CHEMISTRY
UNIT 3: WEATHER

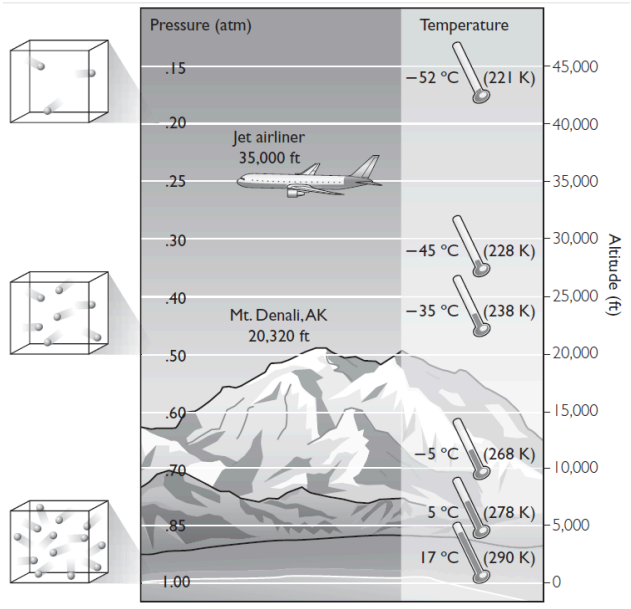
SECTION 3 PACKET

Lesson 15: *"n"* Is for Number

Pressure and Number Density

Chem Catalyst:

Look at the diagram of the Earth's atmosphere. Compare the atmosphere at sea level and at 34,000 ft, the altitude at which airplanes fly.



1. Describe at least three differences.

2. Explain why it is difficult to breathe at 34,000 ft.

Key Question:

- ❖ How is the number of gas molecules in a sample related to pressure?

Objectives:

- ■ Define the number density of a gas.
- ■ Describe the number density of the atmosphere as it relates to altitude.
- ■ Explain the relationship between number density and gas pressure.
- ■ Describe one way to measure gas pressure.

Number Density:

- **Number density**: the number of gas particles per unit volume.

- Number density = n / V
  - Where n is the number of gas particles
  - V is volume

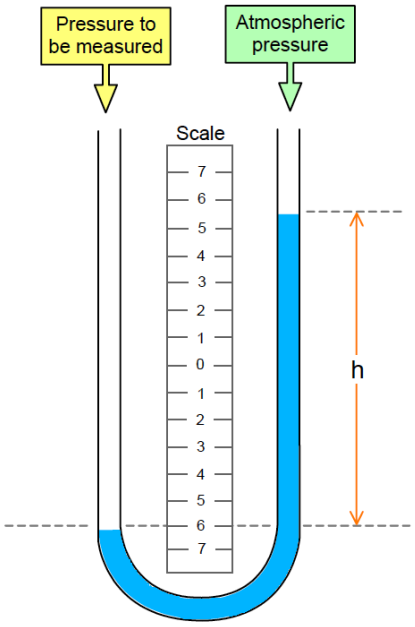
Number Density & Gas Pressure:

- The gas pressure increases as the number of gas molecules per unit volume increases.

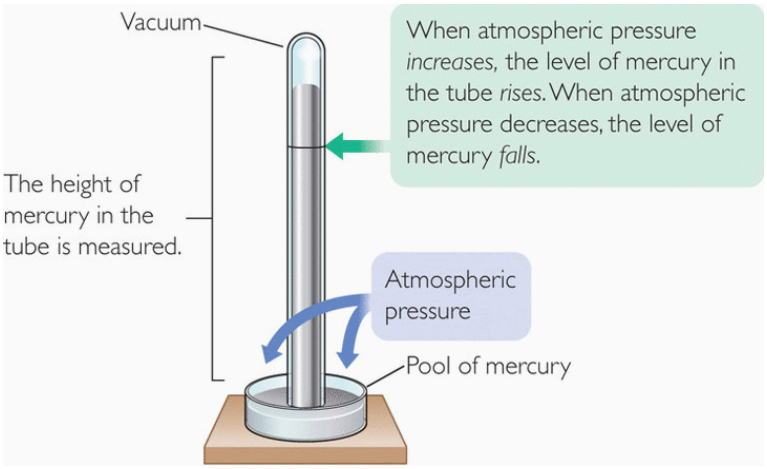
Manometers & Barometers:

- The height of the water levels in a U-tube indicates differences in pressure.
    - Air pressure can be determined by measuring the difference in height of a liquid.

Manometer



Barometer



Key Question Answered:

How is the number of gas molecules in a sample related to pressure?

- The composition of Earth's atmosphere is not uniform.
    - The density of the gas molecules in the air decreases with increasing altitude. This causes the pressure of the atmosphere to decrease with increasing altitude.

