Chapter 10

Warm Up

- How many minutes are in 30 hours?
- How many eggs are in 4.5 dozen?

- How many atoms are in $Ca_3(PO_3)_2$?
- How many atoms are in $Fe_2(CO_3)_3$?

- Where can you find atomic mass?

Today's Agenda

- QOTD: What is a mole? How do chemists measure and convert in moles?

- Intro to the mole
- Using the mole roadmap!
- Conversion practice
- Homework due Friday: Chapter 10 88-120 evens

The Mole

- The __mole__ (mol) is the unit used to measure the amount of a substance.

Much like you talk about a pair, or dozen, the mole makes it easier to talk about amounts of compounds and elements.

- The mole is a convenient way to convert __mass__ to __volume__ or "__count__" (meaning how many).

Avogadro's Number

- Avogadro's number = 6.02×10^{23} particles/mol

He determined the volume of 1 mol of gas, so he named his discovery after himself, of course.

Because elements and compounds are so small, it is hard to describe their amounts with the same mass and volume we use describe milk or body weight.

Representative Particles

- If you measure a mole of water, you measure

  1 water molecule

- If you measure a mole of copper you measure

  1 copper atom

- If you measure a mole of sodium chloride, you measure the NaCl formula unit (formula mass)

Conversions

- If you know that 1 dozen eggs = 12 eggs, and you buy 3 and a half dozen how many eggs do you have??

- $3.5 \text{ dozen} \times \frac{12 \text{ eggs}}{1 \text{ dozen}} = 42 \text{ eggs}$

- Mole conversions are done the same way!

Mole Road Map!

Mass (g) ⇄ **Mole** ⇄ **Volume (L)**

x MM g/mol

÷ MM g/mol

x 22.4 L/mol

÷ 22.4 L/mol

of a gas at STP
T = 273K. 0 °C
P = 1 atm,
760 mmHg
101 KPa

x 6.022 x 10^{23} count/mol

÷ 6.022 x 10^{23} count/mol

Count

(particles, molecules, atoms, formula units(F.U.))

Mole/Count Conversions

- How many molecules are there in 2.5 mol of glucose?

$$2.5 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 1.5 \times 10^{24} \text{ molecules glucose}$$

- How many atoms are there in 3 mol of Aluminum metal?

$$3 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 1.8 \times 10^{24} \text{ atoms Al}$$

More Mole/Count Conversions

- How many moles are there in 2.3×10^{24} molecules of Fe_2O_3 (rust)?

$$2.3 \times 10^{24} \text{ molecules} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} = 3.82 \text{ mol } Fe_2O_3$$

- How many moles are there in 1.42×10^{24} molecules of HF?

$$1.42 \times 10^{24} \text{ molecules} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molecules}} = 2.36 \text{ mol HF}$$

Mole/Mass Conversions

- Molar mass/molecular weight – mass listed on the periodic table for the elements.

- If you are solving the mol/mass conversion of an _element_ – use _atomic mass_ on table.
- If you are solving the mol/mass conversion of a _compound_ – _add up_ the atomic masses of the elements included in the compound.

Find Molar Mass

- Fe – 55.9 g/mol
- Fe_2O_3 - (55.9 g/mol x 2)+(16 g/mol x 3) = 160 g/mol
- CO_2 - (12 g/mol)+(16 g/mol x 2) = 44 g/mol
- $Ca_3(PO_4)_2$ -(40 g/mol x 3)+(31 g/mol x 2)+(16g/mol x 8) = 310 g/mol

Mol/Mass Conversions

- How many grams are in 2 moles of sodium?

$$2 \text{ mol Na} \times \frac{23 \text{ g Na}}{1 \text{ mol Na}} = 46 \text{ g Na}$$

- How many moles are in 4 g of $CuCl_2$?

$$4 \text{ g } CuCl_2 \times \frac{1 \text{ mol } CuCl_2}{134 \text{ g } CuCl_2} = 0.03 \text{ mol } CuCl_2$$

Warm Up

- How many molecules are in 1.3 moles of sodium sulfide?
- How many moles are in 7.2 grams of barium hydroxide?
- How many moles are contained in 4.2×10^{25} atoms of V metal?

Today's Agenda

- Question of the Day: What is the method for mole conversions with two steps?

- Review mole conversions from yesterday!
- Using moles to complete two step conversions.
- Volume conversions and STP calculations.

Mole Road Map!

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x 6.022 x 10^{23} count/mol

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Count

(particles, molecules, atoms, formula units(F.U.))

Mol/Mass Conversions from Yesterday

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Conversions

- 1. How many molecules are there in 5 mol of ethylene glycol?
- 2. Find the number of atoms in 23 g of Mn?
- 3. a)How many moles are there in 20 g of Cu?

  b) in 5 g of NaCl?

- 5. Determine the mass in grams:
- a) 3.57 mol Al
- b) 42.6 mol Si
- c) 34.6 mol $C_2H_6O_2$
- d) 2.13 mol CaF_2

2 – Step Conversions

- How many atoms are there in 6 grams of Ni?

$$6 \text{ grams Ni} \times \frac{1 \text{ mol Ni}}{59 \text{ grams Ni}} \times \frac{6.02 \times 10^{23} \text{ atoms Ni}}{1 \text{ mol Ni}} = 6.12 \times 10^{22} \text{ atoms Ni}$$

- How many grams are there in 5.5×10^{22} atoms of He?

$$5.5 \times 10^{22} \text{ atoms He} \times \frac{1 \text{ mol He}}{6.02 \times 10^{23} \text{ atoms He}} \times \frac{4 \text{ g He}}{1 \text{ mol He}} = 0.366 \text{ grams He}$$

2 – Step Conversions

- Go to the ROADMAP and map out the route from what you are GIVEN to what you are to asked to FIND.

