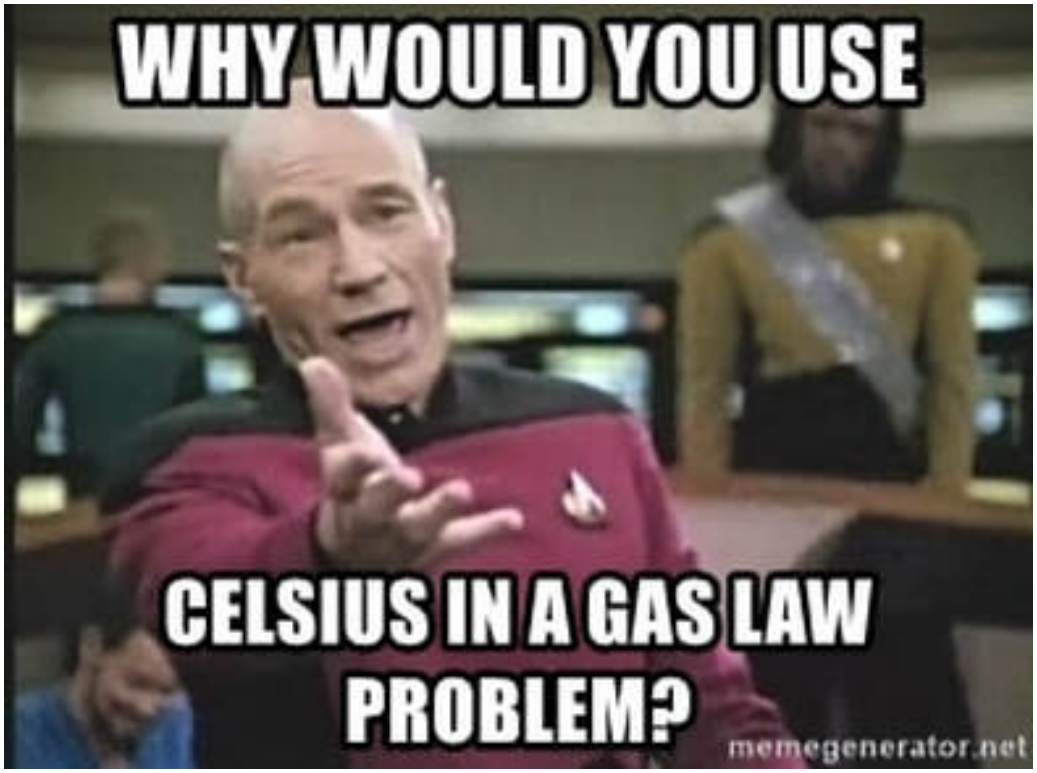
# Unit 3:Gases

## Practice Packet



# 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: _____

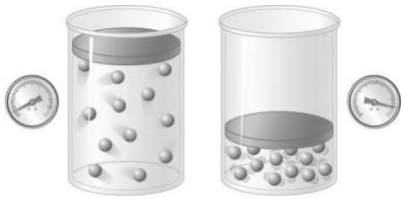
Avogadro's Law: _____

## LESSON 1: KINETIC MOLECULAR THEORY: IDEAL VS REAL GASES

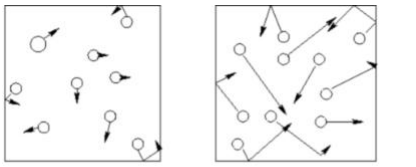
***Objective:***

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

**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 (minimize attraction between particles)?

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?

### REGENTS PRACTICE

1. 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

2. 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

3. 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.

4. 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

5. 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

6. 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

11. 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

12. Convert 345 kPa to atm using table A

13. 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

14. Draw a particle model for $H_2O_{(l)}$ and $H2O_{(g)}$ in the boxes below. Which substance has a greater entropy and why?