- The number density of a gas is the number of gas molecules per unit of volume, *n/V*.
- The pressure of a gas is directly proportional to the number of gas molecules per unit of volume.

Check-in:

A balloon is filled with helium, tied off, and then released. As it climbs into the air, its volume slowly increases.

- Explain what is going on with the helium atoms inside the balloon and the air molecules outside the balloon in terms of number density and pressure.

Safety Instructions

Wear safety goggles for Part 2.

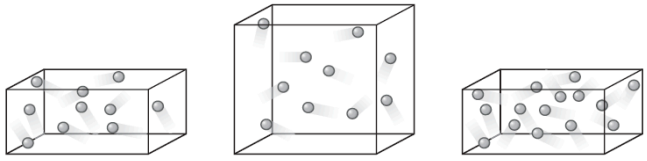
Part 1: The Atmosphere

Use the handout on Earth's atmosphere to help you answer these questions.

1. Give two reasons why the air pressure decreases as the altitude increases.

2. Use the kinetic theory of gases to explain why the gas pressure increases as the number of gas molecules in a container increases. Assume that the temperature does not change.

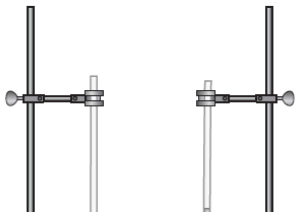
3. The illustrations show three samples of air at the same temperature. List the samples in order of increasing gas pressure. Explain your reasoning using the kinetic theory of gases.



4. The number of gas molecules per unit of volume (such as 1 cm^3) is called the number density of a gas. List the three samples of air in Question 3 in order of increasing number density.

Part 2: Balancing Air Pressure

Procedure and Questions



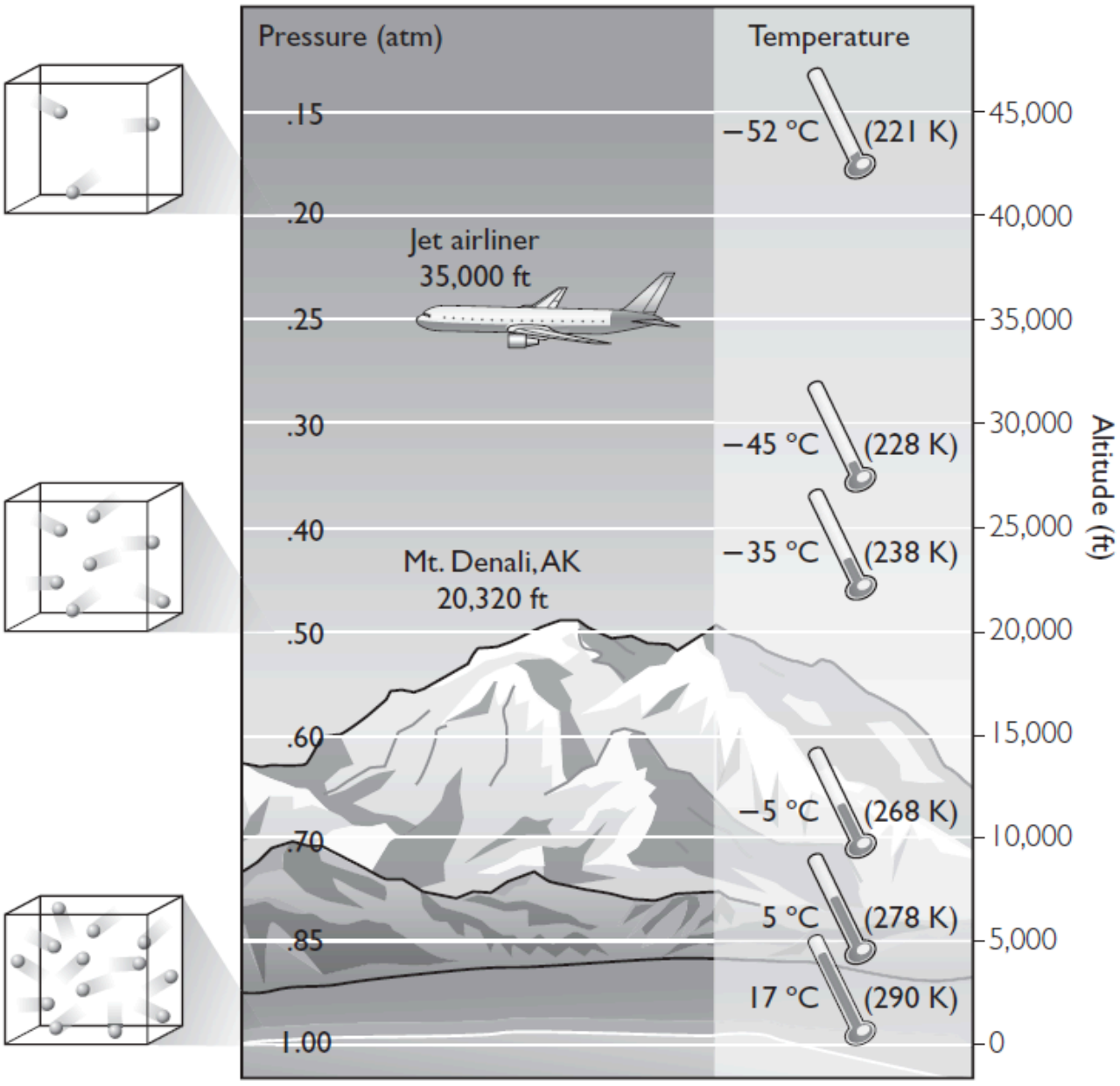
1. Hold the two ends of a piece of plastic tubing so that it forms a U shape with both ends pointing up.
2. Use a wash bottle to fill the tubing with water so that it reaches a level about halfway up each side.

