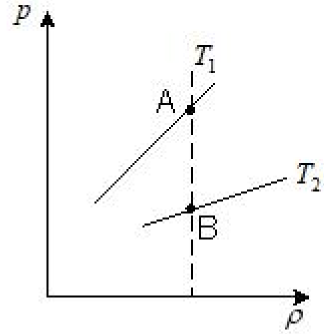
Heat - Kinetic Theory of Gases : Illustrations to Answers of Questions (Typical)

I-01	Asper kinetic theory of gases $pv=\frac{1}{3}mNv_{rms}{}^{2}=\frac{2}{3}N\left(\frac{1}{2}mv_{rms}{}^{2}\right)=\left(\frac{2}{3}N\right)E_m$, here E_m is the kinetic energy of each molecule of gas and $N=nN_A$, here N is number of molecules, n is quanity of gas in moles and N_A is Avagadro's . Constant Further, from Ideal Gas Equation it leads to $pv=nRT$. Combining the two equations, for equal volume of gases having same gquantity of gas on moles it concludes to $nRT=\left(\frac{2}{3}N\right)E_m \Rightarrow T\propto E_m$. Accordingly, at a given temperature kinetic energy of molecules is same. **Thus answer is (d),**
I-02	Behaviour of the ideal gas is equated to $pv=nRT$, which was approximated for real gases by Van der Wall as $\left(p+\frac{a}{v^2}\right)(v-b)=nRT$. Taking each of the possibility ***(a)*** As pressure decreases the equation at low temperature the equation leads to increse in moles of gas in the same volume. This results in larger proportion of volume correction and pressure correction due to decrease in intermolecular distance. This creates a greater departure from Ideal Gas Equation, ***hence this is not the answer.*** (b) As pressure decreases the equation at hgher temperature, it leads to lesser moles of gas in the same volume. This results in smaller proportion of volume correction and pressure correction due to increase in intermolecular distance***. Hence, this is the answer.*** ***(c)*** As pressure increases the equation at lower temperature, it leads to increaser moles of gas in the same volume. This results in larger proportion of volume correction and pressure correction due to decrease in intermolecular distance, ***hence this is not the answer.*** (d) As pressure increases the equation at temperature also increases, it leads to increaser moles of gas in the same volume. This results in smaller proportion of volume correction and pressure correction due to decrease in intermolecular distance, ***hence this is not the answer.*** **Thus answer is option (b)**
I-03	Degree of freedom in translational motion is Three. This is basic to monatomic gases and it leads to $pv=\frac{2}{3}E\Rightarrow p=\frac{2E}{3v}$ to. In case of diatomic molecues in addition to translational motion rotation motion is added and it leads to degree of freedom as 5 and accordingly $p=\frac{2E}{5v}$. In polyatomic gases Two directional vibartional motion are further added on to diatomic gases with total degrees of freedom as 7 and accordingly $p=\frac{2E}{7v}$. **Thus, correct answer is (a)** .