Liquid gas

**ASSESS YOURSELF ON THIS LESSON:**

If you missed any regents practice questions you should see me for extra help and/or re-watch the lesson video assignment

## PRESSURE CONVERSIONS

**1 atmosphere is equal to _____ kPa = _____ mmHg = _____ torr**

**Convert the following to atmospheres**:

1. 560.0 mmHg
2. 7600 mmHg
3. 250.0 mmHg
4. 202.6 kPa
5. 50.6 kPa
6. 150.0 kPa

**Convert the following to kilopascals**:

7. 1.2 atm
8. 0.86 atm
9. 3.25 atm
10. 850 mmHg
11. 450.0 mmHg
12. 1560 mmHg

## LESSON 2: GAS LAWS

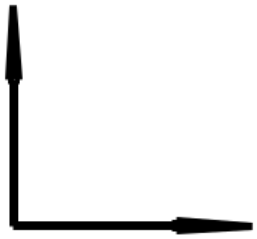
***Objective:***

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

*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 INVERSE relationship.**

*Draw the graph*



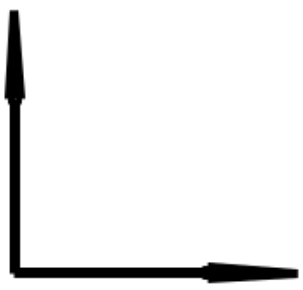
1. Pilots suffer from intestinal pain when they fly because at higher altitudes, the pressure is decreased so the air volume in their body *increases/decreases*_____.

2. Your lungs suck in air when the diaphragm is enlarged. When the diaphragm opens, the lung expands, the volume *increases/decreases* _____ and the pressure *increases/decreases* _____ which allows air in. When the diaphragm collapsed, there is less room so the volume *increases/decreases* _____ and the pressure *increases/decreases* _____.

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*

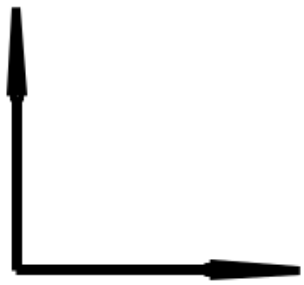


4. Hot air balloons work based on density changes affected by Charles law. To rise, the temperature is *increased/decreased*_____ and the volume *increases/decreases*_____ to make the density lower. To come back down the fire is turned off so the temperature *increases/decreases*_____ and volume *increases/decreases* _____ 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.

**<u>GAY LUSSAC'S LAW</u> 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 <u>direct relationship.</u>**

*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 *higher/lower* _____ and the tires are flat. In the summer, temperatures are increased and pressures are *higher/lower* _____ so the tires are swollen, but the volume the tires air can occupy stays the same.

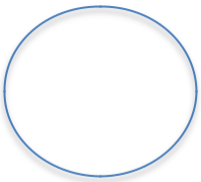
7. Don't put aerosol spray cans in direct heat or flames because they explode. Explain this phenomenon in terms of pressure and temperature.

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

9. Draw a model of this using particle diagrams.

10. If a balloon is squeezed, what happens to its pressure? Explain.

11. Make a model of what is occurring in question 10. Draw six air particles in each.



Before squeezing

During squeezing

## GRAHAM'S LAW

1. At STP, which gas diffuses at the faster rate?
   A) $H_2$ B) $N_2$ C) $CO_2$ D) $NH_3$

2. Which gas diffuses most rapidly at STP?
   A) Ne B) Ar C) $Cl_2$ D) $F_2$

3. Under the same conditions of temperature and pressure, which gas will diffuse at the *slowest* rate?
   A) He B) Ne C) Ar D) Rn

4. Which of the following gases would have the *slowest* rate of diffusion when all of the gases are held at the same temperature and pressure?
   A) $N_2$ B) NO C) $O_2$ D) $CO_2$

5. Which gas would diffuse most rapidly under the same conditions of temperature and pressure?
   A) gas *A*, molecular mass = 4
   B) gas *C*, molecular mass = 36
   C) gas *B*, molecular mass = 16
   D) gas *D*, molecular mass = 49

## AVOGADRO'S LAW

1. The table below shows mass and volume data for four samples of substances at 298 K and 1 atm. Which two samples could consist of the same substance?

