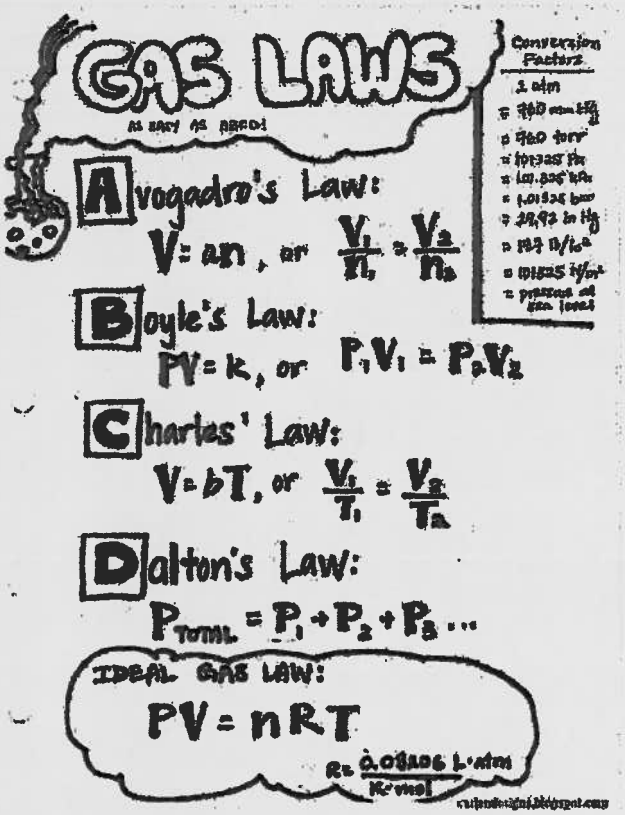


Unit 9: Gases

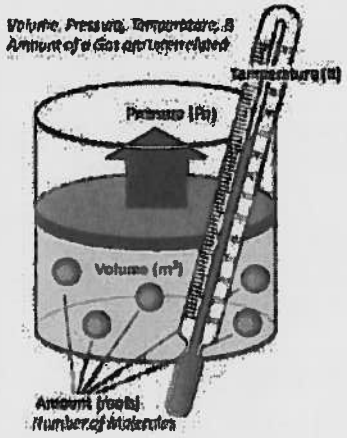
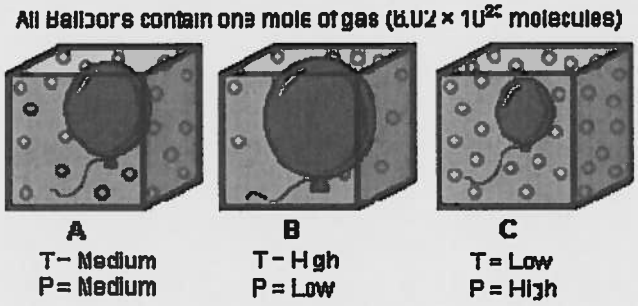


Figure 2. Volume of One Mole of Gas Under Different Conditions



Name_____Per_____

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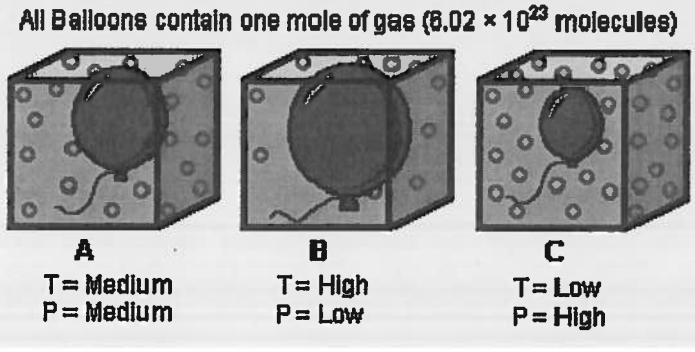
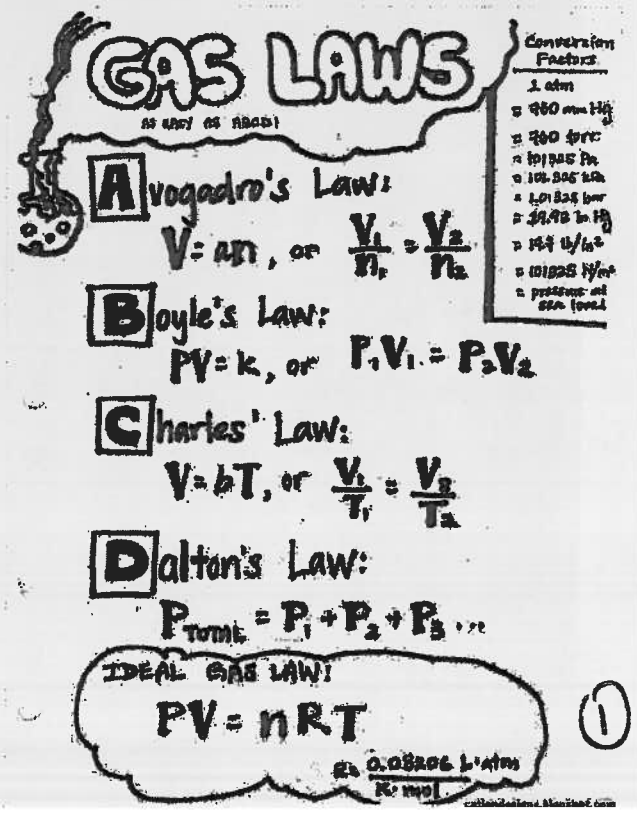
Unit 9: Gas Laws Study Guide

1. Gases have no set volume or shape. They will completely fill any closed contained.
2. Particles have largely broken free of the forces holding them together.
3. As temperature increases, kinetic energy increases.
4. The combined gas law states the relationship between pressure, temperature and volume in a sample of gas.
5. Increasing pressure causes a decrease in volume (inverse relationship).
6. Increasing temperature causes an increase in volume (direct relationship).
7. Increasing temperature causes an increase in pressure.(direct relationship).
8. An ideal gas model is used to explain the behavior of gasses. A real gas is most like an ideal gas when it is at low temperature and high pressure.
9. The Kinetic Molecular Theory (KMT) for an ideal gas states that all gas particles:
    a. are in random motion.
    b. have no forces of attraction between them.
    c. have a negligible volume compared to the distances between them.
    d. have collisions that result in the transfer of energy from one particle to another, but there is no net loss of energy from the collision.
10. Equal volumes of gases at the same temp and pressure have an equal number of particles.

