A transition from the solid phase to the gas phase requires an increase in \[1\] [pressure, volume, temperature] or a reduction in \[2\] [pressure, volume, temperature]. Either method results in disrupting the \[3\] [intramolecular, intermolecular] forces between the particles, leading to a \[4\] [more, less] dense phase.
Question #: 2

Rank the following in order from **lowest** to **highest** boiling point.

HBr, HCl, HF, HI

Lowest 1 < 2 < 3 < 4 Highest

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

---

Question #: 3

Arrange the liquids below, all at 20°C, in order of **increasing** viscosity. Use the names, not the formulas, to fill in the blanks.

\[
\begin{array}{cccc}
\text{OH} & \text{OH} & \text{OH} & \text{H} \\
\text{H}_2\text{C—CH}_2 & \text{H}_2\text{C—CH}_2 & \text{CH}_3—\text{CH}_2—\text{O—CH}_2—\text{CH}_3 & \text{H—O—H} \\
\text{ethanol} & \text{ethylene glycol} & \text{diethyl ether} & \text{water} \\
\end{array}
\]

Lowest 1 < 2 < 3 < 4 Highest

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

---

Question #: 4

Which **two** choices will the applied process will **increase** the rate of vaporization of the liquid?

A. A beaker of water is spilled on the floor.
B. A beaker of water is cooled from 50°C to 22°C.
C. Water is poured from a conical flask to a volumetric flask.
D. The water in a beaker is heated from 50°C to 80°C.

**Question #:** 5

One of the compounds that gives roses their characteristic smell is 2-phenylethanol, C₈H₁₀O. If the normal boiling point of 2-phenylethanol is 493 K, what temperature will **double** the vapor pressure? $\Delta H_{\text{vap}} = 69 \text{ kJ/mol}$

A. 514 K  
B. 374 K  
C. 429 K  
D. 622 K  

**Attachment:**

attachment_for_itemid_7728.png
Question #: 6

Which statement is true about the critical point for a substance?

A. Only a gas exists above the critical temperature.
B. Only a supercritical fluid exists above the critical point.
C. The critical temperature is the temperature above which a liquid is stable.
D. The gas phase cannot exist below a substance's critical pressure.

Question #: 7

Select the two true statement(s).

A. Sublimation is the phase change from solid to gas (vapor).
B. Fusion is an exothermic process.
C. Sublimation is an exothermic process.
D. Deposition is an exothermic process.
Question #: 8

A handful of snowflakes containing 1.56 moles of water sublimes to water vapor at 0 °C. How much heat energy was required?
At 0 °C, \( \Delta H_{\text{fus}} = 6.02 \text{ kJ/mol} \) and \( \Delta H_{\text{vap}} = 45.1 \text{ kJ/mol} \).

\[ \text{kJ} \]

Report your answer to the correct number of significant figures. Do NOT include units in your answer.

1. \__________

Question #: 9

How much energy is required to convert 11.5 g (0.250 mol) of liquid ethanol, \( \text{CH}_3\text{CH}_2\text{OH}(l) \), at – 21.6°C, to gaseous ethanol, \( \text{CH}_3\text{CH}_2\text{OH}(g) \), at 78.4°C?

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point</td>
<td>–114°C</td>
</tr>
<tr>
<td>Boiling point</td>
<td>78.4°C</td>
</tr>
<tr>
<td>( \Delta H_{\text{fus}} )</td>
<td>5.02 kJ/mol</td>
</tr>
<tr>
<td>( \Delta H_{\text{vap}} )</td>
<td>38.6 kJ/mol</td>
</tr>
<tr>
<td>( C_s ) of ( \text{CH}_3\text{CH}_2\text{OH}(s) )</td>
<td>0.97 J/g·°C</td>
</tr>
<tr>
<td>( C_s ) of ( \text{CH}_3\text{CH}_2\text{OH}(l) )</td>
<td>2.46 J/g·°C</td>
</tr>
<tr>
<td>( C_s ) of ( \text{CH}_3\text{CH}_2\text{OH}(g) )</td>
<td>0.95 J/g·°C</td>
</tr>
</tbody>
</table>

