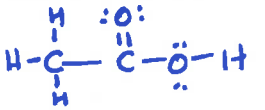
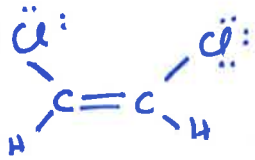
Organic and Intermolecular forces Test Review!!!!!

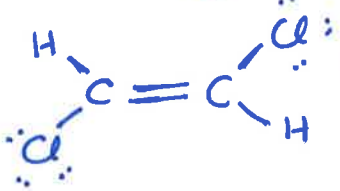
1. a. Draw each compound. b. Identify any geometric or structural isomers.
c. For any isomer pairs, which isomer would have the higher boiling point? Why?

ethanoic acid 

has LDF and Dipole² forces

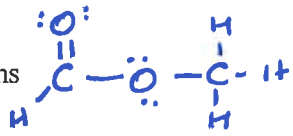
cis-1,2 dichloro ethene 

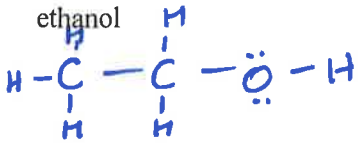
only has LDF

trans-1,2 dichloro ethene 

← these are geometric isomers.

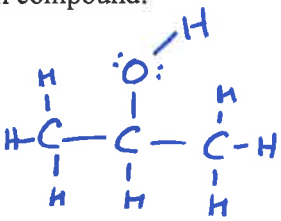
the "cis" molecule will have a higher b.p. since it has a net dipole (is polar), whereas the trans molecule is nonpolar due to symmetry.

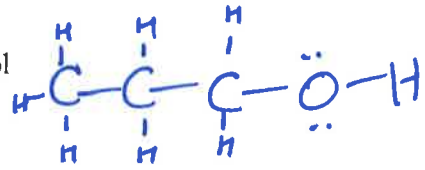
an ester with two total carbons 

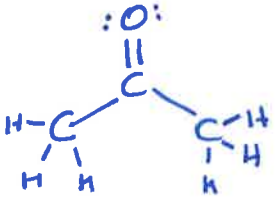
ethanol 

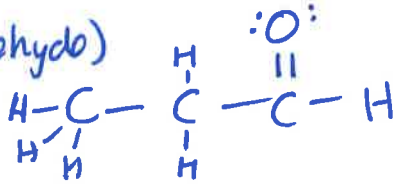
The acid and the ester are structural isomers. Both are polar, but only the acid can H-bond (due to the O-H), so the acid has the higher bp. (H-bonding vs Dipole-Dipole)

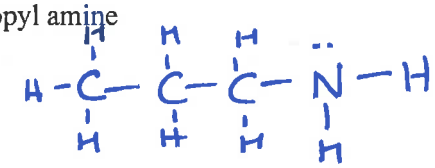
2. Draw each compound:

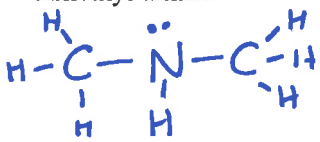
2-propanol 

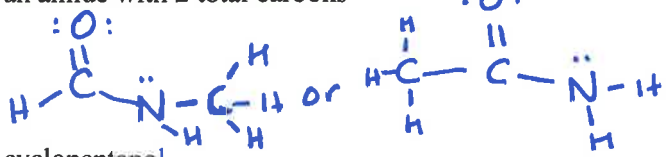
1-propanol 

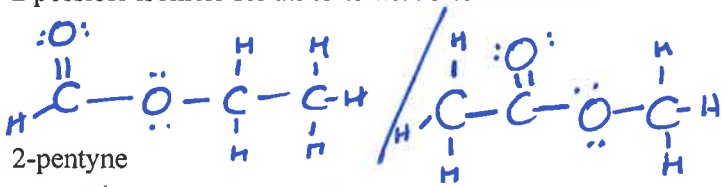
propanone 

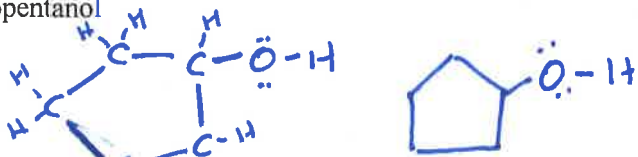
propanal
(aka propanaldehyde) 

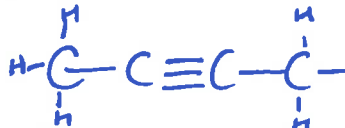
propyl amine 

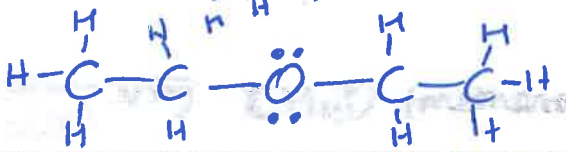
dimethyl amine 

an amide with 2 total carbons 

2 possible isomers for an ester with 3 total carbons 

cyclopentanol 

2-pentyne 

diethyl ether 

1,3 difluorobenzene 

3. Of the compounds in #1 and #2,

-which are acidic? basic? neutral?

propyl amine and dimethyl amine are basic.
ethanoic acid is acidic. all others are ≈ neutral.

-which compounds can hydrogen bond with other molecules of their own kind?

ethanoic acid, ethanol, 2-propanol, propyl amine, both amides, cyclopentanol, 1-propanol, and dimethyl amine.

-which compounds can hydrogen bond with water?

all of these can! So can all 3 esters, propanone, diethyl ether, and propanal. (and some people would also include the Cl and F compounds!)

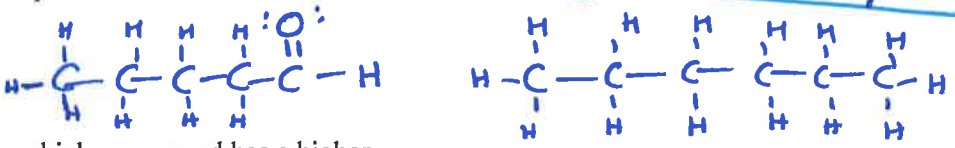
-ID the IMF type in each compound.

Umm... the ones that can H-bond with molecules of their own kind all have H-bonding (and London Forces) (see above!)

cis-dichloro ethene, all 3 esters, propanone, diethyl ether, propanal, and 1,3 difluoro benzene all have Dipole-Dipole Forces (and London) trans dichloro ethene and 2-pentyne have only London Dispersion Forces.

