Chemistry I
YCHS

Instructional Packet
March 25th-April 6th

T. Cleveland

Mrs. Cleveland
Chemistry Weeks 1 & 2

Name ______________________________________

Please LABEL all work with your name and assignment title!

1. Use your gas laws foldable to identify the law being described in each scenario on the Gas Laws - Real World Situations Worksheet.
2. Complete the Chemistry - Graphing the Gas Laws worksheet. Remember to include all appropriate\necessary labels. If you have graph paper or are able to print a sheet of graph paper, you are welcome to use it. Otherwise you may complete the assignment on notebook paper. Either way, do not use less than ½ sheet for each graph.
3. Read the information in Gas Laws Powerpoints and practice the example problems in it.
4. Use your foldable and information in the Powerpoints to complete the Behaviors of Gases Summary Sheet
5. Practice gas laws math on the Gas Laws Problems.Worksheet. Then check your answers. If you have questions, you can email and ask!
6. Complete the Gas Laws Practice Worksheet problems, showing your work.
7. Upload all work\answer in Google classroom, or return to school at the designated time.

2 Enrichment Assignments have been posted but are not for a grade. If you need further understanding, or are more of a visual learning, you may want to check them out if you are able, even if you don't write answers and only follow the steps and answer mentally.

Chemistry Resources:

www.khanacademy.org
www.learnchem.net
www.chemcollective.org
https://www.wiziq.com/tutorials/chemistry

Edited From https://blog.feedspot.com/chemistry_websites/

1. **Chemistry | ScienceDaily** Rockville, MD**About Blog** ScienceDaily features breaking news about the latest scientific discoveries on Earth and Climate Chemistry. Also get articles on organic and inorganic chemistry in the environment - including new techniques and inventions. Updated daily from the world's leading universities and research organizations.

2. **Chemistry | nature.com** London**About Blog** Find the latest research, reviews and news about Chemistry from Nature Research. Nature Research is part of Springer Nature, a leading global research, educational and professional publisher.

3. **Phys.org/ Chemistry** **About Blog** Phys.org news portal provides the latest news on chemistry, biochemistry, polymers, materials science. Its mission is to provide the most complete and comprehensive daily coverage of the full sweep of science, technology, and medicine news.

4. **Chemical & Engineering News | American Chemical Society** Washington DC**About Blog** Chemical & Engineering News delivers the latest chemistry news from the worlds of research, business, education, government, and beyond. If you're a professional looking for chemistry news or are simply a chemistry fan, follow our blog.

5. **Chemistry in its element** Milton Road, Cambridge, United Kingdom**About Blog** A weekly tour of the periodic table, from Chemistry World, the magazine of the Royal Society of Chemistry. **Frequency** 1 post / week **Since** Apr 2008 **Also in** Chemistry Podcasts, Periodic Table Podcasts **Blog** chemistryworld.com/podcasts[redacted]

6. **Chemistry | Reddit.com** **About Blog** Reddit feed on chemistry. A place to post chemistry news, talk about your latest experiment, or socialize with a large group of chemistry enthusiasts. **Frequency** 30 posts / day **Blog** reddit.com/r/chemistry[redacted]

7. **Compound Interest | Explorations of everyday chemical compounds** Cambridge, England**About Blog** Compound Interest' is a blog producing easy-to-understand graphics on a variety of

chemistry topics, focusing particularly on the chemistry we come across on an everyday basis. **Frequency** 1 post / week **Since** Dec 2013 **Also in** UK Chemistry Blogs **Blog** compoundchem.com[redacted]

10. American Chemistry Matters. Washington, DC**About Blog** The American Chemistry Council (ACC) represents a diverse set of companies engaged in the business of chemistry. You will find new studies, research, innovations and many more in the stream of chemistry. **Frequency** 1 post / week **Blog** blog.americanchemistry.com[redacted]

11. The New York Times/Chemistry **About Blog** News about chemistry. Commentary and archival information about chemistry from The New York Times. **Frequency** 1 post / month **Blog** nytimes.com/topic/subject/ch..[redacted]

13. RSC - Green Chemistry Journal **About Blog** The journal publishes original and significant cutting-edge research that is likely to be of wide general appeal. Coverage includes the use of sustainable resource, chemical aspects of renewable energy, the design of new greener and safer chemicals and materials, the use of sustainable resources, the development of environmentally improved routes, synthetic methods. **Frequency** 13 posts / week **Blog** pubs.rsc.org/en/journals/jou..[redacted]

18. Chemistry SciTech Daily **About Blog** Chemistry news. Read chemistry articles from research institutes around the world -- organic and inorganic chemistry -- including new techniques and inventions. **Frequency** 4 posts / week **Blog** scitechdaily.com/news/chemistry[redacted]

Name:______________________________

Gas Law-Real World Situations

Explain in terms of PTV relationships and gas particle motion.

1.A football inflated inside and then taken outdoors on a winter day shrinks slightly.

2.A slightly under inflated rubber life raft left in bright sunlight swells up.

3.A flat tire takes up less space than an inflated tire.

4.Deep sea fish die when brought to the surface.

5.Heating an aerosol can will cause it to explode.

6.Pushing in the plunger of a plugged-up syringe decreases the volume of air trapped under the plunger.

7.An inflated tire feels warm to the touch as more gas is pumped into the tire.

8.The plunger on a turkey syringe thermometer pops out when the turkey is done

9.The bubbles exhaled by a scuba diver grow as they approach the surface of the ocean.

10. A marshmallow expands as it is heated in the microwave.

Chemistry
Graphing the Gas Laws Homework

Directions:

For the three sets of data given in the tables below, graph the data (with graph title, labeled axes with units also, and a best fit-line - you don't need to connect the dots) on three separate graphs. Identify each graph as representing Boyle's Law, Charles' Law, or Gay-Lussac's Law. Explain your choices with a few sentences for each, i.e. provide the correlation between the two types of measurement (like pressure increases as number of moles increases, etc.).

Fill in the "Blank" with pressure, volume, temperature, number of moles, or the ideal gas constant, based on the units given in parentheses.

