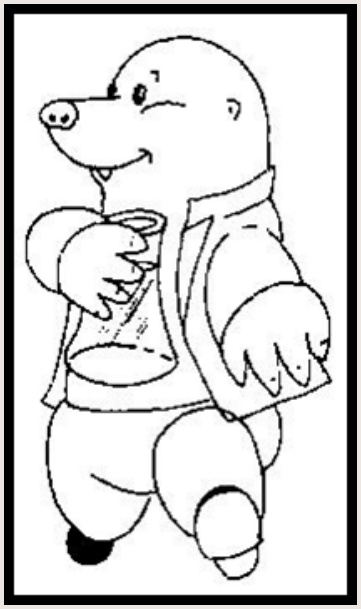
The Mole



Objectives:

What is a mole?
How many particles are in a mole?
How do you find the mass of a mole of an element ?
How do you find the mass of a mole
of an compound or molecule?
How do you convert moles to mass (and back)?

The Mole Concept

No, not that kind of mole!

What is a mole?
How many particles are in a mole?

The mole is a number…..

A HUGE number……

still just a number…..

A mole is a collection of

602,000,000,000,000,000,000,000 particles

or

6.02×10^{23} particles

(also known as Avogadro's number)

These particles may be atoms, molecules, ions, or electrons

1 dozen = 12

1 gross = 144

1 ream = 500

1 mole = 6.02×10^{23}

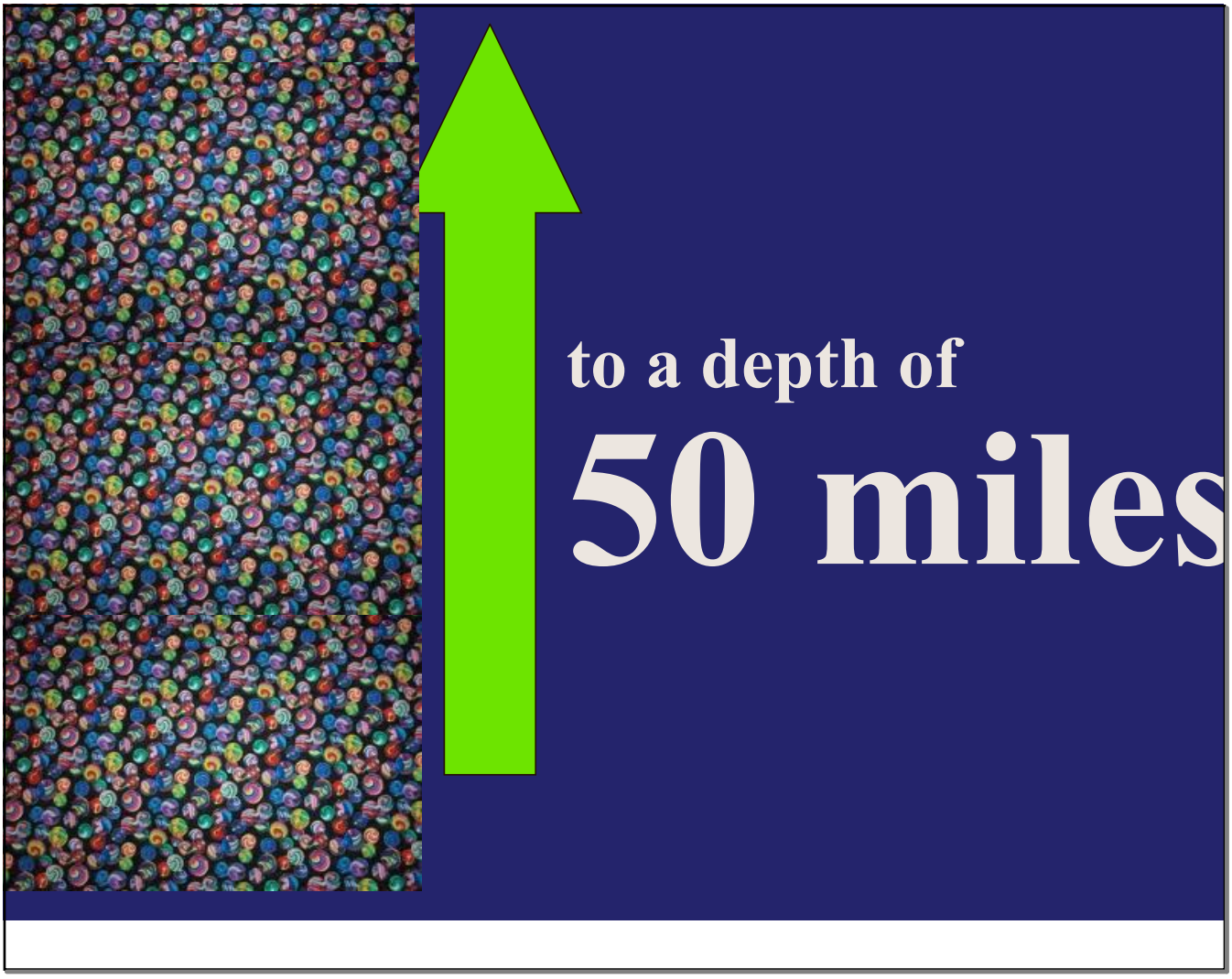
Just how large is this number?
602,000,000,000,000,000,000,000

