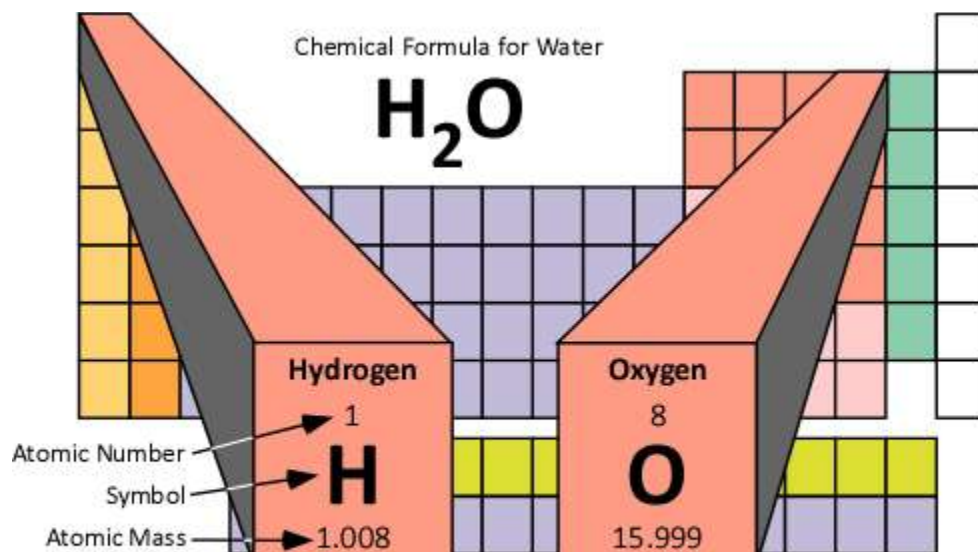


Moles

What is Molar Mass?

- Molar mass is the weight of one **mole** (or 6.02×10^{23} molecules) of any chemical compounds.



$$(2 \text{ Atoms} \times 1.008) + (1 \text{ Atom} \times 15.999)$$

$$\text{Molar Mass} = 18.015 \text{ g/mol}$$

Try these problems on your own

- Find the molar mass of ...
 1. NaCl
 2. Mg
 3. PO_4
 4. $\text{Mg}_3(\text{PO}_4)_2$

Example Problems

- Find the molar mass of ...

1. $\text{NaCl} = 22.98 + 35.35 = \underline{58.48 \text{ g/mole}}$

2. $\text{Mg} = \underline{24.30 \text{ g/mole}}$

3. $\text{PO}_4 = 30.97 + (4 \times 15.99) = \underline{94.93 \text{ g/mole}}$

4. $\text{Mg}_3(\text{PO}_4)_2 =$
 $(3 \times 24.30) + (2 \times 30.97) + (8 \times 15.99) =$
 $\underline{262.76 \text{ g/mole}}$

Changing moles into grams

- Many calculations need to use moles, but you cannot measure out moles directly in a lab. Instead we need to use grams.
- This is why it is important to know how to convert moles into grams.



Moles → Grams

- Let's look at a shopping problem.
 - ❖ 1 video game costs \$24.30. If you want to buy 3 video games, how much will it cost?

3 video games	$\frac{\$24.30}{1 \text{ video game}}$	= \$72.90
--------------------------	--	-----------

Moles → Grams

- Let's look at a chemistry problem.
 - ❖ 1 mole of Mg weighs 24.30 g . If you want 3 moles of Mg, how much will it weigh?

$$\frac{3 \text{ moles of Mg}}{1 \text{ mole of Mg}} \times \frac{24.30 \text{ g}}{1} = 72.90 \text{ g}$$

Moles → Grams

- Let's look at another shopping problem.
 - ❖ 1 dress costs \$30.97. 1 bracelet costs 15.99.
If 3 sisters want to wear 1 dress with 4 bracelets, what is the sisters' total bill?

Each sister = $(1 \text{ dress} \times \$30.97) + (4 \text{ brac} \times \$15.99) = \$94.93$

3 sisters	$\$94.93$	$= \$284.79$
	1 sister	

Moles → Grams

- Let's look at another chemistry problem.
 - ❖ 1 mole of P weighs 30.97g. 1 mole of O weighs 15.99 g. If there are 3 moles of (phosphate) PO_4 , what is the total mass?

$$\text{PO}_4 = (1 \text{ P} \times 30.97\text{g}) + (4 \text{ O} \times 15.99\text{g}) = 94.93\text{g}$$

3 mole PO_4	94.93 g 1 mole PO_4	= 284.79 g
--	--	------------

Grams → Moles

- Let's look at a shopping problem.
 - ❖ 1 video game costs \$24.30. If you have \$97.40 how many video games can you buy?

\$97.40	1 video game	= 4 video games
	\$24.30	

Grams $\rightarrow$ Moles

- Let's look at a chemistry problem.
 - ❖ 1 mole of Mg weighs 24.30 g . If you want 97.2 grams of Mg, how many moles do you have?

$$\frac{97.2 \text{ g Mg}}{24.30 \text{ g Mg}} \times 1 \text{ mole} = 4 \text{ moles}$$

Try these problems on your own

- Sally needs to measure out 4 moles of CaCl_2 (calcium chloride). How many grams will she measure?
- Susie needs to calculate how many moles are in 5.7 grams of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

Grams $\rightarrow$ Moles or Moles $\rightarrow$ Grams

- Sally needs to measure out 4 moles of CaCl_2 (calcium chloride). How many grams will she measure?

❖ 443.92 grams

- Susie needs to calculate how many moles are in 5.7 grams of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

❖ 0.0167 moles

Teeny Tiny Things!

