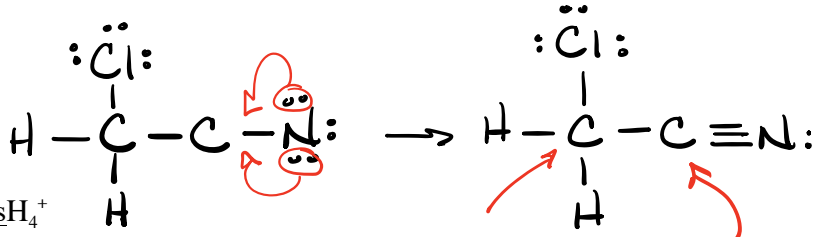
21. $\underline{C}H_3\text{-}\underline{C}O\text{-}CH_3$ (C-C-C sequence; give shape for two centers)

22. $\underline{C}H_3\text{-}\underline{S}H$ (give shape for two centers)

✶ 23. $\underline{Cl}\underline{C}H_2\text{-}\underline{C}N$ (C-C sequence; give shape for two centers)

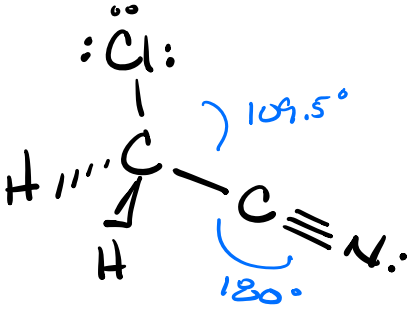


C 2 × 4 = 8
H 2 × 1 = 2
N 1 × 5 = 5
Cl 1 × 7 = 7
22e⁻ ✓

octets ✓
22e⁻ ✓
FC ✓

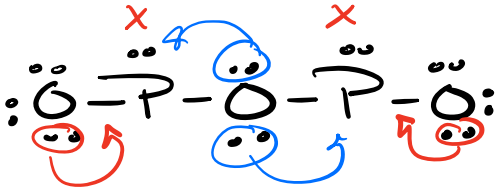
24. $\underline{As}H_4^+$

25. $\underline{Cl}O_2^-$



Sequence O-P-O-P-O

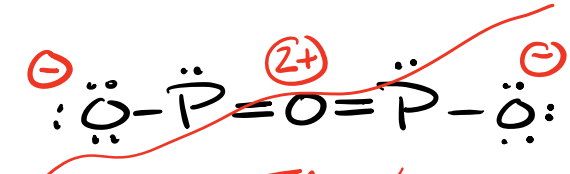
26. O-P-O-P-O (i.e., P_2O_3; give shape for two centers)



