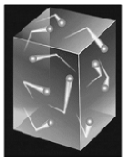
$$\frac{PV}{T} = k$$

Gases



LPT

Gases- A State of Matter

Properties
- may be compressed
- expand to fill their containers uniformly
- have low densities
- may be mixed
- exert constant uniform pressure on the walls of their containers

LPT

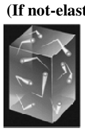
Kinetic (Moving) Theory of Gases

Gases are composed of molecules in constant motion
Gas molecules move in random directions
Molecules of a gas collide frequently with each other & with vessel walls
(why gases mix to uniformity & fill all portions of the containment vessel)

Gas molecules move with an average velocity at a given temperature.
(the average energy of molecules in a gas is the same for all substances)

Distance between gas molecules >> than size of the individual molecules
(why gases can be compressed)

Molecules are perfectly elastic … no energy is lost when molecules collide
(If not-elastic, the temperature of a gas mix would always decrease with time)



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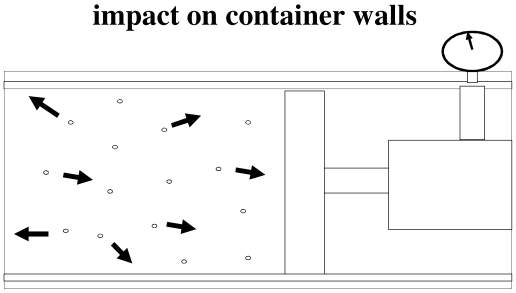
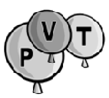
Pressure is result of molecular impact on container walls

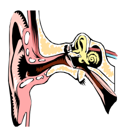


Pressure = force/area

LPT



General Gas Law



$$\frac{p_1 v_1}{t_1} = \frac{p_2 v_2}{t_2}$$

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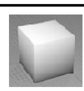
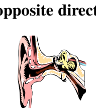
Proportional Thinking



$$\frac{p\,v}{t} = k$$

Variables change to keep k constant

If P constant:	If V constant:	If T constant:
$\frac{\uparrow v}{\uparrow t} = k$	$\frac{\uparrow p}{\uparrow t} = k$	$pv = k$ ($\uparrow \downarrow$)
v and t change (increase or decrease) in same direction	p and t change (increase or decrease) in same direction	p and v change (increase or decrease) in opposite direction



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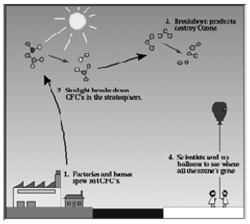
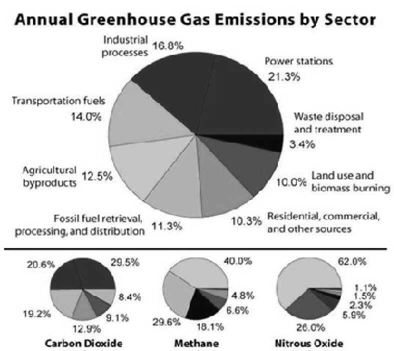
Gases In The News

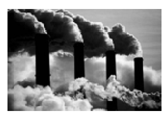


Chlorofluorcarbons (CFC) Deplete Ozone
Ozone loss increases amount of harmful UV reaching the earth
Skin cancers on the rise in Australia and New Zealand
Loss of all Ozone will eliminate life on the surface of the earth

LPT

Gases In The News





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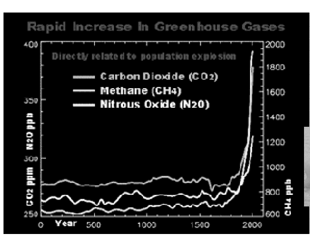
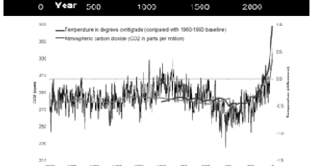
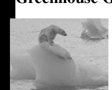


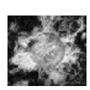


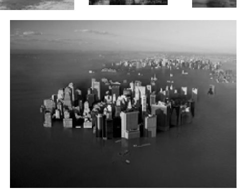
Gases In The News

There appears to be a correlation:

Greenhouse Gases and Temperature







NYC==> 13" in last century

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Gases In The News

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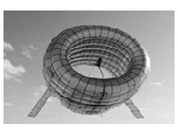
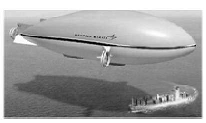
Gases In The News

Lighter than air aircraft re-emerging

Best long-range, low cost, heavy transport vessels known





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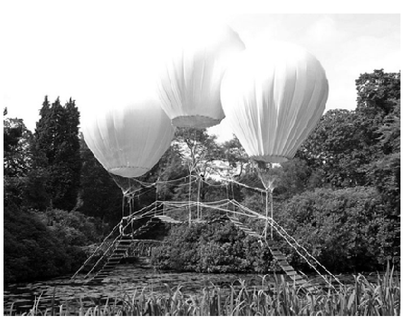
Helium Filled Balloon As Bridge Support



