

## Recitation Worksheet Ten

Name:

ken

UGA ID:

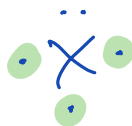
### Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: mine is jmj81738). Do *not* enter your 81x number.
- Download this worksheet and print it if you have a printer. Write the answers in the answer boxes and show your work when appropriate. Using the instructions in the Welcome module on eLC, convert your worksheet to a PDF and then upload it to Gradescope. If you have an iPhone or Android device, you can scan and upload directly through the Gradescope app. The pages must be in the correct order or Gradescope will not be able to read it.
- If you do not have a printer, download the worksheet and type your answers in the answer boxes and upload it to Gradescope. Write your work on separate sheets of paper, convert these pages to a PDF using the instructions in the Welcome module on eLC, then upload them to the dropbox on eLC for this worksheet.
- If you are using an app to annotate the worksheet, make sure the pages are in the correct order and have the same layout as the original or Gradescope will not be able to read it.
- Answers must be written in the corresponding answer box or no credit will be awarded.
- This worksheet is due no later than **11:59 PM on the Friday of the recitation week.**
- The instructions for uploading worksheets to Gradescope can be found in the Content area of eLC in the Welcome Module.
- **You must show your work to receive credit.**

↗ "X"

1. The Lewis symbol of an unknown atom has 2 paired electrons and 3 unpaired electrons. How many bonds is this atom likely to form in a covalent compound? Answer with an integer (e.g. 6).

3



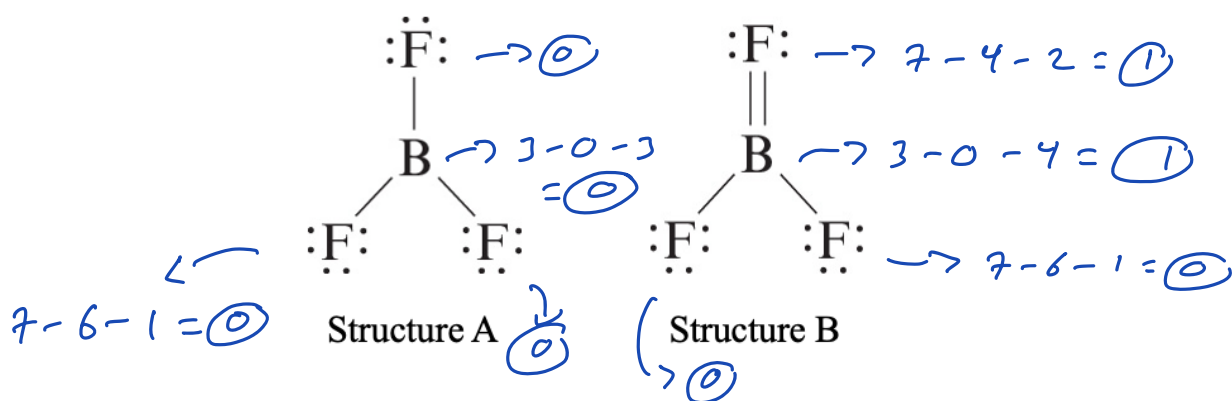
2. What is **true** about choosing the best Lewis structure? Select all that apply.

B D E

- A. Negative formal charges should go on the **least** electronegative atom
- ☒ B. The best Lewis structure minimizes all formal charges
- C. An atom can only expand its octet if there are excess electrons after all atoms have a filled octet when drawing the Lewis structure
- ☒ D. Only atoms with a principal quantum number of 3 or higher in their valence electrons can expand their octet
- ☒ E. An atom in row 3 or greater can expand its octet to minimize its formal charge in the best Lewis structures

$$\text{Formal charge} = \# \text{ valence } e^- - \# \text{ lone pair } e^- - \frac{1}{2} \text{ shared } e^-$$

3. In your textbook, the authors discuss two possible ways that the Lewis structure of the molecule  $\text{BF}_3$  can be drawn (shown below).



I. Which Lewis structure above satisfies the octet rule for all of the atoms? Write the corresponding letter for the structure ("A" or "B").

B

II. Which Lewis structure minimizes the formal charges for all of the atoms? Write the corresponding letter for the structure ("A" or "B").

