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Warm-Up | Molar Masses

Lesson Objectives

By the end of this lesson, you should be able to:

- Define a [ ] and explain its role in the measurement of matter.
- Explain the relationship between the mole and [ ] number.
- Determine the molar mass of a molecule from its chemical formula.

Science Practice: Perform math calculations to determine the number of particles in a given sample of a substance.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

mole	the SI unit for the amount of a substance; the number of atoms in 12 g of [ ], which is 6.02×10^{23}
Avogadro's number	The number of units in a mole, [ ]
molar mass	The mass of 1 mole of substance, which is equal to the molecular or formula mass in [ ]

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Lesson Question

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The Chemist's Dozen

Mole (mol): the [ ] unit for the amount of a substance; the number of atoms in 12 g of C-12, or 6.02×10^{23}

1 mole NaCl
58.44 g
[ ] formula units

1 mole H_2O
18.02 g
6.02×10^{23} molecules

1 mole Mg
[ ] g
6.02×10^{23} atoms

Avogadro's Number

Avogadro's number: the number of units in a mole, 6.02×10^{23}

- Named after Amadeo [ ]
  - Equal volumes of gases contain the same number of particles at the same temperature and [ ].
- Based on mass of carbon-12

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How to Calculate Avogadro's Number

One atom of carbon-12 has a mass of [ ]. How many atoms of carbon-12 are in 12.00 g?

- Set up calculation:

$$12.00\,\text{g C-12} \times \frac{1\,\text{amu}}{\boxed{}} \times \frac{1\,\text{atom C-12}}{12.00\,\text{amu}}$$

- Cancel units and solve:

$$12.00\,\text{g C-12} \times \frac{1\,\text{amu}}{1.66 \times 10^{-24}\,\text{g}} \times \frac{1\,\text{atom C-12}}{12.00\,\text{amu}} = \boxed{}\ \text{C-12}$$

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Molar Mass and Average Atomic Mass

Chemists use the mole and Avogadro's [ ] to relate average atomic mass to molar mass.

- [ ] table: average atomic mass, amu
- **Molar mass**: the mass in grams of 1 mole of a substance

The molar mass of an element, in grams per [ ], has the [ ] value as the average atomic mass of the [ ] in amus.

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Molar Mass of a Compound

What is the molar mass of sodium chloride ([ ])?

- Identify the component elements and their average masses. [ ]

	Average Atomic Mass (g)
Na	22.99
Cl	35.45

- Identify the number of atoms of each element in one unit.
  - NaCl: one atom Na, one atom Cl

Molar Mass of a Compound

- Calculate the mass of one unit.

$$1 \times 22.99$$
$$1 \times 35.45$$
$$58.44 \text{ amu}$$

- Convert from atomic mass units to grams per mole.

$58.44 \text{ amu} = 58.44$ [ ] of NaCl

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Molar Mass of a Compound

What is the molar mass of calcium chloride ($CaCl_2$)?

- Identify component elements and their [ ] atomic masses.

	Average Atomic Mass (g)
Ca	40.08
Cl	35.45

- Identify the number of atoms of each element in one unit.
  - $CaCl_2$: one atom [ ], two atoms Cl

Molar Mass of a Compound

- Calculate the mass of one unit.

$$1 \times 40.08 = 40.08$$
$$2 \times 35.45 = 70.90$$

[ ]

- Convert from atomic mass units to grams per mole.

$110.98 \text{ amu} = 58.44 \text{ gm/mol of}$ [ ]

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Molar Mass of a Compound with Polyatomic Ions

What is the molar mass of aluminum sulfate ($Al_2(SO_4)_3$)?

- Identify component elements and their average atomic masses.

	Average Atomic Mass (g)
Al	26.98
S	32.07
O	16.00

- Identify the number of atoms of each element in one unit.
  - $Al_2(SO_4)_3$: [ ] atoms Al, [ ] atoms S, [ ] atoms O

Molar Mass of a Compound with Polyatomic Ions

- Calculate the mass of one unit.

$$2 \times 26.98 = 53.96$$
$$3 \times 32.07 = 96.21$$
$$12 \times 16.00 = 192.00$$

[ ]

- Convert from atomic mass units to grams per mole.

$342.17 \text{ amu} = 342.17 \text{ gm/mol of}$ [ ]

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How to Calculate the Molar Mass of a Compound

- Identify component elements and their average atomic masses.
    - Use the average atomic mass from the periodic [ ].
- Identify the [ ] of atoms of each element in 1 molecule or formula unit.
    - Use the chemical [ ].
- Calculate the mass of 1 molecule or formula unit.
    - Add the average atomic masses.
    - Account for subscripts and parentheses.
- Convert from atomic mass units to grams per mole.
    - Molar mass in grams per mole = average atomic mass in atomic mass units.

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How to Convert between Molar Mass and Number of Particles

The molar mass of calcium sulfate ($CaSO_4$) is [ ]. How many formula units of $CaSO_4$ are present in 15.255 g?

- Set up the unit conversion.

$$15.255\,\text{g CaSO}_4 \times \frac{1\,\text{mol CaSO}_4}{136.15\,\text{g CaSO}_4} \times \frac{6.02 \times 10^{23}\,\text{formula units}}{[\ ]}$$

- Cancel units and solve.

$$15.255\,\text{g CaSO}_4 \times \frac{1\,\text{mol CaSO}_4}{136.15\,\text{g CaSO}_4} \times \frac{6.02 \times 10^{23}\,\text{formula units}}{1\,\text{mol}}$$

$$= [\ ]\ \text{formula units CaSO}_4$$

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How to Convert between Molar Mass and Number of Particles

The [ ] mass of water (H_2O) is 18.02 g/mol. What is the mass of 8.21×10^{25} molecules of water?

- Set up the unit conversion.

$$8.21 \times 10^{25}\ \text{molecules}\ H_2O \times \frac{1\ \text{mol}}{6.02 \times 10^{23}\ \text{molecules}} \times \frac{18.02\ \text{g}\ H_2O}{[\ ]}$$

- Cancel units and solve.

$$8.21 \times 10^{25}\ \text{molecules}\ H_2O \times \frac{1\ \text{mol}}{6.02 \times 10^{23}\ \text{molecules}} \times \frac{18.02\ \text{g}\ H_2O}{1\ \text{mol}\ H_2O}$$

$$= [\ ]$$

How to Convert between Molar Mass and Number of Particles

- Set up the unit [ ].
  - Use molar mass to convert between mass and moles.
- Cancel [ ] and solve.
  - Make sure the desired units remain after cancellation.

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Summary | Molar Masses

Lesson Question

How are scientists able to count the number of particles in matter?

Answer

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Avogadro's Number and the Mole

- Avogadro's number is the number of atoms, molecules, formula units, or other particles in 1 mole of a substance.
- Avogadro's number is equal to 6.02×10^{23}.
- Avogadro's number is based on the mass of _____.
- One mole of any substance contains exactly the same number of atoms, molecules, or other particles as 1 _____ of any other substance.
- The mole is useful in chemistry because it allows for direct comparisons of amounts.

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Molar Mass and Conversions

- The molar mass of a substance is the mass in [ ] of 1 mole of particles of the substance.
- A substance's molar mass in grams has the same magnitude as the mass of one constituent particle in atomic mass units.
- The average atomic mass of an element given on the periodic table is equal to the element's molar mass.
- The molar mass of a [ ] can be calculated from the molar masses of its component elements.

Use this space to write any questions or thoughts about this lesson.

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