I-04	Behaviour of an ideal gas is given by $pv=\frac{1}{3}mNv_{rms}{}^{2}=\frac{2}{3}N\left(\frac{1}{2}mv_{rms}{}^{2}\right)=\left(\frac{2}{3}N\right)E_m$. Further, Ideal gas equation is $pv=nRT$. These Two equations lead to $\left(\frac{2}{3}N\right)E_m=nRT$. For a given sample of gas number of molecules and molecular mass remains unchanged. Therefore Energy of a molecules of gas and hence sample of a gas is dependent on temerature. **Hence, correct answer is (d).**
I-05	From Kinetic Theory of Gases $pv=\frac{1}{3}mNv_{rms}{}^{2}$, here is the m molecular mass and N is number of molecules in given samples of gases having fixed pv; though this is not given it is assumed for comparison. Thus it leads to

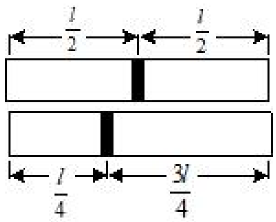
	$mv_{rms}^{2} = \text{C} \Rightarrow \text{v} \propto \frac{1}{\sqrt{m}}$. Thus gas having lightest molecules will have maximum rms speed. Molecular mass of Hydrogen is 2, Nitrogen is 28, Oxygen is 32, and of Carbon-dioxide is 44. Among the given gases Hydrogen is the lightest and hence it will have maximum rms speed. **Thus, correct answer is (a).**
I-06	From Ideal Gas Equation $pv = mNT \Rightarrow p = \left(\frac{mN}{v}\right)T \Rightarrow p \propto \rho T$. It leads to for a certain density $p \propto T$. Since in the given graph for a certain density $T_1 > T_2$. **Thus correct answer is (a).** 
I-07	For Ideal gas $pv = \frac{1}{3}mNv_{rms}^{2}$ and as per Ideal Gas Equation $pv = nRT$. Combining these two equations $\frac{1}{3}mNv_{rms}^{2} = nRT \Rightarrow v_{rms}^{2} \propto T \Rightarrow \left(\sqrt{\sum v^2}\right)^2 \propto T \Rightarrow \sum v^2 \propto T$. **Thus correct answer is (c).** N.B.: In question "Mean Square Speed" is asked and not "rms i.e. Root Mean Square". Accordingly, rms speed is converted into mean square speed. This twist in question needs to be noted carefully and accordingly answered.
I-08	As per definition $v_{rms} = \sqrt{\frac{\sum_{i=1}^{N} v_i^2}{N}} \Rightarrow v_{rms} = \sqrt{\frac{v_a^2}{1}} = v_a$, here v_a is the mean velocity of the molecule which is same when there is only one molecule. ***Hence, answer is (c).***
I-09	From Kinetic Theory of gas $pv = \frac{1}{3}mNv_{rms}^{2}$ and ideal gas equation $pv = nRT$. These two equations lead to $nRT = \frac{1}{3}mNv_{rms}^{2} \Rightarrow T \propto mv_{rms}^{2}$. Given that temperature is same for oxygen and hydrogen whose molecular masses are $m_h = 2$ and $m_o = 32$. And rms speed of oxygen is $v_{rms-0} = 500\,\text{m}\times\text{s}^{-1}$. Accordingly, it would lead to $m_o v_{rms-o}^{2} = m_h v_{rms-h}^{2} \Rightarrow v_{rms-h} = \sqrt{\frac{m_o v_{rms-o}^{2}}{m_h}} = \sqrt{\frac{32\times(500)^2}{2}} = \sqrt{4^2\times(500)^2} = 4\times 500 = 200\,\text{m}\times\text{s}^{-1}$. **Thus, corrwect answer is (b).**
I-10	Ideal Gas Equation is $pv = nRT$. In the given case volume is fixed by the size of the container and temperature is fixed being an isothermal process. Thus in initial case $p_1 v = n_1 RT$. But, when half of the gas is evacuated from the container $p_2 v = n_2 RT = \frac{n_1}{2}RT \Rightarrow 2p_2 v = n_1 RT$. From these Two equations, $p_1 v = 2p_2 v \Rightarrow p_2 = \frac{p_1}{2}$. Given that $p_1 = 200\,\text{kPa} \Rightarrow p_2 = \frac{200}{2}\text{kPa=100kPa}$. **Thus correct answer is (a)**
I-11	From Kinetic Theory of gas $pv = \frac{1}{3}mNv_{rms}^{2}$ and ideal gas equation $pv = nRT$. These two equations lead to

