Gases

Reading:	Ch 13 sections 1 - 5	Homework:	13.1 questions 6, 8 13.2 questions 18*, 20, 22, 24 13.3 questions 30*, 34 13.4 questions 42, 44 13.5 questions 50*, 52*, 58, 60, 62*

* = 'important' homework question

Background

Discussion: What do we already know about gases? Many of the concepts to be covered are based on the interpretation of 'everyday' experiences.

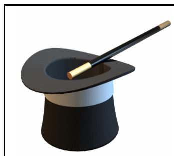
Macroscopic View:

Microscopic View:

1 atm = 760 mmHg (Torr) = 101 kPa

The behavior of a gas can be explained in terms of:

1. **Its VOLUME (in liters)**
2. **Its PRESSURE (most often in atm.)**
3. **Its TEMPERATURE (in Kelvin)**
4. **The number of MOLES (n) of gas present**



Understanding gases is all about understanding the relationships between the VOLUME, PRESSURE, TEMPERATURE and # MOLES (n) of a gas sample.

The Gas Laws

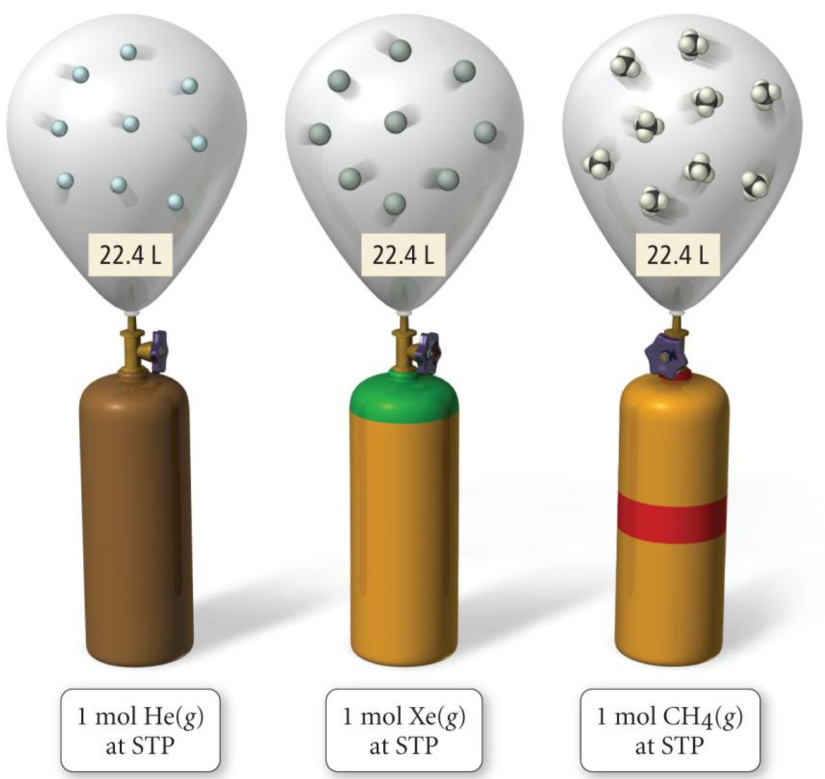
Avogadro's Law:	Relationship between # **MOLES** of gas and **VOLUME** (P and T fixed)

Everyday observation: What takes up more space, 1 mole of gas or 2 moles of gas (assume constant temp. and pressure)?

$$\mathbf{V \propto n \text{ (\# moles)}}$$

At standard temperature (273 K) and pressure (1.0 atm.), 1 mole of ANY gas occupies 22.4 L.

$$\mathbf{1 \text{ mole} = 22.4 \text{ L at STP}}$$

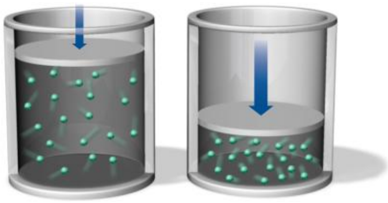


Examples:

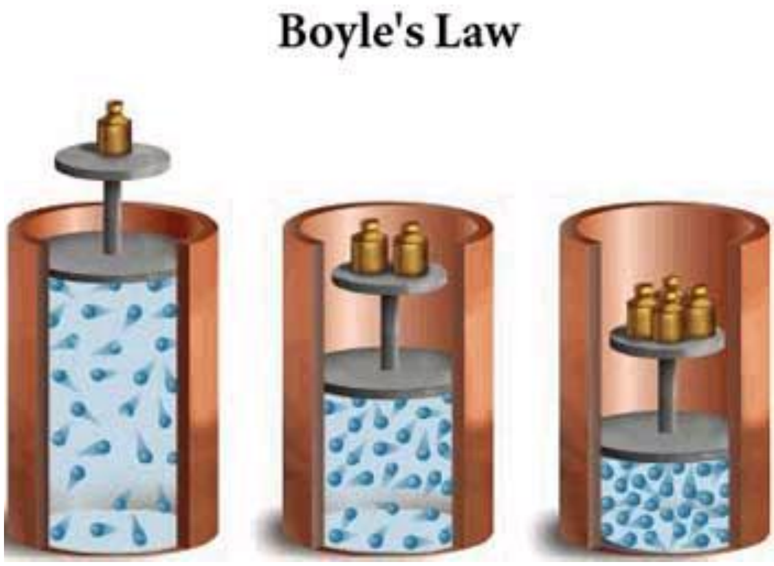
1. What volume does 3.5 moles of H_2 (g) occupy at STP?

