

Chapter 3

- Atomic Masses (3.1)
- The Mole (3.2)
- Molar Mass (3.3)
- Percent Composition (3.4)
- Determining the Formula of a Compound (3.5)
- Chemical Equations (3.6)
- Balancing Chemical Equations (3.7)
- Introducing Stoichiometry (3.8)
- Introducing Limiting Reagents (3.9)

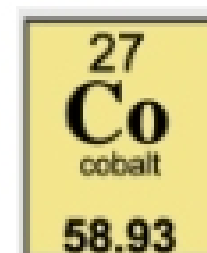
This is the outline for the content we will cover in lecture. Please read the entire chapter.

The Atomic Mass Unit (amu)

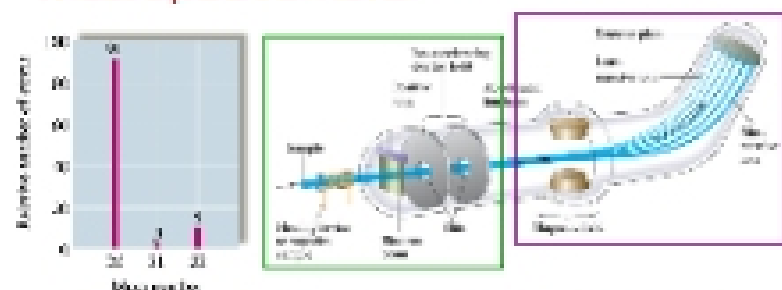
- Defined as 1/12 the mass of a carbon-12 atom
- The masses of all other atoms are given relative to this standard
- The atomic masses you find on the periodic table are a weighted average of the masses of each isotope of that element.

Example: Cobalt

More than 5 isotopes of cobalt exist. The most common isotope is cobalt-59, but several lighter isotopes lead to an atomic mass of 58.93.



Determining isotopic mass using a Mass Spectrometer



- Stream of vaporized atoms is bombarded with high-speed electrons, which knock electrons off the gaseous atoms, turning them into cations.
- Gaseous cations are accelerated through magnetic field, and their paths are bent according to their mass.

Some Isotope Comparisons

Element	Isotope	Mass of isotope (amu)	Relative Abundance %	Average Atomic Mass (amu)
Hydrogen	^1H	1.00783	99.9846%	1.0079
	^2H	2.01410	0.0154%	
Carbon	^{12}C	12 (exact)	98.892%	12.01115
	^{13}C	13.00335	1.108%	
Sulfur	^{32}S	31.972071	95.02%	32.064
	^{33}S	32.971458	0.74%	
	^{34}S	33.967867	4.18%	
	^{36}S	35.967083	0.0156%	
Lithium	^6Li	6.015123	7.5%	6.941
	^7Li	7.016005	92.5%	

Don't confuse "Atomic Mass" with the mass of one atom!!

- An atom can be only one isotope at a time.
 - ^{12}C : 2 = 12, isotopic mass = 12 amu (exactly)
 - ^{13}C : 2 = 13, isotopic mass = 13.003354 amu
- The Atomic Mass (aka Atomic Weight or Average Atomic Mass) is the average of the atomic masses of all of the element's isotopes, weighted by isotopic abundance.
- Naturally occurring carbon has an atomic mass of 12.011 amu
- There is no carbon isotope that weighs 12.011 amu.

Calculating Atomic Mass

Let's say we have a sample of 1000 carbon (C) atoms. Based on isotopic abundance:

989 weigh 12 amu (98.9%)
11 weigh 13 amu (1.1%)

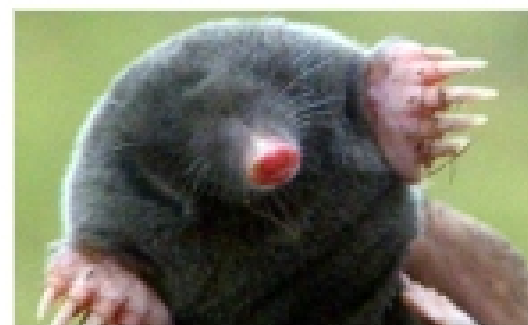
What is the average mass of a carbon atom in this sample?

Counting by Weighing

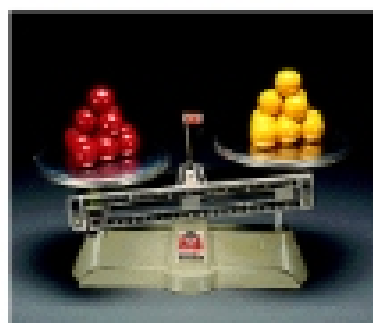
- Chemical reactions occur at the microscopic level, between individual molecules and/or atoms.
- In the lab, we measure substances in terms of grams or milliliters... these are macroscopic measurements.
- The number of molecules in 1 g of water will be different than the number of molecules in 1 g of glucose, because these molecules have different masses.
- We need a way to convert between the microscopic and macroscopic descriptions.

The mole...

NOT this kind of mole



Dozen – mass



12 red marbles (7g each) = 84g
12 yellow marbles (4g each) = 48g

Mole – mass



6.022×10^{23} atoms Fe = 55.85g Fe
 6.022×10^{23} atoms S = 32.07g S

How many ^{12}C atoms in 12 g?



Interpreting the Mole

If we had 1 mol of bicycles...



- How many mol bike seats would we have?
- Tires?
- Spokes? (assuming 36 spokes/wheel)

If we had 1 mol of isopropyl alcohol ($\text{C}_3\text{H}_8\text{O}$)...



- How many mol O atoms would we have?
- Carbon atoms?
- Hydrogen atoms?

What does one mole look like?

For condensed-phase substances (solids and liquids), one mole is a convenient "hand-full" sized quantity.

For gas-phase substances at room temperature at sea level, one mole has a volume of about 22.4 L.



Molar Mass as a Conversion Factor

Molar mass (the mass of one mole of a substance), allows us to convert between macroscopic and particulate points of view.

How many grams of oxygen corresponds to 0.50 moles?

$$? \text{ g O}_2 = 0.5 \text{ mol O}_2 \left(\frac{32 \text{ g O}_2}{1 \text{ mol O}_2} \right) = 16 \text{ g O}_2$$

How many moles of oxygen are there in 1.2 grams?

$$? \text{ mol O}_2 = 1.2 \text{ g O}_2 \left(\frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \right) = 0.038 \text{ mol O}_2$$

Molar Mass

Find the molar mass of carbon dioxide, CO₂:

Calculating the Moles in a Given Mass of a Compound

Problem: Sodium phosphate is a component of some detergents. How many moles are in a 38.6 g sample?



Aluminum (Al)

atomic weight = 26.98 amu.

molar mass = 26.98 g/mol

1 mol Al contains 6.022×10^{23} Al atoms



Lead (Pb)

atomic weight = 207.2 amu.

molar mass = 207.2 g/mol

1 mol Pb contains 6.022×10^{23} Pb atoms

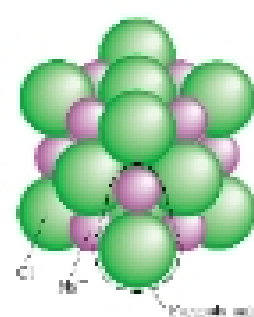


Table salt (NaCl)

formula mass = 58.44 amu
molar mass = 58.44 g/mol

1 mol of table salt contains 6.022×10^{23} NaCl formula units...this means:

6.022×10^{23} sodium ions (Na⁺)

and...

6.022×10^{23} chloride ions (Cl⁻)

