

Lesson 1 For Organic Chemistry

Basically, the study of organic chemistry involves the understanding of the chemistry of those compounds, formed by _____, _____ mainly and also some heteroatoms like ____, ____, and X (halides) etc. Strickly speaking, for those compounds containing carbon and hydrogen only, we called them **hydrocarbons**; meanwhile, for those compounds containing other atoms instead of just C and H, we called them **organic compounds**.

Note that, organic compounds should be classified as ionic/ covalent/ metallic? compounds. It is because all constituent atoms of an organic compounds should be connected by _____ bonds.

Understanding of Carbon and hydrogen

First of all, I would like to ask why carbon can form a variety of organic compounds. To answer this, we should understand more about a carbon atom.

Carbon

Carbon is a group ____ element. So, it has ____ valence electrons. It can form maximumly ____ covalent bonds with others. Those bondings can be in the form of :

C-C s _____ bond, C=C d _____ bond and also \equiv t _____ bond.

Regarding the electronic configuration of carbon, that is $[C] : 1s^2 2s^2 2p^2$, you can see that there are ____ partially filled p-orbitals and also ____ unfilled. By a simple **excitation** process, the electronic configuration of carbon will become : $[C]^* : 1s^2 2s^1 2p^3$. Hence, carbon can use up all its valence electrons to form bonds with other atoms, especially other carbon atoms.

You should be careful that the excitation process for carbon is easy or exo _____ because the **energy gap** between the 2s-orbital and 2p-orbital of carbon is _____. Hence, this nature enable carbon to form carbon carbon bond, that is, the ability to link up itself. This feature is defined as **catenation** 自連. Since carbon has a **proper size** and the **least diffuse valence shell p orbital**, the carbon carbon bond formation is exo _____ enough to **overcome** the energy needed for the excitation of the carbon atom from g _____ state. Thus, carbon is capable of forming longer p-p sigma bonded chains of atoms than other atoms.

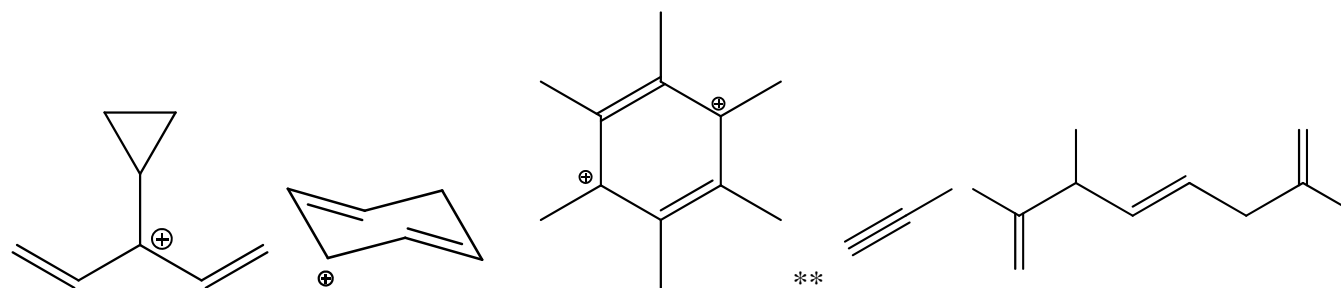
Note that carbon **cannot** extend its _____ because there is an **absence** of low _____ vacant _____ orbitals. So, considering a carbon chain, you can only see a carbon atom attaching with at most 4 atoms only.

→ When a carbon has formed only **three** bonds, a **carbocation** should be observed.

→ When a carbon has beared **six electrons**, that is it is carrying the charge ____, a carbene ions should be observed. (It's important for organic chemistry but it should be out of syllabus)

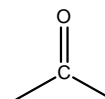
Exercsie 1

Please draw out all the hydrogen atoms missing of the following organic compounds. Note that hydrogen has only ___ valence electron such that it can only form ___ covalent bond.

