1. **Review** Brown & LeMay - **Conceptual Questions** at end of every chapter
2. Approach the AP Problems as actual exam questions.
   - Limit your time to **12-14 minutes** per question.
   - Remember to **READ EACH QUESTION CAREFULLY**, and only answer the question asked. Writing additional information will not earn extra points, you will only lose time.
   - Resist the urge to "look up answers" until you cannot put any additional information down. No matter how insignificant you think your answer might be, **WRITE IT DOWN**.
   - Try your best to be: **Clear, Logical, Well-Organized, with Labeled Units.**
     - **Box** your answer. **Re-check Units** and **Significant Digits**.
   - Ask yourself "Does my answer make sense?"

- **AP Review Questions**
  2013 #6
  2012 #5
  2011 B #6
  2006 B #6

6. **Answer the following questions using principles of molecular structure and intermolecular forces.**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Empirical Formula</th>
<th>Solubility in Water</th>
<th>Boiling Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C₂H₆O</td>
<td>Slightly soluble</td>
<td>−24</td>
</tr>
<tr>
<td>2</td>
<td>C₂H₆O</td>
<td>Soluble</td>
<td>78</td>
</tr>
</tbody>
</table>

Compounds 1 and 2 in the data table above have the same empirical formula, but they have different physical properties.

(a) The skeletal structure for one of the two compounds is shown below in Box X.
   (i) Complete the Lewis electron-dot diagram of the molecule in Box X. Include any lone (nonbonding) pairs of electrons.

![Box X](image1)

![Box Y](image2)
(ii) In Box Y above, draw the complete Lewis electron-dot diagram for the other compound, which is a structural isomer of the compound represented in Box X. Include any lone (nonbonding) pairs of electrons.

(b) On the basis of the complete Lewis electron-dot diagrams you drew in part (a) and the information in the data table above, identify which compound, 1 or 2, has the structure represented in Box X. Justify your answer in terms of the intermolecular forces present in each compound.

Use the information in the following table to answer parts (c) and (d).

<table>
<thead>
<tr>
<th>Name</th>
<th>Lewis Electron-Dot Diagram</th>
<th>Boiling Point (°C)</th>
<th>Vapor Pressure at 20°C (mm Hg)</th>
</tr>
</thead>
</table>
| Dichloromethane       | \[\begin{array}{c}
   \cdot\cdot\cdot \\
   :Cl:\cdot:C\cdot:H \\
   :\cdot:Cl \\
\end{array}\] | 39.6               | 353                           |
| Carbon tetrachloride  | \[\begin{array}{c}
   :\cdot:Cl \\
   :\cdot:Cl\cdot:C\cdot:Cl \\
   :\cdot:Cl \\
\end{array}\]    | 76.7               | 89                            |

(c) Dichloromethane has a greater solubility in water than carbon tetrachloride has. Account for this observation in terms of the intermolecular forces between each of the solutes and water.

(d) In terms of intermolecular forces, explain why dichloromethane has a higher vapor pressure than carbon tetrachloride.

(e) The complete Lewis electron-dot diagram of methanal (formaldehyde) is shown in the box below. Molecules of methanal can form hydrogen bonds with water. In the box below, draw a water molecule in a correct orientation to illustrate a hydrogen bond between a molecule of water and the molecule of methanal. Use a dashed line to represent the hydrogen bond.
2012 AP® CHEMISTRY FREE-RESPONSE QUESTIONS

(c) The student then adds a small crystal of KI(s) to the test tube. The test tube is corked and inverted several times. The I⁻ ion reacts with I₂ to form the I₃⁻ ion, a linear species.

(i) In the box below, draw the complete Lewis electron-dot diagram for the I₃⁻ ion.

(ii) In which layer, water or hexane, would the concentration of I₃⁻ be higher? Explain.

An experiment is performed to compare the solubilities of I₂(s) in different solvents, water and hexane (C₆H₁₄). A student adds 2 mL of H₂O and 2 mL of C₆H₁₄ to a test tube. Because H₂O and C₆H₁₄ are immiscible, two layers are observed in the test tube. The student drops a small, purple crystal of I₂(s) into the test tube, which is then corked and inverted several times. The C₆H₁₄ layer becomes light purple, while the H₂O layer remains virtually colorless.

(d) Explain why the hexane layer is light purple while the water layer is virtually colorless. Your explanation should reference the relative strengths of interactions between molecules of I₂ and the solvents H₂O and C₆H₁₄, and the reasons for the differences.
6. Use principles of molecular structure, intermolecular forces, and kinetic molecular theory to answer the following questions.

(a) A complete Lewis electron-dot diagram of a molecule of ethyl methanoate is given below.

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

(i) Identify the hybridization of the valence electrons of the carbon atom labeled C\(_\text{x}\).

(ii) Estimate the numerical value of the H\(_\text{y}\)-C\(_\text{x}\)-O bond angle in an ethyl methanoate molecule. Explain the basis of your estimate.

(b) Ethyl methanoate, CH\(_3\)CH\(_2\)OCHO, is synthesized in the laboratory from ethanol, C\(_2\)H\(_5\)OH, and methanoic acid, HCOOH, as represented by the following equation.

\[ \text{C}_2\text{H}_5\text{OH}(l) + \text{HCOOH}(l) \rightleftharpoons \text{CH}_3\text{CH}_2\text{OCHO}(l) + \text{H}_2\text{O}(l) \]

(i) In the box below, draw the complete Lewis electron-dot diagram of a methanoic acid molecule.

(ii) In the box below, draw the complete Lewis electron-dot diagrams of a methanoic acid molecule and a water molecule in an orientation that allows a hydrogen bond to form between them.
(c) A small amount of liquid ethyl methanoate (boiling point 54°C) was placed in a rigid closed 2.0 L container containing argon gas at an initial pressure of 1.00 atm and a temperature of 20°C. The pressure in the container was monitored for 70. seconds after the ethyl methanoate was added, and the data in the graph below were obtained. It was observed that some liquid ethyl methanoate remained in the flask after 70. seconds. (Assume that the volume of the remaining liquid is negligible compared to the total volume of the container.)

![Graph showing pressure over time](image)

(i) Explain why the pressure in the flask increased during the first 60. seconds.

(ii) Explain, in terms of processes occurring at the molecular level, why the pressure in the flask remained constant after 60. seconds.

(iii) What is the value of the partial pressure of ethyl methanoate vapor in the container at 60. seconds?

(iv) After 80. seconds, additional liquid ethyl methanoate is added to the container at 20°C. Does the partial pressure of the ethyl methanoate vapor in the container increase, decrease, or stay the same? Explain. (Assume that the volume of the additional liquid ethyl methanoate in the container is negligible compared to the total volume of the container.)

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**2006 AP® CHEMISTRY FREE-RESPONSE QUESTIONS (Form B)**

<table>
<thead>
<tr>
<th>GeCl₄</th>
<th>SeCl₄</th>
<th>ICl⁻</th>
<th>ICl₄⁺</th>
</tr>
</thead>
</table>

6. The species represented above all have the same number of chlorine atoms attached to the central atom.

(a) Draw the Lewis structure (electron-dot diagram) of each of the four species. Show all valence electrons in your structures.

(b) On the basis of the Lewis structures drawn in part (a), answer the following questions about the particular species indicated.

(i) What is the Cl – Ge – Cl bond angle in GeCl₄?

(ii) Is SeCl₄ polar? Explain.

(iii) What is the hybridization of the I atom in ICl⁻?

(iv) What is the geometric shape formed by the atoms in ICl₄⁺?