The Kinetic Theory of Gases

Supplementary Questions

Study Guide 24

Part 1

1. $T_1 = 273\ K$; $P_1 = 1.01 \times 10^5\ Pa$; $V_1 = 3.0 \times 10^{-5}\ m^3$

$T_2 = 313 K$; $P_2 = 4.0 \times 10^5\ Pa$; $V_2 = ?$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow V_2 = \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} \cdot V_1$$

$$\therefore V_2 = \frac{1.01 \times 10^5}{4.0 \times 10^5} \times \frac{313}{273} \times 3.0 \times 10^{-5}$$

$$V_2 = \underline{\underline{8.68 \times 10^{-6}\ m^3}}$$

2. $P_1 = 128 \times 10^3\ Pa$; $V_1 = 1.5\ l$ $(= 0.0015\ m^3)$

$P_2 = ?$; $V_2 = 1.3\ l$ $(= 0.0013\ m^3)$

$$P_1 V_1 = P_2 V_2$$

$$P_2 = P_1 \cdot \frac{V_1}{V_2}$$

$$= 128 \times 10^3 \times \frac{1.5}{1.3}$$

$$\underline{\underline{P_2 = 1.48 \times 10^5\ Pa}}$$

3.

i) $V_1 = 4.5 \times 10^{-3} m^3$; $P_1 = 3.0 \times 10^6 Pa$; $T_1 = 287K$

$V_2 = ?$; $P_2 = 1.01 \times 10^5 Pa$; $T_2 = 273K$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow V_2 = \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} \cdot V_1$$

$$V_2 = \frac{3.0 \times 10^6}{1.01 \times 10^5} \times \frac{273}{287} \times 4.5 \times 10^{-3}$$

$$\underline{\underline{V_2 = 1.27 \times 10^{-1} m^3}}$$

ii) $M = \rho V_2$

$= 1.4 \times 1.27 \times 10^{-1}$

$= \underline{\underline{0.178 \text{ kg}}}$

4. $T_1 = 303\,K$; $P_1 = P$; $V_1 = V$

$T_2 = ?$; $P_2 = P$; $V_2 = 2V$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow T_2 = \frac{P_2}{P_1} \cdot \frac{V_2}{V_1} \cdot T_1$$

$$T_2 = \frac{P}{P} \times \frac{2V}{V} \times 303$$

$$= 2 \times 303$$

$$T_2 = 606\,K = \underline{\underline{333\,^\circ C}}$$

5.

$P_1 = 1.75 \times 10^5$ Pa ; V_1 = Constant ; $T_1 = 292$ K

$P_2 = 2.75 \times 10^5$ Pa ; V_2 = Constant ; $T_2 = ?$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \frac{P_2}{P_1} \cdot T_1$$

$$T_2 = \frac{2.75 \times 10^5}{1.75 \times 10^5} \times 292$$

$$T_2 = 459 \text{ K}$$

$$T_2 = 186\,^\circ\text{C}$$

6.

$V_1 = 250\ cm^3$; $T_1 = 340\ K$; $P_1 = 1{\cdot}04 \times 10^5\ Pa$

$V_2 = ?$; $T_2 = 273\ K$; $P_2 = 1{\cdot}01 \times 10^5\ Pa$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Longrightarrow V_2 = \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} \cdot V_1$$

$$V_2 = \frac{1{\cdot}04 \times 10^5}{1{\cdot}01 \times 10^5} \times \frac{273}{340} \times 250$$

$$V_2 = \underline{\underline{207\ cm^3}}$$

7. $T_1 = 290\,K$; $P_1 = 1.0$ Atm

$T_2 = 278\,K$; $P_2 = 0.75$ Atm.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{V_2}{V_1} = \frac{P_1}{P_2} \cdot \frac{T_2}{T_1}$$

Vol. at 2.5km

$$\frac{V_2}{V_1} = \frac{1.0}{0.75} \times \frac{278}{290}$$

Vol. at ground

$$= \underline{\underline{1.28}}$$

8. i)