Gas Law Data #1:

Blank (atm)	Blank (K)
2.2	201.1
6.7	203.3
5.2	202.6
1.0	200.5
16.0	232.2
13.4	226.4
10.2	205.0
4.9	202.5
1.4	200.7
0.0	200.1

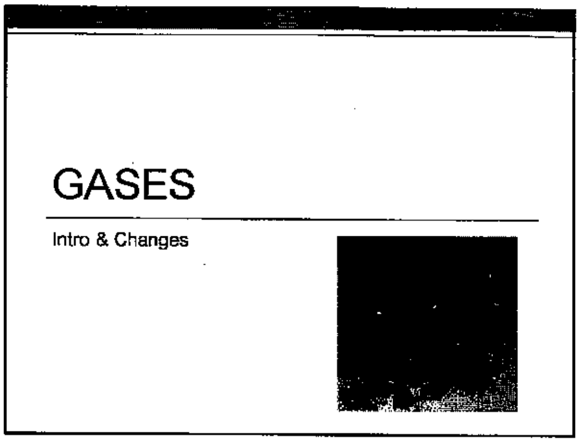
Gas Law Data #2:

Blank (K)	Blank (L)
345.1	5.0
354.0	14.0
342.5	2.5
364.0	23.9
353.3	13.4
345.6	5.6
344.4	4.5
352.6	12.7
351.2	11.1
341.2	1.3

Gas Law Data #3:

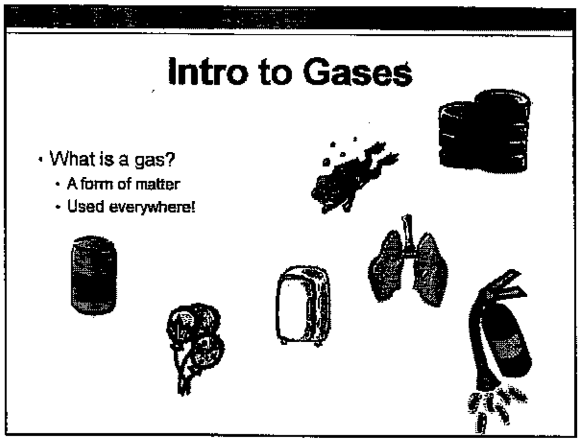
Blank (L)	Blank (atm)
1.9	9.1
0.5	15.1
0.0	20.0

4.3	8.0
5.5	3.6
9.6	1.5
12.7	0.8
4.9	7.1
1.7	13.2
8.3	3.2



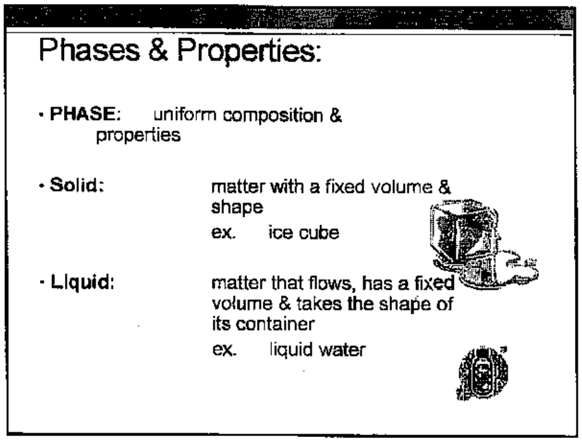
GASES

Intro & Changes



Intro to Gases

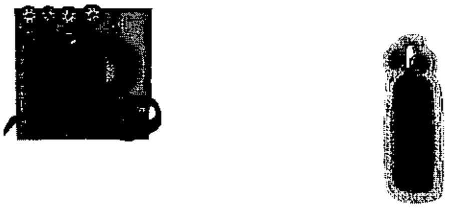
- What is a gas?
  - A form of matter
  - Used everywhere!



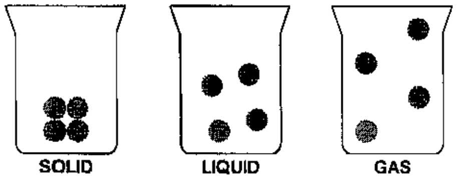
Phases & Properties:

- **PHASE:** uniform composition & properties
- **Solid:** matter with a fixed volume & shape
  ex. ice cube
- **Liquid:** matter that flows, has a fixed volume & takes the shape of its container
  ex. liquid water

- **Gas:** Matter that has no definite volume & takes the shape & volume of its container
  - ex. water vapour
  - ex. He, O_2, CO_2, H_2, Cl_2

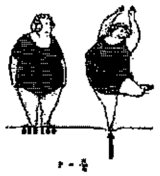


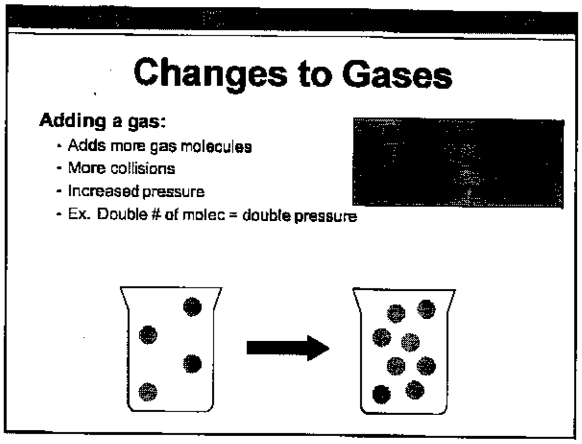
- **Molecules Move:**
  - In solids, molecules close & can hardly move
  - In liquids, more spread out & move a bit more
  - In gas, FAR apart & can move freely



Pressure:

- A force applied over a unit of area.
- For a gas, press results from gas molec **colliding** with the wall of its container
- Measured in units called **Pascals (Pa)** or **kiloPascals (kPa)**

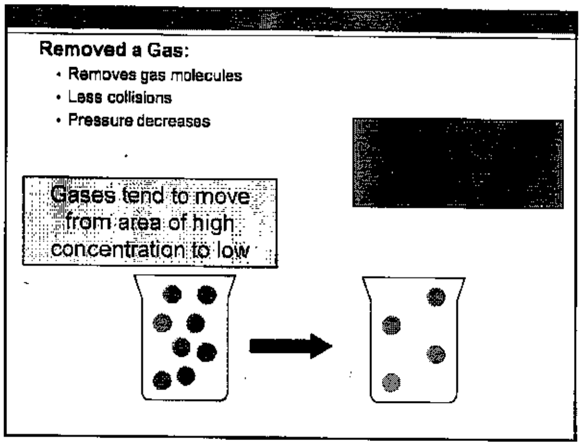




Changes to Gases

Adding a gas:

