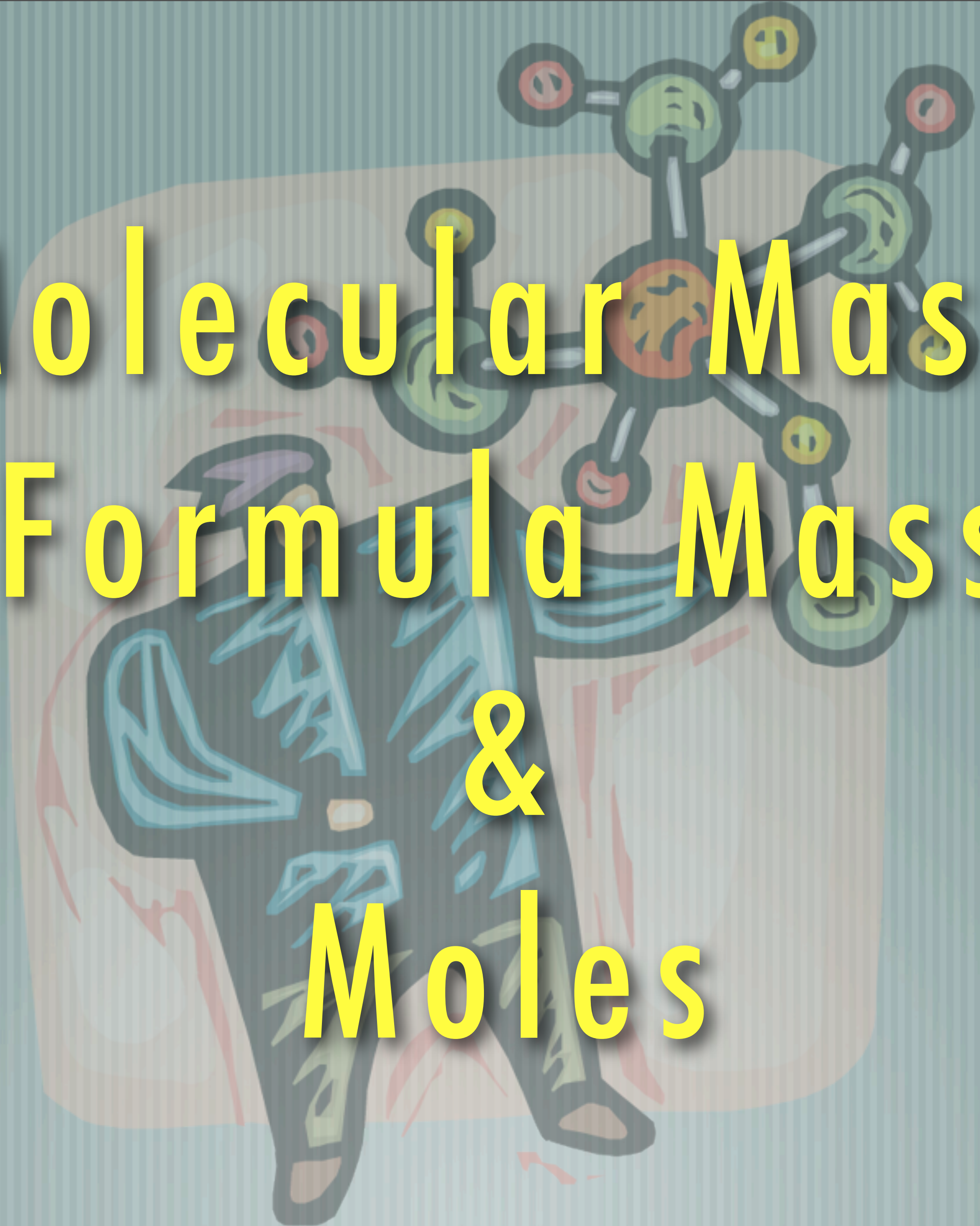


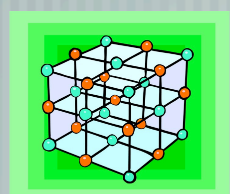
Molecular Mass, Formula Mass & Moles

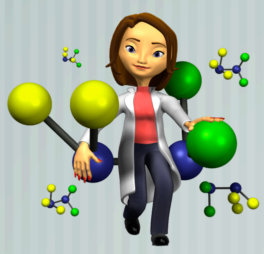
The Physical Science Series

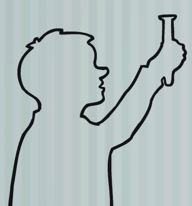
Menu

 Atomic Mass

 Molecular Mass

 Formula Mass

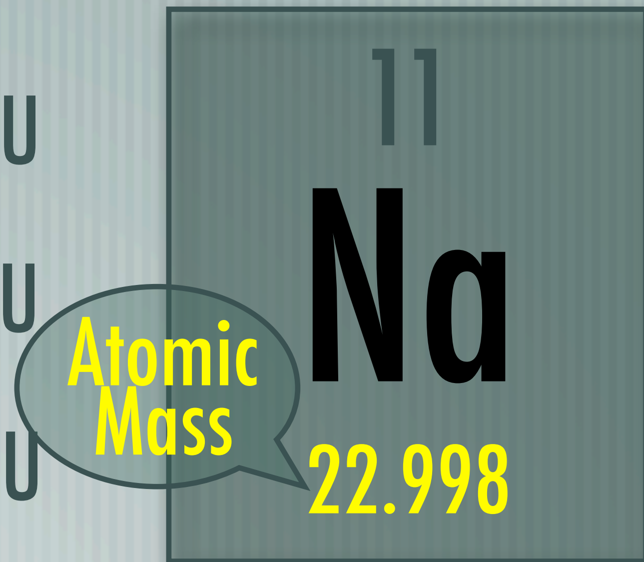
 Moles

 Mole Conversions

Atomic Mass

Atomic Mass of an Atom

- The atomic mass is the mass of an atom of an element. It is measured in Atomic Mass Units.
- A proton + has a mass of 1 AMU