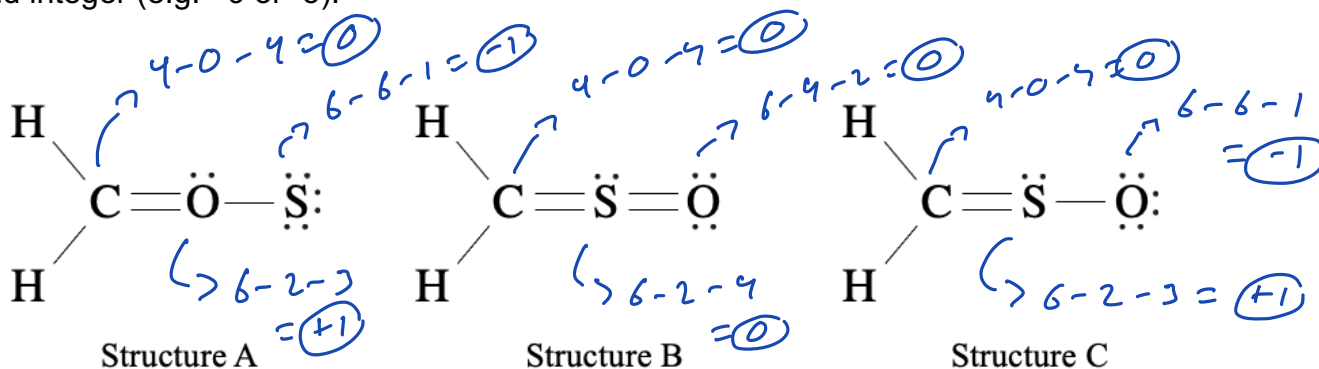
A

III. Which Lewis structure above is best for  $\text{BF}_3$ ? Write the corresponding letter for the structure ("A" or "B").

A

> formal charges minimized

4. Three different Lewis structures of the molecule  $\text{H}_2\text{CSO}$  are provided below. Provide the formal charges of carbon, oxygen, and sulfur for each structure. Answer with a sign and integer (e.g. +9 or -5).



I. Structure A

Carbon:  Oxygen:  Sulfur:

II. Structure B

Carbon:  Oxygen:  Sulfur:

III. Structure C

Carbon:  Oxygen:  Sulfur:

IV. Which Lewis structure above is best for  $\text{H}_2\text{CSO}$ ? Write the corresponding letter for the structure ("A", "B", or "C") in the box below.

$\hookrightarrow$  formal charges minimized



5. What is the formal charge on iodine in the iodate ion (in its best Lewis structure)? What is the oxidation state of iodine in the iodate ion? Answer with signs and integers (e.g. +9 or -5).

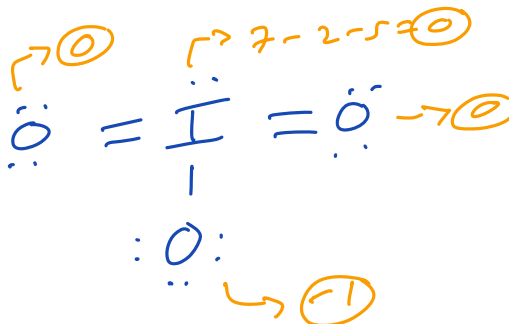
I. Formal charge:

0

II. Oxidation state:

+5

$\text{IO}_3^- \rightarrow 26 \text{ valence e}^-$



\* iodine has expanded octet to minimize formal charge

6. Draw the best Lewis structure of OPCI. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

1

II. Double bonds:

1

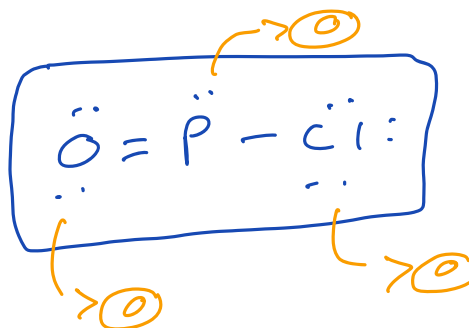
III. Triple bonds:

0

IV. Lone pairs:

6

18 valence e<sup>-</sup>



7. Draw the best Lewis structure of  $\text{OPCl}_2^{1+}$ . How many single bonds, double bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

2

II. Double bonds:

1

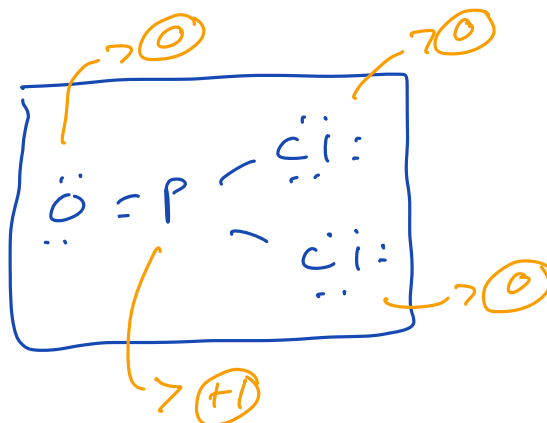
III. Triple bonds:

0

IV. Lone pairs:

8

24 valence e<sup>-</sup>



8. Draw the best Lewis structure of  $\text{O}_2\text{PCl}$ . How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

1

II. Double bonds:

2

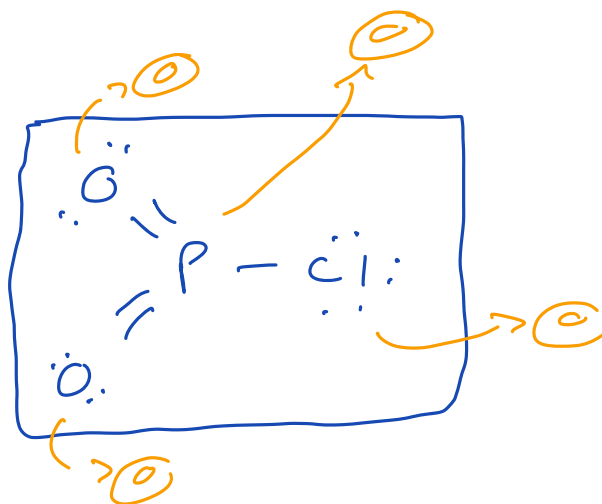
III. Triple bonds:

