Chem 105 Exam 2 Name Key

This exam is schedule for 75 minutes and I anticipate it to take the full time allotted. You are free to leave if you finish. In multiple part problems, points awarded will not be penalized for incorrect answer on previous parts, so simply **move on if you get stuck on one part**. If you need to, make up an answer for the previous part. Always neatly show work for partial credit.

When you draw Lewis structures ALWAYS include lone pairs and redraw them to show the correct molecular geometry! A '*connect the dots*' structure is not complete and will not receive full credit. **Show all formal charge.**

Equations and constants:

$E = h\nu$ $c = 2.998\ x\ 10^8\ {}^{m}/_{s}$ $c = \lambda\nu$ $h = 6.626\ x\ 10^{-34} J$

$E_n = \frac{-2.18x10^{-18}J}{n^2}$ $KE = \frac{1}{2}mv^2$ $E_{coulomb} = 231pm \cdot aJ\frac{q_1q_2}{r}$

$m_{electron} = 9.109x10^{31}kg$ $\lambda = \frac{h}{mv}$ $V_{cylinder} = \pi r^2 h$

1. Name each of the following compounds:

$CaBr_2$ Calcium bromide

$CuClO_4$ copper (I) perchlorate

HBr hydrobromic acid

PF_4 phosphorus tetrafluoride

HNO_3 nitric acid

$MnSO_3$ manganese (II) sulfite

2. Determine the correct molecular formula for each of the following compounds:

Ammonium phosphide $(NH_4)_3P$

iron (III) carbonate $Fe_2(CO_3)_3$

tricarbon tetraphosphide C_3P_4

3. Tales from the past:

Answer each of the following for As^{-3} (Z = 33)

a. Ground State Electron Configuration (condensed form is acceptable):

$[Ar]\,4s^2 3d^{10} 4p^6$

b. First Excited State Electron Configuration (condensed form is acceptable):

$[Ar]\,4s^2 3d^{10} 4p^5 5s^1$

c. List **two** possible sets of quantum numbers for the highest energy ground state electron.

[4,1,0,+½] [4,1,−1,½] [4,1,1,½]

[4,1,0,−½] [4,1,−1,−½] [4,1,1,−½]

4p

d. Some light emitting diodes (LEDs) are made using arsenide. In these devices, red light (λ = 680 nm) is emitted when an electron relaxes from the first excited state to the ground state.

5s → 4p

i. In this emission process, determine which subshell contains the electron **before** the emission occurs. 5s

ii. Which subshell contains the electron **after** the emission occurs?

4p

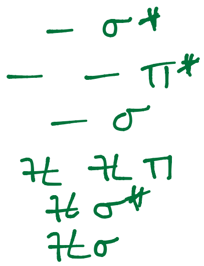
iii. What is the energy difference between the orbitals (in SI units)?

$$680\,nm \left| \frac{10^{-9}\,m}{1\,nm} \right. = 6.80 \times 10^{-7}\,m$$

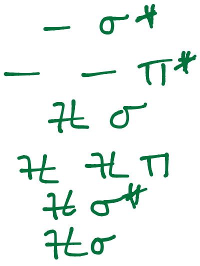
$$E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34}\,J \cdot s\ (2.998 \times 10^{8}\,m/s)}{6.80 \times 10^{-7}\,m} = 2.92 \times 10^{-19}\,J$$

4. Using molecular orbital theory, determine which of these molecules would be attracted to a magnet. For full credit, you must show how you arrived at your answer.
MO order for just carbon and/or nitrogen: σ_{2s}, σ_{2s}^*, π_{2p}, σ_{2p}, π_{2p}^*, σ_{2p}^*
MO order when oxygen and/or fluorine are part of the molecule: σ_{2s}, σ_{2s}^*, σ_{2p}, π_{2p}, π_{2p}^*, σ_{2p}^*

