Name: ______________________ Class: ____________________ Date: ____________________

Instructions: Answer the following questions. Show ALL work for problems to receive full credit. Make sure to include proper units and significant figures for all answers.

[3 pt] 1. Complete the table below illustrating the differences between chemical bonds and intermolecular forces.

Property	**Chemical Bonds**	**IMF Forces**
Strength of Attraction	Strong	Weak
Properties (Chemical or Physical)	Chemical Reactions	Physical Properties
Represented by (in drawings):	Solid Lines	Dashed Lines

Chemical bond is between two atoms (sharing or gain/lose electrons) while an IMF is the attractive force between two molecules. In general chemical bonds are much stronger than IMF's.

Picture should have a solid line for a chemical bond between atoms and show IMF's as a dotted line between two molecules.

[12 pt] 2. For each of the IMF discussed in class, define them **AND** draw an example illustrating the attraction between **TWO** molecules. Properly label each picture.

(a) London Dispersion Forces (LDF)

Nonpolar molecules
Proportional to size
Weakest force

(b) Dipole-Dipole Forces (DD)

Between Dipolar molecules - $\delta^+ - - - \delta^-$
Electrostatic
Stronger than LDF

(c) Hydrogen Bonding (HB)

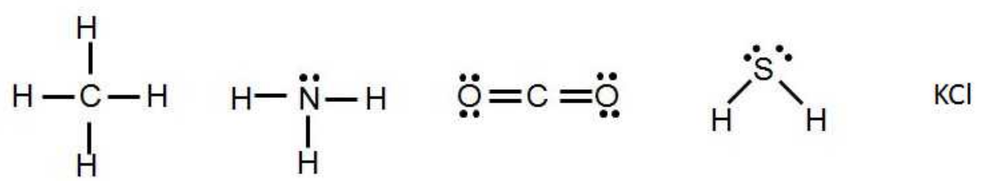
Special case of DD (extra strong DD
Between molecules with H bonded to O,N,F

(d) Ion-Dipole Forces (ID)

Between ions and DD molecules - $\pm - - - \delta^+\delta^-$
Responsible for ionic compounds dissolving in water
Strongest attractive force

3. Which intermolecular force [Dipole-Dipole (DD), Hydrogen Bonding (HB), London Dispersion (LDF), or Ionic (I)] is best described by each of the following statements. If the statement describes more then one force, put down all the forces it applies to. If no force is described by the statement place NONE in the answer blank.
   (a) Attractive force between polar and nonpolar molecules. 3(a) ______
   (b) Primarily electrostatic in nature (opposites attract). 3(b) ______
   (c) Attractive force between nonpolar molecules. 3(c) ______
   (d) Result of a temporarily (or instananeous) dipoles in atoms or molecules. 3(d) ______
   (e) Increases in strength depending on size of molecule. 3(e) ______
   (f) Is present in between all molecules. 3(f) ______
   (g) The strongest attractive force. 3(g) ______
   (h) Primarily between Metal and Nonmetals 3(h) ______
   (i) Attractive force between polar molecules. 3(i) ______
   (j) The weakest attractive force. 3(j) ______

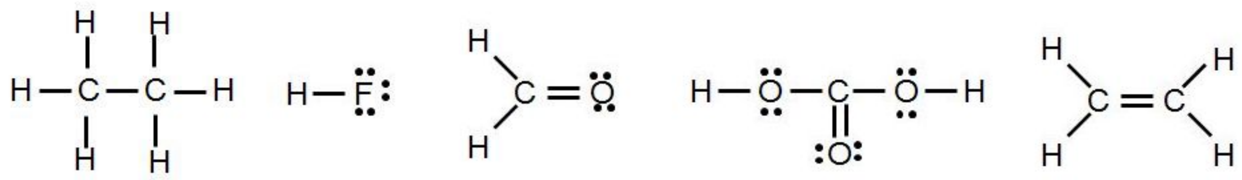
[10 pt] 4. Answer the following questions about the pair of molecules pictured below. **Explain.**



(A) (B) (C) (D) (E)

   (a) Which molecule has the lower Boiling Point? 4(a) **A**
   Boiling Point $\propto$ IMF
   (b) Which molecule has the lower Vapor Pressure? 4(b) **B**
   Vapor Pressure $\propto$ 1/IMF
   (c) If 100 g of each molecule was added to separate beakers of water would lower the freezing point the most? 4(c) **B**
   B has a lower MW therefore more molecules in solution and CP $\propto$ mols
   (d) Which molecule is more likely to to dissolve in water? 4(d) **B**
   HB vs DD
   (e) Which molecule has the strongest attractive forces between the molecules? 4(e) **B**
   B because HB ¿ DD

[5 pt] 5. For each of the molecules below, list which IMF are present between the molecules. Order the molecules (A<B<C etc) from lowest B_p to Highest B_p Explain.



