

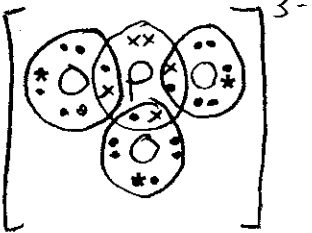
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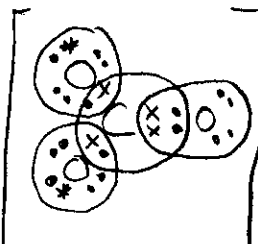
Name: \_\_\_\_\_

**SCH 4U Unit Test**  
**Forces and Molecular Properties**


1. Fill in each table as done on the assignment. Including the oxidation state of the central atom:

$PO_3^{3-}$ 	total # of $e^-$ pairs	4
	$\sigma$ bonding pairs	3
	lone pairs	1
	$\pi$ bonding pairs	0
	base shape	tetrahedral
	actual shape	pyramidal
oxidation state of P $3+$	approx. bond angles	$< 109.5^\circ$

9

$CO_3^{2-}$ 	total # of $e^-$ pairs	4
	$\sigma$ bonding pairs	3
	lone pairs	0
	$\pi$ bonding pairs	1
	base shape	trigonal planar
	actual shape	trigonal planar
oxidation state of C $4+$	approx. bond angles	$\sim 120^\circ$

9

$IF_3$ 	total # of $e^-$ pairs	5
	$\sigma$ bonding pairs	3
	lone pairs	2
	$\pi$ bonding pairs	0
	base shape	trig. bipyramidal
	actual shape	T-shaped
oxidation state of I $3+$	approx. bond angles	$< 90^\circ$

8

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2. Classify each of the following formula according to type of forces by placing each formula in the correct place in the table:

CH<sub>3</sub>COOH (acetic acid)

HF (hydrogen fluoride)

CH<sub>3</sub>COCH<sub>3</sub> (acetone)

ICl (iodine monochloride)

Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> (aluminum sulphate)

Mn (manganese)

(NH<sub>4</sub>)<sub>3</sub>PO<sub>4</sub> (ammonium phosphate)

OF<sub>2</sub> (oxygen difluoride)

C<sub>6</sub>H<sub>6</sub> (benzene)

PCl<sub>5</sub> (phosphorus pentachloride)

Cu<sub>0.85</sub>Zn<sub>0.10</sub>Sn<sub>0.05</sub> (brass)

KCl (potassium chloride)

CBr<sub>4</sub> (carbon tetrabromide)

SiO<sub>2</sub> (quartz)

C<sub>n</sub> (diamond)

Rb<sub>3</sub>N (rubidium nitride)

C<sub>12</sub>H<sub>26</sub> (dodecane)

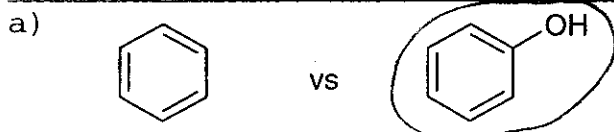
H<sub>2</sub>O (water)

C<sub>2</sub>H<sub>5</sub>OH (ethyl alcohol)

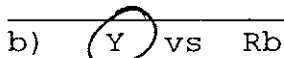
CH<sub>2</sub>O (formaldehyde)

Ionic Crystals (including crystals containing polyatomic ions)	Covalently Bonded Compounds			Metallic Crystals	
	Covalent Network Crystals	Discrete Covalent Molecules			
		van der Waal (intermolecular force)	dipole inter-action (intermolecular force)		hydrogen bond (intermolecular force)
Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> (NH <sub>4</sub> ) <sub>3</sub> PO <sub>4</sub> KCl Rb <sub>3</sub> N	C <sub>n</sub> SiO <sub>2</sub>	C <sub>6</sub> H <sub>6</sub> CBr <sub>4</sub> C <sub>12</sub> H <sub>26</sub> PCl <sub>5</sub>	CH <sub>3</sub> OCH <sub>3</sub> CH <sub>2</sub> O OF <sub>2</sub>	CH <sub>3</sub> COOH C <sub>2</sub> H <sub>5</sub> OH HF H <sub>2</sub> O	CuZnSn Mn