0

IV. Lone pairs:

7

24 valence e<sup>-</sup>



\* Phosphorus expands octet to minimize formal charge

9. Draw the best Lewis structure of  $\text{CH}_3\text{CCH}$ . How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

5

II. Double bonds:

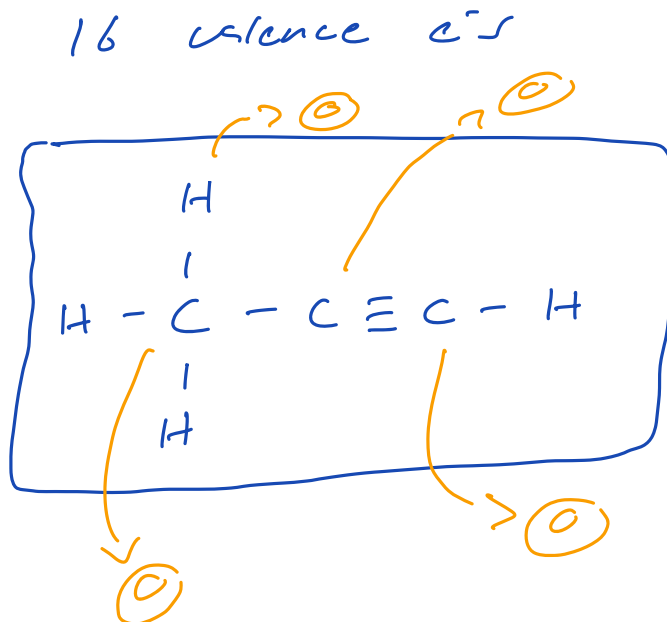
0

III. Triple bonds:

1

IV. Lone pairs:

0



10. Draw the best Lewis structure of a hypothetical molecule,  $\text{MX}_3$ . Both the "M" and "X" atoms have 7 valence electrons each, and "M" will be your central atom. In addition, the atom "M" may expand its octet, but "X" cannot. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

3

II. Double bonds:

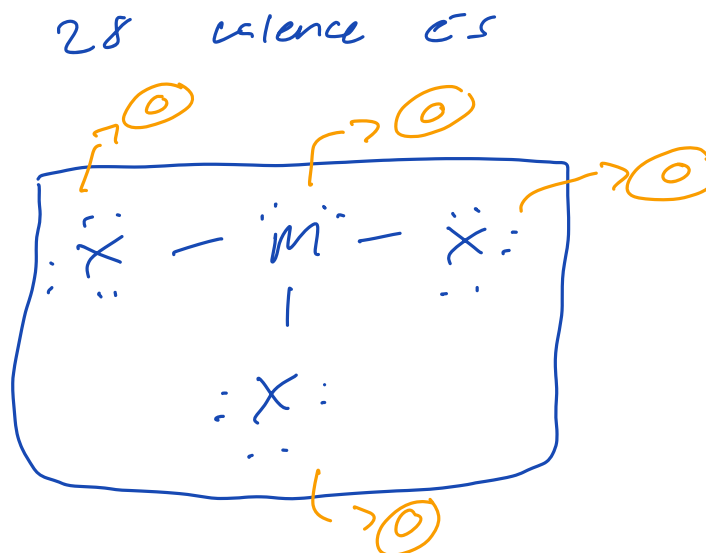
0

III. Triple bonds:

0

IV. Lone pairs:

11



\* "M" expands octet to minimize formal charge

11. Draw the best Lewis structure of  $\text{CH}_3\text{CH}_2\text{COOH}$ . How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

9

II. Double bonds:

1

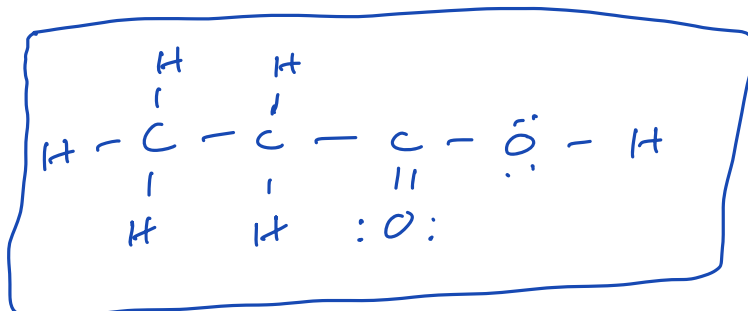
III. Triple bonds:

0

IV. Lone pairs:

4

30 valence  $e^-$ s



All atoms have zero formal charge

12. The best Lewis structure of  $\text{SF}_3\text{N}$  has sulfur as the central atom. Draw the best (hypothetical) Lewis structure of this molecule with **nitrogen as the central atom**. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

