Recitation Worksheet Eleven

Name: UGA ID:

Textbook:
Chemistry & Chemical Reactivity
by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel
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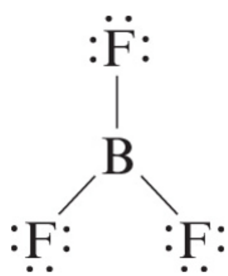
Instructions:

- This recitation worksheet covers Ch. 8.3-8.7.
- 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: Dr. Seivert's MyID is mds73312). **Do not use your 81x number**.
- Your completed worksheet has to be submitted to **Gradescope**. You have multiple options for submission:
  - You may use an app to annotate the worksheet by placing your answers in the answer boxes and showing your work when appropriate. Afterward, submit the worksheet to Gradescope. You will not need to upload anything to eLC.
  - You may print out the worksheet, write your answers in the answer boxes, and show your work on it when appropriate. Afterward, convert the worksheet to a PDF and submit to Gradescope. You will not need to upload anything to eLC.
  - If you do not have access to a printer, you may type your answers directly into the worksheet PDF and then submit it to Gradescope. Write your work on separate sheets of paper, convert them to a PDF, and upload to the appropriate dropbox on eLC.
  - There is a Gradescope app available for both iOS and Android devices that allows you to scan and submit your printed work, or you can submit your fillable PDF directly.
- The following criteria **must** be met to be eligible for full credit:
  - You must make sure the pages are in the correct order and have the same layout as the original worksheet when submitting to Gradescope regardless of your submission type.
  - Answers must be written in the corresponding answer boxes.
  - You must show your work when appropriate.
- This worksheet is due no later than **9:00 AM on the Saturday of the recitation week.**
- A periodic table and formula sheet are attached to the end of this worksheet. Please keep these attached to your worksheet in the correct order when submitting to Gradescope.

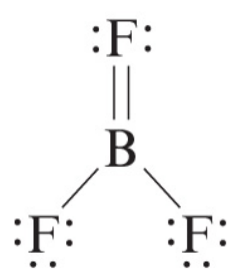
1. What is **true** about choosing the best Lewis structure? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

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

2. Consider two possible ways that the Lewis structure of the molecule BF_3 can be drawn (shown below).



Structure A



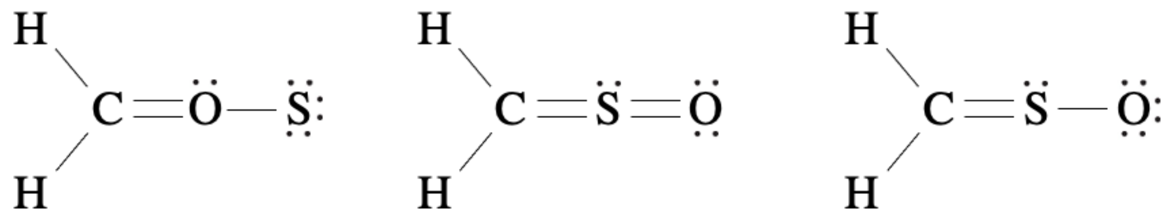
Structure B

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

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

III. Which Lewis structure above is best for BF_3? Write the corresponding letter for the structure ("A" or "B").

3. Three different Lewis structures of the molecule H_2CSO are provided below. Provide the formal charges of carbon, oxygen, and sulfur for each structure. Answer with an integer and sign (e.g. +4, -2) or with a zero if no charge is present.



Structure A　　Structure B　　Structure C

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 H_2CSO? Write the corresponding letter for the structure ("A", "B", or "C") in the box below.

4. 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 an integer and sign (e.g. +4, -2) or with a zero if no charge is present.

I. Formal charge:

II. Oxidation state:

5. Draw the best Lewis structure of OPCl. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer by using integers (e.g. 0, 1, etc.).

I. Single bonds:

II. Double bonds:

III. Triple bonds:

IV. Lone pairs:

6. How many *lone pairs* does the sulfur have in the correct Lewis structure for H_3S^+? Answer by using an integer (e.g. 0, 1, etc.).

7. How many *bonding pairs* surround the sulfur in SO_4^{2-} in its *best* structure? Answer by using an integer (e.g. 0, 1, etc.).

8. Draw the Lewis structure for XeF_2. How many *lone pairs* are present on the central atom? Answer by using an integer (e.g. 0, 1, etc.).

9. Which of the following Lewis structures would be an exception to the octet rule in their best structure? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

A. CBr_4
B. XeF_4
C. NCl_3
D. PO_4^{3-}
E. BCl_3

10. Draw the best Lewis structure of CH_3CCH. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer by using integers (e.g. 0, 1, etc.).

