Chapter 1
Electrons, Bonds and Molecular Properties

Review of Concepts
Fill in the blanks below. To verify that your answers are correct, look in your textbook at the end of Chapter 1. Each of the sentences below appears verbatim in the section entitled Review of Concepts and Vocabulary.

- ______________ isomers share the same molecular formula but have different connectivity of atoms and different physical properties.
- Second-row elements generally obey the _______ rule, bonding to achieve noble gas electron configuration.
- A pair of unshared electrons is called a ____________.
- A formal charge occurs when an atom does not exhibit the appropriate number of __________________.
- An atomic orbital is a region of space associated with ______________, while a molecular orbital is a region of space associated with ______________.
- Methane’s tetrahedral geometry can be explained using four degenerate _____-hybridized orbitals to achieve its four single bonds.
- Ethylene’s planar geometry can be explained using three degenerate _____-hybridized orbitals.
- Acetylene’s linear geometry is achieved via _____-hybridized carbon atoms.
- The geometry of small compounds can be predicted using valence shell electron pair repulsion (VSEPR) theory, which focuses on the number of _______ bonds and ______________ exhibited by each atom.
- The physical properties of compounds are determined by ______________ forces, the attractive forces between molecules.
- London dispersion forces result from the interaction between transient ______________ and are stronger for larger alkanes due to their larger surface area and ability to accommodate more interactions.

Review of Skills
Fill in the blanks and empty boxes below. To verify that your answers are correct, look in your textbook at the end of Chapter 1. The answers appear in the section entitled SkillBuilder Review.

SkillBuilder 1.1 Determining the Constitution of Small Molecules

STEP 1 - DETERMINE THE VALENCY (NUMBER OF EXPECTED BONDS) FOR EACH ATOM IN C₂H₅Cl

<table>
<thead>
<tr>
<th>Each carbon atom is expected to form ___ bonds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each hydrogen atom is expected to form ___ bonds.</td>
</tr>
<tr>
<td>The chlorine atom is expected to form ___ bonds.</td>
</tr>
</tbody>
</table>

STEP 2 - DRAW THE STRUCTURE OF C₂H₅Cl BY PLACING ATOMS WITH THE HIGHEST VALENCY AT THE CENTER, AND PLACING MONOVALENT ATOMS AT THE PERIPHERY

[Diagram of C₂H₅Cl structure]
SkillBuilder 1.2  Drawing the Lewis Dot Structure of an Atom

**STEP 1 - DETERMINE THE NUMBER OF VALENCE ELECTRONS**

Nitrogen is in Group ___ of the periodic table, and is expected to have ___ valence electrons.

**STEP 2 - PLACE ONE ELECTRON BY ITSELF ON EACH SIDE OF THE ATOM**

**STEP 3 - IF THE ATOM HAS MORE THAN FOUR VALENCE ELECTRONS, PAIR THE REMAINING ELECTRONS WITH THE ELECTRONS ALREADY DRAWN**

SkillBuilder 1.3  Drawing the Lewis Structure of a Small Molecule

**STEP 1 - DRAW THE LEWIS DOT STRUCTURE OF EACH ATOM IN CH₂O**

**STEP 2 - FIRST CONNECT ATOMS THAT FORM MORE THAN ONE BOND**

**STEP 3 - CONNECT THE HYDROGEN ATOMS**

**STEP 4 - PAIR ANY UNPAIRED ELECTRONS, SO THAT EACH ATOM ACHIEVES AN OCTET**

SkillBuilder 1.4  Calculating Formal Charge

**STEP 1 - DETERMINE THE APPROPRIATE NUMBER OF VALENCE ELECTRONS**

Nitrogen is in Group ___ of the periodic table, and is expected to have ___ valence electrons.

**STEP 2 - DETERMINE THE NUMBER OF VALENCE ELECTRONS IN THIS CASE**

In this case, the nitrogen atom is using only ___ valence electrons.

