

Basic Gas Properties**Math Relationships**

Directly Proportional

Indirectly Proportional

Algebraic Equivalent

Variables

Variable	What is it?	Definition	Unit
Pressure			
Volume			
Temperature			
Amount			

Temperature Facts

	Celsius	Kelvin	Fahrenheit	Rankine
Water Boils				
Water Freezes				
Absolute Zero				

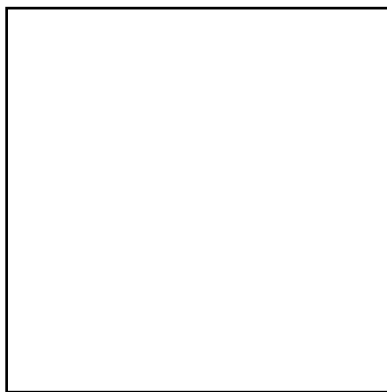
Barometers**STP****Pressure Units**

Robert Boyle

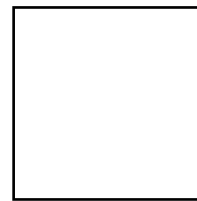
Now, Graphically

What Does This Look Like?

Rigid Container (Box)

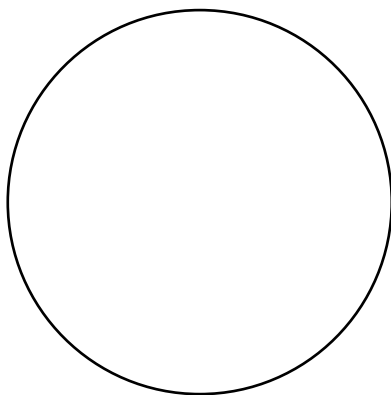


2 Liters

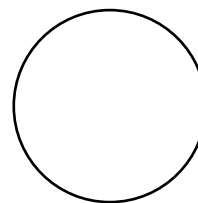


1 Liter

Flexible Container (Balloon)



2 Liters



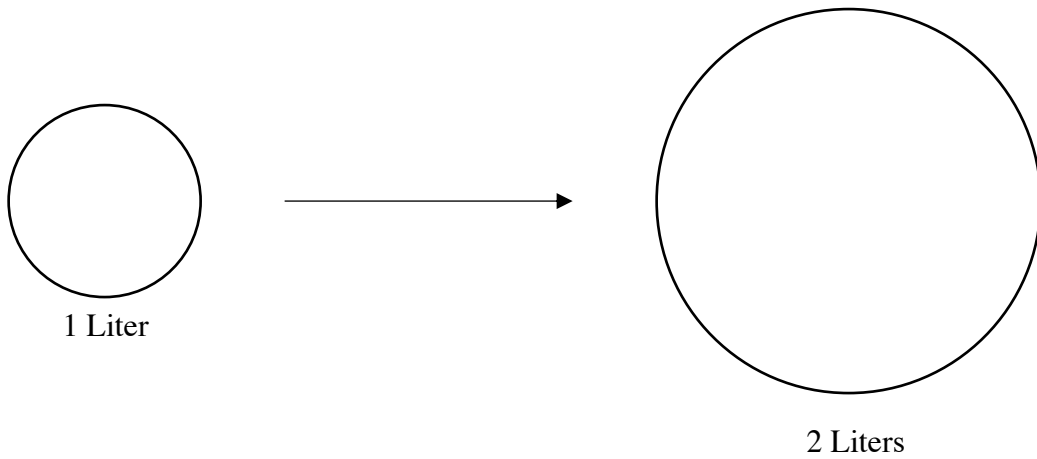
1 Liter

Jacques Charles and Absolute Zero

Graphically, Now

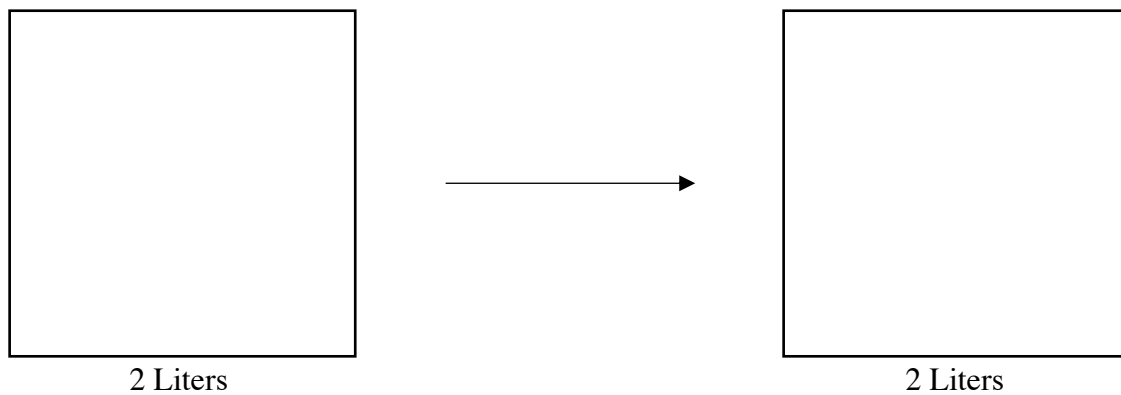
What Does This Look Like?

