210.

Problem 23.35 (RHK)

The envelope and basket of a hot-air balloon have a combined mass of 249 kg, *and the envelop has a capacity of* 2180 m^3. *When envelope is fully inflated with the hot air it provides a lifting capacity of* 272 kg (*in addition to its own mass*). *Assuming that the surrounding air, at* $18.0\,^0\text{C}$, *has a density of* 1.22 kg m^{-3}, *we have to find the temperature of hot air that provides the required lift.*

Solution:

Data of the problem are:

volume of the hot air balloon $= 2180 \text{ m}^3$,

combined mass of basket and envelope $= 249 \text{ kg}$,

total lift to achieved $= \left(249 + 272\right) \text{ kg} = 521 \text{ kg}$, and

density of the surrounding air $= 1.22 \text{ kg m}^{-3}$.

Let the density of hot air inside the balloon that provides the required lift be $\rho \text{ kg m}^{-3}$.

From the buoyancy principle, we have

$$2180 \times (1.22 - \rho) g = 521 g,$$

or

$$\rho = 0.981 \text{ kg m}^{-3}.$$

Assuming ideal gas equation, relation between pressure, p, density, ρ, and temperature, T, is

$$p = \frac{\rho R T}{M},$$

where M is the molar mass. It is given that the temperature of the surrounding air is $18.0\,^{0}\mathrm{C}$ and its density is 1.22 kg m^{-3}. As the pressure of the surrounding air outside the balloon and that of hot air inside the balloon are the same, we have the condition

$$0.981 \text{ kg m}^{-3} \times T = 1.22 \times 291.16 \text{ kg m}^{-3} \text{ K}.$$

or

$$T = 362.09 \text{ K} = (362.09 - 273.16)\ ^{0}\mathrm{C} = 89\,^{0}\mathrm{C}.$$