Figure 2. Volume of One Mole of Gas Under Different Conditions





Unit 9: Gases Vocabulary

1. Gaseous phase

2. Kinetic molecular theory

3. Relationship between number of gas particles and pressure

4. Relationship between pressure and volume

5. Relationship between temperature and pressure

6. Relationship between temperature and volume

7. Ideal gas

8. Real gas

9. Avogadro's hypothesis

Homework Questions

Topic:_____

Question:

Submitted by:_____

Homework Questions

Topic:_____

Question:

Submitted by:_____

Homework Questions

Topic:_____

Question:

Submitted by:_____

Homework Questions

Topic:_____

Question:

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Homework Questions

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Homework Questions

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Homework Questions

Topic:_____

Question:

Submitted by:_____

Gas Laws and Kinetic Molecular Theory Animations

Boyle's Law-Pressure vs. Volume Animations

Find the animation at this web site http://www.dlt.ncssm.edu/tiger/chem5.htm which illustrates Boyle's law.

- Use the animation (compress then expand gas) to answer the following questions.

1. When the gas is compressed, what happens to the space the molecules occupy?

_____

When the gas is expanded?

_____

2. When the gas is compressed, what happens to the rate of collisions (you may have to compare by expanding and compressing a few times)?

_____

_____

3. When the gas is compressed, what happens to the temperature?

_____

What happens to the speed (kinetic energy) of the molecules?

_____

4. Explain the relationship between pressure and volume of a gas using statements about the molecules. Be sure to include what conditions are kept constant.

_____

Charles' Law-Volume vs. Temperature

- Use the animation (heat then cool gas) to answer the following questions.

1. When the gas is heated, what happens to the speed (kinetic energy) of the molecules?

_____

When the gas is cooled?

_____

2. When the gas is heated, what happens to the space the molecules can occupy?

_____

When it is cooled?

_____

3. When the gas is heated or cooled what happens to the rate of collisions of the gas?

_____

_____

4. Explain the relationship between volume and temperature of a gas using statements about the molecules. Be sure to include what conditions are kept constant.

_____

_____

Gay-Lussac's Law-Pressure vs. Temperature

➢ Use the animation (heat then cool gas) to answer the following questions.

1. When the gas is heated what happens to the speed (kinetic energy) of the molecules?

   _____

   When the gas is cooled?

   _____

2. When the gas is heated, what happens to the rate of collisions of the gas molecules?

   _____

   When the gas is cooled?

   _____

3. During the changes above, what happens to the space the molecules occupy?

   _____

   _____

4. Explain the relationship between pressure and temperature of a gas using statements about the molecules. Be sure to include what conditions are kept constant.

   _____

   _____

Topic 9: Gases

9.1: Behavior of Gases

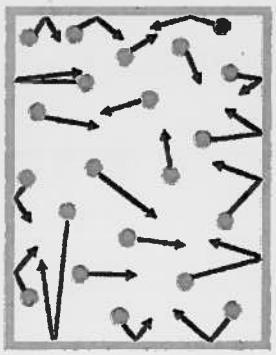
Aim: _____

- ***Behavior of Gases***
  - Gas laws : _____
  - Kinetic molecular theory (KMT): _____

    _____
    - Describes _____

      _____
- ***Kinetic Molecular Theory***
  - What do we know about gases?
    - Minimal _____
      - Neither _____
      - Spread _____
    - Vapor : _____
    - Particles are _____
  - Gases _____

    _____
  - Gas particles collide _____



    - There is no net _____

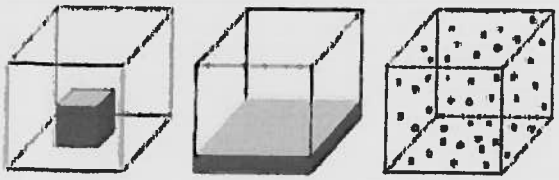
      _____
      - The collisions

        are _____
      - Separated

        _____
        - Volume = _____
  - Gases _____
  - Because of _____

States of Matter

Glenn Research Center



Solid
Liquid
Gas

- ***Standard Temperature and Pressure***
  - Standard Temperature and Pressure (_____)
    - Standard Temperature = _____
    - Standard Pressure
      - 1 atmosphere; = _____
  - Found on _____

Table A
Standard Temperature and Pressure

Name	Value	Unit
Standard Pressure	101.3 kPa 1 atm	kilopascal atmosphere
Standard Temperature	273 K 0°C	kelvin degree Celsius

Regents Question

- Which set of properties does a substance such as CO_2 (g) have?

(1) Definite shape and definite volume

(2) Definite shape but no definite volume

(3) No definite shape but definite volume

(4) No definite shape and no definite volume

Name: _____
Hour: ____ Date: _____

Chemistry: *Unit Conversions for the Gas Laws*

Directions: Complete the following tables, showing your work for each lettered box beside the corresponding letter below. Include units on your work, and write your final answers in the tables.

