Seminar_0

Introduction to the Course. History of organic chemistry.

From the very beginnings of science people have heated substances to see what happened to them. In 1807,**Jons Jacob Berzelius**decided that chemicals could all he divided broadly into two groups based on their behavior when heated. The substances, which burnt or charred on heating – and these were mostly from living things – he called **organic chemicals**. Any substances, which melted or vaporized when they were heated but then returned to their original state, Berzelius said were **inorganic**. Although we now recognize this classification as somewhat shaky, it gave chemists of the day something to focus their work on.

At the same time different inorganic chemicals were being synthesized. However, there was a widespread belief that it was impossible to synthesize organic compounds, that they were formed by animals and plants under the influence of a vital force within the living body. **Friedrich Wohler** put an end to this erroneous belief in 1828, when he heated ammonium cyanate (NH_4OCN) and produced urea (NH_2CONH_2). Wohler showed that the synthesized urea was exactly the same chemically as urea extracted from dog‘s urine – this was the first synthesis of an organic chemical from an inorganic source.

Although the model of the role of the vital force was wrong, the idea that organic chemicals were in someway ‘different’ was correct and valuable. Organic chemicals are all based around carbon atoms and their particular ability to form double or triple bonds, long chains, branched molecules and complex rings.

Carbon atoms have the ability to link together and thereby form molecules made up of many carbon atoms. Add to this the fact that any of the carbon atoms in such a chain can also bond with atoms of other elements, and you see the possibility of an endless number of different carbon–based molecules. Each molecule has its own unique set of physical, chemical, and biological properties. The flavor of vanilla, for example, is perceived when the compound *vanillin* is absorbed by the sensory organs in the mouth and nose. This compound consists of a ring of carbon atoms with oxygen atoms attached in a particular fashion. Vanillin is the essential ingredient in anything having the flavor of vanilla—without vanillin, there is no vanilla flavor. The flavor of chocolate, on the other hand, is generated when not just one but a wide assortment of carbon–based molecules are absorbed in the mouth and nose. One of the more significant of these molecules is *tetramethylpyrazine*, which has a ring of nitrogen and carbon atoms attached in a particular fashion.

Life is based on carbon’s ability to bond with other carbon atoms to form diverse structures. Reflecting this fact, the branch of chemistry that is the study of carbon–containing compounds has come to be known as **organic chemistry**. The term *organic* is derived from *organism* and is not necessarily related to the environment–friendly form of farming. Today, more than 13 million organic compounds are known, and about 100,000 new ones are added to the list each year, including those discovered in nature and those synthesized in the laboratory. (By contrast, there are only 200,000 to 300,000 known *inorganic*compounds, those based on elements other than carbon.)

The study of carbon chemistry is of major importance both in the science of chemistry and in the wider world today. Organic chemists are involved in the production of new materials, in the development of drugs to help combat battle diseases, in the development of safe flavours, colours and preservatives for use in our foods and in the production of pesticides, weedkillers and fungicides to help ensure that healthy crops are grown and that they are not damaged after harvesting.

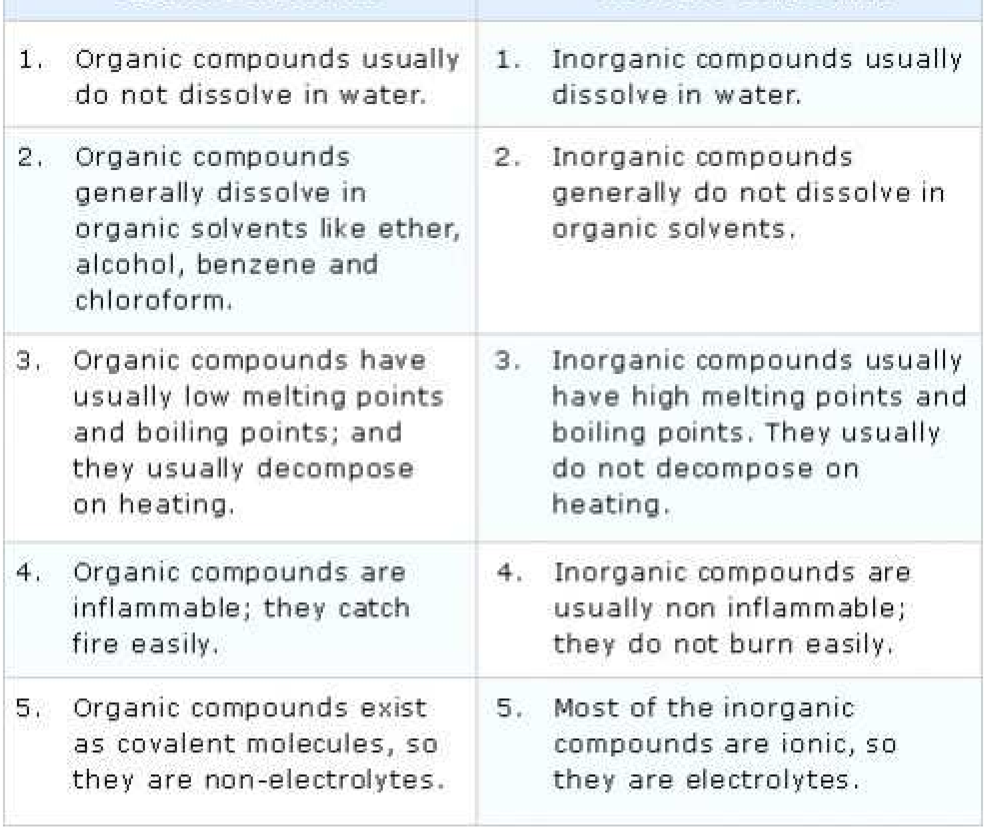
Organic chemists produce dyes to colour our clothes and furniture and work on new antiseptics and anaesthetics to make surgery safer. Organic chemistry has brought great benefits to the human race, but has also been responsible for much damage. When chlorofluorocarbons (CFCs) were first synthesized and used as propellants in aerosols and as refrigerants, it meant that chemicals could be used more conveniently in spray form and the problems of drug storage and food wastage through decay could be substantially reduced. No one had any idea that years later, the reactions of these same chemicals would cause a hole to develop in the protective ozone layer surrounding the earth.

