Transformation
T-STEM 2013
New Directions | New Pathways | New Outcomes

Ideal Gas Law Activity

Overview
The ideal gas law captures the relationship between the pressure, volume, number of moles, and temperature of a gas. In this activity, students discover the relationships between pressure, volume and temperature. They also compute pressure or volume when given appropriate information.

The IdealGasLaw virtual instument, VI, is used in this activity to provide a graphical view of the relationships between pressure, volume, and temperature. The VI is also used to compute unknown values as a check for students' work.

Objectives
Students will be able to:

- Describe the relationships between pressure, volume and temperature of a gas.
- Compute pressure or volume using the ideal gas law and appropriate information.

Standards (TEKS)
Chemistry 7AB

Activity
The ideal gas law establishes the relationship between the **pressure**, **volume**, number of **moles**, and **temperature** of a gas. The law states $PV = nRT$, where

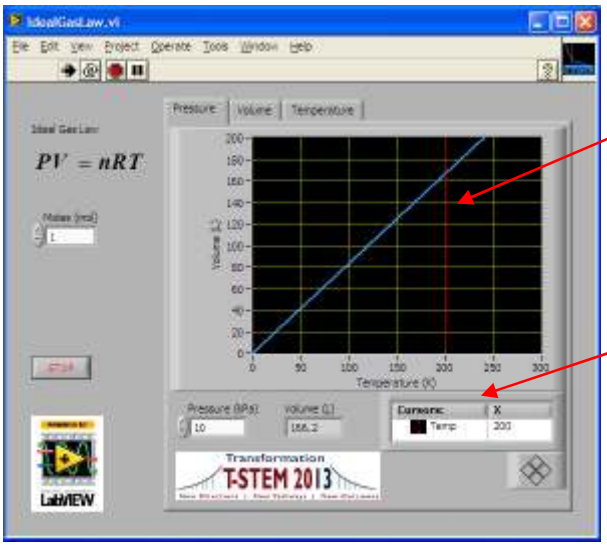
P = pressure
V = volume
n = number of moles of gas
R = ideal gas constant
T = temperature

This activity uses $n = 8.31\frac{\text{L(kPa)}}{\text{(mol)K}}$ as the **ideal gas constant**.

1) Open and run the IdealGasLaw virtual instrument, VI.

On the IdealGasLaw VI you will see a control for setting the number of moles of gas as well as a set of tabs – Pressure, Volume, and Temperature. Each tab has a control for one of the quantities and a graph showing the relationship between the other two.

For example, the Pressure tab has a control to set the pressure and a graph of volume versus temperature. In the graph, you will also see a red vertical line, the cursor.



The position of the cursor controls the temperature used to calculate the volume displayed below the graph. You can click and drag on the vertical line of the cursor to control the temperature or you can enter a value into the cursor legend.

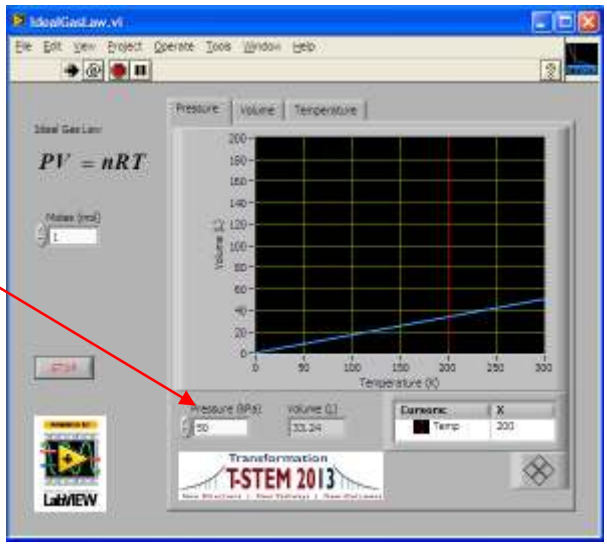
2) If you have a different tab showing, click on the Pressure tab to bring it front.

You will see a graph showing the relationship between temperature and volume for a given pressure. Let's start by seeing what happens to volume when pressure is held constant and the temperature is changed.

3) Set the pressure to 15 kPa. From the graph, what do you expect to happen to the volume of gas if the temperature
    a) increases?
    b) decreases?
4) With pressure remaining constant, use the cursor to increase the temperature. What happens to the volume?
5) Use the ideal gas law to calculate the volume in liters of 1 mole of a gas at a pressure of 100 kPa for each of the following temperatures.
    a) 100 K
    b) 200 K
    c) 300 K
6) Check your answers using the VI.
7) In your own words, describe the relationship between temperature and volume.

Next, let's see what happens to volume when the temperature is held constant and the pressure is changed.

8) Use cursor or cursor legend to set temperature to 200 K.
9) Start with the pressure set to 50 kPa and then use the increment arrows to slowly increase the pressure.