$V_1 = 0.050 m^3$; $P_1 = 2.5 \times 10^6$ Pa

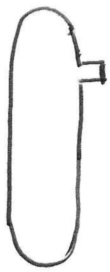
$V_2 = ?$; $P_2 = 1.01 \times 10^5$ Pa

$$P_1 V_1 = P_2 V_2$$

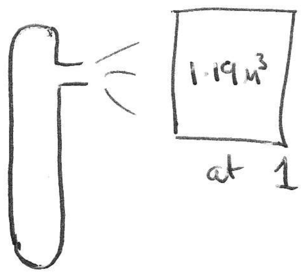
$$V_2 = \frac{P_1}{P_2} \cdot V_1 = \frac{2.5 \times 10^6}{1.01 \times 10^5} \times 0.050$$

$$\therefore V_2 = 1.24 \ m^3$$

ii)



0.05 m³
at 2.5 MPa
(equivalent to 1.24 m³ of air at 1 atm.)



at 1 atm

0.05 m³
at 1 atm
in cylinder

1.19 m³ of air is released from the cylinder.

9. $P_1 = 1.01\times10^5 + 4.2\times10^5$; $V_1 = 2.5\times10^{-2}\,m^3$; $T_1 = 296K$

$= 5.21\times10^5\ Pa$

$V_2 = ?$; $P_2 = 1.01\times10^5\ Pa$; $T_2 = 273\ K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \implies V_2 = \frac{P_1}{P_2}\cdot\frac{T_2}{T_1}\cdot V_1$$

$$\therefore V_2 = \frac{5.21\times10^5}{1.01\times10^5}\times\frac{273}{296}\times 2.5\times10^{-2}$$

$V_2 = 0.1189\ m^3$ at STP.

$m = \rho V_2 = 1.34 \times 0.1189$

$= \underline{\underline{0.159\ kg}}$

10.*

i) $T_1 = 291\,K$; $P_1 = 1.01\times10^5\,Pa$

$T_2 = ?$; $P_2 = 1.01\times10^5 + 2.00\times10^4$

$= 1.21\times10^5\,Pa$

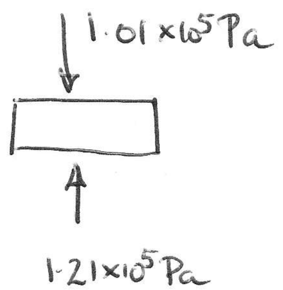
$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = \frac{P_2}{P_1}\cdot T_1$$

$$T_2 = \frac{1.21\times10^5}{1.01\times10^5}\times 291$$

$$= 349\,K$$

$$T_2 = \underline{\underline{75.6\,^\circ C}}$$

ii)



$\Delta P = 2\times10^4\,Pa$

$$F = A\times\Delta P = 3.14\times10^{-4}\times2\times10^4 = \underline{\underline{6.28\,N}}$$

iii) $F = ma \Rightarrow a = \frac{F}{m} = \frac{6.28}{0.025} = \underline{\underline{251.2\,m/s^2}}$

11.*

$P_1 = 190 \times 10^3 + 102 \times 10^3$; $T_1 = 281K$

27.6 Psi

$= 292 \times 10^3$ Pa

$P_2 = ?$; $T_2 = 302K$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \implies P_2 = \frac{T_2}{T_1} \cdot P_1$$

$$P_2 = \frac{302}{281} \times 292 \times 10^3$$

$= 313.8 \times 10^3$ Pa

Pressure above atmospheric:

$313.8 \times 10^3 - 102 \times 10^3$

$= 212 \times 10^3$ Pa

$= 212$ kPa ($=$ 30.74 Psi)

12.* Volume remains constant.

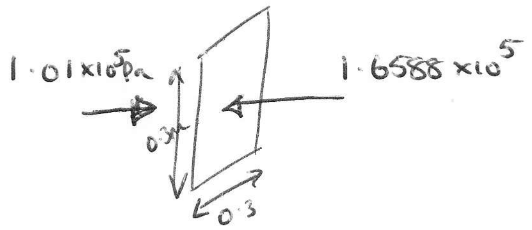
$P_1 = 1.01 \times 10^5\ Pa$; $T_1 = 288K$

