

The Mole and Molar Mass

 Guided Notes – Student Edition

Relative Atomic Mass (A_r)

Recall that an atom's mass depends on the number of _____ and _____ found in its nucleus. Electrons have a much _____ mass by comparison and are therefore not included in the mass value. While it is not possible to weigh individual _____, it is possible to determine the mass of one atom _____ to another. This is done by assigning a value to the mass of an atom of a given element so that it can be used as a point of reference.

Relative Atomic Mass (A_r): Why Carbon?

Atoms were first measured relative to hydrogen, which was given the mass value _____. Soon after, the isotopes of hydrogen, _____ and _____ were discovered which had mass values of _____ and _____ respectively. From here, oxygen was then chosen. However, it was then discovered that oxygen also had isotopes, and so _____ was finally chosen. Eventually, carbon was also found to have isotopes, but rather than opting for yet another element, the carbon isotope with the mass number _____ was chosen. Its mass is defined as _____ atomic mass units (amu). The relative atomic mass (_____) of an atom is therefore defined as its mass related to carbon-12. A_r has no units.

Quantitative Chemistry

Quantitative chemistry is the study of the _____ of substances taking part in a chemical reaction. The amount (_____) of particles (e.g. _____, _____ or _____) is measured in units called _____ (symbol mol). The mole allows scientists to calculate the number of atoms or molecules in a known _____ of any given substance.

Defining the Mole

The mole is the "_____ " used by chemists to indicate the number of particles present in a particular _____. The mole is similar to other counting units, such as a pair (___), or a dozen (___).

The mole is defined as the amount of substance which contains the _____ number of particles (i.e. atoms, ions or molecules) as there are atoms in exactly _____ of carbon-12 (C-12 or ^{12}C).



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One mole of any substances contains _____ atoms. This number is called _____ number after the Italian chemist Amedeo Avogadro and is given the symbol _____.

This means that...

- 12 grams of carbon is the same as _____.
- 1 mole of carbon is equal to _____.
- 6.02×10^{23} carbon atoms have a mass of _____.

Molar Mass

The mass (in _____) of one mole (_____ particles) of a substance (element or compound) is called its _____. It has the symbol _____ and the unit grams per mole or _____.

Molar masses are defined relative to that of _____ (the isotope of carbon with _____ protons and _____ neutrons), which is given a molar mass of _____ (i.e. 12g of C-12 contains 1 mole or 6.02×10^{23} C-12 atoms).

By comparing the mass of each element and compound with carbon-12, the masses of all elements and compounds can be compared with each other (e.g. atomic hydrogen, H-1, has a molar mass of _____, so hydrogen atoms are _____ times lighter than C-12 atoms).

Steps for Calculating the Molar Mass (*M*)

Recall that the molar masses for a compound can be calculated by _____ the molar masses for each atom in the compound.

The following steps review the process:

Calculating Molar Mass

CH₄

6 C 12.01	1 H 1.008	12.01 g mol^{-1} $+ (1.008 \text{ g mol}^{-1}) \times 4$ 16.042 g mol⁻¹
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Step 1: From the formula of the compound, determine the total number of each type of atom.

Step 2: Add the molar masses of the individual atoms.

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Example 1: Calculate $M(\text{CO}_2)$, given $M(\text{C}) = 12 \text{ g mol}^{-1}$, $M(\text{O}) = 16 \text{ g mol}^{-1}$

There is _____ carbon atom and _____ oxygen atoms therefore:

Example 2: Calculate $M(\text{SO}_4^{2-})$, given $M(\text{S}) = 32 \text{ g mol}^{-1}$, $M(\text{O}) = 16 \text{ g mol}^{-1}$

There is _____ sulfur atom and _____ oxygen atoms therefore:

Practice Problems

1. Calculate $M(\text{Ca}(\text{NO}_3)_2)$, given $M(\text{Ca}) = 40 \text{ g mol}^{-1}$, $M(\text{N}) = 14 \text{ g mol}^{-1}$, $M(\text{O}) = 16 \text{ g mol}^{-1}$

Answer:

Explanation:

2. Calculate $M(\text{CuSO}_4 \cdot 5\text{H}_2\text{O})$, given $M(\text{Cu}) = 63.5 \text{ g mol}^{-1}$, $M(\text{S}) = 32 \text{ g mol}^{-1}$, $M(\text{O}) = 16 \text{ g mol}^{-1}$, $M(\text{H}) = 1.0 \text{ g mol}^{-1}$

Answer:

Explanation:

Relative Formula Mass (M_r)

Relative formula mass is another way of referring to _____. However, relative formula mass is usually reserved for _____ compounds (such as _____), which do not actually exist as individual molecules. It can be obtained by adding the relative atomic masses (____) in an ionic compound. M_r has no units.

Isotopes affect Molar Mass

Many elements exist in nature as a number of different _____. Isotopes are atoms of the same element which have _____ numbers of protons and electrons but differ in their number of _____. This gives the isotopes of a particular element their different masses. The molar mass

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value for an element will rarely be a _____ number because they take into account the _____ of all the isotopes of the element.

Example: Molar Mass of Chlorine:

Chlorine has two naturally occurring isotopes:

- Chlorine- _____, comprising about 75% of all chlorine atoms.
- Chlorine- _____, comprising about 25% of all chlorine atoms.

This means that for every _____ Cl-35 atoms there will be _____ Cl-37 atom. Therefore the average molar mass of chlorine will be:

$$\frac{(35 \times 75) + (37 \times 25)}{100} = 35.5$$

Elemental chlorine, therefore, has a molar mass of _____, written $M(\text{Cl}) = 35.5 \text{ g mol}^{-1}$.

Chlorine, by comparison, is on average, $35.5/12 =$ _____ times heavier than an atom of _____.

Practice Problem:

Calculate the relative atomic mass of uranium using the data in the table below:

Isotope	Relative Abundance (%)
²³⁸ U	99.27
²³⁵ U	0.72
²³⁴ U	0.01

Answer: Relative atomic mass =

Explanation: