

### 13 • IMF's, Liquids, and Solids

#### PRACTICE TEST

- Surface tension in a liquid is due to the fact that
  - surface molecules are pulled toward the interior
  - liquids tend toward lowest energy
  - PE is increased for molecules at the surface
  - interior molecules are attracted in all directions
  - all of the above

- In which one of the following will dipole-dipole attractions play the most significant role as the intermolecular attraction?
  - HCl
  - NaCl
  - Kr
  - H<sub>2</sub>O *H-bonding*
  - NH<sub>3</sub> *H-bonding*

- With which type of substances do London dispersion forces play the most significant role?
  - polar molecules
  - metals
  - ionic compounds
  - non-polar molecules
  - network compounds

- The heat of vaporization of H<sub>2</sub>S, at its boiling point (-61°C) is 18.8 kJ/mol. What mass of H<sub>2</sub>S can be vaporized (at its boiling point) with 100 kJ of energy?

- $100 \times \frac{61}{18.8}$
  - $34.1 \times \frac{18.8}{100}$
  - $61 \times 18.8 \times 100 \times 34.1$
  - $18.8 \times \frac{61}{34.1}$
  - $100 \times \frac{34.1}{18.8}$
- 100 kJ = 100,000 J*  
 $\frac{100,000 \text{ J}}{18.8 \text{ kJ/mol}} = 5.32 \text{ mol H}_2\text{S}$   
 $5.32 \text{ mol} \times 34.1 \text{ g/mol} = 182 \text{ g H}_2\text{S}$

- Which one of the following substances exhibits the strongest intermolecular forces of attraction?

- CH<sub>4</sub>
  - C<sub>2</sub>H<sub>6</sub>
  - C<sub>3</sub>H<sub>8</sub>
  - CH<sub>3</sub>OH *H-bonding*
  - CH<sub>3</sub>Cl *dipole-dipole*
- non-polar*

- For which substance would you predict the highest heat of vaporization? *Strongest IMF*

- F<sub>2</sub>
  - H<sub>2</sub>O
  - HF
  - NaCl *ionic*
  - Br<sub>2</sub>
- H-bonding*  
*London*

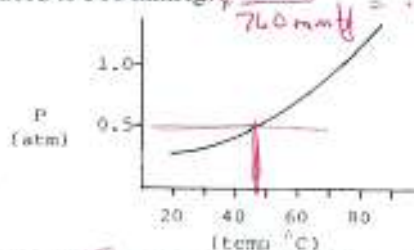
- Which of the following will change the equilibrium vapor pressure of a liquid? *only Temp.*

- Heat up or cool down the liquid
  - Increase the Volume of the container
  - Change the pressure above the liquid
- I only
  - I and II only
  - I, II, and III
  - I and III only
  - II and III only

- Which of the following statements describes a substance above its critical point?

- the substance can be liquefied
- the vapor and liquid phase become indistinguishable
- the substance experiences no intermolecular interactions
- there is a distinct phase boundary between the liquid and vapor
- all of the above

- At what temperature will the liquid (whose vapor pressure is shown below) boil if the air pressure is reduced to 380 mmHg?



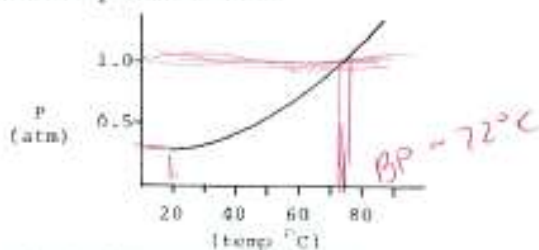
- 30°C
- 50°C
- 70°C
- 100°C
- the liquid will not boil at this pressure

- Which one of the following is linked with the correct intermolecular force of attraction?

