THE MOLE

CALCULATING NUMBER OF REPRESENTATIVE PARTICLES (MOLECULES, ATOMS...)

A mole is a very important unit in chemistry to for measuring the AMOUNT of a substance.

Similar to:

A dozen 12 A grand: 1000

A mole of any substance contains 6.02×10^{23} of representative particles # of those particles. We can use this number as a conversion factor when talking about numbers of particles like molecules or atoms.

$$n = \frac{\#\text{ of particles}}{N_A}$$

Example:

1 Mole of CO_2 molecules contains 6.02×10^{23} molecules?

1 mole of CO_2 molecules contains 3 moles of atoms?

1 mole of CO_2 contains 2 moles of oxygen atoms?

1 Mole of CO_2 molecules contains 1 moles of carbon atoms?

1 Mole of CO_2 contains 6.02×10^{23} atoms of carbon? $1\text{mol} \times 6.02 \times 10^{23} \frac{\text{molec}}{\text{mol}} \times \frac{1\text{ atom C}}{\text{molec}} = 6.02 \times 10^{23}$ atoms

1 Mole of CO_2 contains 1.20×10^{24} atoms of oxygen? $1\text{ mol} \times 6.02 \times 10^{23} \frac{\text{molec}}{\text{mol}} \times \frac{2\text{ atoms O}}{\text{molec}} = 1.20 \times 10^{24}$

2.5 Mole of CO_2 contains _____ atoms? $2.5\text{ mol} \times 6.02 \times 10^{23} \frac{\text{molec}}{\text{mol}} \times \frac{3\text{ atoms}}{\text{molec}} = 4.5 \times 10^{24}$ atoms

PRACTICE:

1. How many atoms of carbon are present in 7.00 moles of carbon dioxide? (CO_2)?

$7.00\text{ mol} \times 6.02 \times 10^{23} \frac{\text{molec}}{\text{mol}} \times \frac{1\text{ atom C}}{\text{molec}} = 4.21 \times 10^{24}$ atoms of C

2. How many atoms of oxygen are present in 7.00 moles of carbon dioxide?

$7.00\text{ mol} \times 6.02 \times 10^{23} \frac{\text{molec}}{\text{mol}} \times \frac{2\text{ atoms O}}{\text{molec}} = 8.43 \times 10^{24}$

3. How many atoms of hydrogen are there in 1.20 moles of ammonia? NH_3

$1.20 \times 6.02 \times 10^{23} \frac{\text{molec}}{\text{mol}} \times \frac{3\text{ atoms H}}{\text{molec}} = 2.17 \times 10^{24}$

4. Magnesium is a light metal used in the manufacture of aircraft, automobile wheels, tools and garden furniture. How many moles of magnesium is 1.25×10^{23} atoms of magnesium?

$n = \frac{\#\text{ of part}}{N_A} = 1.25 \times 10^{23}\text{ atoms} / 6.02 \times 10^{23} = 0.208\text{ mol}$

Molar Mass- Notes

A sample of any element with a mass equal to that element's atomic mass (amu) in grams will contain precisely 1 mole of atoms. The element's molar mass is then found on the periodic table.

What is the molar mass (mass of one mole...)of the following elements?

Na: M= 22.99 g/mol Al: M= 26.98 g/mol Fe: M=_____ Pb: M=_____

When atoms form molecules or formula units, the atoms bond together, and the molecule's weight is the combined weight of all of its parts.

Example M_{H_2O} = $2 \times 1.01 = 2.02$; $1 \times 16.00 = 16.00$; $/ 18.02$ g/mol

* molar mass will have 2 places after decimal based on our periodic table. This affect our sig figs from now on!

