21. Ranking: dipole moments and bond polarity

Know your definitions

bond
- polar $\Delta EN > 0$ covalent $\Delta EN < 1.5$
- nonpolar $\Delta EN = 0$ (H-H) ionic $\Delta EN > 1.5$

molecule
- polar $\Sigma \Delta EN \neq 0$
- nonpolar $\Sigma \Delta EN = \emptyset$

so for example

$CHCl_3$ → has 4 polar bonds and add them up to be a molecule

22. Problem: molecule polarity from VSEPR

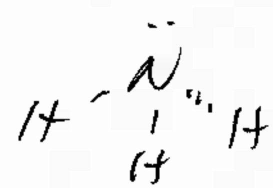
Apply the idea $\Sigma \Delta EN \neq 0$ means polar (assym)

$\Sigma \Delta EN = 0$ mean nonpolar (sym)

But first, draw your Lewis Dot structure

Then assign ΔEN to each bond

Then apply above equation


polar

nonpolar
O = C = O

23. Problem: VB theory of hybrid orbits

Because atomic orbits that bond would have different energies but the actual bonds are same energy

$2s$ ↿⇂ $2p$ ↿ ↿ — CH2 suggests different bonding

but actually hybridization: s^2p^2 —hybrid→ sp^3 ↿ ↿ ↿ ↿ are same bonding energy

something must happen → hybridization

Be able to look at a second row element like O, C, N. and tell me what the hybrid orbits and non bonding e^- orbits are after hybridization

24. Problem: electronic and molecular geometry

First, draw the Lewis Dot structure

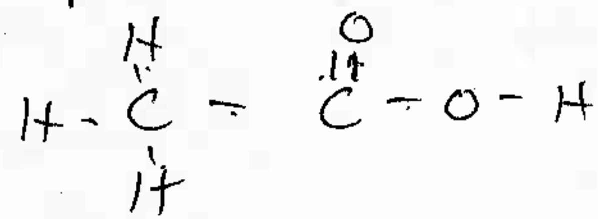
Electronic geometry			Molecular geometry		
# electron region			identify B + N = 13 types		
2	linear	need to memorize	AB_2	linear	need to memorize
3	trigonal		AB_3	trig	
4	tetra		AB_2N	angular	
5	trig bipyr		AB_4	tetra	
6	octa		AB_3N	trig pyr	
			⋮		

25. Problem: number of σ and π bonds in molecule

I will give you a simple organic molecule. Draw its Lewis dot structure.

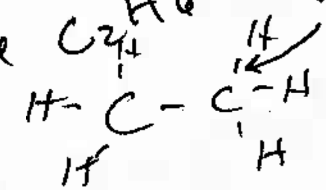
Then, every first bond is a σ bond all other bonds are π bonds.

Example CH_3COOH



← 7 σ bonds
1 π bond

Example C_2H_6



σ_{1s-sp^3}

26. Problem: AOs that comprise MOs in a bond

For every σ or π bond, there are two A.O. (s, p, d, sp, sp^2, sp^3, dsp^3, d^2sp^3) that make the bond.

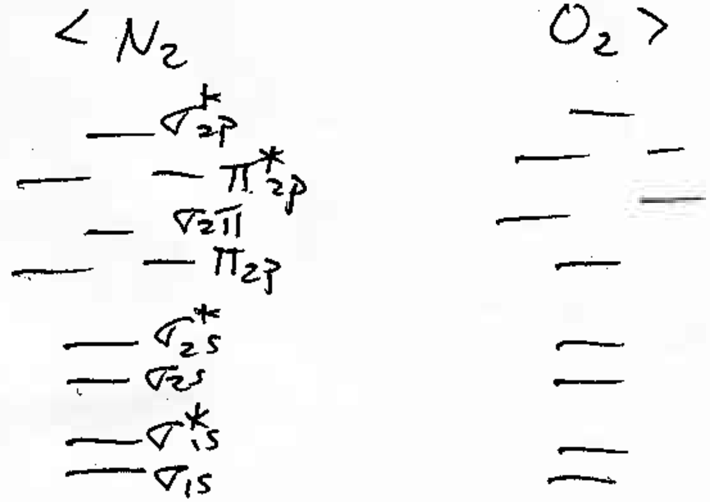
σ_{1s-sp^2} or π_{2p-2p}

↑
2 A.O.s make M.O.

I will give you a simple organic molecule. Draw the Lewis structure. Assign σ + π, and ask what A.Os are that formed them.

27. Problem: filling MOs of diatomic molecules

you need to memorize your sad face and symmetrical MOs for next 4 problem.



Step 1. Count number of electrons (all of them not valence) and then fill the MOs following Aufbau, Hund, Pauli

28. Calculation: bond order from MO

Do the problem above for a diatom.

Then $b.o. = \frac{\#\text{ of bonding} - \#\text{ of antibond }(*)}{2}$

If b.o. = Ø then compound doesn't exist. And the larger the b.o., the more stable the bond.

So He_2^+ has $3e^-$ so it is b.o. of $= \frac{2-1}{2} = 0.5$ (exists barely)

29. Problem: paramagnetism from MO

Do problem #27 again.

