Chapter 1
What is Chemistry?

Before we can start a course on beginning chemistry, we first of all have to explain what chemistry is.

1.1 Background

In ancient times, philosophers would propose ideas which were then accepted by the general population. For example, it was generally believed that mines, such as gold mines, if left for a period of time, would replenish themselves – yet no-one checked inside abandoned mines to see if this was true. Aristotle, a Greek philosopher, argued that one sign of women's inferiority was that women had fewer teeth than men. It would have been unthinkable at the time to open men's and women's mouths and actually count to see if there were any differences – which of course there are not. Everyone believed that the Earth was the centre of everything and that, in the human body, veins and arteries were totally separate systems.

The disconnect between philosophy and reality changed in the Western world beginning about the 1550s. This period marked the beginning of the Scientific Revolution, when ideas were tested against observations. Two of the most crucial steps were the discovery by Nicolaus Copernicus that the Sun was the centre of the solar system and the discovery by William Harvey that the circulation of blood involved both veins and arteries. And it was the Scientific Revolution which marked the dawn of the study of chemistry.

1.2 Chemistry as the Central Science

Chemistry is a science. A ***science*** is a subject for which knowledge is accumulated and analyzed. Scientists study things in nature – rocks, plants, clouds, and so on – and make ***observations***. Explanations for the observations are then proposed and these explanations are called ***hypotheses.*** Experiments are devised to test each hypothesis. If these experiments confirm the hypothesis, then a general ***theory*** is often proposed to account for the observations. For example, as we will see in Chapter 3, scientists believe in the atomic theory of matter, that is, atoms are the building blocks of everything on Earth. Often we continue to use the term "theory" even when the explanation has been confirmed beyond all reasonable doubt. For example, we can now "see" atoms yet we still talk about "atomic theory."

Chemistry is one of the natural sciences. These are the sciences that help us understand the physical world in which we live. The four natural sciences can be simply stated as:

Biology – the study of living organisms
Geology – the study of rocks and of ancient life-forms
Physics – the study of the laws and theories of the universe

Chemistry – the study of matter

Chemistry is often referred to as the central science as rocks, plants, and animals all consist of combinations of the same particles of matter – in other words, they are all chemical. The relationship between chemistry and physics is more complex, for it is physicists who study the fundamental structure of matter.

To try and organize the enormous quantity of scientific knowledge, we try and fit all of it into one of the four categories listed above. However, this doesn't always work. Some knowledge has aspects of two sciences. For this reason, we have interdisciplinary subjects as we show in Figure 1.1.

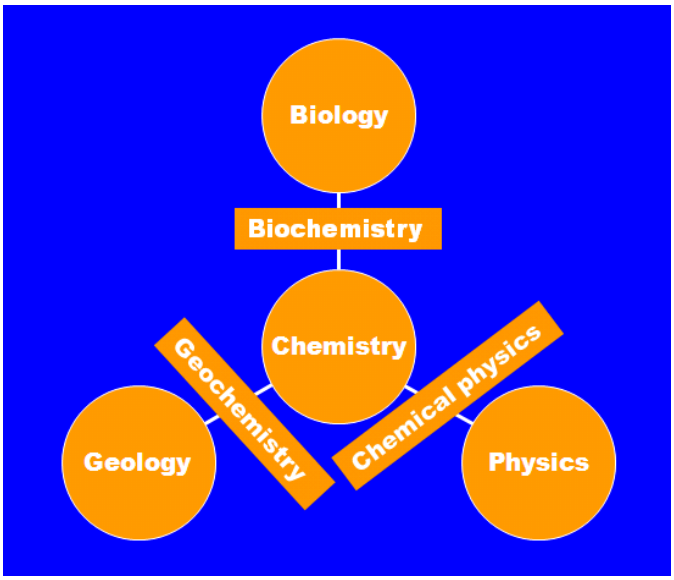

Figure 1.1 The four main natural sciences and the linking interdisciplinary subjects.

