ROSEDALE ACADEMY

Name: *Solutions*

# SCH4U: 1-5 VSEPR Shape and Polarity Lab

## PART 1: VSEPR Shape

### Background

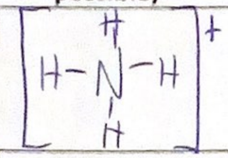
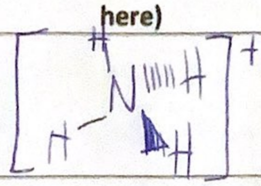
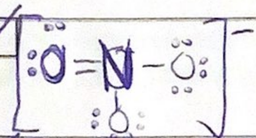
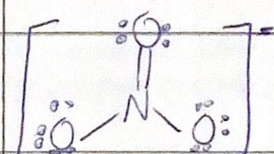
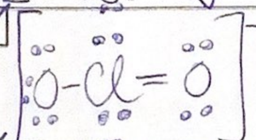
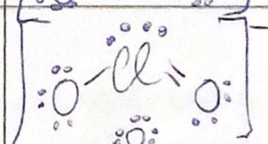
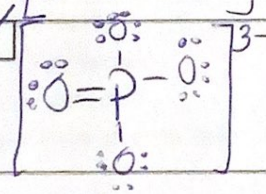
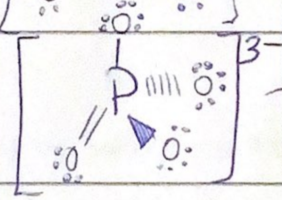
The valence shell electron pair repulsion (VSEPR) theory is how the geometry of a molecule is determined. It's called "vesper" theory for short. The shapes that are possible are tetrahedral, trigonal planar, trigonal pyramidal, bent, and linear. To determine the shape of a molecule, you must look at the central atom. Unbonded electrons around the central are not accounted for in the geometry, however they are important because they determine the geometry. Unbonded electrons around atoms that are not the central atom have little effect on the geometry.

In this experiment, you will draw Lewis structures for some compounds and use them to determine how the molecular models need to be assembled. From the models, you will determine the geometry of the compounds. After completing a few examples, you should start to see how the two-dimensional drawings really exist in three dimensions.

### Observations

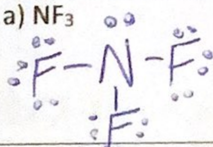
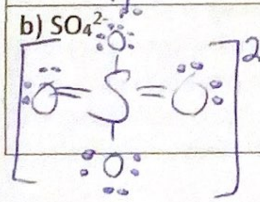
Complete each column in order by using the simulator here:
https://phet.colorado.edu/en/simulation/molecule-shapes *[T/I, 5: 0.5 each]*

| Molecule (write the chemical formula) | Total valence e⁻ | Lewis structure (check the box if a resonance structure is possible) | Lewis structure with proper geometry (use the models to help here) | VSEPR geometry (the name of the shape) |
|---|---|---|---|---|
| Water $H_2O$ | 8 | ☐ H–Ö–H (with lone pairs) | H–O–H bent, with lone pairs on O | Bent |
| Nitrogen $N_2$ (gas?) | 10 | ☐ :N≡N: | :N≡N: | Linear |
| Carbonate $CO_3^-$ | 24 | ☑ $[O{=}C(-O)-O]^{2-}$ (with lone pairs) | $[$trigonal planar $CO_3]^{2-}$ (with lone pairs) | Trigonal Planar |
| Carbon tetrachloride $CCl_4$ | 32 | ☐ $CCl_4$: C bonded to four Cl (with lone pairs) | $CCl_4$ drawn in 3D (wedge/dash) | Tetrahedral |

| Molecule (write the chemical formula) | Total valence $e^-$ | Lewis structure (check the box if a resonance structure is possible) | Lewis structure with proper geometry (use the models to help here) | VSEPR geometry (the name of the shape) |
|---|---|---|---|---|
| Ammonium $NH_4^+$ | 8 | ☐  |  | Tetrahedral |
| Carbon monoxide $CO$ | 10 | ☐ :C≡O: | :C≡O: | Linear |
| Dinitrogen monoxide $N_2O$ | 16 | ☑ (answer may vary) :N≡N–O: | :N≡N–O: | Linear |
| Nitrate $NO_3^-$ | 24 | ☑  |  | Trigonal Planar |
| Chlorite $ClO_2^-$ | 20 | ☑  |  | Bent |
| Phosphate $PO_4^{3-}$ | 32 | ☑  |  | Tetrahedral |

## Analysis

Without using the models, determine the geometry of these compounds (you can draw Lewis structures to help you): *[A, 2: 0.5 each]*

| | |
|---|---|
| a) $NF_3$  Trigonal Pyramidal | c) $F_2$ :F–F: Linear |
| b) $SO_4^{2-}$  Tetrahedral | e) $OCl_2$ :Cl–O–Cl: Bent |

## Conclusion

All of the compounds in this exercise are what kind of compound? Explain why this is important to VSEPR.

