CHAPTER 24
KINETIC THEORY OF GASES

1. Volume of 1 mole of gas

   $PV = nRT \Rightarrow V = \frac{RT}{P} = \frac{0.082 \times 273}{1} = 22.38 \approx 22.4\text{ L} = 22.4 \times 10^{-3} = 2.24 \times 10^{-2}\text{ m}^3$

2. $n = \frac{PV}{RT} = \frac{1 \times 1 \times 10^{-3}}{0.082 \times 273} = \frac{10^{-3}}{22.4} = \frac{1}{22400}$

   No of molecules = $6.023 \times 10^{23} \times \frac{1}{22400} = 2.688 \times 10^{19}$

3. $V = 1\text{ cm}^3$, $T = 0°C$, $P = 10^{-5}$ mm of Hg

   $n = \frac{PV}{RT} = \frac{f gh \times V}{RT} = \frac{1.36 \times 980 \times 10^{-6} \times 1}{8.31 \times 273} = 5.874 \times 10^{-13}$

   No. of moluclues = No × n = $6.023 \times 10^{23} \times 5.874 \times 10^{-13} = 3.538 \times 10^{11}$

4. $n = \frac{PV}{RT} = \frac{1 \times 1 \times 10^{-3}}{0.082 \times 273} = \frac{10^{-3}}{22.4}$

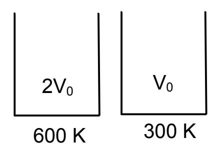
   mass = $\frac{(10^{-3} \times 32)}{22.4}$ g = 1.428×10^{-3} g = 1.428 mg

5. Since mass is same

   $n_1 = n_2 = n$

   $P_1 = \frac{nR \times 300}{V_0}$, $P_2 = \frac{nR \times 600}{2V_0}$

   $\frac{P_1}{P_2} = \frac{nR \times 300}{V_0} \times \frac{2V_0}{nR \times 600} = \frac{1}{1} = 1 : 1$



6. V = 250 cc = 250×10^{-3}

   $P = 10^{-3}$ mm = $10^{-3} \times 10^{-3}$ m = $10^{-6} \times 13600 \times 10$ pascal = 136×10^{-3} pascal

   T = 27°C = 300 K

   $n = \frac{PV}{RT} = \frac{136 \times 10^{-3} \times 250}{8.3 \times 300} \times 10^{-3} = \frac{136 \times 250}{8.3 \times 300} \times 10^{-6}$

   No. of molecules = $\frac{136 \times 250}{8.3 \times 300} \times 10^{-6} \times 6 \times 10^{23} = 81 \times 10^{17} \approx 0.8 \times 10^{15}$

7. $P_1 = 8.0 \times 10^5\ P_a$, $P_2 = 1 \times 10^6\ P_a$, $T_1 = 300$ K, $T_2 = ?$

   Since, $V_1 = V_2 = V$

   $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{8 \times 10^5 \times V}{300} = \frac{1 \times 10^6 \times V}{T_2} \Rightarrow T_2 = \frac{1 \times 10^6 \times 300}{8 \times 10^5} = 375°\text{ K}$

8. m = 2 g, $V = 0.02\text{ m}^3 = 0.02 \times 10^6\text{ cc} = 0.02 \times 10^3$ L, T = 300 K, P = ?

   M = 2 g,

   $PV = nRT \Rightarrow PV = \frac{m}{M}RT \Rightarrow P \times 20 = \frac{2}{2} \times 0.082 \times 300$

   $\Rightarrow P = \frac{0.082 \times 300}{20} = 1.23\text{ atm} = 1.23 \times 10^5\text{ pa} \approx 1.23 \times 10^5\text{ pa}$

9. $P = \frac{nRT}{V} = \frac{m}{M} \times \frac{RT}{V} = \frac{f RT}{M}$

   $f \to 1.25 \times 10^{-3}\text{ g/cm}^3$

   $R \to 8.31 \times 10^7$ ert/deg/mole

   $T \to 273$ K

   $\Rightarrow M = \frac{f RT}{P} = \frac{1.25 \times 10^{-3} \times 8.31 \times 10^7 \times 273}{13.6 \times 980 \times 76} = 0.002796 \times 10^4 \approx 28\text{ g/mol}$

10. T at Simla = 15°C = 15 + 273 = 288 K
P at Simla = 72 cm = $72 \times 10^{-2} \times 13600 \times 9.8$
T at Kalka = 35°C = 35 + 273 = 308 K
P at Kalka = 76 cm = $76 \times 10^{-2} \times 13600 \times 9.8$
PV = nRT

$$\Rightarrow PV = \frac{m}{M}RT \Rightarrow PM = \frac{m}{V}RT \Rightarrow f = \frac{PM}{RT}$$

$$\frac{f\text{Simla}}{f\text{Kalka}} = \frac{P_{Simla} \times M}{RT_{Simla}} \times \frac{RT_{Kalka}}{P_{Kalka} \times M}$$

