Questions for Module # 21

Q.1 The active element of a certain laser is made of a glass rod 30.0 cm long and 1.50 cm in diameter. Assume the average coefficient of linear expansion of the glass is equal to $9.00 \times 10^{-6}(°C)^{-1}$. If the temperature of the rod increases by 65.0°C, what is the increase in (a) its length, (b) its diameter, and (c) its volume?

Solution

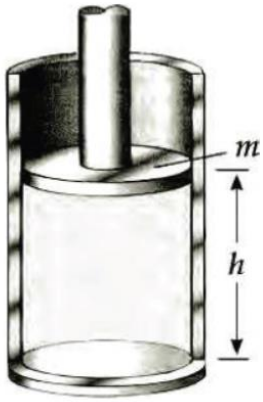
Q.2 A volumetric flask made of Pyrex is calibrated at 20.0°C. It is filled to the 100-mL mark with 35.0°C acetone. After the flask is filled, the acetone cools and the flask warms, so that the combination of acetone and flask reaches a uniform temperature of 32.0°C. The combination is then cooled back to 20.0°C. (a) What is the volume of the acetone when it cools to 20.0°C? (b) At the temperature of 32.0°C, does the level of acetone lie above or below the 100-mL mark on the flask? Explain.

Solution

Q.3 The mass of a hot-air balloon and its cargo (not including the air inside) is 200 kg. The air outside is at 10.0°C and 101 kPa. The volume of the balloon is 400 m^3. To what temperature must the air in the balloon be warmed before the balloon will lift off? (Air density at 10.0°C is 1.244 kg/m^3.)

Solution

Q.4 A vertical cylinder of cross-sectional area *A* is fitted with a tight-fitting, frictionless piston of mass *m*. The piston is not restricted in its motion in any way and is supported by the gas at pressure *P* below it. Atmospheric pressure is P_0. We wish to find the height *h*. (a) What analysis model is appropriate to describe the piston? (b) Write an appropriate force equation for the piston from this analysis model in terms of *P*, P_0, *m*, *A*, and *g*. (c) Suppose *n* moles of an ideal gas are in the cylinder at a temperature of *T*. Substitute for *P* in your answer to (b) to find the height *h* of the piston above the bottom of the cylinder.



Solution

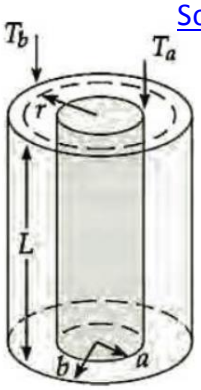
Q.5 A 3.00-g lead bullet at 30.0°C is fired at a speed of 240 m/s into a large block of ice at 0°C, in which it becomes embedded. What quantity of ice melts?

Solution

Q.6 An ideal gas initially at 300 K undergoes an isobaric expansion at 2.50 kPa. If the volume increases from 1.00 m3 to 3.00 m3 and 12.5 kJ is transferred to the gas by heat, what are (a) the change in its internal energy and (b) its final temperature?

Solution

Q.7 The inside of a hollow cylinder is maintained at a temperature *Ta* and the outside is at a lower temperature *Tb* . The wall of the cylinder has a thermal conductivity *k.* Ignoring end effects, show that the rate of energy conduction from the inner surface to the outer surface in the radial direction is,



$$\frac{dQ}{dt} = 2\pi Lk\left[\frac{T_a - T_b}{\ln(b/a)}\right]$$

Solution

Q.8 Water in an electric teakettle is boiling. The power absorbed by the water is 1.00 kW. Assuming the pressure of vapor in the kettle equals atmospheric pressure, determine the speed of effusion of vapor from the kettle's spout if the spout has a cross-sectional area of 2.00 cm^2. Model the steam as an ideal gas.

Solution