5. In general, is there greater air pressure on the side where the water is higher or on the side where it is lower? Explain your thinking.

6. Is the number density of the gas, n/V, greater on the side where the water level is higher or on the side where it is lower? Explain your thinking in terms of the kinetic theory of gases.

7. Suppose you have water levels at equal heights. You put a stopper on one side and leave the other side open. The next day, the water level on the open side is lower. Has a high or low air pressure system moved in? Explain.

8. Making Sense Explain how air pressure is related to the number density of a gas.



Composition of dry air:

Main gases:	**Other gases:**	
$N_2(g)$: 78.084%	$CO_2(g)$: 0.035%	$CH_4(g)$: 0.00017%
$O_2(g)$: 20.946%	$Ne(g)$: 0.0018%	$Kr(g)$: 0.0001%
$Ar(g)$: 0.934%	$He(g)$: 0.0005%	$H_2(g)$: 0.000055%

Lesson 15: Pressure and Number Density Homework

Directions: Read pages 323-326 in your textbook and answer the following questions.

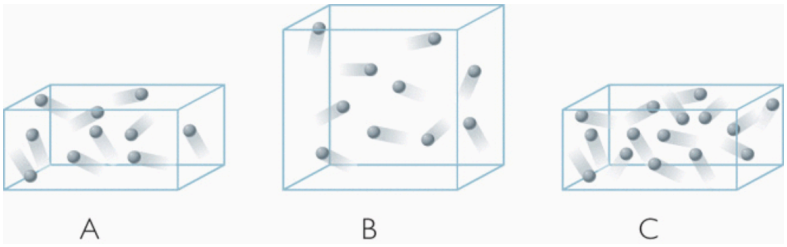
1. Use the kinetic theory of gases to explain the relationship between number density and gas pressure.

2. Explain the difference between a manometer and a barometer.

3. What effect does changing the number of gas particles in a container have on the gas pressure in the container? Use kinetic theory of gases in your explanation.

4. Name three ways you can increase the pressure of a tire.

5. The boxes in the illustrations show tiny samples of air. Assume they are at the same temperature. List the samples in order of increasing gas pressure. Explain your reasoning.



Lesson 16: STP

The Mole and Avogadro's Law

Chem Catalyst:

There are two balloons. One is filled with helium, He, and the other with carbon dioxide, CO_2.

- Describe what happens when the person holding the balloons releases them.

- For the two balloons, state whether these properties are the same or different. Explain your answers.
  - Pressure, *P*
  - Temperature, *T*
  - Volume, *V*
  - Mass, *m*
  - Number density, *n/V*
  - Number of moles, *n*
  - Density, *m/V*

Key Question:

❖ How do chemists keep track of the number of gas particles present in a sample?

Objectives:

- Define a mole.
- Explain Avogadro's Law.
- Define Standard Temperature and Pressure (STP).

Moles:

- Chemists use a unit called a mole to describe the number of gas particles in a sample.

- 1 Mole: 602,000,000,000,000,000,000,000 (6.02×10^{23}) particles, molecules, atoms, formula units, ions, etc.

Gases at STP:

- **Standard Temperature and Pressure (STP)**:
  - Pressure: 1 atmosphere (atm)
  - Temperature: 273 Kelvin, or 0 °C

- **Avogadro's Law**: Equal volumes of gases contain equal numbers of gas particles of gas particles if the temperature and pressure are the same.

- For any gas, there are exactly 6.02×10^{23} particles (1 mole) in 22.4 L of volume at STP.