- Farmers always box eggs in groups of 12, and we call that a dozen.

❖ If we have 3 dozen then

$$\frac{3 \text{ dozen}}{1 \text{ dozen}} \times 12 \text{ eggs} = 36 \text{ eggs}$$

❖ If we have 50 eggs then

$$\frac{50 \text{ eggs}}{12 \text{ eggs}} \times 1 \text{ dozen} = 4.16 \text{ dozen}$$

Teeny Tiny Things!

- Avagadro's determined that 1 mole is equal to 6.02×10^{23} atoms.

❖ If we have 3 moles then

$$\frac{3 \text{ moles}}{1 \text{ mole}} \times 6.02 \times 10^{23} \text{ atoms} = 1.806 \times 10^{24} \text{ atoms}$$

❖ If we have 50,000,000,000 atoms then

$$\frac{5 \times 10^{10} \text{ atoms}}{6.02 \times 10^{23} \text{ atoms}} = 8 \times 10^{-14} \text{ moles}$$

Try these problems on your own

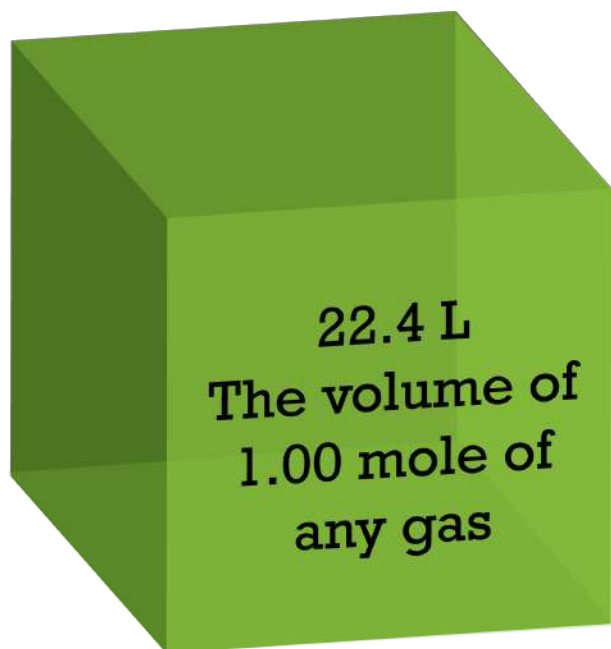
- How many atoms are present in 5 moles of H_2O ?
- How many moles are in 3.61×10^{24} molecules?

Teeny Tiny Things!

- How many atoms are present in 5 moles of H_2O ?
❖ 3.01×10^{24} atoms
- How many moles are in 3.61×10^{24} molecules?
❖ 6 moles

Moles $\rightarrow$ Volume

- Avagadro determined that 1.00 mole of any gas at STP has a volume of 22.4 Liters.



Volume

- Basically,
22.4 L of any gas is equal to 1 mole.

❖ 1 mole of Neon gas (Ne) = 22.4 L

❖ 1 mole of hydrogen gas (H₂) = 22.4 L

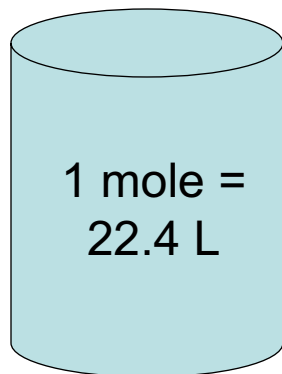
❖ 1 mole of water vapor (H₂O) = 22.4 L

See the pattern???

Moles $\rightarrow$ Volume

- What is the volume of 3 moles of H_2 gas?

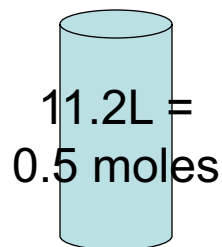
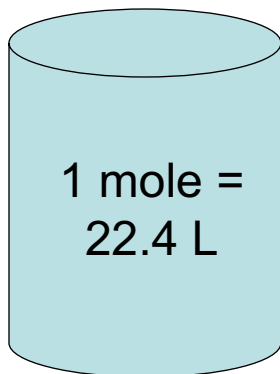
$$\frac{3 \text{ moles } \text{H}_2}{1 \text{ mole } \text{H}_2} \times 22.4 \text{ L} = 67.2 \text{ L}$$



