The Mole

IB PHYSICS | THERMAL PHYSICS

Grouping Items

We can use many different terms to describe the amount of substance.

A pair of shoes

__2__ shoes

A dozen roses

__12__ roses

BONUS!

A Baker's Dozen = **13**

A Score = **20**

A Gross = **144**

Counting Atoms

The primary counting unit for atoms is called

The Mole

$$1 \text{ mole} = 6.02 \times 10^{23} = N_A$$

*This is also called **Avogadro's Number** named after the scientist who first proposed this concept*

How Big is a Mole??

602,000,000,000,000,000,000,000

How Big is a Mole??

A Mole of Moles

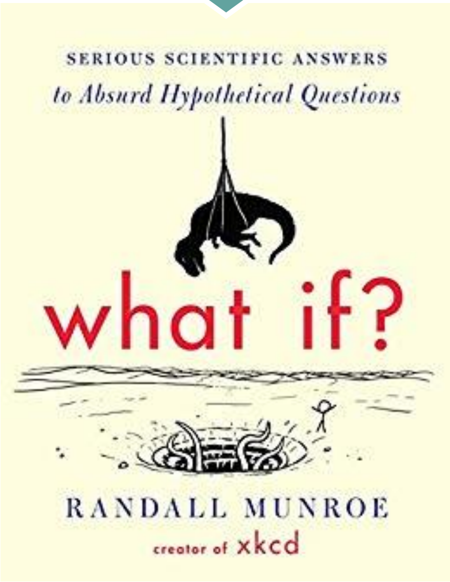
What would happen if you were to gather a mole (unit of measurement) of moles (the small furry critter) in one place?

—Sean Rice

Things get a bit gruesome.

First, some definitions. A mole is a unit. It's not a typical unit, though. It's really just a number—like "dozen" or "billion." If you have a mole of something, it means you have 602,214,129,000,000,000,000,000 of them (usually written 6.022×10^{23}). It's such a big number because it's used for counting numbers of molecules, which there are a lot of.

Taken from the book "What if?" by Randall Munroe



Using Moles in Chemistry

Atoms don't weigh very much on their own:

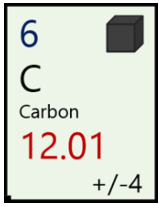
1 Carbon Atom = 1.9927×10^{-23} g

0.000000000000000000000019927 g

1 mole of Carbon Atoms =

$(1.9927 \times 10^{-23} \text{ g}) \times (6.02 \times 10^{23})$ = **~12 g**

Where else have you seen this number for Carbon?



Example IB Questions

10. The mole is defined as

A. $\frac{1}{12}$ the mass of an atom of the isotope carbon-12.

B. the amount of a substance that contains as many elementary entities as the number of atoms in 12 g of the isotope carbon-12.

C. the mass of one atom of the isotope carbon-12.

D. the amount of a substance that contains as many nuclei as the number of nuclei in 12 g of the isotope carbon-12.

Molar Mass

Molar Mass – the mass of __1 mole__ of a substance

Unit	g mol^{-1}

7 N Nitrogen 14.01 -3	16 S Sulfur 32.07 -2

Molar mass of N = **14.01** g mol^{-1}

Molar mass of S = **32.07** g mol^{-1}

Molar Mass

1 mole of copper can be represented by this stack of pure copper pennies

How many atoms are in 1 mole of copper?

6.02×10^{23} atoms

29
Cu
Copper
63.55
+2,1

Molar Mass

1 mole of copper can be represented by this stack of pure copper pennies

What is the mass of one mole of copper?

63.55 g

29
Cu
Copper
63.55
+2,1

Molar Mass

1 mole of copper can be represented by this stack of pure copper pennies

What is the mass of one atom of copper?

29
Cu
Copper
63.55
+2,1

$$\frac{63.55\ \mathrm{g}}{6.02 \times 10^{23}\ atoms} = \mathbf{1.05 \times 10^{-22}\ g}$$

More than one mole...

How much mass would 3 moles of Copper have?

29
Cu
Copper
63.55
+2,1

$$3\ \text{mol} \times 63.55\ \text{g mol}^{-1} =$$

$$\boxed{190.65\ \text{g}}$$

How many moles are in 28 g of Nitrogen?

7
N
Nitrogen
14.01
-3

$$\frac{28\ \text{g}}{14.01\ \text{g mol}^{-1}} = \boxed{\sim 2\ \text{mol}}$$

Example IB Questions

11. What is the mass of carbon-12 that contains the same number of atoms as 14 g of silicon-28?

A. 6 g

B. 12 g

C. 14 g

D. 24 g

$$\frac{14\ \text{g}}{28\ \text{g mol}^{-1}} = 0.5\ \text{mol}$$

$$0.5\ \text{mol} \times 12\ \text{g mol}^{-1} = \mathbf{6\ g}$$

11. A sample contains 4 g of helium and 20 g of neon. The mass number of helium is 4 and the mass number of neon is 20.

What is the ratio $\frac{\text{number of atoms of neon}}{\text{number of atoms of helium}}$?

A. 0.2

B. 1

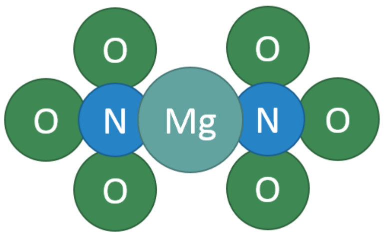
C. 5

D. 80

$$\frac{4\ \text{g}}{4\ \text{g mol}^{-1}} = 1\ \text{mol}$$

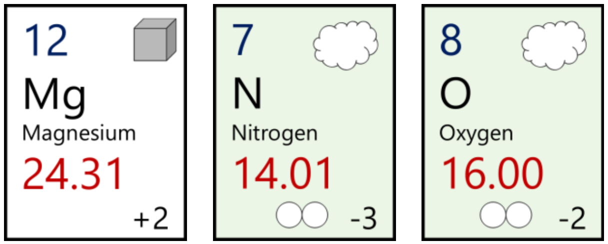
$$\frac{20\ \text{g}}{20\ \text{g mol}^{-1}} = 1\ \text{mol}$$

More than one atom…



What is the mass of one mole of Magnesium Nitrate?

$Mg(NO_3)_2$



Mg N O

$$(1 \times 24.31) + (2 \times 14.01) + (6 \times 16.00)$$

$$= \mathbf{148.33\ g\ mol^{-1}}$$

Lesson Takeaways

- ❑ I can describe the importance of having a large quantity like the "mole" defined
- ❑ I can use the average atomic weight of an element or compound to convert between mass and moles and numbers of atoms