**Question #**: 1

<table>
<thead>
<tr>
<th>Molecular View</th>
<th>State</th>
<th>Density</th>
<th>Shape</th>
<th>Volume</th>
<th>Strength of Intermolecular Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="solid" alt="Solid" /></td>
<td>solid</td>
<td>high</td>
<td>definite</td>
<td>1 [definite, indefinite]</td>
<td>strong</td>
</tr>
<tr>
<td><img src="liquid" alt="Liquid" /></td>
<td>liquid</td>
<td>2 [high, low]</td>
<td>3 [definite, indefinite]</td>
<td>definite</td>
<td>moderate</td>
</tr>
<tr>
<td><img src="gas" alt="Gas" /></td>
<td>gas</td>
<td>low</td>
<td>indefinite</td>
<td>indefinite</td>
<td>4 [strong, weak]</td>
</tr>
</tbody>
</table>

1. _________
2. _________
3. _________
4. _________
**Question #:** 2

Select the **true** statement based on this image.

![Dimethyl Ether and Ethanol](image)

A. Dimethyl ether has the higher boiling point.
B. Since both compounds have the same molar mass, they have the same boiling point.
C. Both compounds display intermolecular hydrogen bonding forces.
D. Ethanol has the higher melting point.

**Question #:** 3

Which liquid has the **lowest** viscosity?

A. H₂O at 5 °C
B. H₂O at 55 °C
C. C₆H₁₄ at 5 °C
D. C₆H₁₄ at 55 °C
Question #: 4

Three sets of containers are shown below with their differences noted (assume all other parameters are identical). Which container from each set will have the **lowest rate of vaporization**?

1. Varying surface area:

   ![Conical (Erlenmeyer) flask, Volumetric flask, Round-bottom flask](image)

2. Varying temperature:

   ![200 K, 400 K, 600 K](image)
3. Varying intermolecular forces:

A. 1. Round-bottom flask  
2. 600 K  
3. C₆H₆
B. 1. Volumetric flask  
2. 600 K  
3. CH₃CH₂OH
C. 1. Volumetric flask  
2. 200 K  
3. HOCH₂CH₂OH
D. 1. Conical (Erlenmeyer) flask  
2. 400 K  
3. HOCH₂CH₂OH
**Question #: 5**

The normal boiling point of benzene (C₆H₆) is 80.0 °C. What is benzene's vapor pressure at 45.0 °C? The heat of vaporization, ΔH_{vap}, of benzene is 30.8 kJ/mol.

A. 0.315 atm  
B. 0.217 atm  
C. 1.10 atm  
D. 0.868 atm

**Question #: 6**

Which statement is **false** about supercritical fluids?

![Pressure vs Temperature Graph](image)

A. The liquid phase cannot exist above a substance's critical temperature.  
B. At the critical point of a substance, the densities of its gas and liquid phases become equal.  
C. Supercritical fluids can act as good, selective solvents.  
D. The gas phase cannot exist below a substance's critical pressure.
Question #: 7

The direct conversion from solid to gas is called __1__ and __2__ [completely, partially] overcomes a substance's intermolecular forces. The direct conversion from solid to liquid is called __3__ (commonly known as "melting") and __4__ [completely, partially] overcomes a substance’s intermolecular forces.

1. __________
2. __________
3. __________
4. __________

Question #: 8

C_{10}H_{20}O(s) (levomenthol) sublimes at 298 K (room temperature), resulting in a minty aroma. ΔH_{fus} = 11.9 kJ/mol and ΔH_{vap} = 83.9 kJ/mol for levomenthol at 298 K. How much heat is required to convert 1.25 moles of solid, crystalline C_{10}H_{20}O(s) to gaseous C_{10}H_{20}O(g)?