A. 12.5 kJ
B. 8.98 kJ
C. 6.21 kJ
D. 14.2 kJ
The phase change that occurs moving in a straight line from point B to point C is __1__. [freezing, fusion, sublimation, vaporization]
The phase change that occurs moving in a straight line from point D to point C is __2__. [condensation, deposition, fusion, sublimation]
Question #: 11

Copper (64 g/mol) crystallizes in a cubic-closest pack structure as shown below. The volume of the unit cell is $4.75 \times 10^{-23}$ cm$^3$. What is the density of copper?

A. $4.49 \times 10^{-8}$ g/cm$^3$
B. 4.81 g/cm$^3$
C. 12.6 g/cm$^3$
D. 8.95 g/cm$^3$

---

Question #: 12

The formula of the ionic compound with the unit cell below is $\underline{1}$. Note that the blue uranium ions and two red nitride ions occupy interior positions and are contained wholly within the cubic unit cell. The remainder of the red nitride ions are located on the corners.

List the formula in the order U# N#, with the lowest whole-number coefficient for each element (even if it is 1).
Solid benzene, C₆H₆(s), is a(n) __1__ [molecular, ionic, nonbonding atomic, metallic, network covalent] crystalline solid. As such, C₆H₆(s) has a relatively __2__ [low, high] melting point compared to carbon nanotubes, pictured below, which are __3__ [molecular, ionic, nonbonding atomic, metallic, network covalent] crystalline solids.
Question #: 14

Which one acts as a **p-type semiconductor**?

A. germanium doped with indium  
B. silicon doped with arsenic  
C. germanium doped with phosphorous  
D. phosphorous doped with gallium
**Question #**: 15

Which **two** statements are **true** regarding the mixing of helium and argon, as shown below?

![Diagram of helium and argon mixing](image)

A. Mixing is spontaneous because it lowers the potential energy of the system.
B. Helium and argon can be considered ideal gases for the purposes of this experiment because they do not experience significant intermolecular attractions.
C. Mixing is spontaneous because it increases the entropy, or energy dispersal, of the system.
D. Helium and argon do not mix spontaneously because their intermolecular forces are not similar in type or size.
E. Heat energy has to be added to the system for mixing to occur.

**Question #**: 16

The liquids CH₃CH₂CH₂CH₂CH₂CH₂OH and H₂O

A. are not miscible because they are both nonpolar molecules.
B. are not miscible because the intermolecular interactions in the liquids are not of similar type and magnitude.
C. are miscible because they are both polar molecules.
D. are miscible because intermolecular interactions in the liquids are of similar type and magnitude.
Question #: 17

An aqueous solution is saturated in both O$_2$(g) and C$_6$H$_{12}$O$_6$(aq) at 35 ºC, and there is some C$_6$H$_{12}$O$_6$(s) present. If the solution is left open to the atmosphere and cooled to 15 ºC, which two are most likely to occur?

A. Some O$_2$(g) bubbles out of solution.
B. Some C$_6$H$_{12}$O$_6$(s) precipitates.
C. Some C$_6$H$_{12}$O$_6$(s) dissolves.
D. Some O$_2$(g) dissolves into solution.
E. Neither the O$_2$(g) nor the KCl(aq) concentration changes.

Question #: 18

What happens when 60.0 g of KNO$_3$ is added to 200.0 g of water 20.0 ºC?

