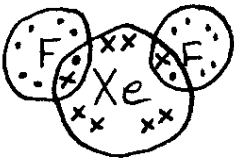


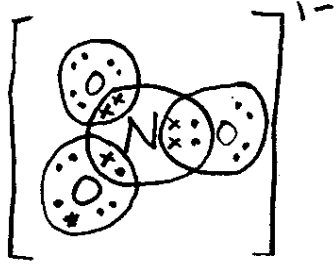
Name: \_\_\_\_\_

SCH 4U Unit Test  
Forces and Molecular Properties

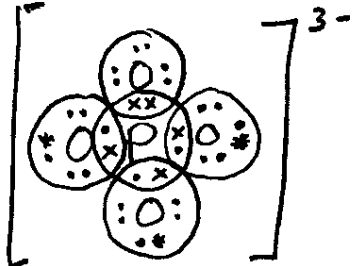
1. Fill in each table as done on the assignment. Including the oxidation state of the central atom:

|   |                            |                      |
|---|----------------------------|----------------------|
| $\text{XeF}_2$<br> | total # of $e^-$ pairs     | 5                    |
|   | $\sigma$ bonding pairs     | 2                    |
|   | lone pairs                 | 3                    |
|   | $\pi$ bonding pairs        | 0                    |
|   | base shape                 | trigonal bipyramidal |
|   | actual shape               | linear               |
|   | oxidation state of Xe $2+$ | approx. bond angles  |

8

|  |                           |                     |
|--|---------------------------|---------------------|
| $\text{NO}_3^{1-}$<br> | 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 N $5+$ | approx. bond angles |

8

|   |                           |                     |
|---|---------------------------|---------------------|
| $\text{PO}_4^{3-}$<br> | total # of $e^-$ pairs    | 4                   |
|   | $\sigma$ bonding pairs    | 4                   |
|   | lone pairs                | 0                   |
|   | $\pi$ bonding pairs       | 0                   |
|   | base shape                | tetrahedral         |
|   | actual shape              | tetrahedral         |
|   | oxidation state of P $5+$ | approx. bond angles |

8

24

- Fe (iron)
- LiF (lithium fluoride)
- K<sub>2</sub>SO<sub>4</sub> (potassium sulphate)
- CO<sub>2</sub> (carbon dioxide)
- C<sub>3</sub>H<sub>8</sub> (propane)
- CH<sub>3</sub>COCH<sub>3</sub> (acetone)
- H<sub>2</sub>O (water)
- Fe<sub>0.95</sub>Ni<sub>0.05</sub>
- Br<sub>2</sub>
- C<sub>3</sub>H<sub>7</sub>OH (isopropyl alcohol)
- NH<sub>3</sub> (ammonia)
- NH<sub>4</sub>NO<sub>3</sub> (ammonium nitrate)
- CH<sub>3</sub>COOH (acetic acid)
- Si (silicon) (b.p. = 3538 K)
- PH<sub>3</sub> (phosphorus trihydride)
- SiO<sub>2</sub> (quartz)
- C<sub>6</sub>H<sub>6</sub> (benzene)
- O<sub>2</sub> (oxygen)

| Ionic Crystals<br>(including crystals containing polyatomic ions)        | Covalently Bonded Compounds              |  |   | Metallic Crystals   |   |
|--|--|--|---|---|---|
|  | Covalent Network Crystals                | Discrete Covalent Molecules  |   |   |   |
|  |  | van der Waal<br>(intermolecular force)   | dipole interaction<br>(intermolecular force)  |   | hydrogen bond<br>(intermolecular force)     |
| LiF<br>K <sub>2</sub> SO <sub>4</sub><br>NH <sub>4</sub> NO <sub>3</sub> | C <sub>n</sub><br>Si<br>SiO <sub>2</sub> | CO <sub>2</sub> ↔ (CO <sub>2</sub> )<br>C <sub>3</sub> H <sub>8</sub><br>Br <sub>2</sub><br>PH <sub>3</sub><br>C <sub>6</sub> H <sub>6</sub><br>O <sub>2</sub> | CH <sub>3</sub> COCH <sub>3</sub><br>C <sub>2</sub> H <sub>5</sub> OC <sub>2</sub> H <sub>5</sub> | H <sub>2</sub> O<br>C <sub>3</sub> H <sub>7</sub> OH<br>NH <sub>3</sub><br>CH <sub>3</sub> COOH | Fe<br>Fe <sub>0.95</sub> Ni <sub>0.05</sub> |

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.

