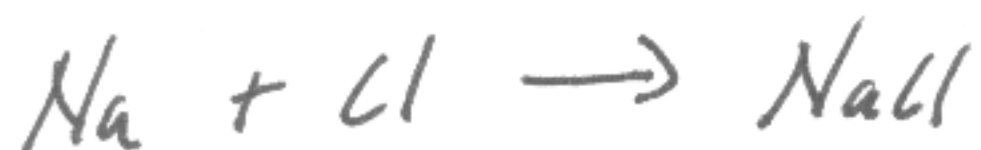


HW3 Key

1. Bond dissociation energy, NaCl



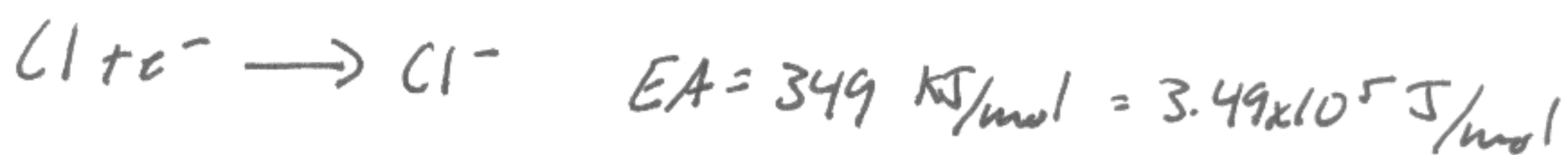
first we have to ionize Na and Cl:

ionize Na:



$$5.14 \text{ eV/atom} \left(\frac{1.602 \times 10^{-19} \text{ J}}{\text{eV}} \right) \left(\frac{6.022 \times 10^{23} \text{ atoms}}{\text{mol}} \right) = \underline{4.96 \times 10^5 \text{ J/mol}}$$

ionize Cl:



but this is the opposite process, so really

$$\underline{EA = -3.49 \times 10^5 \text{ J/mol}}$$

put this together: $V_{\infty} = 4.96 \times 10^5 \text{ J/mol} + -3.49 \times 10^5 \text{ J/mol} = \underline{1.47 \times 10^5 \text{ J/mol}}$

This is how much energy it will take to make the ions

2

$$V_{\text{bond}} = \frac{q_1 q_2}{4\pi \epsilon_0 r} = \frac{(+1)(-1)(1.602 \times 10^{-19} \text{ C})^2}{4\pi (8.854 \times 10^{-12} \text{ C}^2/\text{Jm}) (2.36 \times 10^{-10} \text{ m})}$$

$$V_{\text{bond}} = -9.77 \times 10^{-19} \text{ J/atom} (6.022 \times 10^{23} \text{ atoms/mol})$$

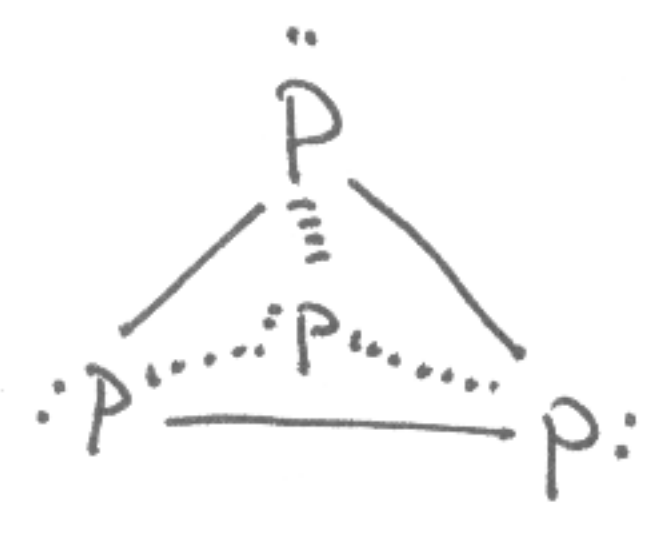
$$\underline{V_{\text{bond}} = -5.89 \times 10^5 \text{ J/mol}}$$