- A neutron 0 has a mass of 1 AMU
- An electron - has a mass of 0 AMU
- The Atomic Mass of an element is shown on the period table.
- The mass is not a whole number because of isotopes.



Note: Drawings not to scale. Protons and neutrons are 1836 x more massive than electrons.

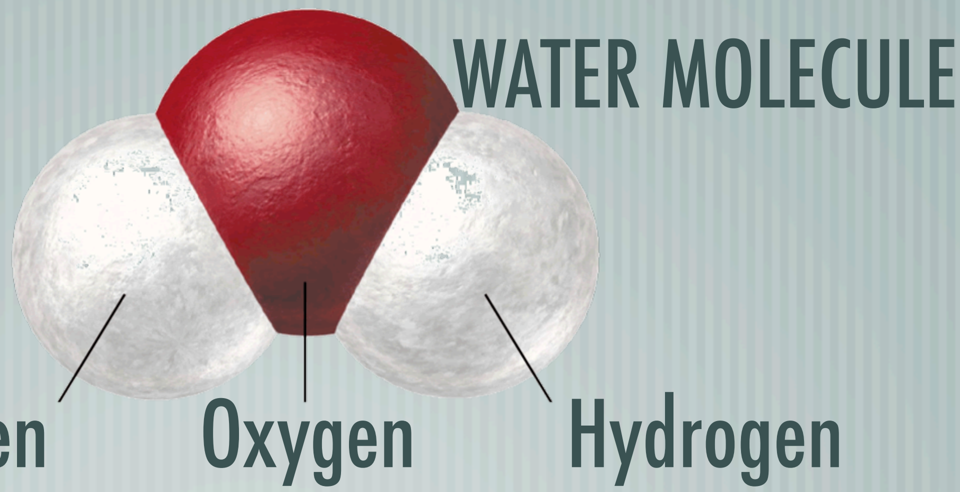
menu

Molecular Mass

menu

Molecular Mass (Covalent)

- Covalent compounds share valence electrons to form molecules.
- Molecular Mass is total mass of all the atoms in a molecule.