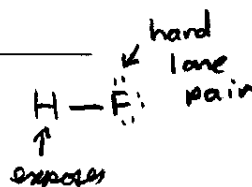
a) HF vs HCl

- HF will hydrogen bond with other HF

- HCl will form dipoles with other HCl

- H-bond is stronger than dipole,  $\therefore \delta^+H \leftrightarrow \delta^-F$  higher M.P. + B.P.

- in both cases intermolecular forces must be overcome



b) SiO<sub>2</sub> vs SiF<sub>4</sub>

- SiO<sub>2</sub> is a covalent network solid,  $\therefore$  covalent intramolecular forces must be overcome

- SiF<sub>4</sub> is a discrete covalent non-polar molecule,  $\therefore$  v.d.w. intermolecular forces must be overcome

- v.d.w. is 1/100 as strong as covalent  $\therefore$  huge difference!

c) H<sub>2</sub>CCl<sub>2</sub> vs CF<sub>4</sub>

- both discrete covalent molecules, both with 42e<sup>-</sup> each,  $\therefore$  equivalent v.d.w. intermolecular forces

- H<sub>2</sub>CCl<sub>2</sub> forms a dipole and therefore has an additional intermolecular force, stronger than v.d.w.

- greater intermolecular force  $\therefore$  higher M.P. + B.P.

d) Mg vs Al

- both metallic intramolecular forces need be overcome

- Mg  $\rightarrow$  Mg<sup>2+</sup> + 2e<sup>-</sup> vs Al  $\rightarrow$  Al<sup>3+</sup> + 3e<sup>-</sup>

- greater cation charge and "thicker e<sup>-</sup> soup" results in a stronger metallic bond

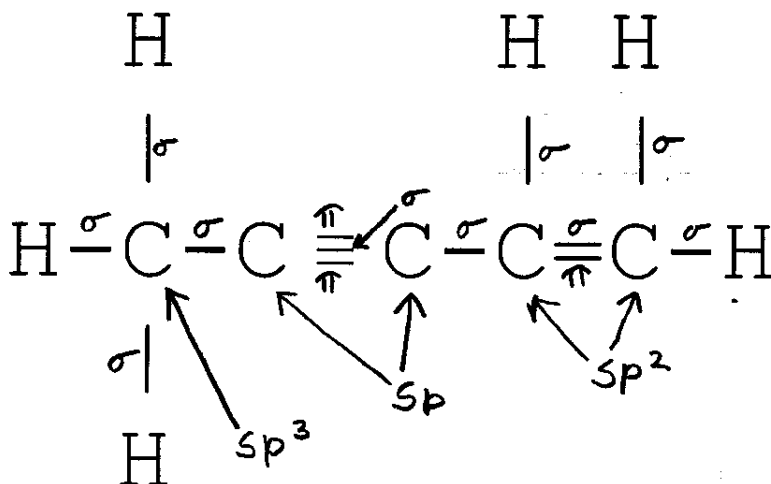
6  
11  
17  
17  
42

6  
9  
9  
9  
9  
42

4. Match each description with the term it best describes.

|          |  |               |                            |
|----------|--|---------------|----------------------------|
| <u>h</u> | always present between molecules within liquids or solids composed of discrete covalent molecules                  | <del>a)</del> | ionic bonding              |
| <u>l</u> | most diverse and specific type of bonding, well studied and complex  | <del>b)</del> | dipole interactions        |
| <u>m</u> | occupies the lattice points in ammonium nitrate ( $\text{NH}_4\text{NO}_3$ )                                       | <del>c)</del> | anisotropic                |
| <u>i</u> | property that is used when determining bond type or bond polarization possibilities                                | <del>d)</del> | metallic bonding           |
| <u>j</u> | requires hard charge polarization and lone pair interaction with N, O or F   | <del>e)</del> | alloy                      |
| <u>o</u> | $sp$ , $sp^2$ , $sp^3$ are examples of   | <del>f)</del> | covalent network crystal   |
| <u>n</u> | a solid that has molecules as the lattice points   | <del>g)</del> | sigma                      |
| <u>c</u> | an adjective that describes a physical property that has a directional characteristic                              | <del>h)</del> | van der Waal force         |
| <u>a</u> | creates macromolecules that may be soluble in water  | <del>i)</del> | electronegativity          |
| <u>k</u> | type of bond that has little effect on shape   | <del>j)</del> | hydrogen bond              |
| <u>f</u> | non-conductive in any state, insoluble in all solvents   | <del>k)</del> | pi                         |
| <u>e</u> | a solid that can have variable composition, a solid solution   | <del>l)</del> | covalent bonding           |
| <u>g</u> | forms the core (central bond) of double and triple bonds   | <del>m)</del> | polyatomic ions            |
| <u>b</u> | present when bond polarizations and geometry make possible regions of partial positive and partial negative charge | <del>n)</del> | molecular solid            |
| <u>d</u> | produces strong yet flexible bonds   | <del>o)</del> | hybridized atomic orbitals |

