

Directions

1. Skim the entire exam before you begin so that you have a sense of the whole: what parts you can do quickly and what parts will require more time. The points for each problem are shown in parenthesis in the left margin. Try to use your time in proportion to the points assigned for each question.
2. You must show all the work necessary to arrive at your answer. **No credit will be given for numerical answers unless your work is shown.** (We want to be able to follow your thought process in order to be able to help make corrections and allot partial credit.)
3. Be sure to include the correct number of significant figures and the appropriate unit when reporting your answers.

Academic Integrity Pledge

During the exam I will

- turn off my cell phone and put it away (out of sight and not on my person)
- close all books, notebooks, etc. and put them under the seat in which I sit
- use only a permitted calculator
- keep my eyes down and focused on my own paper
- write only in ink
- keep my answers covered
- sit in the area assigned to my section
- stop writing when the end of the exam is announced

During the exam I will not

- have any papers other than those provided
- have any writing on my clothing or person or desk
- talk to anyone other than a TA or the instructor

I understand that the *minimum consequence* of any behavior contrary to this pledge is that I will receive a **zero on this exam** that will not be replaced by the percent earned on my final exam.

Scoring

1	<u>9</u> / 15	5	<u>15</u> / 15	MC	15 / 30
2	<u>15</u> / 15	6	<u>15</u> / 15		
3	<u>15</u> / 15	7	<u>15</u> / 15	Total	<u>124</u> / 150
4	<u>15</u> / 15	8	<u>10</u> / 15		

Multiple Choice Answers

- | | | |
|------------------------|------------------------|-------------|
| 1. <u>A</u> | 3. <u>A</u> | 5. <u>E</u> |
| 2. <u>D</u> | 4. <u>E</u> | 6. <u>E</u> |

$5s^1 4d^9$

a. List three metals in the p-block that have two different charges and give the charges.

Pb $\rightarrow +2, +4$

Bi $\rightarrow +3, +5$

Sn $\rightarrow +2, +4$

b. Write the valence electron configuration of the Ag^+ ion?