**STEP 3 - ASSIGN A FORMAL CHARGE TO THE NITROGEN ATOM IN THIS CASE**

SkillBuilder 1.5  Locating Partial Charges

**STEP 1 - CIRCLE THE BONDS BELOW THAT ARE POLAR COVALENT**

**STEP 2 - FOR EACH POLAR COVALENT BOND, DRAW AN ARROW THAT SHOWS THE DIRECTION OF THE DIPOLE MOMENT**

**STEP 3 - INDICATE THE LOCATION OF ALL PARTIAL CHARGES (δ+ and δ-)**

SkillBuilder 1.6  Identifying Electron Configurations

**STEP 1 - IN THE ENERGY DIAGRAM SHOWN HERE, DRAW THE ELECTRON CONFIGURATION OF NITROGEN (USING ARROWS TO REPRESENT ELECTRONS).**

**STEP 2 - FILL IN THE BOXES BELOW WITH THE NUMBERS THAT CORRECTLY DESCRIBE THE ELECTRON CONFIGURATION OF NITROGEN**

Nitrogen

1s 2s 2p

SkillBuilder 1.7  Identifying Hybridization States

**A CARBON ATOM WITH FOUR SINGLE BONDS WILL BE _____ HYBRIDIZED**

**A CARBON ATOM WITH ONE DOUBLE BOND WILL BE _____ HYBRIDIZED**

**A CARBON ATOM WITH A TRIPLE BOND WILL BE _____ HYBRIDIZED**
SkillBuilder 1.8  Predicting Geometry

<table>
<thead>
<tr>
<th># of single bonds</th>
<th>Steric Number</th>
<th>Hybridization State</th>
<th>Electronic Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>NO LONE PAIRS</td>
<td>ONE LONE PAIR</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>TWO LONE PAIRS</td>
<td></td>
</tr>
</tbody>
</table>

**SkillBuilder 1.9  Identifying Molecular Dipole Moments**

**SkillBuilder 1.10  Predicting Physical Properties**

**Dipole-Dipole Interactions**

- Circle the compound below that is expected to have the higher boiling point:
  - CH₃OH
  - CH₂Cl₂
  - CH₃CH₂OH
  - CH₃CH₂CH₂OH

**H-Bonding Interactions**

- Circle the compound below that is expected to have the higher boiling point:
  - CH₃OH
  - CH₂Cl₂
  - CH₃CH₂OH
  - CH₃CH₂CH₂OH

**Carbon Skeleton**

- Circle the compound below that is expected to have the higher boiling point:
  - H₂C=CH₂
  - CH₂Cl
  - CH₃CH₂OH
  - CH₃CH₂CH₂OH

**Solutions**

1.1.

a) \( \text{H} - \text{O} - \text{H} \)

b) \( \text{H} - \text{Cl} \)

c) \( \text{H} - \text{C} - \text{H} \)

d) \( \text{H} - \text{C} - \text{N} \)

e) \( \text{F} - \text{C} - \text{C} - \text{F} \)

f) \( \text{H} - \text{C} - \text{Br} \)

g) \( \text{H} - \text{C} - \text{Cl} \)

1.2.

- \( \text{H} - \text{O} - \text{C} - \text{Cl} \)
- \( \text{H} - \text{Cl} - \text{H} \)

or

- \( \text{H} - \text{C} - \text{C} - \text{H} \)
- \( \text{H} - \text{C} - \text{C} - \text{H} \)

- \( \text{H} - \text{C} - \text{C} - \text{H} \)

- \( \text{H} - \text{C} - \text{C} - \text{H} \)

- \( \text{H} - \text{C} - \text{C} - \text{H} \)
1.3.

\[
\begin{align*}
\text{H-} & \text{C} & \text{H} & \text{OH} & \quad \text{or} & \quad \text{H-} & \text{C} & \text{H} & \text{OHH} & \quad \text{or} & \quad \text{H-} & \text{C} & \text{O} & \text{CH} \\
\text{H} & \text{H} & \text{H} & & \text{or} & \text{H} & \text{H} & \text{H} & \text{or} & \text{H} & \text{H} & \text{H} & \text{H}.
\end{align*}
\]

1.4.

\[
\begin{align*}
\text{H-} & \text{C} & \text{C} & \text{C} & \text{OH} & \quad \text{or} & \quad \text{H-} & \text{C} & \text{C} & \text{C} & \text{OHH} & \quad \text{or} & \quad \text{H-} & \text{C} & \text{C} & \text{O} & \text{CH} \\
\text{H} & \text{H} & \text{H} & \text{H} & & \text{or} & \text{H} & \text{H} & \text{H} & \text{H} & \text{or} & \text{H} & \text{H} & \text{H} & \text{H}.
\end{align*}
\]

1.5.

a) \( \cdot \text{C} \cdot \), b) \( \cdot \text{O} \cdot \), c) \( \cdot \text{F} \cdot \), d) \( \cdot \text{H} \cdot \),

e) \( \cdot \text{Br} \cdot \), f) \( \cdot \text{S} \cdot \), g) \( \cdot \text{Cl} \cdot \), h) \( \cdot \text{I} \cdot \).