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Weather Balloons



NOAA facility at White Lake
Balloon filled with H_2
Launched world-wide every day at same time (7 am/pm $\pm$ 1 hour)
Lasts ~ one-half hour

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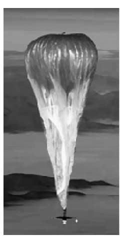
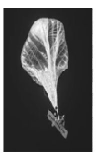
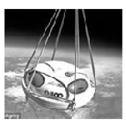
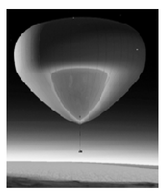
High-Tech Balloons

Project Loon
Google Send
& Receive WiFi



Neptune
Space Tourism



China
International WiFi Eavesdropping

US Border Patrol
Surveillance Balloon

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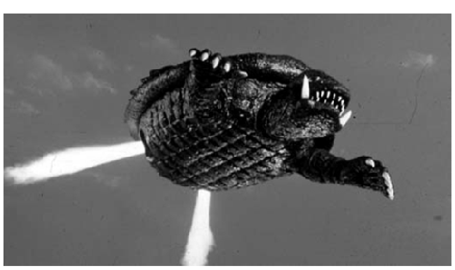
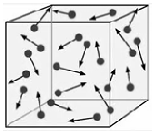
Yes, Indeed, Chemistry is a Gas!

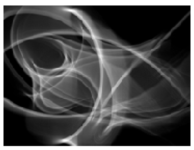



Both H_2 and CH_4 can be biologically produced
So, biological "flamers" are conceivable

LPT



Gas Law Lab
(Boyle & Charles)



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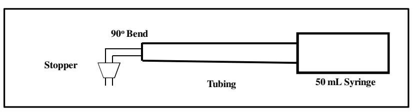
Gases Lab – 50 ml Syringe

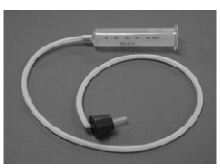
Procedure

Part A: Volume – Temperature (Charles)

•Fill a 250-mL Erlenmeyer flask with about 200 mL of distilled water

•Volume measuring device: rubber stopper, 90° glass bend, rubber tubing, & 50 mL syringe:





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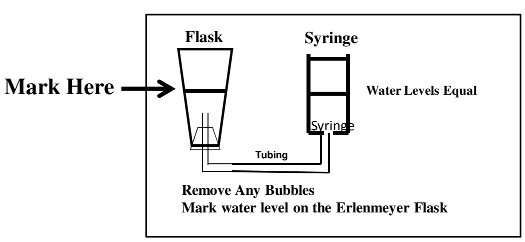
Gases Lab - Erlynmeyer Flask

•Cap the hole in the rubber stopper with your finger. Drain the syringe through the stopper.

•When ~ 10-15 mL of water remains in the syringe,

•Insert the stopper into the Erlenmeyer flask and invert it ➔ all in the same motion

•Keep the Erlenmeyer flask inverted at all times



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Gases Lab - 2 L Beaker

- Place the inverted Erlenmeyer flask in a 2000 mL beaker
- Need 2 L beaker to hold the water bath for temperature control

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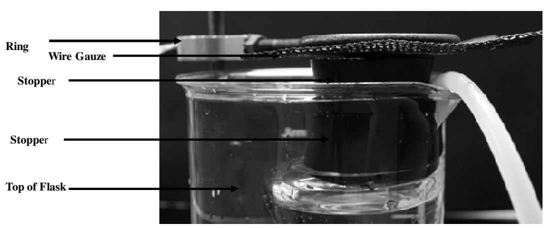
Gases Lab – Ring Stand Ring

- Set the beaker on a ring stand.
- To keep flask from floating, add 2 rubber stoppers on the top of the flask
- Add a wire gauze on top of the rubber stoppers
- Add an iron ring so that it rests on top of the wire gauze.
- Clamp the iron ring to a ring stand

When water is added, the ring/gauze/stoppers hold the flask in place



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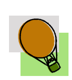
Gases Lab – Ring Stands



- Use 3-fingered clamp on second ring stand to hold syringe in place
- Let the hose between the flask & the syringe hang over the side of the lab bench
  The syringe will have to be moved to equilibrate levels

Syringe must be free to move up & down

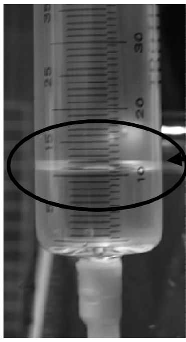
Control by sliding clamp on ring stand

Add thermometer

This is the "flexible U"

LPT

Gases Lab – Recording Volume



Set syringe water level = flask water level

Sight through syringe,
Move syringe to align levels
Record volume to nearest tenth of mL

Most common errors:
Not setting equal water levels
Not equilibrating temperatures

Record initial reading
This will be initial for all measurements

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Gases Lab – Volume vs. Temperature

- Heat water (hotplate) until at least 60 °C; carefully pour into 2 L beaker
The flask in the 2 L beaker must be completely covered by the hot water
Add ice to cool the bath to ~50 °C
- RECORD the VOLUME as the SYRINGE READING for the T = 50.0 °C
- Add ice, with constant stirring, to lower the temperature
- Record Temperature & Syringe Volume for T = 40.0, 30.0, 20.0, and 10.0 °C.