4. Consider the compounds pentanal and hexane.

a. Draw each compound.



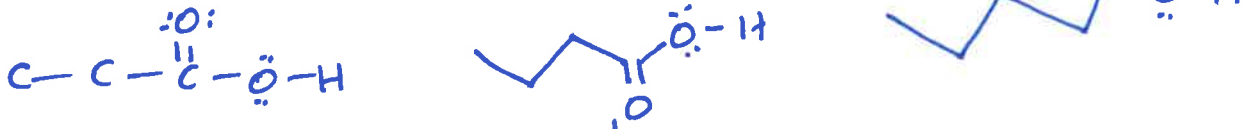
b. At a given temperature, which compound has a higher...

solubility into water? pentanal
boiling point? pentanal
viscosity? pentanal
surface tension? pentanal
vapor pressure? hexane
cohesive forces? pentanal
ability to have "capillary action"? pentanal

(they are similar sizes so have similar strengths of London Dispersion Force.

But pentanaldehyde is polar due to the C=O bond, so also has Dipole Dipole Forces)

5. Consider propanoic acid, butanoic acid, and pentanoic acid.

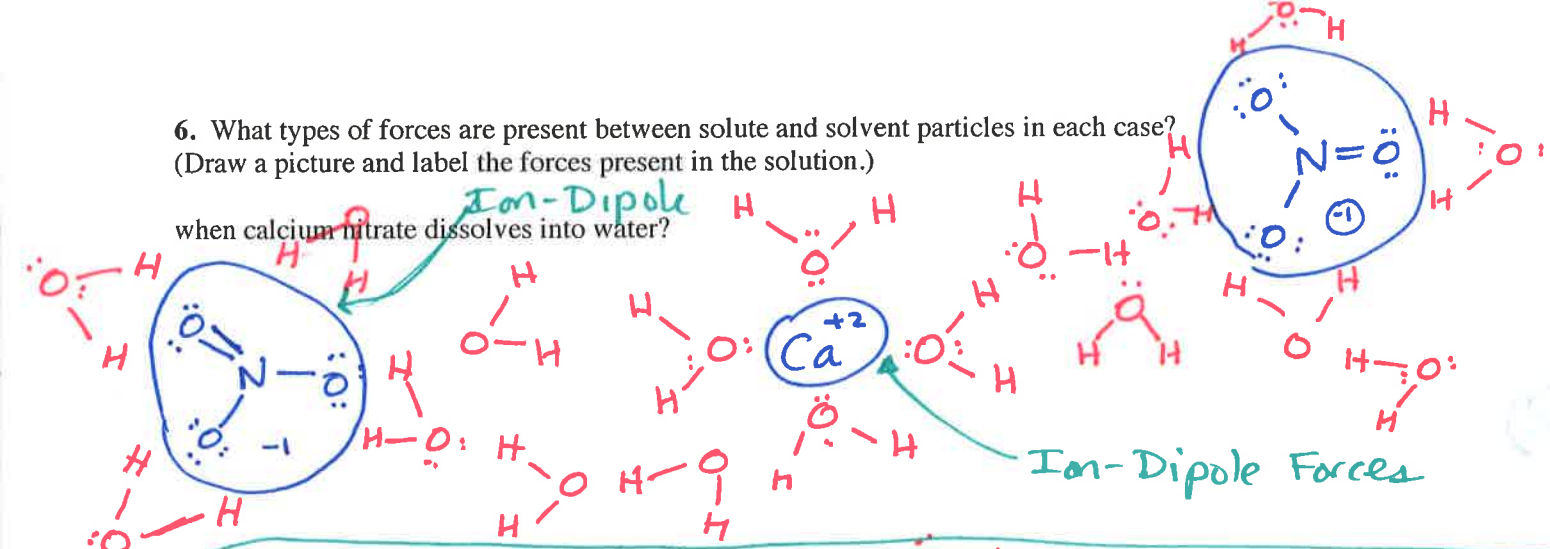


Which is most soluble into water? propanoic acid

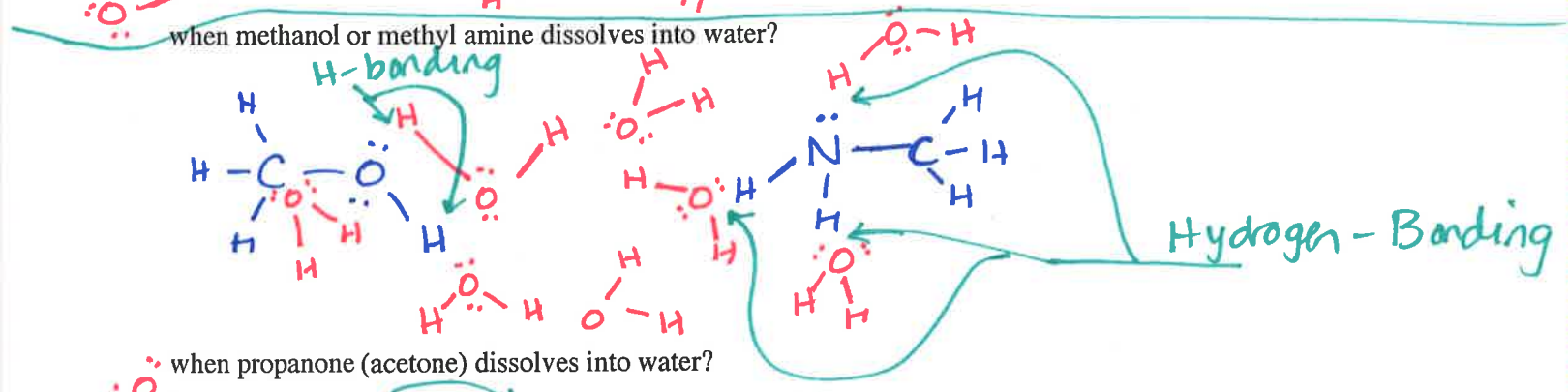
Which has the highest boiling point? pentanoic acid

6. What types of forces are present between solute and solvent particles in each case? (Draw a picture and label the forces present in the solution.)