1.6. Both nitrogen and phosphorous belong to column 5A of the periodic table, and therefore, each of these atoms has five valence electrons. In order to achieve an octet, we expect each of these elements to form three bonds.

1.7. Aluminum is directly beneath boron on the periodic table (Column 3A), and therefore both elements exhibit three valence electrons.

1.8. \( \cdot \text{C} \cdot \) resembles boron because it exhibits three valence electrons.

1.9. \( \cdot \text{C} \cdot \) resembles nitrogen because it exhibits five valence electrons.

1.10.

\[
\begin{align*}
a) & \quad \text{H} & \text{H} & \text{H} & \quad b) & \quad \text{H} & \text{H} & \text{H} & \quad c) & \quad \text{H} & \text{C} & \text{C} & \text{C} & \text{H} & \quad d) & \quad \text{H} & \text{H} & \text{H} \\
\text{H} & \text{C} & \text{C} & \text{H} & \quad \text{H} & \text{C} & \text{C} & \text{H} & \quad \text{H} & \text{C} & \text{C} & \text{H} & \quad \text{H} & \text{H} & \text{H}
\end{align*}
\]

e) \( \text{H} \), f) \( \text{H} \),

g) \( \text{H} \), h) \( \text{H} \).

1.11 The central boron atom lacks an octet of electrons.
1.12

In all of the constitutional isomers above, the nitrogen atom has one lone pair.

1.13.

1.14.

1.15.

1.16.

1.17.

a) 1s\(^2\)2s\(^2\)2p\(^2\)  
b) 1s\(^2\)2s\(^2\)2p\(^4\)  
c) 1s\(^2\)2s\(^2\)2p\(^1\)  
d) 1s\(^2\)2s\(^2\)2p\(^5\)  
e) 1s\(^2\)2s\(^2\)2p\(^6\)3s\(^1\)  
f) 1s\(^2\)2s\(^2\)2p\(^6\)3s\(^2\)3p\(^1\)
1.18. a) $1s^22s^22p^3$  
    b) $1s^22s^22p^1$  
    c) $1s^22s^22p^2$  
    d) $1s^22s^22p^5$

1.19. The bond angles of an equilateral triangle are 60°, but each bond angle of cyclopropane is supposed to be 109.5°. Therefore, each bond angle is severely strained, causing an increase in energy. This form of strain, called ring strain, will be discussed in Chapter 4. The ring strain associated with a three-membered ring is greater than the ring strain of larger rings, because larger rings do not require bond angles of 60°.

1.20
a) The C=O bond of formaldehyde is comprised of one sigma bond and one pi bond.
b) Each C-H bond is formed from the interaction between an $sp^2$ hybridized orbital from carbon and an $s$ orbital from hydrogen.
c) The oxygen atom is $sp^2$ hybridized, so the lone pairs occupy $sp^2$ hybridized orbitals.

1.21. Rotation of a single bond does not cause a reduction in the extent of orbital overlap, because the orbital overlap occurs on the bond axis. In contrast, rotation of a pi bond results in a reduction in the extent of orbital overlap, because the orbital overlap is NOT on the bond axis.

1.22.

All carbon atoms in this molecule are $sp^2$ hybridized, except for the carbon atom highlighted above, which is $sp^3$ hybridized

a)

The carbon atoms highlighted above are $sp^3$ hybridized.

b) All other carbon atoms in this compound are $sp^2$ hybridized.
1.23.

\[
\begin{align*}
&\text{a)} \quad \text{C} \quad \text{C} \quad \text{C} \\
&\quad \text{sp}^2 \\
&\text{H} \quad \text{H} \quad \text{sp} \\
&\quad \text{sp}^2 \\
\end{align*}
\]

\[
\begin{align*}
&\text{b)} \\
&\text{C} \quad \text{C} \quad \text{C} \\
&\quad \text{sp} \\
&\text{H} \quad \text{H} \\
\end{align*}
\]

1.24.

