Kinetic Theory in Action

Mini-Lab Observations and Analysis Questions

Procedure A

	BTB Droplet Observations
Before adding HCl / $NaHSO_3$	
Shortly after adding HCl / $NaHSO_3$	
Minutes after adding HCl / $NaHSO_3$	

1. Draw a series of pictures (3 minimum) showing how one of the BTB drops might look over time if you could view the drop from the side.

2. The BTB changed even though you did not directly add anything to it. Explain how a chemical change occurred in the BTB.

3. Explain why all of the drops do not change color at the same rate? (Why do some of the drops turn color before and complete the change faster than others?) Discuss why the motion of gas is causing this to happen.

4. Write a balanced chemical equation for the reaction of hydrochloric acid and sodium hydrogen sulfite. The products of the reaction are sulfur dioxide, water, and sodium chloride.

5. Which of the three products of the chemical reaction were responsible for the BTB color change? Explain.

Procedure B

	BTB Droplet Observations
Before adding NaOH / NH_4Cl	
Shortly after adding NaOH / NH_4Cl	
Minutes after adding NaOH / NH_4Cl	

6. Write a balanced chemical equation for the reaction of sodium hydroxide and ammonium chloride. The products of this reaction are sodium chloride, water, and ammonia (NH_3).

7. Which of the three products of the chemical reaction were responsible for the BTB color change? Explain.

Reading Guide for Discovery Education - Physical Behavior of Matter

"Explore Tab" Page 1 – Kinetic Molecular Theory

1. What is Kinetic Energy?

2. Watch the video segment "Kinetic Molecular Theory". Define elastic collision.

3. Watch the video segment "Kinetics of Solids, Liquids, and Gases". What are the five basic assumptions of Kinetic Theory regarding properties of a gas?

    a.

    b.

    c.

    d.

    e.

4. Why does decreasing the volume of a gas container increase the pressure of the contained gas?

5. Describe the relationship between temperature and average kinetic energy.

6. Which state of matter (solid, liquid, or gas) represents the state with the least molecular kinetic energy? Explain.

7. How does the addition of energy to a substance influence the effectiveness of the intermolecular forces of that substance?

“Explore Tab” Page 2 – Kinetic Molecular Theory

8. Describe the relationship between the melting point and freezing point of a substance.

9. Describe vaporization.

10. Why doesn't the temperature of a substance change during vaporization?

11. What two factors must be overcome for a molecule at the surface of a liquid to vaporize?

12. Define vapor pressure.

13. Define Normal Boiling Point.

14. 1 atmosphere of pressure = _____ kilopascals of pressure.

15. At a lower atmospheric pressure (i.e. mountaintop), will water boil at a higher or lower temperature? Explain.

16. Differentiate between sublimation and deposition.

17. In a closed system, what two processes must be occurring at the same rate for a liquid/vapor equilibrium to exist?

GAS LAW PRACTICE PROBLEMS WS #1

Conversions, Combined Gas Law

Make the following conversions:

Pressure		
Atmospheres (atm)	Millimeters mercury (mm Hg)	Kilopascal (kPa)
1.0		
	610	
		202
0.75		
		25.0
	811	

Temperature	
Degrees Celcius (˚C)	Kelvin (K)
0	
	373
-25	
	200
378	
	36

For each of the following problems: **show your work**, include the appropriate **unit** with your answer, and include the proper number of **significant digits** in your numerical answer.

1. A high altitude balloon contains 30.0 L of helium gas at 103 kPa. What is the volume when the balloon rises to an altitude where the pressure is only 25.0 kPa? (Assume constant temperature.)

2. A balloon inflated in a room at 24 °C has a volume of 4.00 L. The balloon is then heated to a temperature of 58 °C. What is the new volume if the pressure remains constant?

3. A gas has a pressure of 6.58 kPa at 539 K. What will be the pressure at 211 K if the volume does not change?

4. Exactly 5.00 L of air at -50.0 °C is warmed to 100.0 °C. What is the new volume if the pressure remains constant?

5. A gas with a volume of 4.00 L at a pressure of 205 kPa is allowed to expand to a volume of 12.0L. What is the pressure in the container if the temperature remains constant?

6. The gas left in a used aerosol can is at a pressure of 103 kPa at 25 °C. If this can is thrown into a fire, what is the pressure of the gas when its temperature reaches 928 °C?

7. The volume of a gas-filled balloon is 30.0 L at 40 °C and 153 kPa pressure. What volume will the balloon have at standard temperature and pressure (STP)?

8. A 5.00 L air sample at a temperature of -50 °C has a pressure of 107 kPa. What will be the new pressure if the temperature is raised to 102 °C and the volume expands to 7.00 L?

