1. a. Classify each of the following as **molecular**, **ionic** or **other**.

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</thead>
<tbody>
<tr>
<td>CF₂Cl₂</td>
<td>CO₂</td>
<td>KF</td>
<td>HNCl₂</td>
<td>MgSO₄</td>
<td>Xe</td>
<td>PF₃</td>
<td>HOCl</td>
<td></td>
</tr>
</tbody>
</table>

b. Show the Lewis structure of each substance you classified as **molecular**. For **ionic compounds**, write charges on the cation and anion.

c. Give the total number of electrons in each compound.

d. Draw and name the VSEPR shape for **molecular** compounds.

e. Indicate whether the substance is **polar** or **nonpolar**.

f. Name the **dominant** intermolecular force in each substance.

g. Place the compounds in order of increasing predicted melting point.

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<tbody>
<tr>
<td>b., c., d., e.</td>
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<tr>
<td>1 C 4 e⁻ 2 F 14 e⁻ 2 Cl 14 e⁻ (58 e⁻)</td>
<td>1 C 12 e⁻ 16 e⁻</td>
<td>1 N 5 e⁻ 1 H 1 e⁻ 2 Cl 14 e⁻ 20 e⁻ (42 e⁻)</td>
<td>2+ 2⁻ 60 e⁻</td>
<td>54 e⁻</td>
<td>1 P 5 e⁻ 3 F 21 e⁻ 26 e⁻</td>
<td>1 H 1 e⁻ 1 O 6 e⁻ 1 Cl 7 e⁻ 14 e⁻ (26 e⁻)</td>
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<td></td>
</tr>
<tr>
<td>tetrahedral</td>
<td>linear</td>
<td>trigonal pyramid</td>
<td>nonpolar</td>
<td>polar</td>
<td>trigonal pyramid</td>
<td>H-bond (109.5°)</td>
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</tbody>
</table>

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<tbody>
<tr>
<td>dipole-</td>
<td>London</td>
<td>ion-ion</td>
<td>H-bond</td>
<td>ion-ion</td>
<td>London</td>
<td>dipole-</td>
<td>H-bond</td>
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<td>CO₂</td>
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<td>HNCl₂</td>
<td>KF</td>
<td>MgSO₄</td>
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</table>
2. a. Classify each of the following as **molecular**, **ionic** or **other**.

\[
\begin{array}{lllllllll}
\text{CF}_4 & \text{SeF}_4 & \text{NaBF}_4 & \text{H}_2\text{NOH} & \text{CaS} & \text{Ar} & \text{SO}_3 & \text{HOOH} \\
\end{array}
\]

b. Show the Lewis structure of each substance you classified as **molecular**. For **ionic compounds**, write charges on the cation and anion.

c. Give the total number of electrons in each compound.

d. Draw and name the VSEPR shape for **molecular** compounds.

e. Indicate whether the **substance** is **polar** or **nonpolar**.

f. Name the **dominant** intermolecular force in each substance.

g. Place the compounds in order of decreasing predicted boiling point.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Bond Type</th>
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<tbody>
<tr>
<td>CF(_4)</td>
<td>molecular</td>
</tr>
<tr>
<td>SeF(_4)</td>
<td>molecular</td>
</tr>
<tr>
<td>NaBF(_4)</td>
<td>ionic</td>
</tr>
<tr>
<td>H(_2)NOH</td>
<td>molecular</td>
</tr>
<tr>
<td>CaS</td>
<td>ion-ion</td>
</tr>
<tr>
<td>Ar</td>
<td>nonpolar</td>
</tr>
<tr>
<td>SO(_3)</td>
<td>polar</td>
</tr>
<tr>
<td>HOOH</td>
<td>polar</td>
</tr>
<tr>
<td>SeF(_4)</td>
<td>molecular</td>
</tr>
<tr>
<td>CF(_4)</td>
<td>molecular</td>
</tr>
<tr>
<td>SO(_3)</td>
<td>nonpolar</td>
</tr>
<tr>
<td>Ar</td>
<td>polar</td>
</tr>
</tbody>
</table>

London dipole dipole ion-ion H-bond ion-ion London London H-bond

CaS NaBF\(_4\) H\(_2\)NOH HOOH SeF\(_4\) CF\(_4\) SO\(_3\) Ar
3. Classify the following **solids** as molecular, network (covalent), metallic, ionic or atomic.

   a. benzene, **molecular**
   
   b. diamond, **network**
   c. krypton, **atomic**
   d. Cd, **metallic**
   e. copper(II) chloride, **ionic**
   f. ice, **molecular**
   g. S₈, **molecular**
   h. Mg₅(PO₄)₂, **ionic**
   i. quartz (SiO₂), **network**
   j. P₄, **molecular**

4. For the two dimensional arrays shown below, draw a set of lattice points, a single primitive unit cell and a centered unit cell.

