Name:_____Period:_____
Ms. Randall
Unit 7: Physical Properties of Matter Workbook

The **bold, underlined** words are **important vocabulary words** that you should be able to define and use properly in explanations. This is a study guide for what you will be tested on throughout the year. The objectives are divided into categories of "**Knowledge**" (**what you have to *know***) and "**Application**" (**what you have to be able to *do***).

	PHYSICAL BEHAVIOR OF MATTER	
	Knowledge	**Application**
1.	○ Physical properties of substances can be explained in terms of chemical bonds and **intermolecular forces**. ○ Intermolecular forces created by an unequal distribution of charge result in varying degrees of attraction between molecules. **Hydrogen bonding** is an example of a strong intermolecular force that occurs in compounds containing H bonded to F, O, or N atoms. ○ Physical properties include malleability, solubility, hardness, melting/freezing point, and boiling point.	○ Predict relative melting and boiling points of compounds given information about its chemical bonds or strength of intermolecular forces ○ Predict relative strength of intermolecular forces of a compound given its melting and boiling points
2.	○ The three **phases of matter** (solids, liquids, and gases) have different properties. ○ The structure and arrangement of particles and their interactions determine the physical state (s, l, or g) of a substance at a given temperature and pressure.	○ Draw and interpret a particle diagram to differentiate among solids, liquids, and gases ○ Explain phase change in terms of the changes in energy and intermolecular distances
3.	○ **Heat** is a transfer of energy (**thermal energy**) from a body of higher temperature to a body of lower temperature. Heat (thermal energy) is associated with the random motion of atoms and molecules. (Heat flows from HOT materials to COLD materials) ○ **Temperature** is a measure of the **average kinetic energy** of the particles in a sample of matter. Temperature is NOT energy – it is a *measure* of heat energy.	○ Distinguish between heat energy and temperature in terms of molecular motion and amount of matter ○ Convert between degrees Celsius and degrees Kelvin (Table T)
4.	○ The concepts of **kinetic** and **potential energy** can be used to explain physical processes that include: **fusion** (melting), **solidification** (freezing), **vaporization** (boiling, evaporation), **condensation**, **sublimation**, and **deposition**. ○ The kinetic and potential energy changes involved in these physical processes can be illustrated in a **heating curve** or **cooling curve**.	○ Identify areas of heating and cooling curves that show changes in kinetic and potential energy, heat of vaporization, heat of fusion, and phase changes ○ Calculate the heat involved in a phase or temperature change of a sample of matter using Tables B & T and/or a given heating or cooling curve
5.	○ Physical processes like phase changes can be **exothermic** or **endothermic**.	○ Distinguish between endothermic and exothermic phase changes
6.	○ **Entropy** is a measure of the randomness or disorder of a system. A system with greater disorder has more entropy.	○ Compare the entropy of different phases of matter
7.	○ The concept of an **ideal gas** is a model to explain behavior of gases. ○ A real gas is most like an ideal gas when the real gas is at low pressure and high temperature.	○ Given a choice of pressure and temperature conditions, identify those under which gases behave *most* ideally and/or *least* ideally

8.	○ **<u>The Kinetic Molecular Theory (KMT)</u>** states that, for an IDEAL gas, all gas particles a. are in random, constant, straight-line motion b. are separated by great distances relative to their size (have negligible volume) c. have no attractive forces between them d. have collisions that may result in a transfer of energy between them, but the total energy of the system remains constant	
9.	○ The Kinetic Molecular Theory (KMT) describes the relationships of pressure, volume, temperature, velocity, frequency, and force of collisions among gas molecules.	○ Explain the gas laws in terms of KMT. ○ Solve problems using the combined gas law (Table T) ○ Recognize and draw graphs showing P vs. T, V vs. T, and P vs. V
10.	○ **Equal volumes of gases at the same temperature and pressure contain an equal number of particles.**	

Vocabulary

For each word, provide a short but specific definition from YOUR OWN BRAIN! No boring textbook definitions. Write something to help you remember the word. Explain the word as if you were explaining it to an elementary school student. Give an example if you can. Don't use the words given in your definition!

Kinetic Molecular Theory: _____

Pressure: _____

Volume: _____

Temperature: _____

Boyle's Law: _____

Charles's Law: _____

Gay-Lussac's Law: _____

Combined Gas Law: _____

Graham's Law: _____

Dalton's Law: _____

Avogadro's Law: _____

Kinetic energy_____

Absolute Zero _____

Boiling Point (Normal)_____

Potential Energy_____

Temperature_____

Vapor Pressure_____

Heat _____

Heat of Fusion _____

Heat of Vaporization_____

Heating Curve/cooling curve_____

Lesson 1: Molecular Theory (KMT) Basics **Date:_____**

Objective:

- ***To define temperature as average kinetic energy***
- ***To relate average kinetic energy, states of matter and IMF's***

Check your understanding:

1.) Which statement is true?

(a) At a given temperature, the temperature value is a measure of the total kinetic energy of all the molecules.
(b) At a given temperature, all the particles have the same amount of kinetic energy.
(c) At a given temperature, the average kinetic energy of the molecules is constantly changing.
(d) At a given temperature, the temperature value is a measure of the average kinetic energy of all the molecules.

2.) In which sample do the particles have the highest average kinetic energy?

(a) $H_2O(l)$ @55^oC (b)Br_2 (l) @75^oC (c) NaCl(aq) @30^oC (d) Mg(s) @17^oC

3.) Which sample has particles with the *lowest* average kinetic energy?

(a) 1.0g of I_2 at 50.°C (b) 2.0g of I_2 at 30.°C
(c) 7.0g of I_2 at 40.°C (d) 9.0g of I_2 at 20.°C

4.) Which term is defined as a measure of the average kinetic energy of the particles in a sample of matter?

(a) activation energy (b) potential energy (c) temperature

Practice:

1. **Kinetic energy** is energy due to the **motion** of the particles in a material. The particles in a sample of matter have three possible ways of moving: **vibrating** in place, **rotating** (spinning), and **sliding** past one another. These are described in terms of kinetic energy.
   What is kinetic energy?

2. How particles are arranged (what phase they are in) is dependent on their energy and the effect this has on their attractions for each other.
   What phase has the most energy and therefore the least attractions?