This is how much we get by
bringing the two ions together

Total: $V_{\text{Total}} = \Delta E_d = V_{\text{vdw}} + V_{\text{bond}} = 1.47 \times 10^5 \text{ J/mol} + -5.89 \times 10^5 \text{ J/mol}$

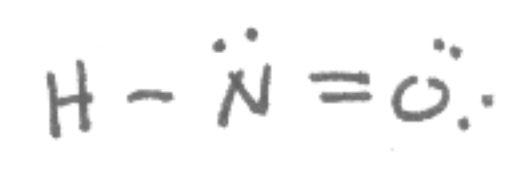
$$\boxed{\Delta E_d = -4.42 \times 10^5 \text{ J/mol}}$$

d. a) P₄ The only way to satisfy all lone pairs is to form a tetrahedron:



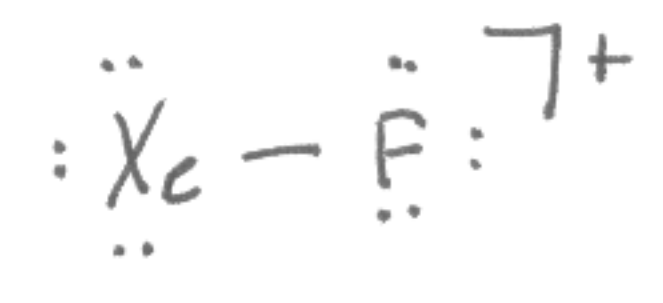
dashed lines mean that P is going back into the paper.

b) HNO



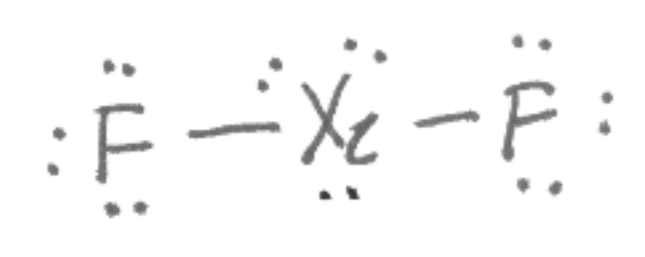
c) XeF⁺

$$\begin{array}{r}
 \text{Xe} = 8e^- \\
 \text{F} = 7e^- \\
 + = -1e^- \\
 \hline
 14e^-
 \end{array}$$