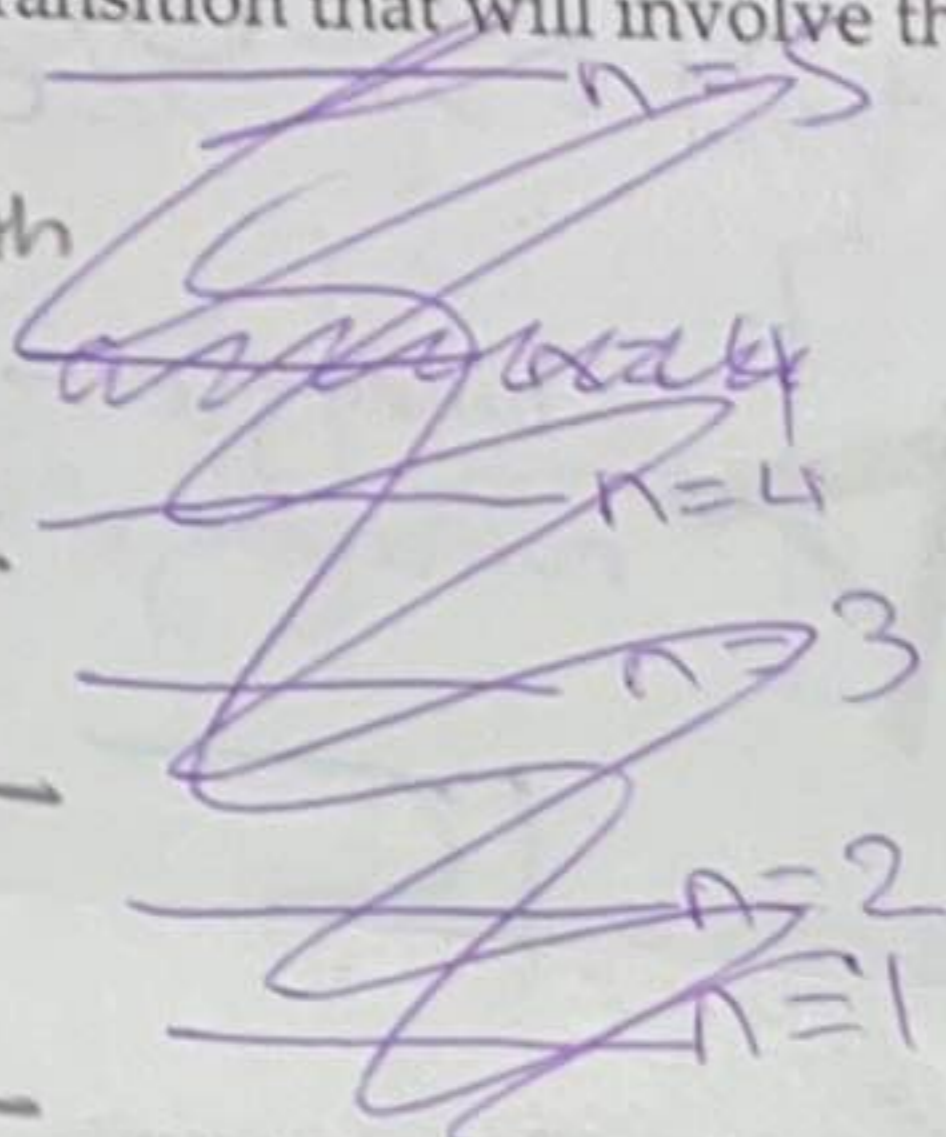
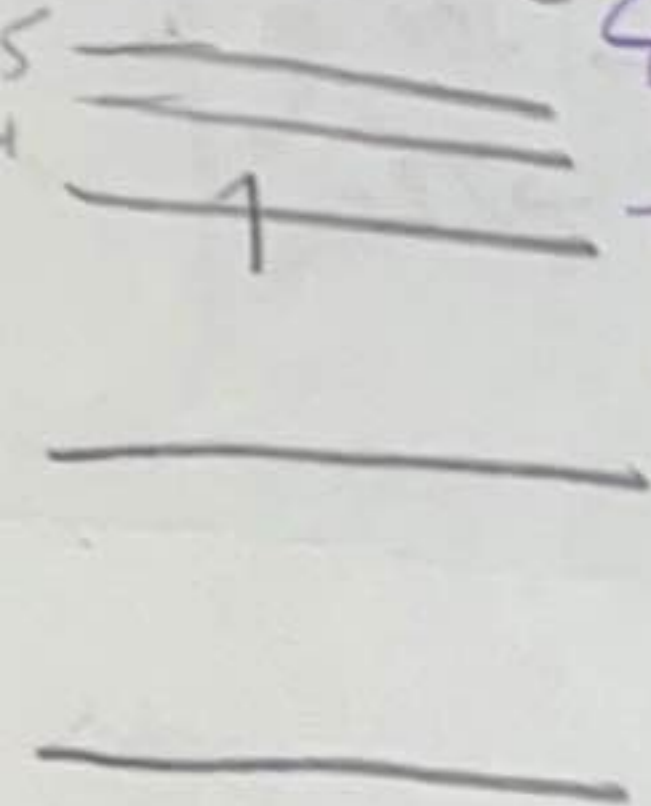
$[Kr] 4d^{10}$

$[Kr] 5s^2 4d^9$

c. Draw an energy level diagram for hydrogen showing the $n = 1$ through $n = 5$ levels. Add an electron in $n = 3$ level.