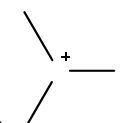


Bonding in organic compounds

As mentioned before, the constituent atoms of a organic compound are linked through the **covalent bond formation**, in which electrons are s_____ between atoms. Most importantly, when a bond is formed by carbon and other heteroatoms like oxygen, which is more **electronegative**, bond p_____ will be resulted in the resultant bond. For example, the carbon atom on carbonyl group is carrying a partial positive charge as a result of _____ polarization.



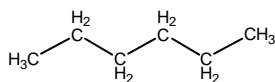
Actually, due to the polarization, the C=O bond bears both covalent and _____ character. That is, the

C=O double bond can be represented by : C=O as usual and also . This concept is essential for the understanding of the **reactivity** of a compound and it is known also as r_____.

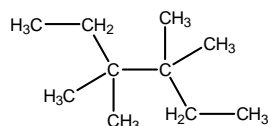
Hybridization Theory --- The understanding of the molecular shape of organic compounds

In HKCEE, we will describe organic compounds as :

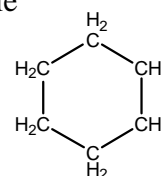
a **straight** chain,



a **branched** chain



or a **ring/cycle**



However, in HKAL, we will focus on a particular carbon atom of the compound and then use a **state** to describe the bonding nature and also the molecular structure being adopted of the target carbon. This concept is related to the **hybridization theory**.

This theory is talking about the fact that **atomic orbitals mix with each other before bond formation**. Through the different modes of mixing, the molecule will have a different shape.

Hybridization Theory

Basically, for carbon, it has three different hybridization state including ____, ____ and ____.

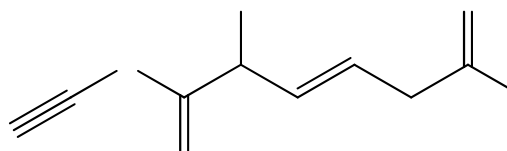
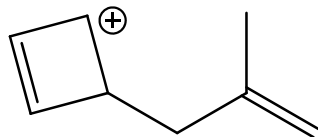
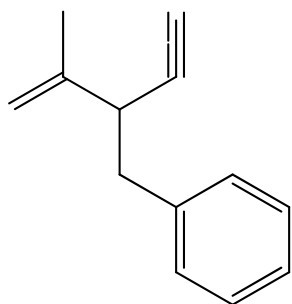
No matter which mode/ state we are talking about, the state is formed by mixing of atomic orbitals of **similar** energy to form new **degenerate** atomic orbitals. In detail, we have :

1. $sp = \text{___} + \text{___}$ → give out **two** sp → leads to the molecular shape = _____
2. $sp^2 = \text{___} + \text{___}p$ → give out **three** sp^2 → leads to the molecular shape = _____
3. $sp^3 = \text{___} + \text{___}p$ → give out **four** sp^3 → leads to the molecular shape = _____

Actually, you only need to know the fact that, mixing of n atomic orbitals will produce n new degenerated hybrid atomic orbitals; Also, the shape of the molecule formed by the carbon with a particular state is governed by the **VSEPR theory**, which can be interpreted as the hybrid orbitals will adopt structure in which m _____ repulsion will be resulted.

Exercise 2

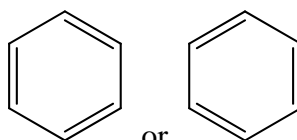
Please indicate the hybridization state of all the carbon with a * and also the corresponding bond angle for the following compounds.



Resonance Concept

Regarding the aromatic compound benzene, actually, we cannot observe the relative positive of the

three pi-bonds. That is, we don't know whether



or

is the exact structure of the

benzene. Hence, to try to represent the actual structure of benzene, we adopt the resonance concept in which the above two **Lewis structures** of benzene can be drawn but not only either one. In practice, we use the symbol \longleftrightarrow to represent the '**transformation**' of the resonance structures.

