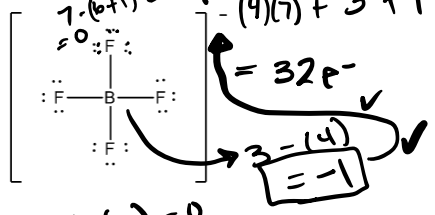
Chapters 10 – 12: This review goes over important concepts needed for your exam but is not exhaustive of everything you need to know and should be used as a supplement (not the sole resource) to your own studying.

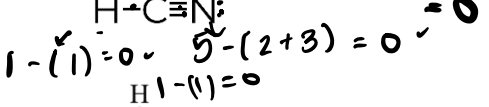
1. Which of the following Lewis structures is incorrect?

- check formal charges & # total e⁻'s = valence e⁻ − (#e⁻ in lone pairs + #bonds)

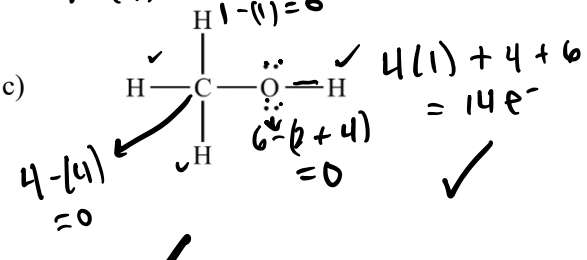
a)



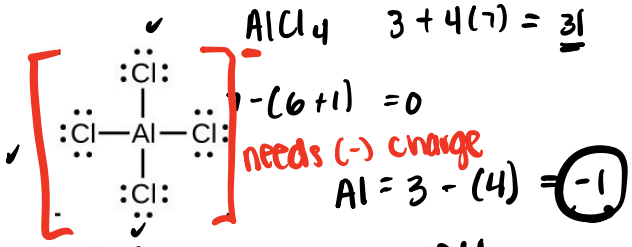
b)



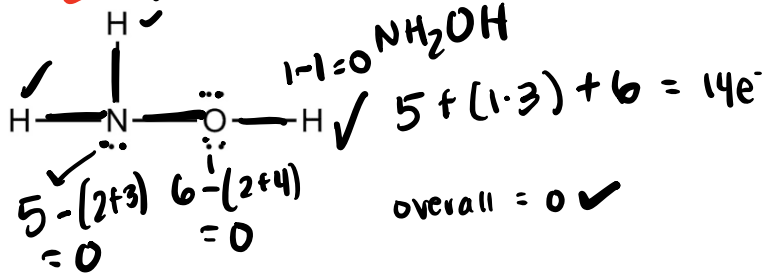
c)



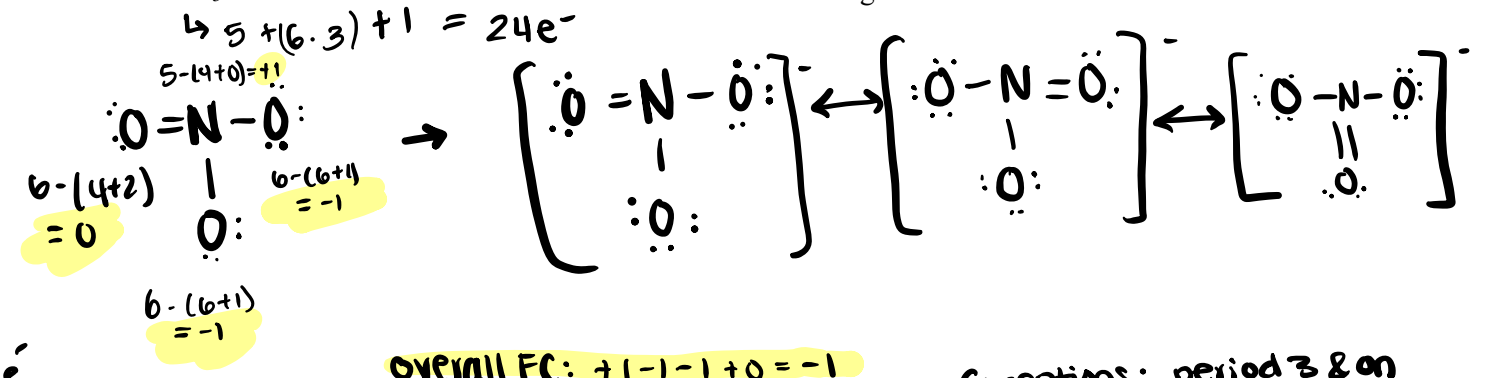
d)



e)



