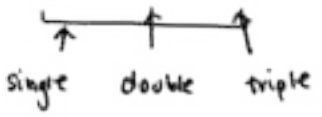
CHM 2045 Exam 3 Review - Spring 2024 - UF Academic Resources

Chapters 9 – 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 is the correct order for increasing bond length?

a) C≡C < C=C < C-C
b) C=C < C≡C < C-C
c) C-C < C=C < C≡C
d) C≡C < C-C < C=C

C-C, C=C, C≡C



shortest → longest
C≡C < C=C < C-C

2. How are bond length and bond strength related?

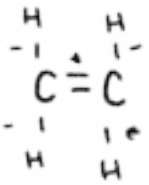
a) Inversely related
b) Directly related
c) Length = ½ Strength
d) Strength = ½ Length

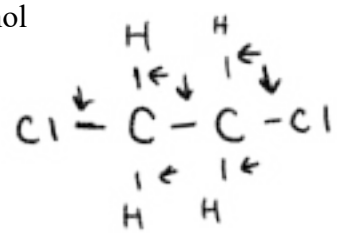
↑ length ↓ strength

3. Calculate the enthalpy of the reaction: $C_2H_4(g) + Cl_2(g) \rightleftharpoons C_2H_4Cl_2(g)$

Given the following bond energies:
C-C 347 kJ/mol C-H 413 kJ/mol H-H 432 kJ/mol
C=C 614 kJ/mol C-Cl 339 kJ/mol H-Cl 427 kJ/mol
C≡C 839 kJ/mol Cl-Cl 243 kJ/mol

a) -1078 kJ
b) +168 kJ
c) -168 kJ
d) +563 kJ
e) -563 kJ





breaking bonds takes energy → endothermic +ΔH
forming bonds releases energy → exothermic −ΔH
bonds broken − bonds formed
reactants − products

1 C=C 4 C-H 1 Cl-Cl | 2 C-Cl 4 C-H 1 C-C

$(1 \cdot 614\,kJ + 4 \cdot 413\,kJ + 243\,kJ) - (2 \cdot 339\,kJ + 4 \cdot 413 + 347\,kJ)$

$= -168\,kJ$

Formal charge = # valence e^- − (# e^- in lone pairs + # bonds)

bonds = ½ # e^- in bonds

4. Which of the following Lewis structures is incorrect?

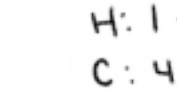
a) 

BF_4^-

B: 3 − (0 + 4) = −1

F: 7 − (6 + 1) = 0

0 · 4 + (−1) = −1 ✓

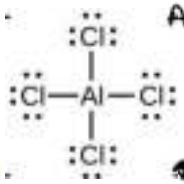
d) 

H: 1 − (0 + 1) = 0

C: 4 − (0 + 4) = 0

N: 5 − (2 + 3) = 0

0

b) 

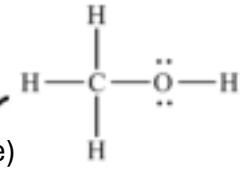
$AlCl_4^-$

Al: 3 − (4 + 0) = −1

Cl: 7 − (6 + 1) = 0

4(0) − 1 = −1

missing charge

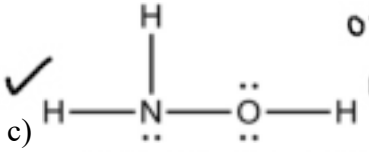
e) 

C: 4 − (0 + 4) = 0

O: 6 − (4 + 2) = 0

H: 1 − (0 + 1) = 0

0

c) 