O 3 × 6 = 18
P 2 × 5 = 10
28e⁻ ✓

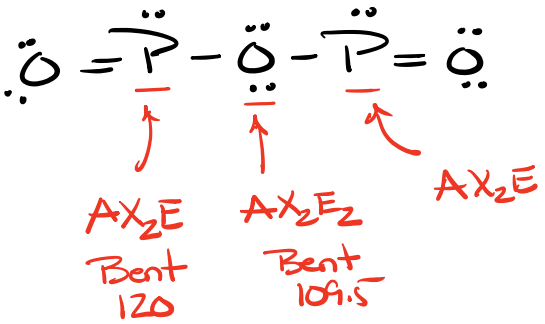
O 3.5
P 2.8
O > P

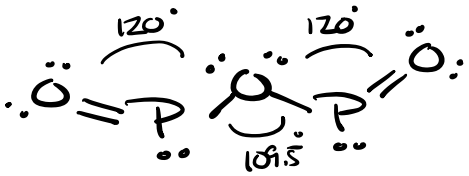
Zero Formal ✓

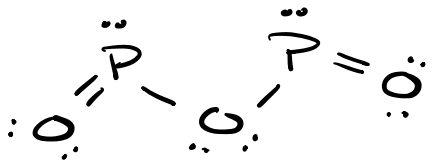


FC ✗

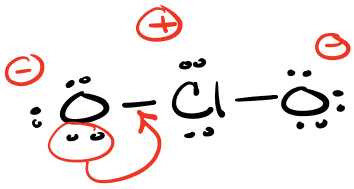
octet ✓
28e⁻ ✓
FC



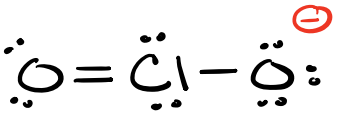




Cl 1 × 7 = 7
O 2 × 6 = 12
19
add for negative charge → + 1
20e⁻



20e⁻ ✓
octet ✓
FC ✗

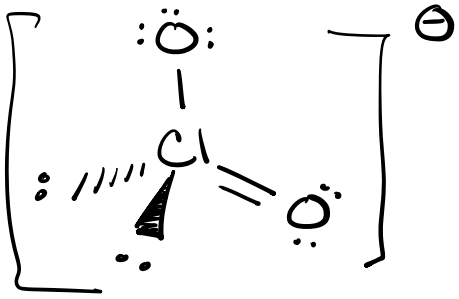


20e⁻ ✓
octet ✓
Cl has 10e⁻?
↑
period 3
10e⁻ ok
FC

forward ◢ wedge bond

backward ||||||| Hash bond

In plane — Straight bond



Polarity & IMF's

Bond Polarity

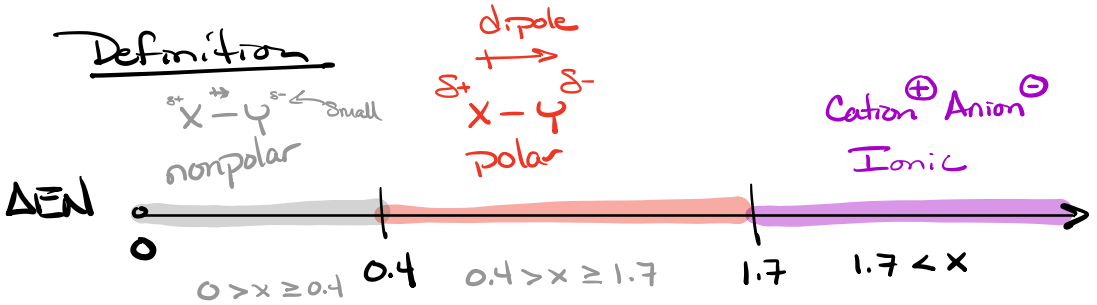
ΔEN = difference in Electronegativity

Δ = delta

$\Delta EN = |EN_1 - EN_2|$ always positive result

H						
2.2						
		C	N	O	F	
		2.5	3.0	3.5	4.0	
		P	S	Cl		
		2.2	2.6	3.2		

Definition



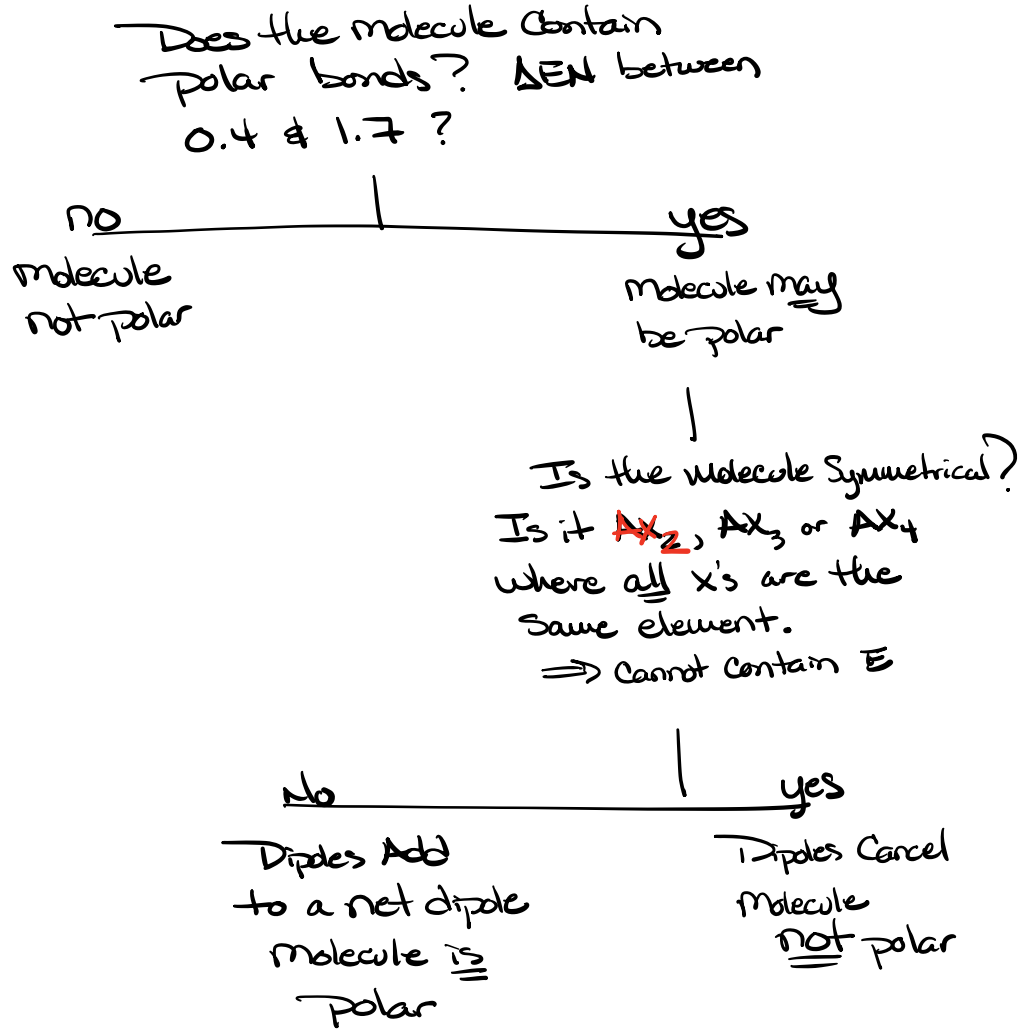
C–H $\Delta EN = |2.5 - 2.2| = 0.3$ nonpolar