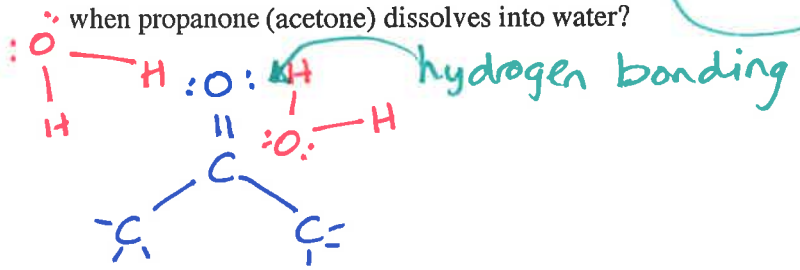
when calcium nitrate dissolves into water?



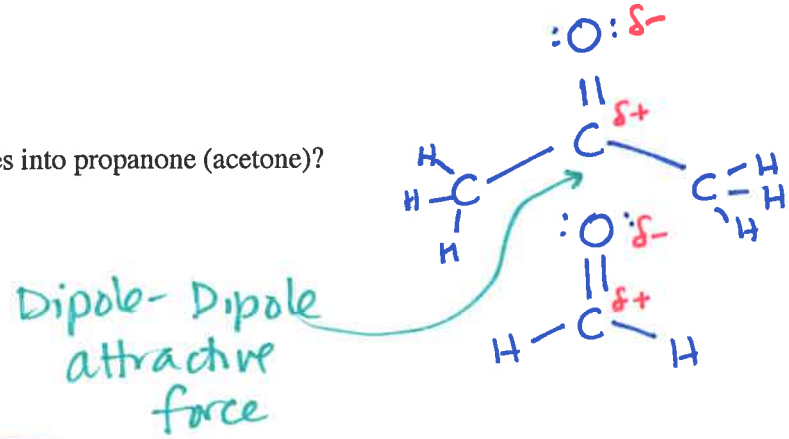
when methanol or methyl amine dissolves into water?



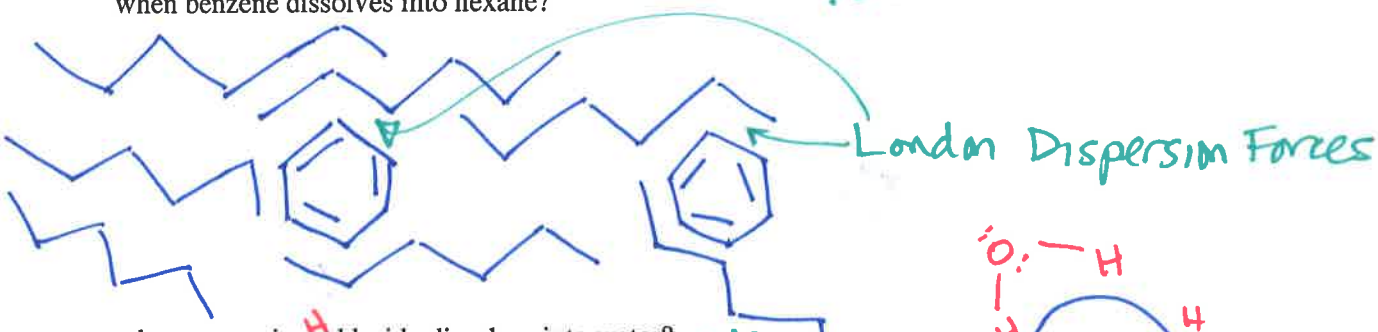
when propanone (acetone) dissolves into water?



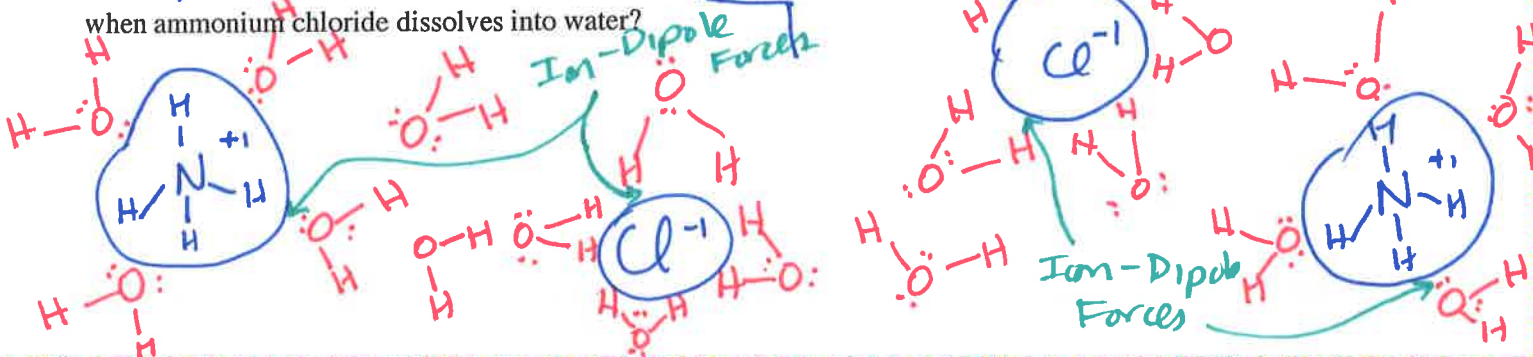
when formaldehyde (methanaldehyde) dissolves into propanone (acetone)?



when benzene dissolves into hexane?



when ammonium chloride dissolves into water?



7. Consider the elements B, Sn, and Pb.

a. Identify a pair of elements (from this list) could mix together to form a substitutional alloy.

Sn and Pb (must be similar radius to form subst. alloy)

b. Identify a pair of elements (from this list) could mix together to form an interstitial alloy.

B and Sn , B and Pb

(Know: B and C atoms have very small radii, so Boron and Carbon can act as the "small" atom in interstitial alloys.)

8 a. Rank these from best (#1) to worst (#4) in terms of electrical conductivity.

pure Ge	Ge doped with P	Fe	I_2
(metalloid) semiconductor. #3	Doped semiconductor #2	metal - good conductor #1	nonmetal nonconductor #4

b. When Germanium is doped with Phosphorus, does this make a p-type or n-type semiconductor? Explain.

Ge atoms have 4 valence electrons.
P atoms have 5 valence electrons.

