Lesson Plan

Lesson: Valence Bond Theory and Hybridisation

Aim: To investigate the Valence Bond Theory and the hybridisation of atomic orbitals

Learning Outcomes:

At the end of the lesson, students will be able to:
1. explain the concept of overlapping of orbitals
2. explain the concept of hybridisation of the s and p orbitals for the C, N and O atoms in the CH₄, C₂H₄, C₂H₂, NH₃ and H₂O molecules.

Assumed prior knowledge:

Students should already:
1. be familiar with the formation of single and multiple covalent bonds.

Underlying Principles

1. Making the invisible, visible.

Time taken to complete the activities: 80 minutes

Differentiation

Questions in the student notes are designed to enable all students to complete the activity. The pop-up answers are provided for the students to view when they have considered their responses. Worksheet questions include questions that require recall, understanding and application of the new concepts learned.
## Development of Lesson:

<table>
<thead>
<tr>
<th>No.</th>
<th>Steps</th>
<th>Strategy</th>
<th>Resources</th>
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| 1   | Set Induction. (Ascertaining prior knowledge and introducing lesson topic for the day). | • Teacher to quiz students on Lewis symbol or structure of atoms and molecules and the Octet Rule.  
      • Teacher to point out to students that Lewis structures do not point out how electrons managed to be shared between atoms and to introduce objectives of the lesson. |                    |
| 2   | Student Activity                           | Teacher to go through Activities 1 - 3 with the students.              | • Courseware       |
|     |                                            | **Activity 1: Sigma bond formation**  
      |                                             | Students get to view how sigma bonds are formed from s-s overlap as in H₂, p-p overlap as in F₂ and s-p overlap as in HF. |                     |
|     |                                            | **Activity 2: Pi bond formation**  
      |                                             | Students get to view how pi bonds are formed due to side-ways overlapping of p orbitals as in O₂. |                     |
|     |                                            | **Activity 3: Bonding and Hybridisation**  
      |                                             | Students get to view how hybridisation of orbitals occur resulting in sp³ hybrid orbitals as in CH₄, sp² hybrid orbitals as in BF₃ and sp hybrid orbitals as BeH₂. |                     |
| 3   | Evaluation                                 | Students to answer questions in the student worksheet on their own.     | • Worksheet        |
| 4   | Extension activity                         | Students to go through the extension activities on their own.           | • Website and References. |
Worksheet answer:

1. Sigma Bond Formation

1.1 Overlap of s orbital with s orbital, or s orbital with p orbital, or p orbital with p orbital.

1.2 a. The Lewis structure of bromine molecule

\[ \overset{\text{Br}}{\text{Br}} \]

b. The valence electronic configuration of bromine atom is \(4s^2 4p^5\).

c. The overlap of bromine atomic orbitals to form the bromine molecule is

\[ \text{Br} \sigma \text{Br} \]

d. One sigma (\(\sigma\)) covalent bond.

e. \(\text{Br}_2\)

1.3 The Lewis structure of hydrogen fluoride is

\[ \text{H} - \overset{\text{F}}{\text{F}} \]

The hydrogen atom has an unpaired electron in its 1\(s\) atomic orbital.
The fluorine atom has an unpaired electron in one of its 2\(p\) atomic orbital
1\(s\) atomic orbital of H overlap with a 2\(p\) atomic orbital of F to form sigma (\(\sigma\)) covalent bond.
The orbital overlap is

\[ \begin{array}{c}
\text{O} \\
\text{F} \\
\text{H}
\end{array} \]

2. **Pi Bond Formation**

2.1 Overlap of two \( p \) orbitals.

2.2 A single covalent bond is made up of a sigma bond.
A double covalent bond is made up of a sigma bond and a pi bond.
A triple covalent bond is made up of a sigma bond and two pi bonds.

2.3 The Lewis structure of CO is

\[ \text{\text{\text{C}≡\text{O}}} \]

The molecule has one sigma bond and two pi bonds.

2.4 a. The Lewis structure of nitrogen molecule is

\[ \text{\text{\text{N}≡\text{N}}} \]

b. The electronic configuration of nitrogen atom is \( 1s^22s^22p^3 \). The valence atomic orbital is the \( 2s \) and \( 2p \) orbitals.
c. The overlap of nitrogen atomic orbitals to form the nitrogen molecule is

\[ \sigma \]

\[ \pi \]

\[ \pi \]


d. Triple covalent bonds made up of one sigma (\( \sigma \)) bond and two pi (\( \pi \)) bonds.

e. The formula of nitrogen molecule is \( N_2 \).

3. Bonding and Hybridisation

3.1 a. The Lewis structure of beryllium fluoride molecule is

\[ \overset{8}{F}\text{-Be}\overset{8}{F} \]

Two sigma (\( \sigma \)) covalent bonds are formed.

b. \( sp \) hybrid orbitals.

The valence orbital diagram for Be atom is

<table>
<thead>
<tr>
<th>2s</th>
<th>2p</th>
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<tbody>
<tr>
<td>1e</td>
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To form two sigma (\( \sigma \)) covalent bonds, one electron in the 2s orbital is excited to one of the empty 2p orbitals.

The 2s and 2p orbitals are then hybridised to form two \( sp \) orbitals.
c. Fluorine atom uses one of its $2p$ orbitals (say $2p_x$) that is half-full.

d. The overlap of orbitals in beryllium fluoride molecule is

![Beryllium Fluoride Molecule Diagram]

3.2  

a. The $2s$ and the three $2p$ atomic orbitals.

b. Four

c. Tetrahedral; $109.5^\circ$

d. The orbital overlap in ammonia molecule is

![Ammonia Molecule Diagram]

3.3  

a. Four $sp^3$ hybrid orbitals of carbon atom.

b. Tetrahedral
3.4 Propene, CH\(_3\)-CH=CH\(_2\), has three carbon centres.

The methyl carbon (CH\(_3\)) forms 4 sigma (\(\sigma\)) bonds. Thus, it uses four \(sp^3\) hybrid orbitals to form the bonds.

Each of the other two carbon atoms form three sigma (\(\sigma\)) bonds and one pi (\(\pi\)) bond. Thus, they use three \(sp^2\) hybrid orbitals to form the \(\sigma\) bonds, and the half-full 2\(p\) (say 2\(p_x\)) orbitals to form the \(\pi\) bond.

The orbital overlap is