Name: _____

The Gas Laws

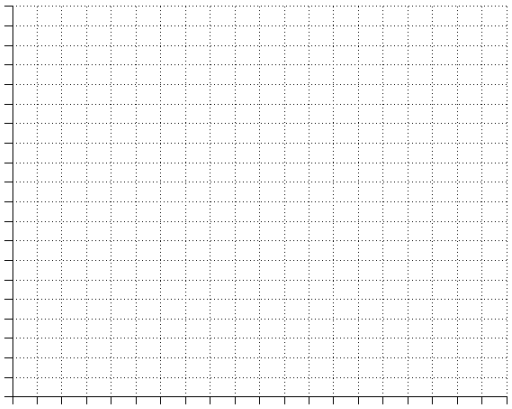
Boyle's Law

Load the following website:
http://www.physics-chemistry-interactive-flash-animation.com/matter_change_state_measurement_mass_volume/pressure_volume_boyle_mariotte_law_ideal_gas_closed_system_MCQ.htm

Pressure and Volume (constant temperature and amount)

a. Drag the plunger to change the volume of the gas (in mL). Change it in increments of 5 mL.
b. The gauge will display the pressure for that volume of gas.
c. Plot at least ten points with varying volumes on the graph below, ensure you label the axis and use an appropriate scale.

What do you notice happens to the pressure as the volume is changed?



_____

_____

_____

This relationship is known as_____.
*For a given amount of gas at a **constant temperature**, the volume of the gas is_____*
to its pressure. That is, as the pressure increases the volume _____or as the volume increases the pressure _____ .

This relationship can be expressed as:

$$V \propto \frac{1}{P}, or$$
$$V = \frac{k}{P}, where\ k\ is\ a\ constant\ so$$
$$PV = k$$

e.g. Consider the following variation of volume with pressure

Pressure (atm)	1	1.5	2	3	4	6	12
Volume (L)	12	8	6	4	3	2	1
k (constant)							

This relationship is very useful as it allows us to determine either the pressure or volume of a ***fixed amount of gas at a constant temperature*** if either the volume or pressure is changed. This can be expressed by this relationship:

$$P_1V_1 = k = P_2V_2$$

$$=$$

Sample question

An observation balloon is filled with helium gas to a volume of 40L at a pressure of 1 atm. Calculate the volume when the balloon rises to an altitude where the pressure is 0.2 atm, assuming the temperature remains constant.

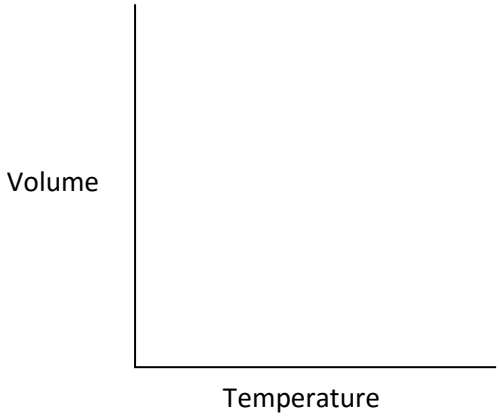
Complete questions 1-5 on page 71

Charles' Law

Load the following website:
http://www.grc.nasa.gov/WWW/K-12/airplane/Animation/frglab2.html

Volume and Temperature (constant pressure and amount (mole) of gas)

a. In the box on the left, freeze mass and pressure
b. Choose "Effect of Changing Temperature on Volume"
c. Observe the movement of the line graph.
d. Record your observation on the graph below.



What do you observe happens to the volume as the temperature changes?

_____

_____

This relationship is known as _____.
The volume of a fixed amount of gas is directly _____ *to the* ***kelvin temperature****, provided the pressure remains constant.* That is, as the temperature increases the volume _____or as the temperature decreases the volume _____ .

_____ temperature is another temperature scale like the Fahrenheit scale. However it is a bit different as there can be no negative values, like there are in the Celsius and Fahrenheit scale. The temperature 0 K (-273°C) is the theoretically lowest value and at this value all molecules have no kinetic energy. 0 K is described as _____ .
Kelvin temperature (K): $K = {}^{\circ}C + 273$

The relationship between volume and temperature can be expressed as:

$$V \propto T$$

$$\frac{V}{T} = b, where\ b\ is\ a\ constant$$

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

$$=$$

Where V_1 is the volume of a fixed amount of gas at _____ temperature of T_1.

