Atoms are made up of smaller particles that are held together by electrical or magnetic forces. Each atom is, in effect, like a mini solar system with a cluster of particles called ‘electrons’ orbiting it. The nucleus has a positive electrical charge and the electrons have negative electrical charges. The charges of the electrons balance out or neutralize the charge of the nucleus. In effect, unless an imbalance occurs, e.g. an electron is gained or lost by an atom, the electrical charge remains nil (it is balanced).

Elements differ from one other in terms of atomic weight. By knowing the atomic weights of the different parts (different elements) of a nutrient salt, the proportion of the total weight of that salt, which is made up of the element wanted to feed the plant with, can be calculated.

Example: Ammonium Sulphate (also called Sulphate of Ammonia) is composed of the following:

- Two atoms of nitrogen
- Eight atoms of hydrogen
- One atom of sulphur
- Four atoms of oxygen

The plant is required to be fed two atoms of nitrogen. However, the plant is provided with the entire aforementioned list, as it is the most convenient method to apply the nitrogen.

Only 21.3% of the total weight is actually nitrogen. The rest of the weight is made up of hydrogen, sulphur and oxygen.

Ammonium nitrate is at times used as an alternative form of nitrogen. This chemical salt has a larger proportion of nitrogen, being 35%. If ammonium nitrate were used instead of ammonium sulphate, less of the chemical would need to be applied to feed the plant with the same amount of nitrogen.

Writing Chemical Names

The different elements have been given standard letter abbreviations. Chemical compounds or nutrient salts can be written using these abbreviations.

The elements, which are generally considered most essential to plant growth, plus those commonly found in nutrient salts, are listed below with their atomic weights and abbreviations:

Boron	B	11	Manganese	Mn	55
Calcium	Ca	40	Molybdenum	Mo	96
Carbon	C	12	Nitrogen	N	14
Chlorine	Cl	35	Oxygen	O	16
Cobalt	Co	59	Phosphorus	P	31
Copper	Cu	64	Potassium	K	39
Hydrogen	H	1	Sodium	Na	23
Iron	Fe	56	Sulphur	S	32
Magnesium	Mg	24	Zinc	Zn	65

What Does a Plant Need?

Plants require different nutrients in different quantities. The quantity of nutrient required by a plant will vary from one plant to another and from time to time throughout different stages of its growth.

The plant, in very large quantities, needs some nutrient elements, whilst others are only required in very small quantities. Those used in large quantities are called major elements; ones needed in small quantities are termed as minor elements. Major and minor elements are both just as essential to good plant growth, despite the differences in the quantities that the plant uses.

The most ideal range of concentration of nutrient to be put into nutrient solutions is as follows:

Nutrient Element	Concentration (mg/litre or ppm)		
Nitrogen (nitrate)	70	-	400
Nitrogen (ammonium)	0	-	31
Phosphorus	30	-	100
Potassium	100	-	400
Calcium	150	-	400
Magnesium	25	-	75
Iron	0.5	-	5
Boron	0.1	-	1
Zinc	0.02	-	0.2
Copper	0.1	-	0.5
Manganese	0.5	-	2
Molybdenum	0.01	-	0.1

The Ideal formula

Although the title of this work indicates it, there is no such thing as an ideal formula. There are hundreds of published formulae and from this overwhelming mass one might write out an optimum range for each of the nutrient elements.

An example of such a scheme is shown below:

Major Elements	Minimum ppm	Maximum ppm	Optimum ppm
Nitrogen	90	200	140
Phosphorus	30	90	60
Potassium	200	400	300
Calcium	120	240	150
Magnesium	40	60	50

There are two other factors that play an important role in the choice of formulae, being:

a) **Climatic conditions**: It is beyond the scope of this course to state the reasons, however, the potassium/nitrogen ratio is most important and should be varied with the climate. During the longer summer days, the plant needs more nitrogen and less potassium than during the shorter darker winter days. Therefore, it is common practice to double the ratio potassium/nitrogen during the winter.

b) **Plant type**: The type of plant that is being grown, leafy or otherwise has an influence on the formulation. Lettuce and cabbage would benefit from a formula with higher nitrogen content, than that which would be given to tomato plants.

By and large, plants are very tolerant and nearly all do well on one general nutrient mixture, with the following reservations:

- The pH value must be adjusted.
- The winter and summer mixtures are used in the respective seasons.

Before ending the discussion on major elements, it should be understood that certain types of them can exist, combined with oxygen or hydrogen, as a group known as a 'radical'**.** For example, nitrogen is found in salts as the ammonium radical or as the nitrate radical. The plant in solution assimilates either form; the ammonium form being the easiest assimilated. For this reason, not more than 20% of the total nitrogen in the ammonium form should be included in the formulation. In cloudy weather, ammonium nitrate should be kept minimum.

Minor or Trace Elements

Other than the major elements, six other elements are necessary in minute quantities. These have previously been stated and include iron, manganese, copper, boron, zinc and molybdenum, although many other elements such as aluminium, chlorine, silicon and sodium have been found in traces in plants. There is a general agreement over the levels of trace elements, which should be supplied to plants. If the concentrations are too high, they are definitely toxic to plants. For this reason, their concentrations in the nutrient solution must be strictly controlled. The following table gives the minimum, maximum and optimum suggested levels of the trace elements in the final solution.

	Minimum ppm	Maximum ppm	Optimum ppm
Iron (Fe)	2.00	5.00	4.00
Manganese (Mn)	0.1	1.00	0.50
Copper (Cu)	0.01	0.10	0.05
Boron (B)	0.10	1.00	0.50
Zinc (Zn)	0.02	0.20	0.10
Molybdenum (Mo)	0.01	0.10	0.02

Since the trace elements are required in such small concentrations, their compounding and mixing with the nutrient solution presents a problem if one is not a chemist. It is advocated by many to use two stock solutions of trace elements, one for iron and the other for the rest of the elements. The more practical scheme is to weigh out ten times the amount of each salt that is required and dissolve this into the same litre of water. It is then easy matter to add 100 millilitres to each batch of the nutrient solution.

TUTOR TALK: As with all course studies you should always attempt to read as much other material as possible on the subject. We do suggest that you contact either your local bookstore or an online seller of books to increase your studies even further.