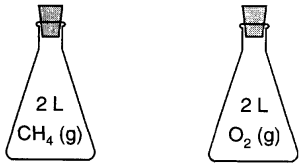
A) *A* and *B* C) *A* and *C*
B) *B* and *C* D) *C* and *D*

Masses and Volumes of Four Samples

| Sample | Mass (g) | Volume (mL) |
|---|---|---|
| A | 30. | 60. |
| B | 40. | 50. |
| C | 45 | 90. |
| D | 90. | 120. |

2. 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.

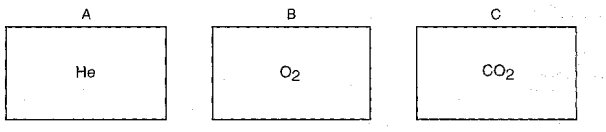
3. At the same temperature and pressure, 1.0 liter of CO(g) and 1.0 liter of CO2(g) have
A) equal masses and the same number of molecules
B) different masses and a different number of molecules
C) equal volumes and the same number of molecules
D) different volumes and a different number of molecules




4. Each stoppered flask to the right 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

5. A sample of H2(g) and a sample of N2(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

6. The diagrams below represent three 1-liter containers of gas, *A*, *B*, and *C*. Each container is at STP.




Which statement correctly compares the number of molecules in the containers?
A) Container *A* has the greatest number of molecules.
B) Container *B* has the greatest number of molecules.
C) Container *C* has the greatest number of molecules.
D) All three containers have the same number of molecules.

7. The table below shows mass and volume data for four samples of substances at 298 K and 1 atm. Which two samples could consist of the same substance?

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

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9. At the same temperature and pressure, 1.0 liter of CO(g) and 1.0 liter of CO2(g) have
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   C) equal volumes and the same number of molecules
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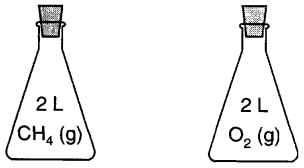


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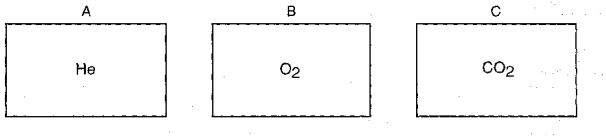


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   B) Container *B* has the greatest number of molecules.
   C) Container *C* has the greatest number of molecules.
   D) All three containers have the same number of molecules.

## DALTON'S LAW

1. Gases *X*, *Y*, and *Z*, in a closed system at constant temperature, have a total pressure of 80 kPa. The partial pressure of each gas is shown below.

| Gas | PartialPressure (kPa) |
|---|---|
| $X$ | $A$ |
| $Y$ | $B$ |
| $Z$ | $C$ |

The partial pressure of gas *X*, in kPa, is equal to

A) $80-(B+C)$ B) $(B+C)-80$

C) $\frac{(B+C)}{80}$ D) $\frac{80}{(B+C)}$

2. What is the pressure of a mixture of $CO_2$, $SO_2$, and $H_2O$ gases, if each gas has a partial pressure of 25 kPa?

A) 25 kPa B) 50 kPa C) 75 kPa D) 101 kPa

3. A flask contains a mixture of $N_2(g)$ and $O_2(g)$ at STP. If the partial pressure exerted by the $N_2(g)$ is 40.0 kPa, the partial pressure of the $O_2(g)$ is

A) 21.3 kPa B) 37.3 kPa C) 61.3 kPa D) 720 kPa

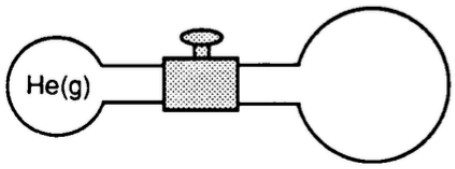
4. Gas samples *A*, *B*, and *C* are contained in a system at STP. The partial pressure of sample *A* is 38.0 kPa and the partial pressure of sample *B* is 19.0 kPa. What is the partial pressure of sample *C*?

A) 19.0 kPa B) 38.0 kPa C) 44.3 kPa D) 63.3 kPa

5. The partial pressures of gases *A*, *B*, and *C* in a mixture are 0.750 atmosphere, 0.250 atmosphere, and 1.25 atmospheres, respectively. What is the total pressure of the gas mixture in kPa?