TEMPERATURE	
K	°C
373 K	(D)
(A)	56°C
(B)	154°C
128 K	(E)
800 K	(F)
(C)	–10°C

PRESSURE		
mm Hg	kPa	atm
890 mm Hg	(K)	(O)
(G)	123 kPa	(P)
(H)	(L)	0.64 atm
3140 mm Hg	(M)	(Q)
(I)	(N)	2.35 atm
(J)	25 kPa	(R)

(A)

(B)

(C)

(D)

(E)

(F)

(G)

(H)

(I)

(J)

(K)

(L)

(M)

(N)

(O)

(P)

(Q)

(R)

10

Name _____ Date _____

Behavior of Gases Questions

____1. Which 5.0-milliliter sample of NH_3 will take the shape of and completely fill a closed 100.0-milliliter container?

1) $NH_3(s)$
2) $NH_3(\ell)$
3) $NH_3(g)$
4) $NH_3(aq)$

____2. Base your answer to the following question on the information below:

Sample	*Mass*	*Pressure*	*Temperature*
Gas *A*	2 moles	760 mm.	273° K.
Gas *B*	1 mole	380 mm.	273° K.
Gas *C*	1 mole	760 mm.	273° K.
Gas *D*	2 moles	760 mm.	546° K.

Which gas contains molecules with the highest average kinetic energy?

1) *A*
2) *B*
3) *C*
4) *D*

____3. The compound whose molecules have the highest average kinetic energy is

1) NO(g) at 25°C
2) N_2O(g) at 15°C
3) NO_2(g) at 30°C
4) N_2O_3(g) at 20°C

____4. Energy is being added to a given sample. Compared to the Celsius temperature of the sample, the Kelvin temperature

1) will always be 273° greater
2) will always be 273° lower
3) will have the same reading at 0°
4) will have the same reading at 273°

____5. According to the kinetic theory of gases, 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.

____6. An assumption of the kinetic theory of gases is that the particles of a gas have

1) little attraction for each other and a significant volume
2) little attraction for each other and an insignificant volume
3) strong attraction for each other and a significant volume
4) strong attraction for each other and an insignificant volume

____7. The concept of an ideal gas is used to explain

1) the mass of a gas sample
2) the behavior of a gas sample
3) why some gases are monatomic
4) why some gases are diatomic

____8. One reason that a real gas deviates from an ideal gas is that the molecules of the real gas have

1) a straight-line motion
2) no net loss of energy on collision
3) a negligible volume
4) forces of attraction for each other

____9. Which gas would deviate *least* from ideal gas behavior at low temperatures?

1) CO_2
2) Cl_2
3) HCl
4) He

____10. As the space between molecules in a gas sample decreases, the tendency for the behavior of this gas to deviate from the ideal gas laws

1) decreases
2) increases
3) remains the same

____11. Which gas would behave most nearly like an ideal gas at STP?

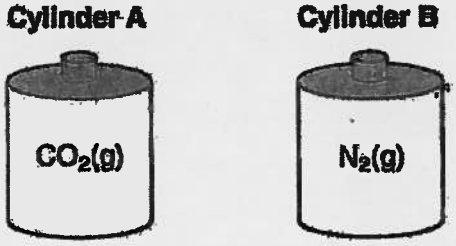
1) CO_2
2) H_2
3) Cl_2
4) NH_3

____12. A real gas behaves more like an ideal gas when the gas molecules are

1) close and have strong attractive forces between them
2) close and have weak attractive forces between them
3) far apart and have strong attractive forces between them
4) far apart and have weak attractive forces between them

13. Base your answer to the following question on the information and diagrams below.

Cylinder A contains 22.0 grams of CO_2(g) and cylinder B contains N_2(g). The volumes, pressures, and temperatures of the two gases are indicated under each cylinder.



What do we know about the number of molecules of CO_2(g) and N_2(g)?

14. Base your answer to the following question on the information below.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

What pressure, in atmospheres (atm), is equal to 45.6 kPa?

Topic 9: Gases

9.2: Ideal vs Real Gases

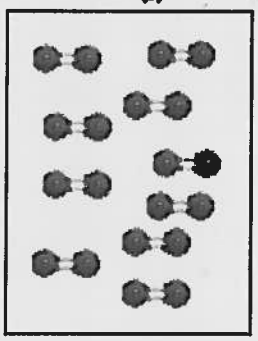
Aim: _____

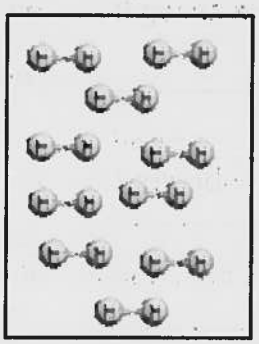
- ***Ideal vs. Real Gases***
  - Kinetic Molecular _____
    _____
    - The "ideal gas" is _____
    - Real gases _____
    - Two _____
- *Do ideal gases really not have attractive forces?*
  - Gases _____
  - When _____
    - Water _____
      - When _____
- *"Gas particles do not occupy volume"... Is this true?*
  - Gas _____
  - As _____
  - At high _____
    _____

Ideal Gas	Real Gas

- Are any gases truly ideal?
  - "Ideal" _____
  - No _____
- Which gases will act most like ideal gases?
  - Hydrogen _____
    - Small _____
- Why aren't real gases more like the "ideal"?
  - Gases _____
    - These _____ _____
      _____
- Under what conditions of temp and pressure will gases act most ideal?
  - _____
    - Farthest _____

- ***Avogadro's Hypothesis***





Equal Volumes and the Same Temperature and Pressure

  - Avogadro's number = _____
  - Different _____
    - The _____
    - Same _____
      _____

Regents Question

- Explain why the number of molecules of N_2 (g) in cylinder B in the same as the number of molecules of CO_2 (g) in cylinder A.

Cylinder A	Cylinder B
V= 12.3 L P= 1.0 atm T= 300. K	V= 12.3 L P= 1.0 atm T= 300. K

Name _____ Date _____

Gases Practice

1. A sample of oxygen gas is sealed in container X. A sample of hydrogen gas is sealed in container Z. Both samples have the same volume, temperature, and pressure. Which statement is true?
   A) Container X contains more gas molecules than container Z.
   B) Container X contains fewer gas molecules than container Z.
   C) Containers X and Z both contain the same number of gas molecules.
   D) Containers X and Z both contain the same mass of gas.