I. Single bonds:

4

II. Double bonds:

0

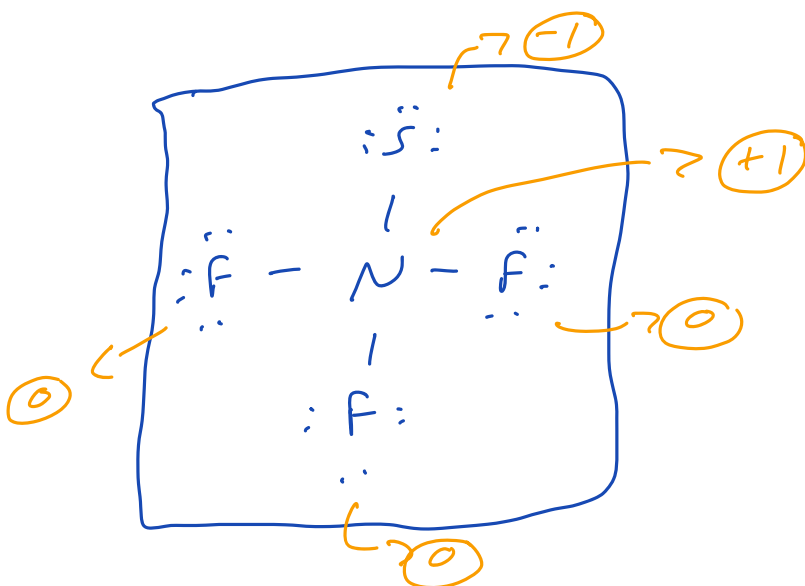
III. Triple bonds:

0

IV. Lone pairs:

12

32 valence  $e^-$ s

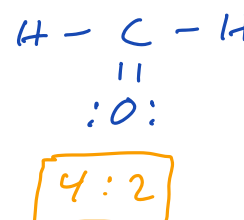
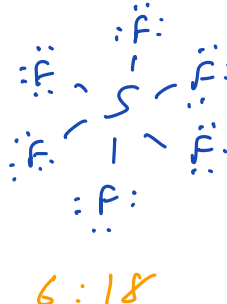
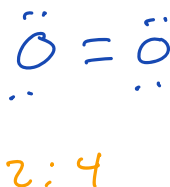
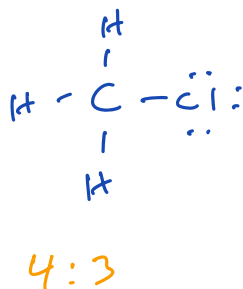


(be careful... nitrogen may not expand its octet)

13. Which of the following compounds would have the highest ratio of bonding pairs to lone pairs (bond pairs/lone pairs)?

**D**

- A.  $\text{CH}_3\text{Cl}$
- B.  $\text{O}_2$
- C.  $\text{SF}_6$
- D.  $\text{CH}_2\text{O}$**
- E. More than one of the above has the same ratio



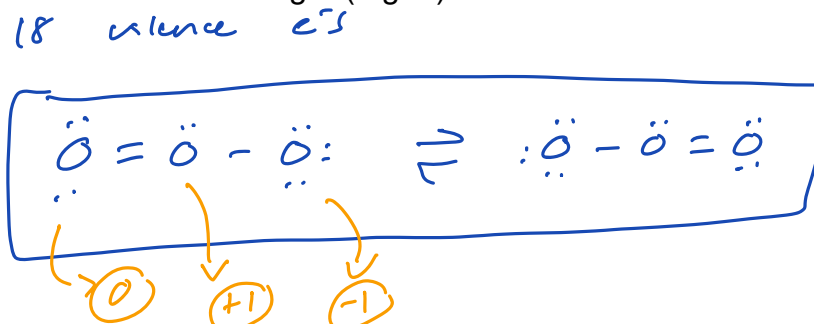
14. Which of the following compounds would be the most reactive?

**B**

- A.  $\text{SO}_4^{2-}$  → 32 valence e<sup>-</sup>s
- B.  $\text{ClO}$**  → 13 valence e<sup>-</sup>s → free radical (odd # of e<sup>-</sup>s)
- C.  $\text{OF}_2$  → 20 valence e<sup>-</sup>s
- D.  $\text{CCl}_4$  → 32 valence e<sup>-</sup>s
- E.  $\text{N}_2$  → 10 valence e<sup>-</sup>s

15. How many equivalent, best resonance structures are possible for the ozone molecule ( $\text{O}_3$ )? Answer with an integer (e.g. 6).