A. All 60.0 g of KNO$_3$ dissolves, resulting in an unsaturated solution.
B. All 60.0 g of KNO$_3$ dissolves, resulting in a saturated solution.
C. All 60.0 g of KNO$_3$ dissolves, resulting in a supersaturated solution.
D. A portion of the 60.0 g of KNO$_3$ dissolves, resulting in a saturated solution with KNO$_3$(s) remaining.
**Question #**: 19

The molality of a solution prepared by dissolving 18.0 grams of ammonium nitrate (NH₄NO₃, 80.0 g/mol) in 40.0 grams of water is \( \frac{1}{1} \) m. Report your answer to three significant digits. Do NOT include units in your answer.

1. \( \frac{1}{1} \)

**Question #**: 20

A 1.50 kg water sample contains 0.0078 g of Zn²⁺ ions. What is the concentration of zinc in ppm?

- A. 5.2 ppm
- B. 7.2 ppm
- C. 3.6 ppm
- D. 1.8 ppm

**Question #**: 21

A 4.25 M glycerol (C₃H₈O₃, 92 g/mol) solution has a density of 1.195 g/mL and a molal concentration of \( \frac{1}{1} \) m. Report your answer with two significant figures. Do NOT include units in your answer.

1. \( \frac{1}{1} \)
Question #: 22

What is the vapor pressure of a solution of 55.8 g (0.900 mol) of ethylene glycol, a nonvolatile nonelectrolyte, in 144 g (8.00 mol) of water at 110.0 °C? The vapor pressure of pure water at 110.0 °C is 1070 torr.

A. 962 torr  
B. 839 torr  
C. 1020 torr  
D. 1210 torr

Question #: 23

What is the freezing point of a solution containing 21.9 g (0.0750 mol) of iron(III) carbonate, Fe₂(CO₃)₃, dissolved in 0.175 kg of water?

\[ K_f(H_2O) = 1.86 \, ^\circ C/m \]

Report your answer with **three** significant figures. Do NOT include units in your answer.

1. __________

Question #: 24

An osmotic cell with a semipermeable membrane is set up with pure water in the left chamber and 1.50 M KCl in the right chamber. What happens as the cell reaches equilibrium?
A. The liquid level in the left (H₂O) cell rises.
B. The liquid level in the right (1.50 M KCl) cell rises.
C. The levels remain the same.

Question #: 25

Of the aqueous solutions below, solution _1_ (A, B, or C) has the highest boiling point and solution _2_ (A, B, or C) has the highest freezing point.

A. 0.01 m MgCl₂
B. 0.02 m KF
C. 0.01 m FeI₄

1. __________
2. __________
A transition from the solid phase to the gas phase requires an increase in \[1\] [pressure, volume, temperature] or a reduction in \[2\] [pressure, volume, temperature]. Either method results in disrupting the \[3\] [intramolecular, intermolecular] forces between the particles, leading to a \[4\] [more, less] dense phase.
1. temperature
2. pressure
3. intermolecular
4. less

Question #: 2

Rank the following in order from lowest to highest boiling point.

HBr, HCl, HF, HI

Lowest 1 < 2 < 3 < 4 Highest

1. HCl
2. HBr
3. HI
4. HF

Question #: 3

Arrange the liquids below, all at 20°C, in order of increasing viscosity. Use the names, not the formulas, to fill in the blanks.

<table>
<thead>
<tr>
<th>OH</th>
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<th>OH</th>
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</thead>
<tbody>
<tr>
<td>H₂C—CH₂</td>
<td>H₂C—CH₂</td>
<td>CH₃—CH₂—O—CH₂—CH₃</td>
</tr>
<tr>
<td>ethanol</td>
<td>ethylene glycol</td>
<td>diethyl ether</td>
</tr>
</tbody>
</table>

water
Lowest 1 < 2 < 3 < 4 Highest

1. diethyl ether
2. ethanol
3. water
4. ethylene glycol

**Question #: 4**

Which **two** choices will the applied process will **increase** the rate of vaporization of the liquid?

✓ A. A beaker of water is spilled on the floor.

B. A beaker of water is cooled from 50°C to 22°C.

C. Water is poured from a conical flask to a volumetric flask.

✓ D. The water in a beaker is heated from 50°C to 80 °C.