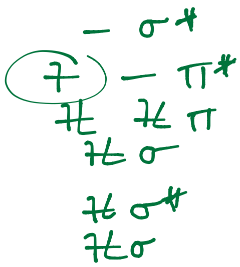
C_2 → 8e⁻



CN^{-1} → 10e⁻



NO^{-1} → 11 e⁻



unpaired e⁻, so paramagnetic

5. Arsenic (As) and antimony (Sb) can both form cations AND anions while other members of Group 5a are only stable as cations OR anions.
   a. Which members of Group 5A are stable as only cations?
      Pb
   b. Which members of Group 5A are only stable as anions?
      P + N
   c. Why are As and Sb able to be cations or anions, but other group members are restricted to one or the other?
      they are metalloids

6. Is Ru^{4-} (Z=44) a common ion? Clearly justify your answer.

No!
metals are NOT anions

What is the electron configuration for two stable Ruthenium ions?

Just like Fe!

Ru^{+2} [Kr] $4d^6$
Ru^{+3} [Kr] $4d^5$

7. Each of the following molecules are structurally related (central oxygen with a bent molecular geometry). H_2O, H_2S, H_2Se, H_2Te, CH_3OCH_3

Please justify this trend in melting temperatures:

$H_2O > CH_3OCH_3 > H_2Se$ ← LDF only

↑ H-bonds ↑ dipole-dipole

H–S = not polar

C–O = polar

H–O = polar + H-bond

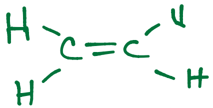
Please rank H_2Se, H_2Te, H_2O and H_2S by INCREASING melting temperatures.

$\underbrace{H_2S < H_2Se < H_2Te} < H_2O$

LDF only,
so bigger molecules
have higher LDF

↑ H-bond = much stronger than LDF

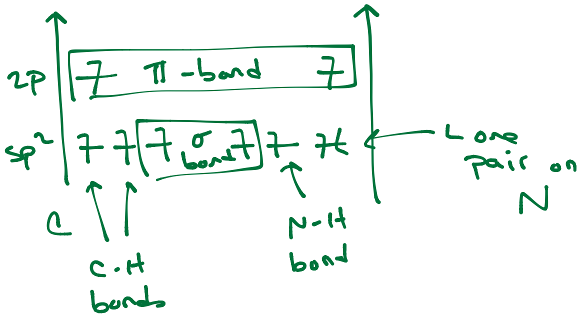
8. Identify all intermolecular forces present in the following compounds:

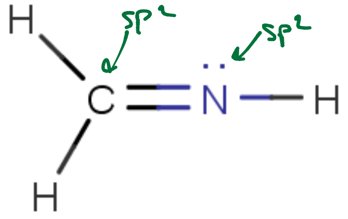
NH3	NaNO3	C2H2
	Ionic compound	
LDF dipole/dipole H-bond	Ion-ion LDF	Non polar LDF only

9. Describe how non-polar molecules can interact through intermolecular forces. A complete answer will include a discussion of why some non-polar molecules have strong intermolecular forces and others do not.

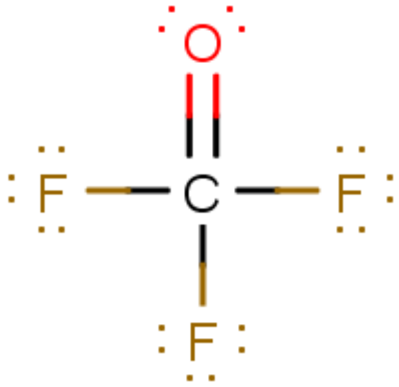
All molecules can interact through LDF. These forces increase in strength as molecules get bigger.

10. Using **Hybridization Theory**, sketch an energy diagram for the bond between carbon and nitrogen in CH_2NH. In your diagram, identify what each electron is doing – you may reference the Lewis structure shown below (note that lone pairs are not shown in this image).