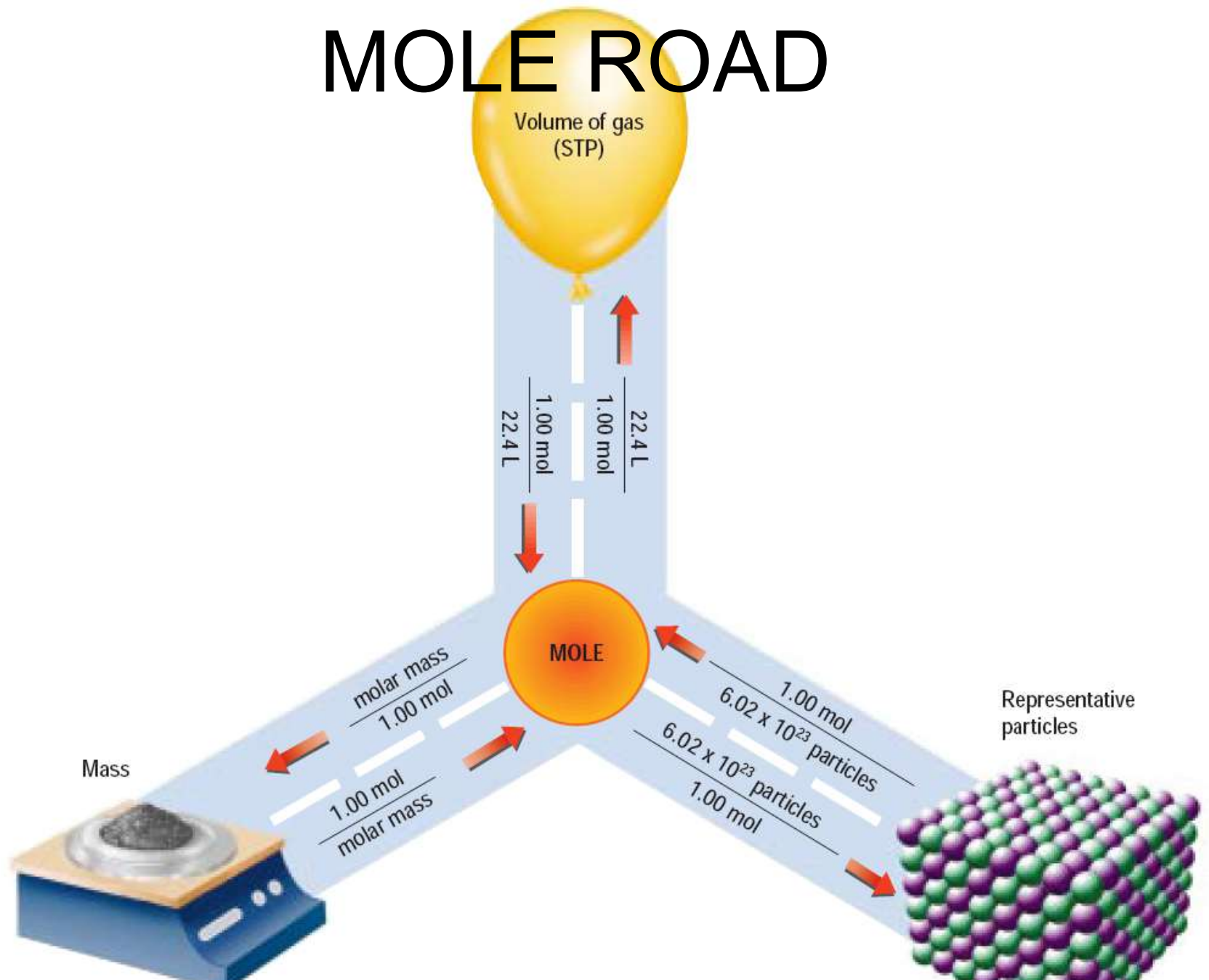
Volume $\rightarrow$ Moles

- How many moles are in 11.2 L of H_2 gas?

$$\frac{11.2 \text{ L } \cancel{\text{H}_2}}{22.4 \text{ L } \cancel{\text{H}_2}} \times 1 \text{ mole } \text{H}_2 = 0.5 \text{ moles } \text{H}_2$$