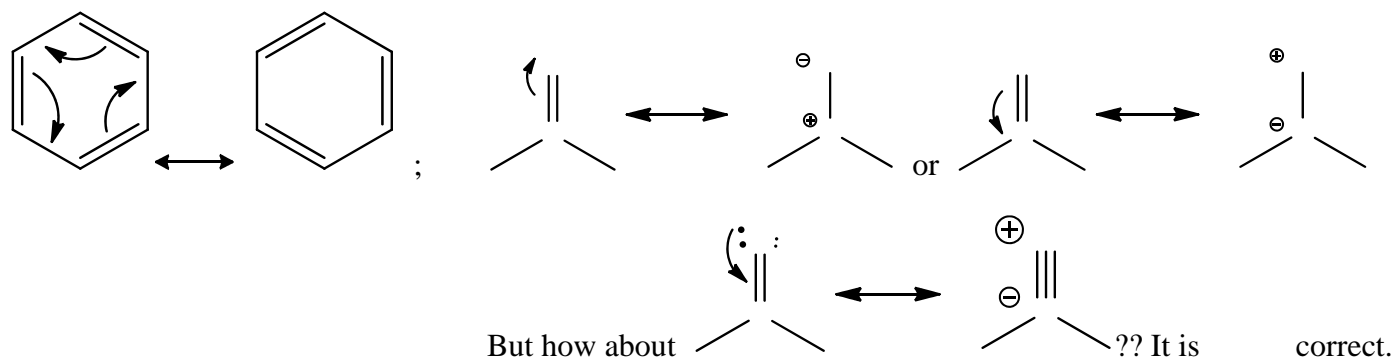
- Basically, the more the resonance structures of a compound can be drawn, the more stable it will be.
- It is called the **stabilization effect** by resonance. (It is the energetical / kinetical ? aspect.)
- Note that resonance structures are **not in equilibrium** with each other.

Resonance Concept --- How can we draw the resonance structure of 'different' compounds?

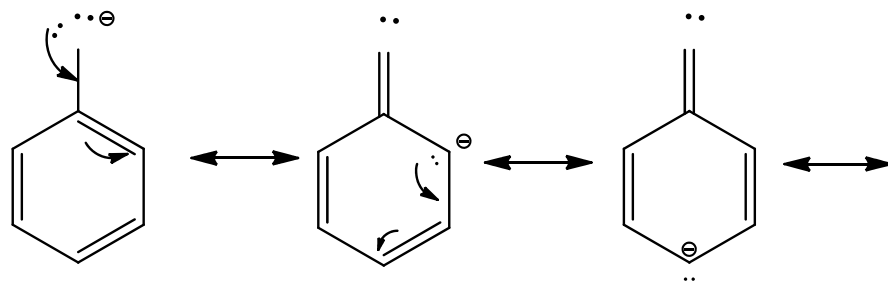
Rules

1. In resonance structures, only the **electrons** move but **not** the atoms.
2. **Pi-electrons and lone pair of electrons** are more readily resonated (moved) than sigma electrons.
3. Electrons prefer to move towards e_____ atoms like oxygen or nitrogen.
- **4. Electrons on atom must jump on a bond while electrons on a bond must just on an _____.
- **5. **Conservation** of _____ held.
6. We need only to consider the resonance structures for **conjugated system**, in which there is an **alternative** pattern of C-C, C=C, C-C, C=C...

Case 1 --- For **neutral** compounds (The easiest case)

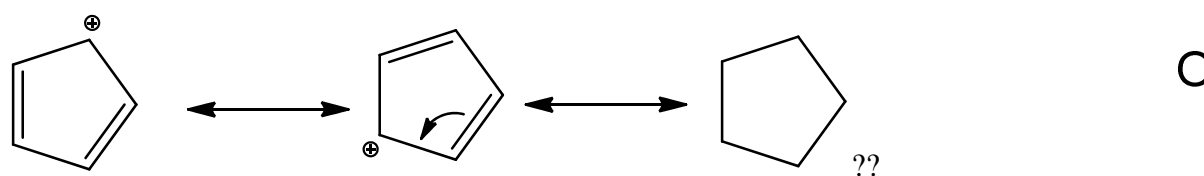


Case 2 --- For negatively charged compounds



→ Always remind yourself that it is the movement of electron p_____ but **not** a single electron.

Case 3 --- For **positively charged** compounds e.g. **carbocations**



→ You should be careful that a carbocation bears _____ electron. So, here is the movement of the pi-electrons but not the same in the case of oxygen of **phenoxide** above.

→ **Stability** of carbocation can be increased by resonance.