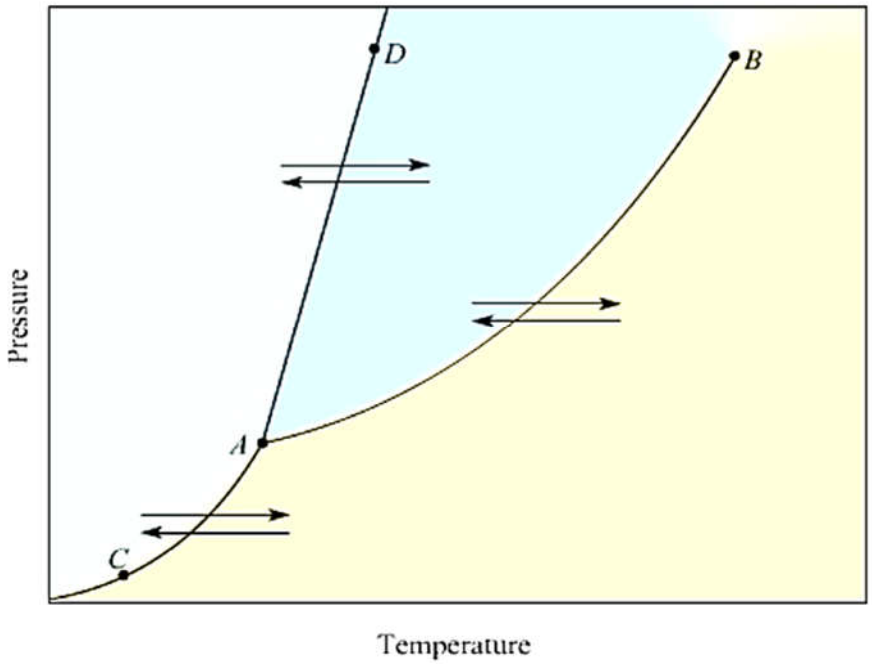
AP Chemistry
Ms. Ye

Name _____
Date _____Block_____

<u>Phase Diagrams:</u> A *phase diagram* is a graphical way to summarize the conditions under which equilibria exist between the different states of matter. It also allows us to predict the phase of a substance that is stable at any given **temperature** and **pressure**.



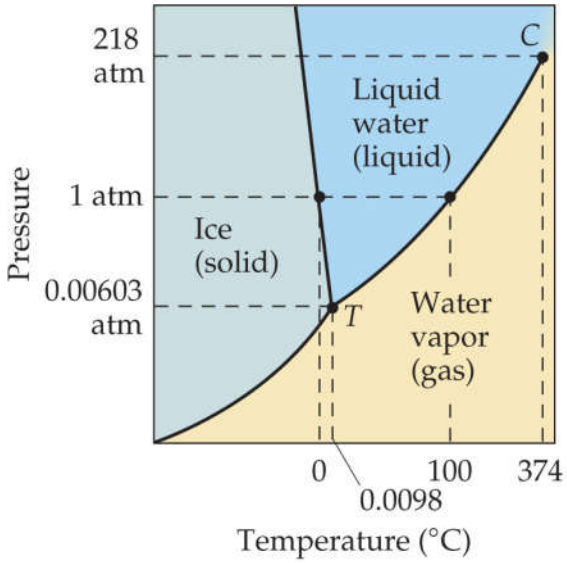
1. Label the three phases of matter on the diagram.
   Hint: the best way to remember which area corresponds to each of these states is to remember the conditions of temperature and pressure that are most likely to be associated with a solid, a liquid, and a gas. Low temperatures and high pressures favor the formation of a solid. Gases, on the other hand, are most likely to be found at high temperatures and low pressures. Liquids lie between these extremes.

2. Label the phase changes on the diagram. How are they represented?

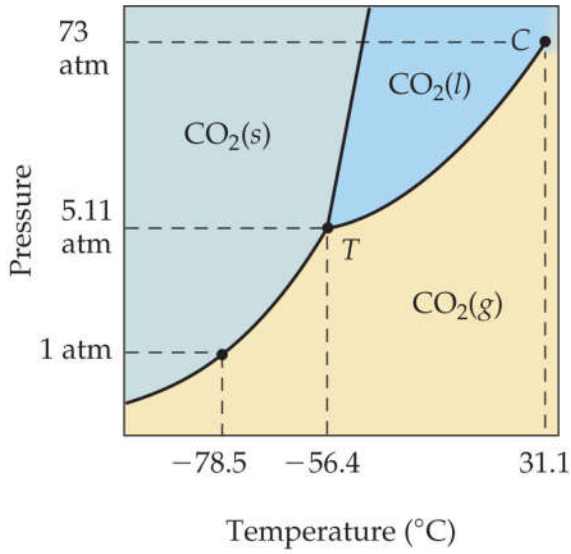
3. Identify the **triple point** on the diagram. What is the significance of this point?