**2**

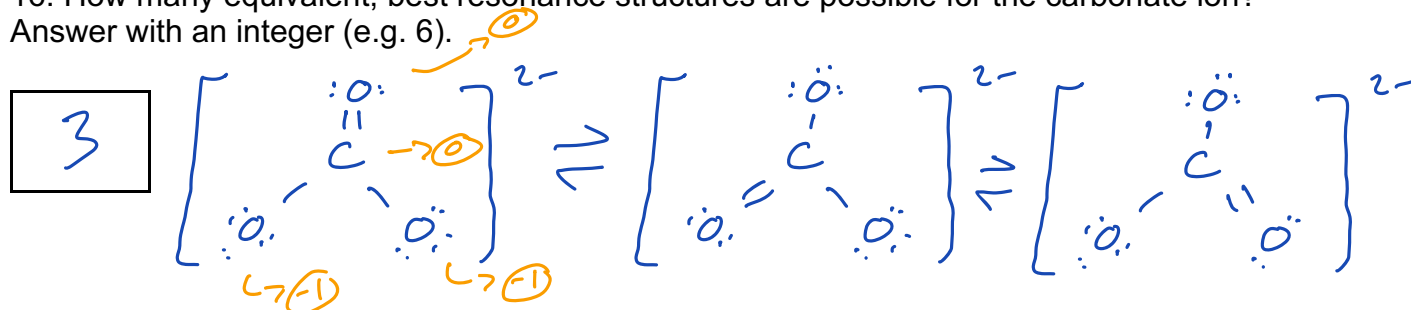


(be careful... oxygen may not expand its octet)



$\text{CO}_3^{2-} \rightarrow 25 \text{ valence e}^-$

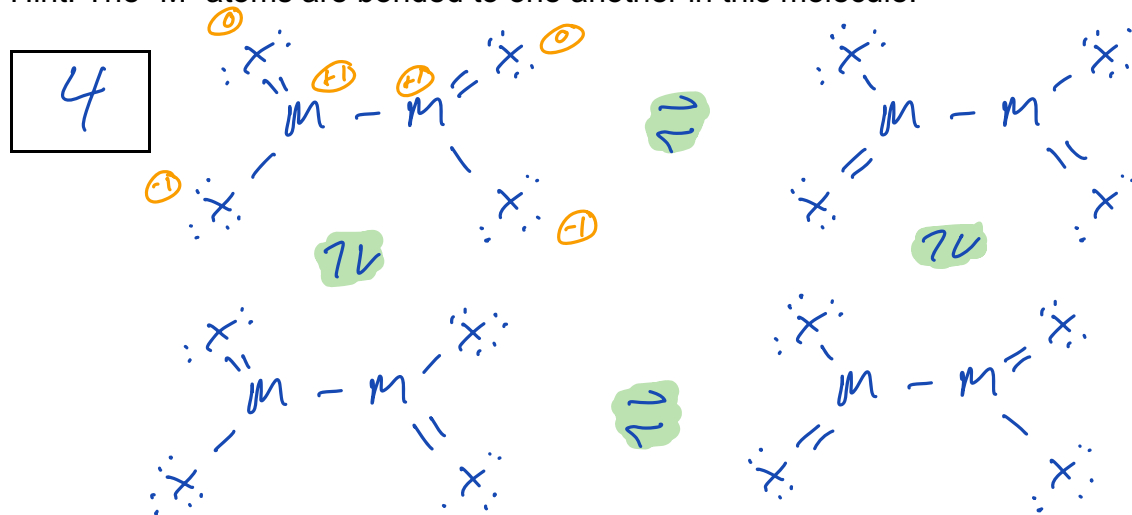
16. How many equivalent, best resonance structures are possible for the carbonate ion? Answer with an integer (e.g. 6).



17. Consider a hypothetical molecule,  $\text{M}_2\text{X}_4$ . Each "M" atom has 5 valence electrons and each "X" atom has 6 valence electrons. In addition, the "X" atoms are more electronegative than the "M" atoms, and none of the atoms may expand their octet. Based on this information, how many equivalent, best resonance structures are possible for the  $\text{M}_2\text{X}_4$  molecule? Answer with an integer (e.g. 6).

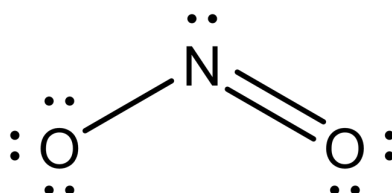
34 valence e<sup>-</sup>

Hint: The "M" atoms are bonded to one another in this molecule.



18. What is false about the resonance structures of  $\text{NO}_2^{1-}$ , one of which is shown below?

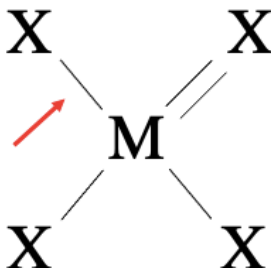
C



- A. The NO bond length is somewhere between the length of a NO single bond and a NO double bond
- B. One of the atoms must always have a negative formal charge because of the overall charge of the polyatomic ion
- C. The electrons in the N=O bond rapidly switch back and forth between the two structures
- D. The electrons that make up the NO bonds are delocalized across the structure
- E. The lone pair on nitrogen is localized to nitrogen

19. One of the equivalent, best resonance structures of a hypothetical molecule,  $MX_4$ , is provided below. What is the bond order for the M-X bond pointed out by the red arrow in this molecule?