[K/U, 1; C, 2]

all compounds are non-metals, which is important b/c covalent bonding will occur which implies electrons will be shared between atoms, forming single, double, triple bonds. (answers may slightly vary)

## PART 2: Polarity

### Background

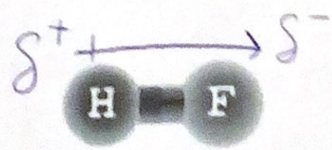
VSEPR shape can be an indication of overall polarity of a molecule. After completing 1-5D: Molecular Polarity Simulation, please answer the following questions by applying your understanding of bond polarity.

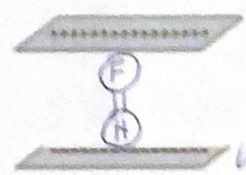
### Analysis

[A, 6]

**HF** - The ball and stick structure for HF is shown. Answer the following and do what is asked

- ❑ Which atom is more electronegative? F
- ❑ Draw a bond polarity arrow (bond dipole)
- ❑ Draw the partial charges on the molecule
- ❑ Would you expect this to move in an electric field? Draw it in the field provided.

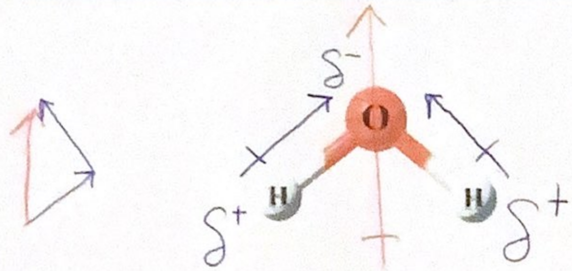


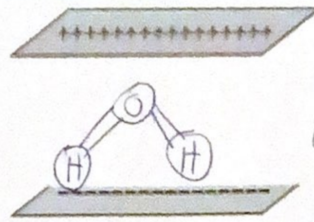




yes, it will move in electric field

**$H_2O$** - The ball and stick structure for $H_2O$ is given. Answer the following and do what is asked.

- ❑ Which atom is more electronegative? O
- ❑ Draw a bond polarity arrow (bond dipole)
- ❑ Place partial charges on the molecule
- ❑ In a different color draw a molecular dipole arrow.
- ❑ Would you expect this to move in an electric field? Draw it in the field provided.

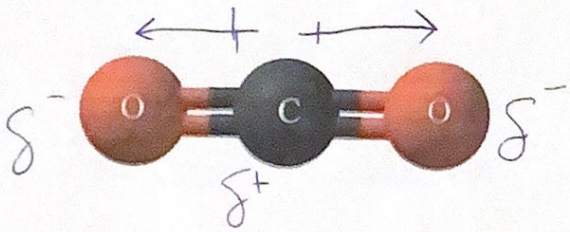


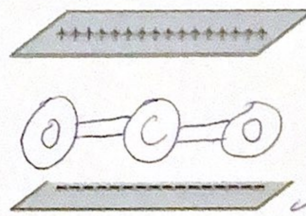



yes, it will move in electric field

## $CO_2$ - The ball and stick structure for $CO_2$ is given. Answer the following and do what is asked.

- ☑ Which atom is more electronegative? O
- ☑ Draw a bond polarity arrow (bond dipole)
- ☑ Place partial charges on the molecule
- ❑ In a different color draw a molecular dipole arrow. – no net dipole?
- ❑ Would you expect this to move in an electric field? Draw it in the field provided.



No, it won't move in electric field

**Conclusion**

Explain why it is important to consider both VSEPR shape and bond polarity to determine the overall polarity of a molecule. Use the HF (hydrogen fluoride) and $CO_2$ (carbon dioxide) as examples.

*[K/U, 2; C, 2]*

- The dipoles between bonds may cancel out depending on the molecules shape to determine if net dipole cancels out.
- Bond Polarity: The EN difference must be >0.5 for polar bond.

$\delta^+$ H — F $\delta^-$ (net dipole)
Linear ΔEN = 1.8
∴ polar

$\delta^-$ O = C = O $\delta^-$ ($\delta^+$ on C) → these cancel (different direction)
Linear ΔEN = 1
∴ non-polar