4. Point B is known as the **critical point.** The line extending from A to B stops. What do you think this mean in terms of phase change?

Phase Diagram of H_2O



Phase Diagram of CO_2



1. **Look at the phase diagram for water:** Even though a phase change could occur along any of the solid lines, the two points labeled at 0°C and 100°C are known as the "normal melting point" and "normal boiling point", respectively. Based on the pressure that these occur at, what do you think is meant by **"normal"** melting or boiling point?

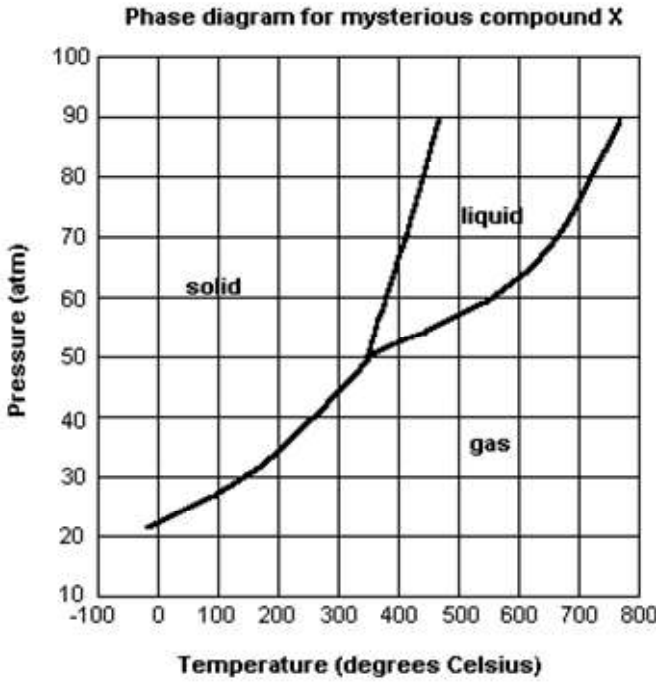
2. Given the phase diagram above, what phase would water be in if it had the following properties:
   a. 50 °C and 0.5 atm
   b. -50°C and 0.5 atm
   c. 125 °C and 1.0 atm

3. Look at the **slope** of the "solid-liquid" line for both water and CO_2.
   a. What is the main difference between the two graphs?

   b. For H_2O, if the sample is at a temperature just below 0°C, does an increase in pressure result in melting or freezing?

   c. How do you determine the density of a solid just by looking at the phase diagram?

Practice:



1) What is the critical temperature of compound X?

2) If you had a bottle containing compound X in your closet, what phase would it most likely be in?

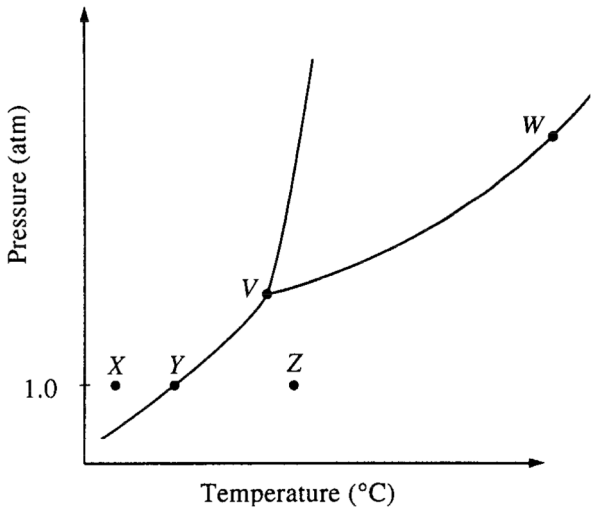
3) At what temperature and pressure will all three phases coexist?