At each step:
Must move syringe up and down
So level of syringe = flask

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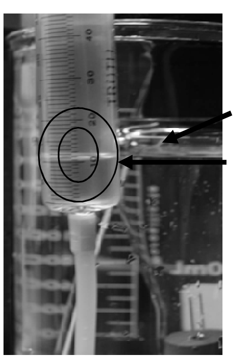
Gases Lab – What's Happening



As Gas Volume (Trapped Gas) changes,

The change is measured here
(Data point – initial reading)

Total Volume = Trapped Gas + Δ Syringe

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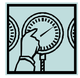
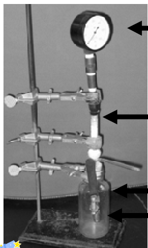
Gases Lab – Vacuum Gauge



Procedure
Part B: Volume – Pressure (Boyle)



Vacuum Gauge (mmHg below atmospheric)

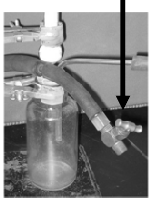
Drierite (Desiccant-keeps water out of gauge)

Safety Flask (keeps water out of vacuum Line)

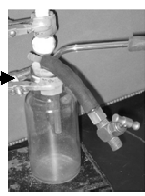
Needle Valve (controls vacuum) by air bleed)

Gases Lab – T-Valve

Needle Valve –Bleeding Air Here Controls Vacuum



To vacuum



To syringe

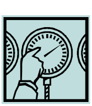
Use vacuum tubing:
Short Tubing Connects to the syringe
Long Tubing Connects to the Vacuum Line

Gases Lab – Complete Apparatus

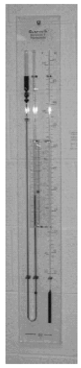
- **Completely open the needle valve**
- **Carefully open the needle valve**
- **Watch fluid level**
  (too much vacuum ➔ liquid moves into vacuum line)

All adjustments should be done with the needle valve
Close the needle valve to obtain a reading of 50 mm Hg

- **Adjust the syringe water level = water level in the flask**
- **RECORD the VOLUME of SYRINGE READING**
- **Repeat for 100, 150, and 200 mm of Hg**
- **Read the barometer (same reading for all measures)**



Gases Lab – Barometer



Behind Instructor's Desk

Read Atmospheric Pressure in mmHg

Pressure in the Apparatus is:

Atmospheric (barometric) Pressure – Vacuum Gauge Reading

Instructor will write pressure on the blackboard

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What's Happening

The volume of trapped air (in the flask) is changing with pressure
This change is measured with the syringe

Total gas volume (for each different pressure point):

Trapped air (measured later) plus syringe volume change
Barometric pressure is the pressure of the air that surrounds the apparatus
The vacuum gauge indicates the decrease in pressure within the apparatus

Pressure on the gas = barometric pressure – vacuum gauge pressure.

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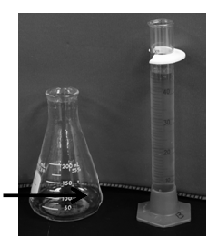
Gases Lab – Measuring Trapped Gas Volume

Disassemble the apparatus
Empty the flask to the sharpie mark
Measure volume with a 50 mL graduated cylinder

Record this as the Trapped Air (Gas) Volume.



Pour into 50 mL gradudate

Record Volume

Fill to mark

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Data Interpretation
Plot temperature versus volume graph for Part A of this experiment.
(Temperature values on the x-axis; higher temperatures on the right)
Plot the corresponding total volume of the gas in the flask values on the y-axis

Conclusion

Indicate:
Change of gas volume with change in temperature
Product of the pressure and volume of the gas at constant temperature

Hints:
If V/T = a constant (within experimental error), then V & T are directly proportional
If P x V = a constant (within experimental error), then P & V are inversely proportional

Questions:
"Molecular explanation" means think about what are the molecules doing … do not just recite the gas laws. (i.e. use Kinetic Theory of Gases)

LPT

This Lab Always Produces Good Results

Somewhere, Charles & Boyle Are Smiling

LPT

Let's Boldly Go Explore Today's Lab

LPT