PHY101 HW10 Solutions Fall 2017

1) Use $PV = Nk_BT$. Since we have $P_iV_i = N_ik_BT_i$ and $P_fV_i = N_fk_BT_f$.
If $T_i = T_f$ and $V_f = V_i$, then we can subtract the two equations from each other to arrive at: $(P_f - P_i)V_i = (N_f - N_i)k_BT_i$, or

$$\frac{(P_f - P_i)V_i}{k_BT_i} = (N_f - N_i)$$

$$\frac{(15\,atm - 20\,atm)(1\,m^3)}{(1.38\times10^{-23}\,J/K)(273\,K)} = -1.3\times10^{26}$$

so 1.3×10^{26} molecules were released.

2) $\langle K_{total}\rangle = N\langle K_{tr}\rangle = N\underbrace{\frac{3}{2}k_BT}_{\langle K_{tr}\rangle = \frac{3}{2}k_BT} = \frac{3}{2}PV = \frac{3}{2}(1.01\times10^5\,Pa)(.001\,m^3) = 152\,J$.

3) Use the conservation of energy, or $U_{chem} = \frac{1}{2}mV_f^2 \Rightarrow V_f = \sqrt{\frac{2U_{chem}}{m}}$

$$V_f = \sqrt{\frac{2(418\times10^3\,J)}{83\,kg}} = 100\,m/s$$

4) a) Find Q, where Q is given by $Q = mc\Delta T = (75\,kg)\left(3.5\times10^3 \frac{J}{kg\,K}\right)(34°c - 40.8°c)$ (from table in book)

$= -1\times10^6\,J$ → heat removed due to minus sign

b) How much heat is required to melt 7.5 kg of ice? $Q = m L_f$ (table)

$= (7.5\,kg)\left(333.7\times10^3 \frac{J}{kg}\right)$

$= 2.5\times10^6\,J$

Since $2.5\times10^6\,J > 1\times10^6\,J$, there will be ice remaining in the bath. How much? Well $m_{ice} = \frac{Q}{L_f} = \frac{1\times10^6\,J}{333.7\,\frac{J}{kg}} = 3\,kg$ → So $7.5\,kg - 3\,kg = \underline{4.5\,kg}$

5) a) The net work done is equal to the area inside the curves, so

$W_{net} = (4\,atm - 1\,atm)\left(1.0\times10^5 \frac{Pa}{atm}\right)(.8\,m^3 - .2\,m^3) = 182{,}000\,J$

b) The net flow into the engine is equal to the work done per cycle ($\Delta U = 0 = Q + W$). So $Q_{net} = 182\,kJ$.

6) $e = 1 - \frac{T_c}{T_H} = 1 - \frac{(273+4)K}{(273+18\,K)} = .0481$ → or 48.1% efficient.