4) If I have a bottle of compound X at a pressure of 45 atm and temperature of 100^0C, what will happen if I raise the temperature to 400^0 C?

5) Why can't compound X be boiled at a temperature of 200^0 C?

6) If I wanted to, could I drink compound X? Explain.

7) Which is more dense, solid X or liquid X? Explain.



1. What does point V represent? What characteristics are specific to the system only at point V?

2. What does each point on the curve between V and W represent?

3. Describe the changes that the system undergoes as the temperature slowly increase from X to Y to Z at 1.0 atm

4. In a solid-liquid mixture of this substance, will the solid float or sink? Explain.

IMFs and Properties of Matter

- **Intermolecular forces= _____**

- In general, for the same chemical substance, molecules in the _____ phase will have _____ intermolecular forces between them than molecules in the _____ phase

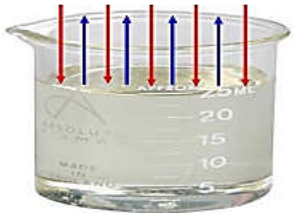
- In order for a substance to melt or boil (change phase), enough _____ must be supplied so that the molecules may _____ holding them together.

IMFs and Properties of Liquids:

Atmospheric Pressure=pressure exerted by the _____

Vapor Pressure=pressure exerted by the _____

_____



↑ = _____ pressure

↓ = _____ pressure

***Boiling point of a liquid**:

_____

= _____

_____

Demo: Atmospheric Pressure and Boiling Point

1. 10 mL of warm water was drawn into the syringe. What happens when you pull up on the syringe by about another 10 mL so that there is a gap of air above the liquid?

2. When you pulled up on the syringe, were you increasing or decreasing the air pressure that is being exerted down on the liquid?

3. Explain why it is possible to boil water at a temperature less than 100˚C.

Demo: Vapor Pressure and Boiling Point

1. What happens when you add heat to the flask.

2. Explain how the demo works by relating temperature, vapor pressure, IMFs, and boiling point.

Demo: IMFs and Boiling Point

1. Water ___does_____does not___ boil at room temperature

2. Liquid butane was placed into a ziplock bag. Record your observations.

3. Compared to water, liquid butane has ___stronger____weaker__ attractive forces. Explain.

4. Describe the relationship between boiling point and intermolecular forces. (include direct or inverse relationship in description)

Demo: IMFs and Volatility

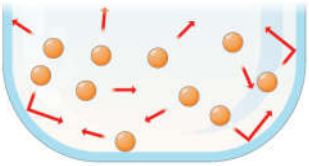
1. Two liquids were swabbed on a dark surface. Record your observations.

2. Compared to water, acetone has __stronger____weaker__ attractive forces. Explain.

3. Describe the relationship between volatility and intermolecular forces. (include direct or inverse relationship in description)

Demo: IMFs and Vapor Pressure

Pressure is caused by the collisions of gaseous molecules to the surface of a container



Vapor Pressure is the pressure caused by the liquid particles that turn into gaseous particles and collide with the surface of the closed container

1. Which has more vapor pressure? Acetone or Alcohol
Explain your answer using your observations.

2. From the previous demo, we know that acetone has _stronger_ _weaker_ attractive forces between its molecules than alcohol.

3. Describe the relationship between vapor pressure and intermolecular forces. (include direct or inverse relationship in description)

Demo: Vapor Pressure & Temperature

1. The vapor pressure _increased_ _decreased_ when the flask with liquid was heated. Explain your answer using your observations.

2. When you increase the heat, describe what is happening to the attractive forces between the liquid molecules in the flask. How does this impact vapor pressure?

3. Describe the relationship between vapor pressure and temperature. (include direct or inverse relationship in description)

Solutions

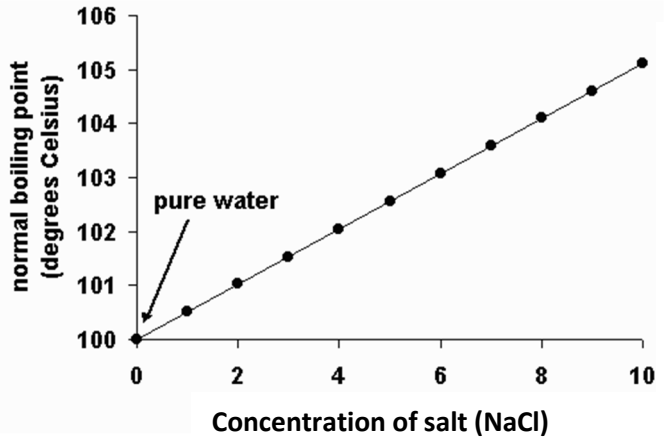
- ***Solutions*** are _____ mixtures that may be solid, liquid, or gaseous.
- **Solute vs. Solvent**

  The _____ is what is being dissolved.

