutions of nickel(II) sulfate were prepared. Violet colored light (410 nm) was passed through the solutions and the absorbance recorded. The Beer's Law plot above was created.

a) Estimate the **concentration** of a solution whose absorbance is 0.30. Include units.

b) 10.0 mL of a solution whose absorbance was 0.70 was diluted with the addition of 40.0 mL of water. What will be the absorbance for the new solution?

c) You want to prepare 50.0 mL of a nickel(II) sulfate solution whose absorbance will be 0.50. What **mass** of the salt should you use?

27) Explain <u>why</u> $\mathbf{C_1V_1 = C_2V_2}$ when diluting a solution.

Solution Concentration

Name: _____

In these problems, assume "concentration" refers to **molarity** unless stated otherwise.

1) A student dissolves 5.00 g of copper(II) nitrate trihydrate in water to make 100.0 mL solution. Calculate the **concentration** of the solution.

$Cu(NO_3)_2 \cdot 3H_2O$

$$5.00\,g \times \frac{1\ mol}{241.63\,g} \times \frac{1}{1000\,mL} \times \frac{1000\,mL}{1\ L} = 0.207\ mol/L$$

2) A student dissolved 20.0 g of calcium chloride, $CaCl_2$, to make 500.0 mL solution. What is the solution's **concentration**?

$$20.0\,g \times \frac{1\ mol}{110.98\,g} \times \frac{1}{500.0\,mL} \times \frac{1000\,mL}{1\ L} = 0.360\ mol/L$$

3) What is the **molarity** of a sucrose solution, ($C_{12}H_{22}O_{11}$), if 10.0 g of sucrose is dissolved to make 50.0 mL of solution?

$$n = \frac{m}{M} = \frac{10.0\,g}{342.34\,g/mol} = 0.0292\ mol$$

$$C = \frac{n}{V} = \frac{0.0292\ mol}{0.0500\,L} = 0.584\ M$$

4) The lab technician dissolved 12.8 g of naphthalene, $C_{10}H_8$, in ethanol to prepare 2.00 L of solution.

a) What is the solute and what is the solvent in this solution?

Solute = naphthalene

Solvent = ethanol

b) What is the solution's concentration?

$$12.8\,g\ C_{10}H_8 \times \frac{1\ mol}{128.18\,g} \times \frac{1}{2.00\,L} = 0.0499\ M$$

5) What **mass** of $Mg(NO_3)_2$ is needed to prepare 250.0 mL of 0.120-M solution?

$$250.0\,mL \times \frac{1\ L}{1000\,mL} \times \frac{0.120\ mol}{1\ L} \times \frac{148.33\,g}{1\ mol} = 4.45\,g\ Mg(NO_3)_2$$

6) A chemist has pipetted 10.00 mL of 0.0500-M $CaCl_2$ into a test tube. How many **moles** of $CaCl_2$ is this?

$$10.00\,mL \times \frac{1\ L}{1000\,mL} \times \frac{0.0500\ mol}{1\ L} = 5.00 \times 10^{-4}\ mol$$

OR $n = CV$

7) A student used a graduated cylinder to obtain 25.0 mL of ethanol. She poured the ethanol into a 200.0-mL volumetric flask and added distilled water to prepare a solution. Pure ethanol (C_2H_5OH) has a density of 0.789 g/mL.

a) How many **moles** of ethanol were used?

$$25.0\,mL\ C_2H_5OH \times \frac{0.789\,g}{1\,mL} \times \frac{1\ mol}{46.08\,g} = 0.428\ mol\ C_2H_5OH$$

b) Calculate the **molarity** of the solution.

$$C = \frac{n}{V} = \frac{0.428\ mol}{0.2000\,L} = 2.14\ M$$

c) How many **molecules** of ethanol are in the solution?

$$0.428\ mol \times \frac{N_A\ molec}{1\ mol} = 2.58 \times 10^{23}\ molecules\ C_2H_5OH$$

8) You need to prepare 100.0 mL of 0.200-M $CuSO_4$ by dissolving $CuSO_4 \cdot 5H_2O$.

a) How many **moles** of $CuSO_4 \cdot 5H_2O$ are needed?

