Exam 3 results - 74% on MC

free response - 29/48 EXAM 3 total avg - 62% (C+)

- partial credit given, esp. redox problem

Review session for final - Wed 7-9pm rm 100
Dec. 5

Final Exam: Friday Dec 7, 3-5pm rm 100.

HW #4 due @ final lecture (Tues Dec. 4)
evaluations on this Thursday.

gases	liquids	solids
1. fill the container	1. conform to container shape	1. definite shape
2. compressible	2. not very compressible	2. not compressible
3. low density	3. in between (closer to solid)	3. high density
4. diffuses rapidly (through gases)	4. diffuses through other liquids	4. very slow diffusion
5. very disordered	5. disordered	5. ordered (usually)

pressure - forces molecules together.

Temp - as temp decreases, K.E. decreases - molecules get closer.

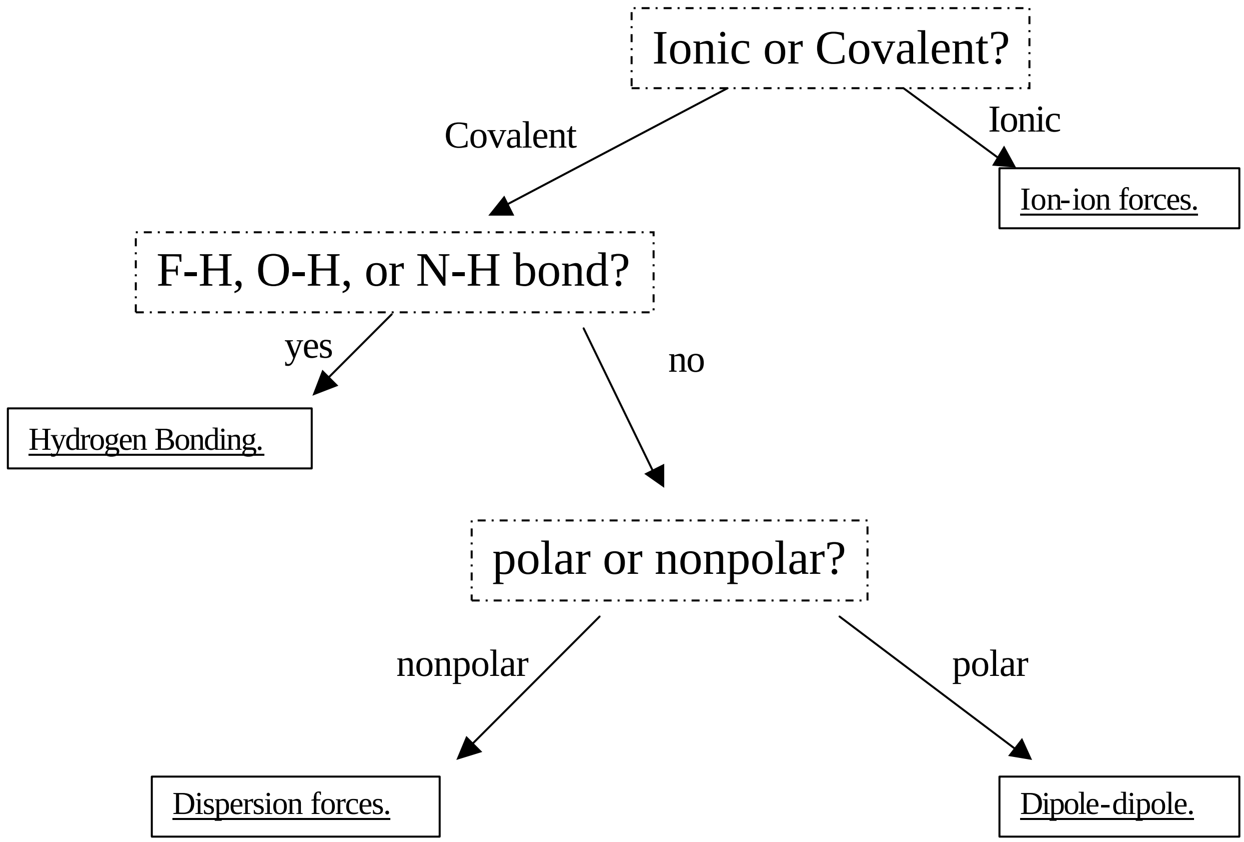
Some terminology

* **inter**molecular forces - forces between 2 (or more) molecules

intramolecular forces - forces within a molecule (covalent bond)

* without intermolecular forces, liquids & solids wouldn't exist

Flow Chart for Intermolecular Forces within Pure Substances



4 different Kinds of intermolecular forces we discuss
(esp. for liquids)

1. <u>ion-ion</u> forces. (note: strange because we are talking about molecules. but we still call it an IM force)

force of attraction between 2 oppositely charged ions (+ & -)
ex) Na^+Cl^-

<u>very strong</u> forces. melting point NaCl ~ 800°C
boiling point - really, really high.

$$F \propto \frac{q^+ q^-}{d^2}$$ (Coulomb's law) higher the charge, higher the B.P./M.P.

note - ion-ion bonding is also an intramolecular force (only one I can think of that's both)

2. <u>dipole-dipole</u> forces.

force of attraction between polar covalent molecules because of the δ^+ on one molecule being attracted to the δ^- on another molecule.