C–O $\Delta EN = |3.5 - 2.5| = 1.0$ polar

F–H $\Delta EN = |4.0 - 2.2| = 1.8$ Ionic

Molecular Polarity — If a molecule is polar or not.

Flow Chart



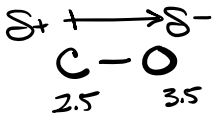
CO_2 Carbon dioxide

AX_2 linear w/ 180°

C-O $\Delta EN = |3.5 - 2.5| = 1.0$ polar

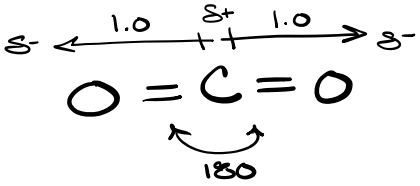
vector

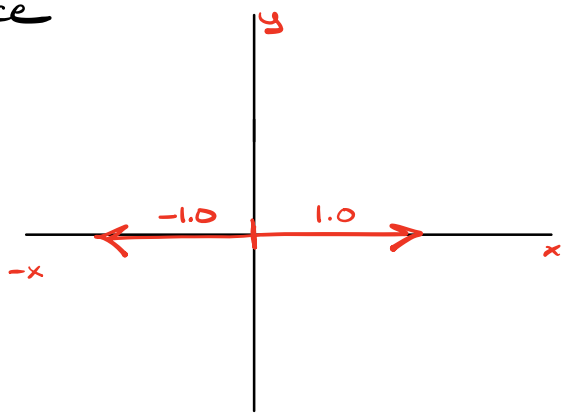
Vector = has magnitude & direction



Δ
Capital delta
Change difference

δ
Lowercase delta
Charge
Partial
difference





Equal in magnetude & opposite in direction

$-1.0 + 1.0 = 0$

net vector

AX_2 Linear

$X - A - X$ Always Cancels

They canceled each other

HCN Hydrogen Cyanide

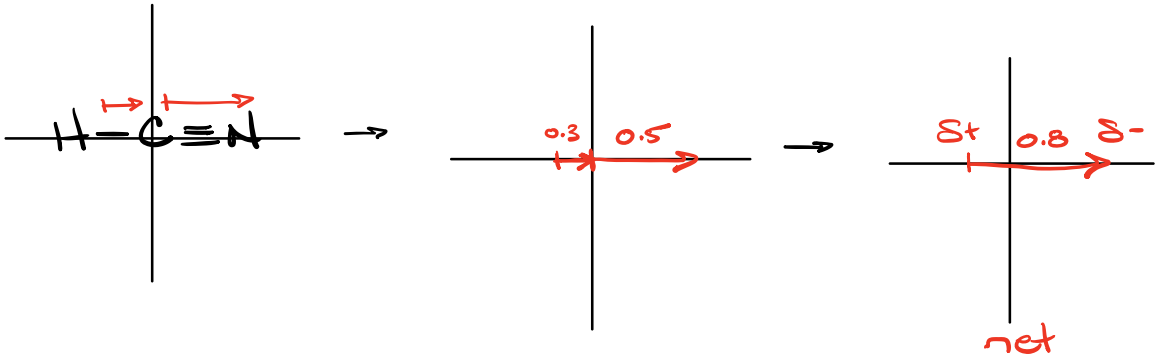
H—C≡N:

