

Fourth Edition (© 2018 McGraw-Hill)

## Chapter 1

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### Answers to "Why?" in the text

Page 31:

Oxygen has an atomic mass of 16 whereas it is 14 for nitrogen. The  $O_2$  molecule is therefore heavier than the  $N_2$  molecule. Thus, from  $\frac{1}{2}mv^2 = 3(\frac{1}{2}kT)$ , the rms velocity of  $O_2$  molecules is smaller than that of  $N_2$  molecules.

Page 34, footnote 11

For small extensions, the difference between the engineering and instantaneous strains due to a temperature change are the same. Historically, mechanical and civil engineers measured extension by monitoring the change in length,  $\Delta L$ ; and the instantaneous length  $L$  was not measured. It is not trivial to measure both the instantaneous length and the extension simultaneously. However, since we know  $L_o$  and measure  $\Delta L$ , the instantaneous length  $L = L_o + \Delta L$ . Is the difference important? Consider a sample of length  $L_o$  that extends to a final length  $L$  due to a temperature change from  $T_o$  to  $T$ . Let  $\epsilon = (L - L_o) / L_o = \Delta L / L_o$  be the engineering strain.

The engineering definition of strain and hence the thermal expansion coefficient is

$$\text{Engineering strain} = \frac{\delta L}{L_o} = \lambda \delta T$$

so that thermal expansion from  $T_o$  to  $T$  gives,

$$\int_{L_o}^L \frac{dL}{L_o} = \int_{T_o}^T \lambda dT \quad \therefore \quad \frac{\Delta L}{L_o} = \lambda(T - T_o) \quad \therefore \quad \epsilon = \lambda(T - T_o) \quad (1)$$

where  $\epsilon = \Delta L / L_o$  is the engineering strain as defined above

Physics definition of strain and hence the thermal expansion coefficient is

$$\text{Instantaneous strain} = \frac{\delta L}{L} = \lambda \delta T$$

so that thermal expansion from  $T_o$  to  $T$  gives,

$$\int_{L_o}^L \frac{dL}{L} = \int_{T_o}^T \lambda dT \quad \therefore \quad \ln\left(\frac{L}{L_o}\right) = \lambda(T - T_o) \quad \therefore \quad \ln(1 + \epsilon) = \lambda(T - T_o) \quad (2)$$

We can expand the  $\ln(1 + \epsilon)$  term for small  $\epsilon$ , so that Equation (2) essentially becomes Equation (1)

**1.1 Virial theorem** The Li atom has a nucleus with a  $+3e$  positive charge, which is surrounded by a full  $1s$  shell with two electrons, and a single valence electron in the outer  $2s$  subshell. The atomic radius of the

# Physics Solutions Manual Chapter 1

**Paul A. Tipler, Gene Mosca**



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