So, when the occasional P atom is present in the Ge, the P-atom will have an "extra" valence electron, which will be (somewhat) able to move through the crystal. electrons are negative, so this "extra" electron makes it n-type doping (n = negative)

n-type (negative-type)

c. What could Ge be doped with to make the other type of semiconductor? Explain

To make a p-type semiconductor, you'd need to dope Ge with something with 3 valence electrons (1 less than 4!) so you could use Gallium (Ga) or something else from column IIIA.

d. Determine the intermolecular force present in each of the three elements listed in part (a).

Germanium : covalent network solid.
Iron : metallic Bonding
I_2 : London Dispersion Force.

9a. What is the hybridization of carbon in and bond ∠

nanotubes	diamond	graphite	buckyball/fullerene
sp^2, 120°	sp^3, 109.5°	sp^2, 120°	sp^2, 120°

b. which of these can conduct electricity? nanotubes, graphite, buckyballs

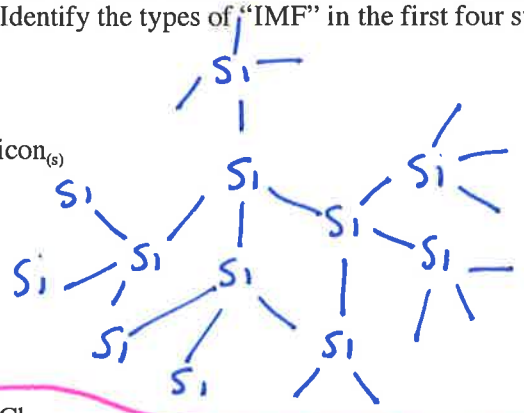
c. which of these can dissolve in water? none of them can

d. which of these could dissolve in nonpolar solvents, like benzene? buckyballs (C_{60} is a nonpolar molecule!)

e. Silicon has the same structure and hybridization as the carbon atoms have in diamond.

10a. Sketch each of the substances below to show the structure/arrangement.
b. Classify each substance as a conductor, semiconductor, or non conductor.
c. Identify the types of "IMF" in the first four substances.

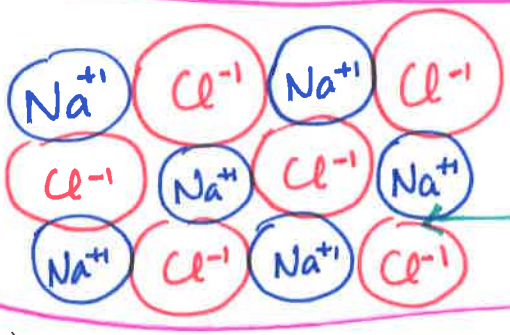
Silicon$_{(s)}$



Each Si is single bonded to 4 other Si atoms.
all ∠ are 109.5°

Silicon is a semiconductor.
Si is a covalent network solid

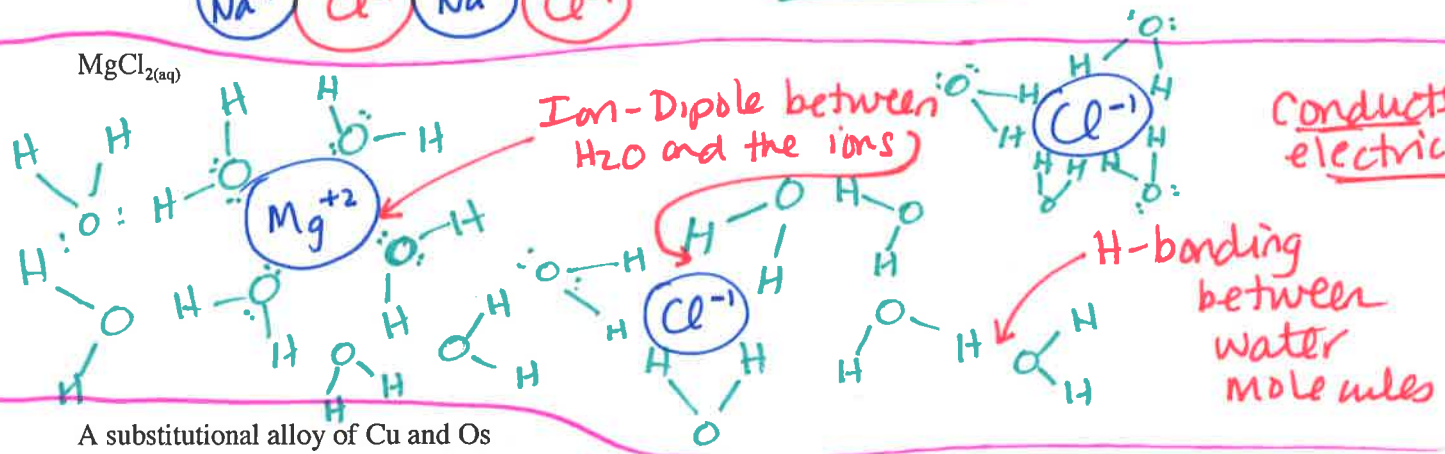
$NaCl_{(s)}$



nonconductor since the NaCl is solid.

Ion-Ion Forces (Ionic Bonding)

$MgCl_{2(aq)}$



Ion-Dipole between H_2O and the ions

Conducts electricity!

H-bonding between water molecules

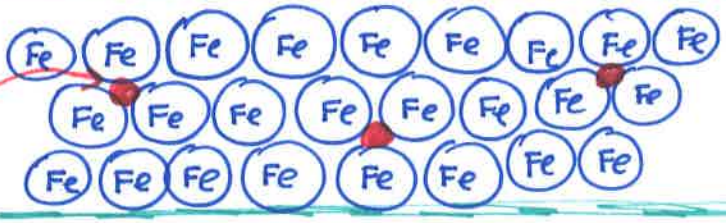
A substitutional alloy of Cu and Os

Conductor!
metallic bonding

Steel (an interstitial alloy)

Conductor!

the red atoms are carbons



10. Sig Figs! In this problem you will write a Petrarchian Sonnet about significant figures. Your rhyme scheme in the octave/octet must be ABBAABBA. Your sestet rhyme scheme must be CDDECE. To receive full credit, your sestet must solve the problem that you presented in the octave, and lines 4, 5, and 6 of the sestet must also be a 5-7-5 Haiku. Be prepared to perform your sonnet to the key of E sharp with a 13/7 time signature. Please use your best "inward singing" voice while performing the alto and soprano vocals simultaneously. Do NOT use scientific notation - that's just tacky.