$P_2 = ?$; $T_2 = 473K$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Longrightarrow P_2 = \frac{T_2}{T_1} \cdot P_1$$

$$P_2 = \frac{473}{288} \times 1.01 \times 10^5$$

$$= 1.6588 \times 10^5\ Pa$$



$$\Delta P = 1.6588 \times 10^5 - 1.01 \times 10^5 = 6.488 \times 10^4\ Pa$$

$$A = 0.3^2 = 0.09\ m^2$$

$$F = A \times \Delta P = 0.09 \times 6.488 \times 10^4$$

$$= 5840N$$

13.*

$P_1 = P$; $V_1 = V$; $T_1 = T$

$P_2 = ?$; $V_2 = 2V$; $T_2 = 3T$

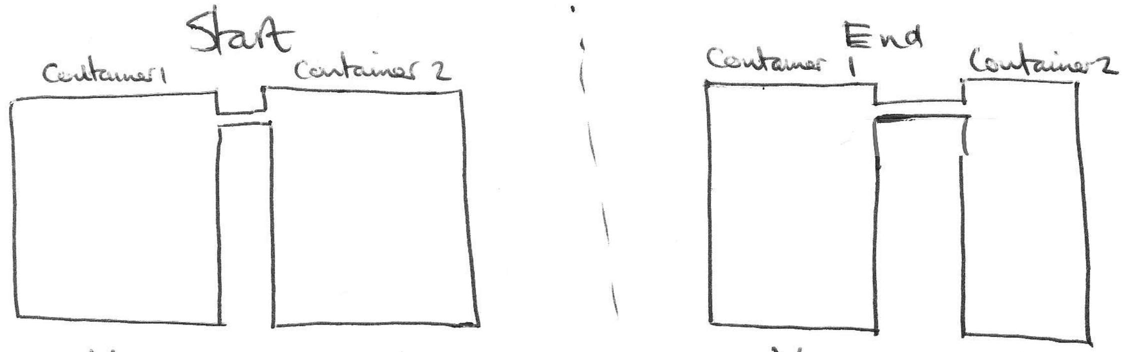
$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Longrightarrow P_2 = \frac{T_2}{T_1} \cdot \frac{V_1}{V_2} \cdot P_1$$

$$\therefore P_2 = \frac{3T}{T} \times \frac{V}{2V} \times P$$

$$\underline{\underline{P_2 = \frac{3P}{2}}}$$

B.

14.**



	Container 1 (Start)	Container 2 (Start)	Container 1 (End)	Container 2 (End)
Volume	V	V	V	V
Mass of gas	m	m	m_1	m_2
Temp:	$27°C$ (= 300K)	$27°C$	$27°C$	$127°C$ (= 400K)
Pressure:	2.1×10^5 Pa	2.1×10^5 Pa	p	p.

* Let Molar Mass of gas be M.

* Number of Moles of gas in each container initially is $\frac{m}{M}$ $\Longrightarrow$ total no. of Moles $= \frac{2m}{M}$

$\Longrightarrow$ $\underline{m_1 + m_2 = 2m}$

* Initially (entire system) : $pV = nRT \Longrightarrow 2.1 \times 10^5 \times 2V = \frac{\overbrace{m_1+m_2}^{=2m}}{M} \times R \times 300$

* Finally : (container 1) $pV = \frac{m_1}{M} R \times 300$

* Finally : (container 2) $pV = \frac{m_2}{M} R \times 400$.

$$\therefore \quad \frac{m_1}{M} R \times 300 = \frac{m_2}{M} R \times 400$$

or $\quad 300 m_1 = 400 m_2$

$$\underline{\underline{3m_1 = 4m_2}}$$

$$\therefore 2m = m_1 + m_2 = m_1 + \frac{3}{4} m_1 = \underline{\underline{1{\cdot}75 m_1}}$$

$$\therefore \quad 2{\cdot}1 \times 10^5 \times 2V = \frac{\overset{=2m}{1{\cdot}75 m_1}}{M} \times R \times 300$$

and $\quad pV = \dfrac{m_1}{M} \times R \times 300$

$$\therefore \quad \frac{2{\cdot}1 \times 10^5 \times 2V}{pV} = 1{\cdot}75$$

$$\therefore \quad p = \frac{2{\cdot}1 \times 10^5 \times 2}{1{\cdot}75} = \underline{\underline{2{\cdot}4 \times 10^5 \text{ Pa}}}$$