A) 2.25 kPa B) 202 kPa C) 228 kPa D) 301 kPa

6. The diagram below shows two flasks connected by a stopcock. Flask *A* contains helium gas. Flask *B* contains a vacuum.




FLASK A (100 mL) FLASK B (400 mL)

What final volume will the gas occupy after the stopcock is opened?

A) 100 ml B) 300 ml C) 400 ml D) 500 ml

7. A mixture of oxygen, nitrogen, and hydrogen gases exerts a total pressure of 74 kPa at 0ºC. The partial pressure of the oxygen is 20 kPa and the partial pressure of the nitrogen is 40 kPa. What is the partial pressure of the hydrogen gas in this mixture?

A) 14 kPa B) 20 kPa C) 40 kPa D) 74 kPa

## REGENTS PRACTICE

1. 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) $5 \times 10^{23}$ molecules of $CO_2(g)$

2. At the same temperature and pressure, 1.0 liter of CO (g) and 1.0 liter of $CO_2$ (g) have
   A) Equal volumes and the same number of molecules
   B) Equal masses and the same number of molecules
   C) Different masses and a different number of molecules
   D) Different volumes and a different number of molecules

3. 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

4. At STP, which gas diffuses at the faster rate?
   a) $H_2$ b) $N_2$ c) $CO_2$ d) $NH_3$

5. 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)

6. When a sample of a gas is heated at constant pressure, the average kinetic energy of its molecules
   A) decreases, and the volume of the gas increases
   B) decreases, and the volume of the gas decreases
   C) increases, and the volume of the gas increases
   D) increases, and the volume of the gas decreases

7. Under which conditions of temperature and pressure would a sample of H2(g) behave most like an ideal gas?
   A) 0°C and 100 kPa B) 0°C and 300 kPa C) 150°C and 100 kPa D) 150°C and 300 kPa

8. 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

9. 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

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

A) temperature B) pressure C) thermal energy D) chemical energy

11. At which temperature would atoms of a He(g) sample have the greatest average kinetic energy?

A) 25°C B) 37°C C) 273 K D) 298 K

12. The average kinetic energy of water molecules is greatest in which of these samples?

A) 10 g of water at 35°C
B) 100 g of water at 25°C
C) 10 g of water at 55°C
D) 100 g of water at 45°C

13. Which change in the temperature of a 1-gram sample of water would cause the greatest increase in the average kinetic energy of its molecules?

A) 1°C to 10°C B) 10°C to 1°C C) 50°C to 60°C D) 60°C to 50°C

14. What is the equivalent of 0 Kelvin on the Celsius scale?

A) –100º B) 100º C) –273º D) 273º

15. The temperature of a sample of a substance changes from 10.°C to 20.°C. How many Kelvin does the temperature change?

A) 10. B) 20. C) 283 D) 293

16. Which temperature is equal to +20 K?

A) –253ºC B) –293ºC C) 253°C D) 293°C

17. Which Kelvin temperature is equal to –73ºC?
    A) 100 K  B) 173 K  C) 200 K  D) 346 K

18. 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?
    A) The number of gas molecules increases.
    B) The number of collisions between gas molecules per unit time decreases.
    C) The average velocity of the gas molecules increases.
    D) The volume of the gas decreases.

19. Under which conditions of temperature and pressure would He 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

20. 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

21. 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 diatomic
    D) why some gases are monatomic

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

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

24. 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

25. According to the kinetic theory of gases, which assumption is correct?
    A) Gas particles strongly attract each other.
    B) Gas particles travel in curved paths.
    C) The volume of gas particles prevents random motion.
    D) Energy may be transferred between colliding particles.

**ASSESS YOURSELF ON THIS LESSON:**

If you missed any regents practice questions you should see me for extra help and/or re-watch the lesson video assignment

# LESSON 3: COMBINED GAS LAW

***Objective:***

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

***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…***

***SHOW ALL WORK including units!!!!***

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?

