Chapter 12

12-3 Moon : 100K → 375K

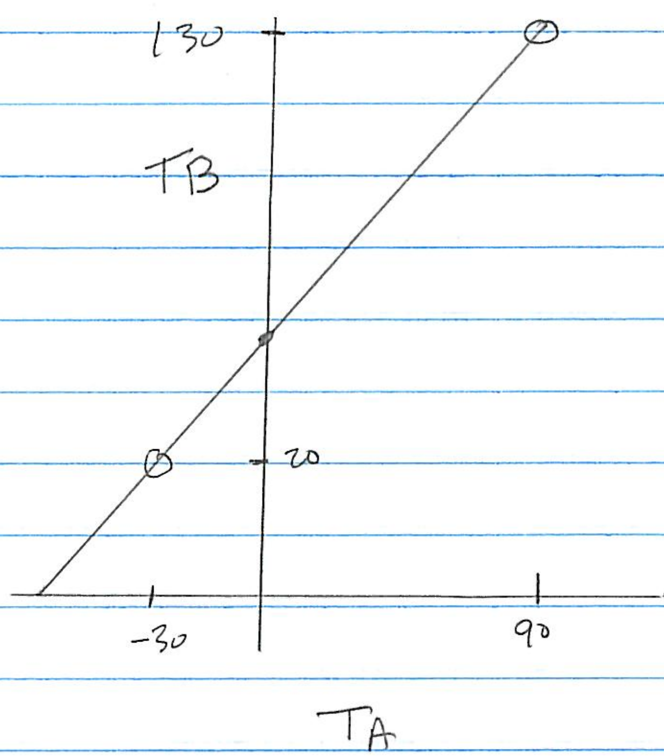
$T_C = T_K - 273°$: $-173°C \rightarrow +102°C$