2. Draw NO_3^- and its resonance structures. Calculate its formal charges.



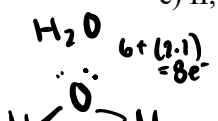
B → 6e⁻

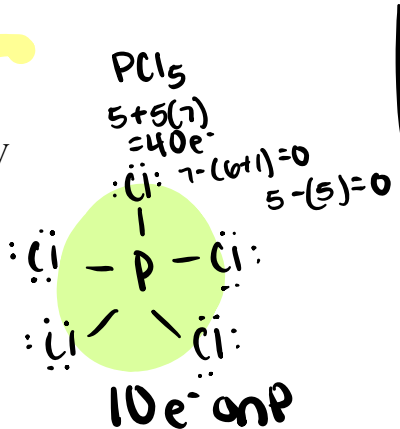
3. Which of the following are exceptions to the octet rule? need 8e⁻

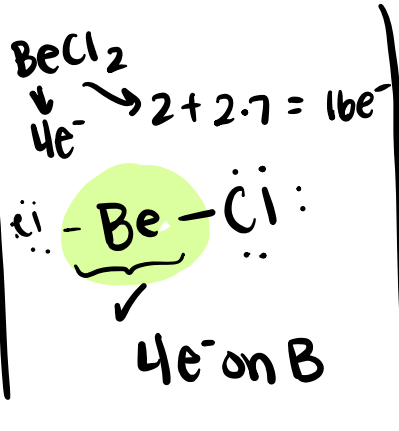
I. PCl_5 II. $BeCl_2$ III. CH_4 IV. SF_6 V. H_2O

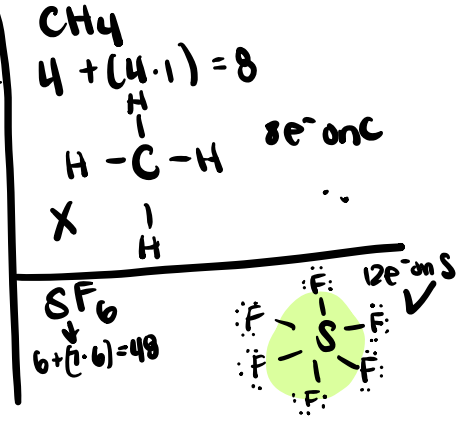
Exceptions: period 3 & on
B → 6e⁻
Be → 4e⁻

a) I, III, V
b) I, II, IV
c) II, IV
d) I, II, V
e) II, III, IV







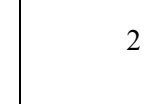
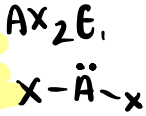
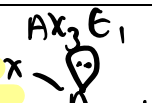
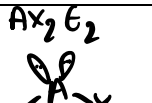
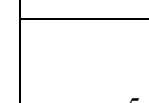
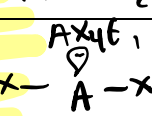
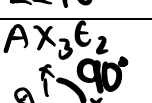
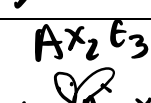
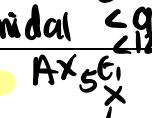
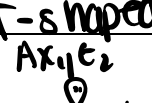
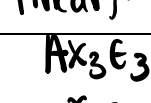
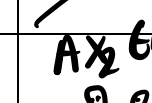


4.VSEPR Theory. Fill in the following chart including the structure, bond angles, shape name, and AXyEz format.