5. How many whole atoms are in a primitive cubic unit cell? **1**

6. How many whole atoms are in a body-centered cubic unit cell? **2**

7. How many whole atoms are in a face-centered cubic unit cell? **4**

8. Polonium crystallizes in a sc unit cell with a density of 9.20 g/cm³. Calculate the radius of a Po atom.

   \[
   \frac{209 \text{ g Po}}{1 \text{ mole Po}} \times \frac{1 \text{ mole Po}}{6.022 \times 10^{23} \text{ atoms Po}} \times \frac{1 \text{ atom Po}}{1 \text{ unit cell}} \times \frac{1 \text{ cm}^3}{9.20 \text{ g Po}} = 3.773 \times 10^{-23} \text{ cm}^3 = V
   \]

   \[
   a = \sqrt[3]{V} = \sqrt[3]{3.773 \times 10^{-23} \text{ cm}^3} = 3.354 \times 10^{-8} \text{ cm}
   \]

   \[
   \frac{a}{2} = r = \frac{3.354 \times 10^{-8}}{2} = 1.68 \times 10^{-8} \text{ cm} = 1.68 \text{ Å}
   \]
9. Copper crystallizes in a **fcc** unit cell, and has an atomic radius of 128 pm. Calculate the density of copper.

\[
\frac{63.546 \text{ g Cu}}{1 \text{ mole Cu}} \times \frac{1 \text{ mole Cu}}{6.022 \times 10^{23} \text{ atoms Cu}} \times \frac{4 \text{ atoms Cu}}{1 \text{ unit cell}} = 4.2209 \times 10^{-22} \text{ g/unit cell}
\]

\[
r = \frac{a\sqrt{2}}{4}; \quad a = \frac{4r}{\sqrt{2}} = \frac{4(1.28 \times 10^{-8} \text{ cm})}{\sqrt{2}} = 3.6204 \times 10^{-8} \text{ cm}
\]

\[
V = a^3 = (3.6204 \times 10^{-8} \text{ cm})^3 = 4.7453 \times 10^{-23} \text{ cm}^3
\]

\[
density = \frac{\text{mass of unit cell}}{\text{volume of unit cell}} = \frac{4.2209 \times 10^{-22} \text{ g/unit cell}}{4.7453 \times 10^{-23} \text{ cm}^3/\text{unit cell}} = 8.89 \text{ g/cm}^3
\]

10. The radius of iron is 124 pm, and it crystallizes in a **bcc** unit cell, what is the volume of the unit cell.

\[
r = \frac{a\sqrt{3}}{4}; \quad a = \frac{4r}{\sqrt{3}} = \frac{4(124 \text{ pm})}{\sqrt{3}} = 286.365 \text{ pm}
\]

\[
V = a^3 = (286.365 \text{ pm})^3 = 2.35 \times 10^7 \text{ pm}^3
\]

11. For the **heating curve** below:
12. Calculate the energy released when 12.76 g of CH$_2$FCF$_3$ goes from 0.0 °C to –75.0 °C.

**normal mp CH$_2$FCF$_3$(s) = –101.0 °C**

**normal bp CH$_2$FCF$_3$(l) = –26.6 °C**

**$\Delta H_{\text{vaporization}}$ CH$_2$FCF$_3$(l) = 22.02 kJ/mole**

- **s CH$_2$FCF$_3$(l) = 1.423 J/g·°C**
- **s CH$_2$FCF$_3$(g) = 0.875 J/g·°C**

1. \[ q = m\Delta T = 12.76 \text{ g} \times 0.875 \text{ J/g·°C} \times (–26.6 – 0.0 \text{ °C}) \]
   \[ = –296.989 \text{ J} \]

2. \[ \Delta H = –22020 \text{ J/mole} \times 12.76 \text{ g} \times 1 \text{ mole/102.03 g} \]
   \[ = –2753.849 \text{ J} \]

3. \[ q = m\Delta T = 12.76 \text{ g} \times 1.423 \text{ J/g·°C} \times (–75.0 – (–26.6 \text{ °C})) \]
   \[ = –878.822 \text{ J} \]

$q_{\text{total}} = (–296.989 \text{ J}) + (–2753.849 \text{ J}) + (–878.822 \text{ J}) = –3929.66 \text{ J} = –3.930 \text{ kJ}$
13. Given the phase diagram of xenon, Xe, answer the following:

![Phase diagram of xenon]

a. Estimate the normal boiling point of xenon. 
   \[ \text{Normal boiling point} = -107 \, ^\circ \text{C} \]

b. Estimate the normal melting point of xenon. 
   \[ \text{Normal melting point} = -112 \, ^\circ \text{C} \]

c. Estimate the vapor pressure of Xe(l) at \(-110 \, ^\circ \text{C}\). 
   \[ \text{Vapor pressure} = 0.8 \, \text{atm} \]

d. Is Xe(l) or Xe(s) more dense? Explain. 
   Xe(s), the mp line slopes to the right.