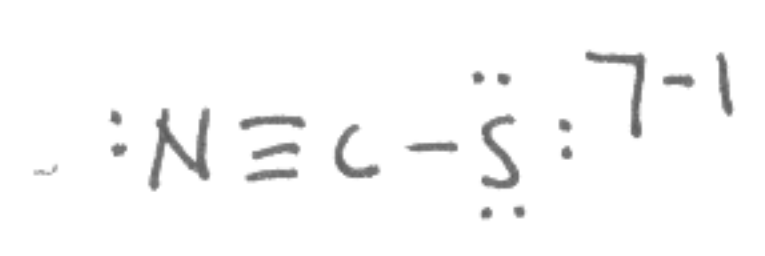


d) XeF₂

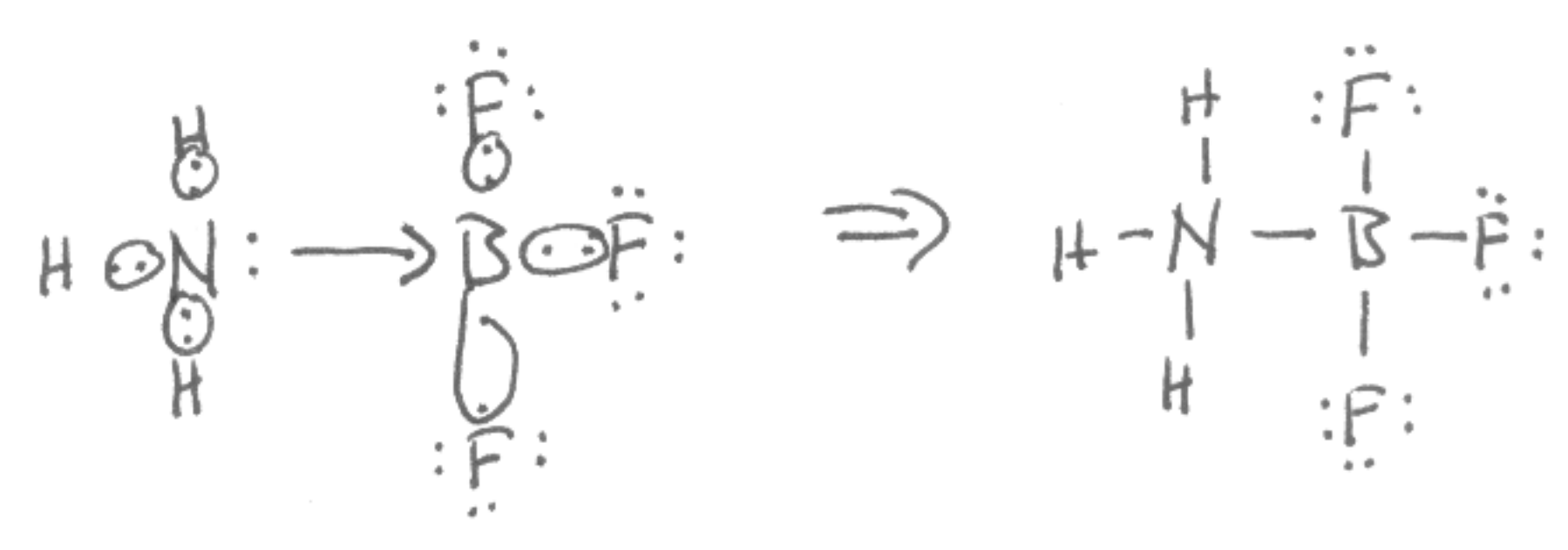
$$\begin{array}{r}
 \text{Xe} = 8e^- \\
 2\text{F} = 14e^- \\
 \hline
 22e^-
 \end{array}$$



