29. a. London  e. London  
b. dipole-dipole  f. dipole-dipole  
c. H-bonding  g. ion-ion  
d. ion-ion  

30. a. ion-ion  e. H-bonding  
b. London  f. dipole-dipole  
c. London  g. London  
d. dipole-dipole  

31. a. O=C=O nonpolar  O=C=S polar - greater force  
b. O-Se-O polar - greater ΔEN  O=S=O polar – smaller ΔEN  
c. CH₃CH₂CH₂NH₂  NH₂CH₂CH₂NH₂  
Both can H-bond, but NH₂CH₂CH₂NH₂ has twice as many.  

c. CH₃CH₂CH₂NH₂ nonpolar  O=CH₂ polar – greater force  
c. O=CH₂ polar – H-bond  H=CH₂ polar  

33. a. Looking at the molecules in three dimensions (below), neopentane looks more spherical. A sphere has a minimum surface area. The London forces on these nonpolar molecules operate at the surface. More surface area (n-pentane) means more London forces. More London forces means higher boiling point.
b. Ethanol can H-bond (O-H). Dimethyl ether is polar, but H-bonding is stronger.
c. HF can H-bond.
d. LiCl is ionic, ion-ion forces are the largest.
e. $n$-pentane has more surface area and more electrons so its London forces are greater than $n$-propane.
f. Dimethyl ether is polar; dipole-dipole forces stronger than London.

36. a. All are nonpolar with the same shape (for example). London forces are the dominate. The depend on the number of electrons. CBr$_4$ has 146, compared with 42 in CF$_4$ and 74 in CCl$_4$. CBr$_4$ is the highest boiling point.
b. LiF is ionic, Cl$_2$ is nonpolar and HBr is polar. The London forces of Cl$_2$ are the weakest, giving it the lowest freezing point.
c. CH$_3$OCH$_3$ is polar, CH$_3$CH$_2$OH can H-bond and CH$_3$CH$_2$CH$_3$ is nonpolar. The H-bond in CH$_3$CH$_2$OH is the strongest making it more difficult for the molecules to go into the vapor phase.
d. HF and H$_2$O$_2$ can H-bond. H$_2$S is just polar. H$_2$O$_2$ can H-bond through more X-H bonds, therefore the H-bond is strongest in H$_2$O$_2$. Intermolecular forces resist flow, so H$_2$O$_2$ is the most viscous.
e. H$_2$CO is polar, CH$_3$CH$_3$ and CH$_4$ are nonpolar, with CH$_4$ having fewer electrons. Heat of vaporization goes along with strength of intermolecular forces. H$_2$CO has dipole-dipole forces, so it would have the greatest heat of vaporization.
f. I$_2$ is nonpolar, CsBr and CaO are ionic, but the lattice energy in CaO is greater (2+, 2- ions, versus 1+, 1- ions). I$_2$ is the weakest intermolecular force; easiest to melt; smallest enthalpy of fusion.
40. All are nonpolar molecules. The magnitude of the London forces depends on the number of electrons. CO₂ has 22, CS₂ 38 and CSe₂ has 74 e-.

46. In a face-centered cubic, \( r = \frac{\sqrt{2}a}{4} \) and \( a = \frac{3\sqrt{V}}{8} \).

\[
\frac{58.69 \text{ g Ni}}{1 \text{ mole Ni}} \times \frac{1 \text{ mole Ni}}{6.022 \times 10^{23} \text{ atoms}} \times \frac{4 \text{ atoms Ni}}{1 \text{ unit cell}} \times \frac{1 \text{ cm}^3}{6.84 \text{ g Ni}} = 5.699 \times 10^{-23} \text{ cm}^3/\text{uc}
\]

= volume of the unit cell.

\[
a = \frac{\sqrt[3]{5.699 \times 10^{-23} \text{ cm}^3}}{3} = 3.848 \times 10^{-8} \text{ cm}
\]

\[
r = \frac{\sqrt{2}a}{4} = \frac{\sqrt{2} \times (3.848 \times 10^{-8} \text{ cm})}{4} = 1.36 \times 10^{-8} \text{ cm} = 136 \text{ pm}
\]

48. Need to find the formula weight (FW) of the metal.

\[
\frac{(4.09 \times 10^{-8} \text{ cm})^3}{1 \text{ unit cell}} \times \frac{10.5 \text{ g X}}{1 \text{ cm}^3} \times \frac{1 \text{ unit cell}}{4 \text{ atoms X}} \times \frac{6.022 \times 10^{23} \text{ atoms X}}{1 \text{ mole X}} = 108 \text{ g/mole}
\]

The metal with a FW close to 108 is Ag (107.868 g/mole).

