Introduction to moles and molarity

Introduction

In this lecture we will look at moles, molarity and Avogadro's constant, and then later move on to look at Amounts, Volumes and Concentrations.

What is a mole?

A mole, in this case, is not...

A mole! This has nothing to do with chemistry.
Photograph by Michael David Hill, 2005 from WikiMedia Commons

A mole in chemistry is not as depicted as above, it is in fact an SI Unit and is defined as the amount of any substance that contains the same number of ions, molecules or atoms as given by:

The number of atoms in 12 g of Carbon 12

This number, which happens to be 6.0221415×10^{23}, is also known as Avogadro's constant or number.

Why are moles important?

Moles are important because of the way chemistry works.

In the lab we weigh out compounds to make solutions, or to carry out reactions. In a reaction you may have 1 molecule of compound A reacting with one molecule of compound B to give 1 molecule of compound C. Now if one molecule of compound A weighed 10, and one molecule of compound B weighed 20, then the resulting compound C would weigh 30 - see below (assuming that all A and B were converted to C).

$$A + B \rightleftharpoons C$$

Now, if you weighed out 100 of compound A you would have 10 molecules (that is, each molecule of A is 10). If you then weighed out 100 of compound B you would have 5 molecules of B as each molecule weighs 20. Reacting these amounts of A and B together, where 1 A reacts with 1 B, would result in all result in all 5 of B being used, which would only require 5 of A (hence leaving 5 of the 10 A unused), producing 5 C. Clearly the reaction has not been efficient as not all of A was used.

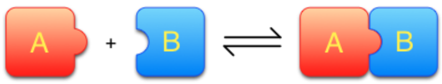
The problem here was the 'amounts' used were weights and although they were equal for A and B this did not mean that the same number of molecules of A and B, 10 and 5 respectively, were available. What was really needed was for the same number of molecules of A and B to be present, i.e. 10 molecules of A, and 10 molecules of B, giving 10 molecules of C. And this is where moles come in.

If each molecule of A weighs 10, then 10 molecules of A would weigh 10 x 10 = 100.

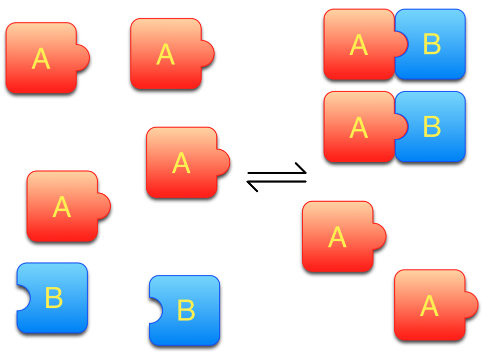
If each molecule of B weights 20, the 10 molecules of B would weigh 20 x 10 = 200.

Hence, we should weigh out 100 of A (giving 10 molecules), and 200 of B (also giving 10 molecules). We now have the molecules in a 1:1 ratio so they can react to give 10 molecules of C.

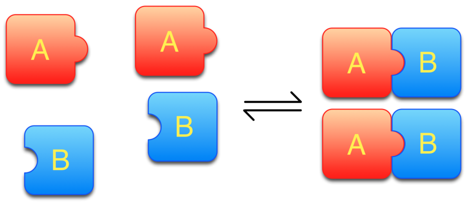
If you are having trouble getting this have a look at the following figures which walks you through the reactions.



Reactions and moles - Say A weighs 10 and B weighs 20, and A and B react together as shown above to form AB. A and B are said to react 1:1. How much of A and how much of B would you require?



Reactions and moles - If you weigh out 40 of A you would have 4 As. If you weigh out 40 of B, you will have 2 Bs (remember each A weighs 10, and each B weighs 20). Now when the 1:1 reaction runs you use up all the Bs and are left with 2 As, and you form two ABs, as shown above.



Reactions and moles - However, if you weigh out 20 of A and 40 of B you will have you had 2 As and 2 Bs. You have a 1:1 ratio of A and B and these can react to form 2 ABs, with no left over As. Here you have used moles for the reaction.

It is worth spending some time considering why moles are important, and why you need to understand them.

What is molarity?

Molarity is a measure of concentration and is just moles per litre.

That is, a 1 Molar (1 M) solution is just:

1 mole of a compound made up to a 1 litre solution

As 1 mole is the just the molecular weight of a compound then a 1 Molar (1 M) solution can be defined as:

the molecular weight of a compound made up to 1 litre

So, for example, if a compound has a molecular weight of 10 g/mol, then 10 g of the compound made up to 1 litre is a 1 Molar (1 M solution).

Avogadro's constant

This is the critical number, and is 6.0221415×10^{23}. What this represents is the number of atoms, ions or molecules in 1 mole.

This number can be useful when trying to convert between moles and number of molecules present, because the number of moles present multiplied by Avogadro's constant gives you the molecules or atoms.

Missing something? A mistake?

Have I missed something in this section? Is there something you would like to be included? Have I made a mistake?

If the answer is yes to any of the above questions then please email me at: drnickmorris@gmail.com and tell me what you would like included and why, or what the mistake is and where it can be found. Thanks.

Test your understanding

You can test your understanding of moles and molarity by heading over to:

https://maths4biosciences.com