3. As particles gain energy, the attractions between them decrease. Why does this happen?

4. The strength of attractions between particles can be evaluated based on properties such as melting and boiling points, heat of fusion and heat of vaporization, and vapor pressure.
   Will a substance with low attractions have a low or high melting/boiling point?

5. The structure and arrangement of particles and their interactions determines the physical state of a substance at a given temperature and pressure.
   What phase are most metals at STP? Nonmetals?

ASSESS YOURSELF ON THIS LESSON: _____/5

If you missed more than 1, do the Additional Practice.

ADDITIONAL PRACTICE LESSON 1:

1. ***In terms of changes in Intermolecular forces of attraction and movement***, what is the relationship between strength of particle attractions and melting point temperature?

2. ***In terms of changes in kinetic and/or potential energy,*** what causes a solid to melt?

3. CO_2 is a substance that sublimes(s→g). What can be inferred about the strength of the attractions between CO_2 molecules, as compared to a substance that melts instead?

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/3

If you missed more than 1 you should see me for extra help and/or re-read the lesson.

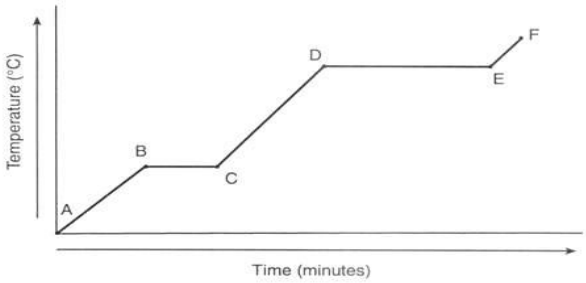
Lesson 2: Heating and Cooling Curves **Date:**

Objective:

- ***Determine the direction of heat flow***
- ***To apply changes in heat and temperature to phase changes***

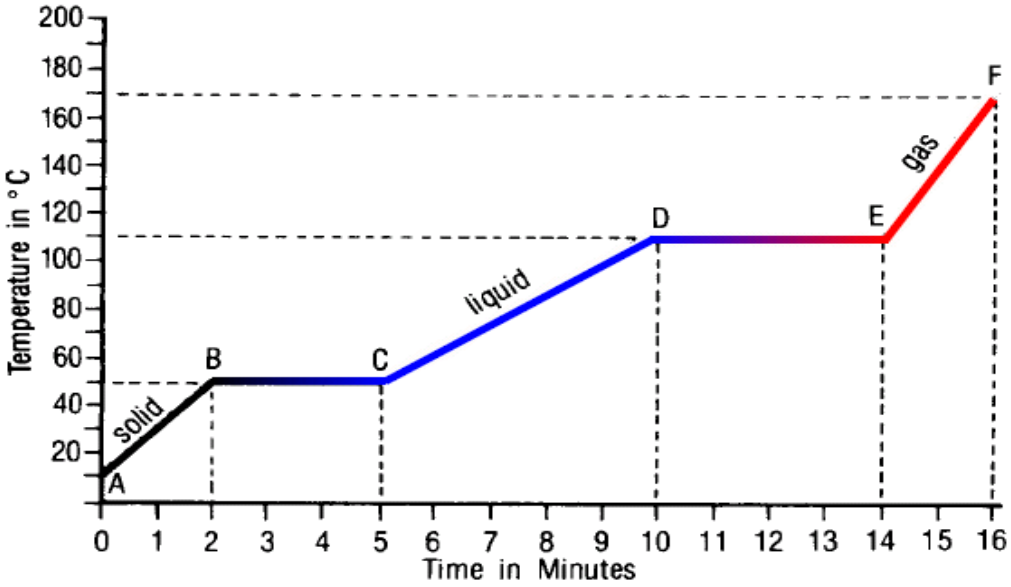
Check your understanding:

1. Identify the phase(s) represented by the following line segments in the diagram below:
   a. AB _____ d. DE _____
   b. BC _____ e. EF _____
   c. CD _____



2. What line segment(s) represent the melting point? _____
3. What line segment(s) represent the boiling point? _____
4. What takes more energy: to melt this substance or to vaporize it? Give evidence to support your answer.
   _____
5. What type of energy is being used during the line segments AB, CD, EF? _____
6. What type of energy is being used during the line segments BC & DE? _____
7. At what point will the particles be moving the slowest? _____
8. If this substance were water, at what temperature would segment BC occur? _____ ^{o}C
9. If this substance were water, at what temperature would segment DE occur? _____ ^{o}C

Practice:



1. From this diagram identify the following:

a. The melting point temperature: _____

b. The boiling point temperature: _____

c. The line segment where heat is being added, causing a change in the temperature of the **solid** phase: _____

d. The segment where heat is being added, causing a change in the kinetic energy of the particles when they are in the **liquid** phase: _____

e. The segment where heat is being added, causing a change in the speed of the particles when they are in the **gas** phase: _____

f. The segment**s** where added heat causes an increase in potential energy: _____ &_____

So… Let's compare Potential Energy and Kinetic Energy one more time.
(Answer the following blanks with KE/PE and circle either increasing or decreasing.)

On the flat segments: _____ is constant and _____ is increasing / decreasing.

And on the diagonal segments: _____ is constant and _____ is increasing / decreasing.

2. As ice melts, its temperature remains at 0°C until it has completely melted. Its potential energy:

(1) decreases (2) increases (3) remains the same

3. Which change of phase represents sublimation?

(1) $H_2O(g) \rightarrow H_2O(l)$ (2) $H_2O(l) \rightarrow H_2O(s)$ (3) $CO_2(s) \rightarrow CO_2(g)$ (4) $CO_2(s) \rightarrow CO_2(l)$

4. Which change of phase is exothermic?

(1) gas to liquid (2) solid to liquid (3) solid to gas (4) liquid to gas

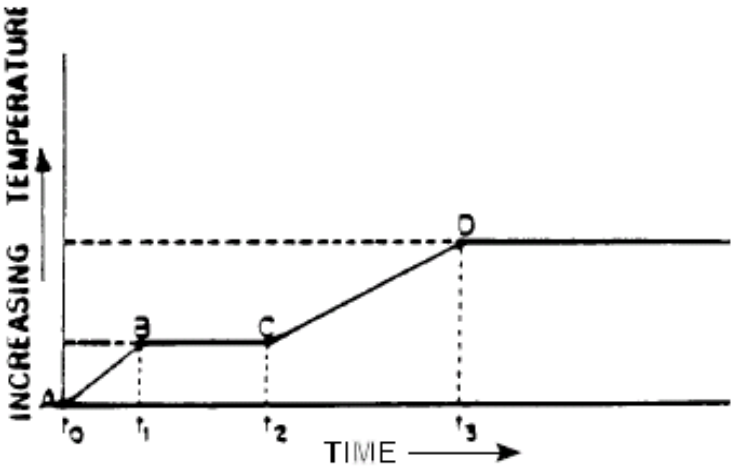
5. Which term can be used to describe the change of a substance from the solid phase to the liquid phase?