O: 6 − (4 + 2) = 0 ✓

H: 1 − (0 + 1) = 0 ✓

N: 5 − (2 + 3) = 0 ✓

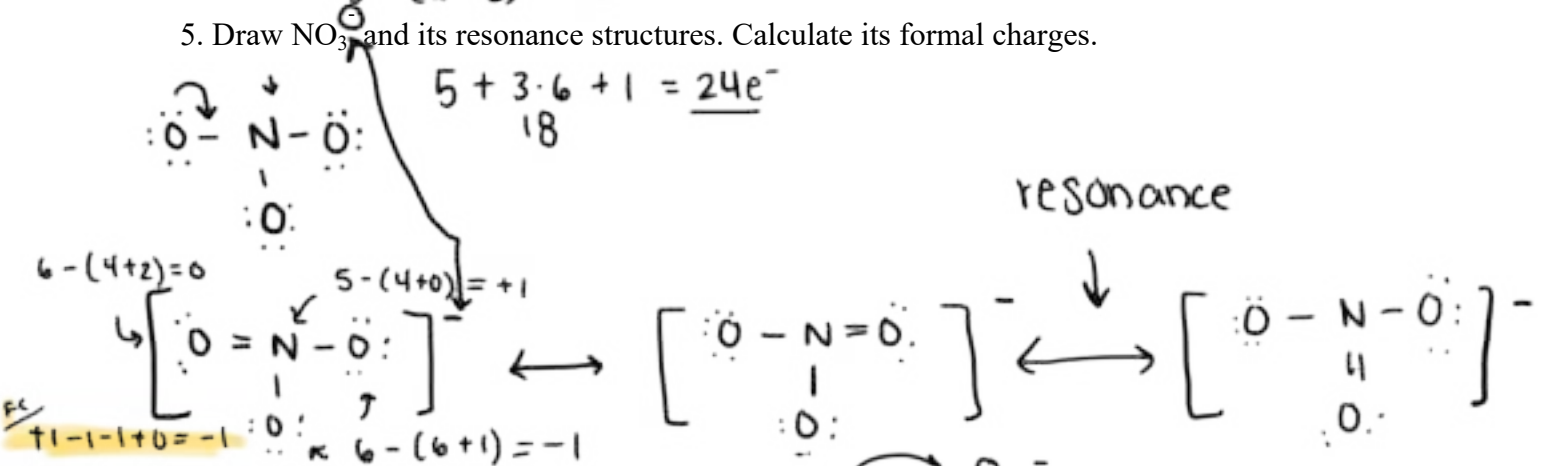
→ checked formal charges

→ total # e^-

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

5 + 3 · 6 + 1 = 24 e^-

18



6. Which of the following are exceptions to the octet rule?

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

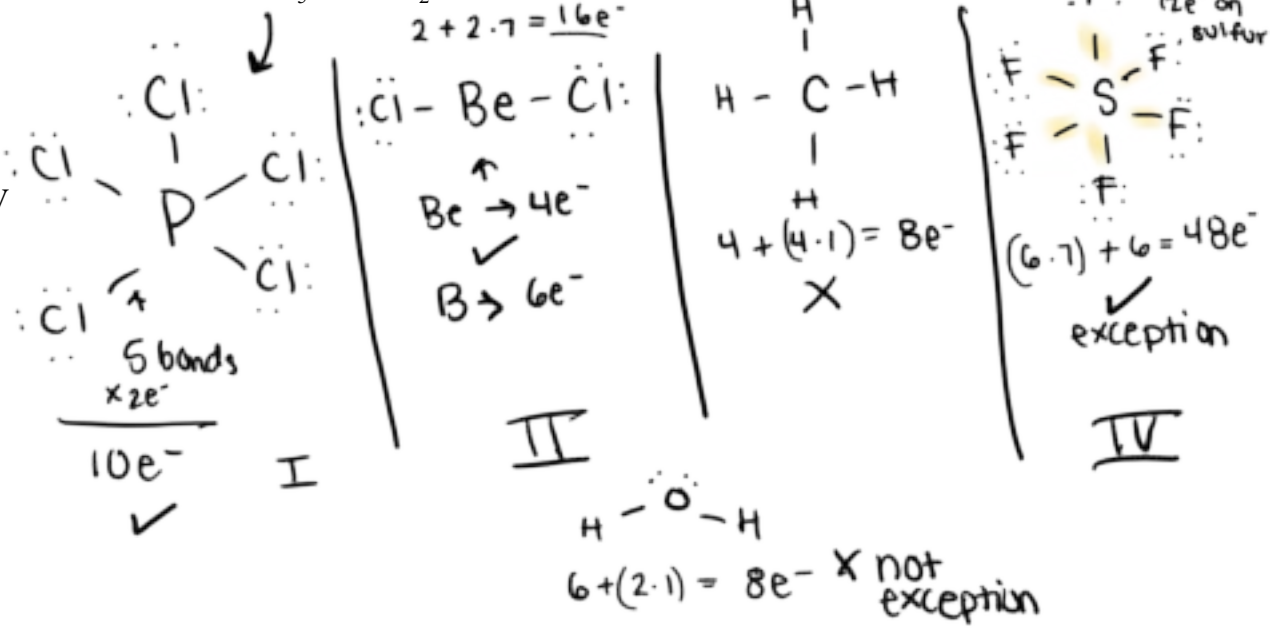
a) I, III, V

b) I, II, IV

c) II, IV

d) I, II, V

e) II, III, IV



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

lone pairs

central atom

bonded atoms

VSEPR Geometries

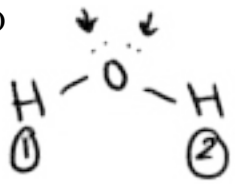
Electron Pairs ↓	0 Lone Pair	1 Lone Pair	2 Lone Pair	3 Lone Pair	4 Lone Pair
1					
2	AX_2 ← NO lone pairs x- A- x linear 180°				
3	AX_3 x – A – x | x trigonal planar 120°	AX_2E_1 x – Ä – x bent < 120°			
4	AX_4 x | x – A – x | x 109.5 tetrahedral	AX_3E_1 x – Ä – x | x trigonal pyramidal < 109.5	AX_2E_2 x – A – x bent << 109.5		