Flexible Container (Balloon)



Joseph Gay-Lussac

What Does This Look Like?



Combined Gas Law**Amadeo Avogadro****Ideal Gases**

1)

2)

3)

4)

Ideal Gas Law

$$R = 0.0821 \frac{\text{liter atm}}{\text{mol K}} = 62.4 \frac{\text{liter mmHg}}{\text{mol K}} = 62.4 \frac{\text{liter torr}}{\text{mol K}} = 8.31 \frac{\text{liter kPa}}{\text{mol K}}$$

1) 25.00 grams of Neon are held at 2.99 atm and 400. Kelvin. What is the volume of the sample?

2) If an ideal gas is held at STP and occupies 35.4 L how many moles of the ideal gas are present?

3) What is the pressure exerted by 64.00 g of oxygen gas at 273 Kelvin in 1.00 liter?

4) What is the temperature of a sample of 1.00 moles of Xenon held in a 3.75 L container at 1.25 atm?

Molar Volume

5) What is the volume of one mole of an ideal gas at STP?

6) What is the volume of one mole of an ideal gas at 25 Celsius and 1.00 atmosphere?

7) Fill in the following table:

Pressure	Volume	Moles	Temperature
7.5 atm	1.50 liter	0.25 moles	
750 torr	7.50 liter		273 Kelvin
125 kPa		2.50 moles	100.0 Celsius
	5.25 L	3.55 moles	100 Kelvin

Stoichiometry

Molecules of A ----- Moles of A ----- Mass of A ----- Liquid Volume of A

Balanced Chemical Equation

Molecules of B ----- Moles of B ----- Mass of B ----- Liquid Volume of B

1) How many liters of carbon dioxide will form at STP from the reaction of 50.0 grams of CaCO_3 with excess hydrochloric acid?

Reaction

Calculations

2) Oxygen gas is prepared by the decomposition of KClO_3 . If you need 1.00 L of oxygen gas, how much KClO_3 do you need to start with at STP?

Reaction

Calculations

3) Hydrogen chloride gas is produced by the decomposition of ammonium chloride. How many liters of HCl can be produced by the reaction of 250.0 g of ammonium chloride at STP?

Reaction

Calculations

4) Calcium hydride reacts with water to produce hydrogen gas. How many grams of calcium hydride are needed to produce 10.0 L of hydrogen 27°C and 740 torr?

Reaction

Calculations

5) C_2H_2 gas is produced in miner's lamps by reacting CaC_2 with water. What volume of C_2H_2 at 755 torr and 24°C can be produced by 1.00 g of CaC_2 with excess water?

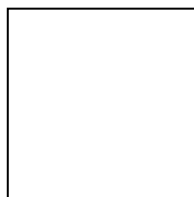
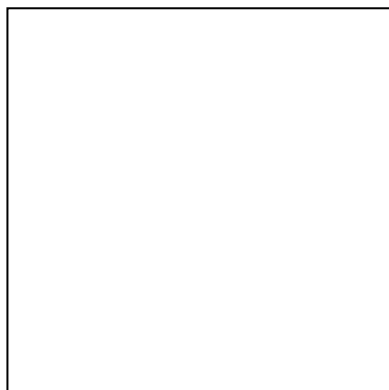
Reaction

Calculations

Gas Density and Determining Molar Masses

Can we solve the ideal gas law for molar mass or density even if we do not see it in the equation?

What does density look like at the molecular level?



- 1) What is the density of uranium hexafluoride at STP?
- 2) What is the density of uranium hexafluoride at 500. K and 0.500 atm?
- 3) What is the density of carbon tetrachloride at 714 torr and 125°C?
- 4) You have a gas that is either SO_2 or SO_3 . To identify which one it is you measure the density of the gas to be 2.67 g/L at 1.00 atm and 25°C. Which gas is it?