- NH<sub>3</sub>.....*H-bond*.....dipole-dipole
- AlH<sub>3</sub>.....London dispersion forces
- H<sub>2</sub>.....*London*.....hydrogen bonding
- C<sub>2</sub>H<sub>4</sub>.....*London*.....covalent bonding
- HCl.....*dipole-dipole*.....ionic

*Al-H is non-polar molecule*

11. The vapor pressure graph of an unknown liquid is shown below. Which of the following statements about this liquid is/are true?



- I. This liquid has weaker IMF's than water.  
 II. The liquid's normal boiling point is around 75°C.  
 III. The liquid boils at room temperature when the pressure is dropped to about 0.25 atm.
- a) II and III only      d) I only  
 b) II only              e) I, II, and III  
 c) I and III

12. How much energy does it require to melt 25.0 g benzene,  $C_6H_6$ ? The heat of fusion of benzene is 2.37 kJ/mol. [molar mass = 78.0 g/mol]

- a) 8.25 kJ      d) 0.759 kJ  
 b) 59.3 kJ      e) none of these  
 c) 4625 kJ

$25.0 \text{ g C}_6\text{H}_6 \times \frac{1 \text{ mol C}_6\text{H}_6}{78.0 \text{ g}} \times 2.37 \text{ kJ/mol} = 0.759 \text{ kJ}$

13. What type of solid(s) can contain covalent bonds?

- a) molecular      d) network  
 b) metallic      e) all but "b"  
 c) ionic

ex.  $NaHCO_3$

14. Which type of solid generally has the highest melting point?

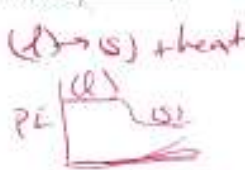
- a) metallic      c) molecular  
 b) ionic      d) network  
 (diamond), etc.

15. Which substance below exhibits the weakest IMFs?

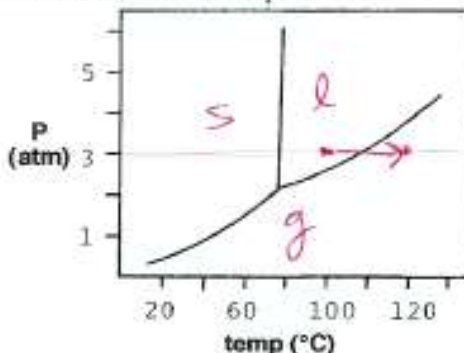
- a)  $IF_3$       b)  $SO_2$       c)  $CO_2$       d)  $SiO_2$       e)  $PH_3$   
 Trigonal bipyram. polar      linear network      pyramidal polar

16. During the condensing of a liquid, the kinetic energy \_\_\_\_\_ and the potential energy \_\_\_\_\_.

- a) stays the same, increases  
 b) increases, decreases  
 c) increases, increases  
 d) decreases, stays the same  
 e) stays the same, decreases

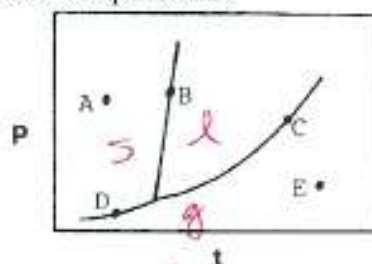


17. The phase diagram of a substance is given below. What occurs when the substance is heated from 100°C to 120°C at 3 atm pressure?



- a) it melts      d) it freezes  
 b) it sublimates      e) no phase change occurs  
 c) it boils

18. A typical phase diagram for a substance is given below. At what point on the diagram do solid and liquid exist at equilibrium?