(1) condensation (2) vaporization (3) evaporation (4) fusion

6. Which sample contains particles arranged in regular geometric pattern?

(1) $CO_2(l)$ (2) $CO_2(s)$ (3) $CO_2(g)$ (4) $CO_2(aq)$

Base your answers to questions 7 and 8 on the diagram below which represents a substance being from a solid to a gas, the pressure remaining constant



7. The substance begins to boil at point

(1) E (3) C
(2) B (4) D

8. Between points B and C the substance exists in

(1) the solid state, only
(2) the liquid state, only
(3) both the solid and liquid states
(4) neither the solid nor the liquid state

9. Object *A* at 40.°C and object *B* at 80.°C are placed in contact with each other. Which statement describes the heat flow between the objects?

(a) Heat flows from object *A* to object *B.*
(b) Heat flows from object *B* to object *A.*
(c) Heat flows in both directions between the objects.
(d) No heat flow occurs between the objects.

10. What occurs when a 35-gram aluminum cube at 100.°C is placed in 90. grams of water at 25°C in an insulated cup?

(1) Heat is transferred from the aluminum to the water, and the temperature of the water decreases.
(2) Heat is transferred from the aluminum to the water, and the temperature of the water increases.
(3) Heat is transferred from the water to the aluminum, and the temperature of the water decreases.
(4) Heat is transferred from the water to the aluminum, and the temperature of the water increases.

11. A person with a body temperature of 37°C holds an ice cube with a temperature of 0°C in a room where the air temperature is 20.°C. The direction of heat flow is

(a) from the person to the ice, only
(b) from the person to the ice and air, and from the air to the ice
(c) from the ice to the person, only
(d) from the ice to the person and air, and from the air to the person

ASSESS YOURSELF ON THIS LESSON: _____/11
If you missed more than 2, do the Additional Practice.

ADDITIONAL PRACTICE LESSON 2:

1.) Which term is defined as a measure of the average kinetic energy of the particles in a sample of matter?

(a) activation energy (b) potential energy (c) temperature

2.) Explain what happens to an ice cube in your hand if you are in a room that has a temperature of 20 degrees Celsius.

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/2
If you missed any you should see me for extra help and/or re-read the lesson.

Lesson 3: Measurement of Heat Energy(Potential energy): **Date:_____**

Objective:

- ***Calculate heat, specific heat mass and change in temperature of a reaction***

Check your understanding:

1. What is the specific heat of silver if a 93.9 g sample cools from 215.0°C to 196.0°C with the loss of 428 J of energy?

2. If 100.0 J are added to 20.0 g of water at 30.0°C, what will be the **final** temperature of the water?

3. What is the total number of kilojoules of heat needed to change 15.0 g of ice to water at 0°C?

4. In question 3 is heat being absorbed or released? Is this process endothermic or exothermic?

Practice: Use the Heat Equations on Table T and the Physical Constants for Water on Table B in your reference to complete the following problems. **SHOW ALL WORK.**

1. A 5.00 gram sample of water is heated so that its temperature increases from 10.0°C to 15.0°C. What is the total amount of energy absorbed by the water?

2. When a sample of 25.0 g of water is cooled from 20.0°C to 10.0°C, what is the number of Joules of energy released?

3. What is the total number of kilojoules of heat needed to change 150. grams of ice to liquid water at 0ºC?

4. How much energy is required to vaporize 10.00 grams of water at its boiling point?

5. How many joules of heat energy are released when 50.0 grams of water are cooled from 70.0 °C to 60.0 °C?

6. What is the total number of joules of heat energy absorbed when the temperature of 200.0 grams of water is raised from 10.0 °C to 40.0 °C?

7. The temperature of a sample of water in the liquid phase is raised 30.0 °C by the addition of 3762 J. What is the mass of the water?

8. When 418. Joules of heat energy are added to 10.0 grams of water at 20.0 °C, what will the final temperature of the water be?

9. When 20.0 grams of a substance is completely melted at 0˚C, 3444 J is absorbed. What is the heat of fusion of this substance?

10. What would be the temperature change if 3.0 grams of water absorbed 15 Joules of heat?

Challenge: Calculate the amount of heat needed to heat a 20g piece of ice at -10˚C. to water vapor at 115˚C. (Hint: refer to heating curve and formulas)

ASSESS YOURSELF ON THIS LESSON: _____/10

If you missed more than 2, do the Additional Practice.

ADDITIONAL PRACTICE LESSON 3:

1. How many Joules of energy are needed to change the temperature of 100.0 grams of water from 20.0C to 40.0C?

2. How many kilojoules of energy are needed to change the temperature of 15.0 grams of water from 35.0C to 75.0C?

3. If the temperature of water is changed from 10.0C to 35.0C by the addition of 350.0J, how many grams were heated?

4. What is the total number of joules required to freeze a 10 g sample of water at 0°C?

5. How much energy is required to vaporize 10.00 g of water at its boiling point?

6. What is the total number of joules of heat needed to change 25 g of ice to water at 0°C?

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/6

If you missed more than 1 you should see me for extra help and/or re-read the lesson.

Lesson 4: Calorimetry **Date:_____**

Objective:

- ***To calculate the transfer of heat between substances using the calorimetry formula***

Check your understanding: SHOW ALL WORK!