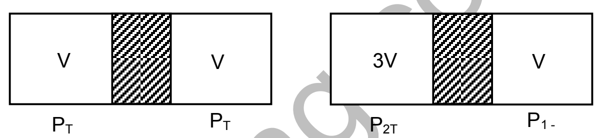
$$= \frac{72 \times 10^{-2} \times 13600 \times 9.8 \times 308}{288 \times 76 \times 10^{-2} \times 13600 \times 9.8} = \frac{72 \times 308}{76 \times 288} = 1.013$$

$$\frac{f\text{Kalka}}{f\text{Simla}} = \frac{1}{1.013} = 0.987$$

11. $n_1 = n_2 = n$

$$P_1 = \frac{nRT}{V}, \qquad P_2 = \frac{nRT}{3V}$$

$$\frac{P_1}{P_2} = \frac{nRT}{V} \times \frac{3V}{nRT} = 3 : 1$$



12. r.m.s velocity of hydrogen molecules = ?
T = 300 K, R = 8.3, M = 2 g = 2×10^{-3} Kg

$$C = \sqrt{\frac{3RT}{M}} \Rightarrow C = \sqrt{\frac{3 \times 8.3 \times 300}{2 \times 10^{-3}}} = 1932.\ 6 \text{ m/s} \approx 1930 \text{ m/s}$$

Let the temp. at which the C = 2 × 1932.6 is T′

$$2 \times 1932.6 = \sqrt{\frac{3 \times 8.3 \times T'}{2 \times 10^{-3}}} \Rightarrow (2 \times 1932.6)^2 = \frac{3 \times 8.3 \times T'}{2 \times 10^{-3}}$$

$$\Rightarrow \frac{(2 \times 1932.6)^2 \times 2 \times 10^{-3}}{3 \times 8.3} = T'$$

$\Rightarrow T' = 1199.98 \approx 1200$ K.

13. $V_{rms} = \sqrt{\frac{3P}{f}}$ $\qquad$ P = 10^5 Pa = 1 atm, $\qquad$ $f = \frac{1.77 \times 10^{-4}}{10^{-3}}$

$$= \sqrt{\frac{3 \times 10^5 \times 10^{-3}}{1.77 \times 10^{-4}}} = 1301.8 \approx 1302 \text{ m/s.}$$

14. Agv. K.E. = 3/2 KT
3/2 KT = $0.04 \times 1.6 \times 10^{-19}$
$\Rightarrow (3/2) \times 1.38 \times 10^{-23} \times T = 0.04 \times 1.6 \times 10^{-19}$

$$\Rightarrow T = \frac{2 \times 0.04 \times 1.6 \times 10^{-19}}{3 \times 1.38 \times 10^{-23}} = 0.0309178 \times 10^4 = 309.178 \approx 310 \text{ K}$$

15. $$V_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.3 \times 300}{3.14 \times 0.032}}$$

$$T = \frac{\text{Distance}}{\text{Speed}} = \frac{6400000 \times 2}{445.25} = 445.25 \text{ m/s}$$

$$= \frac{28747.83}{3600} \text{ km} = 7.985 \approx 8 \text{ hrs.}$$

16. M = 4×10^{-3} Kg

$$V_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.3 \times 273}{3.14 \times 4 \times 10^{-3}}} = 1201.35$$

Momentum = M × V_{avg} = $6.64 \times 10^{-27} \times 1201.35 = 7.97 \times 10^{-24} \approx 8 \times 10^{-24}$ Kg-m/s.

17. $V_{avg} = \sqrt{\frac{8RT}{\pi M}} = \frac{8 \times 8.3 \times 300}{3.14 \times 0.032}$

Now, $\frac{8RT_1}{\pi \times 2} = \frac{8RT_2}{\pi \times 4}$ $\qquad\qquad$ $\frac{T_1}{T_2} = \frac{1}{2}$

18. Mean speed of the molecule = $\sqrt{\frac{8RT}{\pi M}}$

Escape velocity = $\sqrt{2gr}$

$\sqrt{\frac{8RT}{\pi M}} = \sqrt{2gr} \quad \Rightarrow \frac{8RT}{\pi M} = 2gr$

$\Rightarrow T = \frac{2gr\pi M}{8R} = \frac{2 \times 9.8 \times 6400000 \times 3.14 \times 2 \times 10^{-3}}{8 \times 8.3}$ = 11863.9 ≈ 11800 m/s.

19. $V_{avg} = \sqrt{\frac{8RT}{\pi M}}$

$\frac{V_{avg}H_2}{V_{avg}N_2} = \sqrt{\frac{8RT}{\pi \times 2}} \times \sqrt{\frac{\pi \times 28}{8RT}} = \sqrt{\frac{28}{2}} = \sqrt{14} = 3.74$

20. The left side of the container has a gas, let having molecular wt. M_1
Right part has Mol. wt = M_2
Temperature of both left and right chambers are equal as the separating wall is diathermic

$\sqrt{\frac{3RT}{M_1}} = \sqrt{\frac{8RT}{\pi M_2}} \Rightarrow \frac{3RT}{M_1} = \frac{8RT}{\pi M_2} \Rightarrow \frac{M_1}{\pi M_2} = \frac{3}{8} \Rightarrow \frac{M_1}{M_2} = \frac{3\pi}{8} = 1.1775 \approx 1.18$