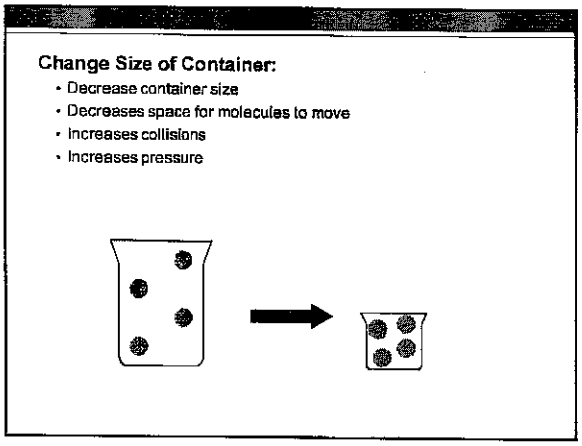
- Adds more gas molecules
- More collisions
- Increased pressure
- Ex. Double # of molec = double pressure



Removed a Gas:

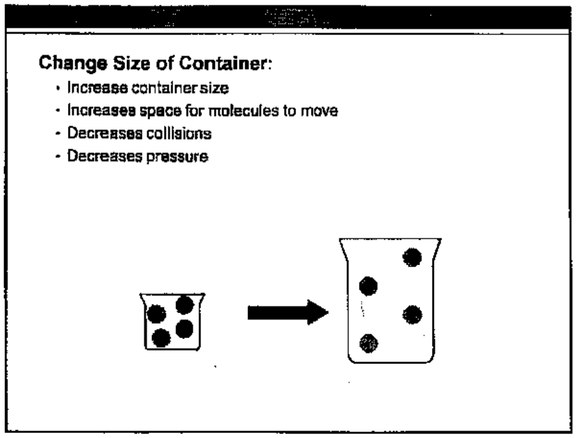
- Removes gas molecules
- Less collisions
- Pressure decreases

Gases tend to move from area of high concentration to low



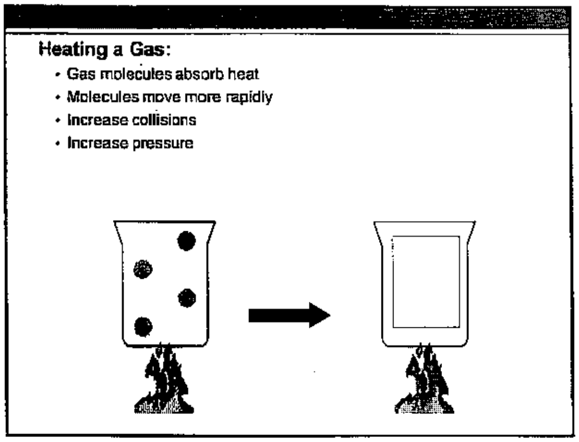
Change Size of Container:

- Decrease container size
- Decreases space for molecules to move
- Increases collisions
- Increases pressure



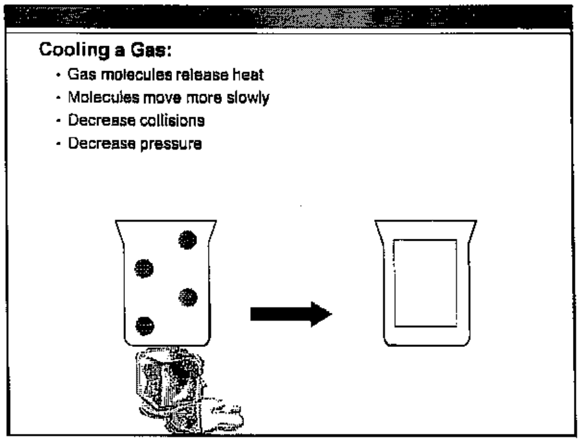
Change Size of Container:

- Increase container size
- Increases space for molecules to move
- Decreases collisions
- Decreases pressure



Heating a Gas:

- Gas molecules absorb heat
- Molecules move more rapidly
- Increase collisions
- Increase pressure



Cooling a Gas:

- Gas molecules release heat
- Molecules move more slowly
- Decrease collisions
- Decrease pressure

Summary:

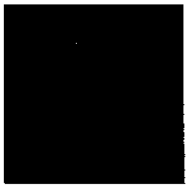
Add more gas	↑ **Pressure**
Remove gas	↓ **Pressure**
Reduce Size	↑ **Pressure**
Increase Size	↓ **Pressure**
Increase Temp	↑ **Pressure**
Decrease Temp	↓ **Pressure**

Kinetic Molecular Theory:

- All of these beliefs are based on the **Kinetic Theory:**
  - A gas is composed of particles
  - Gas particles move rapidly & are in constant random motion
  - All collisions are perfectly elastic
  - Kinetic energy proportional to temperature

  - The elements of the kinetic molecular theory are often on the Quebec final examination!

THE LAWS OF DALTON AND GRAHAM



Dalton's Law of Partial Pressures

- The total pressure of a mixture of gases equals the sum of the partial pressures of the individual gases.

[illegible]

- Hydrogen gas is collected over water at 22.5°C. Find the pressure of the dry gas if the atmospheric pressure is 94.4 kPa.

The total pressure in the collection bottle is equal to atmospheric pressure and is a mixture of H_2 and water vapor

Look up water-vapor pressure on p.899 for 22.5°C.

Sig Figs: Round to least number of decimal places...

Practice this Question

- A gas is collected over water at a temp of 35.0°C when the barometric pressure is 742.0 torr. What is the partial pressure of the dry gas?

The total pressure in the collection bottle is equal to barometric pressure and is a mixture of the "gas" and water vapor.

Look up water vapor pressure on p 899 for 35.0°C.

Sig Figs: Round to least number of decimal places

Graham's Law

- **Diffusion**
  - Spreading of gas molecules throughout a container until evenly distributed.
- **Effusion**
  - Passing of gas molecules through a tiny opening in a container

Graham's Law

- **Speed of diffusion/effusion**
  - Kinetic energy is determined by the temperature of the gas.
  - At the same temp & KE, heavier molecules move more slowly.
    - Larger $m \Rightarrow$ smaller v

$$KE = \frac{1}{2}mv^2$$

Graham's Law

- **Graham's Law**
  - Rate of diffusion of a gas is inversely related to the square root of its molar mass.
  - The equation shows the ratio of Gas A's speed to Gas B's speed.