\[
\begin{align*}
&\text{c} < b < a \\
&\text{a is the longest bond} \\
&\text{and c is the shortest bond}
\end{align*}
\]

1.25.

a) The nitrogen atom has three bonds and one lone pair, and is therefore trigonal pyramidal.
b) The oxygen atom has three bonds and one lone pair, and is therefore trigonal pyramidal.
c) The boron atom has four bonds and no lone pairs, and is therefore tetrahedral.
d) The boron atom has three bonds and no lone pairs, and is therefore trigonal planar.
e) The boron atom has four bonds and no lone pairs, and is therefore tetrahedral.
f) The carbon atom has four bonds and no lone pairs, and is therefore tetrahedral.
g) The carbon atom has four bonds and no lone pairs, and is therefore tetrahedral.
h) The carbon atom has four bonds and no lone pairs, and is therefore tetrahedral.

1.26.

(a) All carbon atoms in this molecule are tetrahedral except for the highlighted carbon atom, which is trigonal planar.

The oxygen atom (of the OH group) has bent geometry, and the nitrogen atom is trigonal pyramidal.

(b) All carbon atoms are tetrahedral except for the carbon atoms highlighted, which are trigonal planar.

The oxygen atom and the highlighted nitrogen atom have bent geometry, and the other nitrogen atom is trigonal pyramidal.
1.27. The carbon atom of the carbocation has three bonds and no lone pairs, and is therefore trigonal planar. The carbon atom of the carbanion has three bonds and one lone pair, and is therefore trigonal pyramidal.

1.28. Every carbon atom in benzene is \(sp^2\) hybridized and trigonal planar. Therefore, the entire molecule is planar (all of the atoms in this molecule occupy the same plane).

1.29.

(a) \(\text{Cl}\) \(\text{Cl}\) \(\text{Cl}\) 
(b) \(\text{H}_3\text{C}\) \(\text{O}\) \(\text{CH}_3\) 
(c) \(\text{H}\) \(\text{N}\) 
(d) \(\text{Br}\) \(\text{Cl}\) 

(e) \(\text{H}\) \(\text{C}\) \(\text{O}\) \(\text{C}\) \(\text{H}\) 
(f) none 
(g) none 
(h) none

(i) \(\text{C}\) \(\text{Cl}\) \(\text{Cl}\) 
(j) none 
(k) none 
(l) none

1.30. CHCl₃ is expected to have a larger dipole moment than CBrCl₃, because the bromine atom in the latter compound serves to nearly cancel out the effects of the other three chlorine atoms (as is the case in CCl₄).

1.31. The carbon atom of CO₂ has a steric number of two, and therefore has linear geometry. As a result, the individual dipole moments of each C=O bond cancel each other completely to give no overall molecular dipole moment. In contrast, the sulfur atom in SO₂ has a steric number of three (because it also has a lone pair, in addition to the two S=O bonds), which means that it has bent geometry. As a result, the individual dipole moments of each S=O bond do NOT cancel each other completely, and the molecule does have a molecular dipole moment.
1.32.
   a) The latter, because it is less branched.
   b) The latter, because it has more carbon atoms.
   c) The latter, because it has an OH bond.
   d) The former, because it is less branched.

1.33.

   Increasing boiling point

1.34.

   a)  
   b)  
   c)  
   d)  
   e)  
   f)  
1.35.  

a) 

\[ \begin{align*} 
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\end{align*} \]

\[ \begin{align*} 
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\end{align*} \]

b)

\[ \begin{align*} 
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\end{align*} \]

\[ \begin{align*} 
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\text{H} & \text{-C} \text{-H} \\
\end{align*} \]

1.36.

a)  

\[ \begin{align*} 
\text{H} & \delta^+ \delta^- \\
\text{Br} & \\
\end{align*} \]

b)  

\[ \begin{align*} 
\text{H} & \delta^+ \delta^- \\
\text{Cl} & \\
\end{align*} \]

c)  

\[ \begin{align*} 
\text{O} & \delta^+ \delta^- \\
\delta^- & \\
\end{align*} \]

d)  

\[ \begin{align*} 
\text{H} & \delta^+ \delta^- \\
\text{O} & \delta^+ \delta^- \\
\end{align*} \]

1.37.

a) NaBr, because the difference in electronegativity between Na and Br is greater than the difference in electronegativity between H and Br.

b) FCl, because the disparity in electronegativity between F and Cl is greater than the disparity in electronegativity Br and Cl.

