

# *CH 222 Winter 2025:* **“Valence Bond and Molecular Orbitals (*online*)”** *Lab - Instructions*

*Note: This is the lab for section 01 and section W1 of CH 222 only.*

- If you are taking section 01 or section H1 of CH 222, please use this link:  
<http://mhchem.org/r/3a.htm>*
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*Step One:*

**Watch the lab video** for the “VB and MO” lab, found here: <http://mhchem.org/y/3.htm>  
There is no data to record at the end of the video.

*Step Two:*

**Complete pages Ib-3-5 through Ib-3-12** using the “VB and MO” video and the actual lab instructions on pages Ib-3-2 through Ib-3-3. Include your name on page Ib-3-5!

*Step Three:*

Section 01: Submit your lab during recitation in **AC 2501 at 1:10 PM on Monday, January 27**. A **printed copy is required** for full credit; emailed labs will invoke a point penalty.

Section W1: **Submit your lab** (pages Ib-2-7 through Ib-2-12 *only* to avoid a point penalty) as a *single PDF file to the instructor via email (mike.russell@mhcc.edu) on Wednesday, January 29 by 11:59 PM*. I recommend a free program (ex: CamScanner, <https://camscanner.com>) or a website (ex: CombinePDF, <https://combinepdf.com>) to convert your work to a PDF file.

*If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!*

# VALENCE BOND (VB) THEORY

*and*

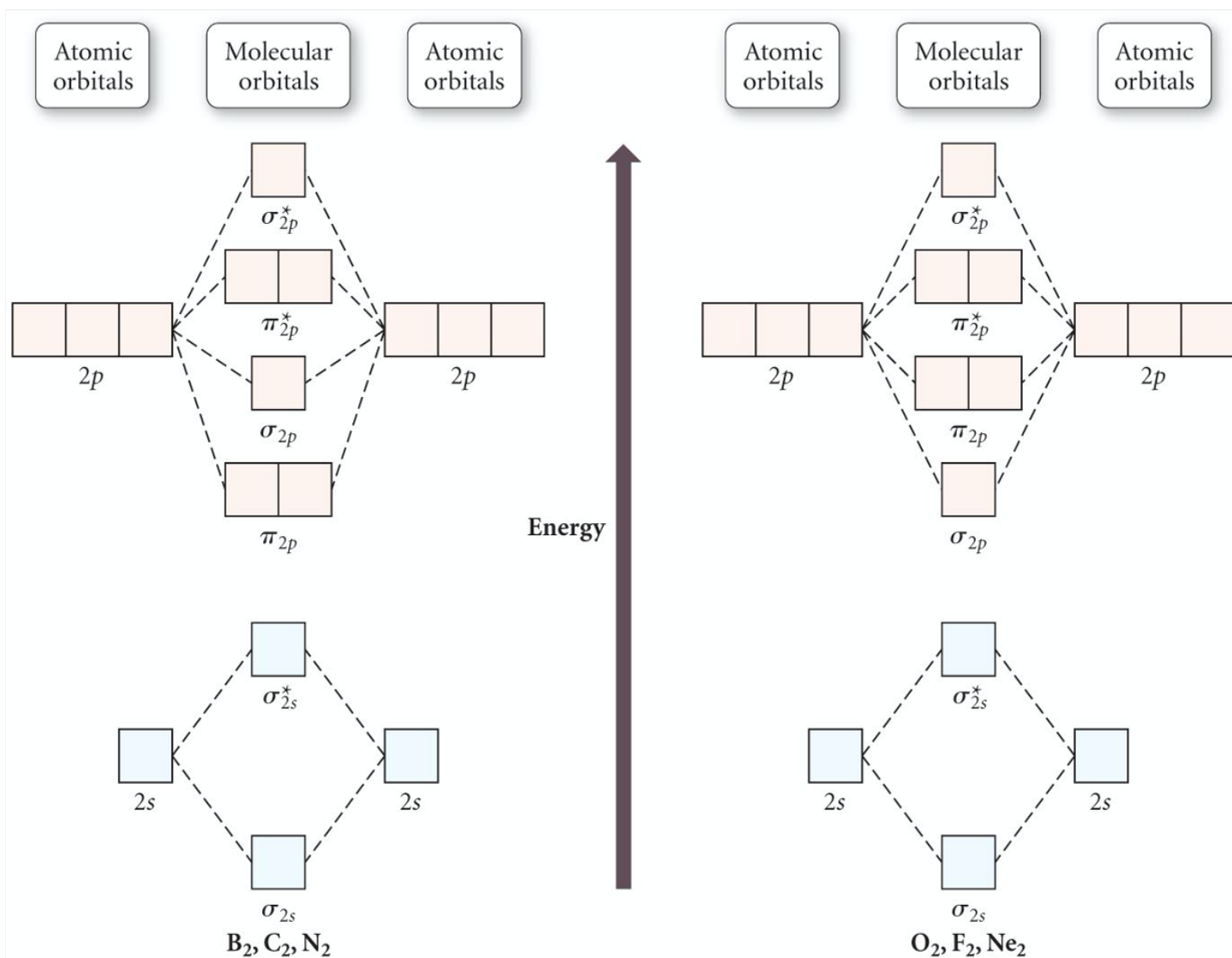
# MOLECULAR ORBITAL (MO) THEORY

## LAB

This lab contains a series of handouts that you should complete. Neatness counts!