e) SCN⁻



f) H₃NBF₃

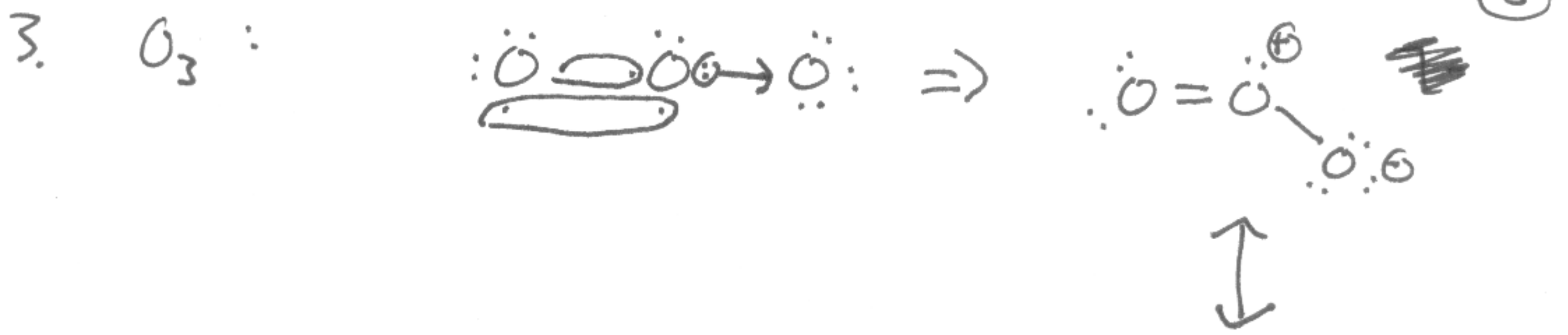


g) CH_3COO^-



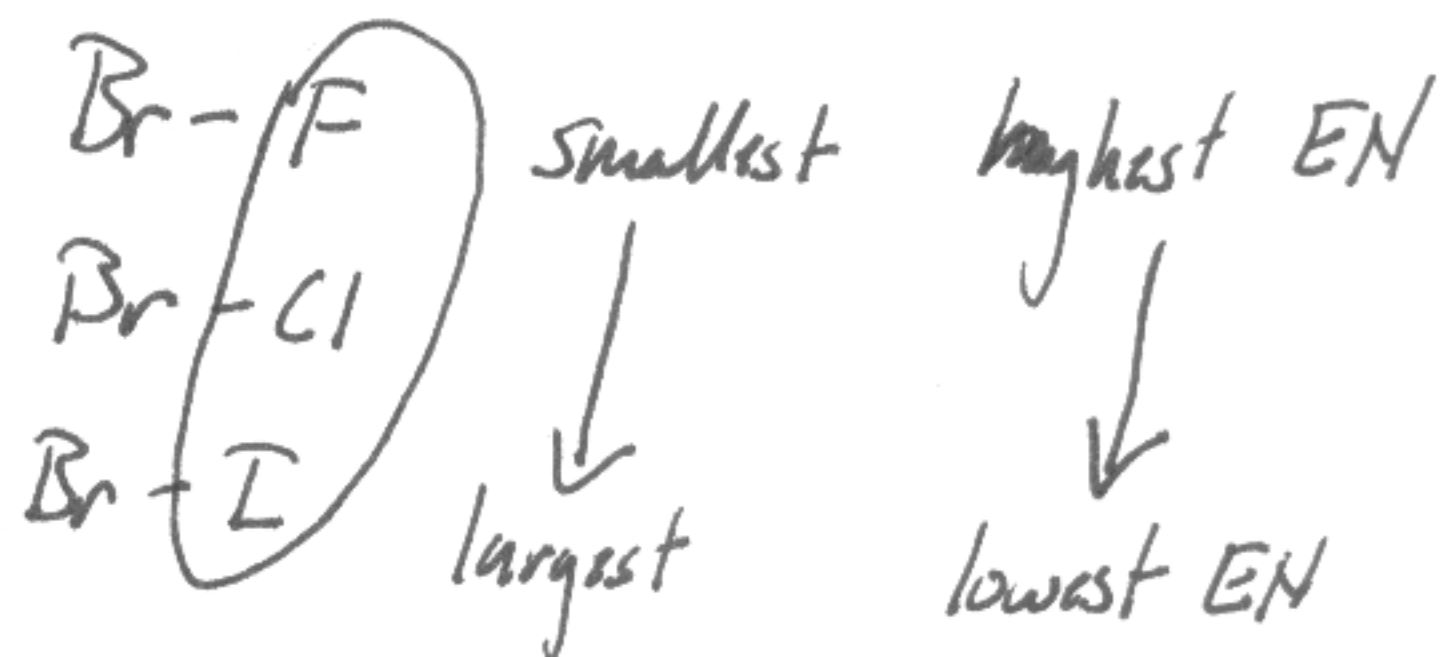
h) HCO_3^-





From VSEPR, the electrons in the bonds and lone pairs around the central O will want to push as far away from each other as possible. This means that O_3 will have a bent structure. The information about the dipole moment really isn't relevant here. Even if the molecule was linear, because each O atom is distinct, the molecule still could have a dipole moment.