I. Single bonds: $\boxed{}$

II. Double bonds: $\boxed{}$

III. Triple bonds: $\boxed{}$

IV. Lone pairs: $\boxed{}$

11. Draw the best Lewis structure of a hypothetical molecule, 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 by using integers (e.g. 0, 1, etc.).

I. Single bonds: $\boxed{}$

II. Double bonds: $\boxed{}$

III. Triple bonds: $\boxed{}$

IV. Lone pairs: $\boxed{}$

12. Draw the best Lewis structure of $NH_2CH_2CH_2COOH$. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer by using integers (e.g. 0, 1, etc.).

I. Single bonds: ☐

II. Double bonds: ☐

III. Triple bonds: ☐

IV. Lone pairs: ☐

13. The best Lewis structure of SF_3N 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 by using integers (e.g. 0, 1, etc.).

I. Single bonds: ☐

II. Double bonds: ☐

III. Triple bonds: ☐

IV. Lone pairs: ☐

14. Draw the best Lewis structure of $CH_2CHCCBr$. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer by using integers (e.g. 0, 1, etc.).

I. Single bonds:

II. Double bonds:

III. Triple bonds:

IV. Lone pairs:

15. Which of the following are **true** of the *best* Lewis structure for NCO^-? Assume the atoms bond in the order they are written. Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

A. There are two double bonds
B. There is a triple bond between C and N
C. There is a triple bond between C and O
D. The sum of the number of lone pairs on the terminal atoms is 4
E. There is a positive formal charge on the central atom
F. There is a negative formal charge on N
G. There is a negative formal charge on O

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

A. CH_3Cl
B. O_2
C. SF_6
D. CH_2O
E. More than one of the above has the same ratio

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

A. SO_4^{2-}
B. ClO
C. OF_2
D. CCl_4
E. N_2

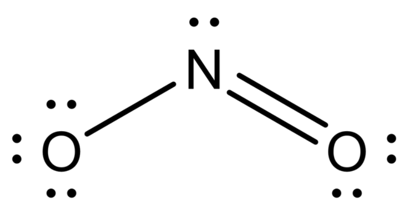
18. How many equivalent, best resonance structures are possible for the ozone molecule (O_3)? Answer by using an integer (e.g. 0, 1, etc.).

19. How many equivalent, best resonance structures are possible for the carbonate ion? Answer by using an integer (e.g. 0, 1, etc.).

20. Consider a hypothetical molecule, M_2X_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 M_2X_4 molecule? Answer by using an integer (e.g. 0, 1, etc.).

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

21. What is **false** about the resonance structures of NO_2^-, one of which is shown below?



A. One of the atoms must always have a negative formal charge because of the overall charge of the polyatomic ion
B. The electrons in the N=O bond rapidly switch back and forth between the two structures
C. The electrons that make up the NO bonds are delocalized across the structure
D. The lone pair on nitrogen is localized to nitrogen
E. None of the above are false

Extra Practice Questions: these questions will not be graded.

1. Draw the best Lewis structure of $OPCl_2^+$. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer by using integers (e.g. 0, 1, etc.).

I. Single bonds:

II. Double bonds:

III. Triple bonds:

IV. Lone pairs:

2. Draw the best Lewis structure of O_2PCl. How many single bonds, double bonds, triple bonds, and lone pairs are present? Answer by using integers (e.g. 0, 1, etc.).

I. Single bonds:

II. Double bonds:

III. Triple bonds:

IV. Lone pairs:

3. Draw the best Lewis structure of ICl_5. How many lone pairs are present? Answer by using an integer (e.g. 0, 1, etc.).

4. Draw the best Lewis structure of SF_4. How many lone pairs are present? Answer by using an integer (e.g. 0, 1, etc.).

5. Draw the best Lewis structure of SeO_4^{2-}. How many lone pairs are present? Answer by using an integer (e.g. 0, 1, etc.).

6. Draw the best Lewis structure of XeO_3. How many lone pairs are present? Answer by using an integer (e.g. 0, 1, etc.).

7. Draw the best Lewis structure of $XeOF_4$. How many lone pairs are present? Answer by using an integer (e.g. 0, 1, etc.).

8. Draw the best Lewis structure of H_3CNCO. How many lone pairs are present? Answer by using an integer (e.g. 0, 1, etc.).

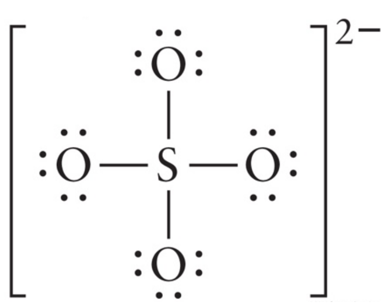
Hint: the formula above is written in the general order the atoms are connected (i.e. the nitrogen atom will be between both the carbon atoms, etc.)