Check-In:

One balloon contains 22.4 L of argon gas, Ar. Another balloon contains 22.4 L of neon gas, Ne. Both balloons are at 273 K and 1 atm.

1) Do the balloons contain the same number of atoms? Why or why not?

2) Will the balloons have the same mass? Why or why not?

LESSON 16 CLASSWORK

STP
The Mole and Avogadro's Law

Name _____

Date _____ Period _____

Volume (L)	Boxes filled at sea level P = 1 atm	Boxes filled on Mt. Denali P = 0.5 atm	Boxes filled outside airplane in flight P = 0.25 atm
11.2 L	0.500 mole	0.250 mole	
22.4 L	1.00 mole	0.500 mole	0.250 mole
33.6 L	1.50 moles		
44.8 L			

2. Describe at least three patterns that you notice in the data.

3. Analyze the data at sea level.

a. What is the number density, n/V, in moles of gas molecules per liter of gas in the 22.4 L box at sea level?

b. What is the number density of the gas in all four air samples at sea level?

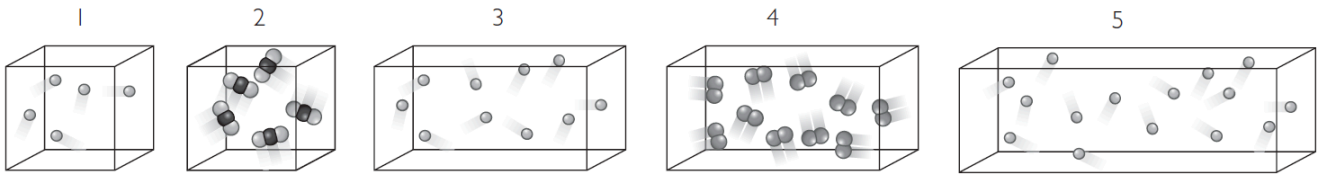
4. What is the number density for each location?

5. Explain why the pressure is higher at sea level than on Mt. Denali.

6. How many moles of gas would be in a 25.0 L box at sea level?

Part 2: Number and Mass

Consider samples of different gases. For each sample $T = 273$ K and $P = 1$ atm. (*Note:* The drawings simply represent the number of gas particles in correct proportion to one another.)



1	2	3	4	5
He 0.50 mole 11.2 L 2.0 g	CO_2 0.50 mole 11.2 L 22.0 g	He 1.0 mole 22.4 L 4.0 g	N_2 1.0 mole 22.4 L 28.0 g	He 1.5 moles 33.6 L 6.0 g

1. In the boxes showing helium gas, how many moles does each sphere represent?

2. Which box(es) has/have the most gas particles?

3. Which box(es) has/have the most total atoms?

4. There are twice as many total atoms in box 4 as in box 3, yet both boxes are at the same pressure. Explain why.

5. The masses of boxes 3 and 4 are different. Explain why.

6. Describe or sketch a box containing 8.0 g of He atoms at 1 atm pressure. Show the relative number of He atoms and the size of this box compared to the size of the boxes in the table.

7. Making Sense If you know that two gas samples are at the same temperature, what do you need to know in order to determine which gas is at a greater pressure?

8. If You Finish Early Consult the illustrations in Part 2. At a temperature of 273 K and a pressure of 1 atm, what volume does 1.0 mole of a gas occupy? Does it matter what the gas is? Explain.

Review of the Mole

1 mole = 6.02 X 10^{23} molecules

1 mole = 22.4L @ STP

Gas	Moles	Mass (g)	Atoms or Molecules	Volume (L) @ STP
Ar	1.00			
Ne	1.00			
O_2	1.00			
N_2	1.00			
F_2	1.00			
Cl_2	1.00			
Ar	2.00			
Ne	2.00			
O_2	2.00			
N_2	0.500			
Cl_2	0.500			

Mole Homework

1 mole = 6.02 X 10^{23} molecules

1 mole = 22.4L @ STP

Gas	Moles	Mass (g)	Atoms or Molecules	Volume (L) @ STP
He	1.00			
Xe	1.00			
H_2	1.00			
I_2	1.00			
Br_2	1.00			
He	0.500			
Xe	0.500			
Xe	2.50			
H_2	2.50			
I_2	3.00			
Br_2	3.00			

Lesson 16: Mole & Avogadro's Law

1. **Suppose you have 22.4L of the following gases at STP: neon, Ne, argon, Ar, and xenon, Xe.**

   a. How many moles are there in each gas sample?

   b. How many atoms are there in each gas sample?

   c. What is the number density of atoms, n/V, for each sample?

   d. Which sample has the largest mass? Explain your reasoning.

   e. Which sample has the largest mass density, m/V?