- The molecular mass of water is 18.015 AMU.
  2 Hydrogen (2 x 1.008 AMU) + 1 Oxygen (15.999 AMU)

Molecular Mass (Covalent)

BF_3

Boron Trifluoride

B x 1 = 10.82 AMU

+ F x 3 = 57.000 AMU

67.82 AMU

Sig Figs in + and -

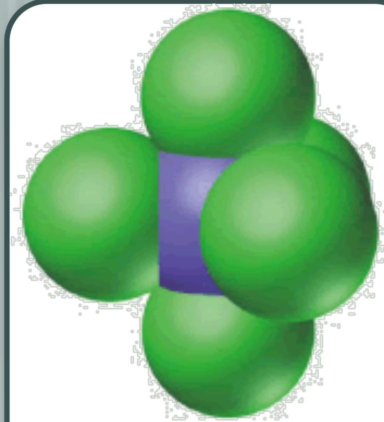
Round your answer to the least precise mass you are adding.

Phosphorus Pentachloride

P x 1 = 30.974 AMU

+ Cl x 5 = 177.265 AMU

208.239 AMU



PC1$_5$

To determine the molecular mass of a covalent compound, simply add the masses of all the atoms in the compound.

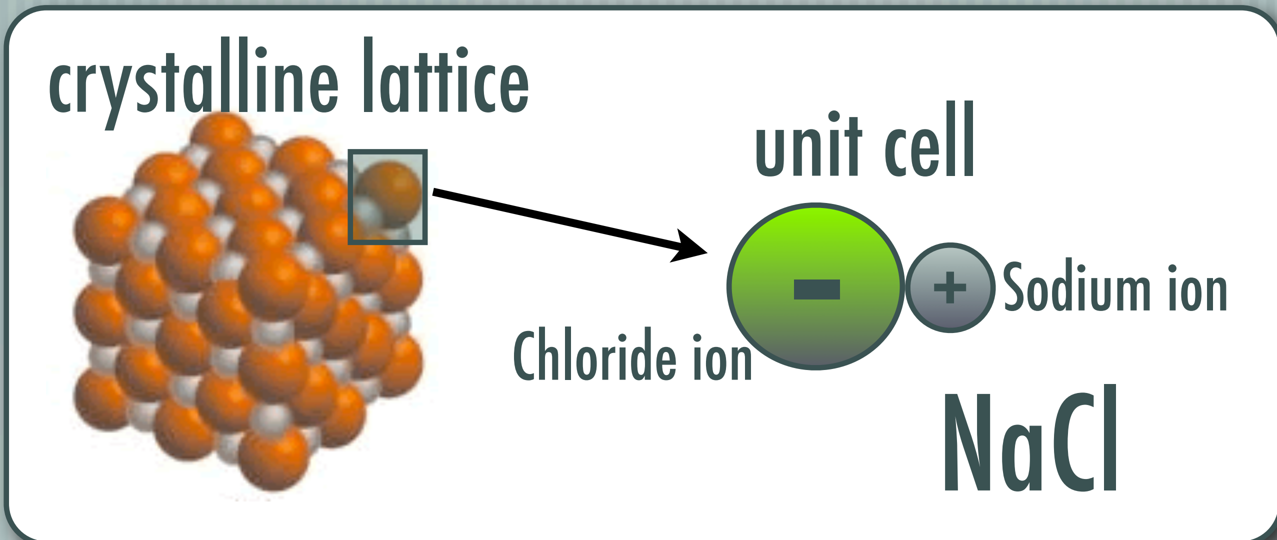
menu

Formula Mass

menu

Formula Mass (Ionic)