5	AX_5 x – A – x | | x x 90°; 120° trigonal bipyramidal	AX_4E_1 x – Ä – x | | x x seesaw <90°; <120°	AX_3E_2 x – A – x | x 90° T-shaped	AX_2E_3 x – Ä – x linear	
6	AX_6 x x x x – A – x | x octahedral 90°	AX_5E_1 x x x – A – x | x square pyramidal <90°	AX_4E_2 x – A – x x – A – x square planar 90°	AX_3E_3 x | A – x | x T-shaped <90°	AX_2E_4 x – A – x linear 180°

electron geometries → # electron groups around A

#e⁻ groups ↑ # bonded atoms & lone pairs ↑ → If 0 lone pairs, EG = MG!

8. Name to electron geometry, molecular geometry, and bond angles for the following compounds:

a) H_2O



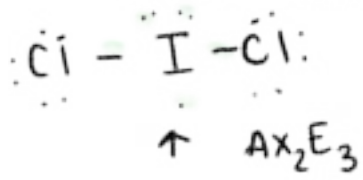
AX_2E_2 → 4 e⁻ groups

EG: tetrahedral

MG: bent

< 109.5°

b) ICl_2 7 + 7 + 1 = 21 e⁻



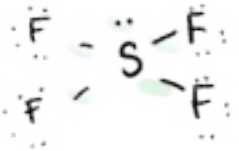
→ 5e⁻ groups EG: trigonal bipyramidal

AX_2E_3

MG: linear

180°

c) SF_4 6 + 7·4 = 34e⁻



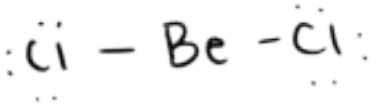
5e⁻ groups EG: trigonal bipyramidal

AX_4E_1

MG: seesaw

< 90°; < 120°

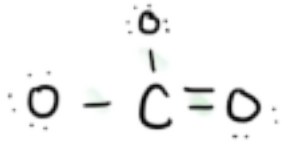
d) $BeCl_2$ 7(2) + 2 = 16e⁻



AX_2 EG/MG: linear

180°

e) CO_3^{2-} 4 + 3·6 + 2 = 24 (18)