y = # substituents

↳ A - central atom, X - substituents, E - lone pairs z = # lone pairs

VSEPR Geometries

Electron Pairs ↓	0 Lone Pair	1 Lone Pair	2 Lone Pair	3 Lone Pair	4 Lone Pair
2	AX_2  linear 180°				
3	AX_3  trigonal planar 120°	AX_2E_1  Bent ∠120°			
4	AX_4  tetrahedral 109.5°	AX_3E_1  trigonal pyramidal ∠104.5°	AX_2E_2  bent ∠<109.5°		
5	AX_5  trigonal bipyramidal	AX_4E_1  seesaw <90° <120°	AX_3E_2  T-shaped	AX_2E_3  linear; 180°	
6	AX_6  octahedral 90°	AX_5E_1  square pyramidal <90°	AX_4E_2  square planar 90°	AX_3E_3  T-shaped <90°	AX_2E_4  Linear 180°

E↑ = # e⁻ groups

M↑ = specifics; bond v. lone pairs

5. Name to electron geometry, molecular geometry, and bond angles for the following compounds: * SF_4

a) H_2O

AX_2E_2

→ tetrahedral (EG)

→ bent (MG)

→ <109.5°

b) ICl_2^-

7 + 7 + 7 = 21

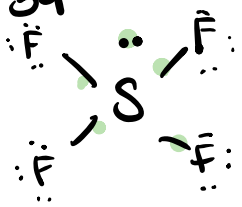
AX_2E_3

} trigonal bipyramidal (EG)

linear MG

180°

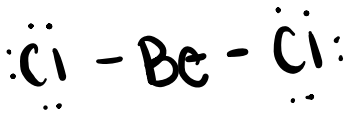
c) SF_4 $6+4(7) = 34$



AX_4E_1 } trigonal bipyramidal (EG), seesaw (MG); $< 90°$, $< 120°$

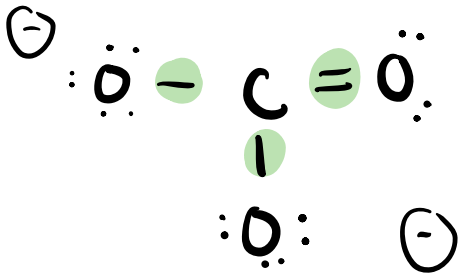
d) $BeCl_2$

$2 + 2(7) = 16\ e^-$



AX_2 } linear (MG), linear (EG), 180°

e) CO_3^{2-} $4 + (6 \cdot 3) + 2 = 24e^-$

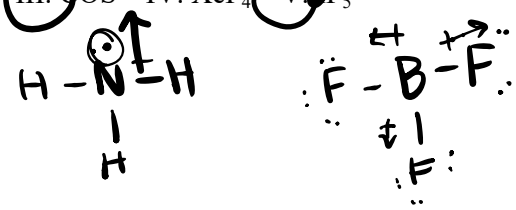


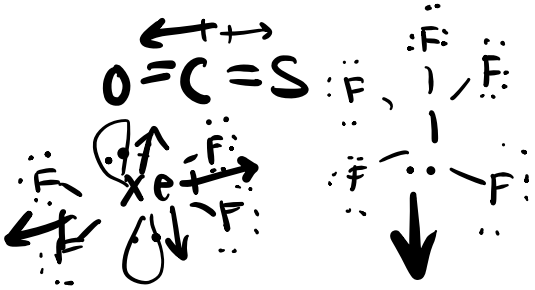
} trigonal planar (EG), trigonal planar (MG), 120°

6. Which of the following molecules are polar?

I. NH_3 ✓ II. BF_3 ✗ III. OCS ✓ IV. XeF_4 ✗ V. BrF_5 ✓ $8+4(7) = 36$ $7 \cdot 6 = 42$

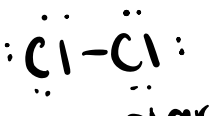
a) I, III, V
b) I, II, III
c) II, III, V
d) All
e) None



