

Physics Challenge for Teachers and Students

Boris Korsunsky, Column Editor
Weston High School, Weston, MA 02493
korsunbo@post.harvard.edu

Solution to February 2010 Challenge

► The Role of the Mole

One mole of a monatomic gas is heated in such a way that its molar specific heat is $2R$. During the heating, the volume of the gas is doubled. By what factor does the temperature of the gas change?

Solution:

We shall start from the first law of thermodynamics,

$$dE = dQ - p dV,$$

where E is the internal energy of the system, p is the pressure, V is the molar volume, and Q is the heat transferred by the surroundings. For an ideal gas, E depends on the temperature only.

Also, the ideal gas law states that

$$pV = RT$$

(T is the absolute temperature.)

For a monatomic gas,

$$E = 3RT/2.$$

Hence,

$$dQ = dE + p dV = (3R/2) dT + p dV = (3R/2) dT + (RT/V) dV.$$

The transformation applied to the gas is such that

$$dQ = 2R dT$$

Therefore,

$$(RT/V) dV = (R/2) dT$$

or

$$2 d(\ln V) = d(\ln T).$$

Hence

$$V^2/T = \text{const.}$$

Therefore, doubling the volume of the gas will multiply its temperature by a factor of four.

(Contributed by André Bellemans, Université Libre de Bruxelles, Belgium)

We would also like to recognize the following contributors:

R. R. Bukrey (retired, Loyola University, Evanston, IL)

Phil Cahill (Lockheed Martin Corp., North Yorkshire, United Kingdom)

Daniel Cartin (Naval Academy Preparatory School, Middletown, RI)

Rafael Parpinel Cavina, student (Universidade de São Paulo, Sao Paulo, Brazil)

Matthew Cochran (Kauai Community College, Lihue, HI)

David S. Corti (Purdue University, West Lafayette, IN)

R. C. Dhandhanian (KalraShukla, Mumbai, India)

Don Easton (Lacombe, Alberta, Canada)

Fernando Ferreira (Universidade da Beira Interior, Covilhã, Portugal)

Fredrick P. Gram (Cuyahoga Community College, Cleveland, OH)

Art Hovey (Milford, CT)

J. Iñiguez (Universidad de Salamanca, Salamanca, Spain)

David Jones (Florida International University, Miami, FL)

Mark Lenfestey (Homestead High School, Fort Wayne, IN)

John Mallinckrodt (Cal Poly Pomona, Pomona, CA)

Stephen McAndrew (Trinity Grammar School, Summer Hill, NSW, Australia)

Jeff Melmed (Eastern Maine Community College, Bangor, ME)

Daniel Mixson (Naval Academy Preparatory School, Newport, RI)

Carl E. Mungan (U.S. Naval Academy, Annapolis, MD)

Michael Rapport (Anne Arundel Community College, Arnold, MD)

Jason L. Smith (Richland Community College, Decatur, IL)

Cássio dos Santos Sousa, student (Colégio Objetivo, São Paulo, Brazil)

Mark Uline (Northwestern University, Evanston, IL)

Many thanks to all contributors and we hope to hear from you in the future!

Please send correspondence to:

Boris Korsunsky
korsunbo@post.harvard.edu