## REGENTS PRACTICE

1. 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
   a. decrease and the volume of the gas sample to decrease
   b. decrease and the volume of the gas sample to increase
   c. increase and the volume of the gas sample to decrease
   d. increase and the volume of the gas sample to increase

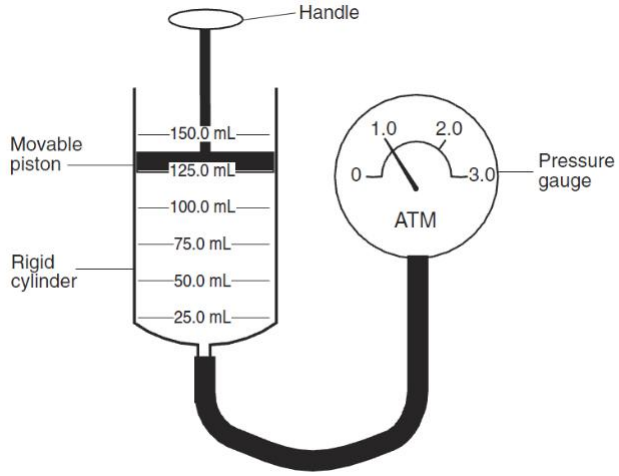
2. Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the *unbalanced* equation below.

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

   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.

3. 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 LESSON:**

If you missed any regents practice questions you should see me for extra help and/or re-watch the lesson video assignment

# Unit Review

## Kinetic Molecular Theory

Gases are spread out and constantly moving in random straight line motion. **Ideal gases** have no mass, no volume, and no attractive forces.

a. Give an example of the most ideal gas on the periodic table : _____

b. Under what conditions of temperature and pressure will a gas behave ideally? _____

c. Draw five particles of He in the gas phase:

## Combined Gas Law

**Volume** is the amount of space a substance takes up. **Pressure** is the amount of force that substance has on another object measured in atmospheres or kilopascals. **Temperature** is the measure of kinetic energy a sample has measured in degrees Celsius or Kelvin. Standard temperature and pressures are listed on Table A. The calculation formula is on table T.

a. What are the possible values for standard temperature? _____ and _____

b. What are the possible values for standard pressure? _____ and _____

c. When pressure increases, volume _____.

d. When pressure increases, temperature _____.

e. When temperature increases, volume _____.

f. The pressure of a gas is 1.2 atm at 300K. Calculate the pressure at 250K if the gas is in a rigid container.

g. The volume of a gas at 500K is 50.6L. Calculate the volume at 750K.

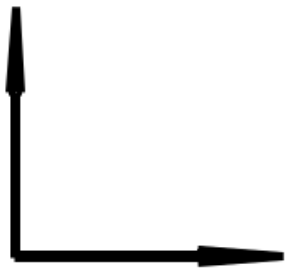
h. A 1.5L sample of a gas at 150kPa and 250K is changed to STP. What is the new volume?

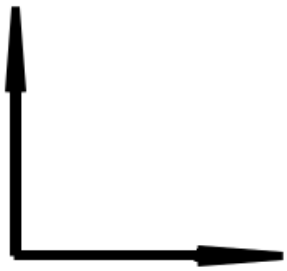
i. Sketch graphs to represent the following relationships & <u>name the law</u>:

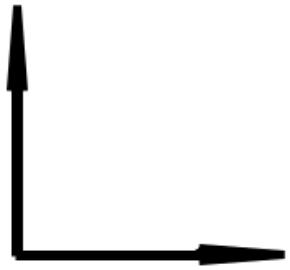
1) Pressure and volume

2) Pressure and temperature

3) Volume and temperature







**Avogadro's Law** states that two different gases at the same temperature, pressure and volume must have the same number of molecules. (Molecules also could mean moles. Not the same atoms or grams!)

a. Which sample would have the same number of molecules as 11.2L of He (g) at 273K and 202kPa?

1) 11.2L of $N_2$(g) at 300K and 202kPa
2) 22.4L of Ne(g) at 546K and 404K
3) 11.2L of $CH_4$(g) at 273K and 202kPa

b. At what volume will 22.4L of $O_2$ (g) at 303K and 1.2atm have the same number of molecules as Neon gas at 303K and 1.2atm? _____

**Grahams Law** states that light gases diffuse the fastest. Diffuse means to spread out and travel.

a. Which gas on the periodic table diffuses the fastest? _____