AX_3 EG|MG: trigonal planar

120°

9. Which of the following molecules are polar?

I. NH_3 II. BF_3 III. COS IV. XeF_4 V. IF_5 → imbalance

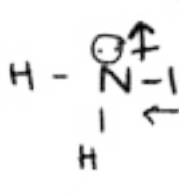
a) I, III, V

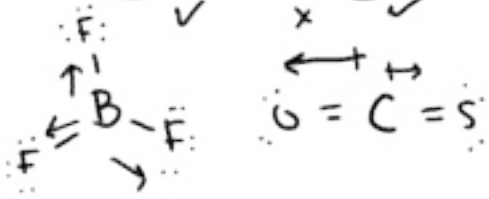
b) I, II, III

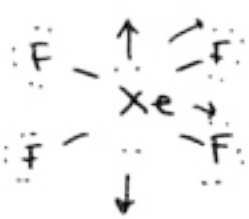
c) II, III, V

d) All

e) None







AX_4E_2

8 + 4·7 = 36e⁻

32e⁻ on F

4e⁻ as lone pairs Xe

bonds b/w nonmetals
↑ ΔEN = 0.4 - 1.9

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

a) Cl_2 ✗ → :Cl - Cl: → same 2 nonmetals, ΔEN = 0

b) $SOCl_2$ ✗ → diff strengths, polar molecule

c) $BeBr_2$ → :Br - Be - Br: → nonpolar, ΔEN = 2.8 - 1.5 = 1.3

d) NH_3 → polar

e) H_2O → polar

nonpolar covalent: ΔEN: 0 - 0.4

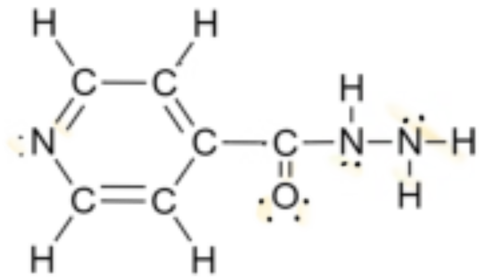
F → 4, Cl → 3, Br → 2.8

11. How many σ bonds are in this molecule?

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

σ - bonds : 17

π bonds : 4



12. 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

e⁻ groups: 1 → s, 2 → sp, 3 → sp^2, 4 → sp^3

3 e⁻ group C → sp^2; N (ring): sp^2; N: sp^3; O: sp^2

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

✓ a) NH_3 should have a higher boiling point than CH_4 LDF

✗ b) PH_3 should have a higher boiling point than NH_3 dipole

✓ c) SO_2 should have a higher boiling point than CO_2 LDF

d) A and C

e) All of the above

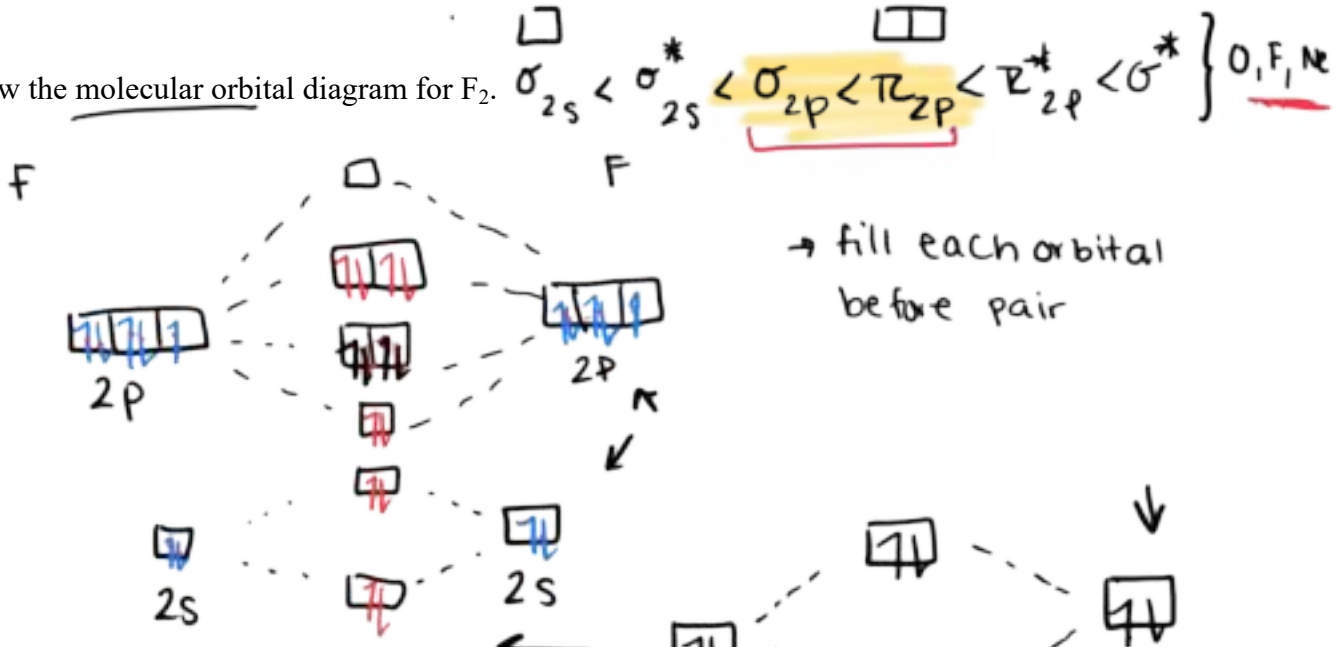
IMF: NH_3 & CH_4 (nonpolar) → H bonding < LDF