3. For each pair of compounds, circle the one with the higher melting and/or boiling point. In the space provided give the rationale for your choice. Including precise reference to the attractive forces that must be overcome to melt or boil each compound as well as any other forces that may be present and why this leads to the choice you have made. Be specific as to whether the forces that must be overcome are intramolecular or intermolecular. Include any additional relevant information that has helped your choice. Use point form.



phenol - intermolecular H-bond } both cov. intra } 4  
 benzene - intermolecular v.d.w. } (discrete cov. molecules)  
 H-bond > v.d.w. ∴ higher M.P.



both metallic intramolecular forces

- higher charge, stronger metallic bond

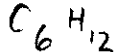
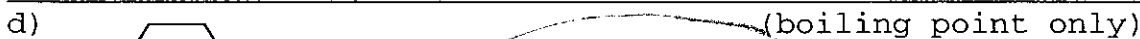
∴ higher M.P. (also check periodic table!)



$\text{HF}$  - intermolecular H-bond } both cov. intra

$\text{HCl}$  - intermolecular dipole } (discrete cov. molecules) } 4

H-bond > dipole ∴ higher M.P.

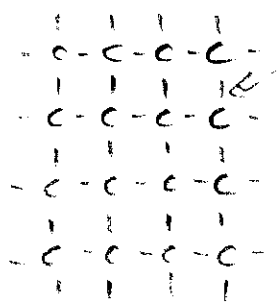


both cov. intra } (discrete cov. molecules) } 4

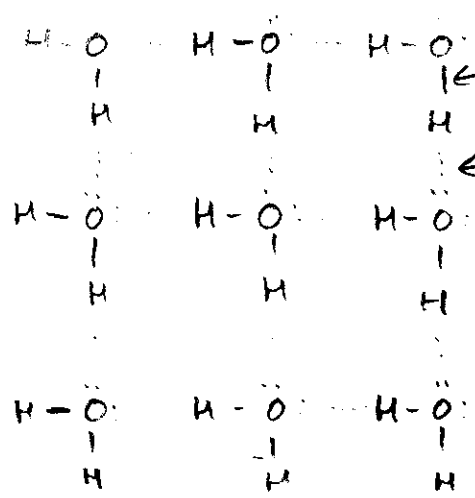
- both equivalent v.d.w. intermolecular forces

- the snaky 1-hexene will have stronger liquid attractions than the symmetrical cyclohexane

4. Both water and diamond contain covalent bonds. The covalent bond in water has an approximate bond strength of 464 kJ/mol while the single carbon carbon bonds in diamond are approximately 347 kJ/mol. Does this mean that diamond will have a lower melting point in comparison to water? Explain FULLY with reference to attractive forces, diagrams etc. By the way, this is an open ended question.



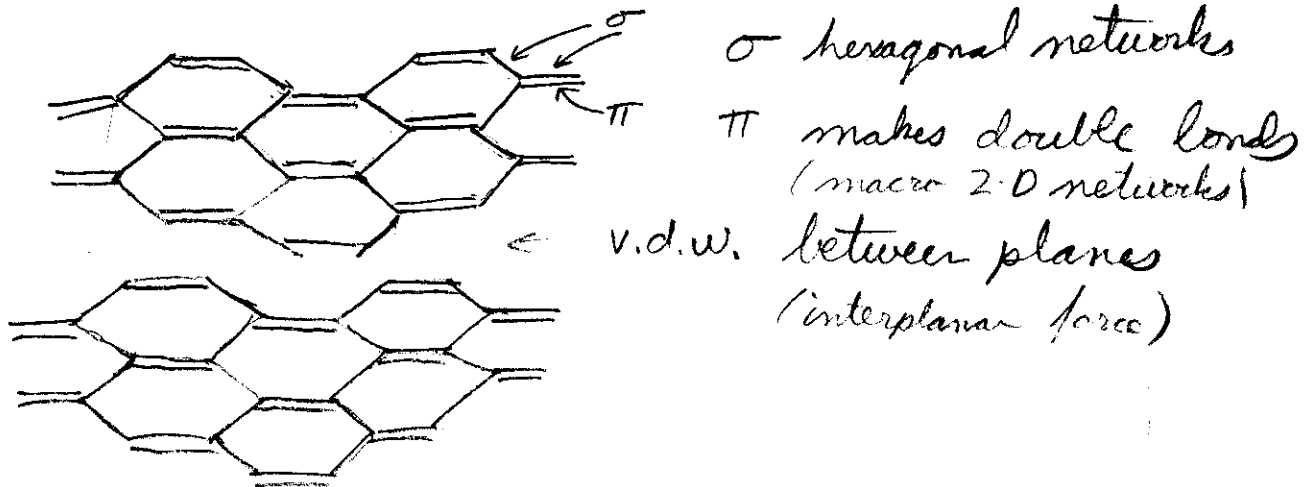
cov. intramolecular (347 kJ/mol)  
 (cov. network solid macromolecule)  
 - covalent bonds must be affected to melt and boil



