Chem1311Ch5Ep2 Transcript

00:00:01

Hello, and welcome to the second episode of Gases and gas laws.

00:00:10

Previously, in gases and gas laws, we explored the physical characteristics of gases.

00:00:20

We defined pressure and carried out unit conversions with it.

00:00:30

And we considered Boyles law, Charles Law, and Avogadro's Law.

00:00:40

In today's episode.

00:00:44

We will derive the ideal gas law from Charles', Boyle's and Avogadro's laws.

00:00:55

We will calculate the value of the gas.

00:00:58

Constant from the molar volume of a gas.

00:01:07

And we will use the ideal gas law and the combined gas law to solve for pressure, volume, temperature or number of moles.

00:01:22

We previously learned that according to Boyle's Law, when the pressure of a gas decreases, its volume will increase, as long as the temperature and number of moles remain unchanged.

00:01:36

This diagram illustrates that point.

00:01:46

We also learned that according to Charles Law.

00:01:49

The volume of a gas increases with increasing temperature, as long as the pressure and number of moles remain constant.

00:02:00

Likewise, pressure will increase with increasing temperature.

00:02:05

Is the volume and number of moles remain constant?

00:02:13

And we learned that according to Avogadro's Law.

00:02:17

The volume and the number of moles of gas are directly proportional.

00:02:22

If the temperature and pressure remain constant.

00:02:36

The ideal gas equation is derived from these gas laws.

00:02:45

Boyle's law states that the pressure is inversely proportional to the volume.

00:03:00

Logically, that also means that the volume is inversely proportional to the pressure.

00:03:10

Charles Law states that volume and temperature are proportional.

00:03:16

Or directly proportional if you prefer.

00:03:21

And Avogadro's law states that the volume.

00:03:25

Is proportional to the number of moles.

00:03:37

If we combine all three statements into one.

00:03:46

Then we have an all-inclusive proportionality statement.

00:03:58

To write it as an equation, we simply need to introduce a constant.

00:04:09

“R” is the symbol for the gas constant, and that's just the constant we need.

00:04:30

To arrive to the final form of the ideal gas law.

00:04:35

PV is equal to nRT.

00:04:38

Wow, it even sounds pleasant.

00:04:49

But we need to find the value of R to make this equation useful.

00:04:56

R is a gas constant, so you can expect that problems will not give you that information.

00:05:04

You'll simply need to remember it.

00:05:13

The standard temperature of gases is 273.15 Kelvin or zero degrees Celsius.

00:05:21

And the standard pressure is 1 atmosphere.

00:05:26

Logically chosen quantities.

00:05:29

Together they are called the standard temperature and pressure or STP.

00:05:37

Often times, to save writing you will come across that term STP and be expected to understand that means.

00:05:48

Zero degrees Celsius and one atmosphere pressure.

00:05:56

An interesting fact is that at STP the molar volume of any gas is 22.414 liters.

00:06:08

Regardless of whether it's helium, oxygen, air or whatever.

00:06:14

All of them.

00:06:16

At STP will occupy 22.4 liters.

00:06:21

And just to give you an idea of how much that is, this photo shows you for comparison that quantity.

00:06:39

If we take the ideal gas law and substitute the values corresponding to a mole of gas at STP.

00:06:48

We can actually find the value of R.

00:07:06

And if we solve it.

00:07:08

That is why we use 0.0821 liter-atmosphere per Kelvin-mole as the gas constant.

00:07:19

A very useful quantity to know.

00:07:23

Write it down.

00:07:32

Another formula that can be derived from the ideal gas law is the combined gas law.

00:07:44

If you consider.

00:07:47

Two gas samples.

00:07:49

Or even one gas sample under different conditions.

00:07:53

You can use this combined gas law.

00:08:05

Because if two polynomials are both equal to a third.

00:08:11

Then they must be equal to each other.

00:08:19

This is the combined gas law.

00:08:23

Because it combines pressure, volume, moles and temperatures, or is a combination of the previous gas laws.

00:08:45

The ideal gas law and the combined gas law will suffice to solve the vast majority of the gas law problems you will encounter.

00:08:55

You really will not be using the individual gas laws like Charles and Boyle's laws.

00:09:07

You will use the ideal gas law when there is only one set of conditions.

00:09:14

And you will use the combined gas law when a sample is subjected to change.

00:09:26

Let's put it in practice.

00:09:29

Here's our first example.

00:09:34

We will use the ideal gas law because we were only given one volume, one temperature and one number of moles.

00:09:49

The ask is pressure.

00:09:52

So we will have to solve.

00:09:55

For pressure.

00:10:04

Now we simply substitute the values for each variable.

00:10:10

Notice that the gas constant was not in the problem.

00:10:15

Because you already memorized it, didn't you?

00:10:18

I know you did.

00:10:22

Then we proceed to cancel all excess units just to be sure we got it all right.

00:10:31

There goes the moles.

00:10:34

And the liters.

00:10:38

And the Kelvin.

00:10:41

To end up with units of atmospheres.

00:10:48

And our final answer is 9.42 atmospheres.

00:11:02

Notice that the temperature was changed to Kelvin.

00:11:06

This is non-negotiable.

00:11:10

You must always use Kelvin temperatures.

00:11:14

And if you are using the ideal gas law.

00:11:16

Your pressure must be in atmospheres.

00:11:26

The next problem.

00:11:27

Will also require us to use the ideal gas law.

00:11:39

The ask is “what volume?”

00:11:41

So we will have to solve for volume.

00:11:51

The amount of gas we were given is in units of grams, so we will have to first convert it to moles so we can fit it in our equation.

00:12:13

Now that we have our answer.

00:12:17

We will be using the standard temperature and pressure.

00:12:22

So we can substitute all the variables now for the given values.

00:12:31

And also as always, make sure that the excess units cancel.

00:12:40

This gives us an answer of 9.74 liters.

00:12:44

As the volume.

00:12:56

This next example has two different pressures, so we will be using the combined gas law.

00:13:07

When using the combined gas law.

00:13:11

Identify any variables that remain constant.

00:13:20

We are told that the temperature is constant.

00:13:24

And because no gas escapes.

00:13:27

The number of moles will also be constant.

00:13:31

Therefore, they can be eliminated from our equation before we get started.

00:13:37

With what remains, the ask is the final volume, so we will have to solve for it.

00:13:48

And now we're ready.

00:13:54

Now we substitute the variables for the given values.

00:13:58

Making sure to cancel all excess units.

00:14:03

To get a final volume of 1.4 liters.

00:14:23

This next example.

00:14:25

Has two different temperatures, so we'll once again be using the combined gas law.

00:14:37

We are told that the volume is constant.

00:14:41

And since no gas is lost.

00:14:44

The number of moles is also constant.

00:14:53

The ask is the final pressure.

00:14:56

So we must solve for it.

00:15:07

We then substitute the variables for the given values.

00:15:14

And we cancel Kelvin.

00:15:17

For a final answer of 1.48 atmospheres pressure.

00:15:35

The next example has two temperatures and two pressures.

00:15:40

So we will be using the combined gas law.

00:15:50

The amount of gas remains constant, so we can eliminate it as a variable.

00:16:00

And the askis the final volume.

00:16:03

So we will have to solve for it.

00:16:14

Next, we will substitute the given values for the variables.

00:16:24

We will then cancel all excess units.

00:16:28

And finally.

00:16:31

We get a final answer of 14 milliliters.

00:16:41

Always make sure that your units cancel when solving a problem.

00:16:46

It is possible that you may need to do unit conversions before you substitute all your values.

00:17:00

And that's all there is.

00:17:02

There isn't anymore.