B



4 best resonance structures

Bond order is averaged  $\rightarrow$

$$\frac{1 + 2 + 1 + 1}{4}$$

$$= 1.25$$

- A. 1
- ☒ B. 1.25
- C. 1.5
- D. 2
- E. The bond order rapidly switches from being either 1 or 2
- F. There is not enough information to determine this

### Extra Practice Questions: these questions will not be graded.

1. Draw the best Lewis structure for the organic compound  $CH_2CHCCl$ . How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer with integers (e.g. 6).

26 valence  $e^-$ s

I. Single bonds:

5

II. Double bonds:

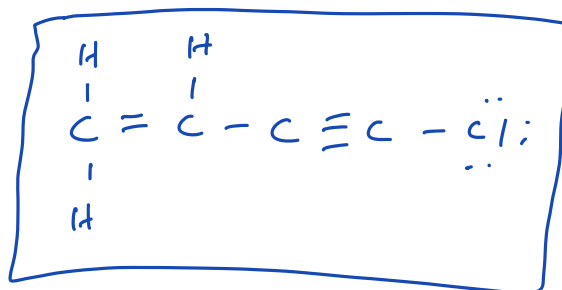
1

III. Triple bonds:

1

IV. Lone pairs:

3

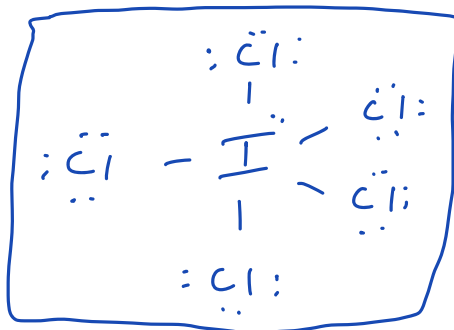


All atoms have zero formal charge

2. Draw the best Lewis structure of  $\text{ICl}_5$ . How many lone pairs are present? Answer with an integer (e.g. 6).

42 valence e<sup>-</sup>s

16

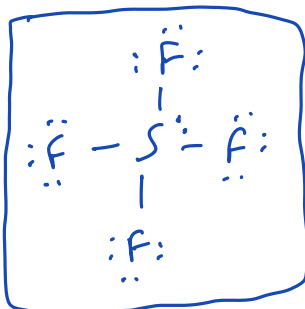


All atoms have zero formal charge

3. Draw the best Lewis structure of  $\text{SF}_4$ . How many lone pairs are present? Answer with an integer (e.g. 6).

34 valence e<sup>-</sup>s

13

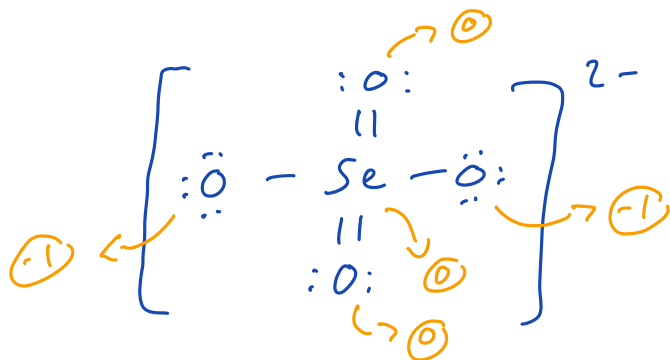


All atoms have zero formal charge  
(sulfur expands octet)

4. Draw the best Lewis structure of  $\text{SeO}_4^{2-}$ . How many lone pairs are present? Answer with an integer (e.g. 6).

32 valence e<sup>-</sup>s

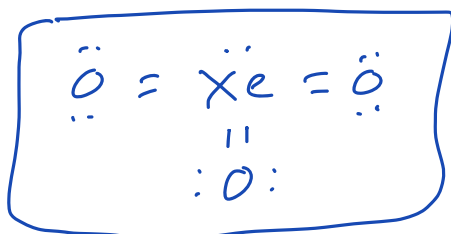
10



5. Draw the best Lewis structure of  $\text{XeO}_3$ . How many lone pairs are present? Answer with an integer (e.g. 6).

26 valence e<sup>-</sup>s

7

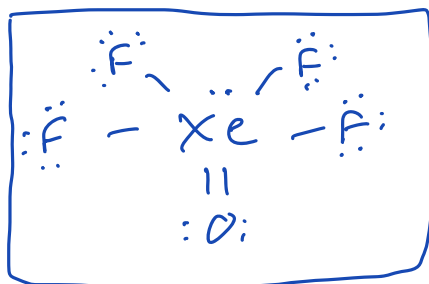


All atoms have zero formal charge  
(xenon expands octet)

6. Draw the best Lewis structure of  $\text{XeOF}_4$ . How many lone pairs are present? Answer with an integer (e.g. 6).

42 valence e's

15



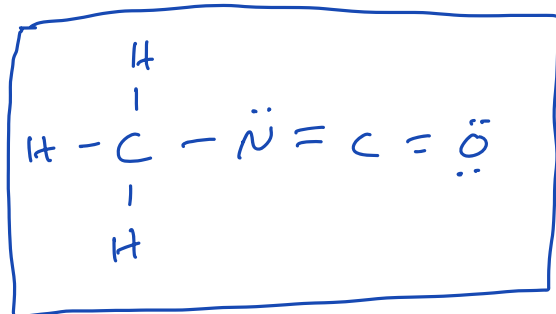
All atoms have zero formal charge  
(Xenon expands octet)

7. Draw the best Lewis structure of  $\text{H}_3\text{CNCO}$ . How many lone pairs are present? Answer with an integer (e.g. 6).