It is really hard to relate to a number this large …….but let's try and see if we can make sense the enormity of the number.

If all 5 billion people on Earth were to do nothing but count the atoms in 1 mole of an element, 24 hours a day, at the rate of 1 atom per second…….

It would take 4 million years !!

1 mole of marbles is enough marbles to cover the entire Earth…


to a depth of
50 miles

A mole of dollars ??

How many years would it take you to spend 1 mole of dollars, if you spend at a rate of $1 billion per second ?

$ 6.02 x 10^{23} → Years

$1,000,000,000 per second

Using dimensional analysis/ factor label:

$$\$6.02\times10^{23} \times \frac{1\text{sec}}{\$1\times10^{9}} \times \frac{1\text{min}}{60\text{sec}} \times \frac{1\text{hr}}{60\text{min}} \times \frac{1\text{day}}{24\text{hr}} \times \frac{1\text{ yr}}{365\text{day}}$$

= 19,089,294.77 years

over 19 million years!!!

What would you be called if you have 1 mole of dollars?

a mole-ionaire!

And yet there is...

1 mole of H_2O molecules

(that's 6.022 x 10^{23} molecules of water)

in only 18 mL of water !!

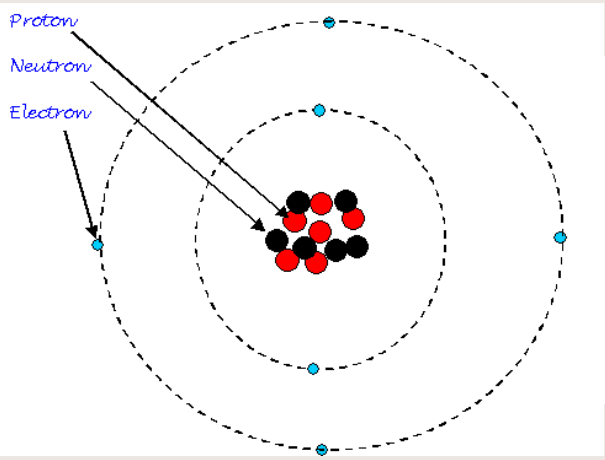
Molar Mass

The mass of 1 mole of a substance in grams

How do we find the mass of a mole of a certain element?

official definition:

mole= # of atoms in exactly 12.000 g of pure ^{12}C

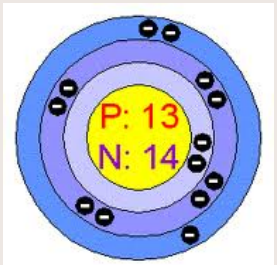


Carbon-12 or ^{12}C

How do we find the mass of a mole of a certain element?

13
Al
aluminum
26.98

What is this number?