1. count # of e^-s
2. write down the correct M.O. (s and/or symmetric)
3. Fill in e^-s
4. If ↑ ← magnet. ↑↓ ← diamagnetic (no magnet)

30. Ranking: bond length from bond order

Do problem #27 again

1. count the e^-s
2. write down the MO
3. Fill e^-s
4. calculate b.o. (#28)
5. The bigger the b.o., the smaller the bond length.

31. Calculation: ideal gas law very boring plug & chug

Either $PV = nRT$ and I will give you information

Through n like

$n = g/mw$ or $n \Rightarrow 6.02 \times 10^{23}$ particles

or $\rho = g/ml \rightarrow$ density

~~or a change of state problem~~

~~$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ← stick it in an crank it out.~~

32. Calculation: stoichiometry and PV=nRT I have done this problem multiple times on quizzes & examples.

1. I give you a rxn involving gases.

   $C_3H_8 + 5O_2 \rightleftharpoons 3CO_2 + 4H_2O$

2. I give you an amount of reactant in g, moles, etc
3. you turn it stoichiometrically into moles of products
4. you stick n into $n = \frac{PV}{RT}$ calculation to get P, V, T

33. Calculation: relative ratio of gas speeds This is done on both quizzes and exams.

Given that $T \equiv$ constant so $E = kT$

and $\bar{E}_k$ is same for all gases in a system

and given $E = \frac{1}{2} m v^2$ for all molecules, then speed is inversely square relation to m

$$\underbrace{m_1 v_1^2}_{\text{gas 1}} = \underbrace{m_2 v_2^2}_{\text{gas 2}} \qquad \frac{m_1}{m_2} = \frac{v_2^2}{v_1^2}$$

Hint: Don't get it backward. Calculate what it asks.

I want you to ratio the masses or speeds

34. Theory: gas non-ideality $PV \neq nRT$

$$(P + \text{f.f.})(V + \text{f.f.}) = nRT$$

(first f.f.) is attractive forces (like inst. dipoles, dipoles, H-bond) a-term

(second f.f.) the size of the gases b-term

$a \equiv$ a is bigger with more attractive (IMF) forces: $H_2 < CHCl_3 < H_2O$

$b \equiv$ is bigger with bigger gases: $H_2 < H_2O < CHCl_3$

35. Theory: intermolecular forces

inst. dipoles	≡	< 1 kJ/mole	≡	nonpolar bonds (CH_4)
dipoles	≡	5 kJ/mole	≡	polar bonds ($CHCl_3$)
H-bonding	≡	20 kJ/mole	≡	$H_2O > HF > NH_3$ and all -OH + -NH compds
ionic	≡	200 kJ/mole	≡	charge density $CaO > NaCl$

The ranking is done by creating 4 bins

non-polar		polar		H-bond		Ionic
The size matters inside bin	<	The ΔEN matters inside the bin	<	OH > HF > NH inside the bin	<	charge density ranking
$CH_4 < C_2H_6$		$CH_3F > CH_3Cl$				# 13 system type

36. Definition: physical properties of solutions

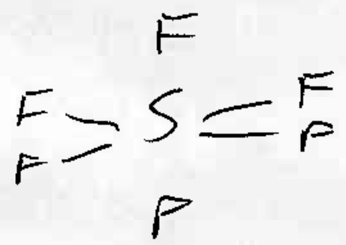
I promise to be fair on this one but have a general knowledge of definition of

viscosity
cap. action
evap.
b.p.
f.p.
surface tension
ΔH vap
vapour pressure

37. Problem: assigning IMF to molecules

use the concept in 35. I will give you a collection of molecules, you tell me what kind of IMF they have

Example



inst. dipole $\Sigma \Delta E = 0$

$S=C=N$ polar because $\Sigma \Delta E \neq 0$

$CH_3CH_2-NH_2$ (amine N-H) H bonding

NaCl is a salt $\Delta EN > 1.5$

38. Ranking: physical properties by IMF

Just do #35 for a series of molecules create the 4 bins, sort inside the bins and rank.

Remember that all phys. properties except 2 are proportional to IMF IMF ↑ so does BP↑ f.p.↑, vis↑ s.t↑

The two exceptions are IMF↑ v.p↓ IMF↑ evap↓

39. Ranking: physical properties by IMF

What do you want to bet that I will have a ranking with IMF ↑ prop ↑ and one with IMF ↑ prop ↓

Example Rank b.p. for

$CaCl_2$, CaO, H_2O, CH_3NH_2, $CHCl_3$, $CHBr_3$
C_2H_6, He, SF_6

Inst. dipole | dipole | H bond | ionic charge density

He < C_2H_6 < SF_6 | < $CHBr_3$ < $CHCl_3$ | < CH_3NH_2 < H_2O | < $CaCl_2$ < CaO

size B.n 1 | B.n 2 ΔEN | B.n 3 | b.n 4

40. Ranking: ~~physical properties by IMF~~ types of solids

~~[illegible]~~

There are 4 types of solids

NaCl → Ionic ≡ salts, something from left + right of table
Fe → metals ≡ left of table
SiO_2, graphite → covalent networks = right of table, not molecules
H_2O → molecular ≡ right side of table and molecules that do IMF