PH_3 & NH_3 → dipole < H bonding

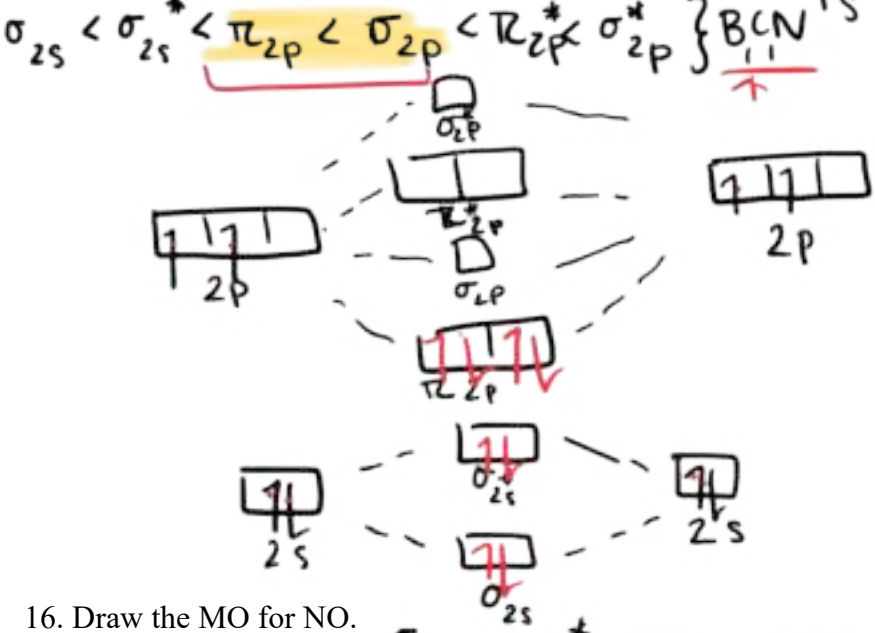
SO_2 & CO_2 → dipole > LDF

N, O, F: N-H, O-H, F-H } to experience H-bonding IMF

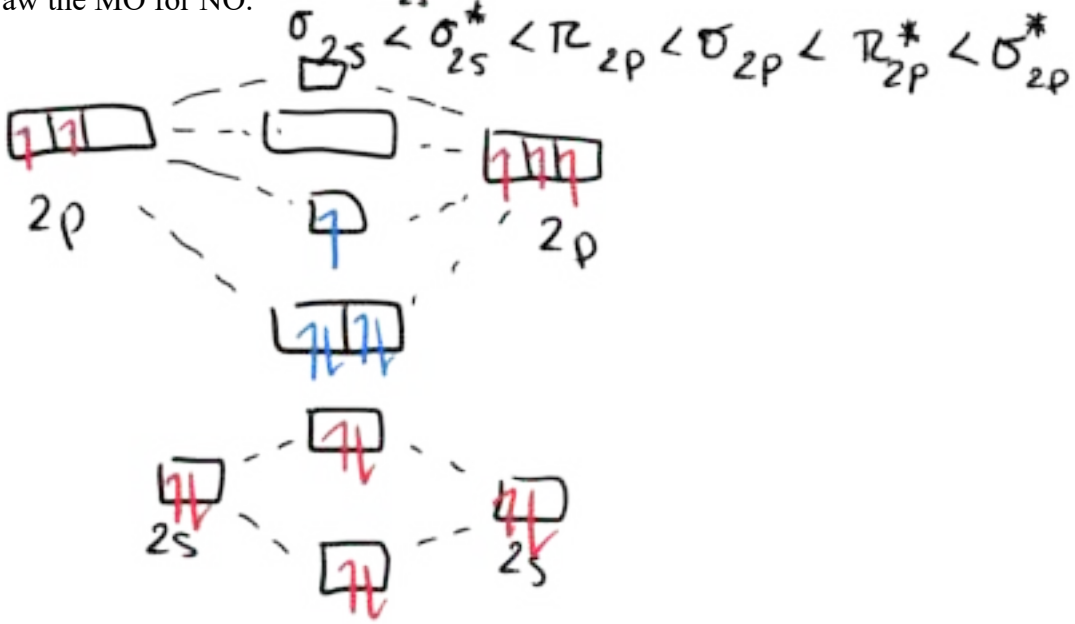
14. Draw the molecular orbital diagram for F_2.



15. Draw the molecular orbital diagram for C_2.



16. Draw the MO for NO.



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