14. Calculate the difference in solubility of nitrogen (mole fraction in air = 0.78) in blood at sea level (P = 1.0 atm) versus 10 m underwater (P = 2.0 atm). Assume that blood is identical to water and \( k_{N_2} = 7.0 \times 10^{-4} \, \text{mole/L·atm} \).

\[
C_{N_2} = kP_{N_2} = 7.0 \times 10^{-4} \, \text{mole/L·atm} \times (1.0 \, \text{atm} \times 0.78) = 5.5 \times 10^{-4} \, \text{M} \, \text{N}_2
\]

\[
C_{N_2} = kP_{N_2} = 7.0 \times 10^{-4} \, \text{mole/L·atm} \times (2.0 \, \text{atm} \times 0.78) = 1.1 \times 10^{-3} \, \text{M} \, \text{N}_2
\]

15. Calculate the concentration of oxygen gas in water at sea level and 1.00 atm. The partial pressure of oxygen gas is 0.21 atm and Henry’s constant for oxygen (in water at RT) is \( 1.3 \times 10^{-3} \, \text{M·atm}^{-1} \).

\[
C_{O_2} = kP_{O_2} = 1.3 \times 10^{-3} \, \text{mole/L·atm} \times (1.00 \, \text{atm} \times 0.21) = 2.7 \times 10^{-4} \, \text{M} \, \text{O}_2
\]

16. Is solid iodine (I\(_2\)), more soluble in benzene (see #3), or chloroform, CH\(_3\)Cl?

   benzene; I\(_2\) is nonpolar and so is benzene
17. Classify the following as molecular or ionic. What is the value of \( i \) for each when dissolved in water?

a. copper(II) chloride \( \text{CuCl}_2 \), ionic, \( i = 3 \)
b. \( \text{CH}_3\text{F} \) molecular, \( i = 1 \)
c. \( \text{Mg}_3(\text{PO}_4)_2 \) ionic, \( i = 5 \)
d. sucrose, \( \text{C}_{12}\text{H}_{22}\text{O}_{11} \) molecular, \( i = 1 \)
e. benzene, \( \text{C}_6\text{H}_6 \) molecular, \( i = 1 \)

18. A solution is prepared by dissolving 5.00 g of glucose, \( \text{C}_6\text{H}_{12}\text{O}_6 \), in 100.0 g of water. Calculate:

a. the vapor pressure of water at 90 °C. The vapor pressure of pure water at 90 °C is 525.8 torr.

\[
P_{\text{sol'n}} = \chi_{\text{water}}P^o_{\text{water}} = (0.995)(525.8 \text{ torr}) = 523.2 \text{ torr}
\]

b. the boiling point of the solution.

\[
\Delta T_b = iK_bp_m = (1)(0.52 \, ^\circ\text{C}/m)(0.2775 \, m) = 0.14 \, ^\circ\text{C} \text{ higher}
\]

\[
T_b = 100.0 \, ^\circ\text{C} + 0.14 \, ^\circ\text{C} = 100.14 \, ^\circ\text{C}
\]

19. a. Calculate the freezing point of a solution of 2.00 moles of NaCl in 100.00 mL of water (density of water = 1.00 g/mL).

\[
\frac{2.00 \, \text{mole NaCl}}{0.10000 \, \text{kg H}_2\text{O}} = 20.0 \, m \text{ NaCl}
\]

\[
\Delta T_f = iK_fp_m = (2)(1.86 \, ^\circ\text{C}/m)(20.0 \, m) = 74.4 \, ^\circ\text{C} \text{ lower}
\]

\[
T_f = 0.0 \, ^\circ\text{C} - 74.4 \, ^\circ\text{C} = -74.4 \, ^\circ\text{C}
\]
b. Calculate the freezing point of a solution of 2.00 moles of CaCl$_2$ in 100.00 mL of water.

\[
\frac{2.00 \text{ mole CaCl}_2}{0.10000 \text{ kg H}_2\text{O}} = 20.0 \text{ m CaCl}_2
\]

\[
\Delta T_f = i K_b m = (3)(1.86 \degree\text{C/m})(20.0 \text{ m}) = 112 \degree\text{C lower}
\]

\[
T_f = 0.0 \degree\text{C} - 112 \degree\text{C} = -112 \degree\text{C}
\]