Organic chemists also play a major role in analysing the way some organic compounds have polluted our Earth and its atmosphere, and are at the forefront of looking for ways to minimize the damage and prevent it from happening again.

Because organic compounds are so closely tied to living organisms and because they have many applications – from flavorings to fuels, polymers, medicines, agriculture, and more – it is important to have a basic understanding of them.

Inorganic chemistry looks at the compounds of the 91 naturally occurring elements and their reactions with each other, while organic chemistry simply considers the compounds of carbon. The number of these organic compounds is quite awesome – in the region of more than 13 million – far outstripping the number of compounds of all of the other elements known. Almost all plastics, synthetic and natural fibres such as polyester, wool and cotton, dyes, drugs, pesticides, flavorings and foodstuffs consist largely of organic compounds. The complex structural molecules that make up living cells and the enzymes that control the reactions within them are also organic chemicals, as is crude oil and all the oil–based products we use. It might appear that the enormous scope of carbon chemistry would make it almost impossible to study in any meaningful way. How can we then hope to get to grips with these millions of different chemicals? Fortunately the very properties of carbon that make possible such diversity of chemicals also ensure that the compounds that result fall into distinct types or families.

Differences between Organic and Inorganic Compounds

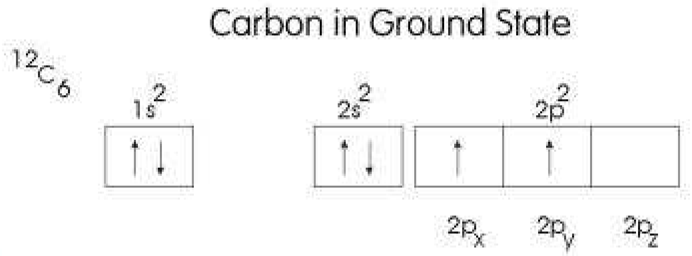


Organic Compounds	Inorganic Compounds
1. Organic compounds usually do not dissolve in water.	1. Inorganic compounds usually dissolve in water.
2. Organic compounds generally dissolve in organic solvents like ether, alcohol, benzene and chloroform.	2. Inorganic compounds generally do not dissolve in organic solvents.
3. Organic compounds have usually low melting points and boiling points; and they usually decompose on heating.	3. Inorganic compounds usually have high melting points and boiling points. They usually do not decompose on heating.
4. Organic compounds are inflammable; they catch fire easily.	4. Inorganic compounds are usually non inflammable; they do not burn easily.
5. Organic compounds exist as covalent molecules, so they are non-electrolytes.	5. Most of the inorganic compounds are ionic, so they are electrolytes.

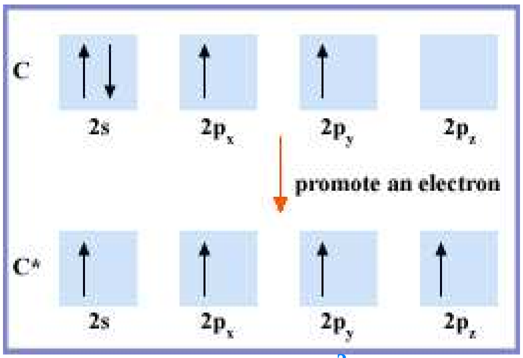
Nature of chemical bonds

The electronic structure of carbon in organic compounds:

We know that carbon tends to form four covalent bonds by sharing electrons with other atoms, and the arrangement of the four bonds around a carbon atom is tetrahedral, or very nearly so. The electronic structure of carbon in the ground state is $1s^2 2s^2 2p^2$.