Answers will vary.

11.

Substance	Boiling Point (°C)	Solubility in water (moles compound per 100 g H_2O)
1-propanol	97	miscible
1-butanol	117	0.11
1-pentanol	138	0.030
1-hexanol	157	0.0058

as # of carbons increases, polarizability and surface area increase, so London Forces increase, so bp increases.

but as # carbons increase, the nonpolar part of the molecule gets larger, so solubility into polar solvents like H_2O decreases.

a. These four liquids have boiling points of 97, 157, 138, and 117 (celsius) and solubilities of 0.0058, 0.11, miscible, and 0.030. Use this data to fill in the table, above.

b. If each of the liquids are at room temperature,
Which liquid would have the highest vapor pressure? 1-propanol
Which liquid would have the highest solubility into carbon tetrachloride? 1-hexanol
(CCl_4 is nonpolar due to symmetry)

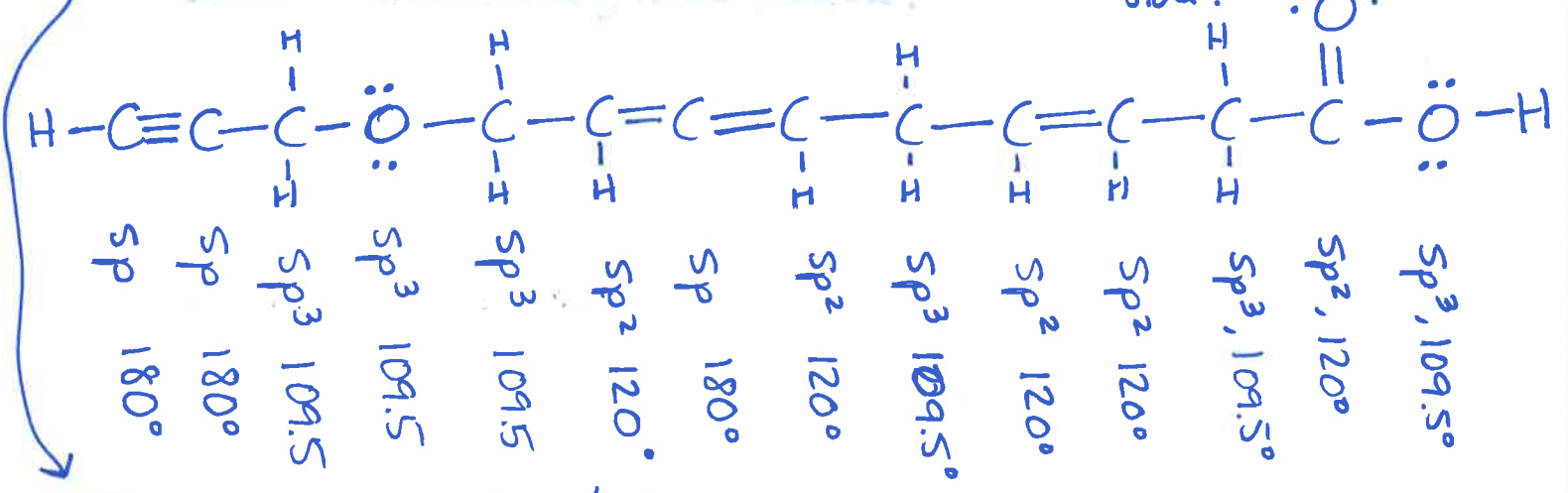
c. Propylene Glycol (1,2-propanediol; $C_3H_6(OH)_2$) has a similar molar mass to butanol.
How would you expect propylene glycol and butanol to compare in terms of viscosity, boiling point, and vapor pressure?

propylene glycol will have higher viscosity and b.p. than butanol.
butanol will have a higher VP at a given temp.

d. Fullerenes/Buckyballs are slightly soluble in some solvents.
Which of the four liquids in the chart would be the best solvent for fullerenes? 1-hexanol
C_{60} / C_{70} / C_{36} etc are all nonpolar molecules since $\Delta EN = 0$.

12. Sketch the following molecule to show all the bonds, atoms, and lone pairs.
a. Determine the ideal bond-to-bond angle around each carbon and oxygen.
b. Determine the hybridization of each carbon and oxygen.
c. Determine the total number of pi bonds in the molecule. 6!
d. Does this molecule have the possibility of geometric isomers? Why/why not? yes! It has C=C double bonds with different groups attached on each side.
e. Is this compound saturated? Why/why not?

$HC\equiv C-CH_2-O-CH_2-CH=C=CH-CH_2-CH=CH-CH_2-CH=CH-CH_2-COOH$

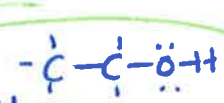


e) no, it is unsaturated.
compounds w/ C=C or C≡C (or both) are unsaturated; they contain less than the "max" # of hydrogens.

13. For each pair of compounds, circle the compound with the stronger intermolecular force/higher melting point/higher boiling point.

ethanal — Dipole-Dipole

or

ethanol  — H-bonding

C_8H_{18} — London

or

$C_7H_{15}OH$ — H-bonding

Covalent network solid — Diamond

or

Tin — metallic bonding

KNO_3 (+1/-1)

or

K_2O (+1/-2)

Both are ionic, but ions have greater charge in K_2O

H-bonding — H_2O

or

SiO_2 — C.N.S.

hexane

or

nonane

Both just have London, so the bigger one wins

Ion-Ion — NaOH

or

CH_3OH — H-bonding

metallic bonding — magnesium

or

graphite — CNS

H-bonding — CH_3OH

or

Kr — London

AgCl (+1/-1)

or

CuS (+2/-2)

Both ionic, but CuS has larger charges

H-bond — $C_3H_7\ddot{O}H$ (alcohol)

or

$CH_3\text{-}\ddot{O}\text{-}CH_2CH_3$ (ether) — Dipole - Dipole

$CH_3CH_2CH_2CH_2\text{-}O\text{-}CH_2CH_3$

or

$CH_3\text{-}O\text{-}CH_2CH_3$

Both Dipole - Dipole, but the larger one has Stronger London Forces

CF_4

or

CI_4

Both nonpolar (symmetry) So just London Forces, So the bigger one wins.