  The _____ is what is doing the dissolving

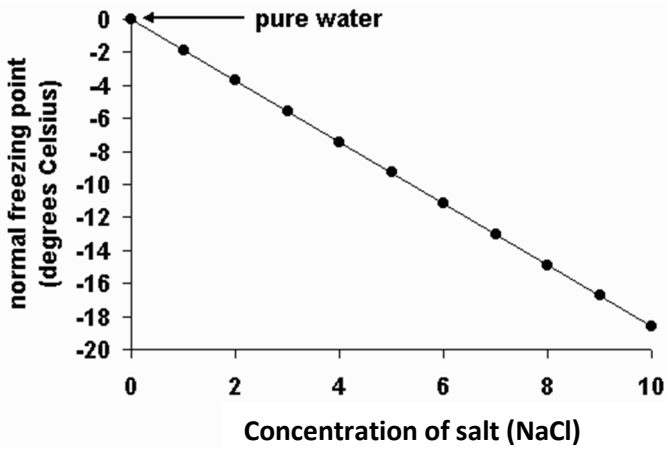
  Solutes and solvents can be in any of the 3 phases of matter

Solutions, IMFs and Colligative Properties



1. What is the boiling point of pure water?

2. What happens to the boiling point of water as you increase the concentration of salt added?



1. What is the freezing point of pure water?

2. What happens to the freezing point of water as you increase the concentration of salt added?

1. Why do you think people pour salt on the roads/sidewalks in the winter?

2. Why do you think people add salt to water when making pasta?

Summary:

The addition of a solute to a solvent causes the **boiling point** of the solvent to _____.

This phenomenon is known as _____ _____ _____

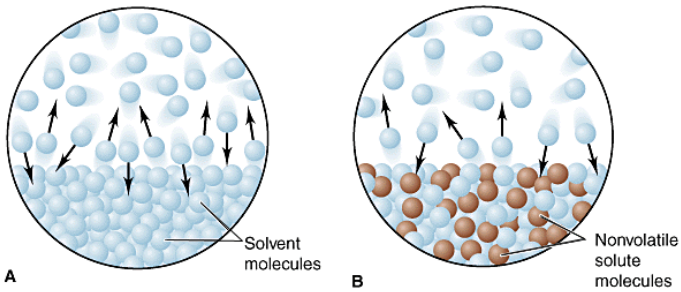
The addition of a solute to a solvent causes the **freezing point** of the solvent to _____.

This phenomenon is known as _____ _____ _____

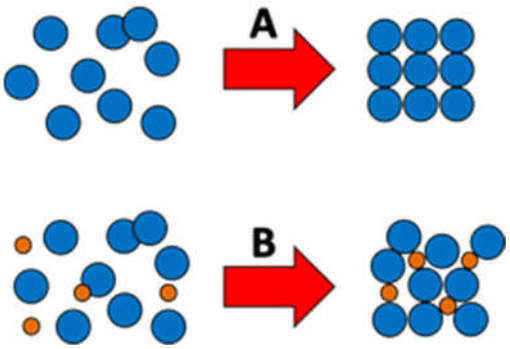
The _____ the concentration of **solute particles**, the _____ the effect.

Why does this happen?

- When a solute is dissolved in a solvent, the vapor pressure of the resulting solution will be _____ than the vapor pressure of the pure solvent.
- Recall that particles of a solvent escape the liquid phase to form a gas at the surface of the liquid. When a solvent is pure, its particles occupy the entire surface area. However, when a solute is added, a mix of _____ and _____ particles occupy the surface area. With fewer solvent particles at the surface, _____ particles enter the _____ state, and the vapor pressure is _____.
- Recall that boiling occurs when the _____ from the surface of the liquid is _____ to the _____ pushing down on the surface. If adding a solute _____ the _____, the solution must be heated to a _____ temperature in order to make _____



