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1. Rank the following molecules in order of increasing intermolecular forces:



- A.  $\text{NCl}_3 < \text{CO}_2 < \text{CH}_3\text{CH}_2\text{OH}$       C.  $\text{CO}_2 < \text{CH}_3\text{CH}_2\text{OH} < \text{NCl}_3$   
B.  $\text{CO}_2 < \text{NCl}_3 < \text{CH}_3\text{CH}_2\text{OH}$       D.  $\text{CH}_3\text{CH}_2\text{OH} < \text{CO}_2 < \text{NCl}_3$

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2. Which of the following has the compound with the **greater** viscosity listed **first**? All pairs are at the same temperature unless stated otherwise.

- A. benzene ( $\text{C}_6\text{H}_6$ ),  $\text{H}_2\text{O}$   
B.  $(\text{CH}_3)_4\text{C}$  (neopentane, nearly spherical shape),  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$  (*n*-pentane, straight chain)  
C.  $\text{CH}_3\text{CH}_3\text{OH}$ ,  $\text{CH}_3\text{OCH}_3$   
D.  $\text{H}_2\text{O}$  at  $50\text{ }^\circ\text{C}$ ,  $\text{H}_2\text{O}$  at  $25\text{ }^\circ\text{C}$

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3. Which answer lists changes that will all **increase** the rate of vaporization?

- A. increasing temperature, increasing surface area, increasing intermolecular forces  
B. increasing temperature, increasing surface area, decreasing intermolecular forces  
C. decreasing temperature, increasing surface area, increasing intermolecular forces  
D. increasing temperature, decreasing surface area, decreasing intermolecular forces

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4. Acetone has a heat of vaporization of  $32.0\text{ kJ/mol}$  and a vapor pressure of  $221\text{ torr}$  at  $25.0\text{ }^\circ\text{C}$ . What is the normal boiling point of acetone?

- A.  $56.5\text{ }^\circ\text{C}$       C.  $34.2\text{ }^\circ\text{C}$   
B.  $26.5\text{ }^\circ\text{C}$       D.  $65.6\text{ }^\circ\text{C}$
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5. Which one of the following statements is **true**?
- A. The critical point is defined only by temperature; pressure has no effect.
  - B. The critical point is defined only by pressure; temperature has no effect.
  - C. Only the gas phase is present above the critical point.
  - D. Neither a distinct liquid phase nor a distinct gas phase exists above the critical point.
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6. Fusion is
- A. the phase transition from solid to liquid.
  - B. the phase transition from gas to solid.
  - C. the phase transition from liquid to gas.
  - D. the phase transition from solid to gas.
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7. Which of the following is the **most endothermic** process?

- A.  $\text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l)$
  - B.  $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$
  - C.  $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(g)$
  - D.  $\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g)$
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8. How much heat is evolved in converting 36.03 g of steam at 100.0 °C to liquid water at 20.0 °C?