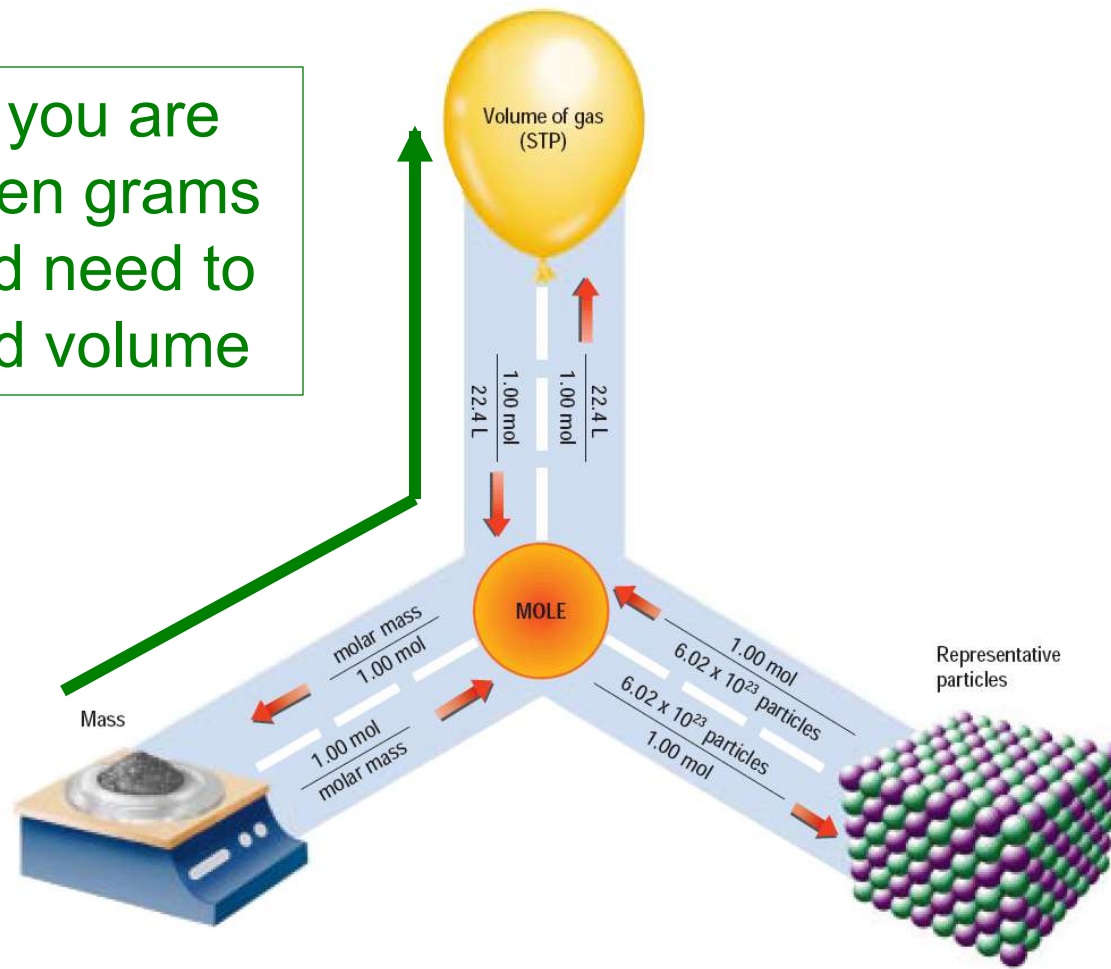


MOLE ROAD



You can follow the road to do multiple step problems

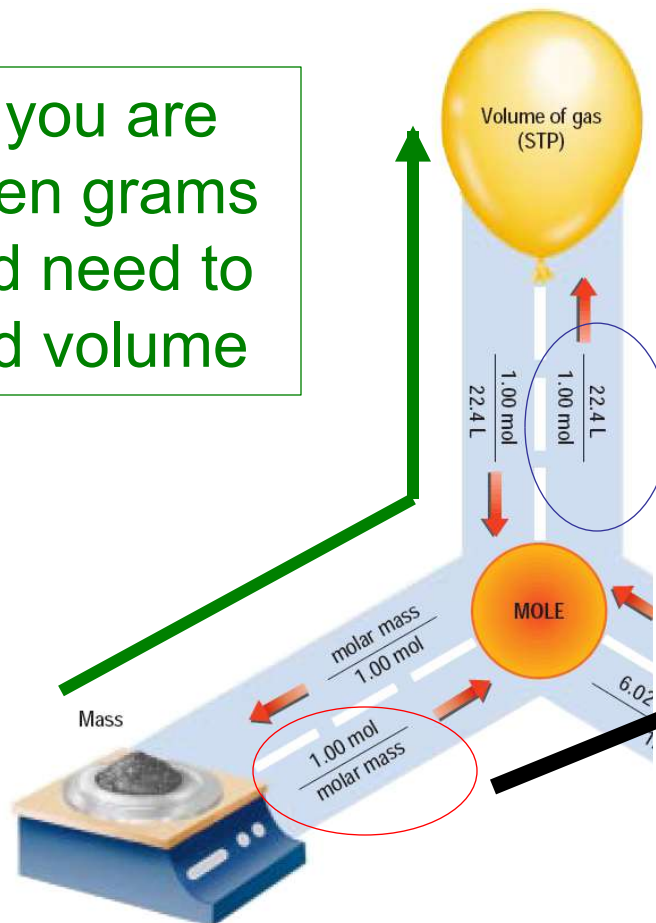
If you are given grams and need to find volume



You can follow the road to do multiple step problems

If you are given grams and need to find volume

What is the volume of 5.0 grams of CO₂ gas?



$$\frac{5.0 \text{ g CO}_2}{44 \text{ g CO}_2} \times \frac{1 \text{ mole CO}_2}{1 \text{ mole CO}_2} \times \frac{22.4 \text{ L CO}_2}{1 \text{ mole CO}_2} =$$

2.55 L CO₂

Try these problems on your own

- George needs to know the volume of 2.5 grams of helium gas.
- Timmy has 78.4 L of Ne gas, how many atoms does he have?

Try these problems on your own

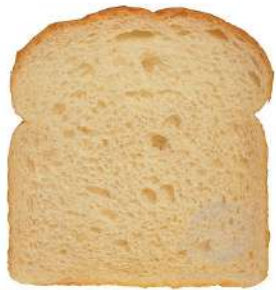
- George needs to know the volume of 2.5 grams of helium gas.

❖ 14 Liters

- Timmy has 78.4 L of Ne gas, how many atoms does he have?

❖ 2.1×10^{24} atoms

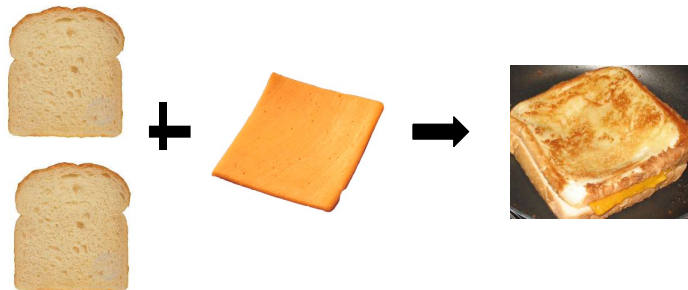
Cheese Sandwich Ratio



+



Cheese Sandwich



The ratio of Bread to Cheese is 2:1

So does that mean if you have 4 pieces of bread, how many slices of cheese will you need?

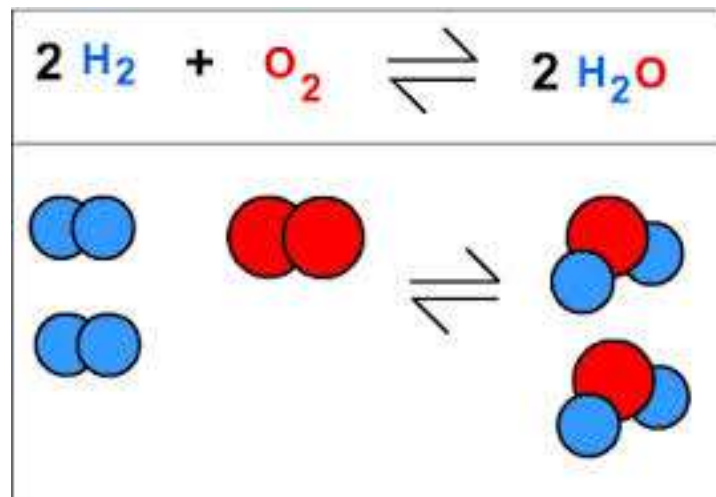
4 slices of bread	1 slice of cheese	=	2 cheese slices
	2 slices of bread		

Mole Ratio

- The Balanced chemical equation tells us the Mole Ratio of the compounds.