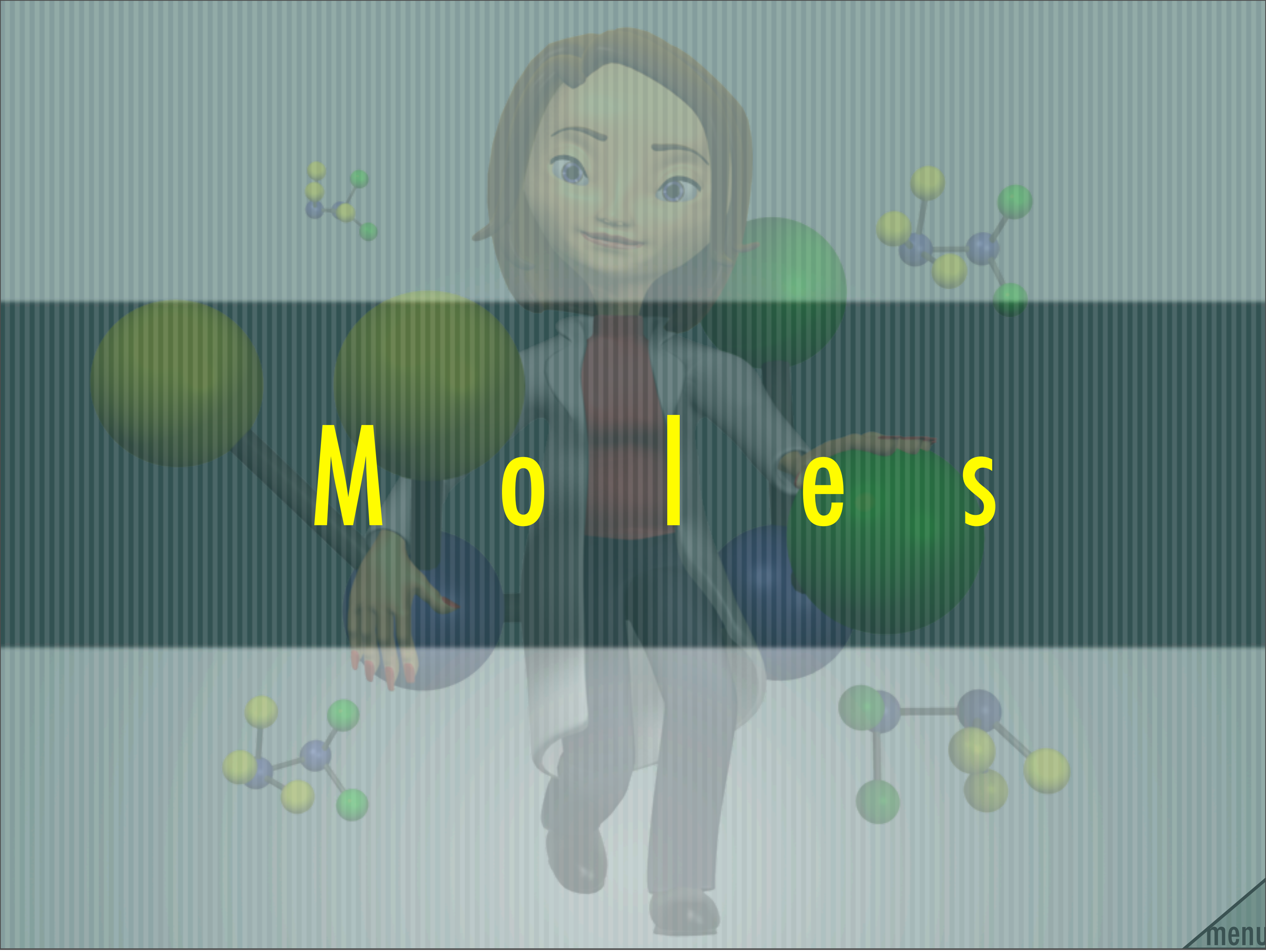
- Formula mass is the mass of a unit cell in an ionic compound.
- A unit cell is composed of ions in the ratio of the formula.



The formula mass of salt is 58.448 AMU.

1 Sodium cation (22.991 AMU) + 1 Chloride anion (35.457 AMU)

Calculate formula mass the same way you do molecular mass.


M o l e s
menu

Moles

- Number: A mole is an amount of a substance equal to a quanity of 602 sextillion particles (atoms, molecules, or unit cells). Written as 602,000,000,000,000,000,000,000 = 6.02×10^{23}
- Mass: A mole is the atomic mass (element), molecular mass (covalent compound) or the formula mass (ionic compound) of a substance expressed in grams.
- Since atoms, molecules and unit cells are extremely small, a mole is a huge number of particles but a small mass.
- Mass of a sample ≠ number of particles in the sample!

menu

The Mole: Number vs. Mass

One mole of:	Number of particles	Molar Mass
C	6.02×10^{23} atoms	12.011 g
CF_4	6.02×10^{23} molecules	88.01 g
$Al(OH)_3$	6.02×10^{23} unit cells	78.00 g
N_2O_5	6.02×10^{23} molecules	108.011 g
Cu	6.02×10^{23} atoms	63.546 g
Fe_2O_3	6.02×10^{23} unit cells	159.70 g
SiO_2	6.02×10^{23} molecules	60.09 g

Mole Conversions

menu

Moles: Converting units

- Suppose you are given 70.0 grams of salt and asked to calculate the number of unit cells in the sample. How would you do it?