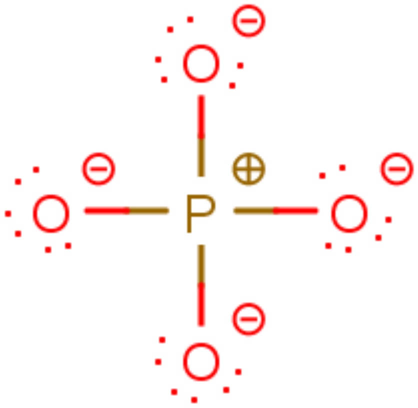




11. What is wrong with each of the following structures?



Carbon breaks the octet rule!



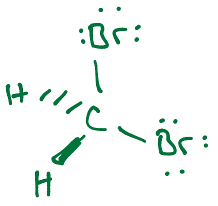
P can expand its octet, so it will do so to minimize formal charge

12. Draw the Lewis structure for each molecule below. Make sure to follow the guidelines on the first page. **Draw ALL resonance structures. Label all formal charge.**

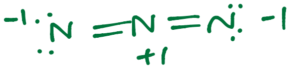
On each molecule:

- a. Identify all polar bonds.
- b. Determine the molecular geometry around the central atom.
- c. For neutral molecules, indicate whether they are polar or nonpolar.

CH_2Br_2 (polar or [✓ nonpolar])

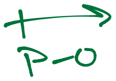


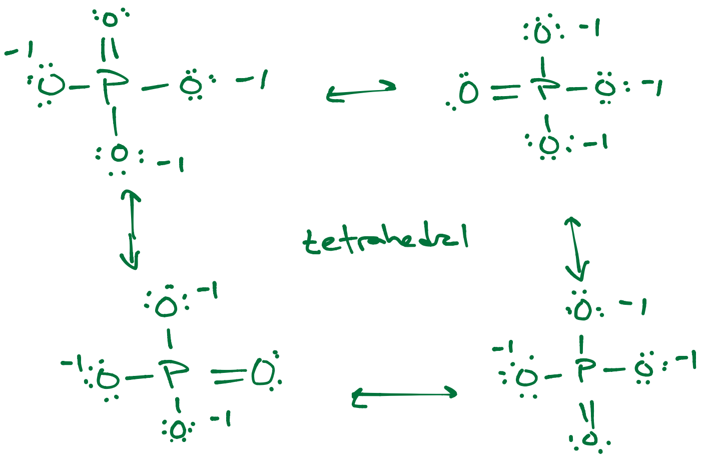
N_3^{-1}



linear

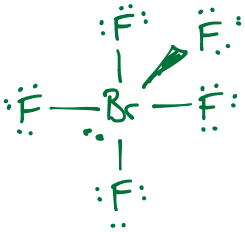
PO_4^{-3}

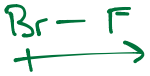




tetrahedral

BrF_5 ([✓ polar] or nonpolar)

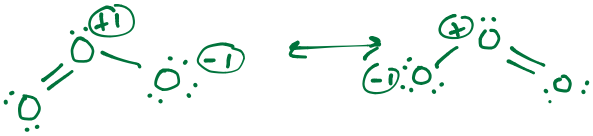




Square pyramidal

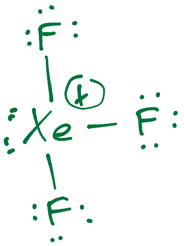
O_3 (polar or nonpolar)