$T_F = \frac{9}{5} T_C + 32$: $-279°F \rightarrow 216°F$

12-4 A: 90°A, B: 110°B $\left.\right\}$ $\frac{90}{110} = \frac{9}{11}$

(a) $1°A \Rightarrow \frac{11}{9}°B$

(b) Plot T_B vs T_A



TA

Slope is $11/9$

y-intercept is $\simeq 55$

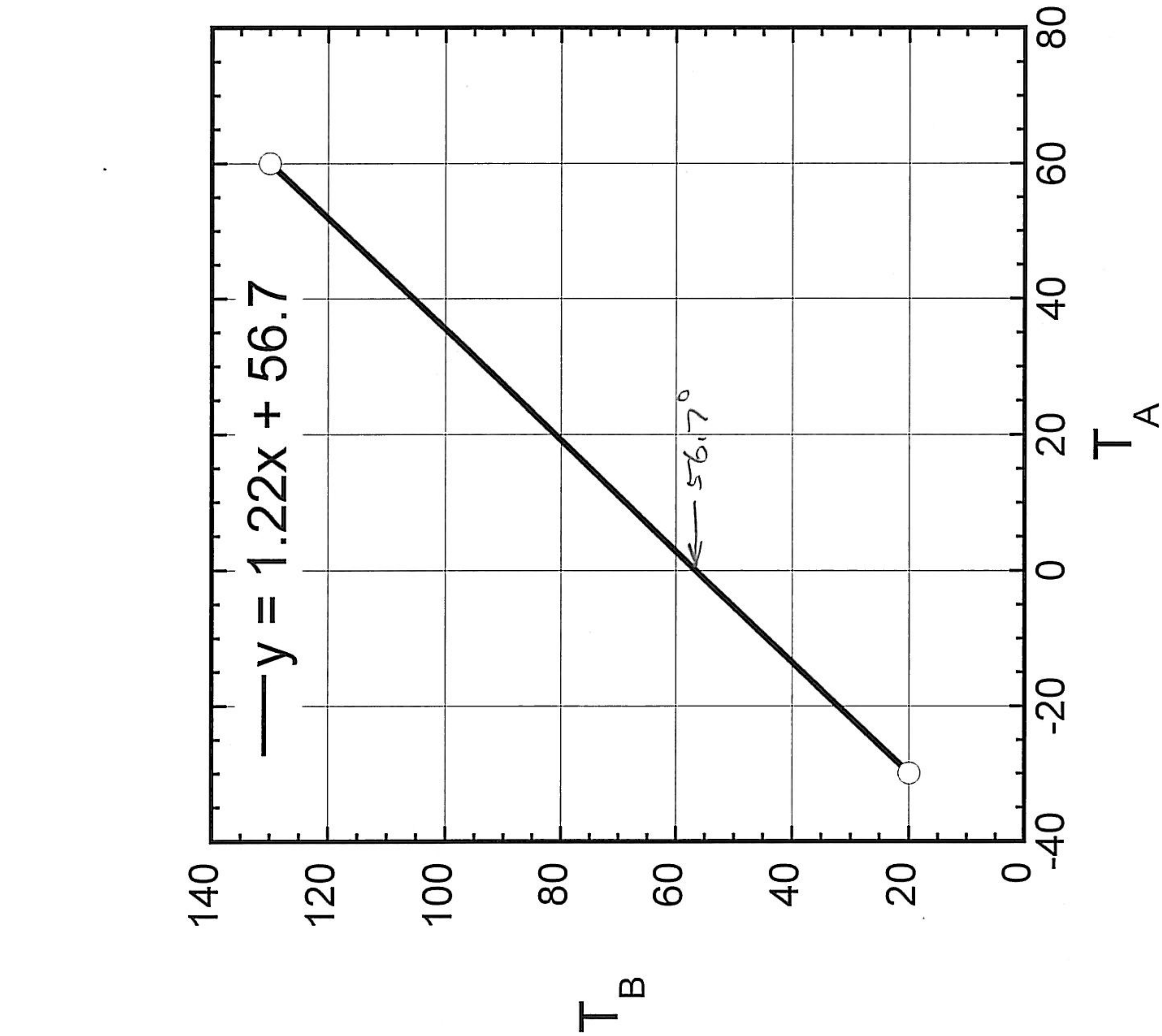
50 $$T_B \cong \frac{11}{9} T_A + 55°$$

$T_A = +40$

$T_B \simeq 104°$

Better plot on next page →

12-4 (b)



12-7

$P = 5000\,Pa$ at $T = 0°C$

CV GAS thermometer* has $P \propto$ Absolute Temp (°K)

OR $$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$T_1 = 0°C \Rightarrow T_1 = 273\,K$

$P_2 = 2000\,Pa$

$$T_2 = \frac{P_2}{P_1} T_1 = \frac{2000}{5000} \cdot 273$$

$T_2 = 109\,K$

$T_{2,C} = T_{2K} - 273 = -164\,°C$

* CONSTANT VOLUME GAS thermometer

12-11

$$\begin{cases} \Delta L = 0.53\,m \\ \Delta T = 30^\circ C \\ \text{STEEL} \end{cases}$$

$$\Delta L = \alpha L_0 \Delta T$$

$$L_0 = \frac{\Delta L}{\alpha \Delta T} = \frac{0.53}{12\times10^{-6} \times 30^\circ C} \cong 1.5\ km$$

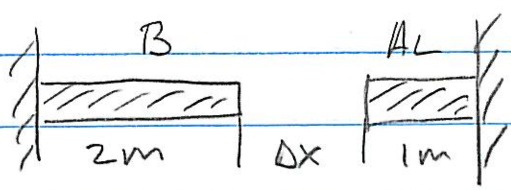
12-15

$$\Delta L = \alpha L_0 \Delta T$$

$$2.3\times10^{-5}\,m = \alpha\ 1.8\times10^{-2}\,m \cdot 75^\circ$$

$$\alpha = 1.7\times10^{-5}\ \text{per}\ ^\circ C$$

12-19



$\Delta X = 1.3\times10^{-3}\,m$

@ $T_0 = 28^\circ C$

$$\Delta L_B + \Delta L_{AL} = \Delta X = \left(\alpha_B L_{0B} + \alpha_{AL} L_{0AL}\right)\Delta T$$

$$1.3\times10^{-3}\,m = \left[19\cdot10^{-6}(2m) + 23\cdot10^{-6}(1m)\right](T-28)$$

$$1.3\times10^{-3} = 6.1\times10^{-5}(T-28)$$

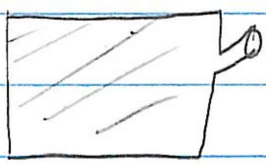
$$T-28 = 21 \Rightarrow T = 49^\circ C$$

12-35

Volume expansion coeffs

$\beta_{STEEL} = 87\times10^{-6}\ /^{\circ}C$

$\beta_{gasoline} = 950\times10^{-6}\ /^{\circ}C$



So neglect change in dimensions of gAS TANK

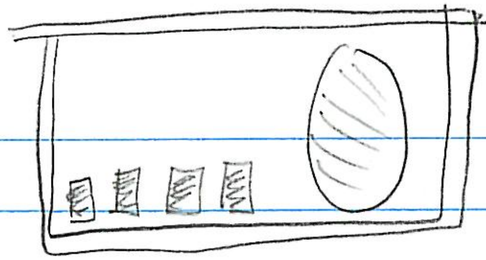
$\Delta V_{gAS} = \beta_{gas}\, V_0\, \Delta T$