2. A real gas differs from an ideal gas because the molecules of real gas have
   A) some volume and no attraction for each other
   B) some volume and some attraction for each other
   C) no volume and no attraction for each other
   D) no volume and some attraction for each other

3. Under which conditions of temperature and pressure would helium behave most like an ideal gas?
   A) 50 K and 20 kPa
   B) 50 K and 600 kPa
   C) 750 K and 20 kPa
   D) 750 K and 600 kPa

4. A sample of $H_2(g)$ and a sample of $N_2(g)$ at STP contain the same number of molecules. Each sample must have
   A) the same volume, but a different mass
   B) the same mass, but a different volume
   C) both the same volume and the same mass
   D) neither the same volume nor the same mass

5. A real gas behaves more like an ideal gas when the gas molecules are
   A) close and have strong attractive forces between them
   B) close and have weak attractive forces between them
   C) far apart and have strong attractive forces between them
   D) far apart and have weak attractive forces between them

6. A 10.-liter flask at a given temperature and pressure contains 6.0×10^{23} molecules of hydrogen gas. Under the same conditions of temperature and pressure, how many molecules would a 10.-liter flask of nitrogen gas contain?
   A) 1.0×10^{23}
   B) 6.0×10^{23}
   C) 1.0×10^{24}
   D) 6.0×10^{24}

7. Which of the following gases behaves most like an ideal gas?
   A) $H_2(g)$
   B) $O_2(g)$
   C) $NH_3(g)$
   D) $CO_2(g)$

8. A closed container holds 3.0 moles of CO_2 gas at STP. What is the total number of moles of $Ne(g)$ that can be placed in a container of the same size at STP?
   A) 1.0 mole
   B) 1.5 moles
   C) 3.0 moles
   D) 0.0 moles

9. The concept of an ideal gas is used to explain
   A) the mass of a gas sample
   B) the behavior of a gas sample
   C) why some gases are monatomic
   D) why some gases are diatomic

10. Two basic properties of the gas phase are
    A) a definite shape and a definite volume
    B) a definite shape but no definite volume
    C) no definite shape but a definite volume
    D) no definite shape and no definite volume

11. Which statement correctly describes a sample of gas confined in a sealed container?
    A) It always has a definite volume, and it takes the shape of the container.
    B) It takes the shape and the volume of any container in which it is confined.
    C) It has a crystalline structure.
    D) It consists of particles arranged in a regular geometric pattern.

12. The kinetic molecular theory assumes that the particles of an ideal gas
    A) are in random, constant, straight-line motion
    B) are arranged in a regular geometric pattern
    C) have strong attractive forces between them
    D) have collisions that result in the system losing energy

13. Which diagram best represents a gas in a closed container?

A)

C)

B)

D)

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

Data for 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?

A) *A* and *B*
B) *A* and *C*
C) *B* and *C*
D) *B* and D

15. Which grouping of the three phases of bromine is listed in order from left to right for increasing distance between bromine molecules?

A) gas, liquid, solid
B) liquid, solid, gas
C) solid, gas, liquid
D) solid, liquid, gas

Topic 9: Gases
9.3: Gas Laws

Aim: _____

- ***Pressure vs. Number of Particles***
  - Gases _____
  - Collisions _____
  - The _____
    _____
    - Example:

- ***Pressure vs. Volume***
  - What happens if you push the piston in?
    - Push piston in, _____
      _____
  - What happens if you pull the piston out?
    - Pull piston out, _____
      _____
  - How are pressure and volume related?
    - Pressure and volume are _____
      - Indirect _____

- ***Temperature vs. Pressure***
  - Temperature = _____
    - As temperature _____
    - Increase in _____
      - The particles _____
    - Increase _____
      - Temperature and pressure are _____

- ***Temperature vs. Volume***
  - If I put a gas within a container, with a piston, how would temperature affect volume if pressure stayed the same?
    - If temperature _____
      _____
    - As _____
      - _____

- ***Temperature vs. Velocity***
  - What happens to speed as temperature increases?
    - As temperature _____
      - The _____
        _____
        - $KE = (1/2)mv^2$
  - What happens to speed as temperature decreases?
    - As temperature _____
      - The lower _____
        - $KE = (1/2)mv^2$

- ***Combined Gas Law Equation***
  - What happened to pressure as temperature was changed?
    - As pressure _____, temperature _____ = direct
  - What happened to volume as temperature was changed?
    - As volume _____, temperature _____ = direct
  - What happened to volume as pressure was changed?
    - As pressure _____, volume _____ = indirect
  - The relationship _____

Combined Gas Law	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	P = pressure V = volume T = temperature

    - Found on TABLE T in the reference tables

- This law _____
  - If a property _____
    - The property _____
      - Temperature must be in _____
      - Pressure must be in the _____
    - Volume must be in the _____

- What volume will a gas occupy if the pressure of 244cm^3 gas at 4.0 atm is increased to 6.0 atm? Assume the temperature remains constant.

- A 125 mL sample of He gas is at 100°C and 0.981 atm. If the sample is cooled to 25°C and the pressure is increased to 1.15 atm, what will the new volume be?

- What is the new volume of a gas if the original volume is 40.0mL, the pressure is changed from 100.0kPa to 50.0 kPa and the temperature is changed from 30°C to 60°C?

- A 42.0mL sample of a gas at 27.0°C has a pressure of 50.0kPa. What will the new pressure be if the volume is changed to 63.0mL and the temperature to -123°C?

- The volume of a sample of gas at 273°C is 200.0L. If the volume is decreased to 100.0L at constant pressure, what will be the new temperature of the gas?