Technically, polar but non-polar is accepted b/c formal charge

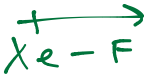


best

XeF_3^{+1}

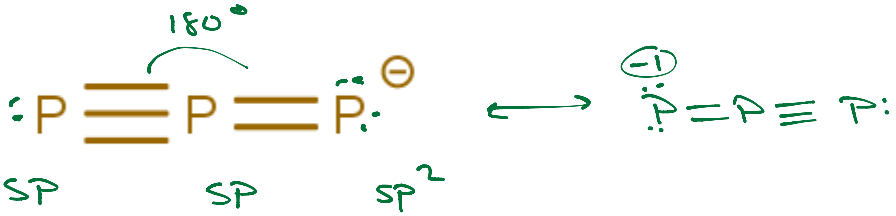


T-shape

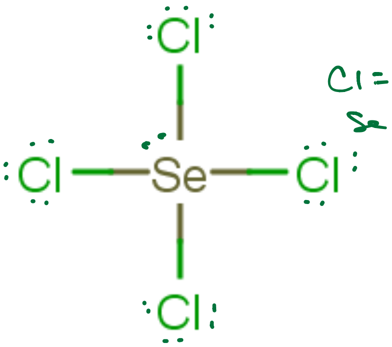


13. **Incomplete** Lewis structure for three molecules are shown below. Complete each of the following:

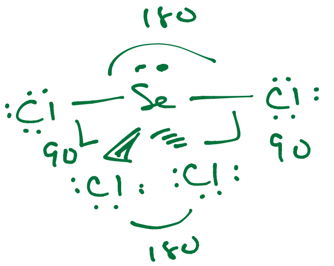
- a. Add lone pairs to complete the structures.
- b. Draw resonance forms if they exist.
- c. Determine the hybridization around **all** atoms.
- d. Determine the molecular geometry around all **central** atoms.
- e. Redraw each molecule so that the molecular geometry is clearly shown.
- f. Determine all bond angles (if all bond angles are the same, you only need to label one).



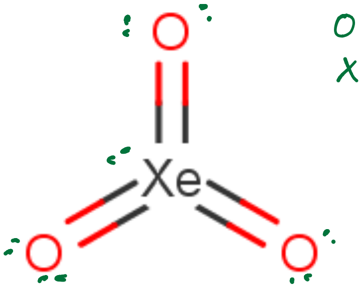
linear



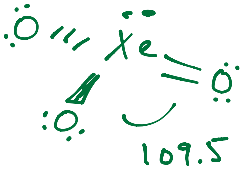
Cl = sp^3
Se = sp^3d



Seesaw



O = sp^2
Xe = sp^3



trigonal pyramidal

14. Answer **ONE** of the following. You much fully explain your answer to receive credit

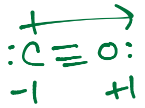
a. Consider N_2, O_2, and CO. N-N and O-O bonds are both non-polar, while C-O bonds are polar. Based on this, we would predict that CO would have a significantly higher boiling temperature than the other two; however, the trend is $N_2 < CO < O_2$. Explain this trend.

b. $XeBr_2F_2$ can be polar or nonpolar depending on the arrangement of atoms. Draw this molecule in two ways that clearly explains the previous statement. Make sure to show bond polarity to support your answer.

c. Which of these molecules has the shortest Br-O bond? BrO^{-1}, BrO_2^{-1}, BrO_3^{-1}, or BrO_4^{-1}

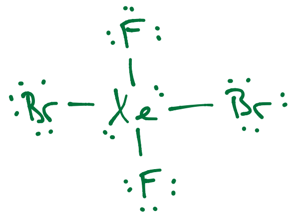
a) So CO behave like a non polar molecule even though

think formal charge compared to polar bonds

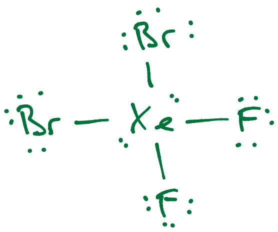


FC opposes/cancels polarity

b)

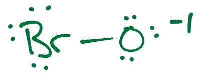


non-polar

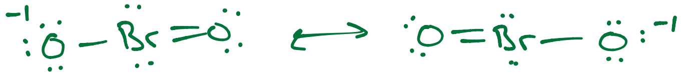


polar

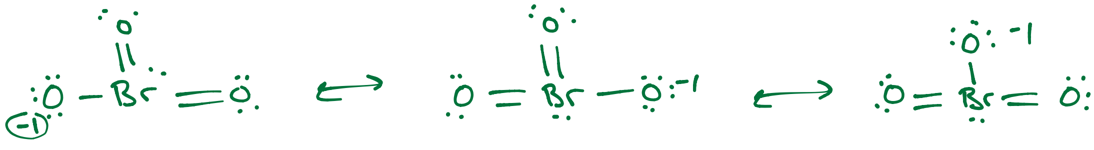
c)



