Slide 1

MOLES! MOLES! MOLES!

Joe's 2nd Rule of Chemistry

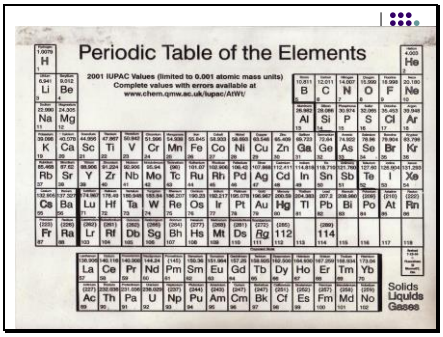
Slide 2

Mass in amus

The weighted average isotope mass is what is present in the periodic table.

We saw that it is better to view the units of these "atomic masses" as the number of grams per mole (g/mol) of an atom.

Slide 3



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Avogadro's Number

Carbon has an atomic mass of 12.011 amu.
Nitrogen has an atomic mass of 14.007 amu.

Suppose I have enough carbon atoms so that the sample weighs 12.011 grams.
If I have the same number of nitrogen atoms, it should weigh 14.007 grams.

That number of atoms is called Avogadro's Number!

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Avogadro's Number

6.022×10^{23} particles is the number of particles that makes this work!

If you have 6.022×10^{23} atoms of any element, then its mass in grams is the same as its atomic mass in amu.

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Call it a mole

12 is a dozen
144 is a gross
500 is a ream
6.022×10^{23} is a "mole".

A mole is just a collection of objects. It doesn't have to be atoms, it could be anything. If you have 6.022×10^{23} of them, you have a mole of them.

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$6.02214150 \times 10^{23}$ anythings per mole

How many ^{12}C atoms in a mole of ^{12}C?

$6.02214150 \times 10^{23}$

How many ping pong balls in a mole of ping pong balls?

$6.02214150 \times 10^{23}$

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Avogadro's number

Just another conversion factor:

$$\frac{6.022 \times 10^{23} \text{ things}}{\text{mole}}$$

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MOLES! MOLES! MOLES!

Chemistry is largely a question of UNITS! UNITS! UNITS! And MOLES! MOLES! MOLES!

If you can grasp the significance of units and moles, this course becomes very simple.

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MOLES! MOLES! MOLES!

A mole is just a collection, a way of counting large numbers of things. After all, atoms and molecules are very small; if you have a collection of them that you can see, it has a lot of particles in it!

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Mg + O → MgO

This is a chemical reaction. Magnesium mixed with oxygen yields magnesium oxide.

1 atom of Mg combines with 1 atom of oxygen to form 1 molecule of MgO

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Grams is good, moles is better

The implication of my chemical reaction is that it isn't the mass of the chemicals that matters, but the number of atoms or molecules. Things react by colliding with other things on a particle (atom or molecule) by particle basis.

If I want to track the chemistry, I need to know how many atoms/molecules are in my sample.

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Grams is good, moles is better

Grams is easy to measure – you just throw it on a balance.

Moles is necessary to understand the chemistry.

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The Power of 6.022 x 10^{23}

The key to the power of Avogadro's number of particles is that it relates the number of particles to a measurable mass.

If you have 6.022x10^{23} atoms of carbon, it weighs 12.011 grams.

This means that atomic mass (also called "molar mass") is best expressed not in "amu", but the equivalent grams/mole.

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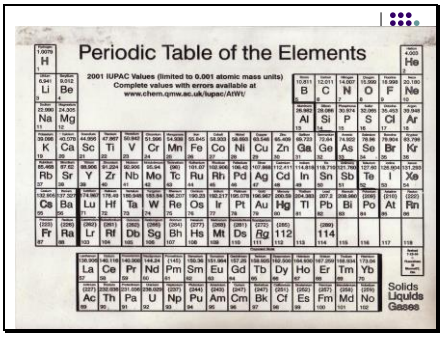

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1 amu = 1.66053873x10^{-27} kg

Carbon-12 has a mass of 12 amu (by definition)

12 amu = $\frac{12\ g}{mole}$ * $\frac{1\ mole}{6.022x10^{23}\ atoms}$

12 amu = 1.993 x 10^{-23} grams
1 amu = 1.66x10^{-24} grams

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Sample Problem

I have 36.0 g of carbon, how many moles do I have?

