Solutions Assignment 5

1.19 $v = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$ m = mass, M = molar mass = $N_A m$

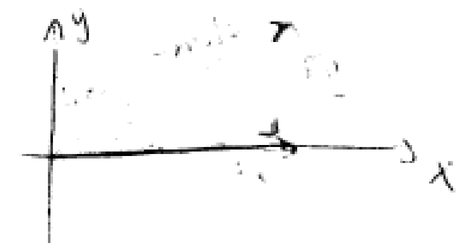
molar masses $O \approx 16$, $H = 1$.

$v_O \approx \frac{\sqrt{3RT}}{4}$ $v_H \approx \sqrt{3RT}$ $v_H = 4 v_O$.

hydrogen molecules move 4 times faster than oxygen molecules.

1.21 $m = 2g = 2 \times 10^{-3}$ kg
$v = 15\ ms^{-1}$
$A = 0.5 m^2$
Rate $= 30 s^{-1}$

$F_{window} = -F_{stone} = -\frac{m\Delta v}{\Delta t}$
$\Delta v = v_f - v_i = -2v = -30$
$\Delta t = \frac{1}{30} = 0.0333$



Pressure $= \frac{F}{A} = -\frac{m \Delta v}{A \Delta t}$

$F_x = -m\Delta v \cos 45°$

so: $P = \frac{F}{A} = \frac{-m\Delta v \cos 45°}{A \Delta t} = \frac{(-2\times10^{-3})(-30)(\frac{1}{\sqrt{2}})}{(0.5)(0.033)}$
$\approx 2.54\ N/m^2$
$\approx 2.54\ Pa$.

atmospheric pressure ≈ 100 kPa $= 1 \times 10^5$ Pa

1.23 helium = monatomic gas $\Rightarrow f = 3$ (degrees freedom)
$U = f \cdot N \cdot \frac{1}{2} kT$

$PV = Nk_BT = nRT$ $\quad U = \frac{3}{2} Nk_BT = \frac{3}{2} PV$

take N=1 $\Rightarrow U = \frac{3}{2} PV$
1 litre helium $\Rightarrow V = 1 \times 10^{-3} m^3$

$$U = \left(\frac{3}{2}\right)(1 \times 10^5)(1 \times 10^{-3}) = 150 J$$

(ii) air = nitrogen/oxygen mixture $\Rightarrow$ both diatomic $\Rightarrow f = 7$.

so: $U = \frac{7}{2} PV = \left(\frac{7}{2}\right)(1 \times 10^5)(1 \times 10^{-3}) = 350 J$

1.24 for solids $U = 3Nk_BT$ room temp = 300 K
molecular weight Pb = 207.21 $g\,mol^{-1}$
1g Pb = $\frac{1}{207.21}$ = 0.0048 mol.

1 mole = 6.022×10^{23} atoms (Avogadro's number)
0.0048 moles = 2.906×10^{21} atoms

$$U = (3)(2.906 \times 10^{21})(1.38 \times 10^{-23})(300K) \approx 36.09 J$$

1.41 (b) C_v for water = 4.2 $kJ\,kg^{-1}K^{-1}$
goes from 20°C → 24°C = 4K difference
250g water, want 1kg
so: $Q = (4)(0.25)(4.2) = 4.2 kJ$

(a) gain by water = loss by metal = 4.2 kJ

(c) $C = \frac{\Delta Q}{\Delta T} = \frac{4.2 kJ}{(100-24)} = 55.26 JK^{-1} = 0.055 kJK^{-1}$

(d) $C_v = \frac{C}{m} = \frac{55.26}{0.1} = 552.6\, J\,kg^{-1}K^{-1} = 0.55\, kJ\,kg^{-1}$