2. **Suppose you have 22.4L of the following gases at STP: hydrogen, H_2, nitrogen, N_2, and carbon dioxide, CO_2.**

   a. How many moles are there in each gas sample?

   b. How many molecules are there in each gas sample?

   c. What is the number density of molecules, n/V, for each sample?

   d. Which sample has the largest mass? Explain your reasoning.

   e. Which sample has the largest number of atoms? Explain your reasoning.

   f. Which sample has the largest mass density, m/V?

3. Which has more atoms, 8.0g He or 40.0g Ar? Explain your answer.

4. Which has more particles, a balloon filled with 10L of oxygen, O_2, gas or a balloon filled with 15L of hydrogen, H_2, gas? Explain your reasoning and assume STP.

5. At 25^{o}C, which balloon has a greater volume, an oxygen, O_2, balloon at 1.2atm with a mass of 16g, or a helium, He, balloon at 1.2atm with a mass of 2.0g?

Lesson 17: Take a Breath

Ideal Gas Law

Chem Catalyst:

1. Describe how you can determine the volume of a breath of air.

2. Name four factors that might affect the volume you measured.

3. What do you need to know in order to determine the number of molecules in a breath of air?

Key Question:

- ❖ How can you calculate the number of moles of a gas if you know *P*, *V*, and *T*?

Objectives:

- ■ Define the ideal gas law.
- ■ Define the universal gas constant, *R*.
- ■ Complete calculations for finding *n*, using the ideal gas law.

Ideal Gas Law:

- **The equation for the ideal gas law is:**
  - **PV = nRT**
  - Where R is equivalent to the proportionality constant, *k*, for this equation:
  - R = 0.0821 L·atm/mol·K
    - Note that R is the same for all gases, but the value of R changes if the units change.

Observations From The Lab:

- We should see differences in the volume of one breath of air from group to group.
- There is more than one way to figure out the volume of air that was exhaled into the bottle.

Key Question Answered:

How can you calculate the number of moles of a gas if you know P, V, and T?

- The ideal gas law relates volume, pressure, temperature, and the number of moles of a gas sample.
- $PV = nRT$, where $R = 0.0821$ L·atm/mol·K

Check-In:

You cap a 1.0 L plastic bottle on a mountaintop where the air pressure is 0.50 atm and the temperature is 298 K.

1) How many moles of gas are in the bottle?

2) What is the number density, n/V, of the gas inside the bottle on the mountaintop?

3) At sea level, the volume of the bottle becomes 0.50 L. What is the number density of the gas inside the bottle at sea level?

Lesson 17: Ideal Gas Law Practice Problems

PV= nRT V=nRT/P P=nRT/V n=PV/RT T=PV/nR

R = 0.0821 L·atm/mol·K

1. A gas contains 15 moles of molecules at a temperature of 28ºC and a pressure of 1.01 atm. What volume does the gas occupy?

2. A gas has a volume of 31.2L at a temperature of 301K and a pressure of 5.0atm. How many moles of gas are in the sample?

3. 2 moles of a gas has a volume of 10 L at a temperature of 27°C. What must be the pressure of the gas sample?

4. One balloon has 22.4 L of H_2 and another balloon has 22.4 L of O_2 gas. Both balloons are at STP.

   a. Do the balloons contain the same number of particles? Why or why not?

   b. Will the balloons have the same mass? Why or why not?

Lesson 17: Ideal Gas Law Homework

PV= nRT V=nRT/P P=nRT/V n=PV/RT T=PV/nR

R= 0.0821 atm·L/K·mol

1. What is the pressure, in atmospheres, exerted by a 0.500 mol sample of nitrogen in a 10.0L container at 25.0°C?

2. What is the volume occupied by 0.250mol of oxygen at 20.0°C and 0.974 atm of pressure?

3. A sample of hydrogen gas, H_2, has a volume of 8.56 L at 0°C and a pressure of 1.50atm. Calculate the number of moles of H_2 present in this gas sample.

4. How many moles of chlorine are contained in a 0.100 L tank at 27.0ºC and 3.5 atm of pressure?

5. At what temperature will a 0.100 mol sample of neon gas exert a pressure of 0.658 atm in a 5.00L container?

6. What is the volume of 1.00 mol of carbon dioxide at 0ºC and 1.0 atm of pressure?

Lesson 18:Feeling Humid

Humidity, Condensation

ChemCatalyst:

1. Is there water vapor in the air right now? What evidence do you have to support your answer?

2. What do you think "humidity" means? How does humidity depend on temperature?

Key Question:

- ❖ What is humidity and how is it measured?

Objectives:

- ■ Define humidity and relative humidity.
- ■ Explain the relationship between humidity and phenomena such as cloud formation, fog, rainfall, and dew.
- ■ Explain the relationship between water vapor density and air temperature.

