Diagnostic Exam:

14. A gas at 40°C under a pressure of 1800 kPaa has a unit weight of 400 N/m³. Find the molecular weight of the gas.

Solution

Use Ideal Gas

$$pV = mRT$$

$$\left[p = \frac{m}{V} RT \right] g$$

$$pg = \rho g RT$$

$$pg = \gamma \frac{\bar{R}}{m.w} T$$

$$mw = \frac{\gamma \bar{R} T}{pg}$$

③ kg

$$mw = \frac{(0.4\ \cancel{kN}/\cancel{m^3})(8.3143\ kJ/kgmole\text{-}\cancel{K})(273.15+40)\cancel{K}}{(1800\ \cancel{kPa})(9.80665\ m/s^2)}$$

$$mw = 59\ kg/kgmol$$

15. A Helium at 170 kPaa and 15°C isentropically compressed to 1/5th of its original volume. What is its final pressure if k = 1.667 ?

Solution:

$$p_1 V_1^k = p_2 V_2^k = C$$

$$p_2 = p_1 \left[\frac{V_1}{V_2}\right]^k \quad \text{.....} (1)$$

but

$$V_2 = \tfrac{1}{5} V_1 \quad \text{....} (2)$$

Combine Equations (1) & (2)

$$p_2 = p_1 \left[\frac{\cancel{V_1}}{\tfrac{1}{5}\cancel{V_1}}\right]^k = 170 \text{ kPaa} \left[5\right]^{1.667} = 2,486.75 \text{ kPaa}$$

16. Given:

ϕ = 12-inch

h = 0.1 inch

μ = 0.95 Pa.s

n = 2 rpm

Solution:

$$\frac{F}{A} = \mu \frac{du}{dy}$$

$$dF = \mu \frac{du}{dy} dA \quad \text{....} (1)$$

$$dT = dF \times r \quad \text{.....} (2)$$

Combine Equations (1) & (2)

$$dT = \mu \frac{du}{dy} \, dA \, r$$

$$dT = \mu \frac{\omega r}{h} \, r \, dr \, d\theta \, r$$

$$\int_0^T dT = \mu (2\pi) \frac{\omega}{h} \int_0^{\phi/2} r^3 \, dr$$

$$T = \frac{2\pi \mu \omega}{h} \left[\frac{r^4}{4} \right]_0^{\phi/2} = \frac{2\pi \mu \omega}{h} \left[\frac{\phi^4}{64} \right]$$

$$T = \frac{\pi \mu \omega \phi^4}{32h}$$

$$T = \frac{\pi (0.95 \, Pa \cdot \cancel{s}) \left(\frac{2\pi}{\cancel{rev}} \times 2 \, \cancel{rev}/\cancel{min} \times 1 \, \cancel{min}/60 \, \cancel{s} \right)}{32 (0.1 \, \cancel{inch})} (12 \, \cancel{inch})^4 \left[\frac{0.0254 \, m}{\cancel{inch}} \right]^3$$

$$\therefore T = 0.0664 \, N\text{-}m$$

17. Given:

$h = 828\ m$

$T = 50^{\circ}C$

Find: $p_1/p_0 = ?$

Solution:

$$\frac{dp}{dz} = -\gamma \quad \text{....(1)}$$

$$\gamma = \frac{pg}{RT} \quad \text{....(2)}$$

Combine Equations (1) & (2)

$$dp = -\frac{pg}{RT}\,dz$$

$$\int_{p_0}^{p_1} \frac{dp}{p} = -\frac{g}{RT}\int_0^h dz$$

$$\ln\frac{p_1}{p_0} = -\frac{g}{RT}h$$

$$\frac{p_1}{p_0} = e^{-gh/RT}$$

$$\frac{p_1}{p_0} = e^{\left[\frac{-(9.80665\ m/s^2)(828\ m)}{(0.287\ kJ/kg\cdot K)(273.15+50)K}\right]}$$

$$\frac{p_1}{p_0} = 0.9162$$