2. How many atoms of He are there in a 5.0 L party balloon at STP?

Boyles Law:	Relationship between **PRESSURE** and **VOLUME** (n and T fixed)



Everyday observation: If you compress ('squeeze') the container a gas is in, does the gas pressure increase or decrease (assume fixed T and n).

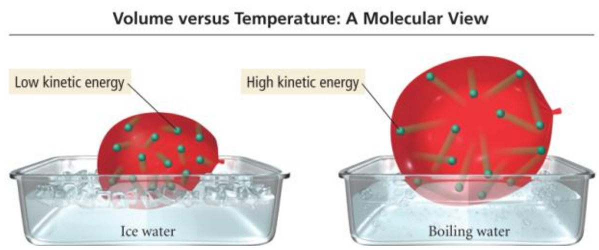


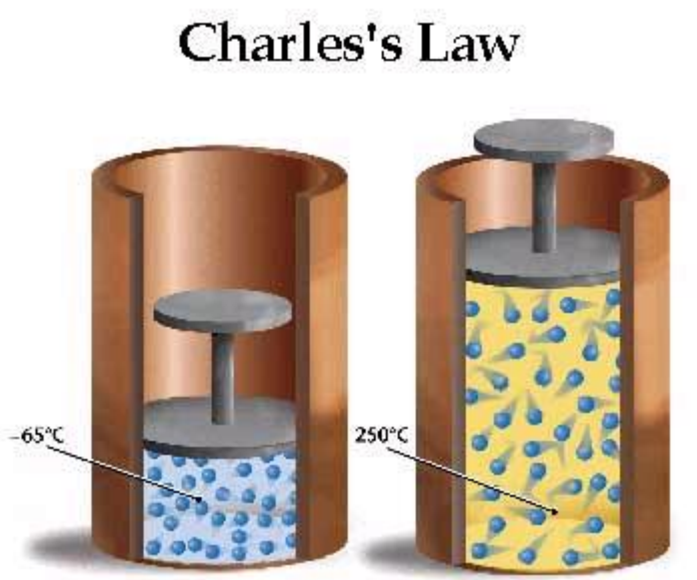
$$\mathbf{P \propto 1/V} \qquad \textbf{\textit{or}} \qquad \mathbf{PV = constant\ (table)}$$

Example: A sample of gas has a pressure of 2.0 atm. If the volume of the container the gas sample is in is decreased by a factor of 10, what is the new pressure of the gas inside? Assume T and n constant.

<u>Charles' Law</u>: Relationship between:
TEMPERATURE and **VOLUME** (n and P fixed) *or*
TEMPERATURE and **PRESSURE** (n and V fixed)*

<u>Everyday observation</u>: Why does a hot air balloon rise? What time of day is best for ballooning?





$$V \propto T$$

<u>Example</u>: A sample of gas occupies 12 L at 31°C. What volume does it occupy at 62°C? Assume P and n are constant.

The Ideal gas Law

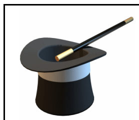
The three gas law equations can be combined to make a new equation (the IDEAL GAS LAW) that can be used to solve ANY 'static*' gas problem

<u>Derivation of the ideal gas law</u>

$$PV = nRT$$

<u>Where</u>: R = 0.08206 L atm /mol K if the atm. pressure unit is used
<u>or</u> R = 8.314 /mol K if the Pa or N/m^2 pressure unit is used

<u>Example</u>: Calcium carbonate decomposes when heated to give solid calcium oxide and carbon dioxide gas. If 250 mL of CO_2 (g) is collected at 31°C and 1.3 atm pressure, then how many moles of CO_2 (g) is collected?



Write down what you are given, *then* solve for the unknown quantity in 'static' problems

P =
V =
n =
R =
T =

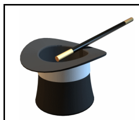
Dynamic Problems: changing P, V or T for a fixed number of moles of gas

Derivation of the 'Dynamic' (before and after) gas law

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

(before) **(after)**

Example: The pressure inside an aerosol can is 1.5 atm. at 25°C. What would the pressure inside the can be at 450°C? *Is there a moral to the story?*



As with the 'static' problems, write down what you are given *then* solve for the unknown quantity in 'dynamic' problems

$P_1 =$	$P_2 =$
$V_1 =$	$V_2 =$
$T_1 =$	$T_2 =$
(before)	(after)

"Air Bag"

The following question was taken from your 3rd practice midterm:

Question 4 (25 points): Vehicle safety 'air' bags actually inflate with nitrogen gas during collisions. If a standard car's 'air' bag has a volume of 36.0 L and inflates to a pressure of 745 Torr at 15 ^{o}C, then:

A. How many moles of N_2 (g) are contained within the inflated 'air' bag described above?

B. If the car's air bag described above was instead inflated at – 20 ^{o}C (i.e. on a Chicago winter's day), to what pressure would the 'air' bag inflate?

Extra credit: Do you think the process described in (b) would be dangerous? Explain.