Part 2 - Ideal Gases

1. i) $pV = nRT$

$$n = \frac{pV}{RT}$$

$$= \frac{200 \times 10^{3} \times 0.2}{8.31 \times 290}$$

$\therefore$ $\underline{\underline{n = 16.6 \text{ moles}}}$

ii) $pV = Nk_BT$

$$N = \frac{pV}{k_BT}$$

$$= \frac{200 \times 10^{3} \times 0.2}{1.38 \times 10^{-23} \times 290}$$

$\therefore$ $\underline{\underline{N = 1.00 \times 10^{25}}}$

2.

i) $pV = Nk_BT$

$$N = \frac{pV}{k_BT}$$

$$= \frac{105 \times 10^3 \times 0.002}{1.38 \times 10^{-23} \times 290}$$

$\therefore N = 5.25 \times 10^{22}$ molecules

ii) $N = \frac{pV}{k_BT}$

$$= \frac{120 \times 10^3 \times 0.002}{1.38 \times 10^{-23} \times 290}$$

$$= 5.997 \times 10^{22}$$

$\Delta N = 5.997 \times 10^{22} - 5.25 \times 10^{22}$

$= 7.47 \times 10^{21}$ molecules

3. i)

$$pV = nRT$$

$$n = \frac{pV}{RT}$$

$$= \frac{8.6 \times 10^{4} \times 3.2 \times 10^{-2}}{8.31 \times \underbrace{(273 + 27)}_{300K}}$$

$$\underline{\underline{n = 1.10 \text{ moles}}}$$

ii)

$$pV = N k_B T$$

$$N = \frac{pV}{k_B T}$$

$$= \frac{8.6 \times 10^{4} \times 3.2 \times 10^{-2}}{1.38 \times 10^{-23} \times 300}$$

$$\therefore N = \underline{\underline{6.65 \times 10^{23} \text{ molecules}}}$$

iii)

$$\frac{6.65 \times 10^{23}}{3.2 \times 10^{-2}} = \underline{\underline{2.08 \times 10^{25} \text{ molecules}/m^3}}$$

4i)

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

$$\therefore T_2 = \frac{P_2}{P_1} \cdot \frac{V_2}{V_1} \cdot T_1$$

$$= 2 \times 2 \times \underbrace{(273 + 30)}_{303\,K}$$

$$= 1212\ K$$

$$= \underline{\underline{939\ {}^{\circ}C}}$$

ii)

$$pV = nRT$$

$$\Rightarrow n = \frac{pV}{RT}$$

$$= \frac{2.00 \times 10^5 \times 1.50 \times 10^3}{8.31 \times 303}$$

$n = 119145.489$ moles

$$\therefore \quad 2 \times 119145.489 = 2.38 \times 10^5\ g$$

$$= \underline{\underline{2.38 \times 10^2\ kg}}$$

5.

$$pV = Nk_BT$$

$$\underbrace{\frac{N}{V}}_{\text{no. of molecules per } m^3} = \frac{p}{k_BT}$$

$$\therefore \frac{N}{V} = \frac{1.01 \times 10^{5}}{1.38 \times 10^{-23} \times 273}$$

$$= \underline{\underline{2.68 \times 10^{25} \text{ molecules}/m^3}}$$

6.

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

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

$$V_1 = 25\,dm^3 = 25 \times (dm)^3$$

$$= 25 \times (10^{-1}\,m)^3$$

$$= 25 \times 10^{-3}\,m^3$$

$$\therefore \quad V_2 = \frac{1 \times 10^6}{5 \times 10^5} \times \frac{600}{300} \times 25 \times 10^{-3}$$

$$\underline{\underline{V_2 = 0.1\,m^3}}$$

7. $V = 100\ l = 0.1\ m^3$

$$pV = nRT$$

$$T = \frac{pV}{nR}$$

$$= \frac{1.01 \times 10^5 \times 0.1}{3 \times 8.31}$$

$$= 405\ K$$

$$T = \underline{\underline{132\ °C}}$$ (i.e. a very hot balloon).