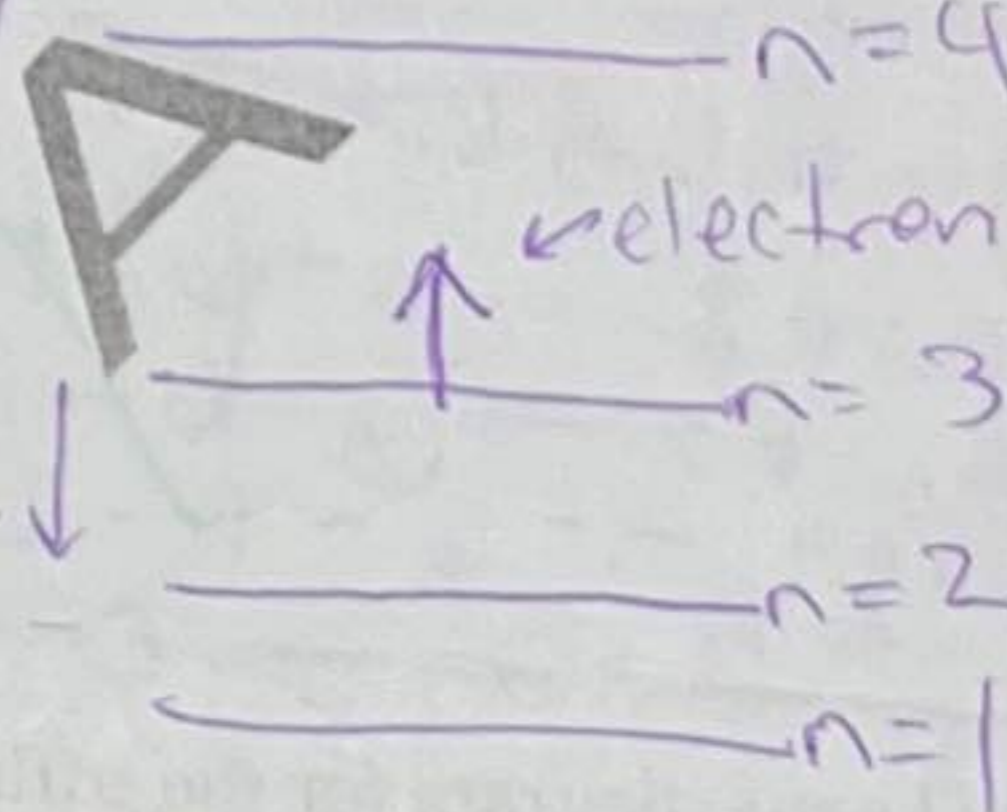
The transition that will involve the highest wavelength is from $n = 3$ to $n = 2 \rightarrow 4$