AX_2 180°

ΔEN

$\overset{\delta+}{C}\xrightarrow{0.5}\overset{\delta-}{N}$ = 3.0 − 2.5 = 0.5 polar

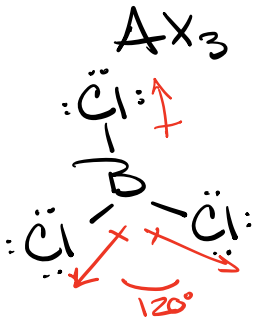
$\overset{\delta+}{H}\xrightarrow{0.3}\overset{\delta-}{C}$ 2.5 − 2.2 = 0.3 nonpolar



$\overset{0.8}{H\rightarrow C\equiv N}$:

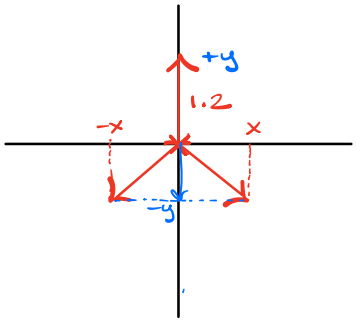
polar

AX_2 where X's are different



$\Delta EN = 3.2 - 2.0 = 1.2$ polar

Molecule is not polar

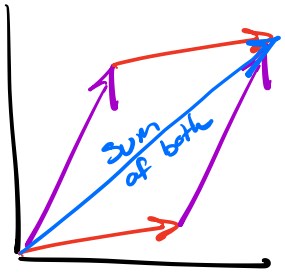


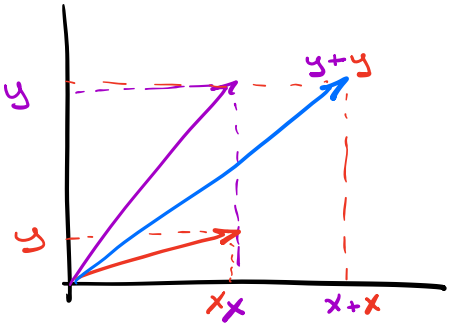
x's = $-x + x = 0$

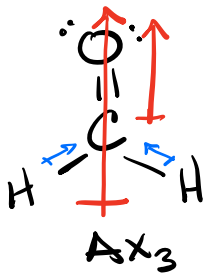
$y = +y - y = 0$

no net dipole

How to Add vectors



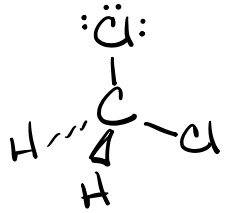




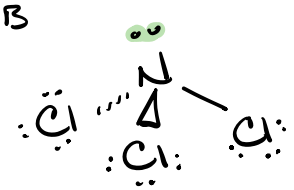
AX_3

but w/ different x's

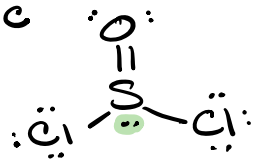
A



B



C



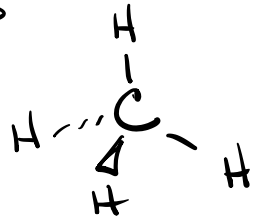
Geometry
Polar bonds
Molecule polar
↳ AX_2, AX_3, AX_4
All X's the same

AX_4 tetrahedral
C-H = 0.3
C-Cl = 0.7 ✓
polar
X's different ⇒ polar

AX_3E
N-Cl = 3.2-3.0 = 0.2
non-polar
not polar

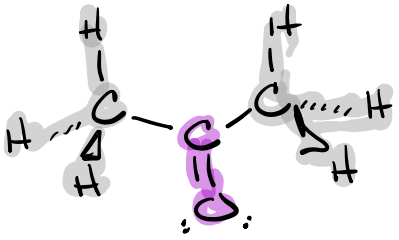
AX_3E
O-S = 3.5-2.6 = 0.9
S-Cl = 3.2-2.6 = 0.6
polar

D



Geometry
Polar bonds
Molecule polar

AX_4
C-H = 0.3 non-polar
⇒ nonpolar



polar

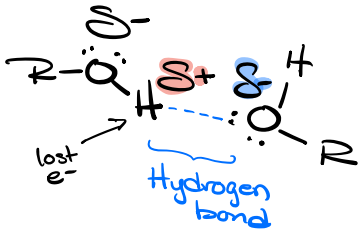
multiple centers
If there are polar bonds ⇒ molecule is always polar.
W/ multiple centers the dipoles can't cancel.