Specific heat, ice = 2.09 J/g·°C

Specific heat, water = 4.18 J/g·°C

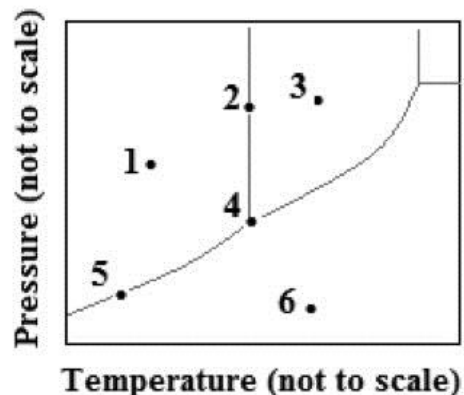
Specific heat, steam = 2.01 J/g·°C

Heat of vaporization, water = 40.7 kJ/mol

Heat of fusion, water = 6.02 kJ/mol

- A. 15.4 kJ
  - B. 80.3 kJ
  - C. 108 kJ
  - D. 93.4 kJ
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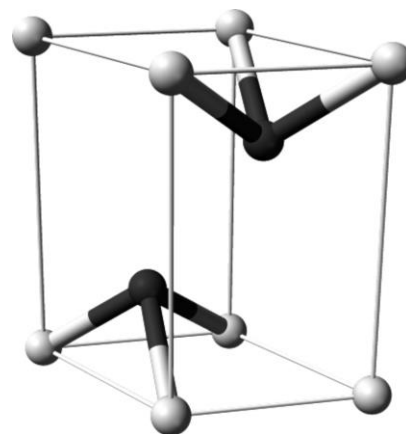
9. Which transition occurs when moving from Point 3 to Point 6 on this phase diagram?



- A. liquid to gas  
B. solid to gas  
C. gas to solid  
D. liquid to solid
10. Which crystal structure contains one atom per unit cell, has a coordination number of six, and a packing efficiency of 52%?

- A. amorphous  
B. simple cubic  
C. body-centered cubic  
D. face-centered cubic

11. A crystalline unit cell containing iodine atoms located wholly inside the cell and magnesium atoms on all the corners is pictured. Determine the formula of the ionic compound.



- A.  $\text{MgI}_2$   
B.  $\text{Mg}_4\text{I}$   
C.  $\text{Mg}_4\text{I}_2$   
D.  $\text{Mg}_2\text{I}_2$

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12. Lead crystallizes as a face-centered cubic unit cell with an edge length of 495.0 pm. What is the density of lead?
- A. 14.45 g/cm<sup>3</sup>                      C. 12.51 g/cm<sup>3</sup>  
B. 9.257 g/cm<sup>3</sup>                      D. 11.35 g/cm<sup>3</sup>

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13. What type of crystalline solid has a high melting point, is composed of two or more elements, and is held together by electrostatic attractions between formula units?
- A. molecular solid                      C. ionic solid  
B. nonbonding atomic solid                      D. network covalent solid
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14. Which statement about mixing is **false**?
- A. Mixing causes less order and greater randomization of energy in the system.
  - B. Mixing decreases the entropy of the system.
  - C. Mixing lowers the potential energy of the system.
  - D. Entropy will sometimes drive mixing even when solute-solvent interactions are less favorable than solute-solute and solvent-solvent interactions.

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15. Which of the following will be miscible, or soluble in all proportions, in hexane ( $C_6H_{14}$ ) but not in water?

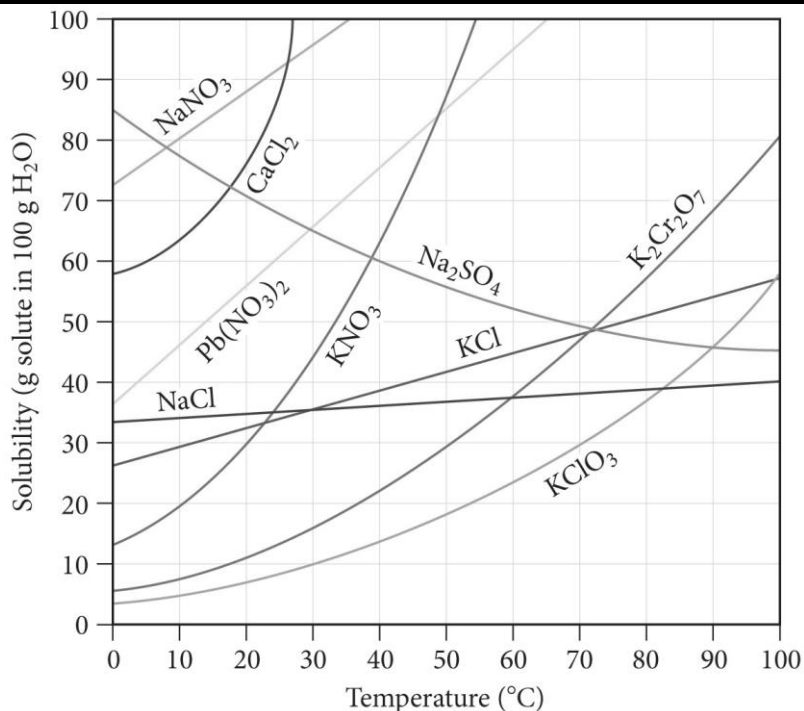
- I. potassium sulfate,  $K_2SO_4$
- II. bromine,  $Br_2$
- III. carbon tetrachloride,  $CCl_4$
- IV. methanol,  $CH_3OH$

