Avogadro’s Number

Hydrogen
1
H
1.0078

A VICTORIA SCIENCE TEACHING RESOURCE

WHAT IS IT?

6.022×10^{23} or 602,200,000,000,000,000,000,000

WHAT DOES IT MEAN?

Avogadro’s Number is the number of atoms, molecules, or other objects that makes up one mole of a substance. For example:

6.022×10^{23} hydrogen atoms represent one mole of hydrogen.

6.022×10^{23} water molecules represent one mole of water.

6.022×10^{23} elephants represent one mole of elephants.

WHAT’S A MOLE?

The mole is the unit of measurement for the amount of a substance as set out by the International System of Units. Other SUI units of measurement include kilograms, metres, and seconds. It’s a very handy way for chemists to work with huge numbers of atoms or molecules.

AVOGADRO’S NUMBER

Avogadro didn’t discover the number himself— it was named after him in recognition of his contributions to chemistry. Avogadro’s number helps chemists to get around the problem that every element has a slightly different mass, or density.

WHY IS THAT A PROBLEM?

Using Moles and Avogadro’s Number

Take this reaction as an example:

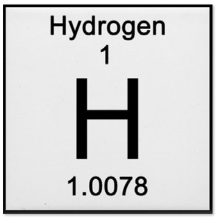
$NaOH + HCl = NaCl + H_2O$.

Because this looks like an even reaction on either side, it would be easy to assume that you can add equal weights of NaOH and HCl together and have them all used up in the reaction. But the elements that make those molecules up have different densities, or as scientists say their ‘atomic mass’ is different. For example, you can’t add one cup of sodium hydroxide and one of hydrochloric acid to get a complete reaction. This is because if you measure out the same volume of these chemicals you’ll have more molecules of the dense one and there won’t be an exact number to react and your end result will not be what you expect.

That’s where Avogadro’s number comes in. It is a really useful way to standardise the way we predict and carry out chemical reactions, in the same way that working in teaspoons, grams or millilitres allows us to mix a perfect sponge cake. Once chemists have worked out how much a mole of a chemical weighs they can always ensure that they have approximately the right number of molecules to make a reaction work fully.

Making Mountains out of Moles

So how do we find out how much a mole of a substance weighs?



If you look at an element on the periodic table, you'll see two numbers. The number at the bottom is its atomic mass.

The atomic mass of an element is used to calculate its mass relative to other elements. So helium, with an atomic mass of 4.0026 is nearly four times as massive as hydrogen.

What's extraordinary about Avogadro's Number is that 6.022×10^{23} atoms of any element will always be equal to their atomic mass in grams. This means one mole of hydrogen is 1.0078 grams. By using the atomic mass of the different elements, we can figure out how much a mole of any molecule weighs.

For example: H_2O has two hydrogens and one oxygen. The atomic mass of hydrogen is 1.0078 and the atomic mass of oxygen is 15.999, so the mass of a mole of water is $2 \times 1.0078 + 15.999$. Therefore, a mole of water, or 6.022×10^{23} molecules, weighs 18.0146 grams.

QUESTIONS

- How many moles of hydrogen are there in one mole of H_2O?
- How many atoms of hydrogen are there?
- Using the periodic table, work out the mass of Sodium Hydroxide and Hydrochloric Acid you'll need to perfectly recreate the following equation.
  $NaOH + HCl = NaCl + H_2O$.
- How many moles of carbon are in the Great Star of Africa, the largest clear cut diamond in the world?
- How large would a mole of moles be?

FURTHER INVESTIGATIONS

- Find out how they figured out Avogadro's Number.
- Why was Avogadro so important to our understanding of chemistry?