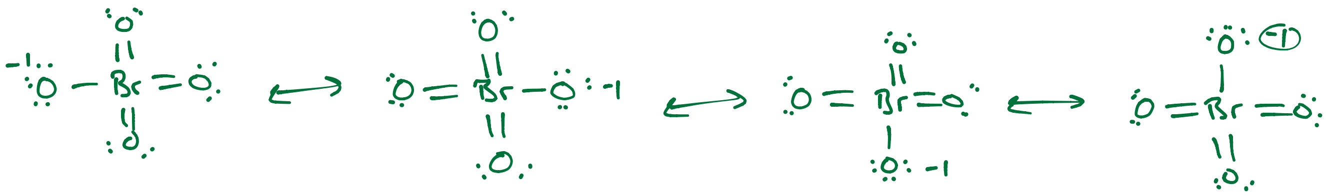
all single



0.5 double



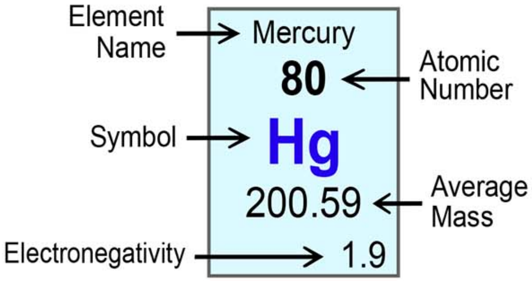
2/3 double



3/4 double

most double bonds = shortest →

Periodic Table of the Elements



1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 **H** 1.01 2.1																		Helium 2 **He** 4.00 ---
Lithium 3 **Li** 6.94 1.0	Beryllium 4 **Be** 9.01 1.5												Boron 5 **B** 10.81 2.0	Carbon 6 **C** 12.01 2.5	Nitrogen 7 **N** 14.01 3.0	Oxygen 8 **O** 16.00 3.5	Fluorine 9 **F** 19.00 4.0	Neon 10 **Ne** 20.18 ---
Sodium 11 **Na** 22.99 0.9	Magnesium 12 **Mg** 24.31 1.2												Aluminum 13 **Al** 26.98 1.5	Silicon 14 **Si** 28.09 1.8	Phosphorus 15 **P** 30.97 2.1	Sulfur 16 **S** 32.07 2.5	Chlorine 17 **Cl** 35.45 3.0	Argon 18 **Ar** 39.95 ---
Potassium 19 **K** 39.10 0.8	Calcium 20 **Ca** 40.08 1.0		Scandium 21 **Sc** 44.96 1.3	Titanium 22 **Ti** 47.88 1.5	Vanadium 23 **V** 50.94 1.6	Chromium 24 **Cr** 52.00 1.6	Manganese 25 **Mn** 54.94 1.5	Iron 26 **Fe** 55.85 1.8	Cobalt 27 **Co** 58.93 1.8	Nickel 28 **Ni** 58.69 1.8	Copper 29 **Cu** 63.55 1.9	Zinc 30 **Zn** 65.39 1.6	Gallium 31 **Ga** 69.72 1.6	Germanium 32 **Ge** 72.61 1.8	Arsenic 33 **As** 74.92 2.0	Selenium 34 **Se** 78.96 2.4	Bromine 35 **Br** 79.90 2.8	Krypton 36 **Kr** 83.80 3.0
Rubidium 37 **Rb** 85.47 0.8	Strontium 38 **Sr** 87.62 1.0		Yttrium 39 **Y** 88.91 1.2	Zirconium 40 **Zr** 91.22 1.4	Niobium 41 **Nb** 92.91 1.6	Molybdenum 42 **Mo** 95.94 1.8	Technetium 43 **Tc** (98) 1.9	Ruthenium 44 **Ru** 101.07 2.2	Rhodium 45 **Rh** 102.91 2.2	Palladium 46 **Pd** 106.42 2.2	Silver 47 **Ag** 107.87 1.9	Cadmium 48 **Cd** 112.41 1.7	Indium 49 **In** 114.82 1.7	Tin 50 **Sn** 118.71 1.8	Antimony 51 **Sb** 121.76 1.9	Tellurium 52 **Te** 127.60 2.1	Iodine 53 **I** 126.90 2.5	Xenon 54 **Xe** 131.29 2.6