21. $V_{mean} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.3 \times 273}{3.14 \times 2 \times 10^{-3}}} = 1698.96$

Total Dist = 1698.96 m

No. of Collisions = $\frac{1698.96}{1.38 \times 10^{-7}} = 1.23 \times 10^{10}$

22. P = 1 atm = 10^5 Pascal
T = 300 K, $\qquad$ M = 2 g = 2×10^{-3} Kg

(a) $V_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.3 \times 300}{3.14 \times 2 \times 10^{-3}}}$ = 1781.004 ≈ 1780 m/s

(b) When the molecules strike at an angle 45°,

Force exerted = mV Cos 45° – (–mV Cos 45°) = 2 mV Cos 45° = 2 m V $\frac{1}{\sqrt{2}} = \sqrt{2}$ mV

No. of molecules striking per unit area = $\frac{\text{Force}}{\sqrt{2}mv \times \text{Area}} = \frac{\text{Pressure}}{\sqrt{2}mV}$

$= \frac{10^5}{\frac{\sqrt{2} \times 2 \times 10^{-3} \times 1780}{6 \times 10^{23}}} = \frac{3}{\sqrt{2} \times 1780} \times 10^{31} = 1.19 \times 10^{-3} \times 10^{31} = 1.19 \times 10^{28} \approx 1.2 \times 10^{28}$

23. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$P_1 \to$ 200 KPa = 2×10^5 pa $\qquad$ P_2 = ?
T_1 = 20°C = 293 K $\qquad$ T_2 = 40°C = 313 K

$V_2 = V_1 + 2\%\ V_1 = \frac{102 \times V_1}{100}$

$\Rightarrow \frac{2 \times 10^5 \times V_1}{293} = \frac{P_2 \times 102 \times V_1}{100 \times 313} \Rightarrow P_2 = \frac{2 \times 10^7 \times 313}{102 \times 293}$ = 209462 Pa = 209.462 KPa

24. $V_1 = 1 \times 10^{-3}\ m^3$, $P_1 = 1.5 \times 10^5$ Pa, $T_1 = 400$ K

$P_1V_1 = n_1R_1T_1$

$\Rightarrow n = \dfrac{P_1V_1}{R_1T_1} = \dfrac{1.5 \times 10^5 \times 1 \times 10^{-3}}{8.3 \times 400}$ $\Rightarrow n = \dfrac{1.5}{8.3 \times 4}$

$\Rightarrow m_1 = \dfrac{1.5}{8.3 \times 4} \times M = \dfrac{1.5}{8.3 \times 4} \times 32 = 1.4457 \approx 1.446$

$P_2 = 1 \times 10^5$ Pa, $V_2 = 1 \times 10^{-3}\ m^3$, $T_2 = 300$ K

$P_2V_2 = n_2R_2T_2$

$\Rightarrow n_2 = \dfrac{P_2V_2}{R_2T_2} = \dfrac{10^5 \times 10^{-3}}{8.3 \times 300} = \dfrac{1}{3 \times 8.3} = 0.040$

$\Rightarrow m_2 = 0.04 \times 32 = 1.285$

$\Delta m = m_1 - m_2 = 1.446 - 1.285 = 0.1608\ g \approx 0.16\ g$

25. $P_1 = 10^5 + \rho gh = 10^5 + 1000 \times 10 \times 3.3 = 1.33 \times 10^5$ pa

$P_2 = 10^5$, $T_1 = T_2 = T$, $V_1 = \dfrac{4}{3}\pi(2 \times 10^{-3})^3$

$V_2 = \dfrac{4}{3}\pi r^3$, $r = ?$

$\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$

$$\Rightarrow \frac{1.33 \times 10^5 \times \frac{4}{3} \times \pi \times (2 \times 10^{-3})^3}{T_1} = \frac{10^5 \times \frac{4}{3} \times \pi r^2}{T_2}$$

$\Rightarrow 1.33 \times 8 \times 10^5 \times 10^{-9} = 10^5 \times r^3$ $\Rightarrow r = \sqrt[3]{10.64 \times 10^{-3}} = 2.19 \times 10^{-3} \approx 2.2$ mm

26. $P_1 = 2$ atm $= 2 \times 10^5$ pa

$V_1 = 0.002\ m^3$, $T_1 = 300$ K

$P_1V_1 = n_1RT_1$

$\Rightarrow n = \dfrac{P_1V_1}{RT_1} = \dfrac{2 \times 10^5 \times 0.002}{8.3 \times 300} = \dfrac{4}{8.3 \times 3} = 0.1606$

$P_2 = 1$ atm $= 10^5$ pa

$V_2 = 0.0005\ m^3$, $T_2 = 300$ K

$P_2V_2 = n_2RT_2$

$\Rightarrow n_2 = \dfrac{P_2V_2}{RT_2} = \dfrac{10^5 \times 0.0005}{8.3 \times 300} = \dfrac{5}{3 \times 8.3} \times \dfrac{1}{10} = 0.02$