H_2O — H-bonding

or

CH_4 — London

13 cont'd. For each pair of compounds, circle the compound with the stronger intermolecular force/higher melting point/higher boiling point.

H-bonding H_2O or $MgSO_4$ ion-ion

H-bonding H_2O or Zn metallic bonding

Dipole^2 butanone or butanol H-bond

H bond H_2O or SiC CNS

London I_2 or SiC CNS

FeO +2/-2 or RbCl +1/-1 Both ionic, but FeO has higher charges

Ion-ion $Mg(OH)_2$ or $C_2H_4(OH)_2$ H-bonding

methyl amine or ethyl amine Both H-bonding, but the larger one (ethyl amine will have stronger London Forces

(Cobalt) Metallic Bonding Co or CO carbon monoxide Dipole-Dipole

London propane vs ethylamine H-bond

CNS Si vs Ar London

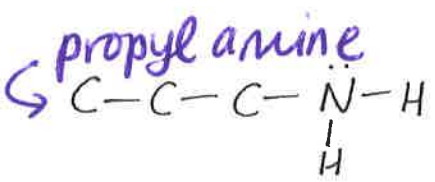
$C_4H_{10}O$ vs $C_{10}H_{22}O$ Both dipole-Dipole (assuming neither is an alcohol) So the bigger one wins- stronger London

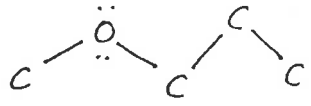
$BaSO_4$ +2/-2 vs BaO +2/-2 Ionic w/same charges, but O^{-2} has a smaller radius than SO_4^{-2} so BaO has stronger coulomb attraction since ions can get close together.

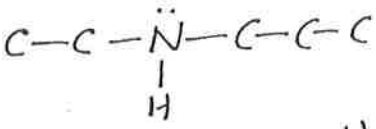
Both London C_5H_{12} vs C_4H_{10}

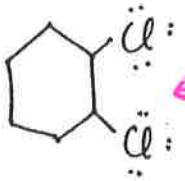
London C_5H_{12} vs Ge CNS

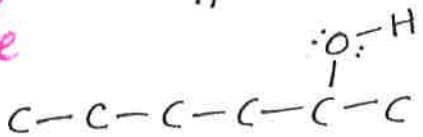
14. Name each compound!

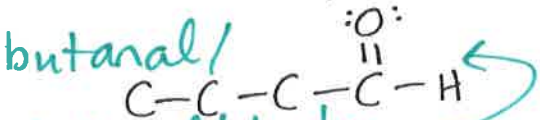

propyl amine

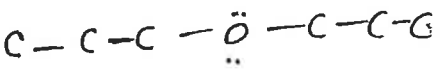

methyl propyl ether

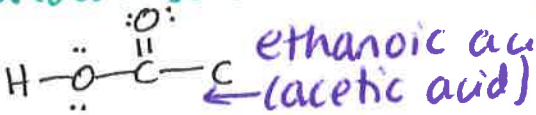

ethyl propyl amine

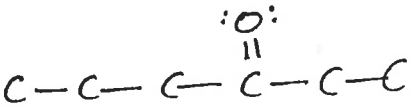

1,2 dichloro cyclohexane

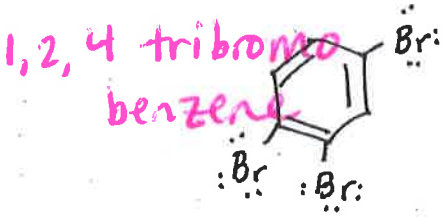

2-hexanol

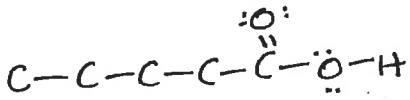

butanal / butanaldehyde

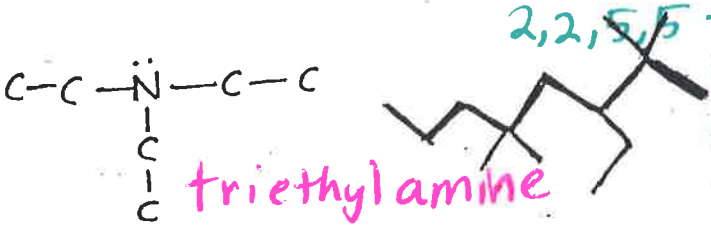

dipropyl ether


ethanoic acid (acetic acid)