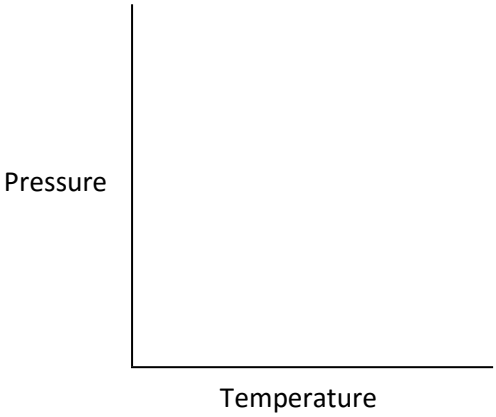
Sample question
A balloon, inflated outside on a hot day when the temperature is 40°C, has a volume of 5.0 L. What would the volume of the balloon be when it is placed in a cool store at 5°C, assuming the pressure remains constant.

Pressure – Temperature Changes

Load the following website:
http://www.grc.nasa.gov/WWW/K-12/airplane/Animation/frglab2.html

Pressure and Temperature (constant volume and amount (mole) of gas)

a. In the box on the left, freeze mass and volume
b. Choose "Effect of Changing Temperature on Pressure
c. Observe the movement of the line graph.
d. Record your observation on the graph below.



What do you observe happens to the pressure as the temperature changes?

_____

_____

The pressure of a fixed amount of gas is directly _____ *to the* ***kelvin*** *temperature, provided the volume remains constant.* That is, as the temperature increases the pressure _____or as the temperature decreases the pressure _____ .
This relation is an adaptation of _____ law.

The relationship between volume and pressure can be expressed as:

$$P \propto T$$

$$\frac{P}{T} = c, where\ c\ is\ a\ constant$$

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

$$=$$

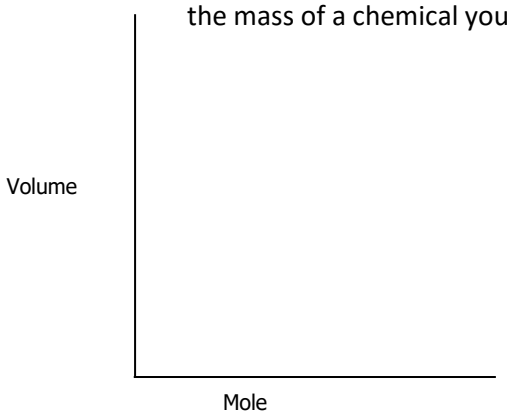
Sample question
On a 25^{O}C day before leaving for a 180 km ride a cyclist pumps his tyres to a pressure of 30 psi. At the end of the ride the cyclist measure the temperature to be 40^{o}C. Determine the new pressure of the tyre.

Complete questions on page 80

Avogadro's Law

Amount (mole) of gas and volume (constant pressure and temperature)

a. Reset the conditions in the left-hand side panel.
b. Freeze temperature and pressure this time.
c. Observe the movement of the line graph.
d. Record you observations in the graph below. Replace mass with mole as if you increase the mass of a chemical you also increase the mole of the chemical.



What do you observe happens to the volume as the number of mole increases?

_____

_____

The volume occupied by a gas is _____ *to the amount (mole) of gas present. This relationship is only true if* _____ *and* _____ *remain constant. This relationship is known as* _____ .

This relationship can be expressed as:

$$V \propto n$$
$$or\ V = an, where\ a\ is\ a\ constant$$
$$\therefore \frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Samples questions

A 0.10 mol sample of oxygen occupies 2.0 L. What volume would be occupied by 0.25 mol of oxygen? Both samples are at the same temperature and pressure.

A balloon contains 0.35 mol of helium and has a vlume of 5.3 L at a certain temperature and pressure. A further 0.12 mol of helium is added, the temperature and pressure being kept constant. Calculate the new volume of the balloon.

A cylinder, volume 20 000 L, contains methane. A second cylinder, volume 500 L, contains 40 mol of methane. Both gas samples are at the same temperature and pressure. Calculate:

- the amount of methane in the first cylinder.
- the mass of methane in the first cylinder.

Fill in the chart below with your observations and collected data. Under "Law" record the name of the law. Under "Constant" record what variables are kept constant. Under "Proportionality", record whether the two changing variables are directly or inversely proportional. Under "Graph", sketch the shape of the graph created by these two variables (you do not need to add numbers).

Variables	Law	Constant	Proportionality	Graph
Pressure and Volume				
Volume and Temperature				
Pressure and Temperature				
Amount (mole) of gas and Volume				

Combined Gas Equation

If we consider all the equations and relationships we have looked at so far:

Boyle's Law: $V_1P_1 = V_2P_2$

Charles' Law: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Pressure-Temperature Change: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Avogadro's Law: $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

These gas laws can be combined to give:

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

This relationship is useful because in realistic cases variables such as _____ , _____ , _____ and _____ will change.