A. 18.6 kJ
B. 94.2 kJ
C. 103 kJ
D. 120. kJ
Question #: 9

How much energy is required to convert 180. g (10.0 mol) of H₂O(l) at 20.0 ºC to H₂O(g) at 100.0 ºC?

melting point = 0.00 ºC
boiling point = 100.0 ºC
ΔH_fus = 6.02 kJ/mol
ΔH_vap = 40.7 kJ/mol
C_s of H₂O(s) = 2.09 J/g ºC
C_s of H₂O(l) = 4.18 J/g ºC
C_s of H₂O(g) = 2.01 J/g ºC

A. 467 kJ
B. 92.3 kJ
C. 638 kJ
D. 359 kJ
Question #: 10

For the substance described by this phase diagram, what phase changes occur as the pressure is increased from 0.010 atm to 100 atm at a temperature of 184 °C?

A. condensation followed by freezing  
B. sublimation followed by vaporization  
C. freezing followed by vaporization  
D. sublimation followed by condensation
Question #: 11

Iridium (192 g/mol) crystallizes in a face-centered cubic structure as shown below. The volume of the unit cell is $5.66 \times 10^{-23}$ cm$^3$. What is the density of iridium?

A. $4.49 \times 10^{-8}$ g/cm$^3$
B. 18.1 g/cm$^3$
C. 22.6 g/cm$^3$
D. 8.92 g/cm$^3$

Question #: 12

β-Brass has the structure shown below at 300 °C. The red circles represent Zn atoms and the yellow circle represents a Cu atom.

The formula of β-brass is __1__.

Enter your answer without spaces or subscripts, e.g., AlF3.
Octasulfur, S₈(s), is a(n) \[1\] [molecular, ionic, nonbonding atomic, metallic, network covalent] crystalline solid. As such, S₈(s) has a relatively \[2\] [low, high] melting point.
Germanium is doped, resulting in the material with the band diagram below.

If the blue dots represent electrons from germanium, red dots represent electrons from the dopant, and the open circle represents an electron hole, what is the identity of the dopant and the type of semiconductor formed?

A. arsenic; n-type
B. indium; p-type
C. silicon; p-type
D. gallium; n-type

---

Dichloromethane (CH\textsubscript{2}Cl\textsubscript{2}) and ethyl acetate (C\textsubscript{4}H\textsubscript{8}O\textsubscript{2}) spontaneously mix with one another because
A. they form strong hydrogen bonds with one another.
B. there is a large increase in potential energy for the mixed liquids compared to the two pure liquids.
C. there is a large increase in entropy for the mixed liquids compared to the two pure liquids.
D. there are strong ion-dipole attractions between dichloromethane and ethyl acetate.

Question #: 16

In a(n) **1** [saturated, supersaturated, unsaturated] solution, the dissolved solute is in dynamic equilibrium with any undissolved solute; additional solute will not dissolve. Added solute will dissolve in a(n) **2** [saturated, supersaturated, unsaturated] solution until equilibrium is reached. A(n) **3** [saturated, supersaturated, unsaturated] solution is an unstable solution in which more than the equilibrium amount of solute is dissolved.

1. __________
2. __________
3. ________
A 35.0 g sample of solid KNO₃ is added, with stirring, to 200.0 g of water at 20.0 °C. What results?

A. All of the KNO₃(s) dissolves at 20.0 °C and the solution remains unsaturated.
B. All of the KNO₃(s) dissolves at 20.0 °C and the solution becomes saturated.
C. All of the KNO₃(s) dissolves at 20.0 °C and the solution becomes supersaturated.
D. Most, but not all, of the KNO₃(s) dissolves at 20.0 °C and the solution becomes saturated.
**Question #**: 18

Which set of conditions results in the **lowest** solubility of \( \text{O}_2(\text{g}) \) in water?

A. high water temperature, low pressure of \( \text{O}_2 \) above the water  
B. low water temperature, high pressure of \( \text{O}_2 \) above the water  
C. low water temperature, low pressure of \( \text{O}_2 \) above the water  
D. high water temperature, high pressure of \( \text{O}_2 \) above the water

**Question #**: 19

What is the molality of a solution of 25.9 g \( \text{CuCl}_2 \) (134 g/mol) dissolved in 250 g of water?