$= 950\times10^{-6} \times 18^{\circ}C\ V_0$

$= 0.017\ V_0$

$V_0 = 20\,gal$, $\Delta V_{gas} = 0.34\ gal$

12-45



Heat lost by watermelon = Heat gained by pop

$$m_w C_w \Delta T_w = m_{pop} C_{pop} \Delta T_{pop}$$

$$6.5\,kg \times 4186\,J/kg\,°C \times (27 - T_f)$$

$$= 12 \times 0.35\,kg \times 3800\,J/kg\,°C \times (T_f - 5°)$$

$$27209\,(27° - T_f) = 15960\,(T_f - 5°C)$$

$$1.7\,(27 - T_f) = T_f - 5$$

$$46 - 1.7T_f = T_f - 5$$

$$51 = 2.7T_f$$

$$T_f \simeq 19\,°C$$

12-53

$\Delta L = \alpha L_0 \Delta T$

$4.3 \times 10^{-3}\,m = 19 \times 10^{-6} \times 0.15\,m \times \Delta T$

$\Delta T = 1509\,°C$

$Q = m c \Delta T$

$m = \dfrac{Q}{C_{Ag}\,\Delta T} = \dfrac{4200\,J}{235\,J/kg°C \times 1509}$

$m = 0.012\,kg$

12-57

Must first heat Al to its boiling point

$Q_1 = m C_{Al} \Delta T = 0.45\,kg \times 900\,J/kg°C \times (660 - 130)$

$= 2.15 \times 10^5\,J$

Then melt it: $Q_2 = m L_f = 0.45 \times 4 \times 10^5\,J/kg$

$= 1.8 \times 10^5\,J$

$Q = Q_1 + Q_2 = 3.95 \times 10^5\,J$

12-59

(a) 2 kg water at 100°C

$$Q = m L_v$$

$$= 2\,kg \times 22.6 \times 10^5\,J/kg$$

$$= 4.52 \times 10^6\,J$$

(b) 2 kg Water at 0°C

First heat water to 100°C

$$Q_1 = m c_w \Delta T$$

$$= 2\,kg \times 4186\,J/kg\,°C \times 100\,°C$$

$$= 8.37 \times 10^5\,J$$

Vaporize water $Q_2 = m L_v = 4.52 \times 10^6\,J$

$$Q = Q_1 + Q_2 = 5.36 \times 10^6\,J$$

12-67 Ice at $-10°C$ + STEAM @ $130°C$

$T_f = 50°C$

Heat absorbed by ICE = HEAT released by steam

ICE

1. heat ICE from $-10°C$ to $0°C$

$$Q_{I1} = m_I C_I \Delta T_I = m_I \, 2000 \, J/kg°C \, (10°)$$
$$= 2 \times 10^4 \, m_I$$

2. melt ICE

$$Q_{I2} = m_I L_f = m_I \cdot 33.5 \times 10^4 \, J/kg$$

3. heat water $0° \rightarrow 50°C$ $(m_w = m_I)$

$$Q_w = m_w C_w \Delta T_w = m_I \cdot 4186 \cdot 50 = 2.09 \times 10^5 \, m_I$$

STEAM

1. Cool steam from $130°C \rightarrow 100°C$

$$Q_{S1} = m_S C_S \Delta T_S = m_S \cdot 2020 \cdot 30° = 6.06 \times 10^4 \, m_S$$

2. Condense steam @ $100°$ to water @ $100°$

$$Q_{S2} = m_S L_v = m_S \cdot 22.6 \times 10^5$$

3. Cool water at $100° \rightarrow 50°$ $(m_w = m_S)$

$$Q_{w3} = m_S C_w \Delta T_w = m_S \, 4186 \cdot 50° = 2.09 \times 10^5 \, m_S$$

continued →

12.67 continued

$$Q_{I1} + Q_{I2} + Q_W = Q_{S1} + Q_{S2} + Q_{W3}$$

$$(2\times10^4 + 33.5\times10^4 + 2.09\times10^5)\, m_I$$

$$= (6.06\times10^4 + 22.6\times10^5 + 2.09\times10^5)\, m_S$$

$$5.64\times10^5\, m_I = 2.52\times10^6\, m_S$$

$$\frac{m_S}{m_I} = 0.22$$

12-71

$$\frac{1}{2}mv^2 = Q$$

$T_0 = 30°C \quad , T_f = 327.3\ °C$

Pb melting point

$$Q = Q_{30° \to 327°} + Q_{melt}$$

$$= m c_{Pb}\ (327-30) \quad + m \cdot 2.32 \times 10^4$$

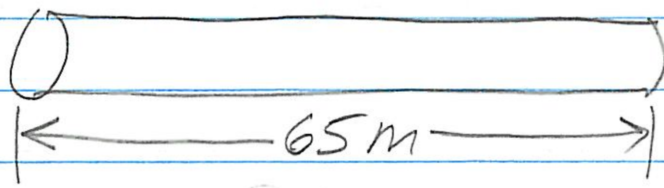
$$= m\left[128(297) \quad + 2.32\times10^4\right]$$

$$= m\left[6.12\times10^4\right]$$

$$\frac{1}{2}\cancel{m}v^2 = \cancel{m} \cdot 6.12\times10^4$$

$$\underline{v = 350\ m/s}$$

12.85



$L_o = 65\,m$ @ $T_o = 18°C$

$L = ?$ @ $T_f = -45°C$

$\Delta L = \alpha L_o \Delta T$

$= 12 \cdot 10^{-6} \cdot 65 \times (18 + 45)$

$= 4.91 \times 10^{-2}\ m$

almost 2 inches