- Note the conversion factor (MM or Av's #) as well as the operation (x or ÷)!

- Set up your conversion and cancel units!!

Try These!

- How many atoms?
- 0.230 g Pb
- 11.5 g Hg
- 4.56×10^{-3} g $MnCl_2$

- What is the mass (g)?
- 3.4×10^{22} atoms He
- 1.25×10^{15} atoms Na_3N
- 2.5×10^{25} atoms MgS

Warm Up!

- How many atoms are in 0.25g of strontium carbonate?

- How many g make up 6.03×10^{24} atoms of Au?

- If you need to find moles from a given mass, what conversion factor do you use? What mathematical operation?

Today's Agenda

- QOTD: How do you convert to volume at STP?

- Homework questions??
- Volume conversions
- Pressure conversions
- Empirical formula practice!

Mol/Volume Conversions

- 1 mol of any _gas_ at STP is 22.4 L/mol.

- Usual gases are He, H_2, F_2, Cl_2, I_2, N_2, O_2, CO_2, HCN, and H_2S

- What is the volume occupied by 3 x 10^{-3} mol of O_2 gas?

$$3\times10^{-3}\ \text{mol} \times \frac{22.4\ \text{L}}{1\ \text{mol}} = .067\ \text{L}$$

What is **STP?**

- **S**tandard **T**emperature and **P**ressure –

T = 273 K or 0 °C

P = 1 atm = 760 mmHg = 101 Kpa

atmosphere millimeters of Mercury Kilo Pascals

How many atm are in 783 mmHg?

783 mmHg x _____ =

1 atm / 760 mmHg

1.03 atm

Pressure Conversions

- How many kPa are in 2.5 atm?

$$2.5\ \text{atm} \times \frac{101\ \text{KPa}}{1\ \text{atm}} = 252.5\ \text{KPa}$$

- How many mmHg are in 160 KPa?

$$160\ \text{KPa} \times \frac{760\ \text{mmHg}}{101\ \text{KPa}} = 1203\ \text{mmHg}$$

Mol/Volume Conversions

- What volume does 125 mol of CH_4 occupy?

$$125 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 2800 \text{ L}$$

What is the mass of that 2800 L?

$$2800 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} \times \frac{16 \text{ g}}{1 \text{ mol}} = 2000 \text{ g} \rightarrow 2 \text{ Kg}$$

Percent Composition by Mass

- Remember this?!?!

- % by mass = $\frac{\text{mass of } \textbf{element} \text{ in 1 mol of cmpnd}}{\text{mass of 1 mol of } \textbf{compound}} \times 100$

Using the eqn above, determine the percent composition of Na and O in $NaHCO_3$

$NaHCO_3$

- MM of $NaHCO_3$ = 23 + 1+ 12 + (3x16)= 84 g/mol
- Na: 23g/mol $\dfrac{23\ g/mol}{84\ g/mol} \times 100 = 27.4\ \%$
- O : 16 g/mol x 3 mol = $\dfrac{48\ g/mol}{84\ g/mol} \times 100 = 57.1\ \%$

Empirical Formula

- The empirical formula is the lowest whole number ratio of elements.
- The empirical formula may be different from the molecular formula!

- For example: Hydrogen peroxide
- Molecular formula H_2O_2
- Empirical formula HO

Empirical Formula

- What is the empirical formula of C_6H_6?

CH

- What is the empirical formula of $C_6H_{12}O_4$?

$C_3H_6O_2$

You can use the percent composition to find the empirical formula

Finding the Empirical Formula

- Method:

1. If you are given percent composition, assume you have 100g.
2. If you have 40% S and 60% O, then you can assume you have 40 g of S and 60 g of O.
3. Convert the g to moles!

$$40\ \text{g S} \times \frac{1\ \text{mol S}}{32\ \text{g S}} = 1.25\ \text{mol S}$$

$$60\ \text{g O} \times \frac{1\ \text{mol O}}{16\ \text{g O}} = 3.75\ \text{mol O}$$

Finding the Empirical Formula

5. Find the mole ratio by dividing by the atom with the smaller number of moles.

1.25 mol S/1.25 = 1 mol S

3.75 mol O/1.25 = 3 mol O

The empirical formula is SO_3!

6. IF step 5 does not result in whole numbers, you must multiply the moles by the smallest factor that will make whole numbers.

Example

- Determine the empirical formula for methyl acetate, which has the following percent composition: 48.64% C, 8.16% H, and 43.2% O

Assume 100 g total and FIND MOLES

$$48.64\ \text{g C} \times \frac{1\ \text{mol}}{12\text{g}} = 4.05\ \text{mol C}$$

$$8.16\ \text{g H} \times \frac{1\ \text{mol}}{1\text{g}} = 8.16\ \text{mol H}$$

$$43.2\ \text{g O} \times \frac{1\ \text{mol}}{16\text{g}} = 2.7\ \text{mol O}$$

Example

Find mole ratio by dividing by the smallest!

4.05 mole C/2.7 = 1.5 mol C x 2= 3 mol C

8.10 mole H/2.7 = 3.0 mol H x 2 = 6 mol H

2.7 mole H/2.7 = 1 mol H x 2 = 2 mol O

Do we have all whole numbers? NOPE!

Multiply moles by 2

$C_3H_6O_2$