9. 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 an integer and sign (e.g. +4, -2) or with a zero if no charge is present.

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

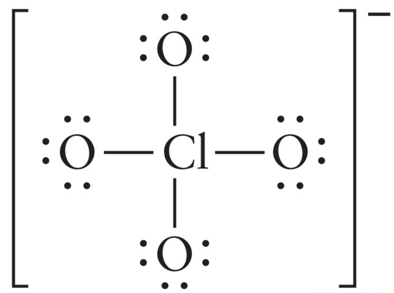
I. SO_4^{2-}

Central atom's formal charge:



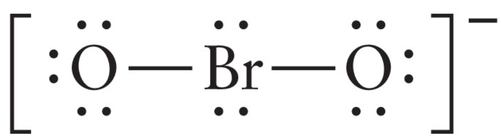
II. ClO_4^-

Central atom's formal charge:



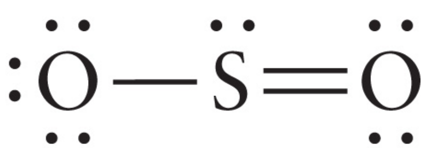
III. BrO_2^-

Central atom's formal charge:



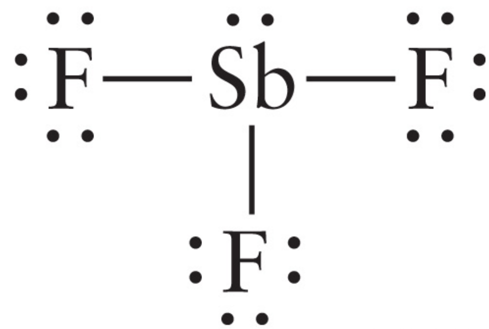
IV. SO_2

Central atom's formal charge:



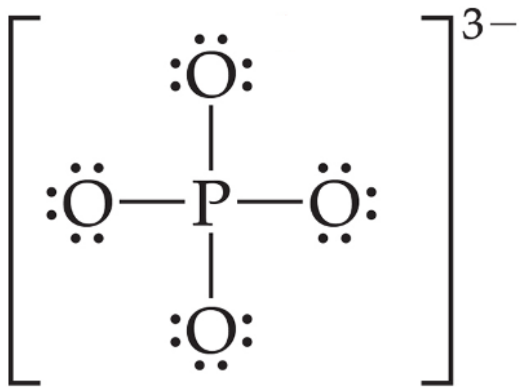
V. SbF_3

Central atom's formal charge: $\boxed{}$



VI. PO_4^{3-}

Central atom's formal charge: $\boxed{}$



10. How many equivalent, best resonance structures are possible for the sulfite ion? Answer by using an integer (e.g. 0, 1, etc.).

11. How many equivalent, best resonance structures are possible for the perbromate ion? Answer by using an integer (e.g. 0, 1, etc.).

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.97	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.95	43 **Tc** [97]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
37 **Cs** 132.91	56 **Ba** 137.33		72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [209]	85 **At** [210]	86 **Rn** [222]
87 **Fr** [223]	88 **Ra** [226]		104 **Rf** [267]	105 **Db** [268]	106 **Sg** [269]	107 **Bh** [270]	108 **Hs** [269]	109 **Mt** [277]	110 **Ds** [281]	111 **Rg** [282]	112 **Cn** [285]	113 **Nh** [286]	114 **Fl** [290]	115 **Mc** [290]	116 **Lv** [293]	117 **Ts** [294]	118 **Og** [294]

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
89 **Ac** [227]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** [237]	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 $kg \cdot m^2/s^2$
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 $kg/m \cdot s^2$
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} J·sec
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: $9.109 \text{ x } 10^{-31}$ kg
Mass of a proton: $1.673 \text{ x } 10^{-27}$ kg
RH = $2.18 \text{ x } 10^{-18}$ J
Specific heat of water = 4.184 J/g·K
Avogadro's number: 6.022×10^{23}
F = 96485 J/(V·mol e^-)
$K_w = 1.0 \times 10^{-14}$ at 25 °C
$k_b = 1.381 \times 10^{-23}$ J/K

Equations
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT

$$KE = \frac{3}{2}RT$$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution} = P_{solvent}\ X_{solvent}$
$P_{solution} = \sum P_j = \sum P_j X_j$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$\Delta S = q_{rev}/T$
$\Delta G = \Delta G° + RT \cdot \ln Q$
R=8.314 J/mol.K
$\Delta G° = -RT \cdot \ln K$
$\Delta G = -nFE_{cell}$
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{E_a}{R}(\frac{1}{T_2} - \frac{1}{T_1})$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$

$$In\frac{K_2}{K_1} = \frac{\Delta H^{\circ}_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$