$n = CV$
$= (0.200\,M)(0.1000\,L)$
$= 0.0200\ mol$

b) What **mass** of $CuSO_4 \cdot 5H_2O$ should you use?

$m = nM$
$= (0.0200\ mol)(249.71\ g/mol)$
$= 4.99\ g\ CuSO_4 \cdot 5H_2O$

9) You dissolved 50.0 g of sodium hydroxide in enough water to make 2.00-L of solution. What is the **concentration** (molarity) of the solution?

$n = \frac{m}{M} = \frac{50.0\ g}{40.00\ g/mol} = 1.25\ mol\ NaOH$

$C = \frac{n}{V} = \frac{1.25\ mol}{2.00\ L} = 0.625\ mol/L$

10) You are asked to prepare 50.0 mL of 0.600-M iron(III) chloride by dissolving $FeCl_3 \cdot 6H_2O$. What **mass** of salt should you use?

$50.0\ mL \times \frac{1\ L}{1000\ mL} \times \frac{0.600\ mol\ FeCl_3}{1\ L} \times \frac{1\ mol\ FeCl_3 \cdot 6H_2O}{1\ mol\ FeCl_3} \times \frac{270.32\ g}{1\ mol}$

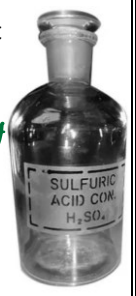
$= 8.11\ g\ FeCl_3 \cdot 6H_2O$

11) You need to prepare 500.0 mL of 40.0% (v/v) isopropyl alcohol in water. In point form, and with specific volumes, describe how to make the solution. Refer to two different types of appropriate lab glassware also.

$\frac{40.0}{100}(500.0\ mL) = 200.\ mL$ alcohol

- Use graduated cylinder to measure 200. mL of alcohol
- Pour it into a 500-mL volumetric flask
- Fill with distilled water to the mark on neck of flask
- Stopper, invert flask, shake to mix solution

12) **Concentrated sulfuric acid**, H_2SO_4, is labeled as 96.2% by mass with a density of 1.84 g/mL.



a) Assume you have 1000.0 g of the acid. What **mass** of sulfuric acid is in the solution?

$\frac{96.2}{100}(1000.0\ g) = 962\ g\ H_2SO_4$

b) How many **moles** of sulfuric acid are there?

$962\ g \times \frac{1\ mol}{98.08\ g} = 9.81\ mol\ H_2SO_4$

c) Use two unit multipliers to find the volume of the solution, in L.

$1000.0\ g \times \frac{1\ mL}{1.84\ g} \times \frac{1\ L}{1000\ mL} = 0.543\ L$

d) What is the **molarity** of the acid solution?

$C = \frac{n}{V} = \frac{9.81\ mol}{0.543\ L} = 18.1\ M$

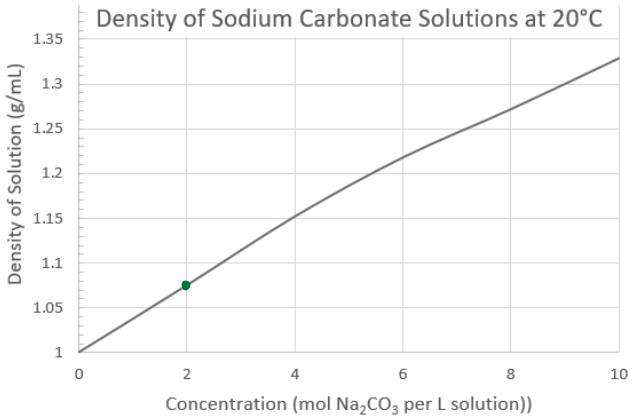
13) A lab tech needs to prepare 500.0 mL of 0.0400-M ammonium sulfate, $(NH_4)_2SO_4$. What mass should of the salt she use?