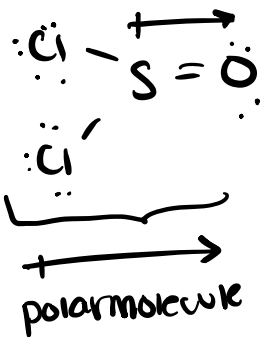


7. Which of the following is a nonpolar molecule with polar covalent bonds?

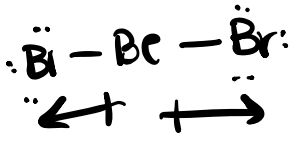
a) Cl_2 ✗
b) $SOCl_2$ ✗
c) $BeBr_2$ ✓
d) NH_3 ✗
e) H_2O ✗



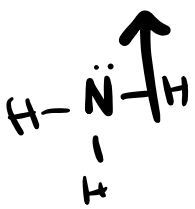
nonpolar bonds



polar molecule

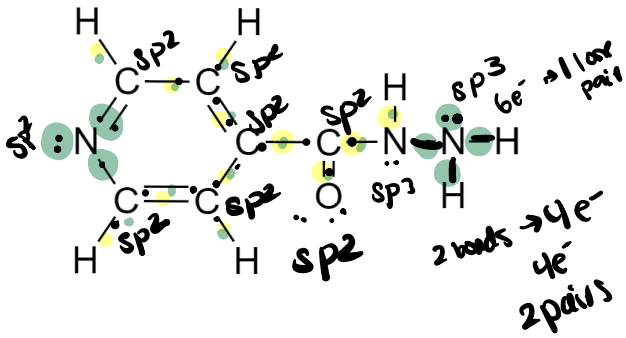


*nonpolar



8. How many σ bonds are in this molecule?

a) 20
b) 36
c) 17
d) 19
e) 16



9. For the previous structure, what are the hybridizations of the C, N, and O atoms?

a) C: sp^2; N (ring): sp^2; N: sp^3; O: sp^2
b) C (ring): sp^3; C (other): sp^2; N (all): sp^2; O: sp^2
c) C: sp^2; N: sp^2; O: sp^2
d) C: sp^3; N (ring): sp^2; N: sp^3; O: sp^2

3e⁻ → sp^2
4e⁻ → sl

O: sp^2
all C: sp^2
N (other): sp^3
N ring = sp^2

10. Which of the following statements is/are likely true:

a) NH3 should have a higher boiling point than CH4 ✓
b) PH3 should have a higher boiling point than NH3 ✗
c) SO2 should have a higher boiling point than CO2 ✓
d) A and C
e) All of the above

- what IMF for those molecules (N, O, F)

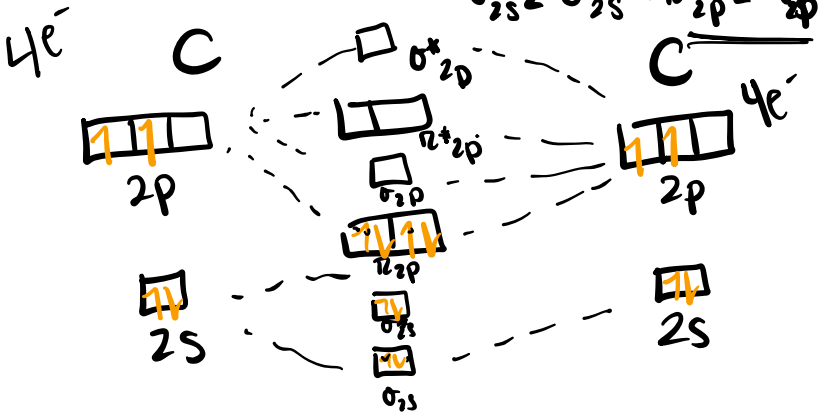
NH_3 → H bonding
CH_4 → LDF
PH_3 → dipole
SO_2 → polar (dipole) > CO_2 → nonpolar (LDF)
O=S=O
O=C=O