? Fig 13.3. Br-F, SO_2.

SO_2: $6 + 2(6) = 18/8 = 2$ w/ $2e^-$ left
(3 things.

remember, to figure out if something is polar, one "side" has to be different than other - need molecular geometry (if not name, at least an approx. pic.)

<u>Medium</u> strength interaction. boiling points (& melting points) are lower than for compounds with ion-ion forces. (we'll come back to this)

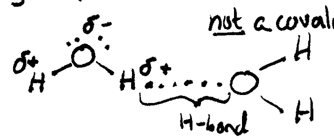
3. <u>Hydrogen bonding</u>.

force of attraction between polar covalent molecules which contain an F–H, N–H, or O–H bond.

(special case of dipole-dipole but a lot stronger). (highly EN, small atoms)

not a covalent bond.

Fig. 13.4.



<u>strong</u> intermolecular force. very important.

compounds w/ H-bonding exhibit "anomalously" high boiling (& usually melting) points.

Fig 13.5.

ex. H_2O, NH_3, CH_3OH, HF

boiling point is good indicator of strength of intermolecular force

4. <u>dispersion forces</u> (also called London forces).
van der Waals forces

force of attraction caused by temporarily-induced dipole-dipole interaction

(explains how nonpolar molecules can form liquids & solids). most important intermolecular force in nonpolar materials.

Fig 13.6 Ar atom (electron cloud a little like an unbalanced washing mashine).

can happen because of nearby cation or anion, but not necessarily.

Once electrons are lopsided, the Ar atom can go polarize <u>other</u> argon atoms

polarized atoms exist fleetingly (unlike the unbalanced washer, they re-balance themselves)

* • the larger the molecule (heavy and/or bulky), the easier it is to induce a dipole (bigger electron clouds)

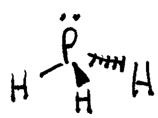
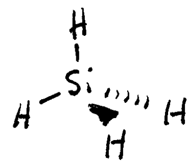
exist in most molecules (dipole-dipole & H-bonded too)

strength of dispersion forces

- "weak" (but not really).
- consider Fig. 13.5.
  within each group (except H-bonded species)
  b.p. <u>increases</u> with increasing m.w.
  this is due to dispersion forces increasing.

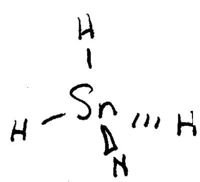
compare PH_3 & SiH_4

mw: 34g/mol   mw: 32g/mol   pretty close

polar     nonpolar.

~ -90°C   ~-110°C slightly lower

↑ dipole-dipole forces.
(+ dispersion forces)

 ~mw 123g/mol   ~ -50°C

dispersion forces only but intermolecular forces are enough to surpass PH_3.

boiling point is indicator of intermolecular forces - the higher the B.P., the stronger the intermolecular attraction.

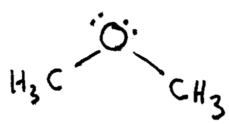
dispersion forces become most important for heavy or bulky molecules

CH_4	methane	−164°C	16g/mol
C_2H_6	ethane	−88.6°C	30g/mol
C_4H_{10}	n-butane	−0.5°C	58g/mol

DNA/RNA building blocks – Fig. 28.15
DNA/RNA bases – Fig. 28.17
DNA hydrogen bonding – Fig 28.18
DNA hydrogen bonding – Fig 28.19

Quiz 8 key

- which compounds exhibit hydrogen bonding?
- If no H-bonding is present, what ~~is~~ other intermolecular forces are present?

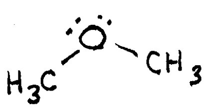


CH_4 $\qquad$ $CH_3\overset{O}{\overset{\|}{C}}{-}OH$ $\qquad$ CH_3OH

note - all 4 molecules have dispersion forces.

$CH_3\overset{O}{\overset{\|}{C}}{-}OH$ & CH_3OH have O-H bonds - hydrogen bonding.
(also dispersion forces).

CH_4 is nonpolar - has only dispersion forces.



is polar - has dipole-dipole forces as well as dispersion forces.