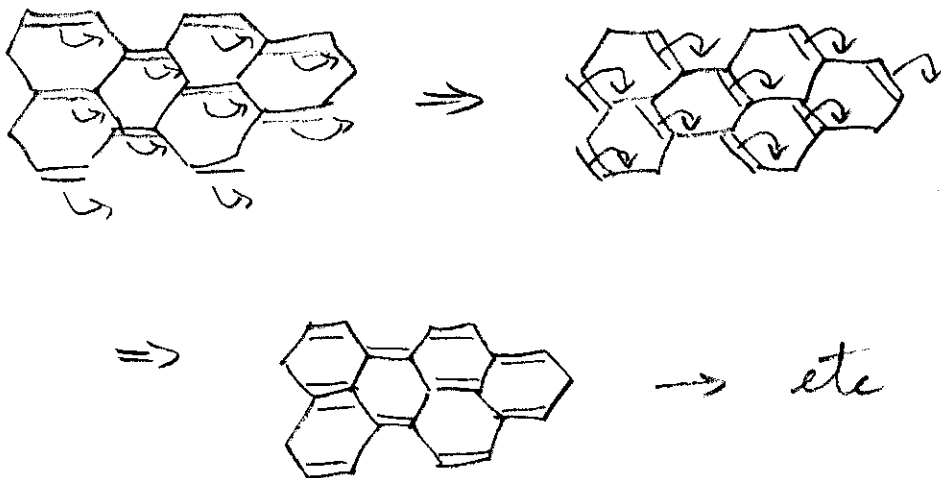
← cov. intramolecular (464 kJ/mol)  
 (discrete cov. molecule)  
 ← H-bond intermolecular  
 - H-bond must be affected to melt or boil

H-bond are 10% the strength of cov. bonds  
 ∴ H<sub>2</sub>O is much easier to melt or boil than diamond

5. Draw a diagram of graphite that shows several planes within graphite and include the details of bonding within each plane. With reference to your diagram indicate:
- the location of sigma bonds
  - the location of pi bonds
  - the area where van der Waals forces are found
  - the reason for the anisotropic conductivity



d) top view



- $\pi$   $e^-$  are delocalized and able to "walk" across the planes ( $e^-$  resonance)
- cannot resonate between planes

6. What are the smallest possible units of solute in each of the following solutions. What forces must be overcome in the solute in order to facilitate dissolving. N.A. may be an appropriate response.

	Smallest Units	Solute Force Overcome
wax (C <sub>50</sub> H <sub>102</sub> ) dissolved in hexane (C <sub>6</sub> H <sub>14</sub> )	C <sub>50</sub> H <sub>102</sub>	v.d.w. (intermolecular)
wax (C <sub>50</sub> H <sub>102</sub> ) dissolved in water (H <sub>2</sub> O)	N.A.	N.A.
NaCl dissolved in hexane (C <sub>6</sub> H <sub>14</sub> )	N.A.	N.A.
NaCl dissolved in water (H <sub>2</sub> O)	$\begin{array}{c} > \vee \vee \\ > \text{Na}^+ < \\ > \wedge \Gamma \end{array} \quad \begin{array}{c} \wedge \\ < \text{Cl}^- > \\ \vee \\ \vee \end{array}$	ionic bond (intramolecular)
(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> dissolved in water (H <sub>2</sub> O)	NH <sub>4</sub> <sup>+</sup> CO <sub>3</sub> <sup>2-</sup> NH <sub>4</sub> <sup>+</sup> etc.	ionic bond found between discrete cov. ions
Au dissolved in mercury (Hg)	Au or Au <sup>3+</sup> + 3e <sup>-</sup>	metallic bond intramolecular