8. $pV = nRT \implies V = \dfrac{nRT}{p}$

$$\rho = \frac{m}{V} = \frac{mP}{nRT}$$

$$\therefore \rho = \frac{0.029 \times 1.01 \times 10^5}{1 \times 8.31 \times 273}$$

$$\therefore \rho = 1.29 \ \text{kg/m}^3$$

9.

i) $n = \frac{N}{N_A} = \frac{6.02 \times 10^{22}}{6.02 \times 10^{23}}$

$\therefore$ $n = 0.1$ moles

ii) $m = nM$ molar mass

$= 0.1 \times 3.55 \times 10^{-2}$

$= 3.55 \times 10^{-3}$ kg

iii) $pV = nRT$

$V = \frac{nRT}{p}$

$= \frac{0.1 \times 8.31 \times 290}{1.15 \times 10^{5}}$

$\therefore V = 2.095... \times 10^{-3}$

$= 2.10 \times 10^{-3}$ m^3

10.* i)

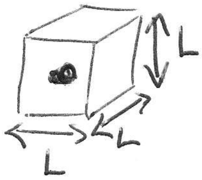
$$pV = N k_B T$$

$$N_L = \frac{N}{V} = \frac{p}{k_B T}$$

$$\therefore N_L = \frac{1.01 \times 10^5}{1.38 \times 10^{-23} \times 273}$$

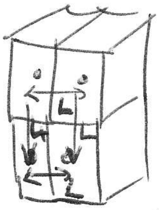
$$\therefore N_L = 2.68 \times 10^{25} \text{ molecules/m}^3$$

ii) $$\frac{1}{N_L} = 3.73 \times 10^{-26} \text{ m}^3/\text{molecule} = \text{Volume each molecule has to itself.}$$



$$L^3 = 3.73 \times 10^{-26} \text{ m}^3$$

$$\therefore L = 3.34 \times 10^{-9} \text{ m}$$



iii) Volume of molecule $= \frac{4}{3}\pi r^3$

$$= \frac{4}{3}\pi \times (1.25 \times 10^{-10})^3$$

$$= 8.18 \times 10^{-30} \text{ m}^3$$

$$\frac{8.18 \times 10^{-30}}{3.73 \times 10^{-26}} = 2.19 \times 10^{-4}$$

11.* X → Y is an isothermal expansion as pressure halves but volume doubles, hence pV = constant.

Y → Z is an isochoric thermal increase, as V remains constant.

Hence,
$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

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

$$= \frac{0.75 \times 10^5}{0.5 \times 10^5} \times 300$$

$$\underline{\underline{T_2 = 450\,K}}$$

12.* i) H_2 : $n_{H_2} = \frac{2}{2}$ $= \underline{\underline{1}}$ mole

mass

Molar Mass

He : $n_{He} = \frac{4}{4} = \underline{\underline{1}}$ mole

ii) $n = n_{H_2} + n_{He}$

$= \underline{\underline{2}}$ moles

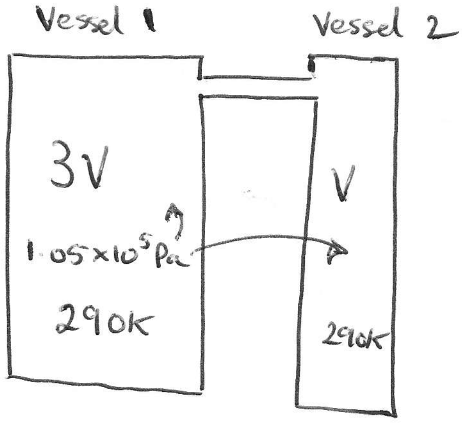
iii) $pV = nRT$

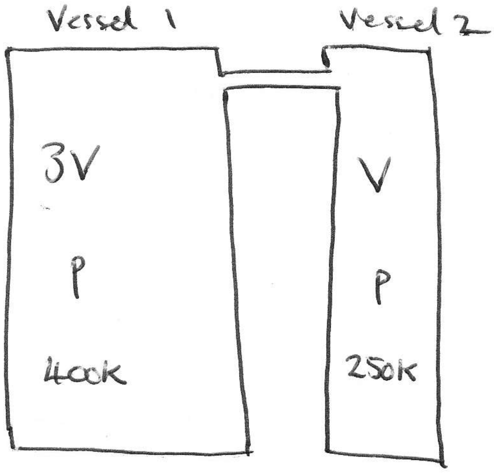
$$p = \frac{nRT}{V}$$

$$= \frac{2 \times 8.31 \times 320}{0.2}$$

$\therefore \underline{\underline{p = 2.66 \times 10^4 \text{ Pa}}}$

13.**





* let M be the Molar Mass of gas.

