TOPICS

• Define and Distinguish between Atomic Mass and Atomic Number
• Isotopes and calculation of atomic weight from isotopic abundances.
• The mole concept

Atomic Number, Z

Elements are arranged in the periodic table according to their atomic number

Atomic Number, Z = Number of Protons in the Nucleus

All atoms of the same element have the same number of protons in the nucleus, Z

Identifying Atomic Number, Z on Periodic Table

<table>
<thead>
<tr>
<th>13</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.9815</td>
<td>atomic weight</td>
</tr>
</tbody>
</table>

Question: Determine from your periodic table, how many protons are in the nucleus of Calcium atom?

Ans:
Relative Atomic Mass

- The mass of atoms are determined relative to a reference element.
- Carbon-12 (carbon with 6 protons and 6 neutrons) is the currently used reference and is assigned a mass of 12.
- Oxygen is ~1.33 times heavier than Carbon-12 hence its relative atomic mass is:
  \[1.33 \times 12 = 15.99\]

Atomic Mass Unit (amu)

- Masses of subatomic particles are expressed in amu
- 1 atomic mass unit = \(\frac{1}{12}\)th the mass of carbon-12
- 1 atomic mass unit = \(1.661 \times 10^{-24}\)g (which is the mass of one proton or one neutron)

Mass Number, A

Mass Number, \(A\) = Number of protons + Number of neutrons

Examples:
What is the mass number of a Carbon atom with 6 protons and 6 neutrons
Ans:
Mass Number, A

Examples:
What is the mass number of a Sodium atom with 11 protons and 12 neutrons
Ans:

Mass Number, A

Question: Calculate the mass of one carbon atom
Ans:

Question: Calculate the mass of $6 \times 10^{23}$ carbon atoms
Ans:

Atomic Symbol

Mass number $A$ → $X$
Atomic number $Z$ → $B$

Element Symbol
Atomic Symbol

Question:
Using the periodic table
(a). determine the number of protons in a phosphorus atom that contains 16 neutrons.
(b). How many electrons are in this atom?
(c). What is the mass number of this phosphorus atom?
(d). Write the atomic symbol for this atom
(e). Calculate the mass of one phosphorus atom
(f). Calculate the mass in grams of $6.02 \times 10^{23}$ atoms of phosphorus
(g). Compare your answer in question (f) above to that in (c). What can you conclude?

Ans:
Determination of Atomic Mass (Mass Spectrometer)

Masses of atoms have been determined experimentally using Mass spectrometer.

It was observed that the mass of atoms are not necessarily integral numbers but contain fractions e.g. the mass of $^{56}\text{Fe}$ is not 58 but 57.9333.

The exception to this observation is $^{12}\text{C}$ which by definition is 12.
Isotopes

• Atoms of the same element with same atomic number, Z, but different mass number (A).

\[ ^{10}\text{B} \quad ^{11}\text{B} \]

1. Isotopes

Atoms of the same element with same atomic number, Z, but different mass number (A).

Other examples:

Hydrogen

2. Isotopes

Percent Abundance

Not all isotopes of an element occur naturally. Also, isotopes occurs to different degrees.

Example:
Isotopes

Percent Abundance

<table>
<thead>
<tr>
<th>Element</th>
<th>Isotope</th>
<th>Number of Proton</th>
<th>Number of Neutrons</th>
<th>Percent Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Because of the existence of isotopes, the mass of a collection of atoms has an average value.

**Average mass** = \[
\text{ATOMIC WEIGHT} = \left( \frac{\text{at. wt.} \times (\% \text{ ab. isot. 1})}{100} \right) + \left( \frac{\text{at. wt.} \times (\% \text{ ab. isot. 2})}{100} \right) + \cdots
\]

**Note:**

Fractional abundance = \[
\left( \frac{\% \text{ ab. isot. 1}}{100} \right)
\]

**Question:**

For Boron the percent abundances are 19.9% for $^{10}\text{B}$ and 80.1% for $^{11}\text{B}$. Calculate the average mass.

**Ans:**
Chemical Counting Unit: The Mole

- The MOLE is the counting unit used in Chemistry
- 1 mole is the amount of substance that contains as many particles (atoms, molecules) as there are in 12.0 g of $^{12}$C.
- 1 mole = $6.023 \times 10^{23}$ particles (atoms, molecules, ions, oranges, yes!!! Oranges!!!)

Particles in a Mole

Avogadro’s Number

$6.0221367 \times 10^{23}$

Amedeo Avogadro
1776-1856

Molar Mass

1 mol of $^{13}$C
= 12.00 g of C
= $6.022 \times 10^{23}$ atoms of C

12.00 g of $^{12}$C is its MOLAR MASS (or mass of 1 mole of $^{12}$C atoms)
Unit of Molar mass is g/mol
Taking into account all of the isotopes of C, the molar mass of C is 12.011 g/mol
Finding Molar Mass From Periodic Table

<table>
<thead>
<tr>
<th>atomic number</th>
<th>symbol</th>
<th>atomic weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Al</td>
<td>26.9815</td>
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</table>

Molar Mass of an element = atomic weight

So,

PROBLEM: How many moles are represented by 0.200 g of Mg?

Mg has a molar mass of 24.3050 g/mol.
Expressions For Calculations Relating to Molar Mass

Device for Remembering How to Do Mass/Mole Calculations

Molar Mass

Question:
What mass in grams is equivalent to 2.50 mol of Iron:

Ans