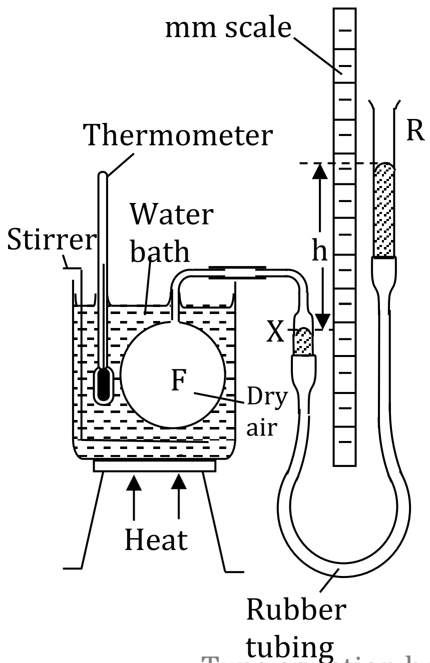
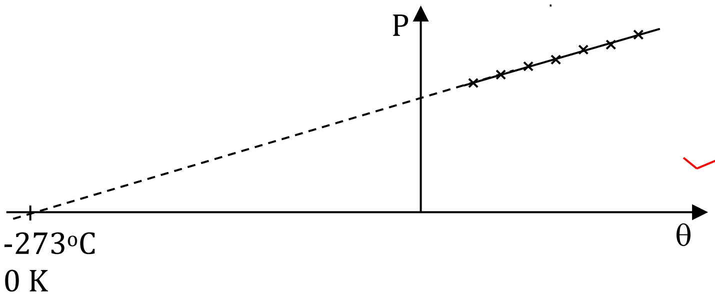
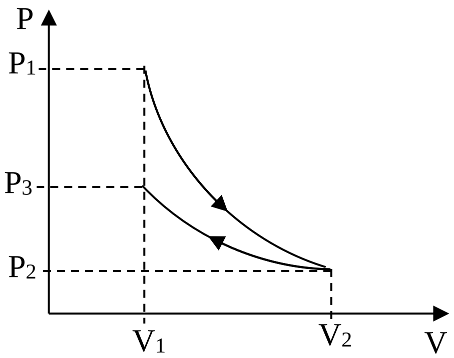
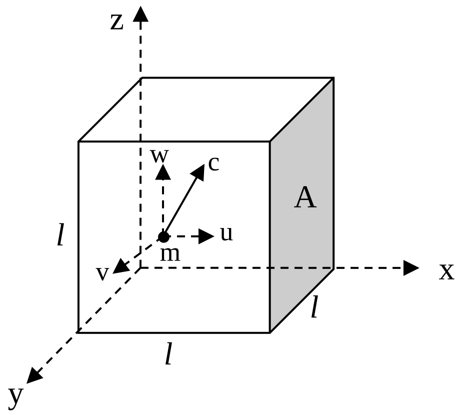
Qn	Answer	Marks
1 (a)	(i) … one which obeys all the gas laws under all conditions and whose internal energy is independent of volume.	1
	(ii) The pressure of a fixed mass of gas, at constant volume is directly proportional to the absolute temperature.	1
	(iii) 	1
	Type equation here. - Dry air is trapped in a flask F by mercury in a rubber tubing which joins up with a reservoir R and F is immersed in a water bath. - The position of R is adjusted until the mercury level at the trapped air is at mark X. The temperature θ of the water bath and the mercury level difference h are recorded. - The temperature of the gas in F is varied by heating the bath. - The heating is stopped and after stirring the reservoir position is adjusted again to restore the mercury level to mark X. The new values of θ and h are recorded. - The procedure is repeated for different values of θ. In each case the absolute temperature of the gas in F is T = θ + 273 and the pressure P = (H + h) mmHg, where H is the atmospheric pressure in mmHg. A graph of P against θ is plotted. It is a straight line which when extrapolated cuts the temperature axis at -273^{o}C, i.e at T = 0 K (since T = θ +273).	½ ½ ½ ½ ½ ½ ½

	 Thus, the pressure, P, is directly proportional to the absolute temperature, T, at constant volume.	½
(b)	(i) …a process which when taken from state P_1, V_1, T_1 to state P_2, V_2, T_2 can be returned from P_2, V_2, T_2 to P_1, V_1, T_1 through exactly the same values of pressure and volume and temperature at every stage.	1
	(ii) - Thick-walled, non-conducting vessel so that no heat may be transferred - The process must occur very fast so as to give no time for heat transfer.	1½ 1½
	(iii) From the first law of thermodynamics $\delta Q = \delta W + \delta U$ where δQ = heat supplied to the gas δW = work done by the gas δU = gain in internal energy Now, for an adiabatic process, $\delta Q = 0$ ∴ $-\delta W = \delta U$ So the work done in compressing the gas, which is $(-\delta W)$, results in increase of internal energy of the gas. So the gas heats up.	1 1 1
(c)	 For the first process $\frac{P_1^{\gamma-1}}{T_1^{\gamma}} = \frac{P_2^{\gamma-1}}{T_2^{\gamma}}$ ∴ $P_2^{\gamma-1} = \left(\frac{T_2}{T_1}\right)^{\gamma}$ ∴ $P_2 = P_1\left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{\gamma-1}} = 3 \times 10^5 \left(\frac{290}{353}\right)^{\frac{1.4}{0.4}} = 3 \times 10^5 \times 0.822^{3.5}$ $= 1.51 \times 10^5$ Pa	1 1