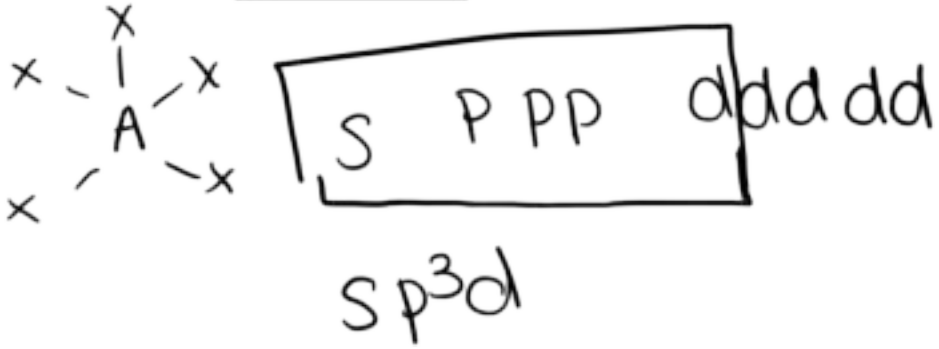
I. A single bond has 1 σ bond. ✓
II. A single bond has 1 π bond. ✗
III. A double bond has 1 σ bond and 1 π bond. ✓
IV. A double bond has 2 π bonds. ✗
V. A double bond has 2 σ bonds. ✗
VI. A triple bond has 3 π bonds. ✗
VII. A triple bond has 1 σ and 2 π bonds. ✓
VIII. A triple bond has 3 σ bonds. ✗