- Freezing: the _____ of the pure substance's ability to form a solid structure (i.e. water forming ice crystals)



Concentrations of Solutions

There are many ways to measure concentration. The most common way that you are familiar with is **molarity (M)**. There are cases when you will be asked to determine the **molality (m)** of a solution. Molality can be useful when dealing with solutions and phase changes since neither moles nor mass is temperature dependent (but volume, and therefore molarity can change with temperature).

$$\text{Molarity:} \quad M = \frac{\text{mol solute}}{\text{L soln}}$$

$$\text{Molality:} \quad m = \frac{\text{mol solute}}{\text{kg solvent}}$$

Practice:

1. A solution is prepared by adding 1.43 mol of KCl to 889 g of water. Determine the molality of this KCl solution.

2. Calculate the molality of a benzene solution prepared by mixing 12.0 g C_6H_6 with 38.0 g CCl_4.

3. Given a 1.75 M NaOH solution having a density of 1.040 g/mL, determine the molality of the solution.

Step 1: Assume 1 L of solution. Use given Molarity to find # moles of solute	
Step 2: Convert to find the mass of solute	
Step 3: Use density to find the mass of the solution (again, assume 1 L total solution)	
Step 4: Find the mass of water by subtracting the mass of solution by the mass of NaOH. Convert to kg. This your mass of **solvent**	
Step 5: divide the moles of solute by the kg of solvent	

4. At 20°C, a 2.32 M aqueous solution of ammonium chloride has a density of 1.0344 g/mL. What is the molality of ammonium chloride in the solution? The formula weight of NH_4Cl is 53.50 g/mol.

IMFs and Phases of Matter WS

1. Fill in the blanks: The ***stronger*** the intermolecular forces between the particles,

(a) The _____ the melting point.

(b) The _____ the boiling point.

(c) The _____ the vapor pressure

(d) The _____ the viscosity

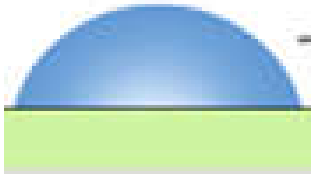
(e) The _____ the surface tension

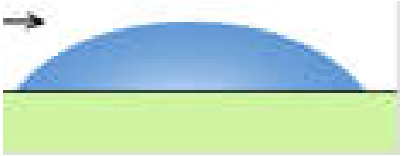
2. At what pressure does normal boiling point occur?

3. At higher altitudes, water tends to boil at temperatures below 100°C. Why?

4. True/False: Boiling only occurs at high temperatures. *Explain your answer.*

5. Circle the image below that represents the liquid with the *most* surface tension





6. From what you know about liquids, what might cause a liquid to have a higher surface tension?

7. Why would a liquid with strong attractive forces be less volatile than a liquid with weaker attractive forces?

8. Why will a liquid that has stronger attractive forces have a lower vapor pressure?

9. How does temperature affect vapor pressure? Why does temperature have this effect?

10. Explain the following phenomena in terms of intermolecular forces.

(a) Water has a greater surface tension than rubbing alcohol.

(b) Water has a higher viscosity than pentane.

(c) HF has a higher boiling point than HCl

(d) Pentane has a higher vapor pressure than octane.

11. For the phase diagram at the right, name the phase or phases that exist at each of the lettered points.

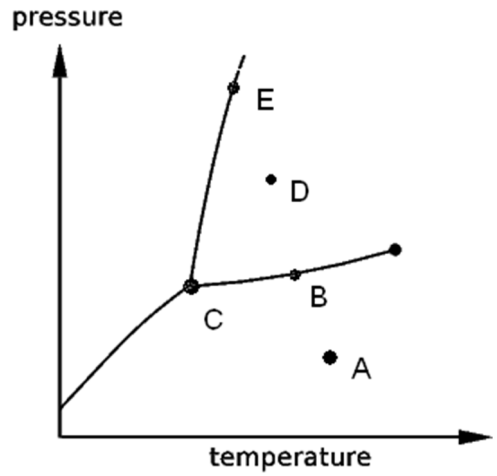
(A)

(B)

(C)

(D)

(E)



12. Referring to the phase diagram in the question above, what change or changes would occur if one

(a) started at point A and raised the pressure?

(b) started at point B and raised the temperature?

13. Determine the molality of a 16.0 M HNO_3 solution. The density of HNO_3 is 1.42 g/mL.