Cesium 55 **Cs** 132.91 0.7	Barium 56 **Ba** 137.33 0.9	**57-70** *	Lutetium 71 **Lu** 174.97 1.1	Hafnium 72 **Hf** 178.49 1.3	Tantalum 73 **Ta** 180.95 1.5	Tungsten 74 **W** 183.84 1.7	Rhenium 75 **Re** 186.21 1.9	Osmium 76 **Os** 190.23 2.2	Iridium 77 **Ir** 192.22 2.2	Platinum 78 **Pt** 195.08 2.2	Gold 79 **Au** 196.97 2.4	Mercury 80 **Hg** 200.59 1.9	Thallium 81 **Tl** 204.38 1.8	Lead 82 **Pb** 207.20 1.8	Bismuth 83 **Bi** 208.98 1.9	Polonium 84 **Po** (209) 2.0	Astatine 85 **At** (210) 2.2	Radon 86 **Rn** (222) 2.4
Francium 87 **Fr** (223) 0.7	Radium 88 **Ra** (226) 0.9	**89-102** **	Lawrencium 103 **Lr** (262) ---	Rutherfordium 104 **Rf** (261) ---	Dubnium 105 **Db** (262) ---	Seaborgium 106 **Sg** (266) ---	Bohrium 107 **Bh** (264) ---	Hassium 108 **Hs** (269) ---	Meitnerium 109 **Mt** (268) ---	Darmstadtium 110 **Ds** (271) ---	Roegentium 111 **Rg** (272) ---	Copernicium 112 **Cn** (277) ---	Ununtrium 113 **Uut** (284) ---	Flerovium 114 **Fl** (289) ---	Ununpentium 115 **Uup** (288) ---	Livermorium 116 **Lv** (293) ---	Ununseptium 117 **Uus** (294) ---	Ununoctium 118 **Uuo** (294) ---

*lanthanides	Lanthanum 57 **La** 138.91 1.1	Cerium 58 **Ce** 140.12 1.1	Praseodymium 59 **Pr** 140.91 1.1	Neodymium 60 **Nd** 144.24 1.1	Promethium 61 **Pm** (145) 1.1	Samarium 62 **Sm** 150.36 1.2	Europium 63 **Eu** 151.97 1.1	Gadolinium 64 **Gd** 157.25 1.2	Terbium 65 **Tb** 158.93 1.1	Dysprosium 66 **Dy** 162.50 1.2	Holmium 67 **Ho** 164.93 1.2	Erbium 68 **Er** 167.26 1.2	Thulium 69 **Tm** 168.93 1.3	Ytterbium 70 **Yb** 173.04 1.1
**actinides	Actinium 89 **Ac** (227) 1.1	Thorium 90 **Th** 232.04 1.3	Protactinium 91 **Pa** 231.04 1.5	Uranium 92 **U** 238.03 1.4	Neptunium 93 **Np** (237) 1.4	Plutonium 94 **Pu** (244) 1.3	Americium 95 **Am** (243) 1.3	Curium 96 **Cm** (247) 1.3	Berkelium 97 **Bk** (247) 1.3	Californium 98 **Cf** (251) 1.3	Einsteinium 99 **Es** (252) 1.3	Fermium 100 **Fm** (257) 1.3	Mendelevium 101 **Md** (258) 1.3	Nobelium 102 **No** (259) 1.3