9. Suppose a gas is kept in a sealed container, but the pressure of the gas is increased from 1.00 atm to 1.13 atm. This is done by changing the temperature. If the initial gas temperature was 0.00 ˚C, what is the final temperature of the gas?

Ideal Gas Law Worksheet

For each of the following problems: **show your work**, include the appropriate **unit** with your answer, and include the proper number of **significant digits** in your numerical answer.

1. You fill a rigid steel cylinder that has a volume of 20.0 L with nitrogen gas (N_2) to a final pressure of 2.00 X 10^4 kPa at 28.0 °C. How many moles of N_2 does the cylinder contain?

2. When the temperature of a rigid hollow sphere containing 685 L of helium gas is held at 621 K, the the pressure of the gas is 1.89 X 10^3 kPa. How many moles of helium does the sphere contain?

3. A deep underground cavern contains 2.24 X 10^6 L of methane gas (CH_4) at a pressure of 14.8 atm and a temperature of 42.0 °C. How many kilograms of CH_4 does this natural-gas deposit contain?

4. What volume will 12.0 g of oxygen gas (O_2) occupy at 25 °C and a pressure of 52.7 kPa?

5. Determine the volume (in L) occupied by 0.202 mol of a gas at standard temperature and pressure (STP).

6. How many oxygen molecules are in 3.36 L of oxygen gas at standard temperature and pressure (STP)?

7. What is the density of oxygen in grams per liter at 23.0°C and 0.850 atm?

Other Gas Laws Worksheet

1. Determine the total volume of oxygen gas (O_2) produced according to the following equation if the reaction was performed at a temperature of 300K, a pressure of 2.90 atm, and began with 15.2g of $KClO_3$.

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$

2. Determine the total pressure of a gas mixture that contains oxygen, nitrogen, and helium if the partial pressures of the gases are as follows: P_{He} = 18.0 kPa; P_{N_2} = 36.7 kPa; and P_{O_2} = 36.7 kPa.

3. A gas mixture containing oxygen, nitrogen, and carbon dioxide has a total pressure of 52.9 kPa. If P_{O_2} = 3.6 kPa and P_{N_2} = 42.0 kPa, what is P_{CO_2}?

4. Which gas effuses faster: hydrogen or helium? How many times faster (based on ratio)?

5. Calcium carbonate decomposes at high temperatures to form carbon dioxide and calcium oxide:

$$\mathbf{CaCO_{3(s)} \rightarrow CO_{2(g)} + CaO_{(s)}}$$

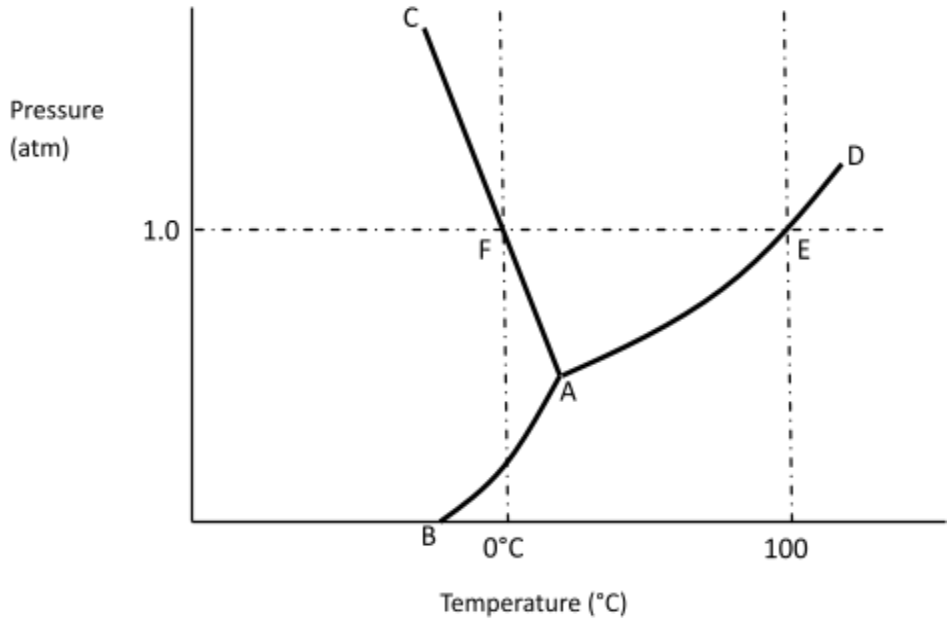
How many grams of calcium carbonate will I need to form 3.45 liters of carbon dioxide at STP?