1) Calculate the molar mass of sodium chloride.

$$\begin{array}{c} \text{Na} = 22.991 \text{ g/mol} \\ \underline{\text{Cl} = +\ 35.457 \text{ g/mol}} \\ \text{NaCl Molar Mass} = 58.448 \text{ g/mol} \end{array}$$

2) Use DA to convert the given mass to unit cells.

Given Mass

$$\frac{70.0 \text{ g.}}{1} \Big| \frac{1 \text{ mole}}{58.448 \text{ g}} \Big| \frac{6.02 \times 10^{23} \text{ unit cells}}{1 \text{ mole}} = 7.21 \times 10^{23} \text{ unit cells}$$

Molar Mass

Mole Conversions

Given Mass ⟷ Moles ⟷ Number of Particles

(grams) (moles) (atoms, molecules, unit cells)

- Whenever you are doing conversions (using DA) always start with your given (what you are given to convert).
- One mole always shows up in your conversion factor. If you are given mass or particles, you must first convert it to moles.
- The only two conversion factors you will ever use contain either:
  1 mole and molar mass or
  1 mole and 602 sextillion atoms, molecules or unit cells.

Covalent Compound

Ionic Compound

Element

menu

Converting mass to # of particles

Given Mass (grams) → **Moles** (moles) → **Number of Particles** (atoms, molecules, unit cells)

Suppose you are given 8.63 grams of sulfur and asked to calculate the number of sulfur atoms in the sample.

Here is how you would do it:

Given Mass

Shows up in every conversion factor!

Atoms is the unit because sulfur is an element!

Number of particles in a mole

$$\frac{8.63\ \cancel{g}}{1} \times \frac{1\ \cancel{mole}}{32.065\ \cancel{g}} \times \frac{6.02 \times 10^{23}\ atoms}{1\ \cancel{mole}}$$

Molar mass of sulfur

Cancel units

Answer: 1.620×10^{23} sulfur atoms

menu

Converting # of particles to mass

Given Mass ← **Moles** ← **Number of Particles**

(grams) (moles) (atoms, molecules, unit cells)

You are told that a sample of copper(II) nitrate contains 3.48×10^{24} unit cells and asked to calculate the mass of the sample. Here is how you would do the calculation:

formula: $Cu(NO_3)_2$ Molar mass: 187.56 g/mol

$$\frac{3.48 \times 10^{24}\ \cancel{\text{unit cells}}}{1} \times \frac{1\ \cancel{\text{mole}}}{6.02 \times 10^{23}\ \cancel{\text{unit cells}}} \times \frac{187.56\ \text{g}}{1\ \cancel{\text{mole}}}$$

Answer: 1084 grams of copper(II) nitrate

menu

Converting moles to mass & particles

Given Mass (grams) ⟵ **Moles** (moles) ⟶ **Number of Particles** (atoms, molecules, unit cells)

You are told you have 17.90 moles of water.
What is the mass and number of molecules in the water?

Formula: H_2O Molar Mass = 18.015 g/mol

$$\frac{17.90 \cancel{\text{ moles of water}}}{1} \times \frac{18.015 \text{ g}}{\cancel{1 \text{ mole}}} = 322.5 \text{ g}$$

$$\frac{17.90 \cancel{\text{ moles of water}}}{1} \times \frac{6.02 \times 10^{23} \text{ molecules}}{\cancel{1 \text{ mole}}} = 1.078 \times 10^{25} \text{ molecules}$$

menu

Remember your Units!

- Molecular and Formula masses measure the masses of tiny individual molecules and unit cells - too small to see. The unit for these measurements is the AMU (Atomic Mass Unit).
- Molar mass is the mass of 602 sextillion atoms, molecules or unit cells. The unit for molar mass and given mass is grams .
- Elements are composed of atoms .
- Covalent compounds are composed of molecules.
- Ionic compounds are composed of unit cells (aka formula units).