1. A small pebble is heated and placed in a foam cup calorimeter containing 25.0 g of water at 25.0°C. The water reaches a final temperature of 26.4°C. How many joules of heat were released by the pebble? (*Hint:* $q_{water} = -q_{pebble}$)

2. A sample of silver with a mass of 63.3 g and a specific heat of 0.240J/g*°C is heated to a temperature of 111.3°C and placed in a container of water at 16.85°C. The final temperature of the silver and water is 19.25°C. Assuming no heat loss, what mass of water was in the container?
   Remember: $(mC\Delta T)_{lost} = (mC\Delta T)_{gained}$

Practice:

1. A 2.50 g sample of zinc is heated, and then placed in a calorimeter containing 65.0 g of water. Temperature of water increases from 20.00 ^{o}C to 22.50 ^{o}C. The specific heat of zinc is 0.390 J/g^{o}C. What was the initial temperature of the zinc metal sample? (final temperatures of zinc and water are the same)

2. A 13.5 g sample of gold is heated, and then placed in a calorimeter containing 60.0 g of water. Temperature of water increases from 19.00 ^{o}C to 20.00 ^{o}C. The specific heat of gold is 0.130 J/g^{o}C. What was the initial temperature of the gold metal sample?

3. A 28.4 g sample of aluminum is heated to 39.4 ^{o}C, then is placed in a calorimeter containing 50.0 g of water. Temperature of water increases from 21.00 ^{o}C to 23.00 ^{o}C. What is the specific heat of aluminum?

ASSESS YOURSELF ON THIS LESSON: _____/3

If you missed any, do the Additional Practice.

ADDITIONAL PRACTICE LESSON 4:

1. How many joules are required to raise the temperature of 100. grams of water from 30.0^{o}C to 40.0^{o}C?

2. How many joules are needed to raise the temperature of 200. grams of water by 20.0^{o}C?

3. If a 2.0 gram sample of water at 5.0^{o}C absorbs 5.0 joules of heat, the temperature of the sample will be raised by how much?

4) The temperature of 50. grams of water was raised to 50.0^{o}C by the addition of 1000. joules of heat energy. What was the initial temperature of the water?

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/4

If you missed more than 1 you should see me for extra help and/or re-read the lesson.

Lesson 5: **Vapor Pressure & Boiling Point Temperature** **Date:**_____

Objective:

- ***To relate vapor pressure to boiling points. To determine the boiling point of a substances using reference table H***

Check your Understanding:

Refer to the *Table H* to answer these questions.

_____ **1.** Which substance has the lowest normal boiling point?

_____ **2.** Which substance evaporates most easily at any temperature?

_____ **3.** Which of the substances has the highest boiling point?

_____ **4.** Which of the substances has the highest vapor pressure at 40°C?

_____**5.** Which substance boils at 79°C?

Practice: Refer to the *Table H* to answer these questions.

1. As temperature increases, vapor pressure _____ because _____
   (increases or decreases?)

2. The stronger the intermolecular forces of attraction (particle attractions or IMF's) the _____ energy required to break them.
   (more or less?)

3. The stronger the IMF's, the _____ the vapor pressure at any given temperature.
   (higher or lower?)
   Explanation: _____

4. The weaker the IMF's, the _____ it is for a liquid to evaporate.
   (harder or easier?)
   Explanation: _____

5. If water is boiling at 70^{o}C, what is the atmospheric pressure? _____ kPa

6. What is meant by "normal" boiling point?

7. At what temperature will ethanol boil when the atmospheric pressure is 50 kPa?

8. What atmospheric pressure will allow propanone to boil at 20°C?

9. What atmospheric pressure will allow water to boil at 90°C?

10. As the atmospheric pressure decreases, the boiling point of water will
    (a) increase
    (b) decrease
    (c) remain the same

11. Based on the boiling point information in Table H, which of the four substances has the greatest attractions between particles? **Explain how you know!**

12. At 65˚C, which compound has a vapor pressure of 58 kPa?

    a. ethanoic acid b. propanone
    c. ethanol d. water

13. Which liquid has the lowest vapor pressure at 65˚C?

a. ethanoic acid b. propanone
c. ethanol d. water

ASSESS YOURSELF ON THIS LESSON: _____/13
If you missed more than 4, do the Additional Practice.

ADDITIONAL PRACTICE LESSON 5:

14. What is the normal boiling point of ethanoic acid? _____ ^{o}C

15. Which of the 4 substances evaporates most rapidly at 50^{o}C? _____

16. Which substance has the *weakest* IMF's between its molecules? _____

17. At 50^{o}C, which substance has the highest vapor pressure? _____

18. If water is boiling at 80^{o}C, ethanol would boil at … _____ ^{o}C

19. When the pressure on the surface of ethanoic acid is 120 kPa, its boiling point will be _____ K

20. Which substance is the most volatile?_____ Explanation: _____

_____

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/7
If you missed more than 2 you should see me for extra help and/or re-read the lesson.

Lesson 6: Real vs. Ideal gases **Date:_____**

Objective:

- ***Differentiate between ideal and real gases***
- ***Determine the conditions which real gases behave most like ideal gases***

Check your understanding:

Ideal gas conditions

1. A gas is composed of very tiny particles which are in a continuous, random _____ motion. (curved/straight line)
2. Collisions between particles may result in a transfer of energy between particles but the net total kinetic energy of the system remains constant.
    - These are called "Elastic Collisions"

3. The volume of the gas particles themselves is ignored in comparison with the volume of space in which they are contained.
    - This is because the particles are very _____. (tiny/large)

4. Gas particles are considered as having no attraction for each other.
    - This is most true for _____ molecules/particles. (small/large)
5. High Temperature and Low Pressure
    - The higher the temperature, the _____ the particles move. (slower/faster)
    - The lower the pressure, the _____ spacing between particles. (more/less)

Real Gas Conditions (Deviations from Ideal Gases):

1. Gases do have volume.
2. Gases do exert some attraction for each other.

These deviations become significant when the space between particles is reduced due to:

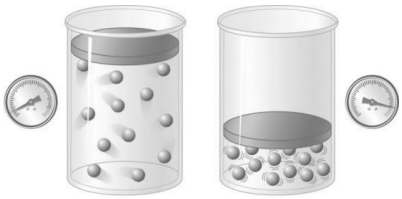
1) Low Temperature
   - The lower the temperature, the _____ the particles move. (slower/faster)
2) High Pressure
   - The higher the pressure, the _____(more/less) spacing between particles.

3) Large molecules

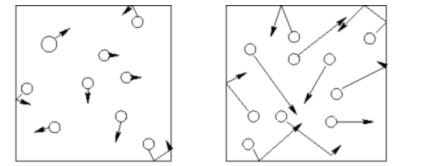
4) Gas particles have a greater attraction for each other.