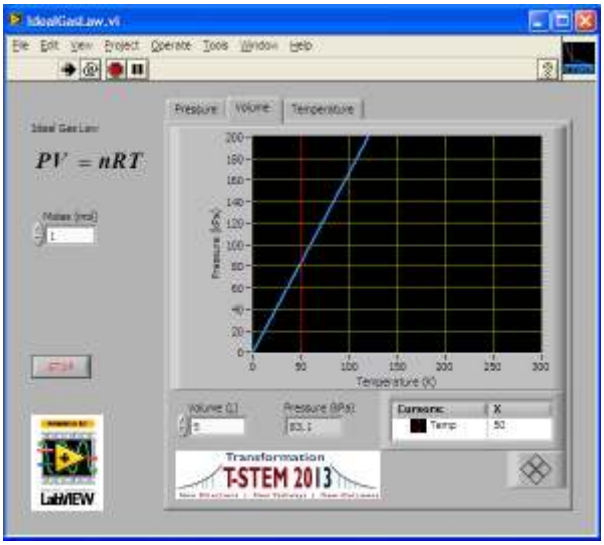


a) What happens to the volume when temperature is held constant and the pressure is increased?
b) What would happen to the volume when temperature is held constant and pressure is decreased?

10) Use the ideal gas law to calculate the volume in liters of 3 moles of a gas at a temperature of 110 K for each of the following pressures. (Hint: May be easier to solve $PV = nRT$ for V and then plug in values.)
    a) 50 kPa
    b) 100 kPa
    c) 150 kPa
11) Check your answers using the VI.
12) In your own words, describe what happens to the volume of a gas when the temperature is held constant and the pressure changes.

The Volume tab has a graph showing the relationship between temperature and pressure for a given volume. You can use this tab to investigate the relationship between temperature and pressure.

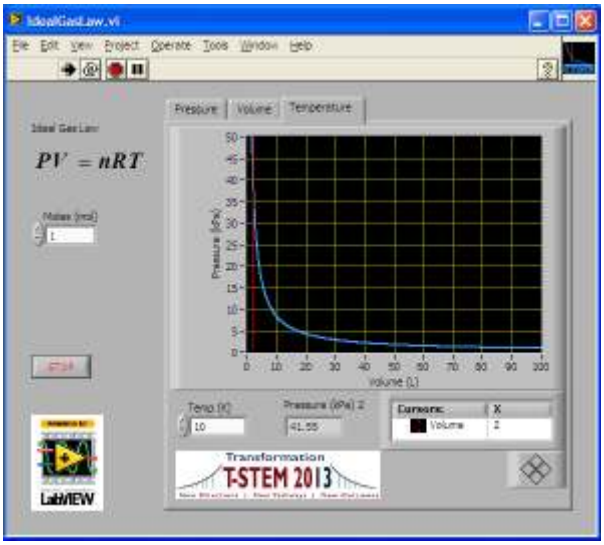
13) Click on the Volume tab to bring it front.
14) Set the volume to 5 L. From the graph, what do you expect to happen to the pressure of gas if the temperature
    a) increases?
    b) decreases?



15) With volume remaining constant, use cursor to increase temperature. What happens to the pressure?
16) With volume still constant, use cursor to decrease temperature. What happens to the pressure?
17) Use the ideal gas law to calculate the pressure in kilopascals (kPa) of 2 moles of a gas at a volume of 55 L for each of the following temperatures.
    a) 100 K
    b) 200 K
    c) 300 K
18) Check your answers using the VI.
19) In your own words, describe the relationship between temperature and pressure.

The Temperature tab has a graph showing the relationship between volume and pressure for a given temperature. You can use this tab to further investigate the relationship between volume and pressure.

20) Set the temperature to 10 K.
21) Starting with the volume set to 2 L, use the cursor to increase the volume.
    a) What happens to the pressure when temperature is held constant and the volume is increased?
    b) What would happen to the pressure when temperature is held constant and volume is decreased?



22) Use the ideal gas law to calculate the pressure in kilopascals (kPa) of 1 mole of gas at a temperature of 270 K with each of the following volumes. (Hint: May be easier to solve $PV = nRT$ for P and then plug in values.)
    a) 20 L
    b) 40 L
    c) 60 L
23) Check your answers using the VI.

When variables change in relationship to one another, sometimes they will change together. That is, if one variable gets doubled so does the other variable. For example, if you buy water by the gallon and you buy twice as many gallons, you will pay twice as much. We call this **direct variation**.

Sometimes the change is opposite. That is, as one variable gets larger, the other gets smaller. We call this **inverse variation**. For example, if you are splitting a pizza equally among friends, then the more friends you include, the less pizza you each get.

24) Is the relationship between the volume and pressure of a gas an example of direct or inverse variation? Explain.
25) Is the relationship between the pressure and temperature of a gas an example of direct or inverse variation? Explain.
26) Is the relationship between the temperature and volume of a gas an example of direct or inverse variation? Explain.
27) Stop the VI. You are done.