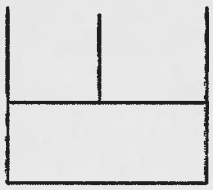
- A gas occupies a volume of 500. mL at a pressure of 380. torr and a temperature of 298K. At what temperature will the gas occupy a volume of 250. mL and have a pressure of 760 torr?

Regents Questions

- At constant pressure, how does the volume of 1 mole of an ideal gas vary?

(1) Directly with Kelvin temperature
(2) Indirectly with the Kelvin temperature
(3) Directly with the mass of the gas
(4) Indirectly with the mass of the gas

- A cylinder with a tightly fitted piston is shown in the diagram:



As the piston moves downward, the number of molecules of air in the cylinder

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

- Under which conditions will the volume of a given sample of a gas always decrease?
  (1) Decreased pressure and decreased temperature
  (2) Decreased pressure and increased temperature
  (3) Increased pressure and decreased temperature
  (4) Increased pressure and increased temperature

Table T — Combined Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P = pressure
V = volume
T = temperature (K)

Overview:

The volume of a given mass of gas depends upon the temperature and pressure of the sample of gas. Given an initial set of conditions, represented by the subscript 1, this law enables one to calculate the new volume of the gas when the temperature and/or pressure changes, represented by the subscript 2. Note that the temperature must be expressed on the Kelvin (K) temperature scale. If standard temperature or pressure are used (STP), refer to Table A for their values.

Example:

When a car 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. Your response must include both a correct numerical setup and the calculated volume.

Solution: From Table A, STP is 1 atm and 273 K.

The unknown is the final volume (V_2) of the nitrogen gas. The known quantities are:
$P_1 = 1.30$ atm, $T_1 = 301$ K, $V_1 = 40.0$ L, $T_2 = 273$ K, $P_2 = 1$ atm.

Equation: $V_2 = \frac{T_2P_1V_1}{T_1P_2}$

Correct numerical setup: $V_2 = \frac{(273\text{ K})(1.30\text{ atm})(40.0\text{ L})}{(301\text{ K})(1.00\text{ atm})}$

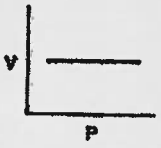
Calculated volume: $V_2 = 47.2$ L

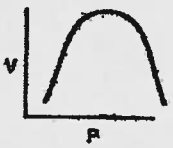
Additional Information:

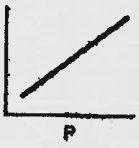
- If the temperature or pressure is unchanged, it can be left out of the equation.
- At constant temperature, the volume of a gas varies inversely with the pressure exerted on it.
- At constant pressure, the volume of a gas varies directly with the temperature.
- Ideal gas conditions are best achieved at high temperature and low pressure.

Set 1 — Combined Gas Law

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

(1) 

(3) 

(2) 

(4) 

1 _____

2. As the temperature of a gas increases at constant pressure, the volume of the gas

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

2 _____

3. 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) $\frac{293}{3.00 \times 4.00}$

3 _____

4. 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 (3) 5.64 atm
(2) 4.43 atm (4) 14.1 atm

4 _____

5. A sample of oxygen gas in one container has a volume of 20.0 milliliters at 297 K and 101.3 kPa. The entire sample is transferred to another container where the temperature is 283 K and the pressure is 94.6 kPa. In the space below, show a correct numerical setup for calculating the new volume of this sample of oxygen gas.

Base your answer to question 6 on the information below.

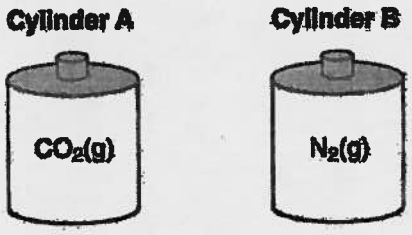
Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the unbalanced equation below.

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

6. 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. In the space below, calculate the volume of the nitrogen gas at STP. Your response must include both a correct numerical setup and the calculated volume.

Base your answer to question 7 using the information and diagrams below and your knowledge of chemistry.

Cylinder *A* contains 22.0 grams of $CO_2(g)$ and cylinder *B* contains $N_2(g)$. The volumes, pressures, and temperatures of the two gases are indicated under each cylinder.



V = 12.3 L
P = 1.0 atm
T = 300. K

V = 12.3 L
P = 1.0 atm
T = 300. K

7. The temperature of the $CO_2(g)$ is increased to 450. K and the volume of cylinder *A* remains constant. In the space below, show a correct numerical setup for calculating the new pressure of the $CO_2(g)$ in cylinder *A*.

Set 2 — Combined Gas Law

8. As the pressure of a given sample of a gas decreases at constant temperature, the volume of the gas

(1) decreases
(2) increases
(3) remains the same 8 _____

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) $20°C \times \frac{80.0\,mL}{40.0\,mL}$

(2) $20°C \times \frac{40.0\,mL}{80.0\,mL}$

(3) $293\,K \times \frac{80.0\,mL}{40.0\,mL}$

(4) $293\,K \times \frac{40.0\,mL}{80.0\,mL}$ 9 _____

10. 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 (3) 566 K
(2) 292 K (4) 2360 K 10 ____

11. A sample of gas occupies a volume of 50.0 milliliters in a cylinder with a movable piston. The pressure of the sample is 0.90 atmosphere and the temperature is 298 K. What is the volume of the sample at STP?

