PHY 2130 Homework solutions
Assignment 10

10.1 (a) $T_F = \frac{9}{5}T_C + 32 = \frac{9}{5}(-273.15) + 32 = \boxed{-460°F}$

(b) $T_C = \frac{5}{9}(T_F - 32) = \frac{5}{9}(98.6 - 32) = \boxed{37.0°C}$

(c) $T_F = \frac{9}{5}T_C + 32 = \frac{9}{5}(T_K - 273.15) + 32 = \frac{9}{5}(-173.15) + 32 = \boxed{-280°F}$

10.11 The increase in temperature is $\Delta T = T_f - T_i = 35°C - (-20°C) = 55°C$.

Thus, $\Delta L = \alpha L_i(\Delta T) = \left[11\times 10^{-6}\ (°C)^{-1}\right](518\text{ m})(55°C) = 0.31\text{ m} = \boxed{31\text{ cm}}$

10.28 (a) $n = \frac{PV}{RT}$

$$= \frac{\left[(9.0\text{ atm})(1.013\times 10^5\text{ Pa/atm})\right]\left[(8.0\text{ L})(1\text{ m}^3/10^3\text{ L})\right]}{(8.31\text{ J/mol}\cdot\text{K})(293\text{ K})} = \boxed{3.0\text{ mol}}$$

(b) $N = n\cdot N_A = (3.0\text{ mol})(6.02\times 10^{23}\text{ molecules/mol}) = \boxed{1.8\times 10^{24}\text{ molecules}}$

10.35 The pressure 100 m below the surface is found, using $P_1 = P_{atm} + \rho gh$, to be

$$P_1 = 1.013\times 10^5\text{ Pa} + (10^3\text{ kg/m}^3)(9.80\text{ m/s}^2)(100\text{ m}) = 1.08\times 10^6\text{ Pa}$$

The ideal gas law, with *T* constant, gives the volume at the surface as

$$V_2 = \left(\frac{P_1}{P_2}\right)V_1 = \left(\frac{P_1}{P_{atm}}\right)V = \left(\frac{1.08\times 10^6\text{ Pa}}{1.013\times 10^5\text{ Pa}}\right)(1.50\text{ cm}^3) = \boxed{16.0\text{ cm}^3}$$

10.36 Since the sample contains three times Avogadro's number of molecules, there must be 3 moles of gas present. The ideal gas law then gives

$$P = \frac{nRT}{V} = \frac{(3\text{ mol})(8.31\text{ J/mol}\cdot\text{K})(293\text{ K})}{(0.200\text{ m})^3} = 9.13\times10^5\text{ Pa}$$

The force this gas will exert on one face of the cubical container is

$$F = PA = (9.13\times10^5\text{ Pa})(0.200\text{ m})^2 = 3.65\times10^4\text{ N} = \boxed{36.5\text{ kN}}$$

10.41 (a) Since each gas is at temperature $T = 423\text{ K}$, the average kinetic energy of a molecule in either gas is

$$KE_{molecule} = \frac{3}{2}k_{\text{B}}T = \frac{3}{2}\left(1.38\times10^{-23}\ \frac{\text{J}}{\text{K}}\right)(423\text{ K}) = \boxed{8.76\times10^{-21}\text{ J}}$$

(b) The rms speed of the molecules in a gas is $v = \sqrt{\dfrac{2KE_{molecule}}{m}}$

For helium, $m = \dfrac{M}{N_{\text{A}}} = \dfrac{4.00\times10^{-3}\text{ kg/mol}}{6.02\times10^{23}\text{ molecules/mol}} = 6.64\times10^{-27}\text{ kg}$,

and $v = \sqrt{\dfrac{2(8.76\times10^{-21}\text{ J})}{6.64\times10^{-27}\text{ kg}}} = \boxed{1.62\text{ km/s}}$

For argon, $m = \dfrac{M}{N_{\text{A}}} = \dfrac{39.9\times10^{-3}\text{ kg/mol}}{6.02\times10^{23}\text{ molecules/mol}} = 6.63\times10^{-26}\text{ kg}$,

and $v = \sqrt{\dfrac{2(8.76\times10^{-21}\text{ J})}{6.63\times10^{-26}\text{ kg}}} = \boxed{514\text{ m/s}}$

11.2 From $Q = mc(\Delta T)$, the change in temperature is

$$\Delta T = \frac{Q}{mc} = \frac{1200\text{ J}}{(50\times10^{-3}\text{ kg})(387\text{ J/kg}\cdot{}^\circ\text{C})} = 62^\circ\text{C}$$

Thus, $T_f = T_i + \Delta T = 25^\circ\text{C} + 62^\circ\text{C} = \boxed{87^\circ\text{C}}$

11.7 The internal energy converted to mechanical energy in the climb is $Q = \Delta PE_g = mgh$. Thus, the required height is

$$h = \frac{Q}{mg} = \frac{(500 \text{ Calories})(4186 \text{ J}/1 \text{ Calorie})}{(75.0 \text{ kg})(9.80 \text{ m/s}^2)} = 2.85 \times 10^3 \text{ m} = \boxed{2.85 \text{ km}}$$

11.13 The energy absorbed by the water equals the energy given up by the iron, so

$$[mc(\Delta T)]_{water} = [mc|\Delta T|]_{iron} \text{ , or}$$

$$(20 \text{ kg})(4186 \text{ J/kg}\cdot°\text{C})(T_f - 22°\text{C}) = (0.40 \text{ kg})(448 \text{ J/kg}\cdot°\text{C})(500°\text{C} - T_f).$$

Solving for the final temperature gives $T_f = \boxed{23°\text{C}}$