1.38.

a)  

\[ \begin{align*} 
\text{H} & \text{O} \\
\text{H} & \\
\text{H} & \\
\text{H} & \\
\end{align*} \]

b)  

\[ \begin{align*} 
\text{H} & \text{O} \\
\text{H} & \\
\text{H} & \\
\text{H} & \\
\end{align*} \]

1.39.

a) All carbon atoms in this molecule are tetrahedral except for the carbon atom bearing the negative charge, which is trigonal pyramidal.

b) The highlighted carbon atom is tetrahedral, and the other two carbon atoms are trigonal planar. The oxygen atom is trigonal pyramidal.

c) Both carbon atoms and the nitrogen atom are tetrahedral. The oxygen atom is bent.

d) All three carbon atoms in this molecule are tetrahedral. The geometry of the oxygen atom is not relevant because it is only attached to one other group.
1.40.

\[
\begin{align*}
\text{H} & : \text{C} : \text{N} : \text{C} : \text{H} \\
\text{H} & : \text{C} : \text{H} : \text{N} : \text{H} \\
\text{H} & : \text{C} : \text{H} : \text{H} : \text{C} \\
\end{align*}
\]

The nitrogen atom has trigonal pyramidal geometry. The compound is expected to have the following molecular dipole moment:

\[
\begin{align*}
\text{H} & : \text{C} : \text{N} : \text{C} : \text{H} \\
\text{H} & : \text{C} : \text{H} : \text{N} : \text{H} \\
\text{H} & : \text{C} : \text{H} : \text{H} : \text{C} \\
\end{align*}
\]

1.41.

\[
\begin{align*}
\text{Br} : \Theta \\
\text{Br} : \text{Al} : \text{Br} \\
\text{Br} : \\
\end{align*}
\]

The central aluminum has tetrahedral geometry.

1.42.

\[
\begin{align*}
\text{H} & : \text{C} : \text{C} : \text{H} \\
\text{H} & : \text{C} : \text{H} : \text{C} : \text{H} \\
\end{align*}
\]

1.43.

a) No  
 b) Yes  
 c) Yes  
 d) No  
 e) No  
 f) Yes

1.44.

a) Oxygen  
 b) Fluorine  
 c) Carbon  
 d) Nitrogen  
 e) Chlorine

1.45.

a) Ionic  
 b) Na-O is ionic, and O-H is polar covalent  
 c) Na-O is ionic, O-C is polar covalent, and each C-H bond is covalent  
 d) The O-H and C-O bonds are polar covalent, and each C-H bond is covalent  
 e) The C=O bond is polar covalent, and each C-H bond is covalent

1.46.

\[
\begin{align*}
\text{H} & : \text{C} : \text{C} : \text{OH} \\
\text{H} & : \text{C} : \text{O} : \text{C} : \text{H} \\
\end{align*}
\]

a) 

\[
\begin{align*}
\text{H} & : \text{C} : \text{OH}  \\
\text{H} & : \text{C} : \text{OH} \\
\text{H} & : \text{C} : \text{OH}  \\
\text{H} & : \text{C} : \text{OH} \\
\end{align*}
\]

b) 

\[
\begin{align*}
\text{H} & : \text{Br}  \\
\text{H} & : \text{Br} \\
\end{align*}
\]

c) 

\[
\begin{align*}
\text{H} & : \text{Br}  \\
\text{H} & : \text{Br} \\
\end{align*}
\]
1.47.

\[
\begin{align*}
&\text{H} - \text{O} - \text{H} \\
&\text{H} - \text{C} - \text{O} - \text{H} \\
&\text{H} - \text{C} - \text{C} - \text{O} - \text{H} \\
&\text{H} - \text{C} - \text{O} - \text{O} - \text{C} - \text{H} \\
&\text{H} - \text{C} - \text{O} - \text{C} - \text{H} \\
&\text{H} - \text{C} - \text{C} - \text{O} - \text{H} \\
&\text{H} - \text{C} - \text{C} - \text{O} - \text{H} \\
&\text{H} - \text{C} - \text{C} - \text{O} - \text{H}
\end{align*}
\]

1.48.