δ<sup>+</sup>H-δ<sup>-</sup>O:δ<sup>-</sup>  
δ<sup>+</sup>H-δ<sup>-</sup>O:δ<sup>-</sup>

7. Provide an example (chemical formula) for each of the following solids:

- covalent network solid: C<sub>n</sub> (SiO<sub>2</sub>)<sub>n</sub>
- ionic solid: NaCl
- metallic solid: Fe
- molecular solid: H<sub>2</sub>O
- ionic solid composed of non-metals only: (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>

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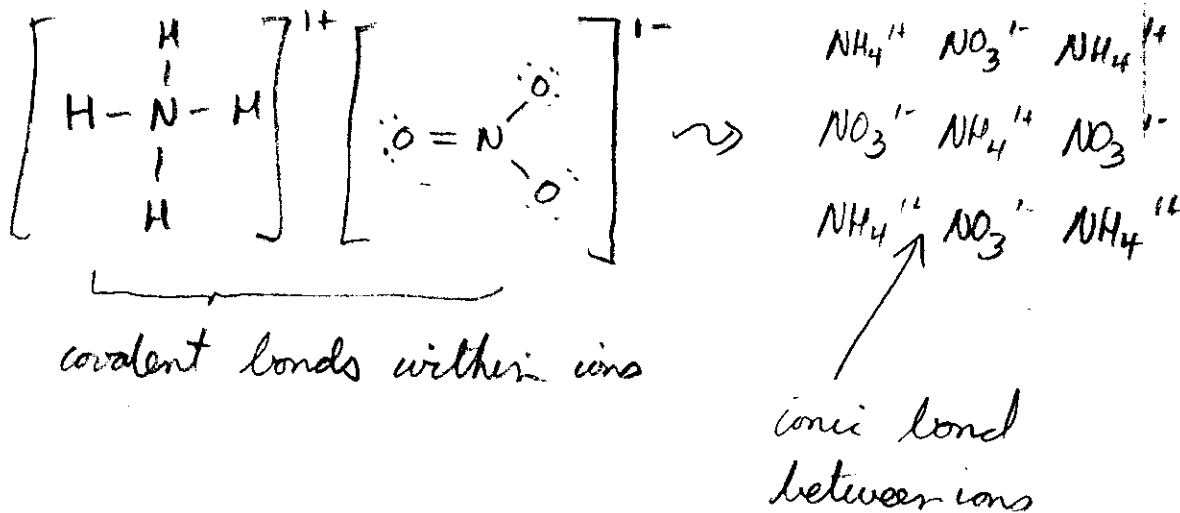
8. Explain the reason for the observed conductivity or lack there of in the following substance (note the states). Be sure to include the exact nature of the charge carriers where appropriate:

state observed conductivity

iron (s)	high - free moving $e^-$ in metallic bond
NaCl (aq)	fair - free moving $Na^+$ and $Cl^-$ ions
NaCl (s)	non-conductive (ions locked in lattice)
$SiO_2$ (s)	non-conductive (no charged particles)
$C_{25}H_{52}$ (l)	non-conductive (no charged particles)
$CH_3COOH$ (aq)	$\rightarrow CH_3COO^- + H^+$ slight conductivity

due to dissociation to free ions

9. How can covalent bonds lead to ionic compounds. What are some of the difficulties in the full classification for such a substance. Answer this question with reference to an example of your choice!



- classified ionic because it behaves as an ionic compound (M.P., B.P., solubility, conductivity)
- no true intramolecular force (intramolecular)
- interionic force is the "second" force

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5

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