$\rightarrow n=4$ is highest wavelength



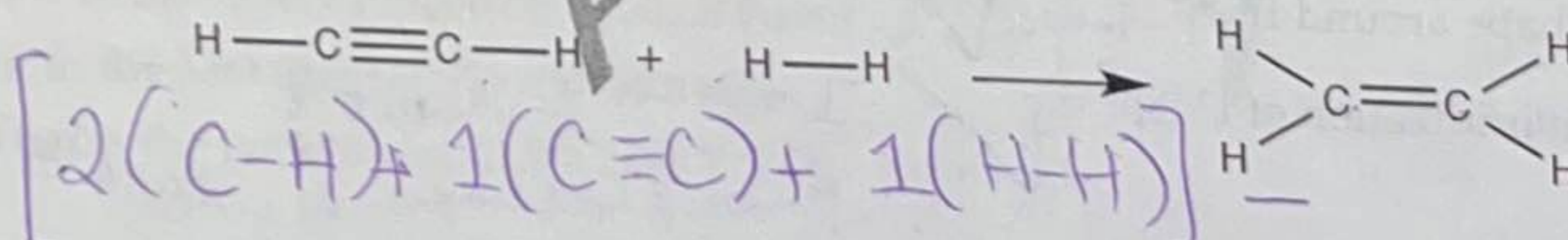
lowest frequency
lowest energy

$n=3$
 $\rightarrow n=2$



trying to show further apart from 3 and 4

2. Calculate the enthalpy for the following reaction from bond energy data.



$$[2(C-H) + 1(C \equiv C) + 1(H-H)] - [4(C-H) + 1(C=C)]$$

$$= [2(413) + 839 + 436] - [4(413) + 614]$$

$$= 2101 - 2266$$

$$= -165 \text{ kJ/mol} \rightarrow \text{exothermic releases energy}$$

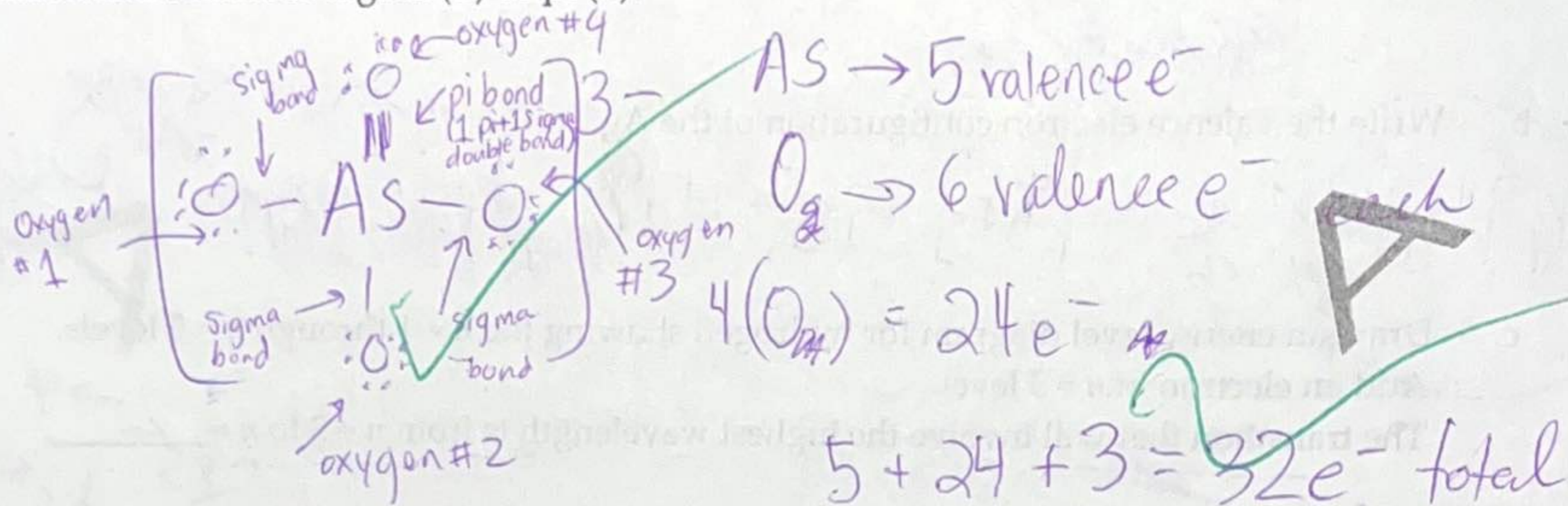
\rightarrow Bonds Broken - Bonds Formed

3. Draw the BEST Lewis diagram for the silicate ion, AsO_4^{3-} .

Show your electron counts and the formal charges for each atom.

No resonance is required.

Label each bond as sigma (σ) or pi (π).



Formal charges

$Oxygen\#1 \rightarrow 6 - 6 - 1 = -1$
 $Oxygen\#2 \rightarrow 6 - 6 - 1 = -1$
 $Oxygen\#3 \rightarrow 6 - 6 - 1 = -1$
 $Oxygen\#4 \rightarrow 6 - 4 - 2 = 0$
 $As \rightarrow 5 - 5 - 0 = 0$

$\text{bonding } e^- \rightarrow 10e^-$
 $\text{non bonding } e^- \rightarrow 22e^-$

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4. a. Draw the Lewis diagram for the trifluoroiodine, IF_3 . Show your electron counts.

b. What is the arrangement around I? *trigonal bipyramidal*

c. What is the shape around I? *T-shaped*

d. What is the hybridization of I? *sp^3d*

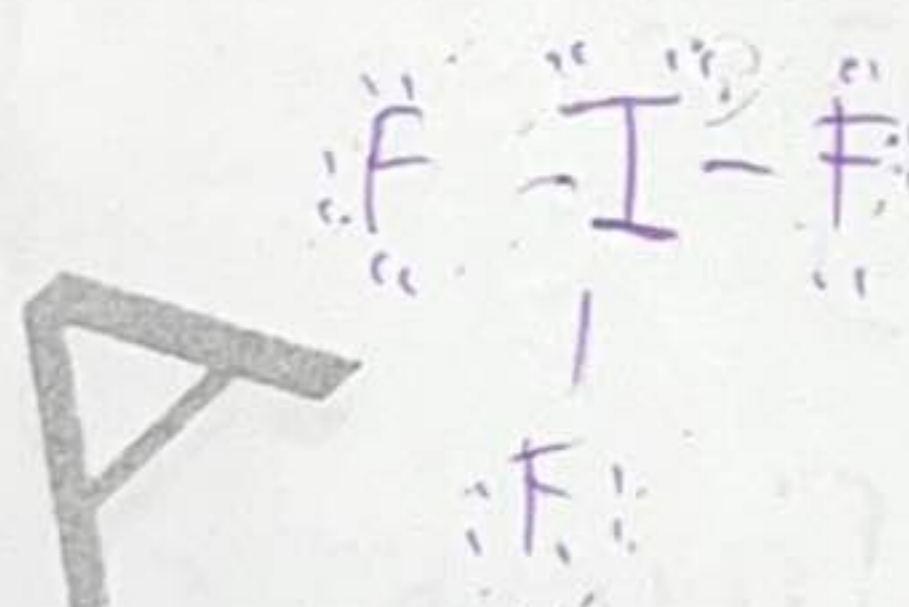
$Iodine \rightarrow 7 \text{ valence } e^-$