Humidity:

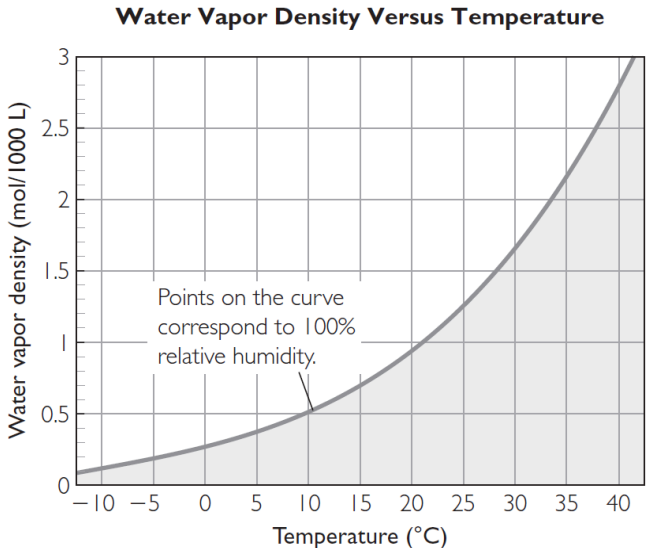
- Humidity: the density of the water vapor in the air at any given time.
  - Humidity is dependent on air temperature and pressure.
- The condensation procedure provides evidence that water vapor is present in the air.

- The temperature at which water vapor condenses indicates how much water vapor is in the air.

Relative Humidity:

- There is an upper limit to the amount of water vapor that can be present in the atmosphere at a given temperature.
- Humidity is sometimes expressed as relative humidity.
- Relative humidity: the amount of water vapor in the air compared to the maximum amount of water vapor possible for a specific temperature, expressed as a percent.

Water Vapor Density (Humidity) vs. Temperature



Key Question Answered:

What is humidity and how is it measured?

- Humidity is a measure of the amount of water vapor in the air. It can be expressed as water vapor density or as relative humidity.

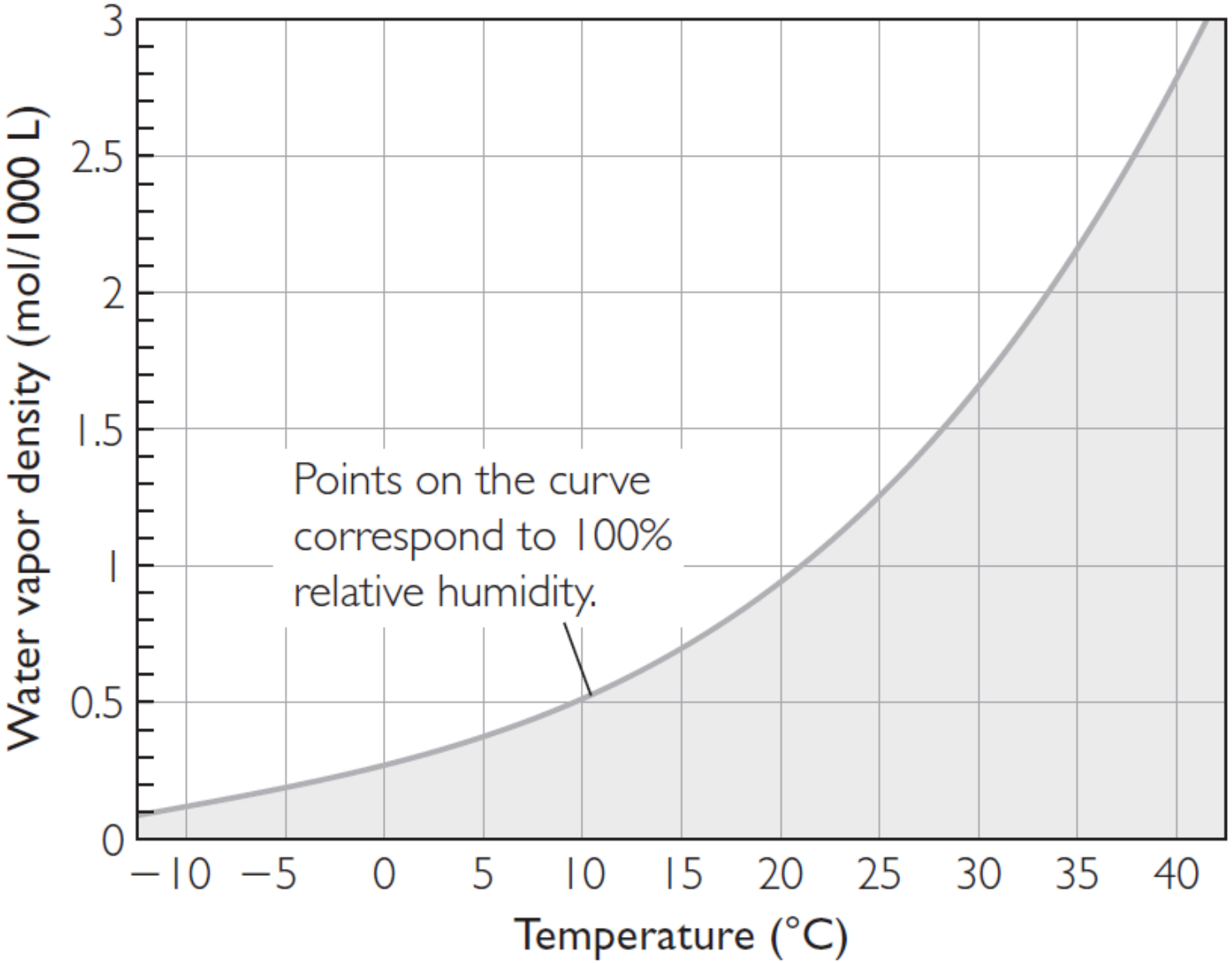
- Water vapor density is affected by both air temperature and air pressure.
- There is a limit to the amount of water vapor that can be present in the air at a given temperature. The maximum amount possible is called 100% relative humidity.