- Watch this video:

[Mole to Mole Video](#)



2 : 1 : 2

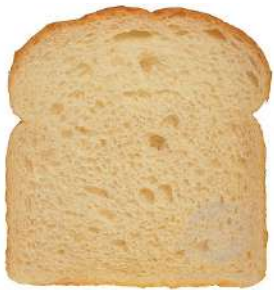
Try these problems on your own

- Use this balanced equation to answer the following questions: $2\text{NaN}_3 \rightarrow 2\text{Na} + 3\text{N}_2$
- If 5 moles of nitrogen are produced, how many moles of sodium nitride were decomposed?
- If 10.5 moles of sodium nitride were decomposed, how many moles of sodium were produced?

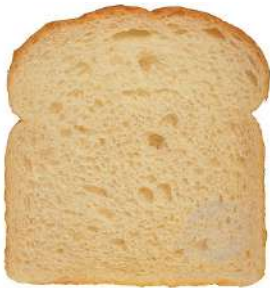
Try these problems on your own

- Use this balanced equation to answer the following questions: $2\text{NaN}_3 \rightarrow 2\text{Na} + 3\text{N}_2$
- If 5 moles of nitrogen are produced, how many moles of sodium nitride were decomposed?
❖ 3.33 moles of NaN_3
- If 10.5 moles of sodium nitride were decomposed, how many moles of sodium were produced?
❖ 10.5 moles of Na

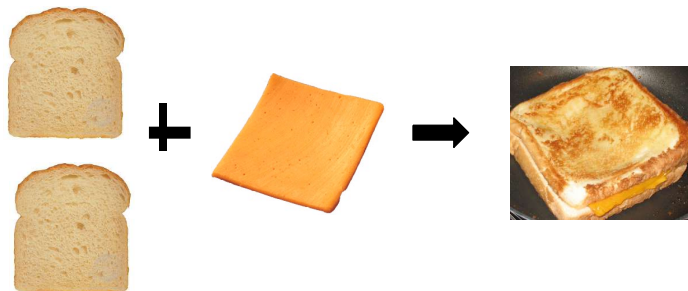
Cheese Sandwich



+



Cheese Sandwich



If each bread slice costs \$0.10, then if you were given \$4.00 worth of bread, how many bread slices do you have?

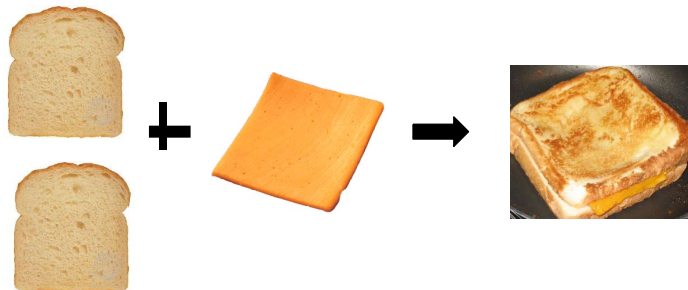
\$4.00		1 bread slice	=	40 bread slices
		\$0.10		

The ratio of Bread to Cheese is 2:1

So does that mean if you spend \$4.00 on bread you have to spend \$2.00 on cheese?

NO!

Cheese Sandwich



If you have 40 slices of bread, how many slices of cheese do you need? The ratio of bread to cheese is 2 bread : 1 cheese.

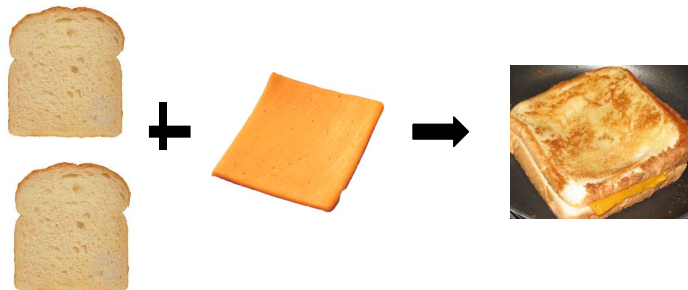
40 bread	1 cheese	= 20 cheese slices
	2 bread	

If each cheese slice costs \$0.25, how much did you spend on cheese?

20 cheese	\$0.25	= \$5.00
	1 cheese	

So if you spend \$4.00 on bread you have to spend \$5.00 on cheese?

Cheese Sandwich



The point of the Cheese Sandwich problem is that you cannot use the ratio on \$money\$, you have to convert it to number of things (moles) in order to use the ratio and then convert back to the unit you were using.