50. Density = mass of unit cell/volume of unit cell

Mass of unit cell = \[
\frac{137.327 \text{ g Ba}}{1 \text{ mole Ba}} \times \frac{1 \text{ mole Ba}}{6.022 \times 10^{23} \text{ atoms Ba}} \times \frac{2 \text{ atoms Ba}}{1 \text{ unit cell}} = 4.5608 \times 10^{-22} \text{ g/unit cell}
\]

Volume of unit cell = \( a^3 \);

\[
a = \frac{4r}{\sqrt{3}} = \frac{4 (2.22 \times 10^{-8} \text{ cm})}{\sqrt{3}} = 5.127 \times 10^{-8} \text{ cm}
\]

\[
a^3 = (5.127 \times 10^{-8} \text{ cm})^3 = 1.348 \times 10^{-22} \text{ cm}^3/\text{unit cell}
\]

Density = \[
\frac{4.5608 \times 10^{-22} \text{ g/unit cell}}{1.3476 \times 10^{-22} \text{ cm}^3/\text{unit cell}} = 3.38 \text{ g/cm}^3
\]
72.  
   a. Diamond, network (covalent)  
   b. PH₃, molecular solid  
   c. H₂, molecular solid  
   d. Mg, metallic  
   e. KCl, ionic solid  
   f. Quartz, network (covalent)  
   g. NH₄NO₃, ionic solid  
   h. SF₂, molecular solid  
   i. Ar, atomic solid  
   j. Cu, metallic  
   k. C₆H₁₂O₆, molecular solid  

87. It is useful to sketch the heating curve:

![Heating Curve of 0.500 kg ice at -20 °C to steam at 250 °C](image)


1. \[ q = m \cdot s \cdot \Delta T = 0.500 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{2.1 \text{ J}}{\text{g} \cdot ^\circ \text{C}} \times (0 \ ^\circ \text{C} - (-20 \ ^\circ \text{C})) \]
   \[ = 21,000 \text{ J} \]

2. \[ \Delta H_{\text{fusion}} = \frac{6.02 \text{ kJ}}{1 \text{ mole ice}} \times \frac{1000 \text{ J}}{1 \text{ kJ}} \times 0.500 \text{ kg ice} \times \frac{1000 \text{ g ice}}{1 \text{ kg ice}} \times \frac{1 \text{ mole ice}}{18.015 \text{ g ice}} \]
   \[ = 167,083 \text{ J} \]

3. \[ q = m \cdot s \cdot \Delta T = 0.500 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{4.2 \text{ J}}{\text{g} \cdot ^\circ \text{C}} \times (100 \ ^\circ \text{C} - 0 \ ^\circ \text{C}) \]
   \[ = 210,000 \text{ J} \]
4. \[ \Delta H_{\text{vap}} = \frac{40.7 \text{ kJ}}{1 \text{ mole water}} \times \frac{1000 \text{ J}}{1 \text{ kJ}} \times \frac{0.500 \text{ kg}}{1 \text{ kg}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mole}}{18.015 \text{ g}} \]

\[ = 1,129,614 \text{ J} \]

5. \[ q = ms\Delta T = 0.500 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{2.0 \text{ J}}{\text{ g} \cdot ^\circ \text{C}} \times (250 ^\circ \text{C} - 100 ^\circ \text{C}) \]

\[ = 150,000 \text{ J} \]

q total \[= 21,000 \text{ J} + 167,083 \text{ J} + 210,000 \text{ J} + 1,129,614 \text{ J} + 150,000 \text{ J} \]

\[ = 16,77697 \text{ J} = 1700 \text{ kJ} \]

91. Looking at the phase diagram:

A Solid
B Liquid
C Gas (Vapor)
D Solid/Liquid equilibrium
E Solid/Liquid/Gas (vapor) equilibrium
F Liquid/Gas (Vapor) equilibrium
G Liquid/Gas (Vapor) equilibrium
H Supercritical Fluid

Triple Point E
Critical Point G
Normal Melting and Boiling Points are indicated on the diagram.

High pressure favors the more dense phase. Since the melting point line slopes to the right, high pressure favors the solid phase, which is the most dense.
93. a. Two (2) triple points.
   b. High pressure triple point: diamond/graphite/liquid
      Low pressure triple point: graphite/liquid/gas (vapor)
   c. Transition to diamond.
   d. High pressure favors the more dense phase: diamond

110. Methyl salicylate can H-bond intramolecularly. This means it will not H-bond to another methyl salicylate in the liquid phase. Methyl 4-hydroxybenzoate can (and does) H-bond intermolecularly in the liquid phase. The dashed line below is the “H-bond”.

![Methyl salicylate molecule](image)