

The Ideal Gas Equation

You are teaching a first semester chemistry course and wish to introduce the ideal gas equation to your students. The ideal gas equation is given by

$$PV = nRT$$

where P is pressure, V is volume, T is temperature, n is the number of moles of gas, and R is a constant equal to $0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$. A mole is essentially a counting unit like a dozen, but much larger. Thus, n is proportional to the number of molecules. The ideal gas equation can either be determined empirically by combining empirically determined proportionalities among the variables, or theoretically by making several simplifying assumptions and applying classical mechanical principles. At the introductory level, the equation is usually justified empirically. The equation predicts how changing one variable defining the state of the gas affects the others and is accurate under sufficiently high temperature and low pressure (room temperature and atmospheric pressure is included in this regime for most gases). Behavior outside the ideal range is beyond the scope of this lecture, but will likely be covered in a later class. Note that the equation also implies that all gases, including mixtures, behave similarly as long as there are no chemical reactions. You may assume that students are familiar with all of the state variables and are capable of converting moles to other measures of the amount of gas.

Design a lesson that integrates cooperative learning. The goals of the lesson are:

- Understand how the ideal gas equation can be deduced from empirical relationships.
- Use the ideal gas equation to qualitatively describe the effect on particular variables due to changes in others and to calculate variables when quantitative data is provided.

Information Flow in a Cell

You are teaching a first semester biology course for non-majors and want to familiarize your students with the roles of DNA, RNA and proteins in information processing in a cell. The idea is commonly referred to as the “central dogma” of biology. DNA is the “archival” macromolecule of the cell – it is faithfully copied during cell division and passed on from one generation to the next. mRNA is the “messenger” of the cell – it is transcribed from DNA to form a blueprint for a protein. Proteins are translated from mRNA by ribosomes and are the “workhorses” of the cell, carrying out many of the functions of the cell – including the replication of DNA and the regulation of which mRNAs are produced and in what quantity in response to environmental stimuli.

Design a lesson that integrates cooperative learning. The goals of the lesson are:

- to understand the basic roles of DNA, RNA and proteins in the cell
- to be able to explain how DNA, RNA and proteins interact with each other in the context of “information flow”

Vector Definition and Representations

You are teaching an introductory physics course and wish to introduce to your students the concept of a vector. A vector is an object that includes both magnitude and direction (ie. displacement, velocity, magnetic field) as opposed to a scalar (speed, energy, temperature) which is just a numeric value. Once a frame of reference is chosen, a vector can be represented as either a set of components (Cartesian) or as a magnitude and a direction (polar). Generally polar coordinates are more natural for measurement, however, in the absence of simplifying symmetries, mathematical operations are more easily performed using Cartesian coordinates. If we are restricted to two dimensions (x , y), the conversion between the two representations, as shown in the figure, is $x = r \cos(\theta)$ and $y = r \sin(\theta)$ where r is the length of the vector and θ is the angle between the x axis and the vector. The opposite conversion is achieved using $r = \sqrt{x^2 + y^2}$, and $\theta = \tan^{-1}(y/x)$.

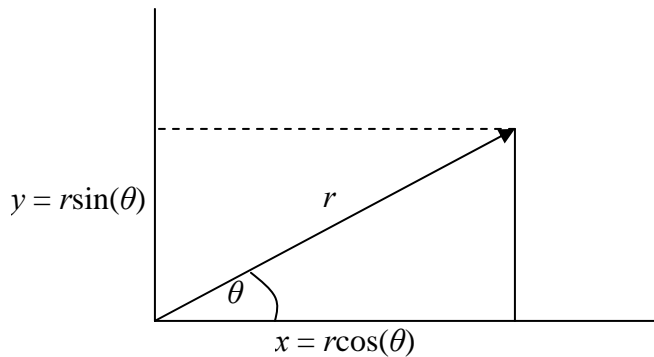


Figure. Conversion between vector representations in two dimensions.

Design a lesson that integrates cooperative learning. The goals of the lesson are:

- Identify vector quantities as opposed to scalar quantities.
- Convert between polar and Cartesian coordinates in two dimensions and identify the advantages of each system.