IMF

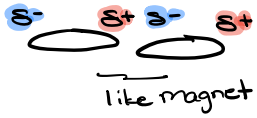
Stronger

Metals — Ionic

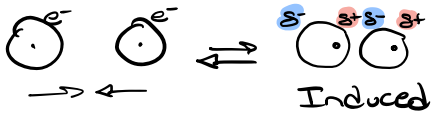
Polar Molecules w/ O-H, N-H, F-H — Hydrogen Bonding (O-H, N-H, F-H) — Special dipole-dipole

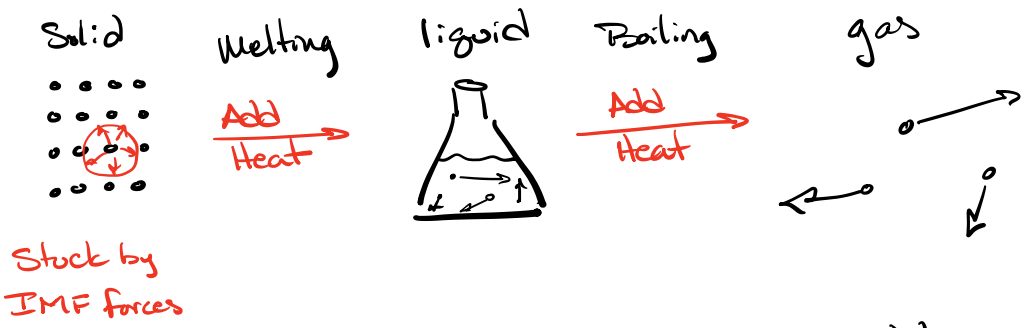


Polar Molecules — Dipole-Dipole



non-polar Molecules — Van der Waal Forces, London dispersion forces, Induced Dipole } Same





Stuck by IMF forces

To change phase must add Enough heat to overwhelm IMF's.

The stronger the IMF, the more heat required.

Higher IMF = Higher Melting Point

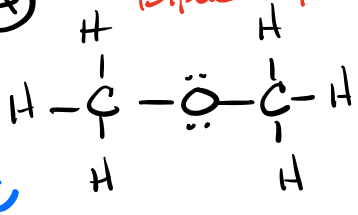
Higher IMF = Higher Boiling Point

Higher Boiling

Stronger IMF

H-bonding

(A)



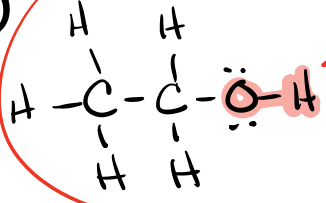
Dipole-Dipole

-32°C

C-O = 1.0 polar

C-H = 0.3

(B)



Dipole-Dipole

78°C

C-O = 1.0 polar

C-H = 0.3

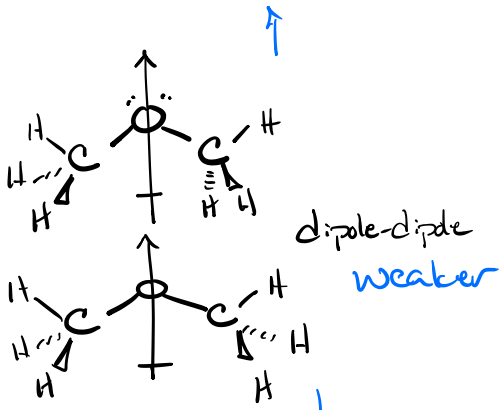
O-H = 1.3

Higher Boiling Point?

① molecule polar or non-polar Both polar molecules

② Type of IMF

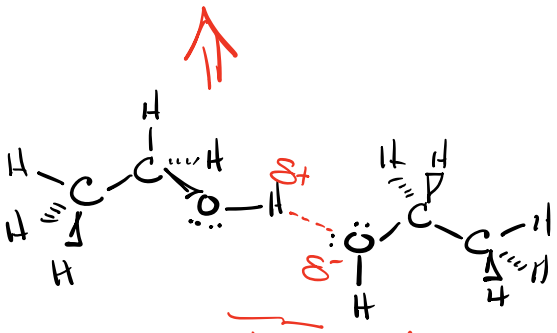
③ Decide Stronger IMF = Higher BP



dipole-dipole

weaker

Requires Less Energy



Hydrogen bond

Stronger

Requires more Energy to pull apart