6. Ethylene burns in oxygen to form carbon dioxide and water vapor:

$$\mathbf{C_2H_{4(g)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 2\ H_2O_{(g)}}$$

How many liters of water can be formed if 1.25 liters of ethylene are consumed in this reaction at at STP?

Phase Diagram #1



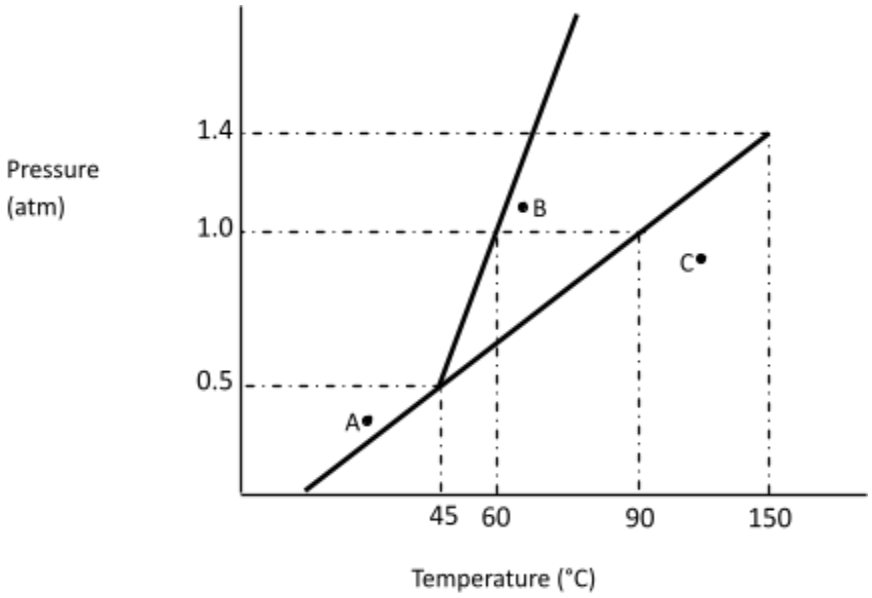
1. On the phase diagram above, write the following in the correct region: **solid, liquid, gas**
2. Label the following points and lines with the words from the word bank below:

Normal Freezing Point Solid-Gas Equilibrium	Normal Boiling Point Liquid-Gas Equilibrium Critical Point	Solid-Liquid Equilibrium Triple Point

   a. Point A : _____
   b. Point E : _____
   c. Point D : _____
   d. Point F : _____
   e. Line AD : _____
   f. Line AB : _____
   g. Line AC : _____

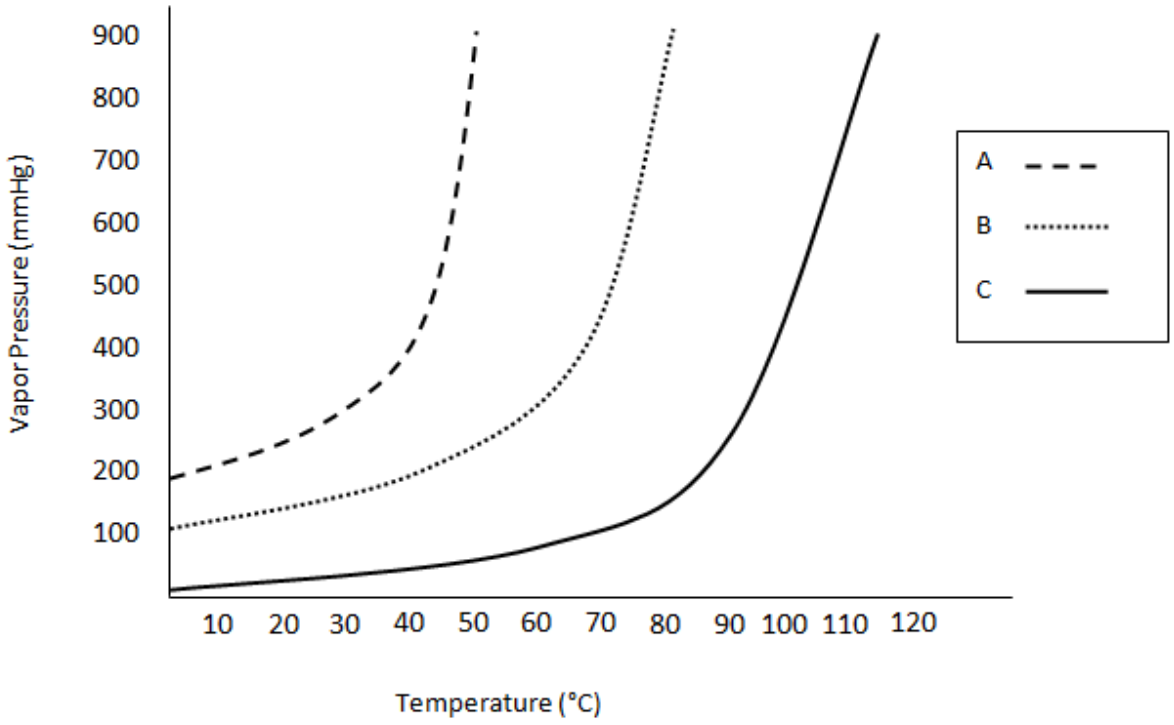
3. What is the most likely identity of this substance? _____