[redacted]

- Determine the relative rate of diffusion for krypton and bromine.

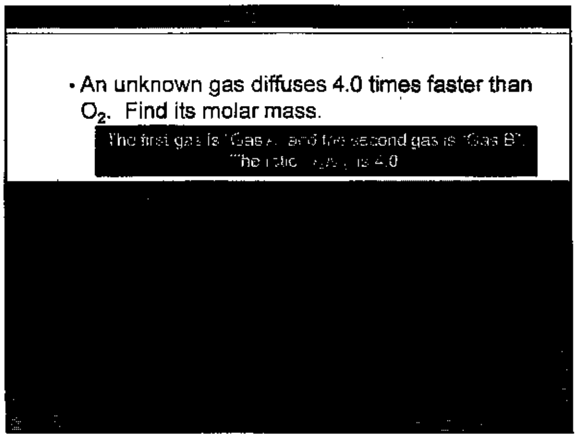
The first gas is "Gas A" and the second gas is "Gas B". Relative rate mean find the ratio "v_A/v_B".

[redacted]

Kr diffuses 1.381 times faster than Br_2.

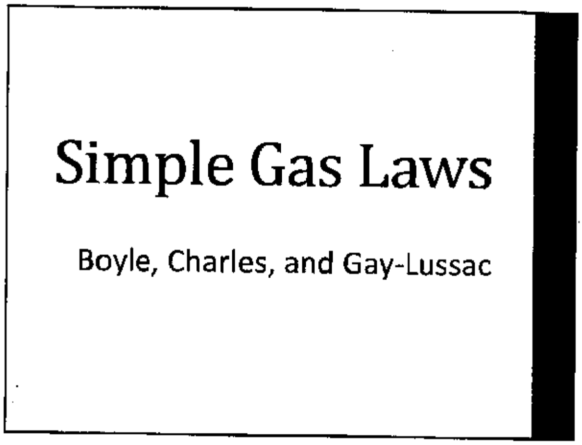
- A molecule of oxygen gas has an average speed of 12.3 m/s at a given temp and pressure. What is the average speed of hydrogen molecules at the same conditions?

[redacted]



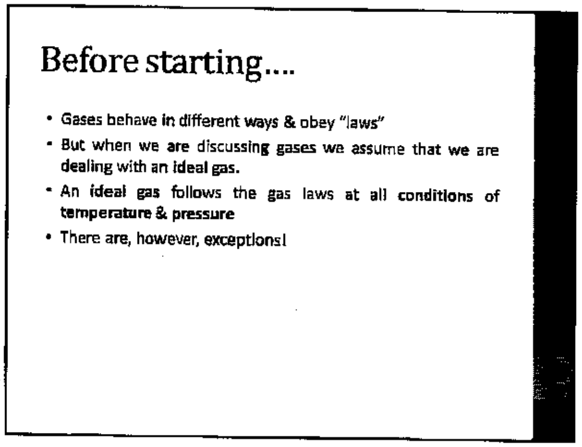
- An unknown gas diffuses 4.0 times faster than O_2. Find its molar mass.

The first gas is "Gas A" and the second gas is "Gas B". The ratio r_A/r_B is 4.0



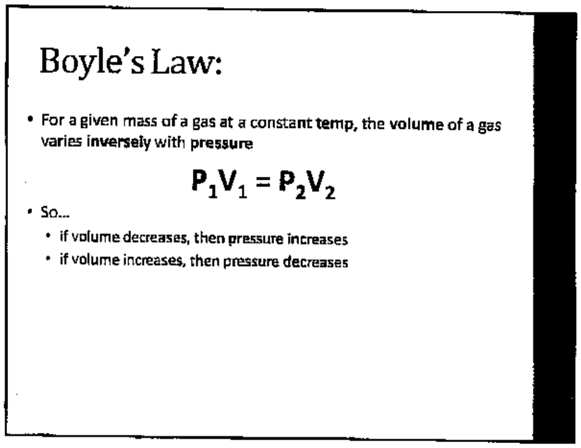
Simple Gas Laws

Boyle, Charles, and Gay-Lussac



Before starting....

- Gases behave in different ways & obey "laws"
- But when we are discussing gases we assume that we are dealing with an **ideal gas.**
- An **ideal gas** follows the gas laws at all **conditions** of **temperature & pressure**
- There are, however, exceptions!



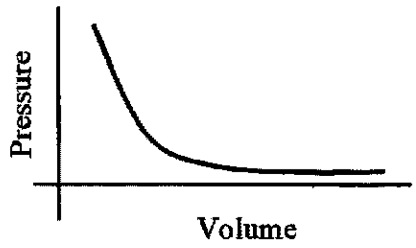
Boyle's Law:

- For a given mass of a gas at a constant **temp**, the **volume** of a gas varies **inversely** with **pressure**

$$P_1V_1 = P_2V_2$$

- So...
  - if volume decreases, then pressure increases
  - if volume increases, then pressure decreases

- Graphically:



Example

- A balloon is filled with 30L of He gas at 100kPa. What is the volume when the balloon rises to an altitude where the pressure is 25kPa?

$P_1V_1 = P_2V$

$(100kPa)(30L) = (25kPa)(V_2)$

$V_2 = \frac{(100kPa)(30L)}{(25kPa)}$

$V_2 = 120L$

Example

- The pressure on 2.50L of anesthetic gas is changed from 100kPa to 40kPa. What will be the new volume if the temperature remains constant?

$P_1V_1 = P_2V_2$

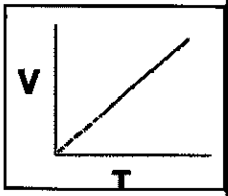
$(100kPa)(2.50L) = (40kPa)(V_2)$

$V_2 = \frac{(100kPa)(2.50L)}{(40kPa)}$

$V_2 = 6.25L$

Charles Law for Temp:

- States that the **volume** of a **fixed** mass of gas is **directly proportional to its temperature, in** Kelvin, if the pressure is kept constant.