Check-In

- The **Dry Bulb** temperature, usually referred to as air temperature, is the air property that is most common used. When people refer to the temperature of the air, they are normally referring to its dry bulb temperature.
- The **Wet Bulb** temperature is the temperature indicated by a moistened thermometer bulb exposed to the air flow. The wet bulb temperature is always lower than the dry bulb temperature but will be identical with 100% relative humidity.

1. On a hot summer day, Mr. R records a dry-bulb temperature of 30°C and a wet-bulb temperature of 12°C. What does this tell you about the relative humidity?

Water Vapor Density Versus Temperature



Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (°C)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	26	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Lesson 18: Humidity Homework

Directions: Read Pages 335-338 in your textbook. Answer the following questions.

1. What does humidity measure?

2. Explain what is meant by relative humidity.

3. Use the graph "Water Vapor Density versus Temperature" to predict the water vapor density at 100% humidity for 35°C.

4. Suppose the humidity is 65% during the day when the temperature is 30°C. *(Use the Water Vapor Density Graph)*

   a. If the temperature drops to 25°C at night, do you expect fog? Explain.

   b. If the temperature drops to 20°C at night, do you expect fog? Explain.

5. On a cold winter day the relative humidity is 50% outdoors, but only 5% indoors. Which answer best explains what is going on?

   a. It must be raining outside.
   b. It must be snowing outside.
   c. The heater is on inside, so the same humidity is a lower relative humidity.
   d. The heater is on inside, and it is evaporating some of the humidity in the air.

Lesson 19: Hurricane!

Extreme Physical Change

ChemCatalyst:

- What is a hurricane? What characteristics does it have?

- Where do hurricanes form? What can you tell about a hurricane from a satellite image?

Key Question:

- ❖ What are hurricanes and what causes them?

Objectives:

- Describe the meteorological conditions that result in a hurricane.
- Explain the role of phase change, air pressure, and temperature in hurricane formation.
- Define climate and global warming.

Formation of Hurricanes:

- **Hurricanes** are destructive storms characterized by strong winds and large amounts of rainfall.

- Tropical depressions can build to tropical storms, which can build to hurricanes.

- There are five categories of hurricane, with category 1 the least intense and category 5 the most intense.
- Tropical storms begin forming when a great deal of warm water evaporates into the atmosphere.
- As the storm moves over areas of warmer water, evaporation increases.
- Water vapor density is related to temperature.

Key Question Answered:

What are hurricanes and what causes them?

- Hurricanes are intense tropical weather systems accompanied by strong winds, massive amounts of rain, and ocean flooding. They form around low pressure and are characterized by spiraling clouds and winds.
- Hurricanes form over the ocean in places where there is extremely warm and moist air.
- Rapid evaporation and subsequent condensation of moisture set up an air pressure differential that further feeds the evaporation and condensation.

Check-In

Why do most hurricanes have their origin near the equator?

LESSON 19 CLASSWORK

Hurricane!

Extreme Physical Change

Name _____

Date _____ Period _____

2. Which hurricanes were the least intense in 2005? What is your evidence?

3. Which hurricanes were the most intense in 2005? What is your evidence?

4. What approximate air pressure range is associated with hurricanes?

5. What wind speed range is associated with hurricanes?

6. How do you think the category number of a hurricane is determined?

7. If a storm system has an air pressure of 980 mb, do you think it will be classified as a hurricane? What is your reasoning?