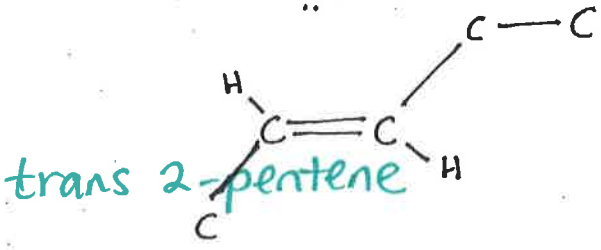

3-hexanone

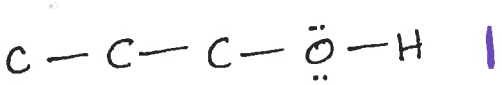

1,2,4 tribromo benzene


pentanoic acid

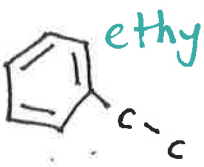

2,2,5,5 tetramethyl 3 ethyl octane

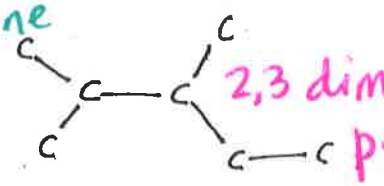
triethylamine

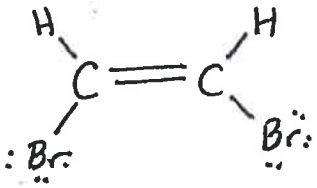

trans 2-pentene

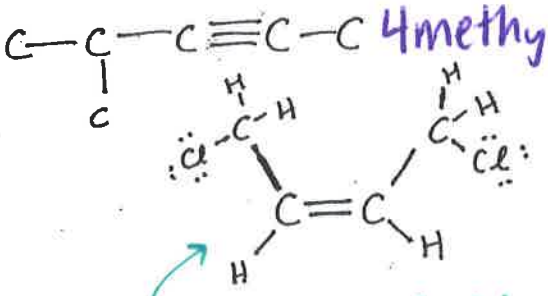

1-propanol

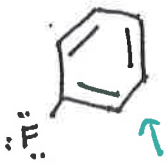

cyclopentanol


ethyl benzene


2,3 dimethyl pentane


cis 1,2 dibromo ethene

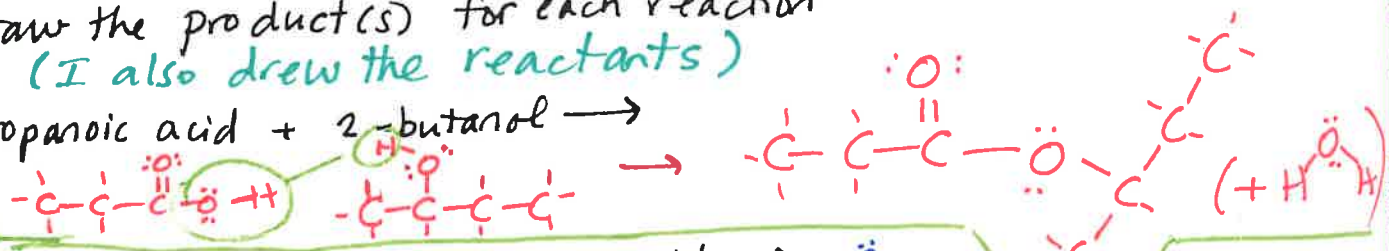

4methyl-2-pentyne


fluorobenzene

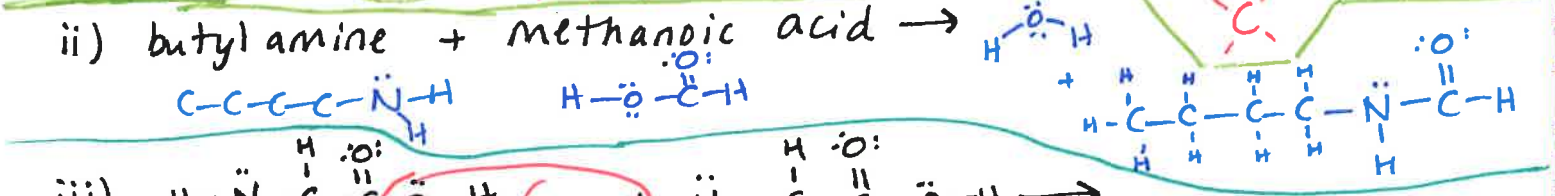
cis-1,4 dichlorobutene

a) Draw the product(s) for each reaction:
(I also drew the reactants)

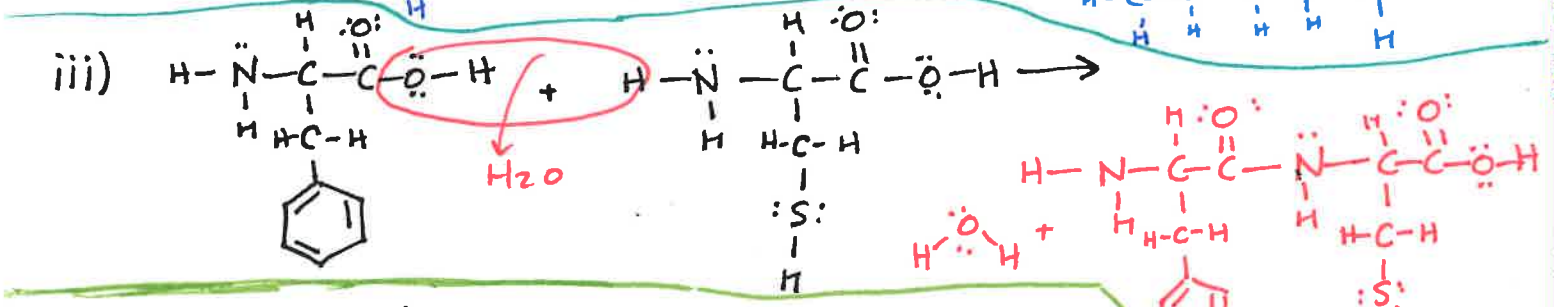
i) propanoic acid + 2-butanol →



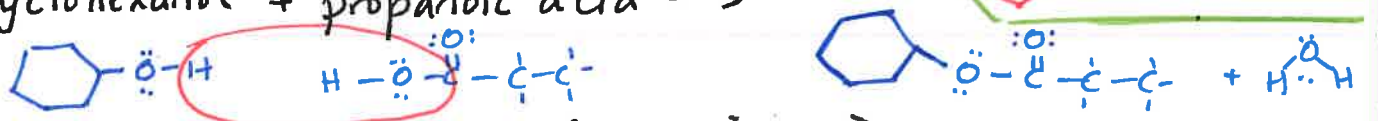
ii) butyl amine + methanoic acid →



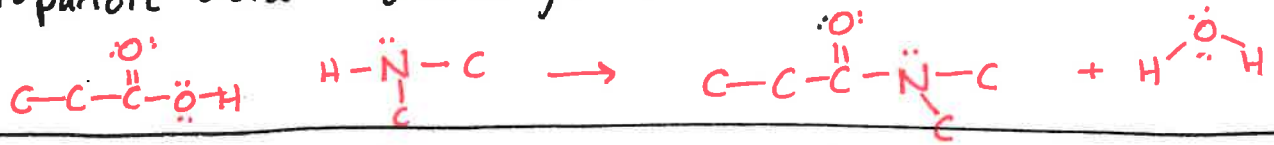
iii)



iv) cyclohexanol + propanoic acid →



v) propanoic acid + dimethyl amine →



b) Complete and balance each reaction

i) C_3H_6 (propene) + H_2 $\xrightarrow{Pt}$ C_3H_8

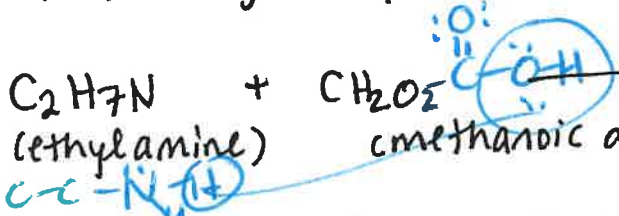
ii) C_2H_2 (ethyne) + $2H_2$ $\xrightarrow{Pt}$ C_2H_6

