THE MOLE

Because substances are composed of particles, one way to measure the amount of a substance is to count the number of representative particles of that substance. Atoms, molecules and ions are very small. Thus, the number of particles in even a relatively small sample of any substance is very large. We can "count" particles, however, if we introduce a term that represents a certain number of particles. Just as a dozen eggs represents 12 eggs:

a mole of a substance represents 6.02×10^{23}

representative particles of that substance.

This experimentally determined number, 6.02×10^{23} , is called Avogadro's number. It is named in honor of Amedeo Avogadro di Quarenga (1776-1856) who was a nineteenth-century Italian scientist and lawyer. His work made the calculation of this number possible. We usually talk about moles of elements or compounds. There is nothing wrong, however, with calling 6.02×10^{23} pencils a mole (1 mol) of pencils.

Avogadro's number, 6.02×10^{23}, is an overwhelming large number, virtually impossible to comprehend or visualize. Try to visualize a mole of raindrops (6.02×10^{23} drops of water) dropping into a tank 30 meters (100 feet) in diameter. To contain the entire mole of raindrops, the sides of the tank would have to be 280 times higher than the distance from the earth to the sun!!! If you are mathematically inclined, you may like to check this calculation, assume that a drop of water is about one-twentieth of a cubic centimeter.

But why is a mole 6.02×10^{23} particles? Why not 2×10^{23}? The reason is very simple. Examine the following table:

Element	Average Mass of 1 atom (amu)	Mass of 6.02×10^{23} atoms (molar mass) (g)
Hydrogen (H)	1.008	1.008
Iron (Fe)	55.8	55.8
Sulfur (s)	32.1	32.1
Oxygen (O)	16.0	16.0

*1 amu=1.66×10^{24} g

It takes 6.02×10^{23} atoms of any element to have a mass equivalent to the atomic mass of the element in grams. This convenient relationship may help you to see why a mole is defined in this manner So we can say that a mole of hydrogen ,H, atoms has a mass of 1.008 g, a mole of carbon ,C, has a mass of 12.0 g, a mole of iron, Fe, is *55.8* g, and so on.

Let's summarize the variety of information which can be extracted from a correctly balanced equation...

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

1 atom	1 molecule	1 molecule
6.02×10^{23} atoms	6.02×10^{23} atoms	6.02×10^{23} atoms
1 mole	1 mole	1 mole
12.Og	32.0g	44.0g

So the definition of a mole enables us to move from an equation expressed in terms of numbers of atoms or molecules to reasonable mass relationship. We can say that a mole of an element is that quantity of the element that equals its atomic mass expressed in grams. The atomic mass of an element expressed in grams contains 6.02 x 1023 atoms.

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The mole is established for our convenience. Since we cannot count atoms directly in any handy way, we need a way to count them indirectly and to express their large numbers easily. We can derive the following relationship between numbers of moles and number of particles...

$$\textbf{number of particles} = \# \text{ mol} \times 6.02 \times 10^{23} \text{ atoms}$$

Particles refer to atoms for elements, molecules for molecular compounds, ions for ionic compounds.
Example:

Calculate: a) the number of atoms in 0.5 mol of carbon
b) the number of atoms in 10.0 mol of titanium
c) the number of moles in 3.0×10^{23} atoms of zinc
d) the number of moles in 1.2×10^{23} atoms of silicon

Mass is expressed in grams (g), moles are expressed in units called moles (mol), molar mass is a rate (2 units) , it is expressed in grams per mole.

Relationship between Mass. Moles and molar Mass

$$\# \text{ moles(mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$$

For each question: (a) write a formula (b) show all work (c) underline answer, report to correct # of sig. figs and show correct units...

I Calculate the **mass** in grams:
a) 5.0 mol of carbon
b) 8.00 mol of aluminium
c) 10.5 mol of oxygen
d) d) 200 mol of copper
e) 3.0 mol CO_2
f) 0.5 mol $Al(NO_3)_3$
g) 0.0l mol$Mg(OH)_2$

2. Calculate **number of moles:**
a) 800 g calcium
b) 73 g
c) 66g of Magnesium
d) 280 g iron
e) 93g phosphate
f) 66g CO_2
g) 8g $S0_3$

#3. Calculate **the number of atoms** in:
a) 3.2 mol magnesium
b) 5.40 mol of iron
c) 10.0 mol of bismuth
d) 2.5 mol of lead

4. Calculate the **number of molecules** in:
a) 5 mol 503
b) b) 0.2 mol AIF_3
c) 1.5 mol MgO
d) 0.23 mol $C0_2$

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e) e) .035 mol H_3P0_4

5. Calculate the **number of mol** in:

a) 3.0 x 10^{23} atoms of carbon

b) 12 x 10^{24} atoms of iron

c) 3.0 x 10^{22} molecules of CO_2

d) 1.2 x 10^{24} molecules of $S0_3$

e) 1.8 x 10^{24} molecules of glucose,

6*. Calculate the **number of atoms** in:

b) 3 mol of H_20

b) 0.1 mol H_2S0_4

c) 2.2 mol HNO_3

c) 0.2 mol Al $(NO_2)_3$

7.* Calculate

a) the # of H_2 molecules in 5 mol of $H_2(g)$

b) the # of H atoms in 5 mol of H_2

8. Calculate the number of H- atoms in each of the following:

b) 3 mol HCI

c) 3 mol H_2S0_4

d) 3 mol H_3P0_4

d) 3 mol $Al(0H)_3$

e) 3 mol $C_6H_{12}O_6$

9. Calculate the **mass** of each of the following:

a) 18 x 10^{23} molecules AlF_3

b) 1.5 x 10^{23} molecules HCI

c) 2.4 x 10^{24} molecules CO_2

d)1.2 x 10^{24} atoms sodium

e) 3.6 x 10^{22} molecules NaOH

f) 6 x 10^{22} atoms of Ag

10. Calculate the **number of molecules** in each of the

a) 7.4 g $Ca(OH)_2$

b) 55.5 g $CaCI_2$

c) 96 g $S0_3$

d) 112 g KOH

e) 0.39 g Na_2S

c) 36 g H_2O

d) 2 kg HF

e) 58 g Mg $(OH)_2$

i) 10 g $CaCO_3$

HOMEWORK

Read section 11.1, 11.2, pages 340 - 343

Practice Problem 11-2, 11-3, 11-4, 11-Sand 11-6

Page 377, # 5, 6, 7, 8, 9, 16, 17,. 18, 19, 20.

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