Phase Diagram #2



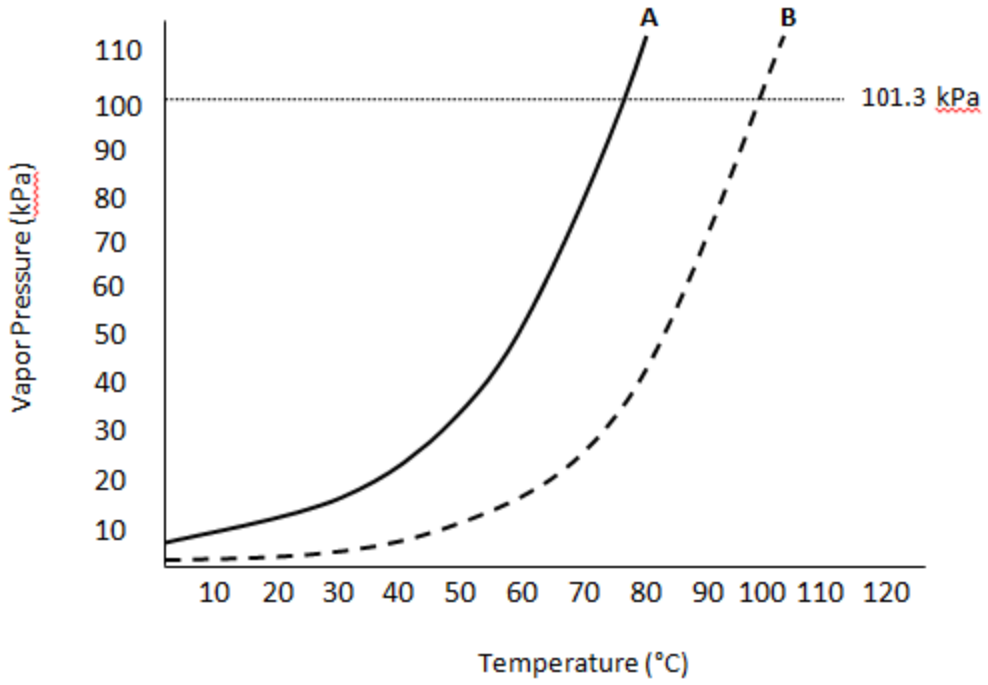
1. At 1.0 atm and 45°C, what state of matter will exist? _____
2. At 0.5 atm and 90°C, what state of matter will exist? _____
3. At 1.4 atm and 90°C, what state of matter will exist? _____
4. What is the Normal boiling point of this substance? _____
5. What is the Normal freezing point of this substance? _____
6. At what temperature and pressure do all three phases of matter coexist?
7. Above what temperature is it impossible to liquefy the substance regardless of pressure?
8. At point A the temperature is increased to 45°C, what phase change will occur?
9. At point B the pressure is increased to 1.4 atm, what phase change will occur?
10. At point C the temperature is decreased to 60°C, what phase change will occur?

Vapor Pressure Diagram #1



1. At what temperature would liquid A boil at a pressure of 400 mmHg? _____
    a. Liquid B? _____
    b. Liquid C? _____
2. How low must the atmospheric pressure be for liquid A to boil at 35°C? _____
    a. Liquid B? _____
    b. Liquid C? _____
3. What is the Normal boiling point of liquid A? _____
    a. Liquid B? _____
    b. Liquid C? _____
4. Which liquid has the strongest intermolecular forces? _____

Vapor Pressure Diagram #2



1. What is the Normal boiling point of water? _____
2. Which line represents water? _____
3. The other line represents carbon tetrachloride, CCl_4. What is the Normal boiling point of carbon tetrachloride, CCl_4? _____
4. What would the boiling point of water be if the air pressure over the liquid was lowered to 60 kPa? _____
5. What would the boiling point of CCl_4 be if the air pressure over the liquid was lowered to 20 kPa? _____
6. What is the most significant IMF for water? For CCl_4?

7. How does the strength of the IMF relate to the vapor pressure?