11. Draw the molecular orbital diagram for F_2.

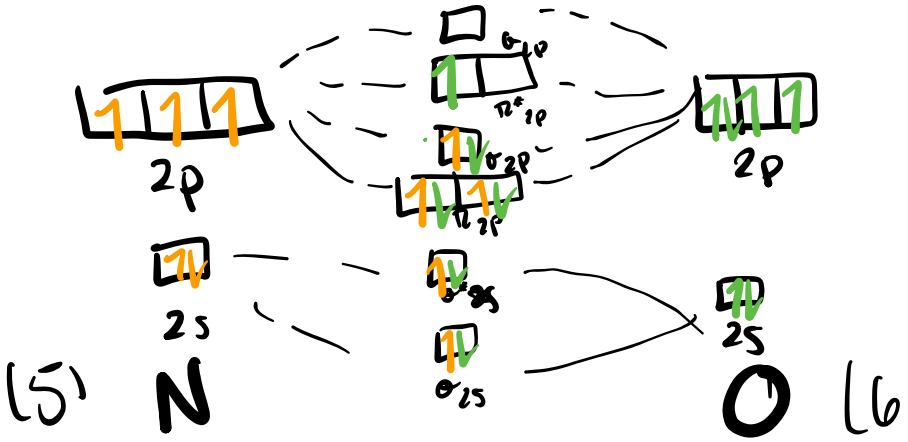
$\sigma_{2s} < \sigma^*_{2s} < \sigma_{2p} < \pi_{2p} < \pi^*_{2p} < \sigma^*_{2p}$ } order for O, F, Ne

12. Draw the molecular orbital diagram for C_2.

$\sigma_{2s} < \sigma^*_{2s} < \pi_{2p} < \sigma_{2p} < \pi^*_{2p} < \sigma^*_{2p}$ } order for B, C, N



13. Draw the MO for NO. $\sigma_{2s} < \sigma^*_{2s} < \pi_{2p} < \sigma_{2p} < \pi^*_{2p} < \sigma^*_{2p}$



14. Which of the following is true about σ bonding and π bonding.

I. A single bond has 1 σ bond. ✓
II. A single bond has 1 π bond. ✗
III. A double bond has 1 σ bond and 1 π bond. ✓
IV. A double bond has 2 π bonds. ✗
V. A double bond has 2 σ bonds. ✗
VI. A triple bond has 3 π bonds. ✗
VII. A triple bond has 1 σ and 2 π bonds. ✓ VIII. A triple bond has 3 σ bonds. ✗

a) II, III, V, VIII
b) I, III, VII
c) I, V, VI
d) II, IV, VIII
e) I, IV, VI

15. Which hybridization will a molecule with a trigonal bipyramidal electron-group arrangement have?

a) sp
b) sp^2
c) sp^3
d) sp^3d
e) sp^3d^2

↳ AX_5 → 5 e⁻ groups
sp - 2
sp^2 - 3
sp^3 - 4
sp^3d - 5
sp^3d^2 - 6

16. According to MO theory, which of the following dicarbon species is expected to have the shortest bond length.
Use the following valence MO order: $\sigma_{2s} < \sigma^*_{2s} < \pi_{2py} = \pi_{2pz} < \sigma_{2px} < \pi^*_{2py} = \pi^*_{2pz} < \sigma^*_{2px}$

↑bond order
↑strength

a) C_2^+ b) C_2^{2-} c) C_2 d) C_2^- e) They all have the same length

bond order = $\frac{1}{2}$ (#e⁻ in bonding orbitals − #e⁻ in antibonding (π) orbitals)

$\frac{1}{2}(5-2) = 1.5$ $\frac{1}{2}(8-2) = 3$ $\frac{1}{2}(6-2) = 2$ $\frac{1}{2}(7-2) = 2.5$

17. Calculate the heat needed to convert 10.0 g of solid bromine from -7.2°C to 70.0°C. Which of the following steps requires the most heat energy: melting the solid bromine, heating the liquid bromine from its melting point to its boiling point, boiling the bromine, or heating the gaseous bromine from its boiling point to110.0°C?