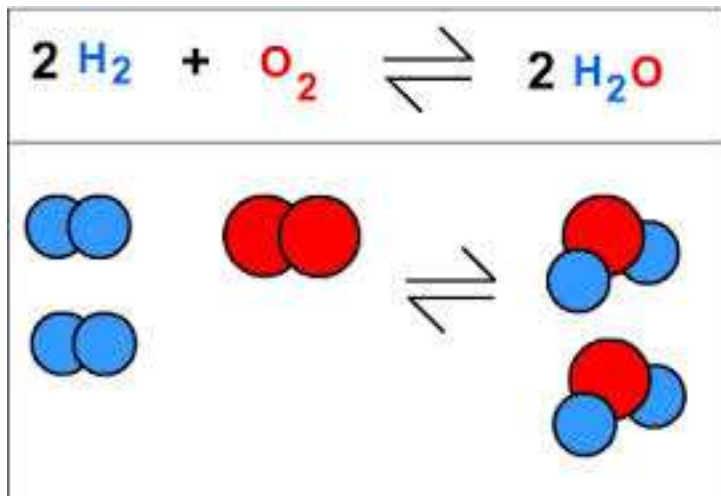
Gram $\rightarrow$ Gram

- Let's show the setup of the cheese sandwich problem all in one big step:

\$4.00 bread	1 bread slice	1 cheese slice	\$0.25 cheese	= \$5.00
	\$0.10 bread	2 bread slice	1 cheese slice	

Gram → Gram

- Let's try a chemistry problem

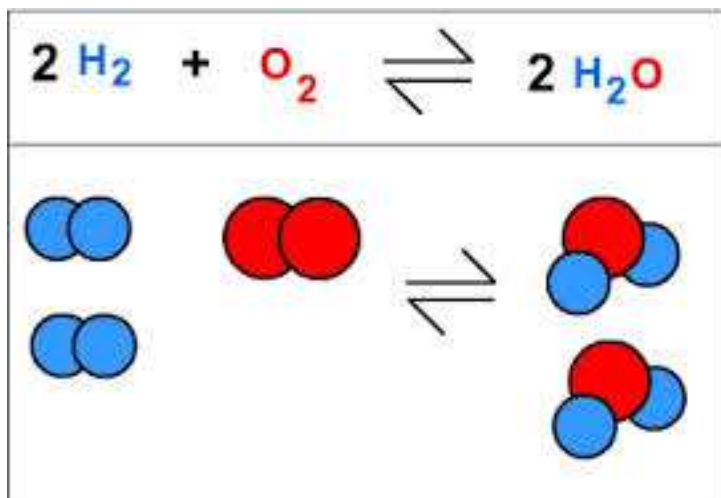


If you have 10 grams of H_2 ,
how many grams of O_2 will
you need to complete the
reaction?

10 grams H_2	1 mole H_2	1 mole O_2	1 mole O_2	$= 79.16 \text{ g O}_2$
	2.02 g H_2	2 mole H_2	1 mole O_2	

Gram → Gram

- Let's try another chemistry problem



If you have 20 grams of O₂,
how many grams of H₂ will
you need to complete the
reaction?

20 grams O ₂	1 mole O ₂	2 mole H ₂ Ratio Step	2 mole H ₂ Molar Mass	= 2.53 g H ₂
	31.98 g O ₂ Molar Mass	1 mole O ₂	1 mole H ₂	

Try these problems on your own

- Use this balanced equation to answer the following questions: $2\text{NaN}_3 \rightarrow 2\text{Na} + 3\text{N}_2$
- If 28.0 grams of nitrogen are produced, how many grams of sodium nitride were decomposed?
- If 32.5 grams of sodium nitride were decomposed, how many grams of sodium were produced?

Try these problems on your own

- Use this balanced equation to answer the following questions: $2\text{NaN}_3 \rightarrow 2\text{Na} + 3\text{N}_2$
- If 28.0 grams of nitrogen are produced, how many grams of sodium nitride were decomposed?
 - ❖ 43.3 grams of NaN_3
- If 32.5 grams of sodium nitride were decomposed, how many grams of sodium were produced?
 - ❖ 11.5 grams Na

Concentration of Solutions

How would you compare the concentrations of these two cups of tea?



DILUTE



CONCENTRATED

Expressing Concentration?

How do we express the concentration of solutions involving a solid solute and a liquid solvent?

Molarity



IMPORTANT DEFINITION

- For solutions with a solid solute and a liquid solvent:

Molarity (M) = $\frac{\text{moles of solute}}{\text{liters of solution}}$

A **practical** problem?

- To prevent dehydration an IV of glucose and sodium chloride is administered to many hospital patients. 100 ml of IV solution contains 5.1 grams of Glucose ($\text{C}_6\text{H}_{12}\text{O}_6$). What is the molarity (M) of the solution?



Step 1

Make sure the units are correct to calculate molarity (M).

Hint: Moles and Liters

5.1 grams, 100 milliliters

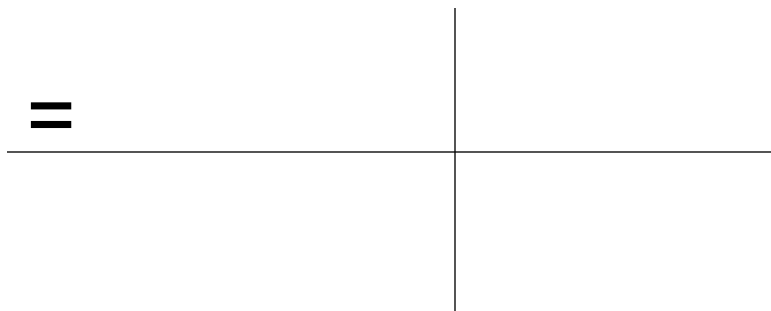
Are the units correct?

Step 2

- Convert to the correct units.