- a) A      b) B      c) C      d) D      e) E

19. Which one of the following as solids has a crystal structure containing discrete (separate) molecules?

- a) potassium      d) carborundum,  $SiC$  network  
 b) glass amorphous      e) hydrogen  
 c) quartz network

20. The heat of sublimation of a compound equals

- a) heat of fusion plus heat of vaporization  
 b) heat of ionization plus heat of crystallization  
 c) heat of vaporization minus heat of fusion  
 d) heat of vaporization plus heat of crystallization  
 e) heat of crystallization plus heat of vaporization

21. The normal boiling point of a liquid
- a) is 100 °C at 1 atm pressure. *For WATER*
  - b) is the temperature at which the vapor pressure is 1 atm. *760 mmHg or 101.3 kPa or 14.7 psi***
  - c) is the temperature at which liquid and vapor are in equilibrium.
  - d) is the temperature at which the vapor pressure equals the external pressure.
  - e) is the temperature at which there is a continuous formation of gaseous bubbles in the liquid.

22. The vapor pressure of a liquid increases with an increase of temperature. Which of the following best explains this increase?
- a) The average kinetic energy of molecules is greater, thus more molecules can enter the gaseous state.**
  - b) The number of gaseous molecules above the liquid remains constant but these molecules have greater average kinetic energy.
  - c) the faster moving molecules in the liquid exert a greater pressure.
  - d) All the molecules have greater kinetic energies.
  - e) The intermolecular forces between the molecules becomes less at higher temperatures.

23. Which of the following indicates very strong intermolecular forces of attraction in a liquid?
- a) A very low boiling point.
  - b) A very low critical temperature.
  - c) A very low heat of vaporization.
  - d) A very low vapor pressure.**
  - e) A very low surface tension.

24. The compounds Br<sub>2</sub> and ICl have almost identical molecular weights, yet ICl boils at 97°C and Br<sub>2</sub> boils at 59 °C. The best explanation for the difference is
- a) ICl is an ionic compound and Br<sub>2</sub> is covalent.
  - b) ICl is a nonpolar molecule and Br<sub>2</sub> is polar.
  - c) ICl has a longer bond than that in Br<sub>2</sub> . ?
  - d) ICl has a measurable dipole moment (is polar) and Br<sub>2</sub> does not (is nonpolar).**
  - e) ICl has a stronger bond than that in Br<sub>2</sub> . ?

25. In some compounds the hydrogen atom is covalently bonded to one atom and simultaneously attracted to another atom in another molecule by an electrostatic interaction. This interaction can occur when hydrogen is bonded to

- a) Cl
- b) Si
- c) N** *or F or O*
- d) C
- e) Br

26. Which of the following compounds shows an abnormal boiling point due to hydrogen bonding?

- a) CH<sub>3</sub>NH<sub>2</sub>**
- b) CH<sub>3</sub>OCH<sub>3</sub>
- c) CH<sub>3</sub>Cl
- d) HCl
- e) CH<sub>3</sub>SH

27. Which of the following has the lowest boiling point?

- a) H<sub>2</sub>O *HB → d<sub>1</sub>*
- b) H<sub>2</sub>S** *smallest*
- c) H<sub>2</sub>Se *least polarizable ← d<sub>2</sub>*
- d) H<sub>2</sub>Te
- e) NH<sub>3</sub> *HB → d<sub>1</sub>*

28. Which of the following would be expected to have the highest heat of vaporization?

- a) H<sub>2</sub>O** *Liq*
- b) NH<sub>3</sub> *Gas*
- c) HF *Gas*
- d) all three are the same

29. Which element is considered a covalent/network solid?

- a) Cr *metal*
- b) O *gas*
- c) Xe *gas*
- d) B** *metalloid*
- e) Na *metal*

30. Which one of the following compounds has intermolecular forces different than the others?

- a) quartz, SiO<sub>2</sub>
- b) C<sub>(diamond)</sub>
- c) carbon dioxide, CO<sub>2</sub>** *London*
- d) C<sub>(graphite)</sub>
- e) silicon carbide, SiC *all others are covalent network solids*

### Answers

1. E	9. B	17. C	25. C
2. A	10. B	18. B	26. A
3. D	11. E	19. E	27. B
4. E	12. D	20. A	28. A
5. D	13. E	21. B	29. D
6. D	14. D	22. A	30. C
7. A	15. C	23. D	
8. B	16. E	24. D	