**Question #: 5**

One of the compounds that gives roses their characteristic smell is 2-phenylethanol, \( C_8H_{10}O \). If the normal boiling point of 2-phenylethanol is 493 K, what temperature will **double** the vapor pressure? \( \Delta H_{vap} = 69 \text{ kJ/mol} \)

✓ A. 514 K

B. 374 K

C. 429 K
Question #: 6

Which statement is **true** about the critical point for a substance?

A. Only a gas exists above the critical temperature.
✓ B. Only a supercritical fluid exists above the critical point.
C. The critical temperature is the temperature above which a liquid is stable.
D. The gas phase cannot exist below a substance’s critical pressure.

Question #: 7

Select the **two true** statement(s).

✓ A. Sublimation is the phase change from solid to gas (vapor).
   B. Fusion is an exothermic process.
   C. Sublimation is an exothermic process.
✓ D. Deposition is an exothermic process.
Question #: 8

A handful of snowflakes containing 1.56 moles of water sublimes to water vapor at 0 °C. How much heat energy was required?

At 0 °C, $\Delta H_{\text{fus}} = 6.02 \text{ kJ/mol}$ and $\Delta H_{\text{vap}} = 45.1 \text{ kJ/mol}$.

1 \_ kJ

Report your answer to the correct number of significant figures. Do NOT include units in your answer

1. 79.7

Question #: 9

How much energy is required to convert 11.5 g (0.250 mol) of liquid ethanol, CH$_3$CH$_2$OH($l$), at –21.6°C, to gaseous ethanol, CH$_3$CH$_2$OH($g$), at 78.4°C?

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</tr>
</tbody>
</table>
Question #: 10

The phase change that occurs moving in a straight line from point B to point C is ___ 1 ___.
[freezing, fusion, sublimation, vaporization]

The phase change that occurs moving in a straight line from point D to point C is ___ 2 ___.
[condensation, deposition, fusion, sublimation]

1. fusion
2. condensation

Question #: 11

Copper (64 g/mol) crystallizes in a cubic-closest pack structure as shown below. The volume of the unit cell is $4.75 \times 10^{-23}$ cm$^3$. What is the density of copper?
The formula of the ionic compound with the unit cell below is \( 1 \). Note that the blue uranium ions and two red nitride ions occupy interior positions and are contained wholly within the cubic unit cell. The remainder of the red nitride ions are located on the corners.

List the formula in the order U\# N\#, with the lowest whole-number coefficient for each element (even if it is 1).
Solid benzene, C₆H₆(s), is a(n) [molecular, ionic, nonbonding atomic, metallic, network covalent] crystalline solid. As such, C₆H₆(s) has a relatively [low, high] melting point compared to carbon nanotubes, pictured below, which are [molecular, ionic, nonbonding atomic, metallic, network covalent] crystalline solids.
1. molecular
2. low
3. network covalent

**Question #**: 14

Which one acts as a **p-type semiconductor**?

- ✓ A. germanium doped with indium
- B. silicon doped with arsenic
- C. germanium doped with phosphorous
- D. phosphorous doped with gallium

**Question #**: 15

Which **two** statements are **true** regarding the mixing of helium and argon, as shown below?
A. Mixing is spontaneous because it lowers the potential energy of the system.
✓B. Helium and argon can be considered ideal gases for the purposes of this experiment because they do not experience significant intermolecular attractions.
✓C. Mixing is spontaneous because it increases the entropy, or energy dispersal, of the system.
D. Helium and argon do not mix spontaneously because their intermolecular forces are not similar in type or size.
E. Heat energy has to be added to the system for mixing to occur.

Question #: 16

The liquids \(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}\) and \(\text{H}_2\text{O}\)

A. are not miscible because they are both nonpolar molecules.
✓B. are not miscible because the intermolecular interactions in the liquids are not of similar type and magnitude.
C. are miscible because they are both polar molecules.
D. are miscible because intermolecular interactions in the liquids are of similar type and magnitude.