Example

- A balloon inflated in a room at 20°C has a volume of 10L. The room is then heated to 40°C. What is the new volume of the balloon if the pressure is unchanged?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad T_1 = 20°C + 273 = 293K$$

$$T_2 = 40°C + 273 = 313K$$

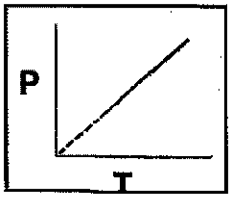
$$\frac{10L}{293K} = \frac{V_2}{313K}$$

$$V_2 = 10.7L$$

- This makes sense – volume should increase when temperature increases!

Gay-Lussac's Law for Temp:

- States that the **pressure of** a gas is directly **proportional** to the **temperature if the volume** is kept constant.



Example:

- Gas that was left in a hairspray can is at a pressure of 200kPa and a temp of 21°C. Someone throws the can in a hot fire and its temperature rises to 900°C. What is the internal pressure on the can?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{200 \text{ kPa}}{294 \text{ K}} = \frac{P_2}{1173 \text{ K}}$$

$$P_2 = \frac{(200 \text{ kPa})(1173\text{K})}{(294\text{K})}$$

$$P_2 = 798\text{kPa}$$

TheoryQues:

- What would happen to the vol. if the temp. of a gas were doubled? Pressure?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{1\text{L}}{273\text{K}} = \frac{V_2}{546\text{K}}$$

[redacted]

[redacted]

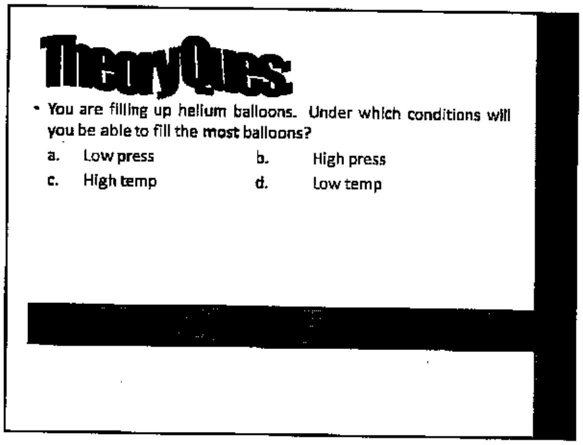
TheoryQues:

- For spring break you drive from Québec to Florida. When you arrive Florida, your car tire bursts. Explain.

Quebec – low temp, so low pr

Florida – higher temp, so vol increases

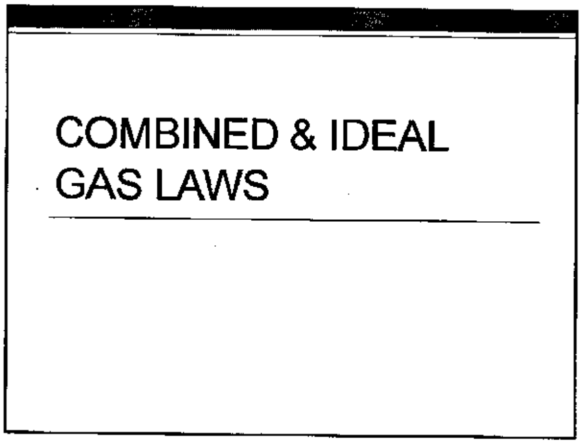
Tire can't hold & bursts



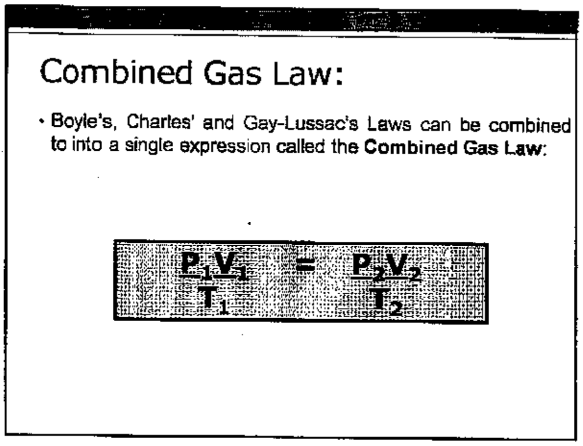
TheoryQues:

- You are filling up helium balloons. Under which conditions will you be able to fill the most balloons?

a. Low press
b. High press
c. High temp
d. Low temp



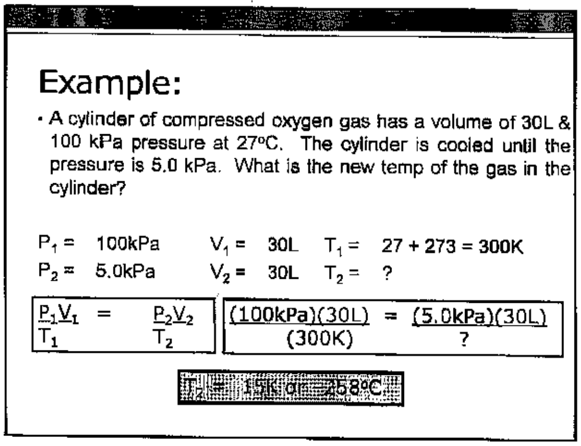
COMBINED & IDEAL GAS LAWS



Combined Gas Law:

- Boyle's, Charles' and Gay-Lussac's Laws can be combined to into a single expression called the **Combined Gas Law**:

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



Example:

- A cylinder of compressed oxygen gas has a volume of 30L & 100 kPa pressure at 27°C. The cylinder is cooled until the pressure is 5.0 kPa. What is the new temp of the gas in the cylinder?

$P_1 =$ 100kPa $V_1 =$ 30L $T_1 =$ 27 + 273 = 300K

$P_2 =$ 5.0kPa $V_2 =$ 30L $T_2 =$?

$$\boxed{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}} \quad \boxed{\frac{(100kPa)(30L)}{(300K)} = \frac{(5.0kPa)(30L)}{?}}$$

$$\boxed{T_2 = 15K \text{ or } -258°C}$$

Ideal Gas Law:

- Expresses the number of **moles** of a gas at a fixed **volume** at a certain **pressure** & **temperature**

- The ideal gas law states that:

$$\frac{P \times V}{T \times n} = \text{Constant "R"}$$

- R has different values depending on the units used for volume, pressure & temperature

R = 8.21×10^{-2} (L x atm) / (K x mol)

R = 62.4 (L x mmHg) /(K x mol)

R = 8.31×10^{3} (L x Pa) / (K x mol)

R = 8.31 (L x kPa)/(K x mol)

- Ideal Gas Law:

$$\boxed{PV = nRT}$$

Example:

- A steel cylinder with a volume of 20.0L is filled with nitrogen gas to a pressure of 20,000 kPa at 27°C.

a) How many moles of N_2 gas does the cylinder contain?