4. The common atom here is the ~~Br~~ Br, so let's organize things around that

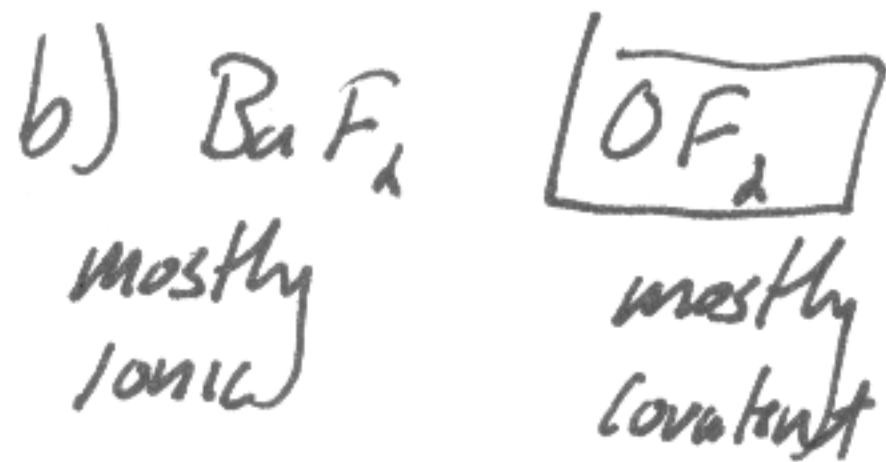
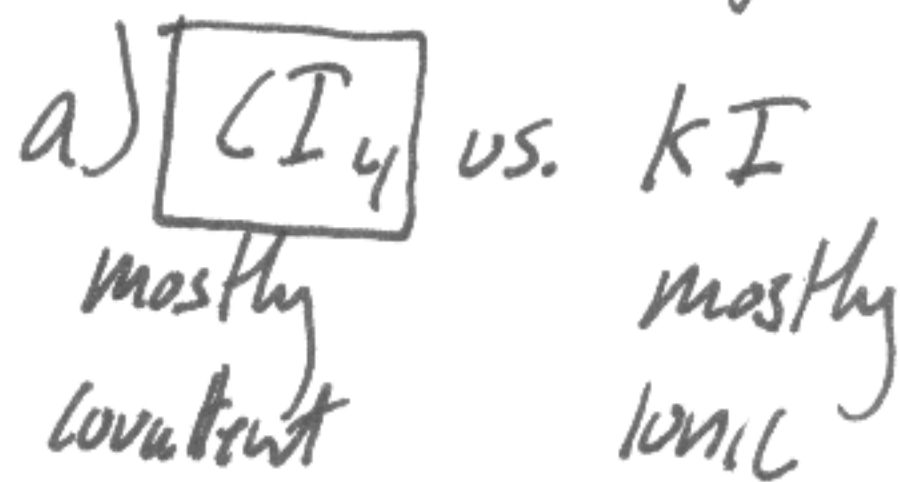