Δn = moles leaked out = 0.16 – 0.02 = 0.14

27. $m = 0.040$ g, $T = 100°C$, $M_{He} = 4$ g

$U = \dfrac{3}{2}nRt = \dfrac{3}{2} \times \dfrac{m}{M} \times RT$ $T' = ?$

Given $\dfrac{3}{2} \times \dfrac{m}{M} \times RT + 12 = \dfrac{3}{2} \times \dfrac{m}{M} \times RT'$

$\Rightarrow 1.5 \times 0.01 \times 8.3 \times 373 + 12 = 1.5 \times 0.01 \times 8.3 \times T'$

$\Rightarrow T' = \dfrac{58.4385}{0.1245} = 469.3855\ K = 196.3°C \approx 196°C$

28. PV^2 = constant

$\Rightarrow P_1V_1^2 = P_2V_2^2$

$\Rightarrow \dfrac{nRT_1}{V_1} \times V_1^2 = \dfrac{nRT_2}{V_2} \times V_2^2$

$\Rightarrow T_1 V_1 = T_2 V_2 = TV = T_1 \times 2V \Rightarrow T_2 = \dfrac{T}{2}$

29. $P_{O_2} = \dfrac{n_{o_2}RT}{V}$, $P_{H_2} = \dfrac{n_{H_2}RT}{V}$

$n_{O_2} = \dfrac{m}{M_{O_2}} = \dfrac{1.60}{32} = 0.05$

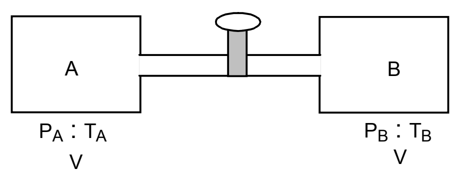
Now, $P_{mix} = \left(\dfrac{n_{O_2} + n_{H_2}}{V}\right)RT$

$n_{H_2} = \dfrac{m}{M_{H_2}} = \dfrac{2.80}{28} = 0.1$

$P_{mix} = \dfrac{(0.05 + 0.1) \times 8.3 \times 300}{0.166} = 2250\ N/m^2$

30. P_1 = Atmospheric pressure = 75 × fg
V_1 = 100 × A
P_2 = Atmospheric pressure + Mercury pessue = 75fg + hg$f$g (if h = height of mercury)
V_2 = (100 – h) A
$P_1V_1 = P_2V_2$
$\Rightarrow 75fg(100A) = (75 + h)fg(100 - h)A$
$\Rightarrow 75 \times 100 = (74 + h)(100 - h) \Rightarrow 7500 = 7500 - 75h + 100h - h^2$
$\Rightarrow h^2 - 25h = 0 \Rightarrow h^2 = 25h \Rightarrow h = 25$ cm
Height of mercury that can be poured = 25 cm

31. Now, Let the final pressure; Volume & Temp be
After connection = $P_A' \rightarrow$ Partial pressure of A
$P_B' \rightarrow$ Partial pressure of B



Now, $\dfrac{P_A' \times 2V}{T} = \dfrac{P_A \times V}{T_A}$

Or $\dfrac{P_A'}{T} = \dfrac{P_A}{2T_A}$ …(1)

Similarly, $\dfrac{P_B'}{T} = \dfrac{P_B}{2T_B}$ …(2)

Adding (1) & (2)

$\dfrac{P_A'}{T} + \dfrac{P_B'}{T} = \dfrac{P_A}{2T_A} + \dfrac{P_B}{2T_B} = \dfrac{1}{2}\left(\dfrac{P_A}{T_A} + \dfrac{P_B}{T_B}\right)$

$\Rightarrow \dfrac{P}{T} = \dfrac{1}{2}\left(\dfrac{P_A}{T_A} + \dfrac{P_B}{T_B}\right)$ $[\therefore P_A' + P_B' = P]$

32. V = 50 cc = $50 \times 10^{-6}\ cm^3$
P = 100 KPa = 10^5 Pa M = 28.8 g
(a) $PV = nrT_1$

$\Rightarrow PV = \dfrac{m}{M}RT_1 \Rightarrow m = \dfrac{PMV}{RT_1} = \dfrac{10^5 \times 28.8 \times 50 \times 10^{-6}}{8.3 \times 273} = \dfrac{50 \times 28.8 \times 10^{-1}}{8.3 \times 273} = 0.0635$ g.