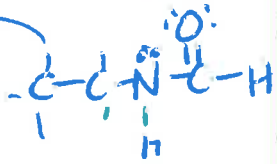
iii) C_7H_{14} (1-heptene) + H_2 $\xrightarrow{Pt}$ C_7H_{16}

iv) C_7H_{12} (1-heptyne) + $2H_2$ $\xrightarrow{Pt}$ C_7H_{16}

v) C_7H_{12} (cycloheptene) + H_2 $\xrightarrow{Pt}$ C_7H_{14}

vi) C_2H_7N (ethylamine) + CH_2O_2 (methanoic acid) → C_3H_7NO + H_2O





vii) CH_4O (methanol) + $C_5H_{10}O_2$ (pentanoic acid) → $C_6H_{12}O_2$ + H_2O

16. Distillation.
Consider the compounds 1-hexanol ($C_6H_{14}O$) and 1-tetradecanol($C_{14}H_{26}O$).
Suppose that a 50/50 mixture of these liquids is placed into a flask and heated, so that the mixture boils.

a. Which compound will be more prevalent in the vapor? Why? Explain in terms of intermolecular forces.

Both liquids have an O-H bond, so both are capable of hydrogen bonding. But the $C_{14}H_{26}O$ will have significantly stronger London Dispersion Forces than the $C_6H_{14}O$. This is because $C_{14}H_{26}O$ is a larger molecule, so it is more polarizable than $C_6H_{14}O$, and it has more surface area than $C_6H_{14}O$. So $C_{14}H_{26}O$ has stronger overall intermolecular forces than $C_6H_{14}O$. This means the $C_{14}H_{26}O$ will not evaporate as easily as $C_6H_{14}O$; $C_{14}H_{26}O$ will have a higher boiling point and a lower vapor pressure at a given temperature.

So $C_6H_{14}O$ will evaporate more, and will have a higher vapor pressure; $C_6H_{14}O$ will be more abundant in the vapor phase.

b. The vapor is run through a condenser and then drips into a collection flask. Which compound will be more prevalent in the collection flask?

$C_6H_{14}O$. (The same compound that is more abundant in the vapor phase will be more abundant in the collection flask; all the vapor condenses to liquid.)

Now consider the compounds hexane (C_6H_{14}) and 1-pentanol ($C_5H_{12}O$).
Suppose that a 50/50 mixture of these liquids is placed into a flask and heated, so that the mixture boils.

c. Which compound will be more prevalent in the vapor phase? Explain in terms of intermolecular forces.

These compounds are similar sizes, so will have similar strengths of London Dispersion forces. But pentanol has a polar O-H bond, so pentanol can hydrogen bond, whereas hexane is nonpolar, so can not H-bond. Since pentanol can hydrogen bond, it has the stronger intermolecular forces, so will have a lower vapor pressure at a given temperature.

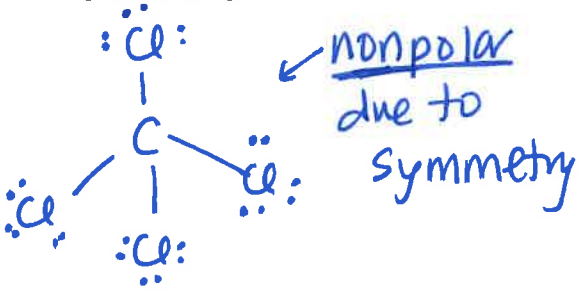
Therefore the hexane will have a higher vapor pressure; hexane will be more abundant in the vapor.

d. After the mixture has been boiling for a while, which liquid will be more prevalent in the original flask?

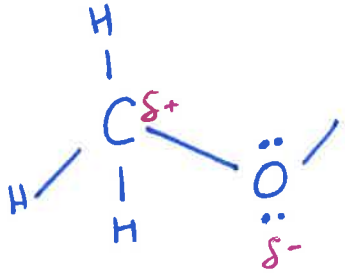
pentanol since less of it boiled away.
(hexane will be more abundant in the collection flask)

17. Consider the compounds carbon tetrachloride and methanol.

a. Draw the complete dot structure for each compound, including geometry, and classify the compound as polar or nonpolar.

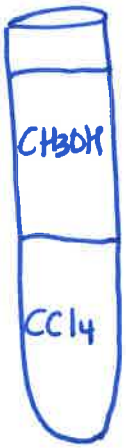


nonpolar due to symmetry



polar due to C–O and O–H bonds, both of which are polar.

b. A large testtube is filled about halfway with carbon tetrachloride and then filled the rest of the way with methanol. The liquids form 2 distinct layers with the carbon tetrachloride on the bottom. A mixture of two compounds ($C_3H_6O_3$ and $C_8H_{18}O$) is added to the testtube and the mixture is shaken up so that the two compounds can dissolve. Which compound will dissolve into which layer/liquid? Explain.



← the $C_3H_6O_3$ will end up in the CH_3OH layer. $C_3H_6O_3$ is highly polar since it has 3 oxygens per the 3 carbons; a large % of the molecule is polar ($C_3H_6O_3$ and CH_3OH are both polar; like dissolves like)

← the $C_8H_{18}O$ will dissolve in the CCl_4 layer. even though $C_8H_{18}O$ is somewhat polar, due to the oxygen, it has a relatively large carbon chain, which is nonpolar. since it is mostly nonpolar it will dissolve with CCl_4, which is nonpolar.

A sample of the mixture from part b ($C_3H_6O_3$ and $C_8H_{18}O$) is placed on some chromatography paper and the paper is placed in a beaker containing solvent at the bottom. The solvent travels up the paper, taking the compounds with it.

c. Which compound ($C_3H_6O_3$ or $C_8H_{18}O$) will travel further up the paper if the solvent is <u>hexane</u>? $C_8H_{18}O$

d. Which compound will travel further up the paper if the solvent is <u>water</u>? $C_3H_6O_3$

(hexane is nonpolar, so the $C_8H_{18}O$ (fairly nonpolar) will dissolve more into the hexane and will be carried further up the paper.)

(water is polar, so the $C_3H_6O_3$ (very polar) will dissolve more into the H_2O and will be carried further up the page.)