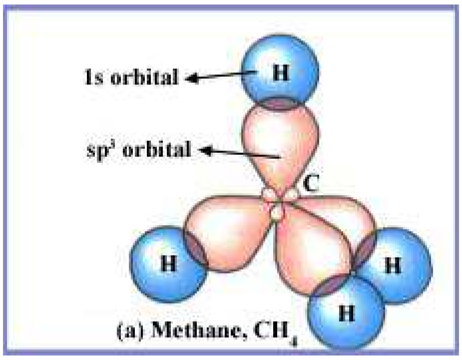
The formation of four covalent bonds is, at first sight, surprising, as only the electrons in the 2p orbital are unpaired in this arrangement. So we might expect carbon to form two bonds. But carbon forms four bonds due to the rearrangement of the electrons in the orbitals. This process is known as **hybridization**.



By combining the **s** orbital with the three **p** orbitals, four **sp**^{3} orbitals are produced, each containing a single electron.

In one type of hybridization **(sp^3 hybridisation)**, the **s** and **p** orbitals mix to form four identical new orbitals known as **sp^3 hybrid orbitals**. In carbon, each of these orbitals contains a single electron, which can then form a single bond. Although hybridization requires energy, this is more than compensated by the formation of four bonds rather than two, since the outer electrons then form an octet.

Due to electrostatic repulsion between the electron pairs, the **sp**^{3} orbitals are oriented tetrahedrally. Overlap between each of the four **sp**^{3} orbitals with the **1s** orbital of a hydrogen atom produces the methane molecule shown below.



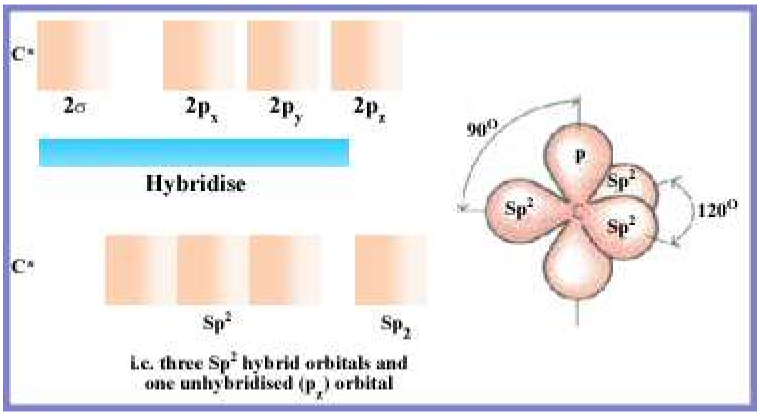
Hybridization explains the tetrahedral structure of Methane

Carbon forms four covalent bonds. This ability, along with the strength of the carbon–carbon bond, allows carbon chains to be built up with many different groups attached, and so produces a great diversity of organic compounds.

In the second type of hybridization(**sp2 hybridization**), only two of carbon's **p** orbitals are hybridized with its **s**orbital, three identical **sp2** hybrid orbitals are produced, as shown in the figure.

These three orbitals lie in a plane at an angle of 120o to each other, with the unhybridized **p** orbital perpendicular to the plane, as shown in the figure. The C=C bond in ethene is formed as a result of overlap between one **sp2** orbital from each of the two carbon atoms, giving a σ bond, plus overlap of the two **2p** orbitals forming another bond. This bond has its electron density concentrated in two regions on either side of the axis of the σ bond, and is called a π **bond**.

Formation of the sp2 hybrid orbitals



(a) By combining the s orbital with two p orbitals, three sp2 orbitals plus a single p orbital are produced, each containing a single electron.
(b) The orientation of the oribatal in an sp2 hybridized carbon atom.

In the third type of hybridization (**sp hybridization**), only one **p** orbital is hybridized with its **s** orbital, two identical **sp** hybrid orbitals are produced, as shown in the figure. In ethyne, the two carbon atoms are **sp**hybridised, leaving two **p** orbitals with a single electron in each. These **p** orbitals overlap to form two π bonds at right–angles to each other, with one **sp** orbital of each carbon atom overlapping to form the σ bond. For example consider the shape of the ethyne molecule – notice that it is linear, with the two hydrogens situated at each end of the molecule.

Formation of sp hybrid orbitals