(b) When the vessel is kept on boiling water

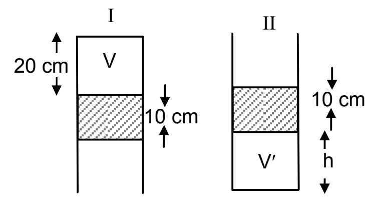
$PV = \dfrac{m}{M}RT_2 \Rightarrow m = \dfrac{PVM}{RT_2} = \dfrac{10^5 \times 28.8 \times 50 \times 10^{-6}}{8.3 \times 373} = \dfrac{50 \times 28.8 \times 10^{-1}}{8.3 \times 373} = 0.0465$

(c) When the vessel is closed

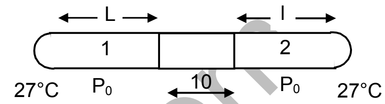
$P \times 50 \times 10^{-6} = \dfrac{0.0465}{28.8} \times 8.3 \times 273$

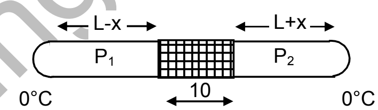
$\Rightarrow P = \dfrac{0.0465 \times 8.3 \times 273}{28.8 \times 50 \times 10^{-6}} = 0.07316 \times 10^6$ Pa ≈ 73 KPa

33. Case I $\rightarrow$ Net pressure on air in volume V
$= P_{atm} - hfg = 75 \times f_{Hg} - 10\, f_{Hg} = 65 \times f_{Hg} \times g$
Case II $\rightarrow$ Net pressure on air in volume 'V' $= P_{atm} + f_{Hg} \times g \times h$
$P_1V_1 = P_2V_2$
$\Rightarrow f_{Hg} \times g \times 65 \times A \times 20 = f_{Hg} \times g \times 75 + f_{Hg} \times g \times 10 \times A \times h$
$\Rightarrow 62 \times 20 = 85\ h \Rightarrow h = \dfrac{65 \times 20}{85} = 15.2\text{ cm} \approx 15\text{ cm}$

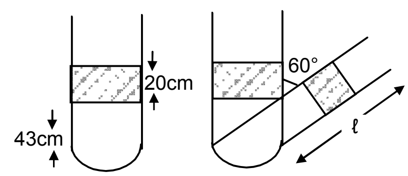


34. $2L + 10 = 100 \Rightarrow 2L = 90 \Rightarrow L = 45$ cm
Applying combined gas eqn to part 1 of the tube
$$\frac{(45A)P_0}{300} = \frac{(45 - x)P_1}{273}$$
$$\Rightarrow P_1 = \frac{273 \times 45 \times P_0}{300(45 - x)}$$
Applying combined gas eqn to part 2 of the tube
$$\frac{45AP_0}{300} = \frac{(45 + x)AP_2}{400}$$
$$\Rightarrow P_2 = \frac{400 \times 45 \times P_0}{300(45 + x)}$$
$P_1 = P_2$
$$\Rightarrow \frac{273 \times 45 \times P_0}{300(45 - x)} = \frac{400 \times 45 \times P_0}{300(45 + x)}$$
$\Rightarrow (45 - x)\,400 = (45 + x)\,273 \qquad \Rightarrow 18000 - 400\,x = 12285 + 273\,x$
$\Rightarrow (400 + 273)x = 18000 - 12285 \qquad \Rightarrow x = 8.49$
$$P_1 = \frac{273 \times 46 \times 76}{300 \times 36.51} = 85\ \%\ 25\text{ cm of Hg}$$
Length of air column on the cooler side $= L - x = 45 - 8.49 = 36.51$

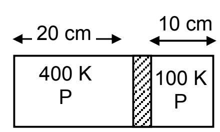


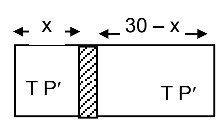


35. Case I Atmospheric pressure + pressure due to mercury column
Case II Atmospheric pressure + Component of the pressure due to mercury column
$P_1V_1 = P_2V_2$
$\Rightarrow (76 \times f_{Hg} \times g + f_{Hg} \times g \times 20) \times A \times 43$
$= (76 \times f_{Hg} \times g + f_{Hg} \times g \times 20 \times \cos 60°)\ A \times \ell$
$\Rightarrow 96 \times 43 = 86 \times \ell$
$$\Rightarrow \ell = \frac{96 \times 43}{86} = 48\text{ cm}$$



36. The middle wall is weakly conducting. Thus after a long time the temperature of both the parts will equalise.
The final position of the separating wall be at distance x from the left end. So it is at a distance 30 – x from the right end
Putting combined gas equation of one side of the separating wall,
$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$
$$\Rightarrow \frac{P \times 20A}{400} = \frac{P' \times A}{T} \qquad \ldots(1)$$
$$\Rightarrow \frac{P \times 10A}{100} = \frac{-P'(30 - x)}{T} \qquad \ldots(2)$$
Equating (1) and (2)
$$\Rightarrow \frac{1}{2} = \frac{x}{30 - x} \qquad \Rightarrow 30 - x = 2x \Rightarrow 3x = 30 \Rightarrow x = 10\text{ cm}$$
The separator will be at a distance 10 cm from left end.





37. $\frac{dV}{dt} = r \Rightarrow dV = r\ dt$

Let the pumped out gas pressure dp

Volume of container = V_0 At a pump dv amount of gas has been pumped out.