In this relationship _____is always measured in _____ and the _____ is always measured in _____ . The units for volume and pressure can vary as long as they are the same for P_1 and P_2 and V_1 and V_2.

Sample questions

A 0.25 mol sample of gas in a 10.0 L cylinder exerts a pressure of 100 kPa at 208°C. A second cylinder, volume 15 L, contains gas a temperature at 100°C and a pressure of 120 kPa. What is the amount of gas in the second container?

A gas exerts a pressure of 2.0 atm, at 30°C in a 10.0 L container. In what size would the same amount of gas exert a pressure of 4.0 atm at 20°C?

Calculate the molar volume of an ideal gas at -10°C and 90.0 kPa. Molar volume at SLC (25°C and 101.1 kPa) is 24.5 L mol^{-1}.

Complete questions 3 and 4 on page 84

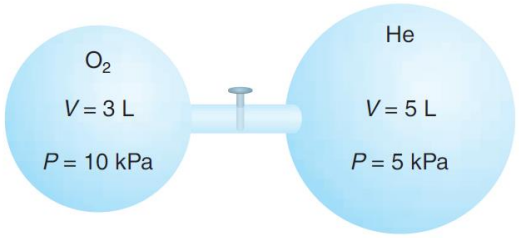
Partial Pressures – Dalton's Law

Dalton's Law of partial pressures states that, at constant temperature volume, the _____ pressure exerted by a mixture of gases is _____ to the sum of all the _____ pressures of the constituent gases.

$$P_{total} = P_1 + P_2 + P_3 + \cdots$$

where P_1, P_2, P_3, etc. represent the partial pressures exerted by the constituent gases.

Dalton's Law of partial pressures holds true because the pressure exerted by each gas irrespective of the pressure exerted by the other gas particles in the mixture.



Sample question

If the valve in the above figure determine the total pressure in the connected spheres.

Complete questions 4 & 5 pg.90

Molar Volume of a Gas

If we take **1 mole** of any gas at a given temperature and pressure it will have a set volume, this set volume is defined as the _____. This relationship can be expressed as:

$$n = \frac{V}{V_m} (at\ a\ given\ temperature\ and\ pressure)$$

As there are so many possible variations of temperature and pressure, scientists for convenience sake, have determined the molar volume (the volume occupied by 1 mole of gas) of gases at 2 different conditions. These are the _____ and _____ .

Standard laboratory conditions (SLC): the temperature is 25°C (298 K) and 101.3 kPa (this closely mimics the conditions of this room). The molar volume of SLC is _____.

Standard temperature and pressure (STP): the temperature is 0°C (273 K) and 101.3 kPa. The molar volume of STP is _____.

To try and remember these values SLC has the higher value because at a higher temperature the gas molecules have more kinetic energy and therefore will bounce around more causing the volume to expand.

Sample questions

Calculate the amount of nitrogen gas in a volume of 6.1 L measured at SLC.

Determine the volume occupied by 16.0 g of oxygen gas (O_2) at SLC.

General Gas Equation

If we consider Boyle's, Charles' and Avogadro's Law

Boyle's Law: $V = \frac{k}{P}$

Charles' Law: $V = bT$

Avogadro's Law: $V = an$

They can be combined to form the **general gas equation**

$$V = R\left(\frac{nT}{P}\right)$$

$$where\ R = k \times b \times a$$

In the **general gas equation** R is referred to as the _____.

This constant as being determined experimentally and has found to be:

$$R = 8.31\ J\ K^{-1}\ mol\text{-}^{-1}$$

Therefore the general gas equation becomes:

$$V = nRT$$

or

$$PV = nRT$$

For the value of 8.31 J K^{-1} mol^{-1} to be true,

- P is measured in _____
- V is measured in _____
- n is measured in _____
- T is measured on the _____

Gases which obey this equation are called _____ . Generally speaking only gases at _____ and _____ obey this equation.

Sample questions

Calculate the amount of oxygen gas (O_2) in a cylinder of 30 L, if the pressure is 20 atm at 30°C.

At what temperature would 3.2 g of helium occupy a volume of 25 L at a pressure of 700 mmHg?

Calculate the mass of helium in a balloon if the volume is 100 L at a pressure of 95 000 Pa and a temperature of O°C

Complete questions 6-12 on page 98