(1) 41 mL (3) 51 mL
(2) 49 mL (4) 55 mL 11 ____

12. Under which conditions does a real gas behave most like an ideal gas?

(1) at low temperatures and high pressures
(2) at low temperatures and low pressures
(3) at high temperatures and high pressures
(4) at high temperatures and low pressures
12 ____

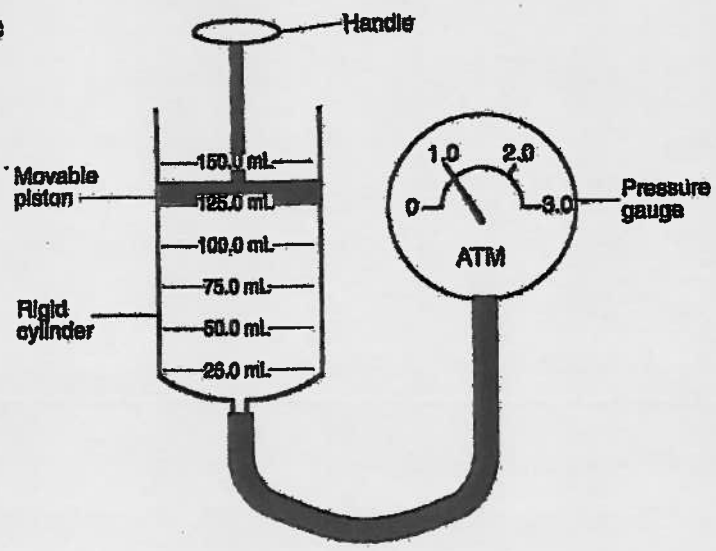
Base your answer to question 13 on the information below.

A lightbulb contains argon gas at a temperature of 295 K and at a pressure of 75 kilopascals. The lightbulb is switched on, and after 30 minutes its temperature is 418 K.

13. In the space below, show a correct numerical setup for calculating the pressure of the gas inside the lightbulb at 418 K. Assume the volume of the lightbulb remains constant.

Base your answers to question 14 using the

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. The temperature of the helium gas sample is 20.0°C.



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

_____

b) The piston is pushed further into the cylinder. In the space below, 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.

Base your answers to question 15 using the information below and your knowledge of chemistry.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

15. *a*) How does this temperature change affect the gas particle motion?

_____

_____

b) The original pressure at 295 K was 100.8 kPa and the pressure at the higher altitude at 252 K is 45.6 kPa. Assume the balloon does not burst. In the space below, show a correct numerical setup for calculating the volume of the balloon at the higher altitude.

Combined Gas Law Problems

Use the combined gas law to solve the following problems:

1) If I initially have a gas at a pressure of 12 atm, a volume of 23 liters, and a temperature of 200 K, and then I raise the pressure to 14 atm and increase the temperature to 300 K, what is the new volume of the gas?

2) A gas takes up a volume of 17 liters, has a pressure of 2.3 atm, and a temperature of 299 K. If I raise the temperature to 350 K and lower the pressure to 1.5 atm, what is the new volume of the gas?

3) A gas that has a volume of 28 liters, a temperature of 45 ^{0}C, and an unknown pressure has its volume increased to 34 liters and its temperature decreased to 35 ^{0}C. If I measure the pressure after the change to be 2.0 atm, what was the original pressure of the gas?

4) A gas has a temperature of 14 ^{0}C, and a volume of 4.5 liters. If the temperature is raised to 29 ^{0}C and the pressure is not changed, what is the new volume of the gas?

5) If I have 17 liters of gas at a temperature of 67 ^{0}C and a pressure of 88.89 atm, what will be the pressure of the gas if I raise the temperature to 94 ^{0}C and decrease the volume to 12 liters?

6) I have an unknown volume of gas at a pressure of 0.5 atm and a temperature of 325 K. If I raise the pressure to 1.2 atm, decrease the temperature to 320 K, and measure the final volume to be 48 liters, what was the initial volume of the gas?

7) If I have 21 liters of gas held at a pressure of 78 atm and a temperature of 900 K, what will be the volume of the gas if I decrease the pressure to 45 atm and decrease the temperature to 750 K?

8) If I have 2.9 L of gas at a pressure of 5 atm and a temperature of 50 ^{0}C, what will be the temperature of the gas if I decrease the volume of the gas to 2.4 L and decrease the pressure to 3 atm?

9) I have an unknown volume of gas held at a temperature of 115 K in a container with a pressure of 60 atm. If by increasing the temperature to 225 K and decreasing the pressure to 30 atm causes the volume of the gas to be 29 liters, how many liters of gas did I start with?

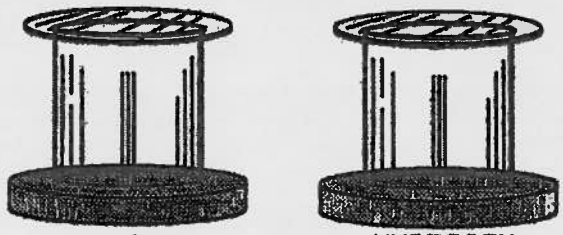
Name_____ Date_____

Gas Laws Questions

____1. The diagrams below represent four 500-milliliter flasks. Each flask contains the gas represented by its symbol. All gas samples are at STP.

Each flask contains the same number of
1) atoms, only
2) molecules, only
3) atoms and molecules

____2. The diagrams below represent 1-mole samples of ammonia and hydrogen bromide gases at STP.



Compared to the ammonia sample, the hydrogen bromide sample has a
1) larger mass and fewer molecules
2) smaller mass and fewer molecules
3) larger mass and an equal number of molecules
4) smaller mass and an equal number of molecules

____3. When a sample of a gas is heated at constant pressure, the average kinetic energy of its molecules
1) decreases, and the volume of the gas increases
2) decreases, and the volume of the gas decreases
3) increases, and the volume of the gas increases
4) increases, and the volume of the gas decreases

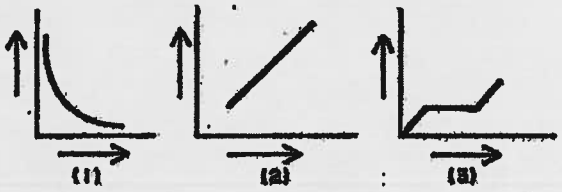
____4. According to the kinetic theory of gases, which assumption is correct?
1) Gas particles strongly attract each other.
2) Gas particles travel in curved paths.
3) The volume of gas particles prevents random motion.
4) Energy may be transferred between colliding particles.