$F \rightarrow 7 \text{ valence } e^- \text{ each} = 21 \text{ total } e^-$

$(7 \times 3) + 7 = 28 e^-$

$\text{Bonding } e^- \Rightarrow 6e^-$

$\text{non bonding } e^- \Rightarrow 22e^-$



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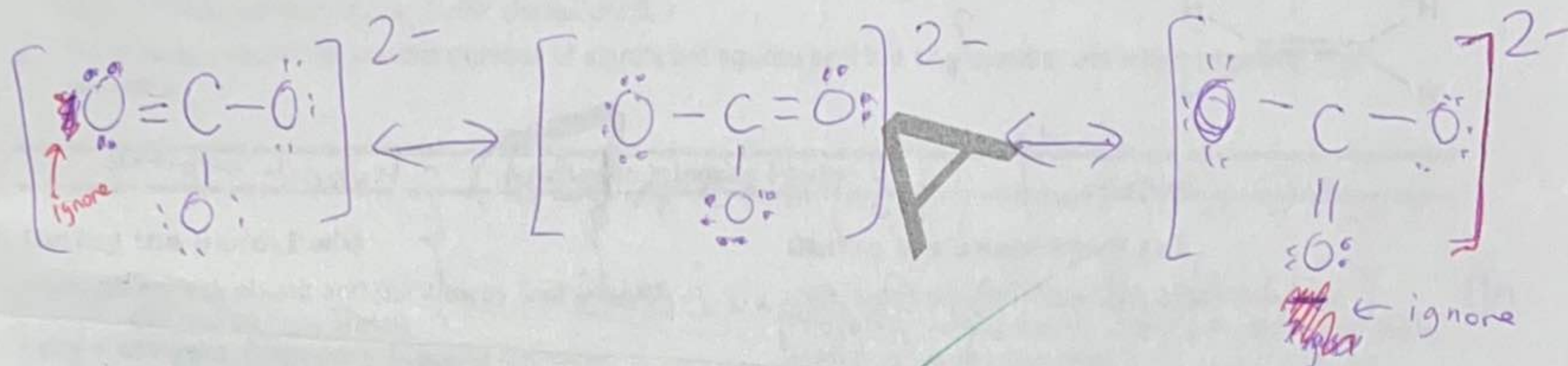
5. a. Draw the Lewis structure for the carbonate ion, CO_3^{2-} .
 Show your electron counts.
 Include any resonance structures needed.

- b. What is the shape around the C atom? ~~tetrahedral~~ trigonal planar
 c. What is the hybridization of the C atom? ~~sp³~~ sp²