V = 20.0L
P = 20,000 kPa
T = 27 + 273 = 300K
R = 8.31

PV = nRT
(20)(20000) = (n)(8.31)(300)

n = 160 moles

b) How many grams of nitrogen gas?

mass = moles x molar mass
mass = 160mol x 28 g/mol

mass = 4480 g

Example:

2.24 x 10^6L CH_4 is at a pressure of 1500kPa & a temp of 42°C. What is the mass of the gas?

P = 1500 kPa
V = 2.24 x 10^6 L
n = ?
R = 8.31
T = 315 K

PV = nRT

(1500)(2.24 x 10^6) = (n)(8.31)(315)

n = 1.28 x 10^6 mol of CH_4

mass = (1.28 x 10^6mol)(16g/mol)

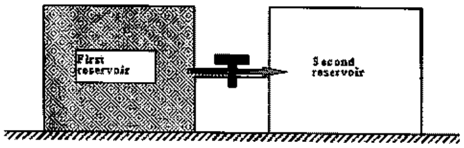
mass = 2.05 x 10^7 g of CH_4

CHALLENGING/ EXCEPTIONAL

GAS LAW PROBLEMS

The first reservoir has a vol of 500L. It's filled with gas at a press of 510 kPa & a temp of 20°C. The second reservoir has a vol of 250L & is initially empty.

When the valve in the tube connecting the two reservoirs is opened, the gas enters the second reservoir and the temp of the gas in the two reservoirs drops to 10°C.



What will be the new pressure of the gas in the two reservoirs?

$$\frac{PV}{T} = \frac{PV}{T}$$

Vol of **BOTH** reservoirs b/c valve is open

$$\frac{(510kPa)(500L)}{(293K)} = \frac{P(\mathbf{750L})}{(283K)}$$

$$\boxed{P_2 = 328.40 \text{ kPa}}$$

2 moles of magnesium metal reacts with HCl to produce hydrogen gas & magnesium chloride at a press of 200kPa & a temp of 25ºC.

What is the **volume** of the produced gas?

Mg	+	2HCl	→	H_2	+	$MgCl_2$
1	:	2	→	1	:	1
2mol	:	?	→	$\boxed{\text{2 mol}}$	:	?

$\boxed{PV = nRT}$

(200kPa)(V) = (2mol)(8.31)(298K)

V = 24.76L

The combustion of **acetylene**, $C_2H_2(g)$, produces carbon dioxide gas & water vapour.

If 15 g of acetylene is burned, what **volume** of $CO_2(g)$ will be obtained at **STP**?

$2\ C_2H_2(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 2\ H_2O(g)$ + Energy

Moles of C_2H_2 = (15 g) ÷ (26 g/mol)

Moles of C_2H_2 = 0.577 mol

Moles of CO_2 = 1.15 mol

Recall STP:

P = 101.3kPa

T = 0ºC or 273K

1 mol in 22.4L

$\boxed{PV = nRT}$

(101.3kPa)(V) = (1.15mol)(8.31)(273K)

V = 25.74L

During a lab experiment, you put an unknown compound into some water.

You observe a bubbling reaction. With the help of a syringe, you remove the gas produced.

Consider the following data:

- Mass of the 140 mL syringe: 23.47 g
- Mass of the syringe with 140 mL of the gas: 23.72 g
- Temperature in the lab: 298.0 K
- Pressure in the room: 101.0 kPa

Which of the following is most likely the identity of the gas produced and collected?

O_2 N_2 CO_2 H_2

$\boxed{PV = nRT}$

(101kPa)(0.140L) = (?)(8.31)(298K)

n = 0.0057 mol

Mass = 23.72 g – 23.47 g

Mass = 0.25 g

Molar mass = 0.25g ÷ 0.0057 mol

Molar mass = 43.86 g/mol

So gas is CO_2

Two gas bottles with identical volumes contain different gases at the same temp and pressure.

One contains 16 g of SO_2. What mass of He is contained in the other bottle?

$\boxed{PV = nRT}$

$\boxed{R = \frac{PV}{nT}}$

R for SO_2 is the same for He, so....

$R_{SO_2} = R_{He}$

$\frac{\cancel{PV}}{n\cancel{T}} = \frac{\cancel{PV}}{n\cancel{T}}$

$\frac{1}{n} = \frac{1}{n}$

$\frac{1}{0.25} = \frac{1}{n}$

n_{SO_2} = 16g ÷ 64g/mol

n_{SO_2} = 0.25 mol

n_{He} = 0.25 moles

$mass_{He}$ = 0.25mol x 4 g/mol

$mass_{He}$ = 1g

An empty 1L container weighs 480g. When this container is filled with nitrogen gas, its total mass is 620g. When it is filled with an unknown gas at the same temp and press, its total mass is 770 g.

Which of the following is the unknown gas?

A) Acetylene, C_2H_2

B) Butane, C_4H_{10}

C) Ethane, C_2H_6

D) Methane, CH_4

$\boxed{PV = nRT}$ $\boxed{R = \frac{PV}{nT}}$

R for N_2 is the same for unknown, so....

$R_{N_2} = R_?$

$\frac{\cancel{P}\cancel{V}}{n\cancel{T}} = \frac{\cancel{P}\cancel{V}}{n\cancel{T}}$

$\frac{1}{n} = \frac{1}{n}$

n_{N_2} = **140g** ÷ 28g/mol

n_{N_2} = 5 mol

$n_{unknown}$ = 5 moles

$mass_{unknown}$ = 290g

Molar $mass_{unknown}$ = 290g ÷ 5 mol

Molar $mass_{unknown}$ = 58 g/mol

unknown gas = BUTANE

Behavior of Gases- Summary

By Ms Phebe Fuentes

Variables that describe a gas:

Variable	Symbol	units
Pressure	P	Atm, kpa, mmHg (1 atm = 760mmHg = 101.3 kPa
Volume	V	L
Temperature	T	K (kelvins = °C +)
Number of particles (moles)	n	Moles

Constants:

Constant	symbol	Value
Ideal gas constant	R	
Standard temperature and pressure	STP	
Volume of ideal gas at STP		

- For the formulas you can always refer to your reference materials sheet, you know....