5. For the given structure identify all bonds as either sigma ( $\sigma$ ) or pi ( $\pi$ ).



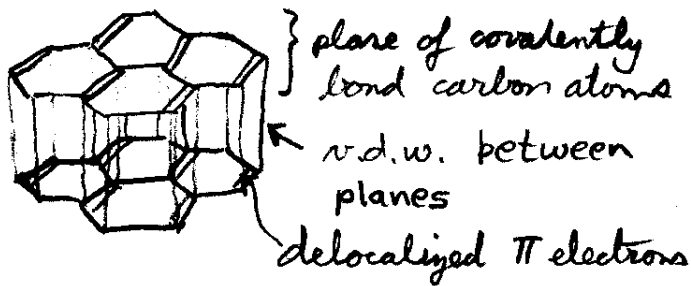
3

6. In the above diagram label the carbons that are  $sp^3$ ,  $sp^2$  and  $sp$  with respect to hybridization (tetrahedral, trigonal planar or linear)

3

7. Describe a two-dimensional covalent network solid of your choice (as if there is a choice)! A diagram would be most helpful to fully explain all types of attractive forces present in the solid. What is special about the  $\pi$  electrons in your solid. Why are words such as intramolecular and intermolecular at times somewhat limited?

Graphite



$\pi$  e<sup>-</sup> can flip position (electronic resonance) which allows electrical conductivity across (through) planes, conduction cannot occur between planes  $\therefore$  anisotropic conductivity

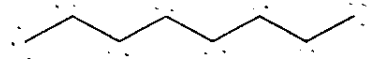
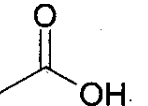
- covalently bonded flat planes }\* intraplamar  
 attracted to adjacent planes }\* interplamar  
 by a v.d.w force

\* "molecule" is hard to define  $\therefore$  the terms intramolecular + intermolecular do not really work (unless one treats a plane as a molecule)

15

8. Given the following structures and information:

$$\begin{array}{r}
 8(6) = 48 \\
 18(1) = 18 \\
 \hline
 66e^- \\
 \\
 6 \\
 6 \\
 8 \\
 8 \\
 4 \\
 \hline
 32e^-
 \end{array}$$

|   | M.P.   | B.P.   |
|---|--------|--------|
|  | -57 °C | 126 °C |
|  | -17 °C | 118 °C |

a) what class of compounds (ionic, covalent network, discrete covalent molecules, or metallic) do these substance belong to?

- discrete covalent molecules

b) what are ALL of the intermolecular forces present in the first compound (octane) in order of decreasing strength

- v.d.w. only

c) what are ALL of the intermolecular forces present in the second compound (acetic acid) in order of decreasing strength

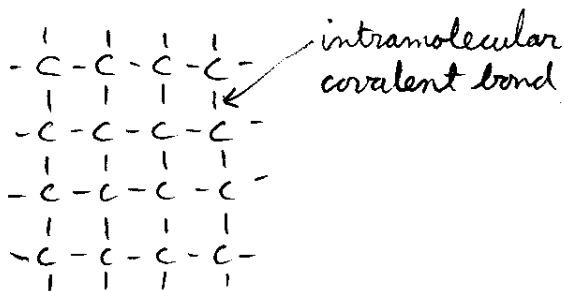
- H-bond, dipole, v.d.w.

d) offer a good explanation as to why the trend in melting point is reversed for these two compounds

- the acetic acid is small + somewhat symmetric and hence can form a well ordered solid crystal structure  
 - this improves attractive forces in the solid + hence raises M.P.

- snaky octane <sup>(66e<sup>-</sup>)</sup> make a good liquid, note the v.d.w. in octane is more than the H-bond in the smaller (less v.d.w.) <sup>(32e<sup>-</sup>)</sup> acetic acid

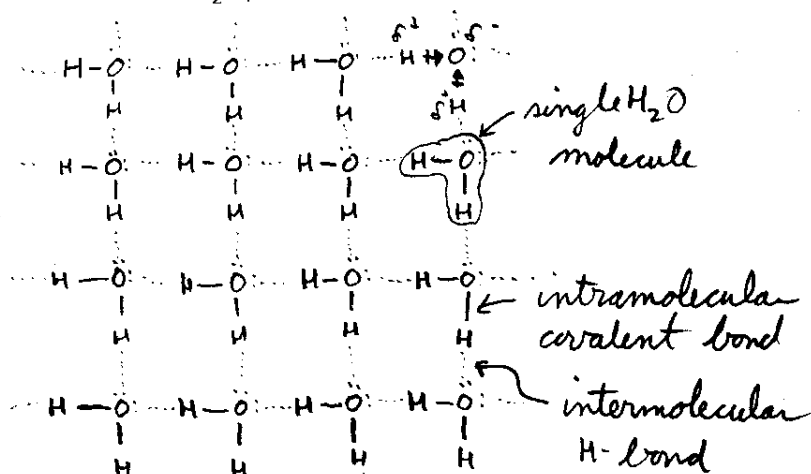
8. Draw a good two-dimensional representation of the three-dimensional structure of diamond, label all forces and classify according intra/ inter etc. What occupies the lattice points? What type of solid is this called.