π → double / triple

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

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

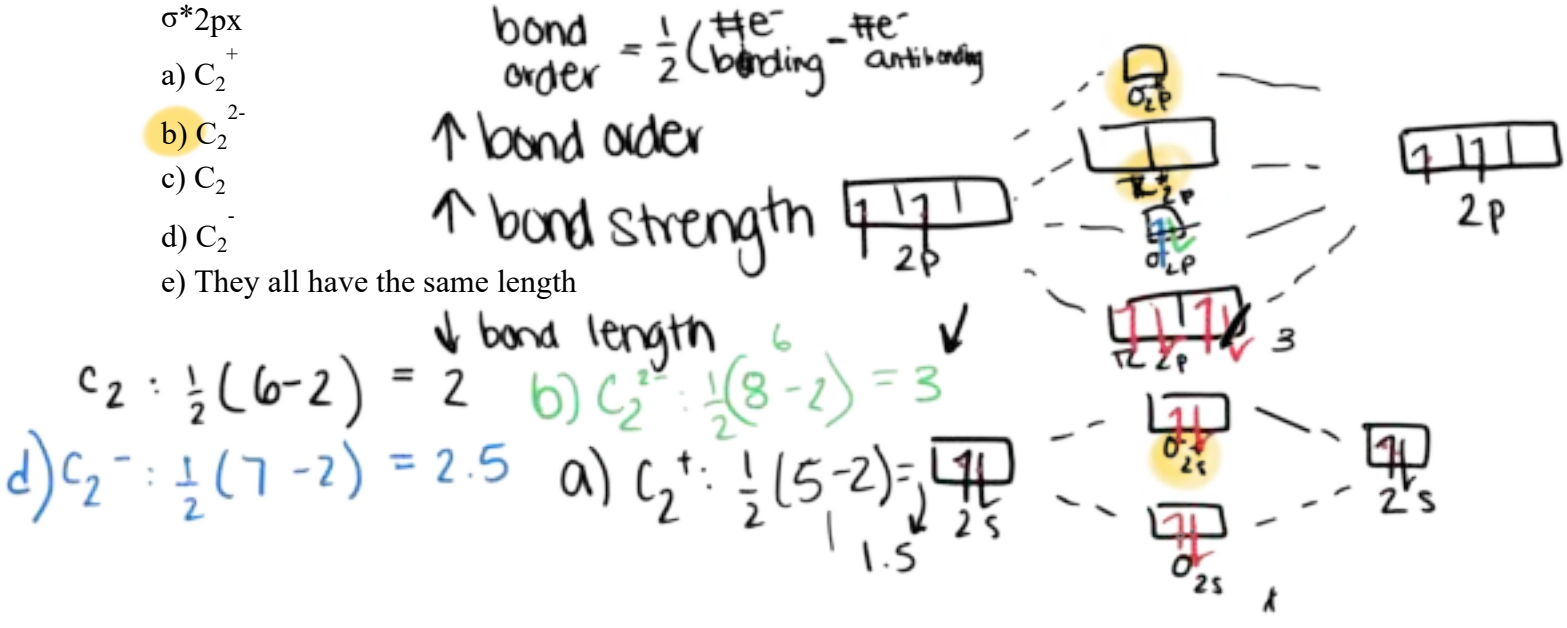
a) sp
b) sp^2
c) sp^3
d) sp^3d
e) sp^3d^2



19. According to MO theory, which of the following dicarbon species is expected to have the shortest bond length.

Use the following valence MO order: σ2s < σ*2s < π2py = π2pz < σ2px < π*2py = π*2pz < σ*2px

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

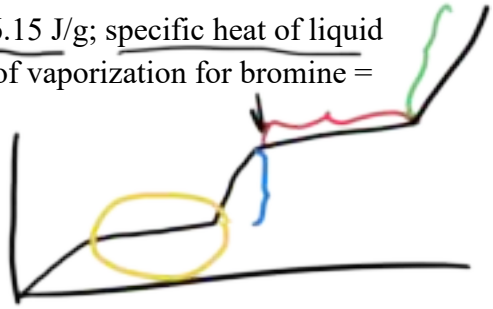


$Br_2(g)$

20. 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.