m_1 = mass of gas in Vessel 1 after heating

m_2 = mass " " " " 2 after cooling

total mass of gas.

$$m = m_1 + m_2 \implies n = \frac{m}{M}$$

* after : Vessel 1 ; Vessel 2

$$3pV = \frac{m_1}{M} R \times 400 \quad ; \quad pV = \frac{m_2}{M} R \times 250$$

$$\therefore \frac{400\,m_1}{3} = 250\,m_2 \implies \underline{\underline{8m_1 = 15m_2}}$$

$$\delta m = \delta m_1 + \delta m_2$$

$$= 15 m_2 + 8 m_2$$

$$= 23 m_2$$

$$\therefore \quad m = \frac{23 m_2}{8}$$

* <u>before</u> : both vessels : $p \times 4V = \frac{m}{M} R T$

$\uparrow$ 1.05×10^5 Pa $\qquad \uparrow$ 290 K

$$\therefore \quad \boxed{4.2 \times 10^5 V = 290 \frac{m}{M} R}$$

$$= 290 \times \frac{23 m_2}{8M} R$$

$$pV = \frac{m_2}{M} R \times 250 \quad \text{and} \quad 4.2 \times 10^5 V = 290 \times \frac{23 m_2}{8M} R$$

$$\therefore \quad \frac{P}{4.2 \times 10^5} = \frac{250}{290 \times 23/8} \Rightarrow \underline{\underline{P = 1.26 \times 10^5 \text{ Pa}}}$$

Part 3 — Energy and Temperature

1. $$E = \frac{3}{2} k_B T$$

$$= 1.5 \times 1.38 \times 10^{-23} \times 10$$

$$\therefore E = \underline{\underline{2.07 \times 10^{-22}\ J}}$$

2. $$E = \frac{3}{2} k_B T$$

$$\therefore T = \frac{2E}{3k_B}$$

$$= \frac{2 \times 6.21 \times 10^{-21}}{3 \times 1.38 \times 10^{-23}}$$

$$\therefore \underline{\underline{T = 300\ K}}$$

3.

$$E = \frac{3}{2} k_B T$$

$$E = \frac{3}{2} \times 1.38 \times 10^{-23} \times 288$$

$$\therefore E = \underline{\underline{5.96 \times 10^{-21}\ J}}$$

All three gases will have the same kinetic energy if we assume they behave as ideal gases.

4. i) $pV = nRT$

$$n = \frac{pV}{RT}$$

$$= \frac{200\times10^{3} \times 8\times10^{-4}}{8.31 \times 300}$$

$\therefore n = 0.0641797$ moles

$m = nM = 0.0641797 \times 4\times10^{-3}$

$\therefore m = \underline{\underline{2.57\times10^{-4}\ kg}}$

ii) $E = \frac{3}{2} k_B T$

$= 1.5 \times 1.38\times10^{-23} \times 300$

$\therefore \underline{\underline{E = 6.21\times10^{-21}\ J}}$

iii) $E_{total} = N \times \frac{3}{2} k_B T = \frac{3}{2} \underbrace{N k_B T}_{pV}$

$\therefore E_{total} = 1.5 \times 200\times10^{3} \times 8\times10^{-4}$

$= \underline{\underline{240\ J}}$

5. $E = \frac{3}{2} k_B T$ = energy of one molecule.

In a mole, there are N_A molecules.

