2 Ideal Gas Law

The **ideal gas law** relates the pressure, volume, temperature, and number of moles for a gas sample.

> **Ideal Gas Law**
>
> The product of the pressure, P, and volume, V, of a gas is proportional to the product of the number of moles, n, and the temperature, T.
>
> $$PV = nRT$$
>
> The two products are related by the constant, R.
>
> $$R = 0.082\,\frac{\mathrm{L \cdot atm}}{\mathrm{mol \cdot K}}$$

The **universal gas constant,** R, is the same for all gases.

Because R has units of L · atm/mol · K, you can use this value of R only if volume is measured in *liters*, pressure in *atmospheres,* temperature in *kelvins,* and number of gas molecules in *moles.* When these units are used, R is always equal to 0.082 L · atm/mol · K.

If you know three of the four variables for any gas sample, you can use the ideal gas law to calculate the fourth variable. This is most useful in determining the moles of gas molecules in a gas sample because the pressure, volume, and temperature can be easily measured.

Example

Moles of Air on Mount Everest

How many moles of air are in a 0.5 L breath on top of Mount Everest? The pressure is 0.33 atm and the temperature is 254 K.

Solution

The ideal gas law relates all these quantities. Insert the values for P, V, T, and R into the equation and solve for n.

$$PV = nRT$$

$$(0.33\ \mathrm{atm})\ (0.5\ \mathrm{L}) = n\left(0.082\,\frac{\mathrm{L \cdot atm}}{\mathrm{mol \cdot K}}\right)(254\ \mathrm{K})$$

$$n = \frac{(0.33\ \mathrm{atm})(0.5\ \mathrm{L})}{\left(0.082\,\frac{\mathrm{L \cdot atm}}{\mathrm{mol \cdot K}}\right)(254\ \mathrm{K})}$$

$$n = 0.008\ \text{mol of air}$$

So there is only 0.008 mol of air molecules in a 0.5 L breath of air atop Mount Everest.

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Topic: Gas Laws

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Key Terms

ideal gas law

universal gas constant, R

Lesson Summary

How can you calculate the number of moles of a gas if you know *P*, *V*, and *T*?

Any sample of gas can be described by four variables: pressure, volume, temperature, and moles. The ideal gas law relates these four variables to each other mathematically: $PV = nRT$, where R is the universal gas constant. The value of R is 0.082 L · atm/mol · K for all gas samples if units of atmospheres, liters, moles, and kelvins are used. If you know three of the four variables for any gas sample, you can use the ideal gas law to calculate the fourth variable.

EXERCISES

Reading Questions

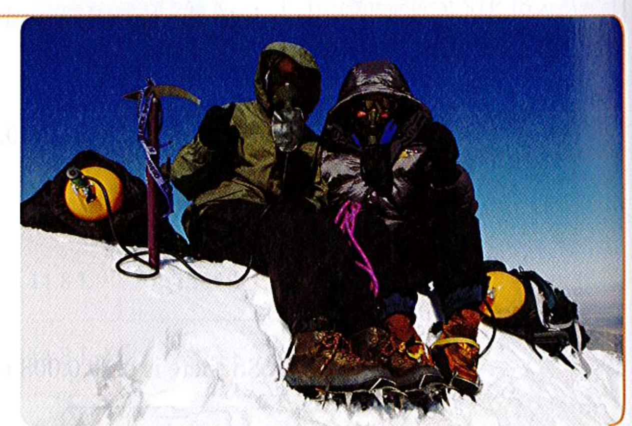
1. What is the ideal gas law?
2. Describe when you might want to use the ideal gas law.

Homework

3. How many moles of hydrogen, H_2, gas are contained in a volume of 2 L at 280 K and 1.5 atm?
4. What volume would 1.5 mol of nitrogen, N_2, gas occupy at standard temperature and pressure?
5. Find the pressure of 3.40 mol of gas if the gas temperature is 40.0 °C and the gas volume is 22.4 L.
6. How many moles of helium, He, gas are contained in a 10,000 L weather balloon at 1 atm and 10 °C?
7. Suppose you have 1.0 mol of gas molecules in 22.4 L at STP. Describe three ways you can get a gas pressure of 0.50 atm.
8. Will the pressure of helium, He, gas be the same as the pressure of oxygen, O_2, if you have 1 mol of each gas, each at a volume of 22.4 L and each at 273 K? Explain your thinking.

HEALTH CONNECTION

Altitude sickness occurs at high altitudes when people cannot get enough oxygen from the air. It causes headaches, dizziness, lethargy, nausea, and lack of appetite. It can be quite dangerous for mountain climbers.



LESSON

18 Feeling Humid

Humidity, Condensation

Think About It

Exercising can make you work up a sweat. Sweating helps to regulate your body temperature. When a breeze blows across your sweaty forehead, you may notice your skin feels cooler. However, on a humid day, with a lot of moisture in the air, it seems as if no amount of sweating helps you to cool down.

What is humidity and how is it measured?

To answer this question, you will explore

1. Evaporation and Condensation
2. Humidity
3. Relative Humidity

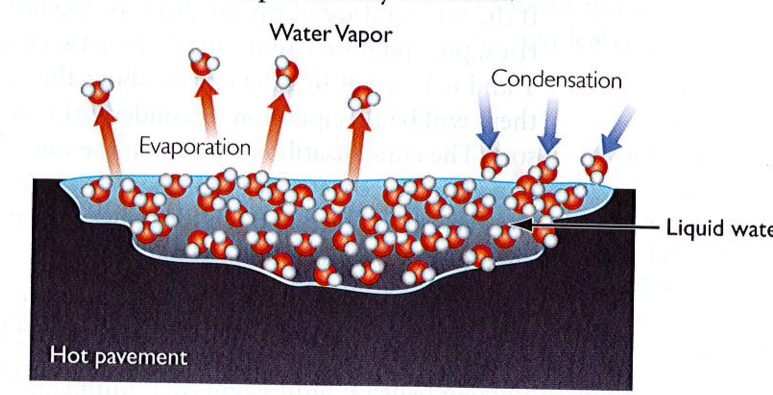
Exploring the Topic

1 Evaporation and Condensation

After a summer rainstorm, puddles of water on the ground often disappear quickly. The rainwater is evaporating. Recall that evaporation is a phase change from a liquid to a gas.

Evaporation is the reverse process of condensation, when water vapor becomes a liquid. These two processes, evaporation and condensation, are both occurring wherever water is present. In fact, there is a competition between the two processes that can result in net evaporation or net condensation.

The rates of both evaporation and condensation depend mainly on temperature and the amount of water vapor already in the air.



Cloud formation, rain and snowfall, fog, frost, and the appearance of dew are all events associated with the condensation of water vapor out of the atmosphere.

Important to Know The water in rain puddles does not have to boil to go into the gas phase. Evaporation takes place on the surface of a liquid all the time. Try leaving a glass of water on a table. The water will gradually disappear, leaving the glass empty.