22 valence e's

Hint: the formula above is written in the general order the atoms are connected (i.e. the nitrogen atom will be between both the carbon atoms, etc.)

3



All atoms have zero formal charge

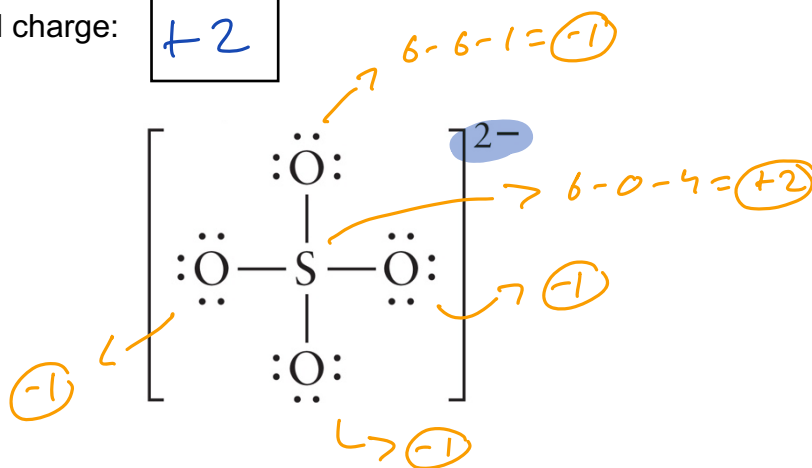
8. Determine the formal charges of the central atoms in the ions and molecules below. For additional practice, determine the formal charges of the surrounding atoms, then verify that the sum of all of the formal charges are equal to the overall charge of the respective ion or molecule. Answer with signs and integers (e.g. +9 or -5).

Please note that the structures provided for the following ions and molecules below **may or may not** represent the best Lewis structure possible.

I.  $\text{SO}_4^{2-}$

Central atom's formal charge:

+2

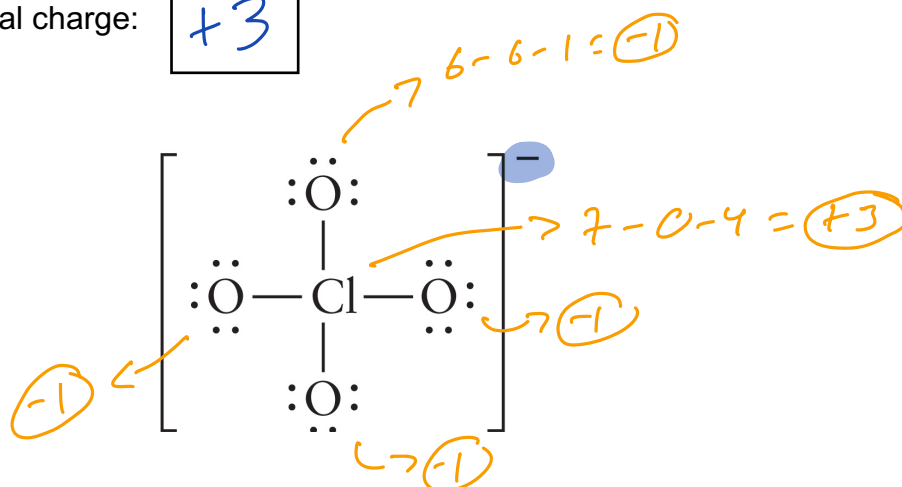


$$\text{Sum} = (4 \times -1) + 2 = -2$$

## II. $\text{ClO}_4^{1-}$

Central atom's formal charge:

$+3$

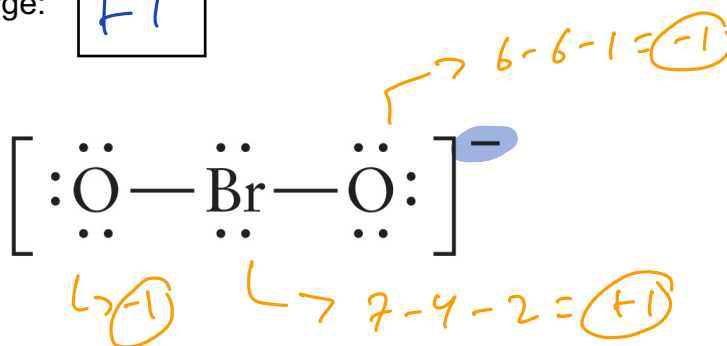


$$\text{Sum} = (4 \times -1) + 3 = -1$$

## III. $\text{BrO}_2^{1-}$

Central atom's formal charge:

$+1$

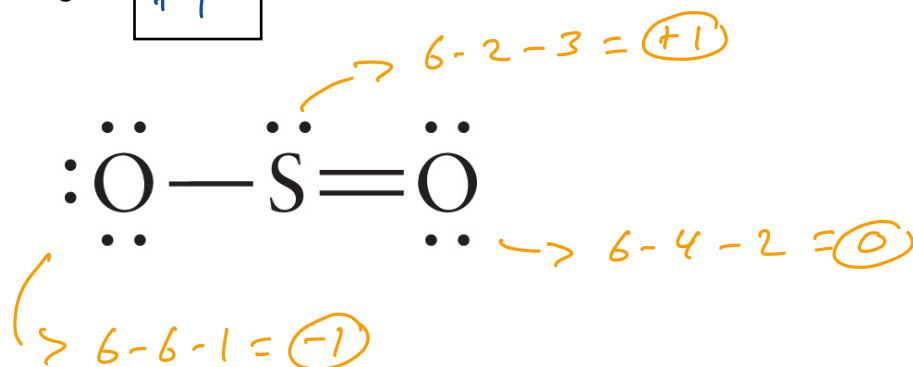


$$\text{Sum} = (2 \times -1) + 1 = -1$$

## IV. $\text{SO}_2$

Central atom's formal charge:

$+1$

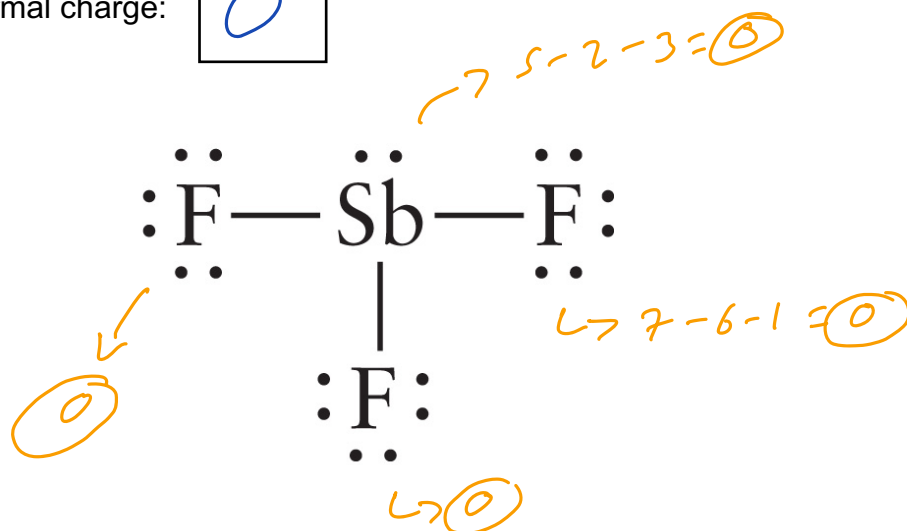


$$\text{Sum} = -1 + 1 + 0 = 0$$

V.  $\text{SbF}_3$

Central atom's formal charge:

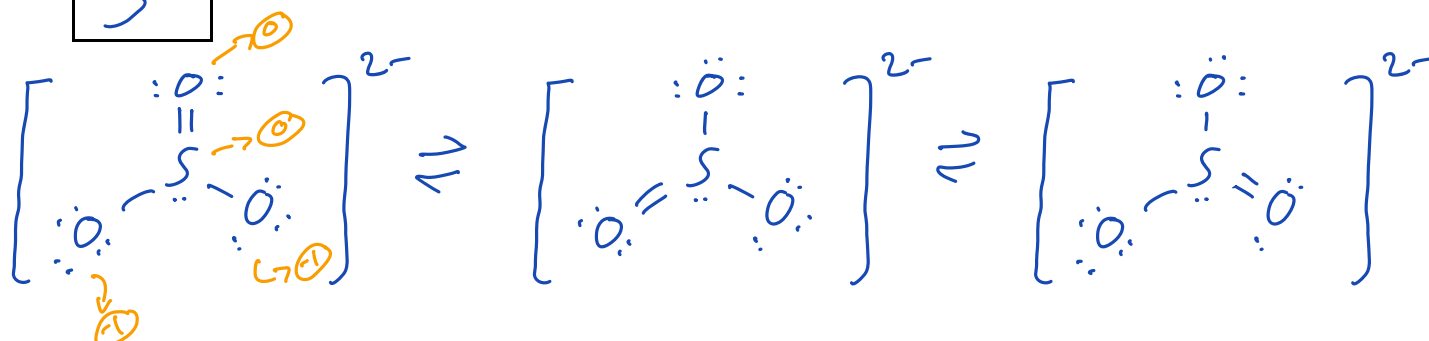
0



9. How many equivalent, best resonance structures are possible for the sulfite ion?

Answer with an integer (e.g. 6).  $\text{SO}_3^{2-} \rightarrow 26 \text{ valence } e^-s$

3



10. How many equivalent, best resonance structures are possible for the perbromate ion? Answer with an integer (e.g. 6).  $\text{BrO}_4^- \rightarrow 32 \text{ valence } e^-s$

4

\* Bromine expands octet to minimize formal charge