$Pdv = -V_0 df \Rightarrow P_V\ df = -V_0\ dp$

$\Rightarrow \int_P^P \frac{dp}{p} = -\int_0^t \frac{dtr}{V_0} \Rightarrow P = P\ e^{-rt/V_0}$

Half of the gas has been pump out, Pressure will be half = $\frac{1}{2} e^{-vt/V_0}$

$\Rightarrow \ln 2 = \frac{rt}{V_0}$ $\qquad \Rightarrow t = \ln^2 \frac{\gamma_0}{r}$

38. $P = \frac{P_0}{1+\left(\frac{V}{V_0}\right)^2}$

$\Rightarrow \frac{nRT}{V} = \frac{P_0}{1+\left(\frac{V}{V_0}\right)^2}$ [PV = nRT according to ideal gas equation]

$\Rightarrow \frac{RT}{V} = \frac{P_0}{1+\left(\frac{V}{V_0}\right)^2}$ [Since n = 1 mole]

$\Rightarrow \frac{RT}{V_0} = \frac{P_0}{1+\left(\frac{V}{V_0}\right)^2}$ [At $V = V_0$]

$\Rightarrow P_0V_0 = RT(1+1) \Rightarrow P_0V_0 = 2\ RT \Rightarrow T = \frac{P_0V_0}{2R}$

39. Internal energy = nRT

Now, PV = nRT

$nT = \frac{PV}{R}$ Here P & V constant

$\Rightarrow$ nT is constant

$\therefore$ Internal energy = R × Constant = Constant

40. Frictional force = μ N

Let the cork moves to a distance = dl

$\therefore$ Work done by frictional force = μNde

Before that the work will not start that means volume remains constant

$\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{1}{300} = \frac{P_2}{600} \Rightarrow P_2 = 2$ atm

$\therefore$ Extra Pressure = 2 atm – 1 atm = 1 atm

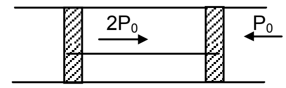
Work done by cork = 1 atm (Adl) $\quad \mu$Ndl = [1atm][Adl]

$N = \frac{1\times 10^5 \times (5\times 10^{-2})^2}{2} = \frac{1\times 10^5 \times \pi \times 25 \times 10^{-5}}{2}$

Total circumference of work = $2\pi r\ \frac{dN}{dl} = \frac{N}{2\pi r}$

$= \frac{1\times 10^5 \times \pi \times 25\times 10^{-5}}{0.2\times 2\pi r} = \frac{1\times 10^5 \times 25 \times 10^{-5}}{0.2\times 2\times 5\times 10^5} = 1.25 \times 10^4$ N/M

41. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$



$\Rightarrow \frac{P_0V}{T_0} = \frac{P'V}{2T_0} \Rightarrow P' = 2\,P_0$

Net pressure = P_0 outwards

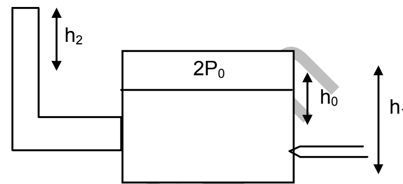
$\therefore$ Tension in wire = P_0 A

Where A is area of tube.

42. (a) $2P_0x = (h_2 + h_0)fg$ [$\therefore$ Since liquid at the same level have same pressure]

$\Rightarrow 2P_0 = h_2\,fg + h_0\,fg$

$\Rightarrow h_2\,fg = 2P_0 - h_0\,fg$



$h_2 = \frac{2P_0}{fg} - \frac{h_0 fg}{fg} = \frac{2P_0}{fg} - h_0$

(b) K.E. of the water = Pressure energy of the water at that layer

$\Rightarrow \frac{1}{2}mV^2 = m \times \frac{P}{f}$

$\Rightarrow V^2 = \frac{2P}{f} = \left[\frac{2}{f\left(P_0 + fg(h_1 - h_0)\right)}\right]$

$\Rightarrow V = \left[\frac{2}{f\left(P_0 + fg(h_1 - h_0)\right)}\right]^{1/2}$

(c) $(x + P_0)fh = 2P_0$

$\therefore 2P_0 + fg\,(h - h_0) = P_0 + fgx$

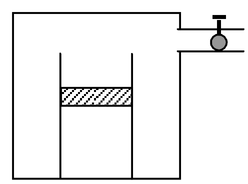
$\therefore X = \frac{P_0}{fg + h_1 - h_0} = h_2 + h_1$

$\therefore$ i.e. x is h_1 meter below the top $\Rightarrow$ x is $-h_1$ above the top

43. A = 100 cm^2 = 10^{-3} m

m = 1 kg, P = 100 K Pa = 10^5 Pa

ℓ = 20 cm



<u>Case I</u> = External pressure exists

<u>Case II</u> = Internal Pressure does not exist

$P_1V_1 = P_2V_2$

$\Rightarrow \left(10^5 + \frac{1\times 9.8}{10^{-3}}\right)V = \frac{1\times 9.8}{10^{-3}} \times V'$

$\Rightarrow (10^5 + 9.8 \times 10^3)A \times \ell = 9.8 \times 10^3 \times A \times \ell'$

$\Rightarrow 10^5 \times 2 \times 10^{-1} + 2 \times 9.8 \times 10^2 = 9.8 \times 10^3 \times \ell'$