Useful handouts from the Chemistry 222 website (<http://mhchem.org/222>):

- Geometry and Polarity Guide (<http://mhchem.org/geopo/>)
- MO Diagram - B<sub>2</sub> through N<sub>2</sub> (<http://mhchem.org/MO>)
- MO Diagram - O<sub>2</sub> through Ne<sub>2</sub> (<http://mhchem.org/MO>)



*Molecular orbital diagrams for B, C, N (left) and O, F and Ne (right).*

*Notice that the 1s interactions are **not** included in these diagrams.*

*Use [core electrons] if not showing the 1s interactions in your molecular orbital diagram.*

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**VALENCE BOND THEORY and MOLECULAR ORBITAL THEORY LAB - Worksheet**
**Name:**
*Hand drawn versions only, no computer generated structures*

 Complete the sections below by providing the appropriate information in the spaces provided. *Neatness counts!*
**Part One: Valence Bond Theory** *Complete the following sections using Valence Bond Theory.*

Molecule/Ion	Lewis Structure (& Isomers, if any)		
<b>SeI<sub>2</sub></b>		<i>Electron Pair Geometry:</i>	<i>Hybridization:</i>
		<i>Molecular Geometry:</i>	<i>Bond Order:</i>
		<i>Polar or Nonpolar:</i>	<i>Resonance Forms? (Y/N)</i>

Molecule/Ion	Lewis Structure (& Isomers, if any)		
<b>AsCl<sub>5</sub></b>		<i>Electron Pair Geometry:</i>	<i>Hybridization:</i>
		<i>Molecular Geometry:</i>	<i>Bond Order:</i>
		<i>Polar or Nonpolar:</i>	<i>Resonance Forms? (Y/N)</i>

Molecule/Ion	Lewis Structure (& Isomers, if any)		
<b>CO<sub>3</sub><sup>2-</sup></b>		<i>Electron Pair Geometry:</i>	<i>Hybridization:</i>
		<i>Molecular Geometry:</i>	<i>Bond Order:</i>
		<i>Polar or Nonpolar:</i>	<i>Resonance Forms? (Y/N)</i>

Molecule/Ion	Lewis Structure (& Isomers, if any)		
<b>ClO<sub>3</sub><sup>-1</sup></b>		<i>Electron Pair Geometry:</i>	<i>Hybridization:</i>
		<i>Molecular Geometry:</i>	<i>Bond Order:</i>
		<i>Polar or Nonpolar:</i>	<i>Resonance Forms? (Y/N)</i>

Molecule/Ion	Lewis Structure (& Isomers, if any)		
$\text{ClO}_4^{-1}$		<i>Electron Pair Geometry:</i>	<i>Hybridization:</i>
		<i>Molecular Geometry:</i>	<i>Bond Order:</i>
		<i>Polar or Nonpolar:</i>	<i>Resonance Forms? (Y/N)</i>

Molecule/Ion	Lewis Structure (& Isomers, if any)		
$\text{XeOF}_4$		<i>Electron Pair Geometry:</i>	<i>Hybridization:</i>
		<i>Molecular Geometry:</i>	<i>Bond Order:</i>
		<i>Polar or Nonpolar:</i>	<i>Resonance Forms? (Y/N)</i>

**Part Two: Molecular Orbital Theory** Complete the following sections using Molecular Orbital Theory. Draw a complete Molecular Orbital diagram to answer these questions (include all 1s and 2s interactions, no short hand notation) and provide the missing information.

Molecule / Ion:  $\text{Li}_2$

Molecular Orbital Diagram:

Bond Order: \_\_\_\_\_

Number of sigma bonds: \_\_\_\_\_

Number of pi bonds: \_\_\_\_\_

(Circle) **Paramagnetic** or **Diamagnetic**

Should this molecule exist? (Circle) **Yes** or **No**

*Molecule / Ion: Be<sub>2</sub>*

*Molecular Orbital Diagram:*

Bond Order: \_\_\_\_\_

Number of sigma bonds: \_\_\_\_\_

Number of pi bonds: \_\_\_\_\_

(Circle) **Paramagnetic** or **Diamagnetic**

Should this molecule exist? (Circle) **Yes** or **No**

*Molecule / Ion: B<sub>2</sub>*

*Molecular Orbital Diagram:*

Bond Order: \_\_\_\_\_

Number of sigma bonds: \_\_\_\_\_

Number of pi bonds: \_\_\_\_\_

(Circle) **Paramagnetic** or **Diamagnetic**

Should this molecule exist? (Circle) **Yes** or **No**

*Molecule / Ion: N<sub>2</sub>*

*Molecular Orbital Diagram:*

Bond Order: \_\_\_\_\_

Number of sigma bonds: \_\_\_\_\_

Number of pi bonds: \_\_\_\_\_

(Circle) **Paramagnetic** or **Diamagnetic**

Should this molecule exist? (Circle) **Yes** or **No**

*Molecule / Ion: F<sub>2</sub>*

*Molecular Orbital Diagram:*

Bond Order: \_\_\_\_\_

Number of sigma bonds: \_\_\_\_\_

Number of pi bonds: \_\_\_\_\_

(Circle) **Paramagnetic** or **Diamagnetic**

Should this molecule exist? (Circle) **Yes** or **No**



Molecule / Ion:  $\text{Ne}_2$

Molecular Orbital Diagram:

Bond Order: \_\_\_\_\_

Number of sigma bonds: \_\_\_\_\_

Number of pi bonds: \_\_\_\_\_

(Circle) **Paramagnetic or Diamagnetic**

Should this molecule exist? (Circle) **Yes or No**

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**Part Three: Theory Comparison** Complete the following sections using both Valence Bond (VB) Theory and Molecular Orbital (MO) Theory. *Shorthand notation for MO Diagrams is recommended, include 1s and 2s interactions.*

Molecule / Ion:  $\text{CN}^{-1}$  (Use the MO Diagram for B, C and N on this problem)

Valence Bond Lewis Structure:

Bond Order (VB): \_\_\_\_\_

Bond Order (MO): \_\_\_\_\_

Number of sigma bonds (VB): \_\_\_\_\_

Number of sigma bonds (MO): \_\_\_\_\_

Number of pi bonds (VB): \_\_\_\_\_

Number of pi bonds (MO): \_\_\_\_\_

(VB) Paramagnetic? (circle) **Yes No**

(MO) Paramagnetic? (circle) **Yes No**

Molecular Orbital Diagram:

Molecule / Ion: **NO<sup>+1</sup>** (Use the MO Diagram for O, F and Ne on this problem)

<i>Valence Bond Lewis Structure:</i>	Bond Order (VB): _____
	Bond Order (MO): _____
	Number of sigma bonds (VB): _____
<i>Molecular Orbital Diagram:</i>	Number of sigma bonds (MO): _____
	Number of pi bonds (VB): _____
	Number of pi bonds (MO): _____
	(VB) Paramagnetic? (circle) <b>Yes No</b>
	(MO) Paramagnetic? (circle) <b>Yes No</b>

Molecule / Ion: **NO** (Use the MO Diagram for O, F and Ne on this problem)

<i>Valence Bond Lewis Structure:</i>	Bond Order (VB): _____
	Bond Order (MO): _____
	Number of sigma bonds (VB): _____
<i>Molecular Orbital Diagram:</i>	Number of sigma bonds (MO): _____
	Number of pi bonds (VB): _____
	Number of pi bonds (MO): _____
	(VB) Paramagnetic? (circle) <b>Yes No</b>
	(MO) Paramagnetic? (circle) <b>Yes No</b>

*Molecule / Ion: O<sub>2</sub>*

<i>Valence Bond Lewis Structure:</i>	Bond Order (VB): _____
	Bond Order (MO): _____
	Number of sigma bonds (VB): _____
<i>Molecular Orbital Diagram:</i>	Number of sigma bonds (MO): _____
	Number of pi bonds (VB): _____
	Number of pi bonds (MO): _____
	(VB) Paramagnetic? ( <i>circle</i> ) <b>Yes No</b>
	(MO) Paramagnetic? ( <i>circle</i> ) <b>Yes No</b>

*Molecule / Ion: OF<sup>-1</sup>*

<i>Valence Bond Lewis Structure:</i>	Bond Order (VB): _____
	Bond Order (MO): _____
	Number of sigma bonds (VB): _____
<i>Molecular Orbital Diagram:</i>	Number of sigma bonds (MO): _____
	Number of pi bonds (VB): _____
	Number of pi bonds (MO): _____
	(VB) Paramagnetic? ( <i>circle</i> ) <b>Yes No</b>
	(MO) Paramagnetic? ( <i>circle</i> ) <b>Yes No</b>

Molecule / Ion:  $\text{Ne}_2^{+2}$

<i>Valence Bond Lewis Structure:</i>	Bond Order (VB): _____
<i>Molecular Orbital Diagram:</i>	Bond Order (MO): _____
	Number of sigma bonds (VB): _____
	Number of sigma bonds (MO): _____
	Number of pi bonds (VB): _____
	Number of pi bonds (MO): _____
	(VB) Paramagnetic? ( <i>circle</i> ) <b>Yes No</b>
	(MO) Paramagnetic? ( <i>circle</i> ) <b>Yes No</b>