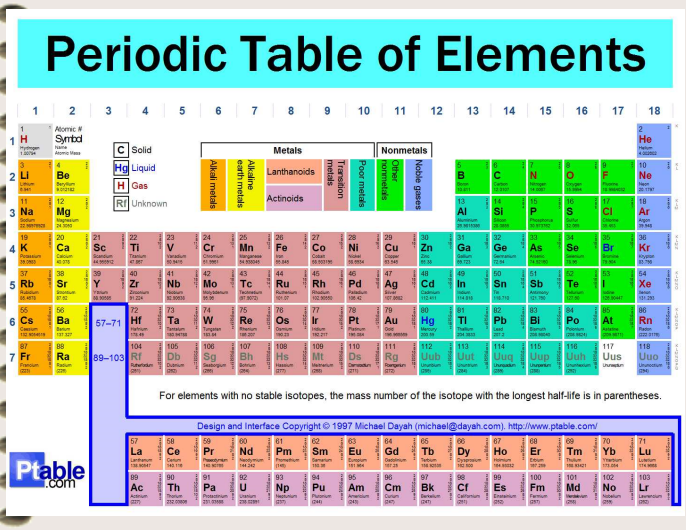


1. 13 P + 14 N = 27 amu
One Al atom has a mass of about 27amu (atomic mass units)

2. 
One mole of Al (6.02×10^{23} atoms) has a mass of 27 grams

How do we find the mass of a mole of a certain element?

1 mole = 6.022×10^{23} particles
= the atomic mass of an element
(expressed in grams)



Use the periodic table

It's really a conversion chart!

Carbon, C

What is the mass of 1 mole of C?

12.0 grams

How many atoms?

6.022×10^{23} atoms

What is the mass of ½ mole of C?

6.0 grams

Gold, Au

What is the mass of 1 mole of Au?

197.0 grams = 1 mol Au

How many atoms?

6.022×10^{23} atoms

What is the mass of ½ mole of Au?

98.5 grams

$$0.5 \text{ mol Au} \left| \frac{197 \text{ g}}{1 \text{ mol Au}} \right. = 98.5$$

Magnesium, Mg

What is the
mass of 1 mole of Mg ?
24.3 grams

What is the
mass of 2 moles of Mg ?
48.6 grams

How many atoms?
1.204×10^{24} atoms



these all contain 1 mole of atoms:

12.0 grams of C
197.0 grams of Au
24.3 grams of Mg.

How do we find the mass of a mole of compound?

Molar Mass:

The mass of 1 mole of a substance in grams

element or compound

A.K.A.

Also known as: formula mass (formula weight) or
gram formula mass or
molecular mass (molecular weight)

Molar Mass of a Compound

H_2O

1. List elements in compound
2. multiply no. of atoms in compound x ave. atomic mass (from PT)
3. add products to get total, in grams/mole

1. 2.

H = 2 x 1.0 = 2.0 g
O = 1 x 16.0 = 16.0 g

3.

18.0 g/mol

molar mass of water = 18.0 grams/mole

Calculate the molar masses:

HCl

H 1 x 1.0
Cl 1 x 35.5
36.5

CO_2

C 1 x 12.0 = 12.0
O 2 x 16.0 = 32.0
44.0 g/mol CO_2

Calculate the molar masses:

$Mg_3(PO_4)_2$

Mg 3 x 24.3 = 72.9
P 2 x 31.0 = 62.0
O 8 x 16.0 = 128.0

262.9 g/mol

$C_{12}H_{22}O_{11}$

P. 23 # 1-14

$Mg(OH)_2$

Mg 1 x 24.3 = 24.3
O 2 x 16.0 = 32.0
H 2 x 1.0 = 2.0

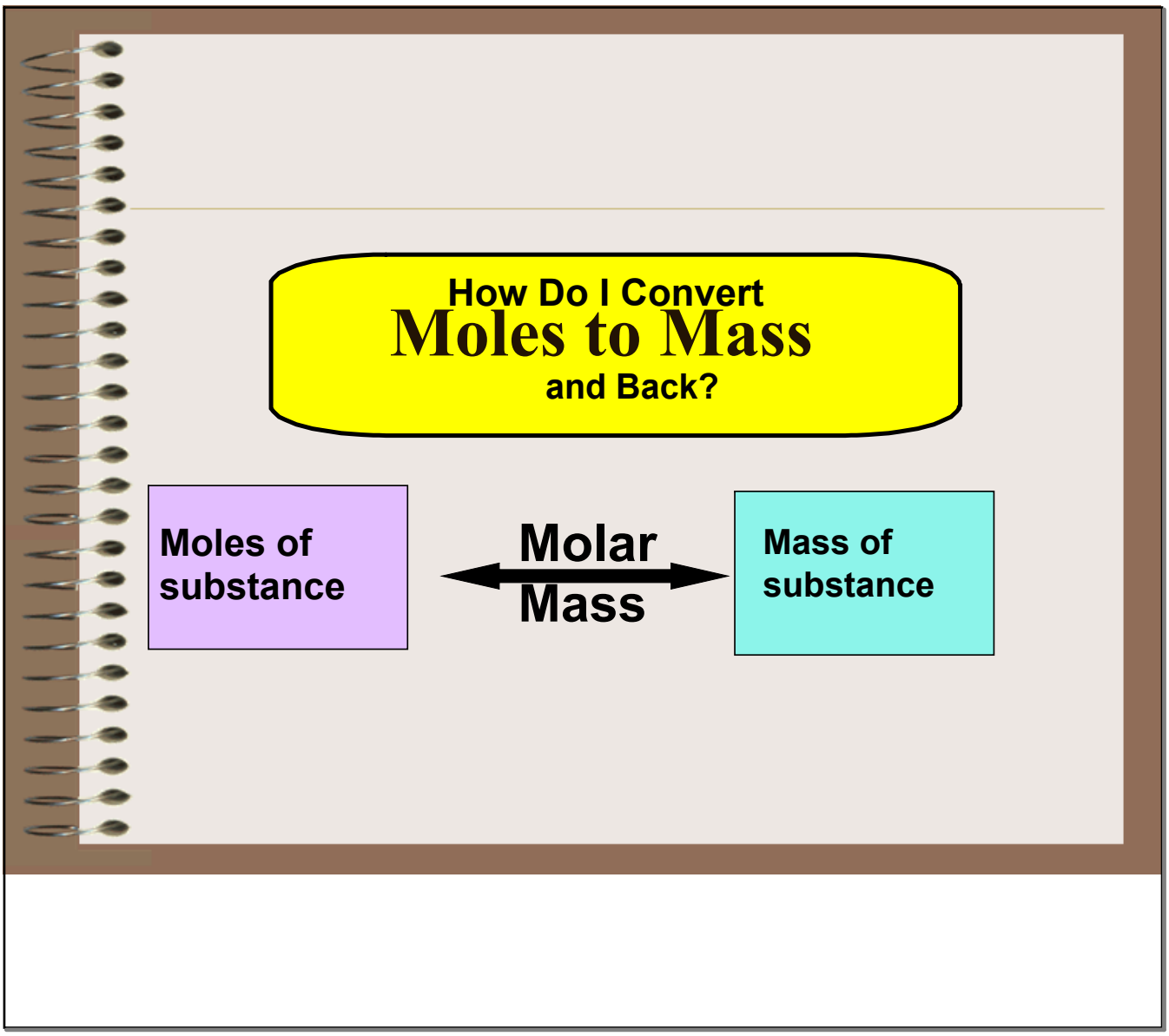
58.3 g/mol

$Cu(CO_3)_2$

Calculate the molar masses:

of a hydrate

$Cu(CO_3)_2 \cdot 3H_2O$


How Do I Convert
Moles to Mass
and Back?
Moles of substance
Molar Mass
Mass of substance

1.Underline "given" -- start with this
2.Circle "goal" -- end with this unit
3.Convert using factors (ratios)-- to cancel units

Calculate the number of moles in 20.0 g of Silver:

$\frac{108\ g\ Ag}{1\ mol\ Ag}$

2.54 cm = 1 in

$20.0\ g\ Ag \times \frac{1\ mol\ Ag}{108\ g\ Ag}$ =

0.19 mol Ag

1.Underline "given" -- start with this
2.Circle "goal" -- end with this unit
3.Convert using factors (ratios)-- to cancel units

Calculate the number of grams in 3 moles of Silver:

$$108\,g = 1\,mol\,Ag$$

$$3\,\cancel{mol}\,Ag \left| \frac{108\,g}{1\,\cancel{mol}} \right. = \boxed{}$$

$$324\,g\,Ag$$

Calculate the number of moles in 6.0 g of $HC_2H_3O_2$:

1. Underline "given" -- start with this
2. Circle "goal" -- end with this unit
3. Convert using factors (ratios)-- to cancel units

$$\frac{6.00\text{ g NaOH}}{} \left| \frac{1\text{ mol NaOH}}{40.00\text{ g NaOH}} \right. = 0.15\text{ mol}$$