$\Rightarrow \ell' = \frac{2\times 10^4 + 19.6 \times 10^2}{9.8 \times 10^3} = 2.24081$ m

44. $P_1V_1 = P_2V_2$

$\Rightarrow \left(\frac{mg}{A} + P_0\right)A\ell \;\; P_0\,A\ell$

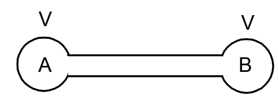
$\Rightarrow \left(\frac{1\times 9.8}{10\times 10^{-4}} + 10^5\right)0.2 = 10^5\,\ell'$

$\Rightarrow (9.8 \times 10^3 + 10^5) \times 0.2 = 10^5\,\ell'$

$\Rightarrow 109.8 \times 10^3 \times 0.2 = 10^5\,\ell'$

$\Rightarrow \ell' = \frac{109.8 \times 0.2}{10^2} = 0.2196 \approx 0.22$ m ≈ 22 cm

45. When the bulbs are maintained at two different temperatures.



The total heat gained by 'B' is the heat lost by 'A'

Let the final temp be x So, $m_1 S\Delta t = m_2 S\Delta t$

$\Rightarrow n_1 M \times s(x - 0) = n_2 M \times S \times (62 - x)$ $\Rightarrow n_1 x = 62n_2 - n_2 x$

$\Rightarrow x = \dfrac{62n_2}{n_1 + n_2} = \dfrac{62n_2}{2n_2} = 31°C = 304$ K

For a single ball Initial Temp = 0°C P = 76 cm of Hg

$\dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2}$ $V_1 = V_2$ Hence $n_1 = n_2$

$\Rightarrow \dfrac{76 \times V}{273} = \dfrac{P_2 \times V}{304} \Rightarrow P_2 = \dfrac{403 \times 76}{273} = 84.630 \approx 84°C$

46. Temp is 20° Relative humidity = 100%

So the air is saturated at 20°C

Dew point is the temperature at which SVP is equal to present vapour pressure

So 20°C is the dew point.

47. T = 25°C P = 104 KPa

RH = $\dfrac{VP}{SVP}$ [SVP = 3.2 KPa, RH = 0.6]

VP = $0.6 \times 3.2 \times 10^3 = 1.92 \times 10^3 \approx 2 \times 10^3$

When vapours are removed VP reduces to zero

Net pressure inside the room now = $104 \times 10^3 - 2 \times 10^3 = 102 \times 10^3$ = 102 KPa

48. Temp = 20°C Dew point = 10°C

The place is saturated at 10°C

Even if the temp drop dew point remains unaffected.

The air has V.P. which is the saturation VP at 10°C. It (SVP) does not change on temp.

49. RH = $\dfrac{VP}{SVP}$

The point where the vapour starts condensing, VP = SVP

We know $P_1V_1 = P_2V_2$

R_H SVP × 10 = SVP × V_2 $\Rightarrow V_2 = 10R_H \Rightarrow 10 \times 0.4 = 4$ cm^3

50. Atm–Pressure = 76 cm of Hg

When water is introduced the water vapour exerts some pressure which counter acts the atm pressure.

The pressure drops to 75.4 cm

Pressure of Vapour = (76 – 75.4) cm = 0.6 cm

R. Humidity = $\dfrac{VP}{SVP} = \dfrac{0.6}{1} = 0.6 = 60\%$

51. From fig. 24.6, we draw $\perp$r, from Y axis to meet the graphs.

Hence we find the temp. to be approximately 65°C & 45°C

52. The temp. of body is 98°F = 37°C

At 37°C from the graph SVP = Just less than 50 mm

B.P. is the temp. when atmospheric pressure equals the atmospheric pressure.

Thus min. pressure to prevent boiling is 50 mm of Hg.

53. Given

SVP at the dew point = 8.9 mm SVP at room temp = 17.5 mm

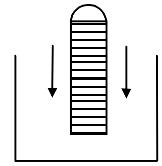
Dew point = 10°C as at this temp. the condensation starts

Room temp = 20°C

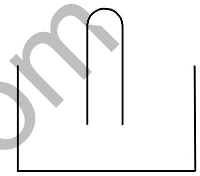
RH = $\dfrac{\text{SVP at dew point}}{\text{SVP at room temp}} = \dfrac{8.9}{17.5} = 0.508 \approx 51\%$

54. 50 cm^3 of saturated vapour is cooled 30° to 20°. The absolute humidity of saturated H_2O vapour 30 g/m^3
Absolute humidity is the mass of water vapour present in a given volume at 30°C, it contains 30 g/m^3
at 50 m^3 it contains 30 × 50 = 1500 g
at 20°C it contains 16 × 50 = 800 g
Water condense = 1500 – 800 = 700 g.