Practice:

KMT is the study of how ideal or _____ gases behave. Real gases behave most like ideal gases under _____ pressure and _____ temperature.



(a) Low pressure (b) High pressure



Cool gas, fewer and less energetic collisions

Hot gas, more and more energetic collision

1. How can you get a real gas to behave the LEAST like an ideal gas?

2. Of the following: H_2, He, CO_2, which would behave least like and ideal gas and why?

3. Which of the gases in question 2 behaves the most like ideal gases/ Why?

4. Why do gases behave the least like ideal gases at low temperatures and high pressures?

5. Two basic properties of the gas phase are

(1) a definite shape and a definite volume
(2) a definite shape but no definite volume
(3) no definite shape but a definite volume
(4) no definite shape and no definite volume

6. According to the kinetic molecular theory, the molecules of an ideal gas

(1) have a strong attraction for each other
(2) have significant volume
(3) move in random, constant, straight-line motion
(4) are closely packed in a regular repeating pattern

7. Helium is most likely to behave as an ideal gas when it is under

(1) high pressure and high temperature
(2) high pressure and low temperature
(3) low pressure and high temperature
(4) low pressure and low temperature

8. Under which conditions of temperature and pressure does oxygen gas behave *least* like an ideal gas?

(1) low temperature and low pressure
(2) low temperature and high pressure
(3) high temperature and low pressure
(4) high temperature and high pressure

9. Under which conditions of temperature and pressure would a real gas behave most like an ideal gas?

(1) 200. K and 50.0 kPa
(2) 200. K and 200.0 kPa
(3) 600. K and 50.0 kPa
(4) 600. K and 200.0 kPa

10. Which list of the phases of H_2O is arranged in order of increasing entropy?

(1) ice, steam, and liquid water
(2) ice, liquid water, and steam
(3) steam, liquid water, and ice
(4) steam, ice, and liquid water

Fill in the blanks below in questions 12-17; using the word bank (Words can be used more than once!)

Attractions	**Colliding**	**Compressed**
Faster	**Slower**	**Increase**
Decrease	**Less**	**More**
Pressure	**Volume**	**Temperature**

12. The particles or molecules in a sample of gas are spread very far apart from each other. As a result they feel no _____ for each other.

13. The molecules in a gas can be forced closer together without changing back to the liquid state, in other words they are able to be _____ into a smaller volume.

14. When you pump up a soccer ball with an air pump, the ball gets harder. This is because you are taking the same amount of space and filling it with _____ gas molecules. As a result, the _____ inside the ball increases. This is because there are more molecules _____ with the inside surface of the ball.

15. _____is a measure of the average kinetic energy of the molecules in a sample. In a hotter sample, the molecules are moving _____ on average compared to a colder sample.

16. When working with gases, it is important to realize that the variables of pressure, _____, temperature, and number of molecules are all inter-related. In other words, changing one of these variables for a gas system will change at least one of the others.

- In a flexible container (one that can change volume, like a balloon), increasing the pressure on a gas will cause the volume to _____.
- In a flexible container, increasing the temperature on a gas will cause volume to _____.
- In a rigid container (one that cannot change volume, like an aerosol can), increasing the temperature will cause the pressure inside the container to _____.
- In a rigid container, increasing the amount of gas inside the container will cause the pressure inside it to _____.

ASSESS YOURSELF ON THIS LESSON: _____/16

If you missed more than 2, do the Additional Practice.

ADDITIONAL PRACTICE: LESSON 6

1. Under which conditions of temperature and pressure does oxygen gas behave *most* like an ideal gas?

(1) low temperature and low pressure
(2) low temperature and high pressure
(3) high temperature and low pressure
(4) high temperature and high pressure

2. According to the kinetic molecular theory, which assumption is correct?

(1) Gas particles strongly attract each other.
(2) Gas particles travel in curved paths.
(3) The volume of gas particles prevents random motion.
(4) Energy may be transferred between colliding particles.

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/2

If you missed any you should see me for extra help and/or reread the lesson.

Lesson 7: Gas Laws **Date:_____**

Objective:

- ***Determine the relationship between pressure, temperature and volume***
- ***Compare different gases in reference to Avagadro's law***

Check your understanding:

1. The volume of a 5.0 mL syringe is changed to 4.5 mL. If the starting pressure was 101.3 kPa, what is the new pressure? (Temperature is constant.)

Make a "shopping list" below!

V_1 = _____ V_2 = _____

P_1 = _____ P_2 = _____

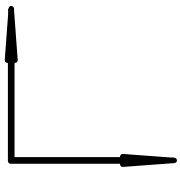
T_1 = _____ T_2 = _____

Practice:

FILL IN THE BLANKS WITH INCREASE(S) OR DECREASE(S).

Boyle's Law relates pressure and volume. When pressure is increased on a gas at constant temperature, the volume _____. This is an indirect relationship.

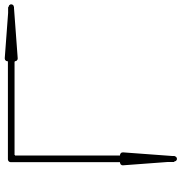
Draw the graph



1. Pilots suffer from intestinal pain when they fly because at higher altitudes, the pressure is decreased so the air volume in their body _____.
2. Your lungs suck in air when the diaphragm is enlarged. When the diaphragm opens, the lung expands the volume _____ and the pressure _____ which allows air in. When the diaphragm collapsed, there is less room so the volume _____ and the pressure _____.
3. Why do you ears pop on an airplane? (Hint: the air pressure decreases at high altitudes.) Explain in terms of pressure and volume.

Charles' Law relates volume and temperature. When temperature is increased on a gas at constant pressure, the volume _____. This is a direct relationship.

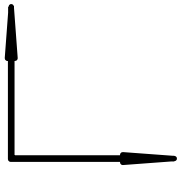
Draw the graph



4. Hot air balloons work based on density changes affected by Charles law. To rise, the temperature is _____ and the volume _____ to make the density low. To come back down the fire is turned off so the temperature _____ and volume _____ so the density increases. The balloon is always inflated so the pressure is relatively constant.
5. A balloon outside in the winter seems to deflate but inside it re-inflates. However the number of gas molecules stays constant. How does that happen? Explain in terms of volume and temperature.

Gay Lussac's Law relates pressure and temperature. When temperature is increased on a gas at constant volume (in a rigid container), the pressure _____ because the gas molecules move more. This is a direct relationship.