What is the first thing I need to ask myself?

1. What do I know?
   36.0 grams of carbon
2. What do I need to know?
   moles of carbon
3. What is the conversion factor?
   atomic mass or molar mass

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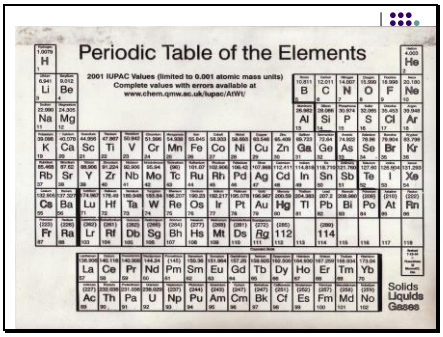

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The Solution

36.0 g C * $\frac{1 \text{ mol C}}{12.011 \text{ g C}}$ = 2.997 mol C

Molar mass (atomic mass) should be viewed as the conversion factor between mass (grams) and moles!

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Sample problem

- A 2 oz bag of M&Ms has 30 pieces in it. What is the mass (in g) of 1 mole of M&Ms?

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Solution

$$\frac{1 \text{ mole M\&M}}{1 \text{ mol}} * \frac{6.022 \times 10^{23} \text{ M\&Ms}}{30 \text{ M\&Ms}} * \frac{2 \text{ oz}}{16 \text{ oz}} * \frac{1 \text{ lb}}{1 \text{ lb}} * \frac{453.6 \text{ g}}{} =$$

= 1.138×10^{24} g

= 1×10^{24} g (because 2 oz = 30 M&Ms only has 1 sig fig)

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Molar Mass

Molar Mass of MgO = Molar mass of Mg + Molar Mass of O

= 24.305 g/mol + 16.000 g/mol

= 40.305 g/mol

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Sample Problem

I have 36.45 g of water (H_2O), how many moles of water is that?

1. What do you know?
   g of water
2. What do you want to know?
   moles of water
3. What do you need to know?
   molar mass of water

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Sample Problem

I have 36.45 g of water (H_2O), how many moles of water is that?

To get the molar mass of water…

…add up the molar masses of each atom

Molar mass H_2O = 2*mass of hydrogen + 1 mass of oxygen

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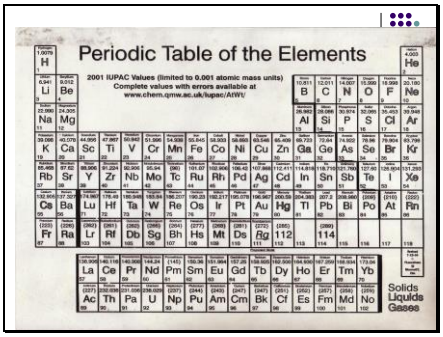

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Sample Problem

I have 36.45 g of water (H_2O), how many moles of water is that?

Molar mass H_2O = 2*mass of hydrogen + 1 mass of oxygen

= 2*(1.00797 g/mol) + 16.000 g/mol

=18.016 g/mol

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Solution

I have 36.45 g of water (H_2O), how many moles of water is that?

$$36.45 \text{ g } H_2O * \frac{1 \text{ mol } H_2O}{18.016 \text{ g } H_2O} = 2.023 \text{ mol } H_2O$$

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Very common calculation

We will constantly be calculating the number of moles of chemical compounds. We will see many more examples throughout the course.

Applying the molar mass is the most common calculation, and it is easy to do once you have the chemical formula – H_2O – which indicates the number of each atom.