$\therefore E_{total} = N_A \cdot E$

$= \frac{3}{2} \underbrace{N_A k_B}_{=R} T$

$= \frac{3}{2} R T$

$= 1.5 \times 8.31 \times 273$

$\therefore E_{total} = 3403\ J$

6.

$$E = \frac{3}{2} k_B T = \frac{1}{2} m \langle v^2 \rangle$$

$$\therefore \quad \langle v^2 \rangle = \frac{3 k_B T}{m}$$

$$T = \frac{m \langle v^2 \rangle}{3 k_B}$$

If $v \Rightarrow 2v$, then $\langle v^2 \rangle \Rightarrow 4 \langle v^2 \rangle$

$$\therefore \ T' = 4 \times \underbrace{\frac{m \langle v^2 \rangle}{3 k_B}}_{T}$$

$\therefore$ Temperature increases by a factor of 4.

7. $$E = \frac{1}{2} M \langle v^2 \rangle = \frac{3}{2} k_B T$$

$$\sqrt{\langle v^2 \rangle} = \sqrt{\frac{3 k_B T}{m}}$$

$$= \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times (273 - 12)}{5.3 \times 10^{-26}}}$$

$$\therefore \sqrt{\langle v^2 \rangle} = \underline{\underline{452 \text{ M/s}}}$$

8. $E = \frac{1}{2} m \langle v^2 \rangle = \frac{3}{2} k_B T$

$$\therefore \sqrt{\langle v^2 \rangle} = \sqrt{\frac{3 k_B T}{m}}$$

$$\therefore \sqrt{\langle v^2 \rangle} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 6000}{6.6 \times 10^{-27}}}$$

$$= 6134.8$$

$$= \underline{\underline{6130 \text{ m/s}}}$$

9.*

$$\frac{1}{2} M_x \langle V_x^2 \rangle = \frac{3}{2} k_B T = \frac{1}{2} M_y \langle V_y^2 \rangle$$

$$\therefore \quad M_x \langle V_x^2 \rangle = M_y \langle V_y^2 \rangle$$

$$\therefore \quad \frac{\langle V_x^2 \rangle}{\langle V_y^2 \rangle} = \frac{M_y}{M_x}$$

$$\therefore \quad \sqrt{\frac{\langle V_x^2 \rangle}{\langle V_y^2 \rangle}} = \sqrt{\frac{M_y}{M_x}}.$$

Since $\quad M_x = 4 M_y$

$$\sqrt{\frac{\langle V_x^2 \rangle}{\langle V_y^2 \rangle}} = \underline{\underline{\frac{1}{2}}}$$

10.*

$$pV = nRT$$

if $p \rightarrow 2p$, then $T \rightarrow 2T$

Since V, n and R are constant.

$$\frac{1}{2} M v^2 = \frac{3}{2} k_B T$$

when heated: $\frac{1}{2} M (v')^2 = \frac{3}{2} k_B (2T)$

$$= 2 \times \underbrace{\frac{3}{2} k_B T}_{\frac{1}{2} M v^2}$$

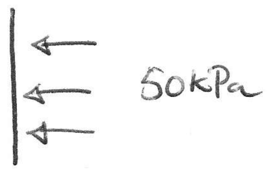
$$\therefore \quad \frac{1}{2} M (v')^2 = 2 \times \frac{1}{2} M v^2$$

or $(v')^2 = 2v^2$

ie. $\underline{\underline{v' = \sqrt{2}\, v}}$

11.* i)

Assume Vacuum.



$$F = p \cdot A$$

$$= 500\times10^{3} \times 1\times10^{-2}$$

$$= \underline{\underline{5000N}}$$

ii)

$$pV = nRT$$

$$T = \frac{pV}{nR}$$

$$= \frac{500\times10^{3} \times 5\times10^{-3}}{1 \times 8.31}$$

$$T = \underline{\underline{300.8\ K}}$$

iii)

$$pV = nRT.$$

$$V = \underbrace{5\times10^{-3}}_{\text{original}} + \underbrace{5\times10^{-3} \times 1\times10^{-2}}_{\text{new extra volume}}$$

$$= \underline{\underline{5.05\times10^{-3}\ m^{3}}}$$

$$T = \frac{pV}{nR} = \frac{200\times10^{3} \times 5.05\times10^{-3}}{1 \times 8.31}$$

$$\underline{\underline{T = 121.5K}}$$