Question #: 17

An aqueous solution is saturated in both \(\text{O}_2(g)\) and \(\text{C}_6\text{H}_{12}\text{O}_6(aq)\) at 35 °C, and there is some \(\text{C}_6\text{H}_{12}\text{O}_6(s)\) present. If the solution is left open to the atmosphere and cooled to 15 °C, which two are most likely to occur?

A. Some \(\text{O}_2(g)\) bubbles out of solution.
✓B. Some \(\text{C}_6\text{H}_{12}\text{O}_6(s)\) precipitates.
C. Some \(\text{C}_6\text{H}_{12}\text{O}_6(s)\) dissolves.
✓D. Some \(\text{O}_2(g)\) dissolves into solution.
E. Neither the \(\text{O}_2(g)\) nor the KCl(aq) concentration changes.

Question #: 18

What happens when 60.0 g of \(\text{KNO}_3\) is added to 200.0 g of water 20.0 °C?
A. All 60.0 g of KNO₃ dissolves, resulting in an unsaturated solution.
✓B. All 60.0 g of KNO₃ dissolves, resulting in a saturated solution.
C. All 60.0 g of KNO₃ dissolves, resulting in a supersaturated solution.
D. A portion of the 60.0 g of KNO₃ dissolves, resulting in a saturated solution with KNO₃(s) remaining.

**Question #: 19**

The molality of a solution prepared by dissolving 18.0 grams of ammonium nitrate (NH₄NO₃, 80.0 g/mol) in 40.0 grams of water is \( \frac{1}{m} \) m. Report your answer to three significant digits. Do NOT include units in your answer.

1. 5.63|5.62|

**Question #: 20**

A 1.50 kg water sample contains 0.0078 g of Zn²⁺ ions. What is the concentration of zinc in ppm?
✓A. 5.2 ppm
B. 7.2 ppm
C. 3.6 ppm
D. 1.8 ppm

---

**Question #: 21**

A 4.25 M glycerol (C\textsubscript{3}H\textsubscript{8}O\textsubscript{3}, 92 g/mol) solution has a density of 1.195 g/mL and a molal concentration of \[ \text{ m } \].

Report your answer with **two** significant figures. Do **NOT** include units in your answer.

1. 5.3

---

**Question #: 22**

What is the vapor pressure of a solution of 55.8 g (0.900 mol) of ethylene glycol, a nonvolatile nonelectrolyte, in 144 g (8.00 mol) of water at 110.0 °C? The vapor pressure of pure water at 110.0 °C is 1070 torr.

✓A. 962 torr
B. 839 torr
C. 1020 torr
D. 1210 torr

---

**Question #: 23**

What is the freezing point of a solution containing 21.9 g (0.0750 mol) of iron(III) carbonate, Fe\textsubscript{2}(CO\textsubscript{3})\textsubscript{3}, dissolved in 0.175 kg of water?

\[ K_f(H_2O) = 1.86 \text{ °C/m} \]

\[ \frac{1}{1^\circ C} \]

Report your answer with **three** significant figures. Do **NOT** include units in your answer.

1. -3.99
**Question #24**

An osmotic cell with a semipermeable membrane is set up with pure water in the left chamber and 1.50 M KCl in the right chamber. What happens as the cell reaches equilibrium?

- A. The liquid level in the left (H₂O) cell rises.
- B. The liquid level in the right (1.50 M KCl) cell rises.  
  ✔️
- C. The levels remain the same.

---

**Question #25**

Of the aqueous solutions below, solution 1 (A, B, or C) has the **highest boiling point** and solution 2 (A, B, or C) has the **highest freezing point**.

A. 0.01 m MgCl₂
B. 0.02 m KF
C. 0.01 m FeI₄⁻

1. C|C.|C|C.|