____5. As the pressure on a given sample of a gas increases at constant temperature, the mass of the sample
1) decreases
2) increases
3) remains the same

____6. A sample of a gas is contained in a closed rigid cylinder. According to kinetic molecular theory, what occurs when the gas inside the cylinder is heated?
1) The number of gas molecules increases.
2) The number of collisions between gas molecules per unit time decreases.
3) The average velocity of the gas molecules increases.
4) The volume of the gas decreases.

____7. A sample of gas *A* was stored in a container at a temperature of 50°C and a pressure of 0.50 atmosphere. Compared to a sample of gas *B* at STP, gas *A* had a
1) higher temperature and a lower pressure
2) higher temperature and a higher pressure
3) lower temperature and a lower pressure
4) lower temperature and a higher pressure

Base your answers to questions 8 and 9 on the graphs shown below.



____8. Which graph best represents how the volume of a given mass of a gas varies with the Kelvin (absolute) temperature at constant pressure?
1) 1
2) 2
3) 3

____9. Which graph best represents how the volume of a given mass of a gas varies with the pressure exerted on it at constant temperature?
1) 1
2) 2
3) 3

____10. Under which conditions will the volume of a given sample of a gas decrease?
1) decreased pressure and decreased temperature
2) decreased pressure and increased temperature
3) increased pressure and decreased temperature
4) increased pressure and increased temperature

11. Base your answer to the following question on the diagram below, which shows a piston confining a gas in a cylinder.

Sketch the general relationship between the pressure and the volume of an ideal gas at constant temperature.

12. Four identical balloons contain equal volumes of gas at STP:

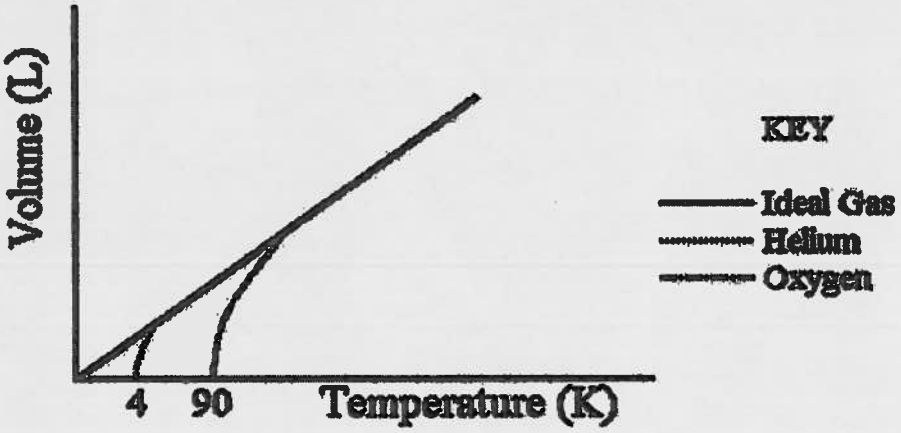
Balloon #1 contains H_2 gas
Balloon #2 contains He gas
Balloon #3 contains O_2 gas
Balloon #4 contains N_2 gas

a Which balloon, if any would weigh the most? Explain.

b According to the Kinetic Molecular Theory, why would the balloons expand if they were heated?

13. Base your answers to the question below on your knowledge of chemistry and the graph below:

The graph shows the relationship between volume and absolute temperature for an ideal gas and two real gases, helium and oxygen .



a Describe the relationship for the ideal gas shown in this graph.

b According to the graph above, what experimental condition is necessary for real gases to behave like an ideal gas?

c At 90 K what happens to oxygen?

d Why does helium behave more like an ideal gas than does oxygen?

14. Base your answer to the following question on the information below.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

How does this temperature change affect the gas particle motion?

Name_____ Date_____

Combined Gas Law Questions

____1. A gas has a pressure of 120 kPa, a temperature of 400. K, and a volume of 50.0 milliliters. What volume will the gas have at a pressure of 60 kPa and a temperature of 200. K?

1) 12.5 ml
2) 50.0 ml
3) 100. ml
4) 200. ml

____2. At constant pressure, what temperature must be reached to increase a 100.-milliliter sample of a gas initially at 300. K to a volume of 200. milliliters?

1) 150. K
2) 200. K
3) 300. K
4) 600. K

____3. A sample of gas has a volume of 2.0 liters at a pressure of 1.0 atmosphere. When the volume increases to 4.0 liters, at constant temperature, the pressure will be

1) 1.0 atm
2) 2.0 atm
3) 0.50 atm
4) 0.25 atm

____4. If the pressure on 36.0 milliliters of a gas at STP is changed to a pressure of 25.3 kPa at constant temperature, the new volume of the gas is

1) 9.00 ml
2) 126 ml
3) 144 ml
4) 226 ml

____5. At a temperature of 273 K, a 400.-milliliter gas sample has a pressure of 760. millimeters of mercury. If the pressure is changed to 380. millimeters of mercury, at which temperature will this gas sample have a volume of 551 milliliters?

1) 100 K
2) 188 K
3) 273 K
4) 546 K

____6. What is the difference in pressure between a gas at 50.0 kPa and a gas at standard pressure?

1) 0.0 kPa
2) 51.3 kPa
3) 101.3 kPa
4) 223 kPa

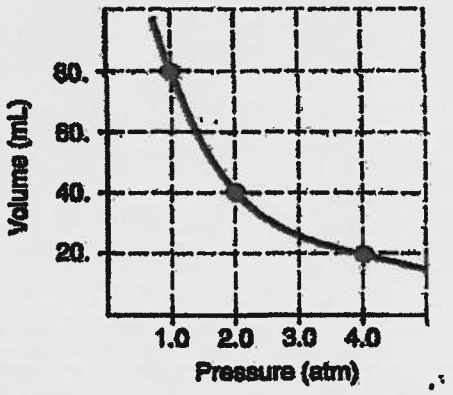
7. Base your answer to the following question on the diagram below, which shows a piston confining a gas in a cylinder.