Draw the graph



6. Drivers need to check the air pressure on their tires during change of seasons. In the winter the temperatures are decreased, the pressure inside the tires is _____ and the tires are flat. In the summer temperatures are increased and pressures are_____ so the tires are swollen. But the volume the tires air can occupy stays the same.

7. Don't put aerosol spray cans in direct heat or flames because they explode. Explain this phenomenon in terms of pressure and temperature.

8. Which sample at STP has the same number of molecules as 5 liters of $NO_2(g)$ at STP?

(1) 5 grams of $H_2(g)$ (3) 5 moles of $O_2(g)$
(2) 5 liters of $CH_4(g)$ (4) 5×10^{23} molecules of $CO_2(g)$

9. At the same temperature and pressure, 1.0 liter of CO (g) and 1.0 liter of CO_2 (g) have

(1) Equal volumes and the same number of molecules
(2) Equal masses and the same number of molecules
(3) Different masses and a different number of molecules
(4) Different volumes and a different number of molecules

10. The table below shows data for the temperature, pressure, and volume of four gas samples.

Gas Sample	Temperature (K)	Pressure (atm)	Volume (mL)
A	100.	2	400.
B	200.	2	200.
C	100.	2	400.
D	200.	4	200.

Which two gas samples have the same total number of molecules?
(1) A and B (2) A and C (3) B and C (4) B and D

11. The volume of a balloon is increased by a factor of 4 . What is the new pressure if the starting pressure is 1 atm?

Make a "shopping list" below!

12. A 2.0 Liter balloon at 273K is heated to 373K. In order to keep pressure constant, what must be the new volume of the balloon?

Make a "shopping list" below!

13. A rigid metal cannister is filled with gas at room temperature (300K) and 1 atmosphere of pressure. The temperature of the cannister is raised to 400K. What is the pressure in atmospheres?

Make a "shopping list" below!

ASSESS YOURSELF ON THIS LESSON: _____/13

If you missed more than 2, do the Additional Practice. If not, go on to the next hw video!!!

ADDITIONAL PRACTICE: LESSON 7

1. At the same temperature and pressure, which sample contains the same number of moles of particles as 1 liter of O_2 (g)?
   (1) 1 L Ne (*g*) (2) 0.5 L SO_2 (*g*) (3) 2 L O_2 (*g*) (4) 1 L of H_2O (l)

2. If the temperature of a substance increases, what happens to its volume? Pressure? Explain.

3. Draw a visual representation of this using particle diagrams.

4. If the volume of a substance increases, what happens to its pressure? Explain.

5. Draw a visual representation of this using particle diagrams.

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/5

If you missed more than 1 you should see me for extra help and/or re-read the lesson .

Lesson 8: Combined Gas Laws **Date:_____**

Objective:

- ***Solve gas law problems using the combined gas law equation***
- ***Convert from Celsius temperatures to Kelvin***
- ***Convert between pressure units (atm and kPa)***

Check your Understanding:

1. A gas has a volume of 2.00 L at 323 K and 3.00 atm. What will be the new volume if the temperature is changed to
   273 K and the pressure is changed to 1.00 atm?

2. A gas has a volume of 100 mL at a temperature of 20. K and a pressure of 760 mm Hg. What will be the new volume when the temperature is changed to 40.0 K and the pressure is changed to 380 mm Hg?

Practice:

Remember the constant can be crossed out in the equation. You should have three numbers and one x. If nothing is constant than use the full combined gas law equation.

1. If the temperature of a 50mL sample of a gas is changed from 200K to 400K under constant pressure, what is the new volume of the gas?

2. The volume of a gas is 204mL when the pressure is 925kPa. At constant temperature, what is the final pressure if the volume increases to 306ml?

3. A balloon has a volume of 1.75L at a temperature of 298K. What will be the volume of the balloon if you take it out into the winter cold air at 258K? Assume pressure is constant.

4. An aerosol spray can with a volume of 456mL contains 3.18g of propane gas as a propellant. If the can is at 23C, and 50atm, what volume would the propane occupy at STP?

5. *Divers get "the bends" if they come up too fast because gas in their blood expands, forming bubbles in their blood. If a diver has 5.0 mL of gas in his blood under a pressure of 250. atm, then rises instantaneously to a depth where his blood has a pressure of 50.0 atm, what will the volume of gas in his blood be?*

6. A gas has a volume of 2.00 L at 323 K and 3.00 atm. What will be the new volume if the temperature is changed to 273 K and the pressure is changed to 1 atm?

7. A gas at STP has a volume of 1.00 L. If the pressure is doubled and the temperature remains constant, what is the new volume of the gas?

8. A 2.5 L sample of gas is at STP. When the temperature is raised to 373°C and the pressure remains constant what will the new volume of the gas be?

9. Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the unbalanced equation below.

$$___\ NaN_3(s) \rightarrow ___\ Na(s) + ___\ N_2(g)$$

a.) Balance the above equation using the smallest whole-number coefficients.

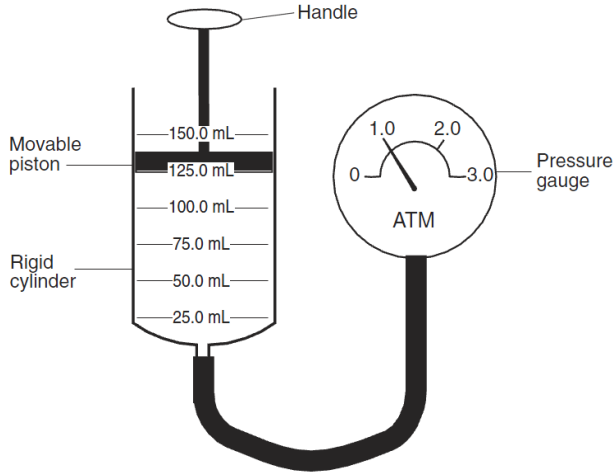
b.) When the air bag inflates, the nitrogen gas is at a pressure of 1.30 atmospheres, a temperature of 301 K, and has a volume of 40.0 liters. Calculate the volume of the nitrogen gas at STP.

ASSESS YOURSELF ON THIS LESSON: _____/9

If you missed more than 2, do the Additional Practice.