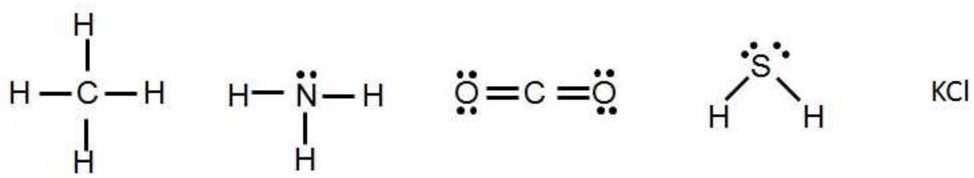
(A) (B) (C) (D) (E)

[4 pt] 6. Using the molecules in the previous question:

(a) Which molecule(s) are more likely to dissolve in water? Explain

(b) Which molecules are more likely to dissolve in pentane (CH3-CH2-CH2-CH2-CH3). Explain.

[6 pt] 7. For each of the molecules below, list which IMF are present between the molecules. Order the molecules (A<B<C etc) from lowest B_p to Highest B_p Explain.



(A) (B) (C) (D) (E)

(a) LDF (weakest MW = 16 g/mol)
(b) HB
(c) LDF (second weakest MW = 44 g/mol)
(d) DD
(e) Ionic

Lowest to Highest Boiling Point A < C < D < B < E

Boiling point is directly proportional to IMF between molecules.
Molecules should be ordered LDF < DD < HB < ID < I

[5 pt] 8. Using the molecules in the previous question:

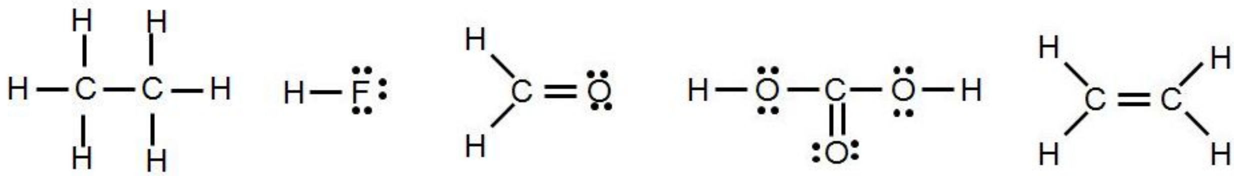
(a) Which molecule(s) are more likely to dissolve in water? Explain. 8(a) **B,D,E**

Like dissolves like, water is very polar so polar molecules (DD, HB,ID,I) will dissolve well in water.

(b) Which molecule(s) are more likely to dissolve in pentane ($CH_3CHCH_2CH_2CH_3$). Explain. 8(b) **A,C**

Like dissolves like, pentane is nonpolar so nonpolar molecules (LDF) will dissolve well in pentane.

[6 pt] 9. For each of the molecules below, list which IMF are present between the molecules. Order the molecules (A<B<C or label one end low, one end high) from lowest B_p to highest B_p Explain.



(A) (B) (C) (D) (E)

(A) - LDF MW = 30 g/mol
(B) - HB
(C) - DD
(D) - Ionic
(E) - LDF MW = 28 g/mol Lowest to Highest Boiling Point E < A < C < B < D

Boiling point is directly proportional to IMF between molecules.
Molecules should be ordered LDF < DD < HB < ID < I

[4 pt] 10. Using the molecules in the previous question:

(a) Which molecule(s) are more likely to dissolve in water? Explain. 10(a) **B,C,D**

Like dissolves like, water is very polar so polar molecules (DD, HB,ID,I) will dissolve well in water.