- A. I and II
- B. I and IV
- C. II and III
- D. III and IV

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16. A supersaturated solution

- A. has a solute and solvent in dynamic equilibrium.
  - B. has more solute than solvent.
  - C. can dissolve more solute.
  - D. has more solute dissolved than predicted by its solubility.
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17. A 200.0 mL portion of water is heated to 100.0 °C and 90.0 g of solid sodium sulfate is added, with stirring, until all of the solid dissolves. The resulting solution is removed from the heat source and allowed to cool to room temperature (25 °C). What happens to the solution?



- A. All of the  $\text{Na}_2\text{SO}_4(aq)$  remains in solution at 25 °C and the solution becomes unsaturated.
- B. All of the  $\text{Na}_2\text{SO}_4(aq)$  remains in solution at 25 °C and the solution remains saturated.
- C. The  $\text{Na}_2\text{SO}_4(aq)$  exceeds the equilibrium solubility at 25 °C and begins to precipitate, leaving behind an unsaturated solution.
- D. The  $\text{Na}_2\text{SO}_4(aq)$  exceeds the equilibrium solubility at 25 °C and begins to precipitate, leaving behind a saturated solution.

18. Which of the following will have the **least**  $\text{CO}_2(g)$  dissolved in solution?

- A. Water boiling at 100 °C open to the atmosphere with  $P(\text{CO}_2) = 3.7 \times 10^{-4}$  atm.
- B. Room temperature water open to the atmosphere with  $P(\text{CO}_2) = 3.7 \times 10^{-4}$  atm.
- C. A freshly opened can of soda at 10 °C that was bottled under  $P(\text{CO}_2) = 4.0$  atm.
- D. A cold can of unopened soda at 10 °C that was bottled under  $P(\text{CO}_2) = 4.0$  atm.



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22. The vapor pressure of benzene,  $C_6H_6$ , at  $26\text{ }^\circ\text{C}$  is  $100.0\text{ torr}$ . How many **moles** of a nonvolatile solute need to be added to  $0.400\text{ mol}$  of benzene to reduce the vapor pressure of the solution to  $80.0\text{ torr}$ ?

A.  $0.100\text{ mol}$

C.  $0.600\text{ mol}$

B.  $0.200\text{ mol}$

D.  $0.800\text{ mol}$

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23. When  $10.0\text{ g}$  of an unknown nonelectrolyte is dissolved in  $0.200\text{ kg}$  of carbon tetrachloride, the freezing point of the resulting solution is  $-31.90\text{ }^\circ\text{C}$ . The freezing point of pure  $CCl_4$  is  $-22.90\text{ }^\circ\text{C}$  and  $K_f(CCl_4)$  is  $29.9\text{ }^\circ\text{C}/m$ . What is the **molar mass** of the unknown compound?

A.  $15.9\text{ g/mol}$

C.  $166\text{ g/mol}$

B.  $139\text{ g/mol}$

D.  $278\text{ g/mol}$

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**Answer Key:**

1. B
2. C
3. B
4. A
5. D
6. A
7. C
8. D
9. A
10. B
11. A
12. D
13. C
14. B
15. C
16. D
17. A
18. A
19. C
20. B
21. D
22. A
23. C
24. B
25. D