$500.0\ mL \times \frac{1\ L}{1000\ mL} \times \frac{0.0400\ mol}{1\ L} \times \frac{132.16\ g}{1\ mol}$

$= 2.64\ g\ (NH_4)_2SO_4$

14) List steps to prepare the solution.

1.	Use electronic balance to obtain 2.64 g of salt
2.	Transfer salt to a 500.0 mL volumetric flask
3.	Fill flask ~ ⅓ full with distilled water
4.	Stopper flask, swirl/shake to dissolve salt
5.	Fill flask to line on neck with more distilled water
6.	Stopper, invert flask, shake to mix ... repeat 3x



15) Examine the graph for these questions.

a) Identify the solute and solvent.

Solute	Solvent
Na_2CO_3	Water

b) What type of concentration is being used for the solutions in the graph?

Molarity

c) A student prepared a solution by dissolving ~~2.12~~ 21.2 g of sodium carbonate in enough water to make 100.0 mL of solution. What is the **concentration** of the solution?

$$21.2\text{ g } Na_2CO_3 \times \frac{1\text{ mol}}{105.99\text{ g}} \times \frac{1}{100.0\text{ mL}} \times \frac{1000\text{ mL}}{1\text{ L}}$$

$$= 2.00\text{ M}$$

d) What should be the **density** of the solution?

~ 1.07 or 1.08 g/mL

e) Both density and molarity change slightly based on temperature changes. Explain why.

Volume of a solution expands when heated.

$C = \frac{n}{V}$ $d = \frac{m}{V}$

both Conc + density will get smaller if V increases

16) You **pipet** 25.00 mL of 0.300-M NaCl solution into a petri dish and allow it to completely evaporate. What **mass** of salt will remain in the dish?

$$25.00\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{0.300\text{ mol}}{1\text{ L}} \times \frac{58.44\text{ g}}{1\text{ mol}}$$

$$= 0.438\text{ g NaCl}$$

17) An experiment calls for 0.25 mol of sodium hydroxide, NaOH. What **volume** of a 0.10-M solution should be used?

$$C = \frac{n}{V} \quad \cdots \quad V = \frac{n}{C} = \frac{0.25\text{ mol}}{0.10\text{ mol/L}}$$

$$V = 2.5\text{ L}$$

18) What **volume** of 6.00-M hydrochloric acid, HCl, will contain 10.0 g of the acid?

$$10.0\text{ g} \times \frac{1\text{ mol}}{36.46\text{ g}} \times \frac{1\text{ L}}{6.00\text{ mol}} \times \frac{\text{mL}}{\text{L}}$$

$$= 45.7\text{ mL}$$

19) Explain what it means to **dilute** an aqueous solution. Mention both the <u>volume</u> and the <u>concentration</u> of the solution.

- to dilute a solution is to make it less concentrated by adding more solvent.
- Volume will increase

20) A student adds 50.0 mL water to 200.0 mL of 0.150-M sucrose solution. Calculate the new **concentration**.

Dilution: $C_1V_1 = C_2V_2$

$$C_2 = \frac{C_1V_1}{V_2} = \frac{(0.150\text{M})(200.0\text{mL})}{250.0\text{ mL}}$$

$$C_2 = 0.120\text{ M}$$

21) A student mixes 6.00 mL of distilled water with 4.00 mL of 0.400-M $CuSO_4$. What is the **concentration** after dilution?

Dilution: $C_1V_1 = C_2V_2$

$C_2 = \frac{C_1V_1}{V_2} = \frac{(0.400\,M)(4.00\,mL)}{10.00\,mL}$ ← total volume

$C_2 = 0.160\,M$

22) You plan to dilute a 2.0-M stock solution to prepare 250.0 mL of 0.050-M solution? What **volume** of stock solution should you use?