A. 0.773 \( m \)  
B. 0.00882 \( m \)  
C. 0.119 \( m \)  
D. 1.21 \( m \)

**Question #**: 20

What is the concentration in parts per million (ppm) of \( \text{K}^+ \) in a solution made by dissolving 5.05 mg \( \text{K}_2\text{SO}_4 \) in 125 g \( \text{H}_2\text{O} \)?

A. 0.232 ppm  
B. 18.1 ppm  
C. 87.4 ppm  
D. 394 ppm
Question #: 21

What is the molarity of a 1.24 m glucose (180. g/mol) solution with a density of 1.011 g/mL?

A. 1.39 M  
B. 1.18 M  
C. 1.03 M  
D. 0.722 M

Question #: 22

Which aqueous solution has the lowest boiling point? Assume ideal van’t Hoff factors.

A. 0.10 m LiBr  
B. 0.10 m (NH₄)₃PO₄  
C. 0.25 m C₁₂H₂₂O₁₁  
D. 0.15 m Ca(OH)₂

Question #: 23

Which substance has the correct van’t Hoff factor indicated?

A. Ca(C₂H₃O₂)₂, i = 3  
B. NH₄Br, i = 6  
C. Na₂SO₄, i = 1  
D. Li₃PO₄, i = 2
**Question #:** 24

A solution at 25 °C contains 0.80 mol H₂O and 0.20 mol of a nonvolatile nonelectrolyte. If $P^\circ(\text{H}_2\text{O})$ is 23.8 torr, what is the vapor pressure of the solution?

A. 16.5 torr  
B. 18.2 torr  
C. 19.0 torr  
D. 27.7 torr

**Question #:** 25

What is the osmotic pressure of a 0.125 M potassium chlorate (KClO₃, 122 g/mol) solution at 300. K?

A. 1.07 atm  
B. 3.48 atm  
C. 2.86 atm  
D. 6.15 atm
**Molecular View**

<table>
<thead>
<tr>
<th>State</th>
<th>Density</th>
<th>Shape</th>
<th>Volume</th>
<th>Intermolecular Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>solid</td>
<td>high</td>
<td>definite</td>
<td>1</td>
<td>strong</td>
</tr>
<tr>
<td>liquid</td>
<td>low</td>
<td>indefinite</td>
<td>2</td>
<td>moderate</td>
</tr>
</tbody>
</table>

- **solid**: high density, definite shape, volume 1 [definite, indefinite]
- **liquid**: low density, indefinite shape, volume 3 [definite, indefinite]
1. definite\text{definate}\text{definate}\
2. high\text{hi}\
3. indefinite\text{indefinate}\text{indefinate}\
4. weak\text{Weak}\text{week}\text{Week}\

Question #: 2

Select the \textbf{true} statement based on this image.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{dimethyl_ether_ethanol.png}
\caption{Dimethyl Ether and Ethanol}
\end{figure}

A. Dimethyl ether has the higher boiling point.
B. Since both compounds have the same molar mass, they have the same boiling point.
C. Both compounds display intermolecular hydrogen bonding forces.
\checkmark D. Ethanol has the higher melting point.

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Which liquid has the lowest viscosity?

A. H₂O at 5 ºC  
B. H₂O at 55 ºC  
C. C₆H₁₄ at 5 ºC  
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Three sets of containers are shown below with their differences noted (assume all other parameters are identical). Which container from each set will have the lowest rate of vaporization?

1. Varying surface area:
   
   ![Conical (Erlenmeyer) flask, Volumetric flask, Round-bottom flask]

2. Varying temperature:
   
   ![200 K, 400 K, 600K]
3. Varying intermolecular forces:

A. 1. Round-bottom flask  
   2. 600 K  
   3. C₆H₆  
B. 1. Volumetric flask  
   2. 600 K  
   3. CH₃CH₂OH  
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B. 0.217 atm
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Which statement is **false** about supercritical fluids?

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The direct conversion from solid to liquid is called __3__ (commonly known as "melting") and __4__ [completely, partially] overcomes a substance's intermolecular forces.

