High School Science Virtual Learning

College Chemistry

Stoichiometry of Gases

April 13th, 2020

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Lesson: April 13th 2020

Objective/Learning Target:
The Learner will be able to apply stoichiometric principles to perform calculations involving Gases under non-standard conditions, calculate Density and Molecular mass. The learner will also be able to describe how an ideal gas differs from a non-ideal (real) gas.

Bell Ringer

Question 1

What are the Standard Conditions or STP?

Question 2

What is the Ideal Gas Equation?

Bell Ringer Answers:

1. STP = 0ºC or 273 K and 1 atm
2. PV = *n*RT

   P= Pressure in atm

   V= Volume in Liters

   n = number of moles

   R = gas constant 0.0821atm L/mol K

   T = temperature in Kelvin

In Stoichiometry up until this point, when we have used gases, we have assumed STP so that we can use the conversion 1 mol = 22.4 L. In today's lesson we are going to learn how to combine the Ideal Gas Equation with the stoichiometry to correct for non-standard conditions. Less face it we are rarely at exactly 0°C and 1 atm so this is an important concept for chemist that deal with gases.

Instruction: Watch the video below on Stoichiometry with gases under non-standard conditions.

Be sure to take notes and write down the example problem for reference later.

Gas Stoichiometry: Equations part 2 Tyler DeWitt

BEWARE: Often in problems they like to use pressure units other than “atm” needed for the Gas Constant:
“R”= 0.0821 L atm/Mol K

You must convert the pressure to atm before you can put it into the Ideal Gas Gas equation PV=nRT.

Use the chart on the next slide to make the conversions necessary.

The table below shows the different commonly used units of measuring gas pressure. Use this table in the pressure unit conversions.

Unit	Abbreviation	1 atm equivalent
atmosphere	atm	1.00 atm (exact)
millimeters of mercury	mmHg	760 mmHg
torr	torr	760 torr
inches of mercury	in. Hg	29.9 in. Hg
pounds per square inch (psi)	$lb/in.^2$	14.7 $lb/in.^2$
pascal	Pa	101,325 Pa

Practice Problem 1:

$$2NH_{3(g)} + H_2SO_{4(aq)} \longrightarrow (NH_4)_2SO_{4(aq)}$$

Calculate the volume of NH_3 (in Liters) needed at 20 ^oC and 25.0 atm to react with 150 kg H_2SO_4

Practice Problem 1 solution:

Step 1: Convert 150 kg H_2SO_4 grams (multiply by 1000g/1kg)

Step 2: Convert to moles (150000 g H_2SO_4 x 1mol/98.09 g)

Step 3: Multiply by the mol to mole ratio

1530 mol H_2SO_4 x (2 mol NH_3/1 mol H_2SO_4)

Step 4: Assemble your PV=*n*RT Variables

P= 25.0 atm V=? *n*= 3060 mol NH_3 R=0.0821atm L/mol K

T= (20 ^oC + 273)= 293 K

(cont)

Practice Problem 1 solution continued:

Step 5: Rearrange PV= *n*RT to solve for V by dividing by P

$$V = nRT/P$$

Step 6: Plug and Chug:

$$V = \frac{3060\ \text{mol}\ NH_3 * 0.0821\ \left(\frac{\text{atm L}}{\text{mol K}}\right) * 293\text{K}}{25.0\ \text{atm}}$$

V= **2941 L NH_3** (all the units cancel except L, which is the unit you want so you have a good chance you set it up correctly)

Density and Molecular Mass

Now we are going to use the Ideal Gas Equation, PV=nRT, to do calculations involving Density of a Gas and Molecular Mass of a gas.

Remember that Density = Mass/Volume or for a gas= grams/Liters

Also *n*=number of moles we find that by grams/Molar Mass or little m over BIG ITALIC M m/*M*

In addition V is measured in Liters

(cont.)

Density and Molecular Mass

So we will substitute in m/*M* for n and we get:

PV = m/*M*RT and rearrange to get m/V=P*M*/RT

m/V = Density(D) substitute and get D=P*M*/RT

Watch this video, take notes and then we will do some practice.

[Ideal Gas Law Practice Problems with Density- Tyler DeWitt]

Density Practice Problem:

A sample of gas of mass 2.929 g occupies a volume of 426 mL at 0o C and 1.00 atm pressure. What is the molecular weight of the gas?

Density Practice Problem Answer:

Step 1: Rearange m/V=P*M*/RT to get Big *M* by itself by multiplying both sides by RT/P you will end up with;

M= mRT/PV

Step 2: Gather your variables;

m=2.929 g **R**= 0.08206 (L atm/mol K) **T**= (0°C + 273K) Must be K **P** = 1 atm (must be atm)

V= (426 ml x 1L/1000ml) = 0.426L (must be in Liters)

Density Practice Problem Answer: (cont)

Step 3: Plug and Chug; $M = mRT/PV$

M= 2.929g (0.08206(~~L atm~~/~~mol~~ ~~K~~))(~~273K~~)/~~1.00 atm~~)(~~0.426L~~)

M=154 g/mol (notice the units g and mol do not cancel which are the correct units for Molecular Mass

You practice Density and Stoichiometry:

Try these problems from the end of the chapter in your textbook. If you don't have your book at home access them here:

https://openstax.org/books/chemistry-atoms-first-2e/pages/8-exercises

The answers to these selections are in the back of the book, or click on the number online and it will take you to the answer.

#49, #51, #55, #65, #67

Non-ideal Gases:

Watch this Crash Course on “Real” Gases

Real Gases: Crash Course

Note: In this video they use a different constant “R”. This is because they are using kPa for pressure instead of **atm**, our book and the college uses **atm**. You can calculate a constant for any unit of pressure, but that would take up a lot of brain space. For our problems, convert to atm first.

Non-ideal Gases Practice Problems:

Question 1: Which properties of gases does the ideal gas equation ignore?

Question 2: Under which conditions are the properties in number 1 important?

Question 3: What is the most important lesson of the video?

Non-ideal Gases Answers:

Question 1: The actual volume of the individual gas molecules and the intermolecular attraction between molecules.

Question 2: Low Temperature and/or High Pressure

Question 3: Never give up!!!!!!

Practice “Real” Gases:

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#101, 103, 105

Extra Practice:

Gas Stoichiometry (both STP and non-STP)

Gas Stoichiometry Quizizz

Summary of all Ideal Gas Calculations, Partial Pressure, Diffusion

Gas Review Quizizz

Extra videos

Ideal Gas Law problems with Molar Mass- Tyler DeWitt

Non-Ideal Gases and the Van der Waals Equation - Professor Dave Explains