Carbon \rightarrow 4 valence e⁻

Oxygen \rightarrow 6 valence e⁻ \rightarrow 6 x 3 = 18 e⁻

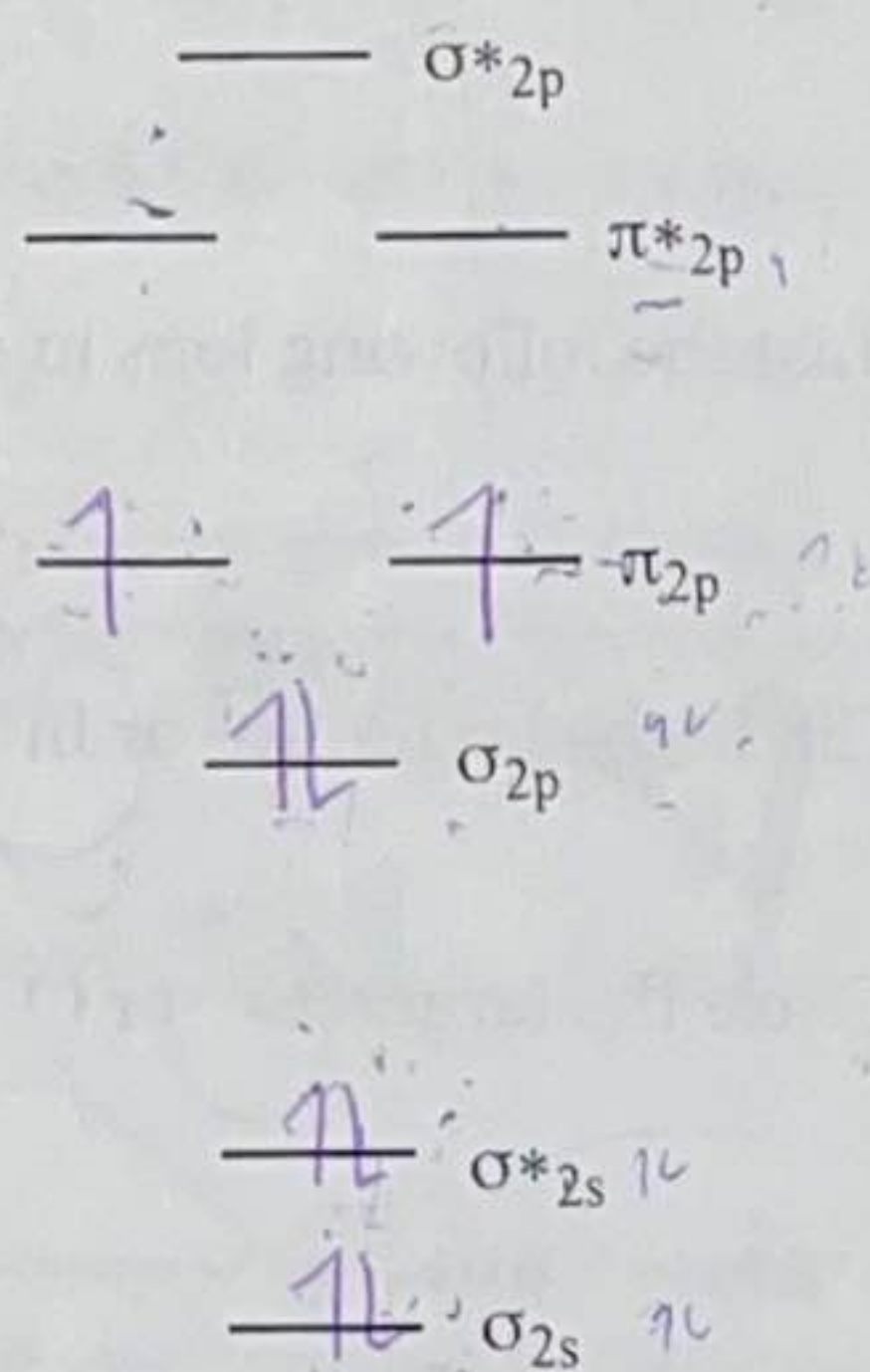
$4 + 6(3) + 2 = 24 \text{ e}^-$ total



6. Consider the BN molecule.

- a. How many valence electrons does it have? 8
 b. Fill in the MO diagram to right for BN.
 c. What is the bond order of BN? Show your work.

$\frac{\text{bonding orbitals} - \text{antibonding orbitals}}{2} = \frac{6 - 2}{2} = 2$



- d. BN is (circle one) DIAMAGNETIC PARAMAGNETIC

- e. What is the bond order of BN^+ . Show your work.

loses one e⁻ from π_{2p}
 $\frac{5 - 2}{2} = 1.5$

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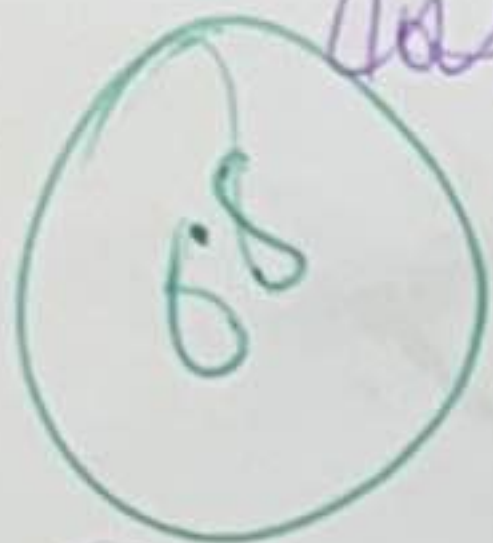
- f. What is the bond order of BN^{2+} . Show your work.