- carbon atoms occupy lattice points
- covalent network solid

6

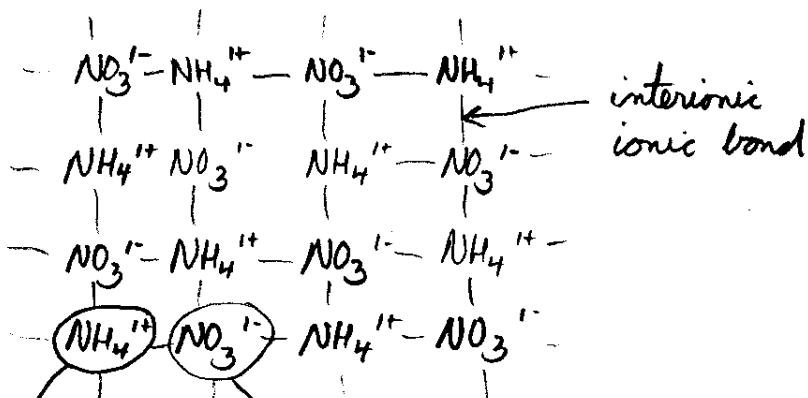
9. Repeat all parts of question #8 for ice (i.e. the solid form of  $H_2O$ )



- water molecules occupy the lattice points
- molecular solid

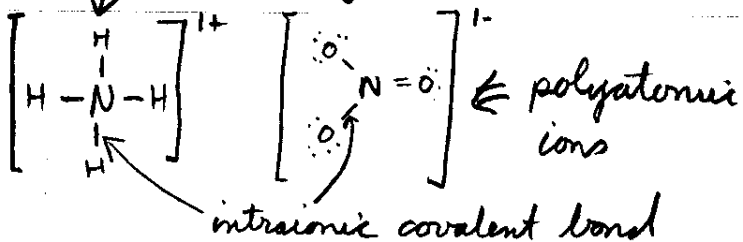
8

10. Repeat all parts of question #8 for ammonium nitrate ( $NH_4NO_3(s)$ ).



- $NH_4^{+}$  &  $NO_3^{-}$  occupy lattice points
- ionic solid (made from non-metals!)

8



2i

11. Explain with clear reference to charge carriers why

a) all metals conduct electricity

- free moving electrons

b) all ionic solids are insulators (do not conduct)

- cations + anions are locked in lattice positions

c) all aqueous solutions of made from ionic solids have some level of conductivity

- hydrated cations and anions are mobile  
(free moving charge carrier)

d) all non-polar liquids are non-conductive

- no free moving charged particles

12. When a solution is formed, the solute is divided up into small particles that interact favourably with the solvent particles. Use the table provided to indicate the exact identity of the solute particles in each situation. Include charges if present. If the given combination is not soluble, indicate this in the instead.

| SOLUTE  | SOLVENT                              | SMALLEST UNITS OF SOLUTE                   |
|---|--------------------------------------|--|
| NaCl  | water                                | $\text{Na}^{1+}$ $\text{Cl}^{1-}$ ions     |
| $\text{AlBr}_3$                                 | water                                | $\text{Al}^{3+}$ $\text{Br}^{1-}$ ions     |
| Au  | water                                | does not dissolve                          |
| $(\text{NH}_4)_2\text{SO}_4$                    | water                                | $\text{NH}_4^{1+}$ $\text{SO}_4^{2-}$ ions |
| $\text{C}_2\text{H}_5\text{OH}$ (ethyl alcohol) | water                                | $\text{C}_2\text{H}_5\text{OH}$ molecules  |
| $\text{C}_8\text{H}_{18}$ (octane)              | water                                | does not dissolve                          |
| $\text{C}_8\text{H}_{18}$ (octane)              | hexane ( $\text{C}_6\text{H}_{14}$ ) | $\text{C}_8\text{H}_{18}$ molecules        |
| Au  | Hg                                   | Au ions + $e^-$ (tricky!)                  |

1

1

1

1

8

12