ADDITIONAL PRACTICE: LESSON 8

1. A rigid cylinder is fitted with a movable piston. The cylinder contains a sample of helium gas, He(g), which has an initial volume of 125.0 milliliters and an initial pressure of 1.0 atmosphere, as shown below. The temperature of the helium gas sample is 20.0°C.



a.) Express the initial volume of the helium gas sample, in liters.

b.) The piston is pushed further into the cylinder. Show a correct numerical setup for calculating the volume of the helium gas that is anticipated when the reading on the pressure gauge is 1.5 atmospheres. The temperature of the helium gas remains constant.

c.) Helium gas is removed from the cylinder and a sample of nitrogen gas, $N_2(g)$, is added to the cylinder. The nitrogen gas has a volume of 125.0 milliliters and a pressure of 1.0 atmosphere at 20.0°C. Compare the number of particles in this nitrogen gas sample to the number of particles in the original helium gas sample.

ASSESS YOURSELF ON THIS ADDITIONAL PRACTICE: _____/3

If you missed any questions you should see me for extra help and/or re-read the lesson,

Practice: **Gas Laws Drill**

1. If the temperature is held constant, what will happen to the pressure exerted by a gas if the volume of the container is decreased?

   (1) increase
   (2) decrease
   (3) remain the same
   (4) increase, or decrease (it depends)

2. Which of the following is NOT true about pressure?

   (1) pressure is exerted equally in all directions
   (2) pressure is defined as force per unit area
   (3) gas pressure can only be measured in units of mm of mercury
   (4) atmospheric pressure decreases with increasing altitude

3. The pressure of a sample of gas is 500. mm Hg and the volume is 30.0 L. If the volume is changed to 50.0 L, what is the new pressure?

   (1) 833 mm Hg (2) 300 mm Hg (3) 7500 mm Hg (4) 3000 mm Hg

4. If the temperature of a sample of gas is decreased at constant pressure, the volume of the gas will:

   (1) increase
   (2) decrease
   (3) remain the same
   (4) increase, or decrease (it depends)

5. Standard temperature and pressure, STP, refers to:

   (1) 100^{o}C and zero atmosphere
   (2) absolute zero and one atmosphere
   (3) 0^{o}C and a pressure of one atmosphere
   (4) 0^{o}C and zero atmosphere

6. A sample of gas in a rigid container (constant volume) is at a temperature of 25.0^{o}C. If the temperature of the gas is increased to 50.0^{o}C, what will happen to the pressure exerted by the gas?

   (1) it will double
   (2) it will halve
   (3) it will increase by a small amount
   (4) it will decrease by a small amount

7. A gas occupies a volume of 444 mL at 273 K and 79.0 kPa. What is the final Kelvin temperature when the volume of the gas is changed to 1880 mL and the pressure is changed to 38.7 kPa?

   (1) 31.5 K (2) 566 K (3) 292 K (4) 2360 K

8. A sample of gas is held at constant pressure. Increasing the Kelvin temperature of this gas sample causes the average kinetic energy of its molecules to

   (1) decrease and the volume of the gas sample to decrease
   (2) decrease and the volume of the gas sample to increase
   (3) increase and the volume of the gas sample to decrease
   (4) increase and the volume of the gas sample to increase

9. A gas occupies a volume of 40.0 milliliters at 20°C. If the volume is increased to 80.0 milliliters at constant pressure, the resulting temperature will be equal to

(1) $20°\text{C} \times \frac{80.0\ \text{mL}}{40.0\ \text{mL}}$ (3) $293\ \text{K} \times \frac{80.0\ \text{mL}}{40.0\ \text{mL}}$

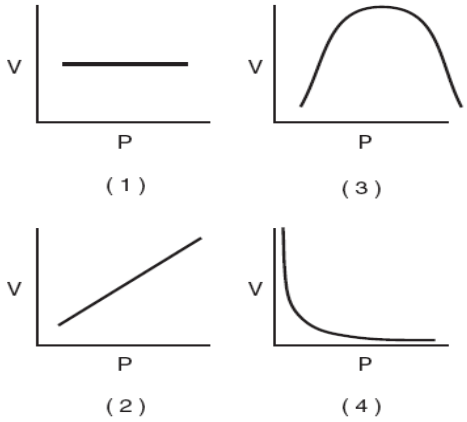
(2) $20°\text{C} \times \frac{40.0\ \text{mL}}{80.0\ \text{mL}}$ (4) $293\ \text{K} \times \frac{40.0\ \text{mL}}{80.0\ \text{mL}}$

10. The volume of a gas is 4.00 liters at 293 K and constant pressure. For the volume of the gas to become 3.00 liters, the Kelvin temperature must be equal to

(1) $\frac{3.00 \times 293}{4.00}$ (3) $\frac{3.00 \times 4.00}{293}$

(2) $\frac{4.00 \times 293}{3.00}$ (4) $\frac{293}{3.00 \times 4.00}$

11. Which graph best represents the pressure - volume relationship for an ideal gas at constant temperature?



12. A sample of helium gas has a volume of 900. milliliters and a pressure of 2.50 atm at 298 K. What is the new pressure when the temperature is changed to 336 K and the volume is decreased to 450. milliliters?

(1) 0.177 atm (2) 4.43 atm (3) 5.64 atm (4) 14.1 atm

Unit Study Guide

Law, Theories, BIG ideas	**Equations, Calculations, Reference Tables**
Laws:	Equation: (When to use & units)
Theories:	Calculations (When to use)
BIG ideas:	Reference Table (Hints & tricks)

Helpful tips, sayings, shortcuts

Things I always forget…

Unit Review: **Physical Behavior of Matter**

Place a checkmark next to each item that you can do! If a sample problem is given, complete it as evidence.

_____1. I can still do everything from Unit 1.	
_____2. I can still do everything from Unit 2.	
_____3. I can still do everything from Unit 3.	
_____4. I can still do everything from Unit 4.	
_____5. I can still do everything from Unit 5.	
_____6. I can still do everything from Unit 6.	

_____7. I can define kinetic energy, potential energy, temperature, heat, endothermic, and exothermic.	**Definitions:** kinetic energy potential energy temperature heat endothermic exothermic

____8. I can use particle diagrams to show the arrangement and spacing of atoms/molecules in different phases.

Draw a particle diagram to represent atoms of Li in each phase.

Solid	Liquid	Gas

_____9. I can compare solids, liquids, and gases in terms of their relative kinetic energy, type of molecular motion, ability to completely fill a container, ability to change shape.