Try these:

$NaOH_{(s)}$ $22.99\text{ g/mol} + 16.00 + 1.01\text{ g/mol} = 40.00\text{ g/mol}$

$Na_2SO_{4(s)}$ $2 \times 22.99\text{ g/mol} + 32.06 + 64.00 = 142.04\text{ g/mol}$

$CuSO_4 \cdot 5H_2O_{(s)}$ $63.55 + 32.06 + 64.00 + 5(18.02) = 249.71\text{ g/mol}$

Grams-Moles- Notes

Given mass, calculating moles

$$n = \frac{m}{M}$$

Example 1: Convert a mass of 1.5 g of calcium carbonate to an amount in moles.

$$n = \frac{m}{M} = \frac{1.5\,g}{100.09\,g/mol} = 0.015\,mol$$

Example 2: Convert a reacting amount of 34.6 mol of sodium sulfate (Na_2SO_4) into mass in grams.

$$m = n \cdot M = 34.6\,mol \cdot 142.04\,g/mol = 4915\,g \hookrightarrow 4.92 \times 10^3\,g$$

Practice

➪**1.** Determine the number of representative particles (atoms) in each of the following.

A. 0.250 mol silver

B. 8.56×10^{-3} mol NaCl

C. 35.4 mol CO_2

D. 0.425 mol N_2

A. $0.250\,mol \times 6.02 \times 10^{23}\,\frac{atoms}{mol} = 1.51 \times 10^{23}$

B. $8.56 \times 10^{-3}\,mol \cdot 6.02 \times 10^{23}\,\frac{form.}{mol} \times \frac{2\,atoms}{form.} = 1.03 \times 10^{22}\,atoms$

C. $35.4\,mol \times 6.02 \times 10^{23}\,\frac{molec}{mol} \times \frac{3\,atoms}{molec} = 6.39 \times 10^{25}\,atoms$

d. $0.425\,mol \times 6.02 \times 10^{23}\,\frac{molec}{mol} \times \frac{2\,atoms}{molec} = 5.12 \times 10^{23}\,atoms$

2. Determine the number of moles in each of the following.

A. 3.25×10^{20} atoms Pb

B. 4.96×10^{24} molecules glucose

C. 1.56×10^{23} formula units NaOH

D. 1.25×10^{25} Cu^{2+} ions

A. $n = 3.25 \times 10^{20}\,atoms / 6.02 \times 10^{23}\,atoms/mol = 0.540\,mol$

B. $n = 4.96 \times 10^{24}\,molec / 6.02 \times 10^{23}\,\frac{molec}{mol} = 8.24\,mol$

C. $\frac{1.56 \times 10^{23}\,form}{6.02 \times 10^{23}\,form/mol} = 0.259\,mol$

D. $\frac{1.25 \times 10^{25}\,ions}{6.02 \times 10^{23}\,ions/mol} = 20.8\,mol$

➪**3.** A. 1.51×10^{15} atoms Si to mol Si

B. 4.25×10^{-2} mol NO_2 to molecules NO_2

C. 8.95×10^{25} molecules CCl_4 to mol CCl_4

D. 5.90 mol Ca to atoms Ca

A. $n = 1.51 \times 10^{15}\,atoms / 6.02 \times 10^{23}\,\frac{atoms}{mol} = 2.51 \times 10^{-9}\,mol$

B. $4.25 \times 10^{-2}\,mol \cdot 6.02 \times 10^{23}\,\frac{molec}{mol} = 2.56 \times 10^{22}\,molec$

C. $n = \frac{8.95 \times 10^{25}\,molec}{6.02 \times 10^{23}\,\frac{molec}{mol}} = 49\,mol$

D. $5.90\,mol \cdot 6.02 \times 10^{23}\,\frac{atoms}{mol} = 3.55 \times 10^{24}\,atoms$

4. A. How many atoms are in 6.2 moles of aluminum?

$$atoms\ \ 6.2 \times 6.02 \times 10^{23}\,\frac{atoms}{mol} = 3.73 \times 10^{24}\,atoms$$

B. Convert 5.3×10^{25} molecules of CO_2 to moles.

$$n = \frac{5.3 \times 10^{25}\,molec}{6.02 \times 10^{23}\,molec/mol} = 88.0\,mol$$

C. How many formula units of sodium acetate are in 0.87 moles of sodium acetate?

$$\#\,particles = 0.87\,mol \times 6.02 \times 10^{23}\,form/mol = 5.24 \times 10^{23}\,form\ units$$

D. Convert 3.00 moles As_2S_3 to grams.

$$m = n \cdot M = 3.00\,mol \cdot 246.02\,g/mol = 738\,g$$