Melting point for bromine -7.2°C, heat of fusion for bromine = 66.15 J/g; specific heat of liquid bromine = 0.474 J/g°C; boiling point for bromine = 58.7°C, heat of vaporization for bromine = 193.21 J/g, specific heat of gaseous bromine = 0.225 J/g°C.

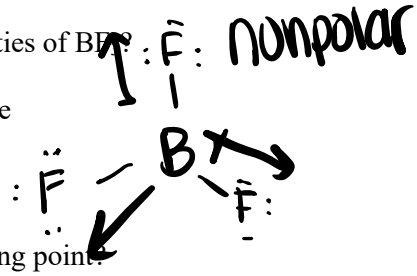
10g Br

- solid → liquid (melting @ -7.2°C)
  66.15 J/g · 10g = 661.5 J
- liquid heating (-7.2°C → 58.7°C)
  10g · 0.474 J/g°C · (58.7 − −7.2)°C = 312.366 J
- liquid → gas (@ 58.7°C 193.21 J/g · 10g = 1932.1 J
- gas heating (58.7 → 70°C) → 10g · .225 J/g°C (70 − 58.7)
  = 25.425 J

total = 2,931.4 J

18. Which response correctly identifies all the interactions that might affect the properties of BF_3?

A) dispersion force, ion-ion interaction
B) hydrogen bonding force, dispersion force
C) permanent dipole force
D) permanent dipole force, dispersion force
E) dispersion force



19. Which response has the following substances arranged in order of **increasing** boiling point?

Ar, $NaClO_3$, H_2O, H_2Se

A) $NaClO_3 < H_2O < H_2Se < Ar$
B) $NaClO_3 < H_2Se < H_2O < Ar$
C) $Ar < NaClO_3 < H_2Se < H_2O$
D) $Ar < H_2O < H_2Se < NaClO_3$
E) $Ar < H_2Se < H_2O < NaClO_3$

LDF < dipole < H bonding < ion

Ar → LDF | ion-dd | H-bonding | dipole

20. Which of the following solutions is matched with its correct intermolecular force between solute and solvent?

A) NH_3 and F_2: hydrogen bonding
B) CH_2F_2 and CH_2O: dispersion
C) Cl_2 and PH_3: dipole-induced dipole
D) HF and NH_3: dipole-dipole
E) PH_3 and H_2O: dispersion

$x = 2R$ ← simple → 1 atom/cell

$x = \frac{4}{\sqrt{3}}R$ ← bcc → 2 atom/cell

$x = \sqrt{8} \cdot R$ ← fcc → 4 cell/unit

21. A certain metal has a specific gravity of 10.200 at 25°C. It crystallizes in a body-centered cubic arrangement with a unit cell edge length of 3.147Å. Determine the atomic weight, the identity of the metal, and the radius of the atom in Å.

↳ g/mol

2 cell/unit

3.147Å

10.200 g/cm³ ↳ density ✓

✓ $V = x^3$

$d = \frac{m}{V}$ *match units

3.147Å

$\frac{10.200\ g}{cm^3}\left(\frac{10^2\ cm}{1\ m}\right)^3 =$

$10.200\ g/cm^3 = \frac{m}{(3.147 \times 10^{-10}\ m)^3}$

$10.2 \times 10^6\ g/m^3 \rightarrow 10.2 \times 10^6\ g/m^3 (3.147 \times 10^{-10}\ m)^3 = m$

$3.1789 \times 10^{-22}\ g = m$

$3.1789 \times 10^{-22}\ g \cdot \frac{1\ cell}{cell} \cdot \frac{2\ atoms}{(bcc)} \cdot \frac{6.022 \times 10^{23}\ atoms}{mol} = 95.79\ g/mol$

Mo

edge length

$X = \frac{4}{\sqrt{3}} \cdot (r)$ ← radius

$\frac{X\sqrt{3}}{4} = r = 1.37Å$