Law	Boyle's Law	Charles' Law	Guy-Lussac's Law	Combined Gas Law	Ideal Gas Law	Dalton's Law
Concept	At a constant temperature, pressure ___________ as volume ____________ (and vice versa)	Volume _________ as pressure __________ (and vice versa)	Temperature ______________ as pressure ____________ (and vice versa)	Combines previous 3 laws	Uses gas constant "R"	Total pressure of a mixture of gases = sum of the pressures exerted by each gas
Relationship	proportional	proportional	proportional	n/a	n/a	n/a
Formula						

Name : ______________________

Date : ______________

Gas Laws

Boyle's Law

$P_1V_1 = P_2V_2$

(assume temperature remains constant)

1. A 3.0 L sample of carbon dioxide gas at 155 kPa is injected into a 5.0 L vessel. What is the new pressure of the gas ?

2. The sample of oxygen gas is compressed from 5.25 L to 1.75 L. If the original pressure was 740. torr, what is the final pressure ?

3. The pressure of a 2.00 L sample of neon gas is raised from 0.95 atm to 1.05 atm. What is the final volume of the gas ?

Charles' Law

$V_1/T_1 = V_2/T_2$

(assume pressure remains constant)

1. A balloon containing helium gas has volume of 750. mL at 25 ºC. What is the volume if the temperature is increased to 55 ºC ?

2. A 2.0 L balloon containing nitrogen gas is cooled from 25.0 ºC to 0.0 ºC. What is the final volume of the balloon.

3. A sample of argon gas is in a vessel with a movable piston at 37 ºC. As the gas is cooled, the volume decreases from 10.0 liters to 4.25 liters. What is the final temperature of the gas ?

K = ºC + 273

Name : ____________________

Date : ____________________

Gas Laws

Avogadro's Law

$V_1 / n_1 = V_2 / n_2$

(assume pressure & temperature remain constant)

1. A flexible vessel containing 0.15 moles of nitrogen gas has a volume of 3.4 L. If more nitrogen gas is injected until the number of moles is quadrupled, what is the new volume ?

2. A chemist releases gas from a vessel with a moveable piston containing 0.50 moles of hydrogen gas at 15.0 L. If he releases 0.35 moles of gas, what is the final volume ?

3. If 0.80 moles of chlorine gas are injected into a flexible vessel already containing 0.20 moles of chlorine gas with a volume of 3.0 L, what is the final volume of the gas ?

Gay-Lussac's Law

$P_1 / T_1 = P_2 / T_2$

(assume volume remains constant)

1. A sample of ozone, O_3, in a rigid vessel has a pressure of 1.20 atmospheres. If the gas is heated from 0 °C to 25 °C, what is the final pressure ?

2. A chemist wants to decrease the pressure of a sample of methane, CH_4, from 300. kPa to 100. kPa. If the original temperature of gas is 95 °C, what must she decrease the temperature to ?

3. A sample of helium gas at 273 K is cooled to 253 K. If the final pressure is 380. torr, what was the original pressure of the gas ?

$K = °C + 273$

Name : Answer Key

Date : ______________

•o Gas Laws o•

Boyle's Law

$P_1V_1 = P_2V_2$

(assume temperature remains constant)

1. A 3.0 L sample of carbon dioxide gas at 155 kPa is injected into a 5.0 L vessel. What is the new pressure of the gas ?

$P_1 = 155\ kPa$
$P_2 = ?$
$V_1 = 3.0\ L$
$V_2 = 5.0\ L$

$P_1V_1 = P_2V_2$
$(155\ kPa)(3.0\ L) = (P_2)(5.0\ L)$
$P_2 = 93\ kPa$

2. The sample of oxygen gas is compressed from 5.25 L to 1.75 L. If the original pressure was 740. torr, what is the final pressure ?

$P_1 = 740.\ torr$
$P_2 = ?$
$V_1 = 5.25\ L$
$V_2 = 1.75\ L$

$P_1V_1 = P_2V_2$
$(740.\ torr)(5.25\ L) = (P_2)(1.75\ L)$
$P_2 = 2,220\ torr = 2.22 \times 10^3\ torr$

3. The pressure of a 2.00 L sample of neon gas is raised from 0.95 atm to 1.05 atm. What is the final volume of the gas ?

$P_1 = 0.95\ atm$
$P_2 = 1.05\ atm$
$V_1 = 2.00\ L$
$V_2 = ?$

$P_1V_1 = P_2V_2$
$(0.95\ atm)(2.00\ L) = (1.05\ atm)(V_2)$
$V_2 = 1.81\ L$

Charles' Law

$V_1/T_1 = V_2/T_2$

(assume pressure remains constant)

1. A balloon containing helium gas has volume of 750. mL at 25 °C. What is the volume if the temperature is increased to 55 °C ?

$V_1 = 750.\ mL$
$V_2 = ?$
$T_1 = 25\ °C + 273 = 298\ K$
$T_2 = 55\ °C + 273 = 328\ K$

$V_1/T_1 = V_2/T_2$
$750.\ mL / 298\ K = V_2 / 328\ K$
$V_2 = 826\ mL$

2. A 2.0 L balloon containing nitrogen gas is cooled from 25.0 °C to 0.0 °C. What is the final volume of the balloon.

$V_1 = 2.0\ L$
$V_2 = ?$
$T_1 = 25\ °C + 273 = 298\ K$
$T_2 = 0\ °C + 273 = 273\ K$

$V_1/T_1 = V_2/T_2$
$2.0\ L / 298\ K = V_2 / 273\ K$
$V_2 = 1.8\ L$

3. A sample of argon gas is in a vessel with a movable piston at 37 °C. As the gas is cooled, the volume decreases from 10.0 liters to 4.25 liters. What is the final temperature of the gas ?