a) increasing bond length: $BrF < BrCl < BrI$

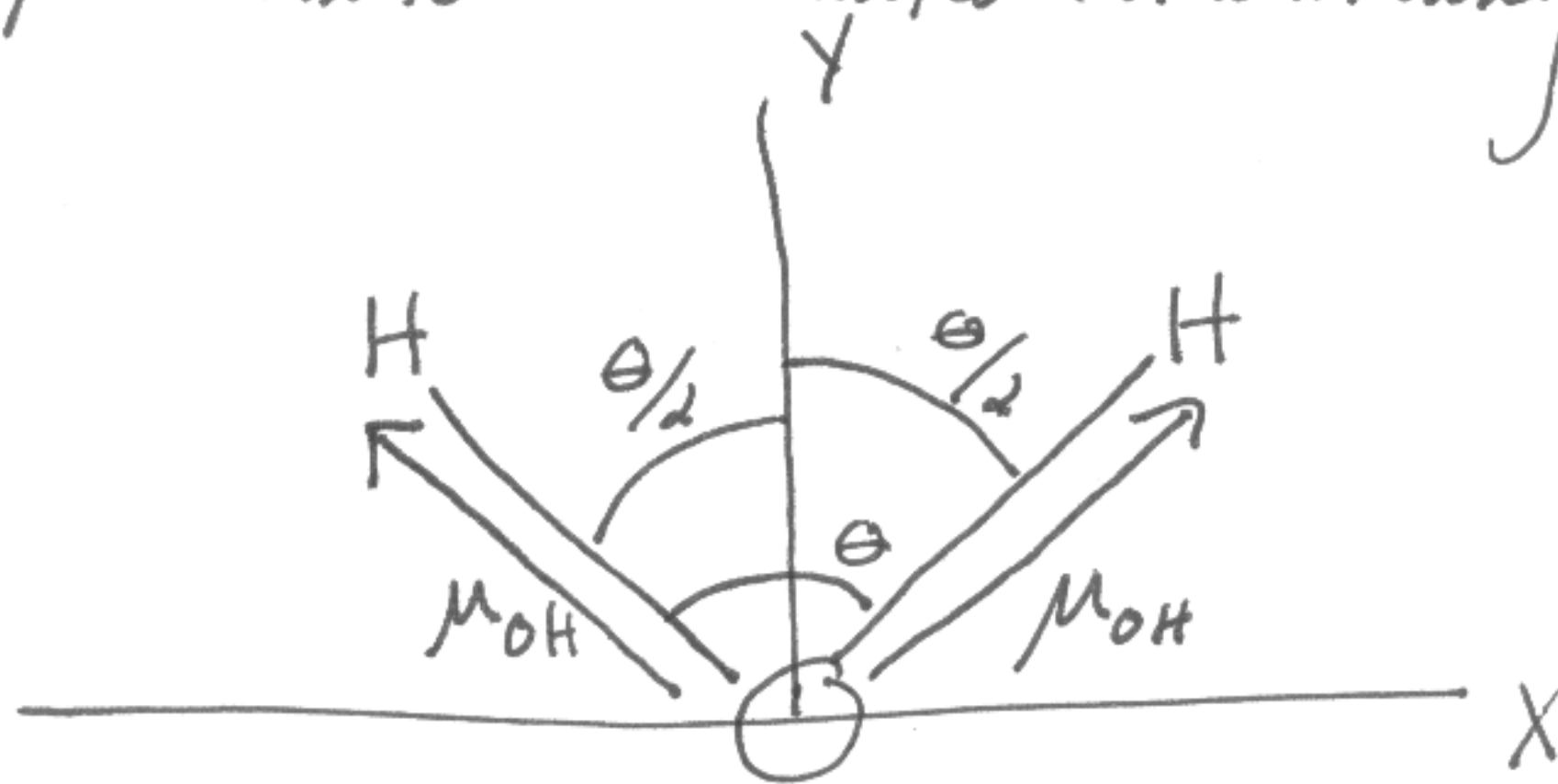
b) increasing bond energy: $BrI < BrCl < BrF$

(6)

5. Ionic compounds tend to have higher melting and boiling points and to be less volatile than covalent compounds. Less volatile \Rightarrow lower vapor pressure, so in each pair, the molecules that is more ionic in character than covalent in character will be less volatile. Use EN differences to estimate greater ionic character, and the more ionic will have higher vapor pressure.