1. sublimation|sublime|subliming|sublamation|
2. completely
3. fusion
4. partially

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C₁₀H₂₀O(s) (levomenthol) sublimes at 298 K (room temperature), resulting in a minty aroma. \( \Delta H_{\text{fus}} = 11.9 \text{ kJ/mol} \) and \( \Delta H_{\text{vap}} = 83.9 \text{ kJ/mol} \) for levomenthol at 298 K. How much heat is required to convert 1.25 moles of solid, crystalline C₁₀H₂₀O(s) to gaseous C₁₀H₂₀O(g)?

A. 18.6 kJ
B. 94.2 kJ
C. 103 kJ

\[ \checkmark \text{D. 120. kJ} \]

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How much energy is required to convert 180. g (10.0 mol) of H₂O(l) at 20.0 °C to H₂O(g) at 100.0 °C?

- melting point = 0.00 °C
- boiling point = 100.0 °C
- \( \Delta H_{\text{fus}} = 6.02 \text{ kJ/mol} \)
- \( \Delta H_{\text{vap}} = 40.7 \text{ kJ/mol} \)
- \( C_s \) of H₂O(s) = 2.09 J/g °C
- \( C_s \) of H₂O(l) = 4.18 J/g °C

A. 18.6 kJ
B. 94.2 kJ
C. 103 kJ

\[ \checkmark \text{D. 120. kJ} \]
\( C_s \) of \( \text{H}_2\text{O}(g) = 2.01 \text{ J/g } ^\circ \text{C} \)

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For the substance described by this phase diagram, what phase changes occur as the pressure is **increased** from 0.010 atm to 100 atm at a temperature of 184 °C?

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Question #: 12

β-Brass has the structure shown below at 300 °C. The red circles represent Zn atoms and the yellow circle represents a Cu atom.
The formula of β-brass is \( \text{ZZnCu} \).
Enter your answer without spaces or subscripts, e.g., AlF₃.
Question #: 13

Octasulfur, $S_8(s)$, is a(n) 1 [molecular, ionic, nonbonding atomic, metallic, network covalent] crystalline solid.
As such, $S_8(s)$ has a relatively 2 [low, high] melting point.

1. molecular|molecule|
2. low|lo|

Question #: 14

Germanium is doped, resulting in the material with the band diagram below.
If the blue dots represent electrons from germanium, red dots represent electrons from the dopant, and the open circle represents an electron hole, what is the identity of the dopant and the type of semiconductor formed?

A. arsenic; n-type
✓B. indium; p-type
C. silicon; p-type
D. gallium; n-type

Dichloromethane (CH₂Cl₂) and ethyl acetate (C₄H₈O₂) spontaneously mix with one another because
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A(n) 3 [saturated, supersaturated, unsaturated] solution is an unstable solution in which more than the equilibrium amount of solute is dissolved.

1. saturated|Saturated|
2. unsaturated|Unsaturated|un-saturated|
3. supersaturated|Supersaturated|super saturated|super|supersaturate|super-saturated|

Question #: 17

A 35.0 g sample of solid KNO₃ is added, with stirring, to 200.0 g of water at 20.0 °C. What results?
A. All of the KNO₃(s) dissolves at 20.0 °C and the solution remains unsaturated.
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Question #: 18

Which set of conditions results in the **lowest** solubility of O₂(g) in water?

A. high water temperature, low pressure of O₂ above the water
B. low water temperature, high pressure of O₂ above the water
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Which aqueous solution has the lowest boiling point? Assume ideal van’t Hoff factors.

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B. 0.10 m (NH₄)₃ PO₄
C. 0.25 m C₁₂H₂₂O₁₁
D. 0.15 m Ca(OH)₂
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Which substance has the correct van’t Hoff factor indicated?

✓ A. \( \text{Ca}(\text{C}_2\text{H}_3\text{O}_2)^{2-} \), \( i = 3 \)
B. \( \text{NH}_4\text{Br} \), \( i = 6 \)
C. \( \text{Na}_2\text{SO}_4 \), \( i = 1 \)
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A solution at 25 °C contains 0.80 mol H₂O and 0.20 mol of a nonvolatile nonelectrolyte. If \( P^o(\text{H}_2\text{O}) \) is 23.8 torr, what is the vapor pressure of the solution?

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