Now you try!

5) What will the density be of PF_5 at STP? (Answer 5.62 g/L)

6) You have data showing that a gas is 92.24% C and 7.76% H. If 632 mL of the gas at 750 Torr and 27°C has a mass of 0.65 g what is the molecular formula of the gas? (Answer C_2H_2)

7) A compound containing 37.5% carbon, 49.9% oxygen, and 12.6% hydrogen was vaporized. What is the empirical formula of the gas? The gas is found to exert 740 torr at 95°C in a 270 mL vessel. If the mass of the gas was 0.276 g what is the molar mass and molecular formula of the compound? (Answer CH_4O or more properly CH_3OH)

Gas Mixtures

Dalton's Law

Collecting a gas over water:

Can you collect all gases over water?

1) Hydrogen gas is collected by water displacement until the pressure in the gas collection tube matches the atmospheric pressure of 755 torr at 25°C. What is the pressure of hydrogen gas in the tube if the vapor pressure of the water is 23.76 torr at this temperature?

2) What mass of water is present in a sample of wet nitrogen collected at 35°C and 735 torr in a 250.0 mL container? The vapor pressure of water at 35°C is 42.18 torr.

The Kinetic Nature of Matter

The Ice Cream Graph

What determines how fast molecules move? Root Mean Square Velocity

Diffusion vs. Effusion

The NH_3/HCl experiment

Thomas Graham

1) A sample of uranium hexafluoride flows at 15 mL/minute. If a second gas at the same temperature flows at 43.92 mL/min what is the molar mass of the second gas?

2) How much faster does nitrogen gas flow than oxygen gas at the same temperature?

3) If water vapor flows at a rate of 25.0 mL/min at what rate will helium gas flow at the same temperature?

Ideal Gases versus Real Gases

Which assumptions are not correct? Why

1)

2)

Graphs!

What are the best conditions for a gas to behave most ideally?

What can we do to account for this?

Van der Waals

$$\left(P + a \left(\frac{n}{V} \right)^2 \right) (V - nb) = nRT$$

Berthelot

$$\left(P + \frac{n^2 a}{TV^2} \right) (V - nb) = nRT$$

Reidlich and Kwong

$$\left(P + \frac{n^2 a}{T^{\frac{1}{2}} V (V - nb)} \right) (V - nb) = nRT$$

Virial Expansion:

$$\frac{PV}{nRT} = 1 + B(t) \frac{n}{V} + C(t) \frac{n^2}{V^2} + D(t) \frac{n^3}{V^3} + \dots$$

Review of basic gas laws**Boyle's Law**

1) What's the pressure when 10.0 L of argon at 5.00 atm is compressed to 5.0 L?

(Answer 10. atm)

2) What is the volume when 15.0 L of neon at 7.55 atm is subjected to 11.55 atm?

(Answer 9.81 L)

3) A sample of gas is at 755 torr and has a volume of 1500 mL. If it is compressed by half what is the new pressure?

(Answer 1510 torr)

Charles' Law

4) What is the volume when 3.75 L of Neon at 25 Celsius is heated to 35 Celsius?

(Answer 3.88 L)

5) If 7.50 liters of helium at 25 Celsius is expanded to 13.50 liters what is the new temperature?

(Answer 536 K)

6) A sample of Helium has a volume of 10.0 L at STP. The volume is expanded to 15.0 L. What is the new temperature? (Answer 410 K)

Combined Gas Law

7) 17.5 L of Helium at STP is heated to 300 Kelvin and 2.00 atm. What is the new volume of the sample?
(Answer 10 L)

8) 10.00 liters of a gas is at 2.00 atmospheres at 100 Kelvin. If it is heated by 50 Kelvin and it expands to 15.00 liters what is the new pressure? (Answer 2. atm)

9) You have 25.0 mL of Hydrogen at STP. If the pressure is increase to 2.00 atm and the volume to 30.0 mL what is the new temperature? (Answer 655 K)

Gay Lussac's Law

10) If a gas exerts 10.0 atmospheres at 25°C what pressure will it exert at 50°C?
(Answer 10.8 atm)

11) If a gas exerts 760 torr at 298 K what temperature will cause it to exert 660 torr?

(Answer 259 K)

12) A cylinder has a gas at 5.00 atm at 298 K. What temperature is necessary to increase the pressure to 7.50 atm? (Answer 447 K)