1 mole $\text{C}_6\text{H}_{12}\text{O}_6$ = _____ grams

=



Still.... Step 2

- How many liters in 100 mL?

$$100 \text{ mL} = 0.1 \text{ L}$$

King(Kilo)

Henry (Hecto)

Died (Deca)

By (Base)

Drinking (Deci)

Chocolate (Centi)

Milk (Milli)

Step 3:

Molarity (M) = $\frac{\text{moles of solute}}{\text{liters of **solution**}}$

$$\text{Molarity (M)} = \frac{0.028 \text{ moles C}_6\text{H}_{12}\text{O}_6}{0.100 \text{ liters}}$$

$$= 0.28 \text{ M}$$

Summarize Molarity

Step 1: Make sure the units are correct to calculate molarity (M).

Step 2: Convert to the correct units

Step 3: Molarity (M) = $\frac{\text{moles of solute}}{\text{liters of solution}}$

Kool-Aid Lab

1. Using your assigned grams of Kool-Aid calculate the Molarity.
2. Use a clean weigh-boat to weigh the Kool-Aid
3. Add the Kool-Aid to the flask first and then fill to the line with water from the water fountain.
4. Arrange bottles at front of the room in order of increasing concentration.

Kool-Aid Lab Questions

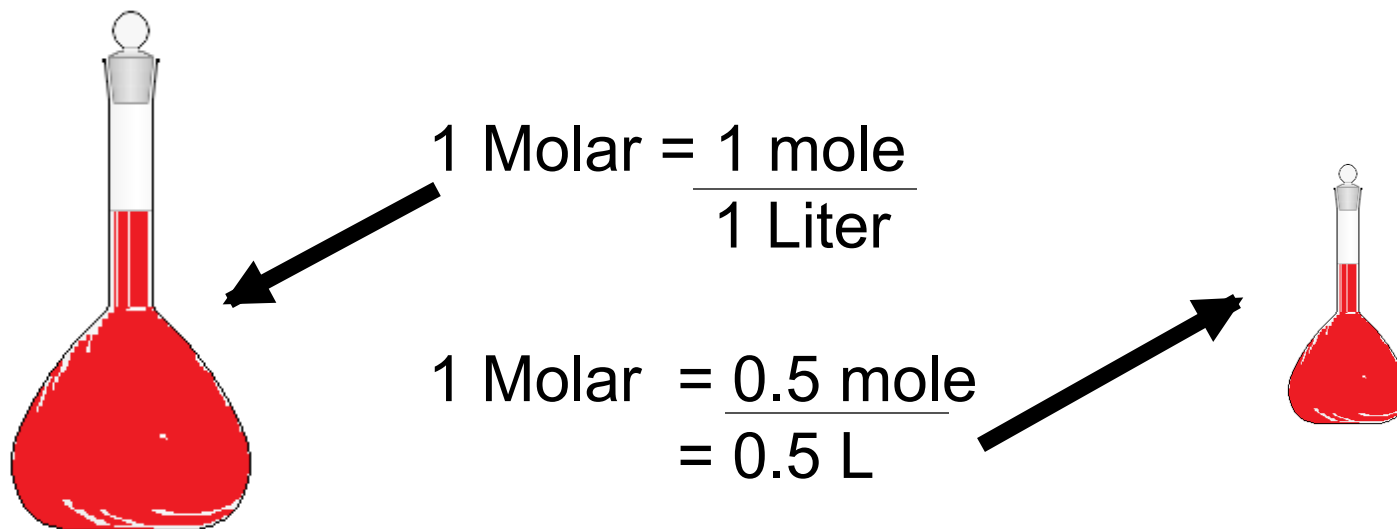
1. On the Kool-Aid label the manufacturer recommends 0.24M. Calculate the grams of the recommended Kool-Aid concentration needed in 500 mL?
2. Which concentration tasted best to you?
3. How does it compare to the manufacturer's recommendation?
4. Complete the practice problems and glue them into this section

Molarity Calculations

1. 0.48M
2. 0.125M
3. 20 moles
4. 0.02 moles
5. 0.02 moles
6. 1.16 grams
7. 147 grams
8. 1.38 mL
9. 250 mL

Molarity= moles / Liters

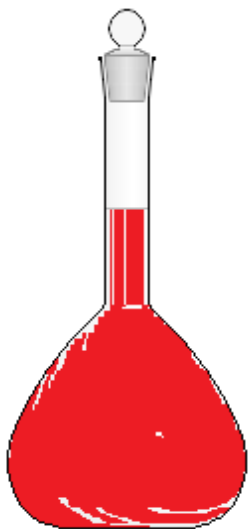
- Molarity = the moles of solute per Liter of solution.



Smaller volume = less moles of solute = same concentration

Molarity Review

- Molarity = the amount of moles per Liter of solution.



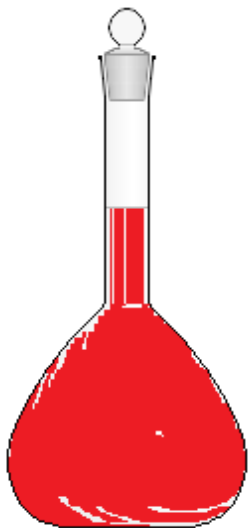
Your koolaid solution contains 0.125 moles in 500 mL. What is the Molarity?

$$M = \frac{\text{moles}}{\text{Liters}} \quad X = \frac{0.125 \text{ mol}}{0.5 \text{ L}}$$

$$X = 0.25 \text{ M}$$

Molarity Review

- Molarity = the amount of moles per Liter of solution.



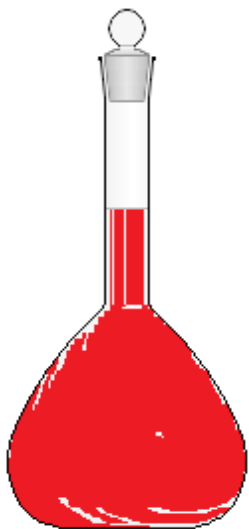
Your koolaid solution Molarity is 0.3M, how many L of solution do you need if you're using 0.2 moles of solute?

$$M = \frac{\text{moles}}{\text{Liters}} \quad 0.3 \text{ M} = \frac{0.2 \text{ mol}}{X \text{ L}}$$

$$X = 0.67 \text{ L}$$

Molarity Review

- Molarity = the amount of moles per Liter of solution.