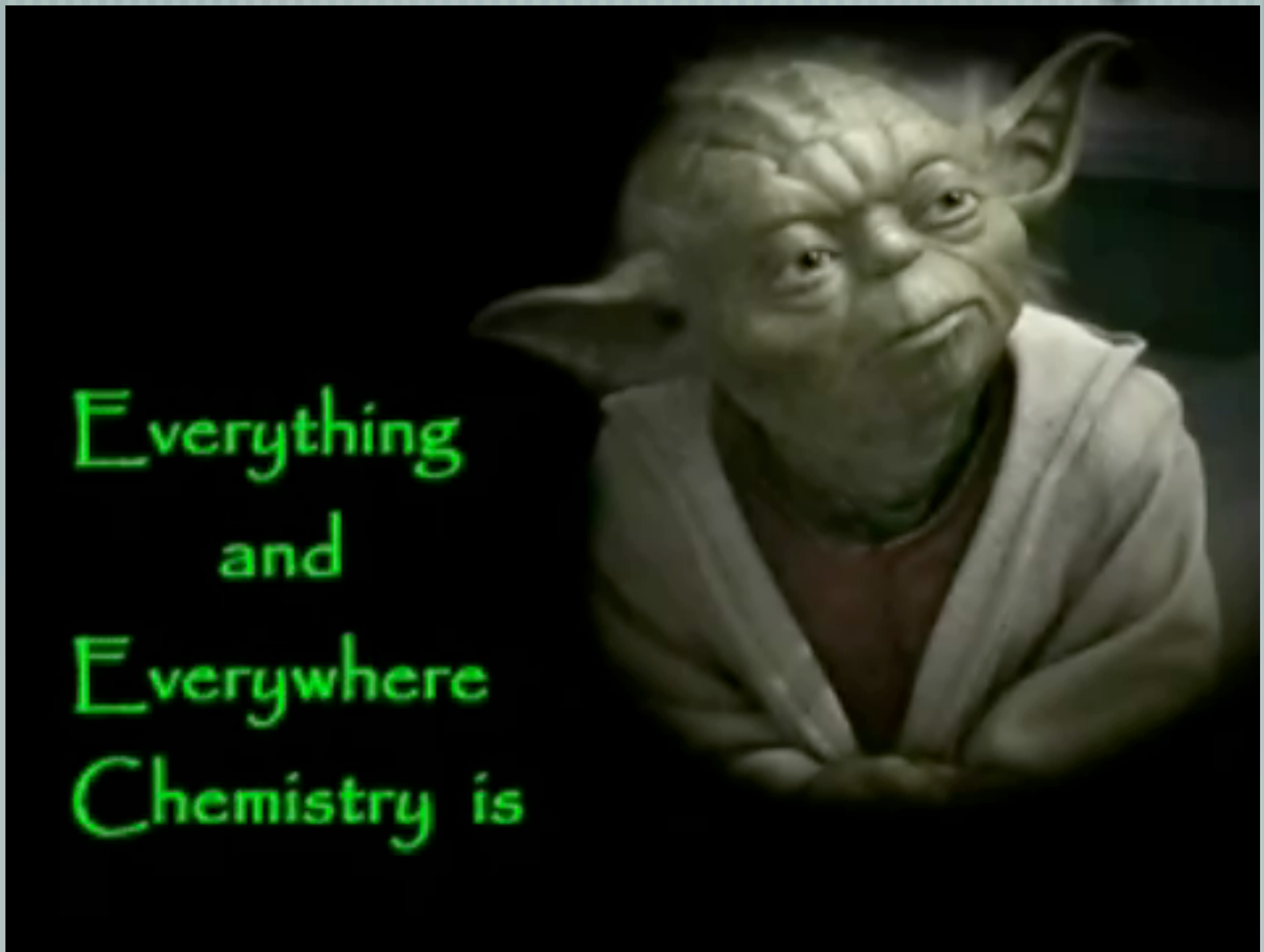
Mole Calculations:

- Given mass is the mass you are given - it can be any amount.
  Molar mass is the mass of one mole of the substance. It is calculated by adding up the atoms/ions and expressing in grams.
- Because you either begin with moles or convert directly to moles, 1 mole shows up in every conversion factor.
- Rules for Sig figs:
  Round to least precise when calculating your molecular/formula or molar mass.
  Round to least number of sig figs when using DA.

menu

What is October 23?

National Mole Day!



menu