The gas volume in the cylinder is 6.2 milliliters and its pressure is 1.4 atmospheres. The piston is then pushed in until the gas volume is 3.1 milliliters while the temperature remains constant.

a Calculate the pressure, in atmospheres, after the change in volume. Show all work.

b Record your answer.

____8. The graph below represents the relationship between pressure and volume of a given mass of a gas at constant temperature.



The product of pressure and volume is constant. According to the graph, what is the product in atmmL?

1) 20.
2) 40.
3) 60.
4) 80.

9. Base your answer to the following question on the information below.

A lightbulb contains argon gas at a temperature of 295 K and at a pressure of 75 kilopascals. The lightbulb is switched on, and after 30 minutes its temperature is 418 K.

Show a correct numerical setup for calculating the pressure of the gas inside the lightbulb at 418 K. Assume the volume of the lightbulb remains constant.

10. Base your answer to the following question on the information below.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

The original pressure at 295 K was 100.8 kPa and the pressure at the higher altitude at 252 K is 45.6 kPa. Assume the balloon does not burst. Show a correct numerical setup for calculating the volume of the balloon at the higher altitude.

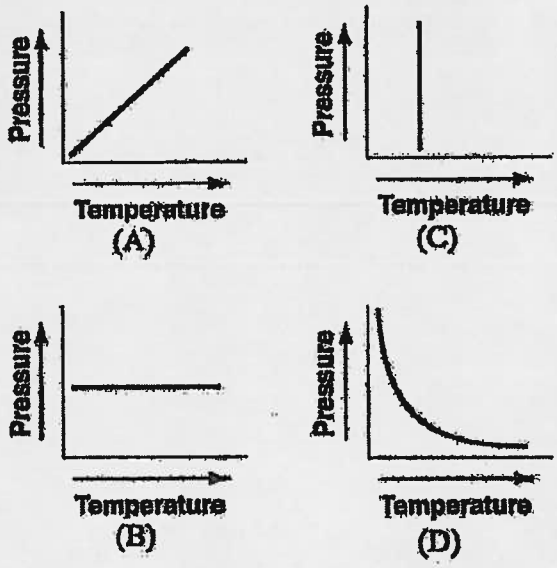
Name_____ Date_____

Gases Review

1. The concept of an ideal gas is used to explain
   (A) the mass of a gas sample
   (B) the behavior of a gas sample
   (C) why some gases are monatomic
   (D) why some gases are diatomic

2. Under which conditions does a real gas behave most like an ideal gas?
   (A) at low temperatures and high pressures
   (B) at low temperatures and low pressures
   (C) at high temperatures and high pressures
   (D) at high temperatures and low pressures

3. Which graph shows the pressure-temperature relationship expected for an ideal gas?



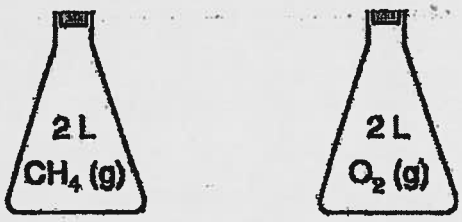
4. An assumption of the kinetic theory of gases is that the particles of a gas have
   (A) little attraction for each other and a significant volume
   (B) little attraction for each other and an insignificant volume
   (C) strong attraction for each other and a significant volume
   (D) strong attraction for each other and an insignificant volume

5. A real gas differs from an ideal gas because the molecules of real gas have
   (A) some volume and no attraction for each other
   (B) some volume and some attraction for each other
   (C) no volume and no attraction for each other
   (D) no volume and some attraction for each other

6. Which of the following gases behaves most like an ideal gas?
   (A) $H_2(g)$ (C) $NH_3(g)$
   (B) $O_2(g)$ (D) $CO_2(g)$

7. A sample of $H_2(g)$ and a sample of $N_2(g)$ at STP contain the same number of molecules. Each sample must have
   (A) the same volume, but a different mass
   (B) the same mass, but a different volume
   (C) both the same volume and the same mass
   (D) neither the same volume nor the same mass

8. Each stoppered flask below contains 2 liters of a gas at STP.



Each gas sample has the same
(A) density
(B) mass
(C) number of molecules
(D) number of atoms

9. 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?
(A) 0.177 atm (C) 5.64 atm
(B) 4.43 atm (D) 14.1 atm

10. 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?
(A) 31.5 K (C) 566 K
(B) 292 K (D) 2360 K

11. A 2.5 liter sample of gas is at STP. When the temperature is raised to 273°C and the pressure remains constant, the new volume of the gas will
(A) 1.25 L (C) 5.0 L
(B) 2.5 L (D) 10. L

12. Base your answer to the following question on the information below.

A lightbulb contains argon gas at a temperature of 295 K and at a pressure of 75 kilopascals. The lightbulb is switched on, and after 30 minutes its temperature is 418 K.

Show a correct numerical setup for calculating the pressure of the gas inside the lightbulb at 418 K. Assume the volume of the lightbulb remains constant.

13. Base your answer to the following question on the diagram below, which shows a piston confining a gas in a cylinder.

The gas volume in the cylinder is 6.2 milliliters and its pressure is 1.4 atmospheres. The piston is then pushed in until the gas volume is 3.1 milliliters while the temperature remains constant.

a Calculate the pressure, in atmospheres, after the change in volume. Show all work.

b Record your answer.

14. A sample of oxygen gas in one container has a volume of 20.0 milliliters at 297 K and 101.3 kPa. The entire sample is transferred to another container where the temperature is 283 K and the pressure is 94.6 kPa. Show a correct numerical setup for calculating the new volume of this sample of oxygen gas.

Base your answers to questions 15 through 17 on the information below.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

15. What pressure, in atmospheres (atm), is equal to 45.6 kPa?

16. What Celsius temperature is equal to 252 K?

17. How does this temperature change affect the gas particle motion?