loses 2 e⁻ from π_{2p}
 $\frac{4 - 2}{2} = 1$

- g. Which has the longest bond (circle one)? BN BN^+ BN^{2+}
 \rightarrow weakest, smaller bond order

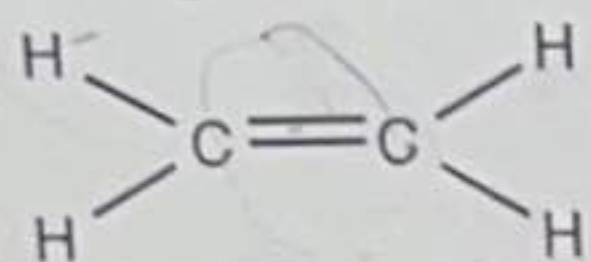
7. a. Using molecular orbital theory, explain two ways to strength (and shorten) a bond.

To strengthen \rightarrow add electrons to the bonding orbital (it will increase the bond order. Higher bond order means stronger bonds)
 Shorten \rightarrow Remove e^- from antibonding orbitals



~~Take a double bond~~
 Remove e^- from antibonding orbitals

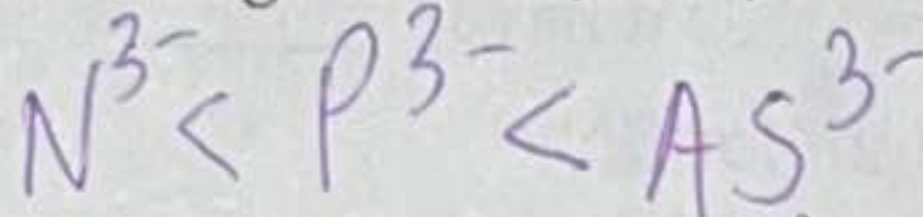
b. The Lewis structure for ethane, C_2H_4 , is shown below. Explain the bonding in the molecule by listing the orbitals (hybrid or atomic) involved for each atom and what type of bond they form.



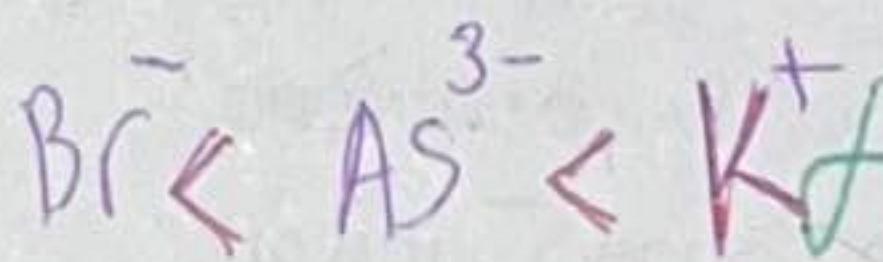
$C=C \rightarrow$ double bond (1 sigma + 1 pi bond) } hybrid orbital
 all $C-H$ bonds \rightarrow single, sigma bonds }

The carbons have sp^2 hybridization

8. a. List the following ions in order of increasing size: N^{3-} , As^{3-} , P^{3-} .

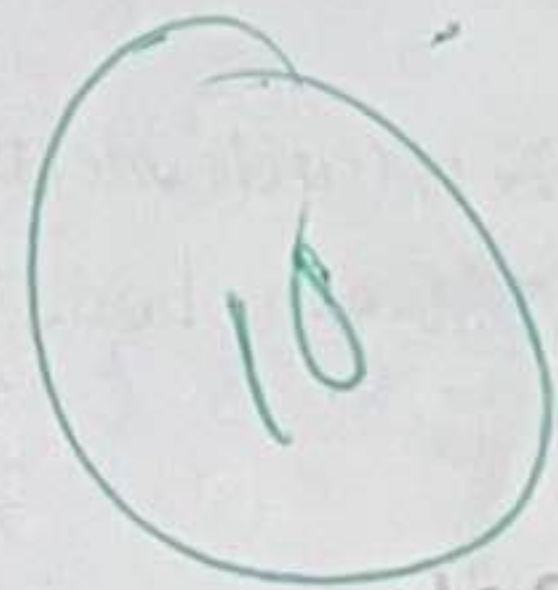


b. List the following ions in order of increasing size: Br^- , K^+ , As^{3-} .



c. Circle the larger: In^+ or In

d. Circle the larger: O^{2-} or O



Cations < atom < anion

one w/ more is smaller