	Now $P_2V_2^{\gamma} = P_1V_1^{\gamma}$ $\therefore \quad V_2 = V_1\left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}}$ For the second process $P_3V_3 = P_2V_2$ $\therefore \quad P_3 = \frac{P_2V_2}{V_3} = \frac{P_2V_2}{V_1} = P_2\left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}} = 1.51 \times 10^5 \times \left(\frac{3}{1.51}\right)^{\frac{1}{1.4}}$ $= 1.51 \times 10^5 \times 1.99^{0.714}$ $= \mathbf{2.47 \times 10^5\ Pa}$	1 1 1 1
Total = 20		
2 (a)	(i) - The volume of the molecules is negligible compared with the volume occupied by the gas. - The attraction between molecules is negligible. - The molecules make perfectly elastic collisions. - The duration of collisions is negligible compared to the time between collisions.	1 1 1 1
	(ii) Consider N molecules of a gas, each of mass m, contained in a cube of side *l*.  Take one of the molecules, having a velocity c at an instant, where c has components of u, v and w respectively in the directions of the three perpendicular axes Ox, Oy and Oz as shown. Thus $c^2 = u^2 + v^2 + w^2$ Consider the component u, perpendicular to the face A. Its velocity after collision is –u (reversed due to elastic collision). Thus, momentum change on impact is $mu - (-mu) = 2mu$ Since the duration of collision is assumed negligible, the time between collisions at A is $2l/u$ The rate of change of momentum $= \frac{\text{momentum change}}{\text{time taken}}$ $= \frac{2mu}{2l/u} = \frac{mu^2}{l}$	½ ½ ½ ½

By Newton's second law, the force on A $= \dfrac{mu^2}{l}$ ½

$\therefore$ pressure on A $= \dfrac{\text{Force}}{\text{area}} = \dfrac{mu^2}{l \times l^2} = \dfrac{mu^2}{l^3}$

This is the pressure due to one molecule. For the N molecules, having different velocities and hence components of different magnitudes in the Ox direction u_1, u_2, u_3, …….,u_N, the pressure on A is ½

$$P = \frac{u_1^2}{l^3} + \frac{u_2^2}{l^3} + \frac{u_3^2}{l^3} + \ldots\ldots + \frac{u_N^2}{l^3} \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$= \frac{m}{l^3}(u_1^2 + u_2^2 + u_3^2 \;\ldots\ldots\ldots + u_N^2) \quad \ldots\ldots \quad (2)$$

½

Let $\overline{u^2}$ be the average value of all the squares of the components in the Ox direction.

Then $\overline{u^2} = \dfrac{u_1^2 + u_2^2 + u_3^2 + \ldots\ldots + u_N^2}{N}$

$\therefore \; N\overline{u^2} = u_1^2 + u_2^2 + u_3^2 \;\ldots\ldots\ldots + u_N^2$

½

From (2): $P = \dfrac{Nm\overline{u^2}}{l^3} \quad \ldots\ldots\ldots\ldots \quad (3)$

Since the pressure is the same on all the faces of the cube, it follows that

$$\frac{Nm\overline{u^2}}{l^3} = \frac{Nm\overline{v^2}}{l^3} = \frac{Nm\overline{w^2}}{l^3}$$ ½

Thus, $\overline{u^2} = \overline{v^2} = \overline{w^2}$

But $c^2 = u^2 + v^2 + w^2$

Therefore the mean square speed, $\overline{c^2} = \overline{u^2} + \overline{v^2} + \overline{w^2}$ ½

$\therefore \; \overline{u^2} = \frac{1}{3}\overline{c^2}$

From (3) $P = \dfrac{1}{3}\dfrac{Nm\overline{c^2}}{l^3} \quad \ldots\ldots\ldots \quad (4)$

$\dfrac{Nm}{l^3}$ is the mass per unit volume = density, ρ ½

$\therefore \quad \mathbf{P = \frac{1}{3}\rho\overline{c^2}} \quad \ldots\ldots\ldots \quad (5)$

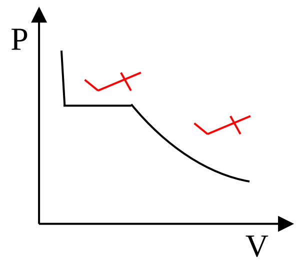
½

(b)

(i) The pressure of a saturated vapour is independent of volume 1

A saturated vapour does not obey the gas laws 1

(ii)



½

½

Both axes must be labelled

	(iii) - At first, when the vapour is not saturated, it tends to obey Boyle's law approximately - Eventually the vapour becomes saturated when it starts condensing. - So the pressure remains constant as the volume is decreased. - When all the vapour has turned into liquid, the volume cannot decrease anymore. Hence the vertical portion of the graph	½ ½ ½ ½
(c)	Total pressure, $p = p_{air} + p_{vap}$ $\therefore \quad p_{air} = p - p_{vap} = (3.00 - 1.013) \times 10^5$ Pa at 100°C $= 1.987 \times 10^5$ Pa Let p_2 = air pressure at 20°C Then $p_2 = \frac{T_2}{T_1} p_1 = \frac{293}{373} \times 1.987 \times 10^5$ $= 1.561 \times 10^5$ Pa $\therefore$ final pressure $= 1.561 \times 10^5 + 0.023 \times 10^5$ $=$ **1.584×10^5 Pa**	1 ½ 1 ½ 1 1
Total = 20		