9.1

(1) $p = \frac{T}{T_0} p_0 = 9.08 \times 10^3$ Pa

(2) $T' = \frac{p'}{p_0} T_0 = 90.37\,K$

$= -182.78\,°C$

9.3

$V_1 = \pi \times 71.12 \times \pi \times 1.5^2\ cm^3$ $\quad p_1 = 1\,atm$

$V_2 = 30 \times \pi \times 1.5^2\ cm^3$ $\quad T_1 = 270.15\,K$

$T_2 = 280.15\,K$

$$20 \times \frac{P_1 V_2}{T_1} = \frac{P_2 V_1}{T_2}$$

$\Rightarrow P_2 = 2.78\,atm$

9.9

$\vec{u}_{12} = \vec{v}_1 - \vec{v}_2$

$u_{12}^2 = v_1^2 + v_2^2 - 2\vec{v}_1 \cdot \vec{v}_2$

$\overline{u_{12}^2} = \overline{v_1^2} + \overline{v_2^2} - \underbrace{2\overline{\vec{v}_1 \cdot \vec{v}_2}}_{=0} \Rightarrow \overline{u_{12}^2} = \overline{v_1^2} + \overline{v_2^2} = 2\overline{v^2}$

$\Rightarrow \bar{u} = \sqrt{2}\,\bar{v}$

9.10

$\overline{(v - \bar{v})^2} \geq 0$

$= \overline{v^2 + \bar{v}^2 - 2v\bar{v}}$

$= \overline{v^2} + \bar{v}^2 - 2\bar{v} \cdot \bar{v}$

$= \overline{v^2} - \bar{v}^2 \geq 0$

$\Rightarrow \sqrt{\overline{v^2}} \geq \bar{v}$

9.14

(1) $\sigma = \pi \frac{d^2}{4}$

(2) $\bar{\lambda} = \frac{\bar{v}}{\bar{Z}} = \frac{\bar{v}}{n\sigma\bar{v}} = \frac{1}{n\sigma} = \frac{4}{\pi d^2 n}$

9.15

(1) $\bar{\varepsilon}_t = \frac{t}{2}kT = \frac{3}{2}kT = 6\times10^{-21}J$

$\bar{\varepsilon}_r = \frac{r}{2}kT = kT = 4\times10^{-21}J$

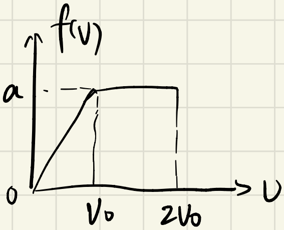
$\bar{\varepsilon}_k = \bar{\varepsilon}_t + \bar{\varepsilon}_r = 1\times10^{-20}J$

(2) $E = \bar{\varepsilon}_k \cdot N = \bar{\varepsilon}_k \cdot \frac{m}{M} \cdot N_A = 1.83\times10^{3}J$

(3) $E_k = \frac{1}{2}mv^2 = 1.4J$

9.18

(1)



$\frac{1}{2}av_0 + av_0 = 1$

$\Rightarrow a = \frac{2}{3v_0}$

(2) $v > v_0$: $N_1 = \frac{2}{3}N$

$v < v_0$: $N_2 = \frac{1}{3}N$

(3) $\bar{v} = \int_0^{+\infty} v f(v)\,dv = \int_0^{v_0} \frac{2}{3v_0^2} v \cdot v\,dv + \int_{v_0}^{2v_0} \frac{2}{3v_0} v\,dv$

$= \frac{2}{9}v_0 + v_0 = \frac{11}{9}v_0$

9.20

火星：

$$V_火 = \sqrt{\frac{2GM_火}{R_火}} = \sqrt{\frac{2G \times 0.108 M_E}{0.531 \times R_E}} = 5\times10^3 m/s$$

$$V_{rms,CO_2} = \sqrt{\frac{3RT_火}{M_{CO_2}}} = 3.7\times10^2 m/s$$

$$V_{rms,H_2} = \sqrt{\frac{3RT_火}{M_{H_2}}} = 1.73\times10^3 m/s$$

$\Rightarrow V_{rms,H_2} > V_{rms,CO_2}$， H_2更易逃逸

木星

$$V_木 = \sqrt{\frac{2GM_木}{R_木}} = \sqrt{\frac{2G\times318M_E}{11.2R_E}} = 6\times10^4 m/s$$

$$V_{rms,H_2} = \sqrt{\frac{3RT_木}{M_{H_2}}} = 1.3\times10^3 m/s$$

9.23

$$f(v)\,dv = 4\pi\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}}\,dv$$

$$\varepsilon_t = \frac{1}{2}mv^2 \Rightarrow v^2 = \frac{2\varepsilon_t}{m} \text{ 代入} \Rightarrow dv = \frac{1}{\sqrt{2m\varepsilon_t}}\,d\varepsilon_t$$

$$\Rightarrow F(\varepsilon_t)\,d\varepsilon_t = 4\pi\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} \cdot \frac{2\varepsilon_t}{m}\, e^{-\frac{\varepsilon_t}{kT}} \frac{1}{\sqrt{2m\varepsilon_t}}\,d\varepsilon_t$$

$$\Rightarrow F(\varepsilon_t)\,d\varepsilon_t = \frac{2}{\sqrt{\pi}}(kT)^{-\frac{3}{2}} \cdot \varepsilon_t^{\frac{1}{2}} \cdot e^{-\frac{\varepsilon_t}{kT}}\,d\varepsilon_t$$

$$\left.\frac{dF(\varepsilon_t)}{d\varepsilon_t}\right|_{\varepsilon_{tp}} = \frac{1}{\sqrt{\pi}}(kT)^{-\frac{3}{2}} \frac{1}{\sqrt{\varepsilon_{tp}}} e^{-\frac{\varepsilon_{tp}}{kT}} - \frac{2}{\sqrt{\pi}}(kT)^{-\frac{5}{2}} \sqrt{\varepsilon_{tp}} \cdot e^{-\frac{\varepsilon_{tp}}{kT}} = 0$$

$$\Rightarrow \varepsilon_{tp} = \frac{kT}{2}$$

$$\frac{1}{2}mv_p^2 = \frac{1}{2}m \cdot \frac{2kT}{m} = kT$$