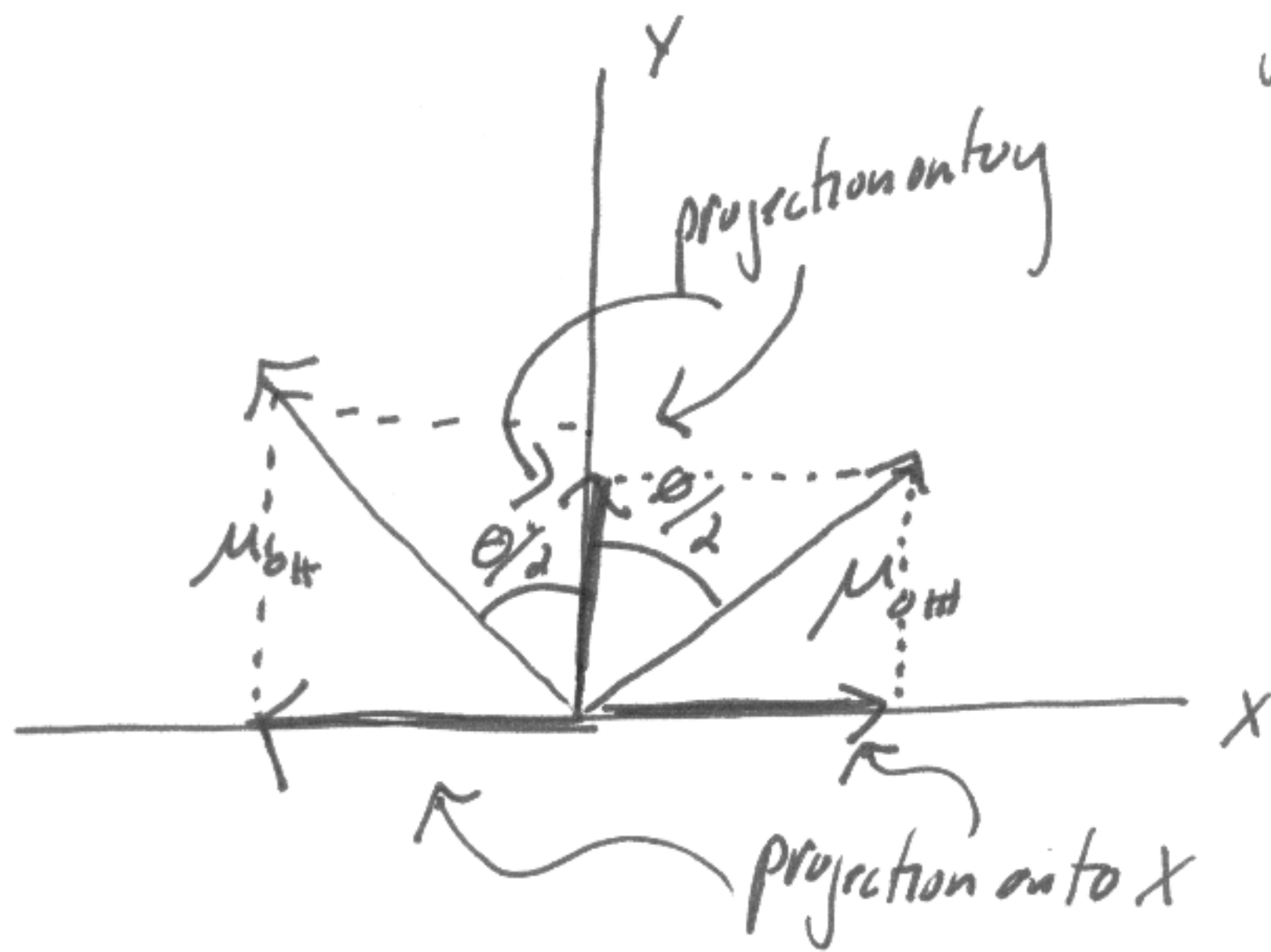


6. Because of the shape of the water molecule, the two O-H bond dipole moments are oriented in the following way:



(7)

To figure out the molecular dipole moment, we need to project the μ_{OH} vector onto the x- and y- axis:



Because the two μ_{OH} are equal, the 2 projections onto the x-axis cancel each other out. The projection onto y-axis is

$$\mu_{Total} = \mu_{OH} \cos\left(\frac{\theta}{2}\right) + \mu_{OH} \cos\left(\frac{\theta}{2}\right)$$

(because there are two OH bonds)

That means the dipole moment of the molecule is:

$$\mu_{H_2O} = 2 \mu_{OH} \cos\left(\frac{\theta}{2}\right)$$

To find μ_{OH} , just rearrange:

$$\mu_{OH} = \frac{\mu_{H_2O}}{2 \cos\left(\frac{\theta}{2}\right)} = \frac{1.86 \text{ D}}{2 \cos\left(\frac{104.5}{2}\right)}$$

$$\mu_{OH} = 1.52 \text{ D}$$