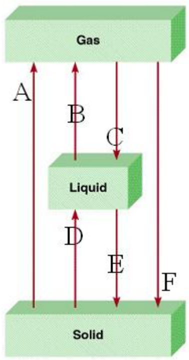
(b) Which molecule(s) are more likely to dissolve in pentane ($CH_3CH_2CH_2CH_2CH_3$). Explain. 10(b) **A,E**

Like dissolves like, pentane is nonpolar so nonpolar molecules (LDF) will dissolve well in pentane.

[6 pt] 11. Sketch a picture showing how $AlCl_3$ will dissolve in water. What is the attractive force between the ions and water molecules?

Should include both cation and anion each surrounded by water (in proper orientation).
Also include *pm* and $\delta^+\delta^-$ symbols

[6 pt] 12. Name each phase change shown below:



(a) Sublimation

(b) Vaporization or Evaporation

(c) Condensation

(d) Melting

(e) Freezing or Fusion

(f) Deposition

[5 pt] 13. For each of the following properties indicate whether they are (D)irectly proportional, (I)nversly proportional, or (N)ot related.

(a) Vapor Pressure and mols of solute in a solution 13(a) **I**

(b) Vapor Pressure and Amount of Liquid in a flask 13(b) **N**

(c) Vapor Pressure and Boiling Point 13(c) **I**

(d) Vapor Pressure and Intermolecular Forces (IMF) 13(d) **I**

(e) Atmospheric Pressure and Vapor Pressure 13(e) **N**

[5 pt] 14. Answer the following questions about solubility: (D)ecrease, (I)ncrease, or (N)o change.

(a) If temperature is increased the solubility of a solid in a liquid will? 14(a) **I**

(b) If the temperature is decreased the solubility of a gas in a liquid will? 14(b) **I**

(c) If the pressure is decreased the solubility of a solid in a liquid will? 14(c) **N**

(d) If the pressure is decreased the solubility of a gas in a liquid will? 14(d) **D**

(e) If the particle size is increased the rate of dissolving a solid in a liquid will? 14(e) **D**

[10 pt] 15. For each of the following properties indicate whether they are (D)irectly proportional, (I)nversly proportional, or (N)ot related.

(a) Vapor Pressure and Boiling Point 15(a) ________

(b) Vapor Pressure and Intermolecular Forces (IMF) 15(b) ________

(c) Vapor Pressure and mols of solute in a solution 15(c) ________

(d) Intermolecular Forces (IMF) and Melting Point 15(d) ________

(e) Vapor Pressure and Amount of Liquid in a flask 15(e) ________

(f) Boiling Point and the mols of solute in a solution 15(f) ________

(g) Atmospheric Pressure and Vapor Pressure 15(g) ________

(h) Rate at which Solids dissolve in Liquids and Particle Size 15(h) ________

(i) Solubility of Solids in Liquids and Temperature 15(i) ________

(j) Solubility of Gasses in Liquids and Pressure 15(j) ________

[5 pt] 16. Sketch a picture showing how $BaCl_2$ will dissolve in water. Label all IMF's present.

Should include both cation and anion each surrounded by water (in proper orientation).
Also include *pm* and $\delta^+\delta^-$ symbols.
Label DD, ID forces

[3 pt] 17. Is a solution consisting of 55.0 grams of $KClO_3$ in 135 mL of water (U)nsaturated, (S)aturated or (SS)upersaturated at 60 ℃ ? Explain.

17. ______________

[3 pt] 18. If you start with a saturated solution of $KClO_3$ at 90 ℃ , and cool it to 50 ℃ , how many grams of $KClO_3$ will precipitate out? Explain.

18. ______________

[5 pt] 19. What is the **boiling point** of a solution made from 25.0 grams of $C_6H_{12}O_6$ dissolved in 250 g of benzene.

19. ______________

[3 pt] 20. Is a solution consisting of 25.0 grams of $KClO_3$ in 100. mL of water (U)nsaturated, (S)aturated or (SS)upersaturated at 40.0 ℃ ? Explain.

20. **SS**

Above the line

[3 pt] 21. If you want to make a saturated solution of $BaCl_2$ and the current solutions is 20.0 grams of $BaCl_2$ in 100. mL of water at 50.0 ℃ how much solute will (circle one - dissolve / precipitate) ?