Dilution: $C_1V_1 = C_2V_2$

$V_1 = \frac{C_2V_2}{C_1} = \frac{(0.050\,M)(250.0\,mL)}{2.0\,M}$

$V_1 = 6.25\,mL$ of stock soln

23) A student pipets 8.00 mL of 0.160-M sodium sulfate into a test tube and then adds 4.00 mL of distilled water. What is the **concentration** of the solution after mixing?

Dilution: $C_1V_1 = C_2V_2$

$C_2 = \frac{C_1V_1}{V_2} = \frac{(0.160\,M)(8.00\,mL)}{12.00\,mL}$

$C_2 = 0.107\,M$

24) You are given 20.0 mL of 0.500-M KOH and asked to use all of it to create a 0.200-M. What **volume** of water should you **add** to do this?

Dilution: $C_1V_1 = C_2V_2$

$V_2 = \frac{C_1V_1}{C_2} = \frac{(0.500\,M)(20.0\,mL)}{0.200\,M}$

$V_2 = 50.0\,mL$ $\quad 50.0\,mL - 20.0\,mL = 30.0\,mL$ water to add

25) You decide to combine 50.0 mL of 0.240-M sucrose solution with 100.0 mL of 0.600-M sucrose. What will be the **concentration** of the new solution?

First soln: $n = CV = (0.240M)(0.0500\,L)$

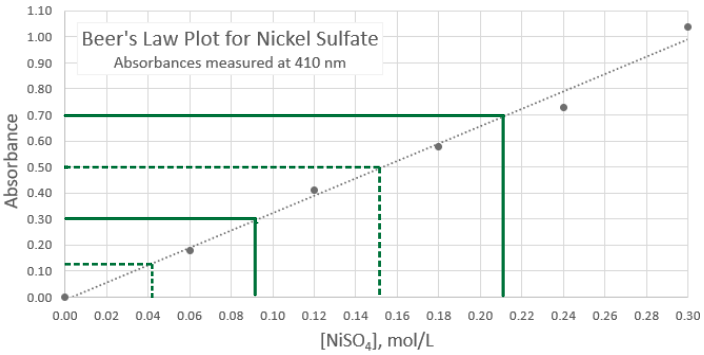
$n = 0.0120$ mol suc.

2nd soln: $n = (0.600M)(0.1000\,L)$

$= 0.0600$ mol suc

$C = \frac{n_{TOT}}{V_{TOT}} = \frac{0.0120 + 0.0600\,mol}{0.0500\,L + 0.1000\,L}$

$C = 0.480\,M$



26) Solutions of nickel(II) sulfate were prepared. Violet colored light (410 nm) was passed through the solutions and the absorbance recorded. The Beer's Law plot above was created.

a) Estimate the **concentration** of a solution whose absorbance is 0.30. Include units.

From graph: $\sim 0.091\,M$

b) 10.0 mL of a solution whose absorbance was 0.70 was diluted with the addition of 40.0 mL of water. What will be the absorbance for the new solution?

Conc $\approx 0.21\,M$

$C_2 = \frac{C_1V_1}{V_2} = \frac{(0.21\,M)(10.0\,mL)}{(50.0\,mL)} = 0.042\,M$

Abs $\approx 0.12\,M$ Answers may Vary

c) You want to prepare 50.0 mL of a nickel(II) sulfate solution whose absorbance will be 0.50. What **mass** of the salt should you use?

Conc $\approx 0.152M$

$n = CV = (0.152M)(0.0500L)$

$= 0.00760$ mol

$m = nM = (0.0076\,mol)(154.75\,g/mol)$

$= 1.18\,g\ NiSO_4$

27) Explain <u>why</u> $C_1V_1 = C_2V_2$ when diluting a solution.

When a solution is diluted, more solvent is added. The moles of solute won't change.

$C_1V_1 = C_2V_2$

moles before = moles after.