55. Pressure is minimum when the vapour present inside are at saturation vapour pressure
As this is the max. pressure which the vapours can exert.
Hence the normal level of mercury drops down by 0.80 cm
$\therefore$ The height of the Hg column = 76 – 0.80 cm = 75.2 cm of Hg.
[$\because$ Given SVP at atmospheric temp = 0.80 cm of Hg]



56. Pressure inside the tube = Atmospheric Pressure = 99.4 KPa
Pressure exerted by O_2 vapour = Atmospheric pressure – V.P.
= 99.4 KPa – 3.4 KPa = 96 KPa



No of moles of O_2 = n
$96 \times 10^3 \times 50 \times 10^{-6} = n \times 8.3 \times 300$

$\Rightarrow n = \dfrac{96 \times 50 \times 10^{-3}}{8.3 \times 300} = 1.9277 \times 10^{-3} \approx 1.93 \times 10^{-3}$

57. Let the barometer has a length = x
Height of air above the mercury column = (x – 74 – 1) = (x – 73)
Pressure of air = 76 – 74 – 1 = 1 cm
For 2nd case height of air above = (x – 72.1 – 1 – 1) = (x – 71.1)
Pressure of air = (74 – 72.1 – 1) = 0.99

$(x - 73)(1) = \dfrac{9}{10}(x - 71.1) \qquad \Rightarrow 10(x - 73) = 9(x - 71.1)$

$\Rightarrow x = 10 \times 73 - 9 \times 71.1 = 730 - 639.9 = 90.1$
Height of air = 90.1
Height of barometer tube above the mercury column = 90.1 + 1 = 91.1 mm

58. Relative humidity = 40%
SVP = 4.6 mm of Hg

$0.4 = \dfrac{VP}{4.6} \qquad \Rightarrow VP = 0.4 \times 4.6 = 1.84$

$\dfrac{P_1V}{T_1} = \dfrac{P_2V}{T_2} \qquad \Rightarrow \dfrac{1.84}{273} = \dfrac{P_2}{293} \Rightarrow P_2 = \dfrac{1.84}{273} \times 293$

Relative humidity at 20°C

$= \dfrac{VP}{SVP} = \dfrac{1.84 \times 293}{273 \times 10} = 0.109 = 10.9\%$

59. $RH = \dfrac{VP}{SVP}$

Given, $0.50 = \dfrac{VP}{3600}$

$\Rightarrow VP = 3600 \times 0.5$
Let the Extra pressure needed be P

So, $P = \dfrac{m}{M} \times \dfrac{RT}{V} = \dfrac{m}{18} \times \dfrac{8.3 \times 300}{1}$

Now, $\dfrac{m}{18} \times 8.3 \times 300 + 3600 \times 0.50 = 3600$ [air is saturated i.e. RH = 100% = 1 or VP = SVP]

$\Rightarrow m = \left(\dfrac{36 - 18}{8.3}\right) \times 6 = 13$ g

60. T = 300 K, Rel. humidity = 20%, V = 50 m^3

SVP at 300 K = 3.3 KPa, V.P. = Relative humidity × SVP = 0.2 × 3.3 × 10^3

$PV = \frac{m}{M}RT \Rightarrow 0.2 \times 3.3 \times 10^3 \times 50 = \frac{m}{18} \times 8.3 \times 300$

$\Rightarrow m = \frac{0.2 \times 3.3 \times 50 \times 18 \times 10^3}{8.3 \times 300} = 238.55 \text{ grams} \approx 238 \text{ g}$

Mass of water present in the room = 238 g.

61. $RH = \frac{VP}{SVP} \Rightarrow 0.20 = \frac{VP}{3.3 \times 10^3} \Rightarrow VP = 0.2 \times 3.3 \times 10^3 = 660$

$PV = nRT \Rightarrow P = \frac{nRT}{V} = \frac{m}{M} \times \frac{RT}{V} = \frac{500}{18} \times \frac{8.3 \times 300}{50} = 1383.3$

Net P = 1383.3 + 660 = 2043.3 Now, $RH = \frac{2034.3}{3300} = 0.619 \approx 62\%$

62. (a) $\text{Rel. humidity} = \frac{VP}{\text{SVP at } 15°C} \Rightarrow 0.4 = \frac{VP}{1.6 \times 10^3} \Rightarrow VP = 0.4 \times 1.6 \times 10^3$

The evaporation occurs as along as the atmosphere does not become saturated.

Net pressure change = $1.6 \times 10^3 - 0.4 \times 1.6 \times 10^3 = (1.6 - 0.4 \times 1.6)10^3 = 0.96 \times 10^3$

Net mass of water evaporated = m $\Rightarrow 0.96 \times 10^3 \times 50 = \frac{m}{18} \times 8.3 \times 288$

$\Rightarrow m = \frac{0.96 \times 50 \times 18 \times 10^3}{8.3 \times 288} = 361.45 \approx 361 \text{ g}$

(b) At 20°C SVP = 2.4 KPa, At 15°C SVP = 1.6 KPa

Net pressure charge = $(2.4 - 1.6) \times 10^3$ Pa = 0.8×10^3 Pa

Mass of water evaporated = $m' = 0.8 \times 10^3\ 50 = \frac{m'}{18} \times 8.3 \times 293$

$\Rightarrow m' = \frac{0.8 \times 50 \times 18 \times 10^3}{8.3 \times 293} = 296.06 \approx 296 \text{ grams}$

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