

3.20 -water vapor is 1% of volume of air, find virtual temp correction:

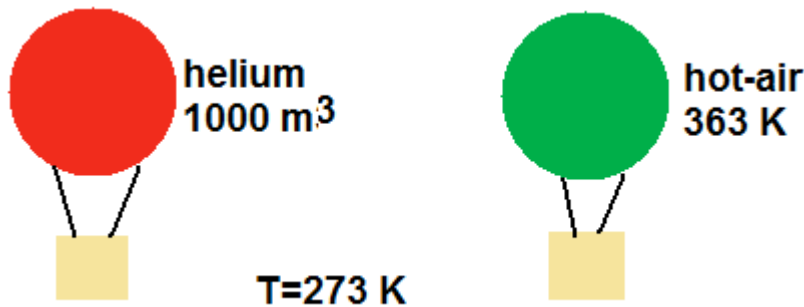
$$\rightarrow T_v = \frac{T}{1 - \frac{e}{p}(1 - \epsilon)}, \text{ so } \frac{T_v}{T} = \frac{1}{1 - \frac{e}{p}(1 - \epsilon)}$$

→ from Dalton's law of partial pressures, and Avogadro's hypothesis we know that a gas occupying 1% of the volume would exert 1% of the pressure

$$\rightarrow \frac{T_v}{T} = \frac{1}{1 - \frac{e}{p}(1 - \epsilon)} = \frac{1}{1 - \frac{.01}{1}(1 - 0.622)} = 1.0038$$

→ assuming a T of 273°K, $T_v=274^\circ\text{K}$, therefore the correction is about 1°K

3.23



- find volume of hot air balloon (V_{hotair}):
 - weight of load is the same
 - pressure is same for both: same altitude: P is a constant for all therefore
 - ideal gas law: $P=\rho RT$
 - R of helium: $8.3143 \text{ (J/}^\circ\text{K mol)}/4.0\text{(grams/mol)}*1000 \text{ grams/kg}=2079 \text{ J/}^\circ\text{K/kg}$
 - assumed that temperature of helium is the same as the ambient temperature
- buoyancy forces are the same: density difference* volume * g:

$$\begin{aligned}
(\rho_{amb} - \rho_{helium}) V_{helium} g &= (\rho_{amb} - \rho_{hotair}) V_{hotair} g = \left[\frac{kgm}{s^2} \right] \\
&= \left(\frac{P}{R_{air} T_{ambient}} - \frac{P}{R_{helium} T_{ambient}} \right) V_{helium} = \left(\frac{P}{R_{air} T_{ambient}} - \frac{P}{R_{air} T_{hotair}} \right) V_{hotair} \\
&= \left(\frac{1 \left[\frac{J}{m^3} \right]}{287 \left[\frac{J}{kg^\circ K} \right] 273^\circ K} - \frac{1 \left[\frac{J}{m^3} \right]}{2079 \left[\frac{J}{kg^\circ K} \right] 273^\circ K} \right) 1000m^3 = \left(\frac{1 \left[\frac{J}{m^3} \right]}{287 \left[\frac{J}{kg^\circ K} \right] 273^\circ K} - \frac{1 \left[\frac{J}{m^3} \right]}{287 \left[\frac{J}{kg^\circ K} \right] 363^\circ K} \right) V_{hotair} \\
&= (1.27631 * 10^{-5} kg/m^3 - 1.76191 * 10^{-6} kg/m^3) 1000m^3 = (1.27631 * 10^{-5} kg/m^3 - 9.5987 * 10^{-6} kg/m^3) V_{hotair} \\
&= 0.0110012kg = (3.1644 * 10^{-6} kg/m^3) * V_{hotair}
\end{aligned}$$

$$V_{hotair} = 3480m^3$$

→ a much larger volume is needed for the hot air balloon: **3480 m³**

3.31

- hiker hikes up 1 km in 3 hours from sea level
- sea-level pressure drops by 8 hPa in same period
- estimate altimeter at end of hike
- assume scale height of 8000 meters
- assume surface sea level pressure (initial) of 101300 Pascals

$$Z_g = H \ln \frac{P_o}{P_g}$$

$$1000m = 8000m \ln \frac{101300 - 800Pa}{P_g}$$

$$P_g = 100500 / e^{(1/8)} = 88690Pa$$

- 887 mb is the pressure reading after the hike at 1km due to the ascent and changing local pressure
- altimeter reading:

$$\begin{aligned}
Z &= 8000m \ln \frac{101300Pa}{88690Pa} \\
&= 1064m
\end{aligned}$$

- the effect of local pressure change ensures that the altimeter will read **~1060 meters**
- demonstrates the need for hikers and pilots to be aware of changing weather if they are relying on their instrument readings for navigation

3.35

- change in enthalpy:
- 3 kg of ice at 0°C heated to liquid water at 40°C
- $dh=c_p dT$
- latent heat of fusion: $3.34 \cdot 10^5 \text{ J/kg}$

$$c_{pw} = 4183.9 + 0.125T = 4184 + 0.125 \cdot 293^\circ\text{K} = 4220 \text{ J/}^\circ\text{K/kg}$$

(293 selected as mid-point: could be more accurate by integration, but the added value is within the magnitude range of rounding error, so the mid-range is sufficient considering the small increment)

- melt ice: $3.34 \cdot 10^5 \text{ J/kg} \cdot 3 \text{ kg} = 1.002 \cdot 10^6 \text{ J}$
- warming water: $4220 \text{ J/}^\circ\text{K/kg} \cdot 3 \text{ kg} \cdot 40^\circ\text{K} = 5.064 \cdot 10^5 \text{ J}$
- $1.002 \cdot 10^6 \text{ J} + 0.5064 \cdot 10^6 \text{ J} = \mathbf{1.51 \cdot 10^6 \text{ J increase in enthalpy}}$

3.39 -how much water must be evaporated to cool a person by 5° C

- assume a X kg person, Y is our fraction of interest
- $L_e = 2.5 \cdot 10^6 \text{ J/kg}$
- $4.2 \cdot 10^3 \text{ J/K/kg}$ specific heat of human body

$$\rightarrow X \text{ kg} \cdot 4.2 \cdot 10^3 \frac{\text{J}}{\text{Kkg}} \cdot 5^\circ \text{K} \cdot \frac{1}{2.5 \cdot 10^6 \left[\frac{\text{J}}{\text{kg}} \right]} = YX \text{ kg}$$

$$Y = 0.0084$$

- **0.84% of body mass in water must be evaporated**