21. **dissolve 23.6 g**

We are below saturation therefore 43.6 g - 20 g = 23.6 g will ppt

[3 pt] 22. If you have 100 mL of a saturated solution of $BaCl_2$ at 70.0 ℃ and cool it to 20.0 ℃ how much solute will precipitate out?

22. **13.7 g**

49.4 g - 35.7 g = 13.7 g

[3 pt] 23. If you have of a saturated solution of $BaCl_2$ in 175 g of water at 30.0 ℃ and heat it to 90.0 ℃ how much additional solute will dissolve? 23. **30.6 g**

55.7-38.2 = 17.5 more grams
$\frac{17.5}{100} = \frac{x}{175}$ x = 30.625 grams more

[3 pt] 24. Is a solution consisting of 55.0 grams of $KClO_3$ in 135 mL of water (U)nsaturated,(S)aturated or (SS)upersaturated at 60 ℃ ? Explain. 24. **SS**

$\frac{55}{135} = \frac{x}{100}$ solve for x = 40.8 g.
40.8 grams >> 20 grams therefore it is SS

[3 pt] 25. What is the final concentration of a dilute solution made from 150.ml of 2.35 M NaOH diluted to a final volume of 500.0 mL 25. **0.705 M NaOH**

(150 mL)(2.35M) = (500 mL)(X)

[3 pt] 26. What is the final concentration of a dilute solution made from 150.ml of 2.35 M NaOH diluted to a final volume of 500.0 mL 26. **0.705 M NaOH**

(150 mL)(2.35M) = (500 mL)(X)

[5 pt] 27. How much energy (in kJ) does it take to make a melt a 125.0 gram ice-cube and then heat the resulting water to 75.0 ℃ ? 27. **81.1 kJ**

2 Steps s(0 ℃) to l(0 ℃) and l(0 ℃) to g(75.0 ℃)

$$q = m\Delta H_{fus} = \frac{125\,\text{g}}{} \times \frac{335\,\text{J}}{\text{g}} \times \frac{1\,\text{kJ}}{1000\,\text{J}} = 41.875\,\text{kJ}$$

$$q = ms\Delta T = \frac{125\,\text{g}}{} \times \frac{4.184\,\text{J}}{\text{g}\cdot{}^\circ\text{C}} \times \frac{75.0\,^\circ\text{C}}{} \times \frac{1\,\text{kJ}}{1000\,\text{J}} = 39.225\,\text{kJ}$$

Add the values together 648.43 kJ (2 SF) = 71.1 kJ

[3 pt] 28. If you have of a saturated solution of $BaCl_2$ in 175 g of water at 30.0 ℃ and heat it to 90.0 ℃ how much additional solute will dissolve? 28. **30.6 g**

55.7-38.2 = 17.5 more grams
$\frac{17.5}{100} = \frac{x}{175}$ x = 30.625 grams more

[3 pt] 29. You work at a secret government research lab to which you were brought blindfolded. One night while cooking dinner you notice that water boils at 105 ℃. Where is the lab most likely located: (A) Space station, (B) A lonely mountain top, (C) Rangely CO - a great place to live, (D) a submarine floating in the middle of the ocean (E) or in a deep dark cave in Greenland? Explain. 29. **D or E**

D or E, as long as its below sea-level because Bp is proportional to Atm. Pressure so a higher boiling point requires higher pressure.

[5 pt] 30. How much energy (in kJ) does it take to make a super hot cup of coffee containing 250 mL of water that starts at room temperature (20. ℃ and liquid) and finishes at 100. ℃ as a gas. 30. **650 kJ**

2 Steps l(20 ℃) to l(100 ℃) and l(100 ℃) to g(100 ℃)

$$q = ms\Delta T = \frac{250\,\text{g}}{} \times \frac{4.184\,\text{J}}{\text{g}\cdot{}^\circ\text{C}} \times \frac{80\,^\circ\text{C}}{} \times \frac{1\,\text{kJ}}{1000\,\text{J}} = 83.68\,\text{kJ}$$

$$q = m\Delta H_{vap} = \frac{250\,\text{g}}{} \times \frac{2259\,\text{J}}{\text{g}} \times \frac{1\,\text{kJ}}{1000\,\text{J}} = 567.75\,\text{kJ}$$