8. Hurricanes form only in places where the ocean water is at least 80 °F. What effect does high temperature have on the water vapor density of the air over the ocean?

9. When do you think hurricane season is for the East Coast of North America?

Part 2: Hurricanes and Temperature

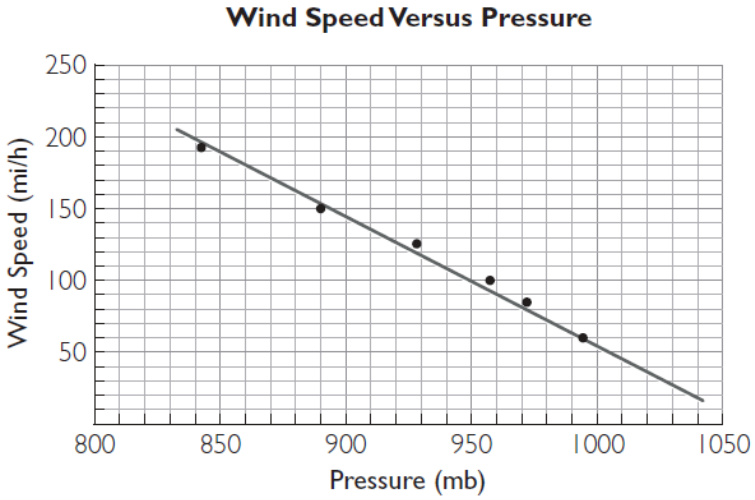
1. As a hurricane travels across the surface of the ocean, its wind speed changes with the temperature of the water. This graph shows wind speed versus ocean temperature for a hurricane.

Wind Speed Versus Temperature

2. How does the wind speed change with ocean surface temperature?

3. If the planet warms 2 °F in the next 30 years, what wind speeds can you predict for the most severe hurricanes at that time?

4. This graph shows wind speed versus pressure for six hurricanes. What pressure corresponds to the wind speed you determined in Question 3?



5. Making Sense What factors affect the severity of a hurricane?

Name	Date	Wind speed (mi/h)	Pressure (millibars)	Category
Tropical storm Bret	June 28–30	40	1002	—
Hurricane Cindy	July 3–7	75	992	1
Hurricane Dennis	July 5–13	150	930	4
Hurricane Emily	July 11–21	155	929	4
Tropical storm Franklin	July 21–29	70	997	—
Tropical storm Harvey	Aug 2–8	63	994	—
Hurricane Irene	Aug 4–18	98	975	2
Tropical depression 10	Aug 13–14	35	1008	—
Hurricane Katrina	Aug 23–31	173	902	5
Tropical storm Lee	Aug 28–Sep 2	40	1007	—
Hurricane Maria	Sep 1–10	115	960	3
Hurricane Ophelia	Sep 6–18	92	976	1
Hurricane Rita	Sep 18–26	173	897	5
Tropical depression 19	Sep 30–Oct 2	35	1006	—
Hurricane Vince	Oct 9–11	75	987	1
Hurricane Wilma	Oct 15–25	175	882	5
Tropical storm Delta	Nov 23–28	70	980	—

LESSON 20
CLASSWORK

Stormy Weather
Unit Review

Name _____

Date _____ Period _____

Purpose

To summarize and review what has been learned in the Weather unit.

1. Explain what happens at a cold front and why.

2. Under what conditions does a front result in precipitation?

3. Why is rainfall measured in inches and not liters or milliliters?

4. Describe how a liquid thermometer measures temperature.

5. Why does it usually snow more on mountaintops than at lower altitudes?

6. Sample A contains 1.0 kg of rain, sample B contains 1.0 kg of solid ice, and sample C contains 1.0 kg of snow. Which sample will have the greatest volume? the least volume? Explain your reasoning.

7. Suppose you have 3 mol of helium in a balloon at STP. What are the temperature, pressure, and volume of the helium in the balloon? How many atoms of helium are in the balloon?

8. A gas in a closed container with a movable piston has an initial pressure of 3.5 atm and a volume of 2.6 L. If the temperature doesn't change and the volume is changed to 3.4 L, what is the new pressure of the gas? What gas law did you use to determine the new pressure?

9. Find the pressure of 3.40 mol of gas if the gas temperature is 40 °C and the gas volume is 68.4 L. What gas law did you use to determine the new pressure?

10. At the beginning of the day, a balloon containing 175 L of air is at a temperature of 78 °F. Later in the day, the volume of the air in the balloon increases to 186 L. What is the new Kelvin temperature of the air in the balloon if the pressure remains the same during the heating? What gas law did you use to determine the new temperature?