	Solid	Liquid	Gas
Relative Kinetic Energy			
Type of Molecular Motion	vibrations, only	vibration and rotation	vibration, rotation, and translation
Ability to Completely Fill a Container			
Ability to Change Shape			

_____10. I can state the change of phase occurring in fusion, solidification, condensation, vaporization, melting, boiling, sublimation, deposition, and freezing.

During fusion a substance changes from _____ to _____.

During solidification a substance changes from _____ to _____.

During condensation a substance changes from _____ to _____.

During vaporization a substance changes from _____ to _____.

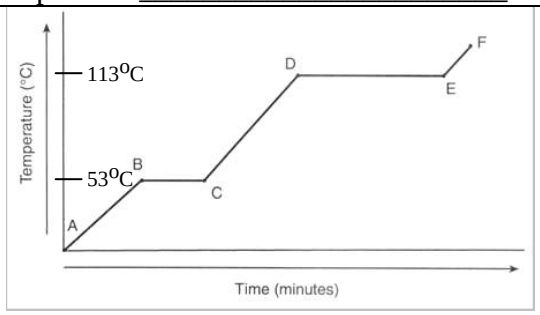
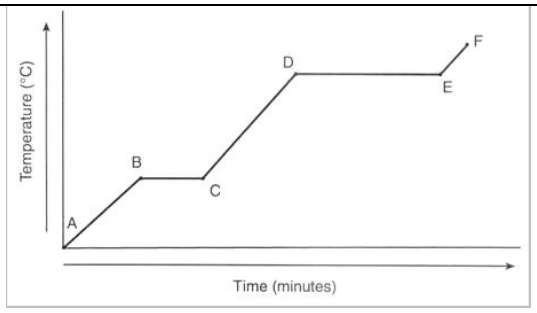
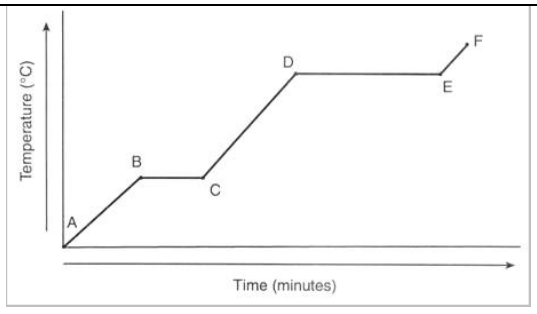
During melting a substance changes from _____ to _____.

During boiling a substance changes from _____ to _____.

During sublimation a substance changes from _____ to _____.

During deposition a substance changes from _____ to _____.

During freezing a substance changes from _____ to _____.

_____11. I can indicate if a phase change is exothermic or endothermic.	For each phase change listed, indicate whether the change is exothermic or endothermic. fusion/melting_____ solidification/freezing_____ condensation_____ vaporization/boiling_____ sublimation_____ deposition_____
_____12. Given a heating/cooling curve, I can determine the temperature at which a substance freezes/melts or condenses/vaporizes.	 What is the freezing point of this substance? What is the boiling point of this substance?
_____13. Given a heating/cooling curve, I can determine which sections of the curve show changes in potential energy.	 On the graph, circle the sections that show a change in potential energy.
_____14. Given a heating/cooling curve, I can determine which sections of the curve show changes in kinetic energy.	 On the graph, circle the sections that show a change in kinetic energy.
_____15. I can state the temperature at which water freezes in °C and K.	What is the freezing point of water in °C and K?

_____16. I can state the temperature at which water melts in ^{O}C and K.	What is the melting point of water in ^{O}C and K?
_____17. I can state the temperature at which water vaporizes/boils in ^{O}C and K.	What is the boiling point of water in ^{O}C and K?
_____18. I can state the temperature at which water condenses in ^{O}C and K.	What is the condensing point of water in ^{O}C and K?
_____19. I can use Reference Table T to determine which "heat" equation is needed for a given problem.	Which heat equation should be used in each of the following: a. How much heat is needed to vaporize 100.0 g of water at 100^{O}C? b. How much heat is needed to raise the temperature of 100.0 g of water by 35^{O}C? c. How much heat is needed to melt 100.0 g of ice at 0^{O}C?
_____20. I can define specific heat capacity, heat of fusion, heat of vaporization.	**Definitions:** specific heat capacity heat of fusion heat of vaporization
_____21. I can use the "heat" equations to solve for any variable, if I am given the other variables.	How many grams of water can be heated by 15.0 ^{O}C using 13,500 J of heat? It takes 5210 J of heat to melt 50.0 g of ethanol at its melting point. What is the heat of fusion of ethanol?

_____22. I can state the 4 parts of the Kinetic Molecular Theory.	The four parts of the Kinetic Molecular Theory are: a. b. c. d.
_____23. I can define an ideal gas.	**<u>Definition:</u>** ideal gas
_____24. I can state the conditions of pressure and temperature under which a gas will act "ideally".	A gas will act most "ideally" under the conditions of _____ pressure and _____ temperature.
_____25. I can state the two elements that act ideally most of the time.	The two elements that act ideally most of the time are _____ & _____.
_____26. I can explain how pressure is created by a gas.	What causes gas molecules to create pressure?
_____27. I can state the relationship between pressure and volume for gases (assuming constant temperature).	At constant temperature, as the pressure on a gas increases, the volume _____.
_____28. I can state the relationship between temperature and volume for gases (assuming constant pressure).	At constant pressure, as the temperature on a gas increases, the volume _____.
_____29. I can state the relationship between temperature and pressure for gases (assuming constant volume).	In a fixed container (AKA "has constant volume), as the temperature on a gas increases, the pressure_____.

_____30. I can state Avogadro's Hypothesis.	Avogadro's Hypothesis says_____ _____
_____31. I can remember to convert ^{O}C to K when using the Combined Gas Law to determine changes in V, P, or T of a gas.	A gas originally occupies 2.3L at 56^{O}C and 101.3 kPa. What will its volume be at 100^{O}C and 105.7 kPa?
_____32. I can define boiling point and vapor pressure.	**Definition:** boiling point vapor pressure
_____33. I can state the condition of pressure that is used for "normal" boiling points.	The normal boiling point of a substance occurs at a pressure of _____atm/_____kPa.
_____34. I can state the relationship between atmospheric pressure and boiling point.	As the atmospheric pressure increases, the boiling point _____.