Add the values together 648.43 kJ (2 SF) = 650 kJ

[3 pt] 31. Is a solution consisting of 55.0 grams of $KClO_3$ in 135 mL of water (U)nsaturated,(S)aturated or (SS)upersaturated at 60℃? Explain. 31. **SS**

$\frac{55}{135} = \frac{x}{100}$ solve for x = 40.8 g.
40.8 grams >> 20 grams therefore it is SS

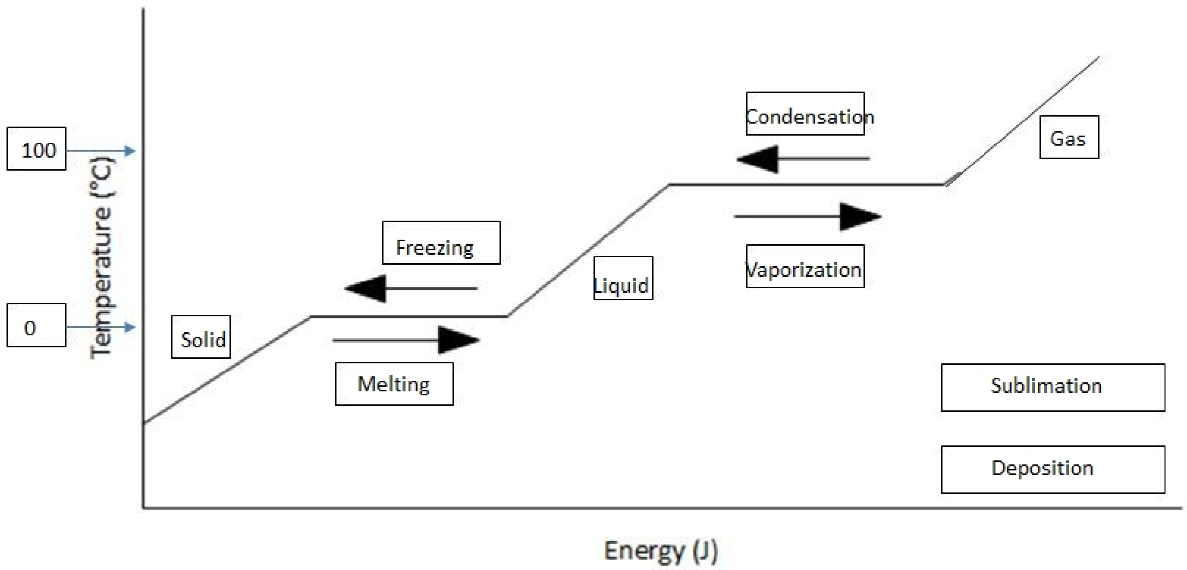
[3 pt] 32. If you start with a saturated solution of $KClO_3$ at 90℃, and cool it to 50℃, how many grams of $KClO_3$ will precipitate out? Explain. 32. **27 g $KClO_3$**

45 g - 18 g = 27 g $KClO_3$

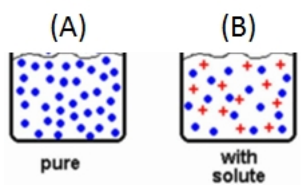
[3 pt] 33. What is the molarity of a solution made by diluting 50.0 mL of 1.35 M HNO_3 to a final volume of 175 mL. Explain. 33. **0.386 M**

Dilution problem so use: $M_1V_1 = M_2V_2$
(50.0 mL)(1.35 M) = (175 mL)M_2
M_2 = 0.386 M

[10 pt] 34. Complete the following heating curve by filling in the boxes with the **NAME** of the appropriate phase transition, temperature, or state of matter. Include the two missing phase transitions in the boxes in the lower right.

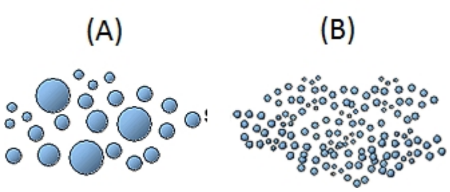


[3 pt] 35. Which container will have the **LOWER** vapor pressure? Explain. 35. **B**



P_v is IP mols of solute (adding a solute decreases the vapor pressure)

[3 pt] 36. Assuming equal amounts (by mass) which will dissolve **FASTER**? Explain? 36. **B**



Rate of dissolving is DP to SA therefore (B)
Rate of dissolving is IP to PS therefore (B)