\[
\begin{align*}
a) \text{C} - \text{O} & & b) \text{C} - \text{Mg} & & c) \text{C} - \text{N} & & d) \text{C} - \text{Li} \\
e) \text{C} - \text{Cl} & & f) \text{C} - \text{H} & & g) \text{O} - \text{H} & & h) \text{N} - \text{H}
\end{align*}
\]

1.49.

a) All bond angles are approximately 109.5°, except for the C-O-H bond angle which is expected to be less than 109.5° as a result of the repulsion of the lone pairs on the oxygen.
b) All bond angles are approximately 120°.
c) All bond angles are approximately 120°.
d) All bond angles are 180°.
e) All bond angles are approximately 109.5°, except for the C-O-C bond angle which is expected to be less than 109.5° as a result of the repulsion of the lone pairs on the oxygen.
f) All bond angles are approximately 109.5°.
g) All bond angles are approximately 109.5°.
h) All bond angles are approximately 109.5° except for the C-C≡N bond angle which is 180°.

1.50.

a) \(sp^3\), trigonal pyramidal
b) \(sp^2\), trigonal planar
c) \(sp^2\), trigonal planar
d) \(sp^3\), trigonal pyramidal
e) \(sp^3\), trigonal pyramidal

1.51. Sixteen sigma bonds and three pi bonds.

1.52.

a) the second, because it possesses an O-H bond.
b) the second, because it has more carbon atoms.
c) the first, because it has a polar bond.

1.53.

a) yes
b) no (this compound can serve as a hydrogen bond acceptor, but not a hydrogen bond donor)
c) no
d) no  
e) no (this compound can serve as a hydrogen bond acceptor, but not a hydrogen bond donor)  
f) yes  
g) no  
h) yes

1.54.  
a) 3  
b) 4  
c) 3  
d) 2

1.55.  

The highlighted carbon atoms are $sp^2$ hybridized and trigonal planar. The remaining four carbon atoms are $sp$ hybridized and linear.

a)  

The highlighted carbon atom is $sp^2$ hybridized and trigonal planar. The remaining three carbon atoms are $sp^3$ hybridized and tetrahedral.

b)  

All carbon atoms are $sp^3$ hybridized and tetrahedral.

c)

1.56.  

The highlighted carbon atoms are $sp^3$ hybridized and tetrahedral. The remaining carbon atoms are $sp^2$ hybridized and trigonal planar.

1.57.  
a) oxygen  
b) fluorine  
c) carbon

1.58.  

The highlighted carbon is $sp^2$ hybridized, bent. The highlighted carbon is $sp^3$ hybridized, trigonal pyramidal.

*nicotine*
1.59.

![Caffeine molecule](image)

1.60. The two isomers are:

- ![Isomer 1](image)
- ![Isomer 2](image)

The first will have a higher boiling point because it possesses an OH group which can form hydrogen bonds.

1.61.

a) ![Structure a](image)

b) ![Structure b](image)

c) ![Structure c](image)

d) ![Structure d](image)

1.62. The third chlorine atom in chloroform partially cancels the effects of the other two chlorine atoms, thereby reducing the molecular dipole moment relative to methylene chloride.

1.63.

a) Compound A and Compound B
b) Compound B
c) Compound B
d) Compound C
e) Compound C
f) Compound A
g) Compound B
h) Compound A is capable of hydrogen bonding
1.64.

a) 
\[
\begin{align*}
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\end{align*}
\]

b) 
\[
\begin{align*}
\text{H} & \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \equiv \text{C} \equiv \text{N} \\
\text{H} & \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \text{H} \\
\end{align*}
\]

c) 
\[
\begin{align*}
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \equiv \text{C} \text{C} \text{C} \text{C} \\
\end{align*}
\]

d) 
\[
\begin{align*}
\text{N} & \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{N} \\
\text{F} & \equiv \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{F} \\
\end{align*}
\]

1.65.

\[
\begin{align*}
\text{H} & \text{C} \text{C} \equiv \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \text{C} \equiv \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \text{C} \equiv \text{C} \text{C} \text{C} \\
\text{H} & \text{C} \text{C} \equiv \text{C} \text{C} \text{C} \\
\end{align*}
\]

1.66.

\[
\begin{align*}
\text{H} & \text{H} \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \text{H} \\
\end{align*}
\]

1.67.

\[
\begin{align*}
\text{H} & \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \\
\text{H} & \text{H} \text{H} \\
\end{align*}
\]