Changing States : $\Delta T = 0°$ Temp



1 · solid → liquid

$66.15\ J/g \cdot 10g = 661.5\ J$

2 · liquid $-7.2°C \rightarrow 58.7°C$ =

$q = mc\Delta T$

$10g \cdot 0.474\ J/g°C \cdot (58.7 - (-7.2)) = 312.366\ J$

$58.7 + 7.2 = 65.9°C$

3 liquid → gas

$193.21\ J/g \cdot 10g = 1932.1\ J$ ←

4 gas

$q = mc\Delta T$

$10g \cdot .225\ J/g°C\ (70°C - 58.7°C) = 25.425\ J$

$70 - 58.7 = 11.3°C$

2,931.4 J

*1 F kJ

21. Which response correctly identifies all the interactions that might affect the properties of BF3?

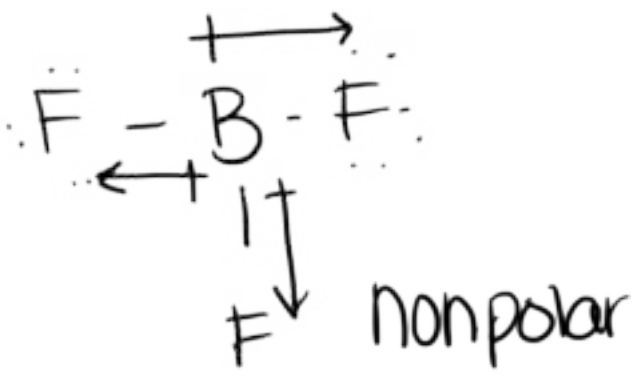
a) dispersion force, ion-ion interaction ×

b) hydrogen bonding force, dispersion force ×

c) permanent dipole force

d) permanent dipole force, dispersion force

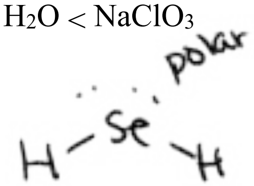
e) dispersion force



22. 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) $Ar < H_2Se < H_2O < NaClO_3$

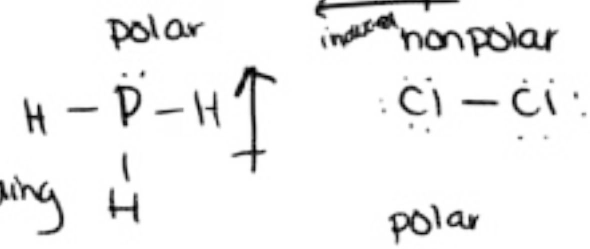
Ar → LDF * weakest
$NaClO_3$ → ion → strongest
H_2O → H bonding
LDF < dipole < H bond < Ion
polar H–O
H_2Se → dipole

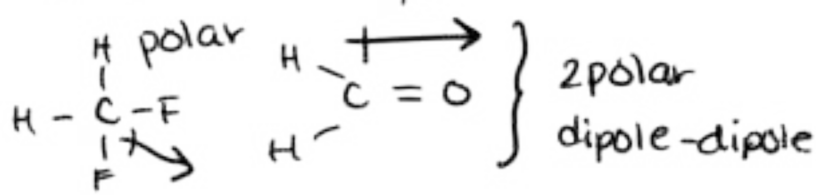


$Ar < H_2Se < H_2O < NaClO_3$

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

A) NH_3 and F_2: hydrogen bonding X (no H)
B) CH_2F_2 and CH_2O: dispersion X
C) Cl_2 and PH_3: dipole-induced dipole ✓ (polar)
D) HF and NH_3: dipole-dipole X H bonding (H-F)
E) PH_3 and H_2O: dispersion x dipole (polar)





24. 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.

V = x^3

simple → 1 atom/cell x (edge) = 2R (radius)
* body-centered (bcc) → 2 atom/cell = $\frac{4}{\sqrt{3}}$ R
face centered → 4 atom/cell → $x = \sqrt{8}$ R

R = ?
m = ? g/mol
identity =
$d = \frac{m}{V}$ $V = x^3$
$d \cdot V = m$

10.2 g/cm³
x = 3.147 Å
$x = \frac{4}{\sqrt{3}} R$
$\frac{\sqrt{3}}{4} \cdot 3.147 Å = \frac{4}{\sqrt{3}} R \cdot \frac{\sqrt{3}}{4}$
r = 1.37 Å

d = 10.2 g/cm³
$x = 3.147 \times 10^{-10}$ m
$d = \frac{10.2 g}{cm^3} \cdot \frac{(100 cm)^3}{(1 m)^3} = 10.2 \times 10^6 g/m^3$
$(10.2 \times 10^6 g/m^3) \cdot (3.147 \times 10^{-10} m)^3 = 3.1789 \times 10^{-22} g$
$\frac{3.1789 \times 10^{-22} g}{cell} \cdot \frac{1 cell}{2 atoms} \cdot \frac{6.022 \times 10^{23} atoms}{1 mol} = 95.7 g/mol$
→ Mo