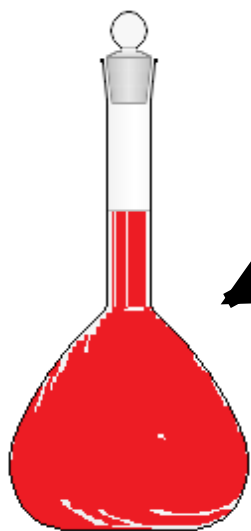
Your koolaid solution Molarity is 0.3M, how many moles of solute do you need if you're solution totals 400mL?

$$M = \frac{\text{moles}}{\text{Liters}} \quad 0.3 \text{ M} = \frac{X \text{ mol}}{0.4\text{L}}$$

$$X = 0.12 \text{ mol}$$

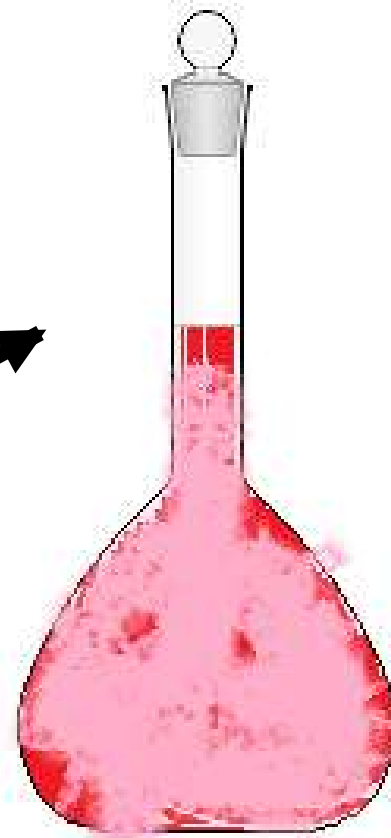
Molarity: $M_1V_1 = M_2V_2$

- Molarity = the amount of moles per Liter of solution.



$$1 \text{ Molar} = \frac{1 \text{ mole}}{1 \text{ Liter}}$$

$$0.5 \text{ Molar} = \frac{1 \text{ mole}}{2 \text{ L}}$$



More Volume = lower concentration

Molarity: $M_1V_1 = M_2V_2$

Joe wants to make 2 L of a 3M solution. What volume of a 5M solution does he need to add?

$$M_1 = 3M$$

$$V_1 = 2L$$

What Variables do you know?

$$M_2 = 5M$$

$$V_2 = X$$

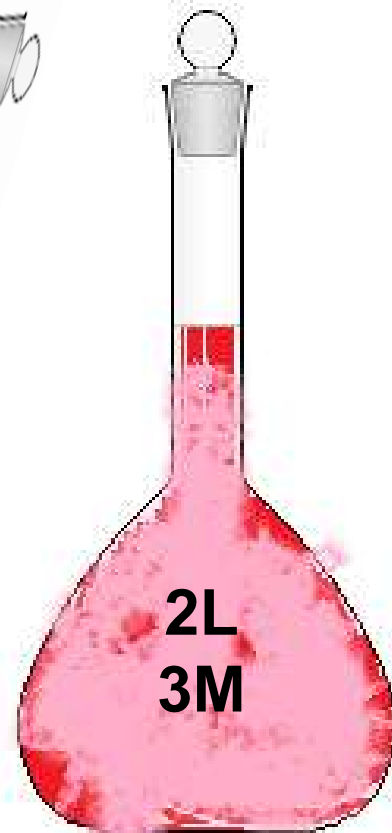
$$(3) (2) = (5) (X)$$

$$6 = 5 (X)$$

$$6 = X$$

$$X = 1.2 L$$

$$\frac{6}{5}$$



Try these problems on your own

- Alex wants to make 300 mL of a 0.5 M solution of HCl. How many moles of HCl will he need? (Hint: change mL into L)
- Molly made a 2 M solution of NaOH. If she used 0.25 moles of sodium hydroxide, what was the volume of her solution?

Try these problems on your own

- Alex wants to make 300 mL of a 0.5 M solution of HCl. How many moles of HCl will he need? (Hint: change mL into L)
❖ 0.15 moles HCl
- Molly made a 2 M solution of NaOH. If she used 0.25 moles of sodium hydroxide, what was the volume of her solution?
❖ 0.125 L

Mole Conversions meets Molarity Problems

- Alex wants to make 300 mL of a 0.5 M solution of HCl. How many **GRAMS** of HCl will he need? (Hint: change mL into L)

Step 1: Solve for moles

Step 2: Change moles into grams

$$0.5\text{M} = \frac{X}{0.3\text{ L}}$$

$$(0.5)(0.3) = X$$

$$0.15\text{ moles} = X$$

0.15 moles HCl	36.46 grams HCl = 5.47 g HCl
	1 mole HCl

Try these problems on your own

- Molly made a 2 M solution of NaOH. If she used 10 grams of sodium hydroxide (NaOH), what was the volume of her solution?

Step 1: Change grams into moles

Step 2: solve for volume

Try these problems on your own

- Molly made a 2 M solution of NaOH. If she used 10 grams of sodium hydroxide (NaOH), what was the volume of her solution?

Step 1: Change grams into moles

Step 2: solve for volume

❖ 0.125 L