$V_1 = 10.0\ L$
$V_2 = 4.25\ L$
$T_1 = 37\ °C + 273 = 310.\ K$
$T_2 = ?$

$V_1/T_1 = V_2/T_2$
$10.0\ L / 310.\ K = 4.25\ L / T_2$
$T_2 = 132\ K$ or $-141\ °C$

$K = °C + 273$

Name : Answer Key

Date : ____________

Gas Laws

Avogadro's Law

$V_1/n_1 = V_2/n_2$

(assume pressure & temperature remain constant)

1. A flexible vessel containing 0.15 moles of nitrogen gas has a volume of 3.4 L. If more nitrogen gas is injected until the number of moles is quadrupled, what is the new volume ?

$V_1 = 3.4\,L$
$V_2 = ?$
$n_1 = 0.15\,mol$
$n_2 = 0.15 \times 4 = 0.60\,mol$

$V_1/n_1 = V_2/n_2$
$3.4\,L / 0.15\,mol = V_2 / 0.60\,mol$
$V_2 = 14\,L$

2. A chemist releases gas from a vessel with a moveable piston containing 0.50 moles of hydrogen gas at 15.0 L. If he releases 0.35 moles of gas, what is the final volume ?

$V_1 = 15.0\,L$
$V_2 = ?$
$n_1 = 0.50\,mol$
$n_2 = 0.50 - 0.35 = 0.15\,mol$

$V_1/n_1 = V_2/n_2$
$15.0\,L / 0.50\,mol = V_2 / 0.15\,mol$
$V_2 = 4.5\,L$

3. If 0.80 moles of chlorine gas are injected into a flexible vessel already containing 0.20 moles of chlorine gas with a volume of 3.0 L, what is the final volume of the gas ?

$V_1 = 3.0\,L$
$V_2 = ?$
$n_1 = 0.20\,mol$
$n_2 = 0.20 + 0.80 = 1.00\,mol$

$V_1/n_1 = V_2/n_2$
$3.0\,L / 0.20\,mol = V_2 / 1.00\,mol$
$V_2 = 15\,L$

Gay-Lussac's Law

$P_1/T_1 = P_2/T_2$

(assume volume remains constant)

1. A sample of ozone, O_3, in a rigid vessel has a pressure of 1.20 atmospheres. If the gas is heated from 0 ºC to 25 ºC, what is the final pressure ?

$P_1 = 1.20\,atm$
$P_2 = ?$
$T_1 = 0\,ºC + 273 = 273\,K$
$T_2 = 25\,ºC + 273 = 298\,K$

$P_1/T_1 = P_2/T_2$
$1.20\,atm / 273\,K = P_2 / 298\,K$
$P_2 = 1.31\,atm$

2. A chemist wants to decrease the pressure of a sample of methane, CH_4, from 300. kPa to 100. kPa. If the original temperature of gas is 95 ºC, what must she decrease the temperature to ?

$P_1 = 300.\,kPa$
$P_2 = 100.\,kPa$
$T_1 = 95\,ºC + 273 = 368\,K$
$T_2 = ?$

$P_1/T_1 = P_2/T_2$
$300.\,kPa / 368\,K = 100.\,kPa / T_2$
$T_2 = 123\,K = -150\,ºC$

3. A sample of helium gas at 273 K is cooled to 253 K. If the final pressure is 380. torr, what was the original pressure of the gas ?

$P_1 = ?$
$P_2 = 380.\,torr$
$T_1 = 273\,K$
$T_2 = 253.\,K$

$P_1/T_1 = P_2/T_2$
$P_1 / 273\,K = 380.\,torr / 253.\,K$
$P_1 = 410.\,torr$

$K = ºC + 273$

Gas Laws Practice Worksheet – Boyles, Gay lussacs, Charles Name:

Boyles Law
Formula: P1V1 = P2V2

1.) A sample of oxygen had an initial volume of 4.0L and was at a standard pressure of 1atm, what would the new volume be if the pressure was increased to 25.00atm?

P1:
V1:
P2:
V2:

2.) A 5mL tank of Carbon dioxide is stored at a pressure of 30mmHg. It is moved to an altitude with a pressure of 28mmHg. What will the new volume of Carbon dioxide be?

P1:
V1:
P2:
V2:

3.) To what pressure must a gas be compressed in order to get into a 3.00 cubic foot tank the entire weight of a gas that occupies 400.0 cu. ft. at standard pressure?

P1:
V1:
P2:
V2:

4.) Boyles law is a ____________ relationship between ____________ and ___________.

Converting between Celsius and Kelvin

5.) Convert the following temperatures from °C to K

a.) 30°C = ________K
b.) 10°C = ________K
c.) 4°C = ________K

6.) The most important thing to remember when working Gas law problems involving temperature is to convert from _________ to ________.

Gay Lussac's Law
Formula: P1 / T1 = P2 / T2

7.) 5.00 L of a gas is collected at 22.0 °C and 745.0 mmHg. When the temperature increases to 35°C what is the new pressure?

P1:
T1:
P2:
T2:

8.) My car tires are filled to 32psi at 20°C, when the first frost happens and the temperature drops to 15°C, what could my tire pressure drop to?

P1:
T1:
P2:
T2:

9.) Gay Lussac's Law is a ____________ relationship between __________ and ____________.

Charles law
Formula: V1 / T1 = V2 / T2

10.) If I have 45L of helium in a balloon at 300K and increase the temperature of the balloon to 350K, what will the new volume of the balloon be?

V1:
T1:
V2:
T2:

11.) 4.40 L of a gas is collected at 50.0 °C. What will be its volume upon cooling to 25.0 °C?

V1:
T1:
V2:
T2:

12.) A 2.50-L volume of hydrogen measured at -100 degrees Celsius is warmed to 100 degrees Celsius. Calculate the volume of the gas at the higher temperature, assuming no change in pressure.

V!:
T1:
V2:
T2:

13.) Charles law is a _____________ relationship between _______________ and __________________.

Basic Relationships

14.) As pressure increases, Temperature should ________________ which makes this a _______________ relationship. (This is ___________ law)

15.) As Temperature decreases, volume should _________________ which makes this a _______________ relationship. (This is ___________ law)

16.) As volume decreases, temperature should________________ which makes this a ______________ relationship. (This is ____________ law)