These interdisciplinary areas link the two parent disciplines as follows:

Biochemistry – the study of the chemical processes that occur in living organisms
Geochemistry – the study of the chemical substances in rocks and minerals
Chemical physics – the study of the interaction of chemical substances and energy

Chemistry itself is such a huge subject that we conventionally divide it into four areas, though again in practice, there is much overlap between them:

Organic chemistry – the study of substances predominantly containing the chemical element, carbon (notice this definition is very different to the use of 'organic' in the context of food origin)
Inorganic chemistry – the study of substances containing all the other chemical elements
Physical chemistry – the study of numerical values associated with chemical substances
Analytical chemistry – the determination of what chemical substances occur in a sample

There are many specialized areas of chemistry, too, such as medicinal and pharmaceutical chemistry, which is the study of chemical substances prescribed for the treatment of illness and disease.

1.3 Chemistry in the 21st Century

There are an enormous number of ways in which chemistry is involved in our lives. Here we have chosen three to highlight: ***environmental chemistry***, ***natural products chemistry***, and ***materials chemistry***.

ENVIRONMENTAL CHEMISTRY

Environmental chemistry is certainly one of the most crucial aspects of science for this century. Our modern civilization requires an enormous range of materials for our daily lives. We need metals, plastics, construction materials, fertilizers, and so on. In the past, when we took raw materials and turned them into something useful, such as iron ore into iron, we were not concerned with all the waste which would also be produced: gases going into the atmosphere, liquids into waterways, and solids into land-fills. Now, environmental chemists are devising chemical routes to make the products that we need without as much waste. Environmental chemists are also looking at ways of reusing waste materials, of devising plastics that break down when their use is over, and of cleaning up the environment.

NATURAL PRODUCTS CHEMISTRY

Pharmaceuticals are chemical compounds which have a medical use. Though many drugs are devised in the laboratory, we still rely on others whose origins are in the living world. A good example was aspirin. From earliest times, it was known that chewing on willow bark reduced pain. Unfortunately, the active chemical compound in willow bark also caused severe stomachache. It was in 1897 that a German chemist, Felix Hoffmann found that if the extracted active compound from willow bark was chemically changed, the product was a stable white powder which alleviated pain without major side effect. The product was named Aspirin®. Today, natural-products chemists are still searching for rare plants, fungi, and other organisms that may contain medically-useful chemical substances either as-is, or which could be altered in the chemical laboratory to be a useful pharmaceutical. Often this search involves asking rural people about the plants used in their herbal medicines.

MATERIALS CHEMISTRY

Our increasingly sophisticated society requires materials for very precise uses. As an example from the last century, people did not want to clean cooking items so it was realized a coat of the water-repellant plastic Teflon was the answer. There is always a search for lighter, stronger, better materials to suit our needs. Aircraft construction is a more recent example. Up until recently, aluminum metal has been the material of choice for aircraft bodies. It is strong and much lighter than iron or other metals. It is also relatively inexpensive. With today's concern

about fuel costs and fuel economy, we want materials which are lighter still while being at least as strong, if not stronger. Chemists have provided an answer with combinations of different materials, including new plastics, which are used in the new generation of commercial aircraft, such as the Boeing 787. These planes will contain very little metal content.

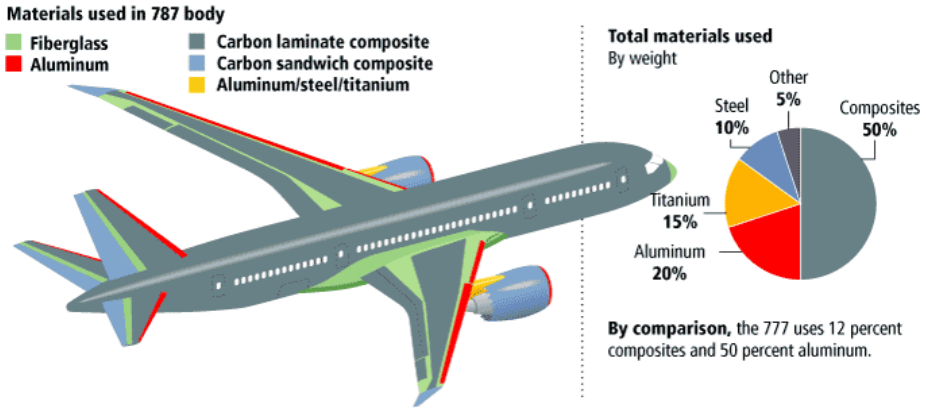

Figure 1.4 The composition of the Boeing 787 airliner

1.4 Where Next?

Chemistry is the study of matter. Thus the next chapter focuses on matter, the types and properties of matter.