	$nRT = \frac{1}{3}mNv_{rms}{}^2$. Thus, let in the initial case $n_1RT = \frac{1}{3}m_1N_1v_{rms-1}{}^2$, Now it is given that, Temperature is doubled, and oxygen molecules dissociate in oxygen atoms then $n_2RT = \frac{1}{3}m_2N_2v_{rms-2}{}^2$ where $n_2 = 2n_1$, $m_2 = \frac{m_1}{2}$, and $N_2 = 2N_1$. Accordingly, $\frac{n_2RT}{n_1RT} = \frac{\frac{1}{3}m_2N_2v_{rms-2}{}^2}{\frac{1}{3}m_1N_1v_{rms-1}{}^2} \Rightarrow \frac{2n_1 \cdot 2T_1}{n_1 \cdot T_1} = \frac{\frac{m_1}{2}2N_1v_{rms-2}{}^2}{m_1N_1v_{rms-2}{}^2}$. It reduces to $4 = \frac{v_{rms-2}{}^2}{v_{rms-1}{}^2} \Rightarrow v_{rms-2}{}^2 = 4v_{rms-1}{}^2 \Rightarrow v_{rms-2} = 2v_{rms-1}$. Given that $v_{rms-1} = v \Rightarrow v_{rms-1} = 2v$. **Thus, option (c) is the answer.**
I-12	Ideal gas equation is $pv = NkT \Rightarrow pv = nN_AkT = nRT$ here is k Boltzmann Constant , N is number of molecules, N_A is Avogadro's, and R Number Universal Gas Constant. Thus, $\frac{pv}{kT} = N$, which is Number of molecules. **Thus, correct answer is option (d).**
I-13	As per Universal Gas Equation $pv = nRT$. The given graph is linear such that $p = \frac{nR}{v}T \Rightarrow p \propto T$, which makes volume (v) to be constant. Such process are called isochoric process. **Thus, answer (c) is correct.**
I-14	It is only in case of saturated vapour that the rates of evaporation and condensation are in equilibrium, and that makes amount of liquid to be stable. It is given that in the closed bottle amount of liquid is continuously decreasing. This can happen only when vapour in remaining part of the bottle is unsaturated. **Thus answer is (b)**.
I-15	It is only in case of saturated vapour that the rates of evaporation and condensation are in equilibrium, and that makes amount of liquid to be stable. It is given that in the closed bottle amount of liquid is constant. This can happen only when vapour in remaining part of the bottle is saturated. **Thus answer is (a)**.
I-16	When vapour is injected into a closed vessel it is at a pressure. In the evacuated bottle it will exoperience sudden expansion its pressure would drop, but pressure in the vessel will increase due to filling of vapour. On contiunous injection of vapour increase in its pressure when it reaches saturated vapour pressure, corresponding to the temperature, an equilibrium in rate of condensation and vapourization would be attained. This condition is given in opetion (d). **Hence, answer is option (d).**
I-17	In a vessel containing water in a state of equilibrium water and vapour would attain an equilibrium in respect of rate of evaporation and condensation. Accordingly, amount of water in the vessels would remain constant. This is the condition given in the problem. Hence, pressure in both the vessels above water level would be same. **Thus, correct answer is (a).**
I-18	Gas molecules in a given space continuously under go Brownian Motion with is molecules having different velocities such that $v_{rms} = \sqrt{\frac{\sum_{i=1}^{N} v_i{}^2}{N}}$. As per assumption in Kinetic theoty of gases, collision of molecules is elastic which would regulate sharing of kinetic energy among colliding molecules in accordance with Law of Conservation of Energy. Thus $\frac{1}{2}m_1v_{1-i}{}^2 + \frac{1}{2}m_2v_{2-i}{}^2 = \frac{1}{2}m_1v_{1-f}{}^2 + \frac{1}{2}m_1v_{2-f}{}^2$. Moreover it would also follow law of conservation of momentum whereby $m_1v_{1-i} + m_2v_{2-i} = m_1v_{1-f} + m_2v_{2-f}$. Solving these equation it will

	lead to two possibilities- (a) If pre-collision kinetic energy of hydrogen molecule is more than kinetic energy of oxygen molecule, then post collision, kinetic energy of hydrogen molecule would decrease and that of oxygen molecule would increase. This is provided in Option (c). (b) If pre-collision kinetic energy of hydrogen molecule is less than kinetic energy of oxygen molecule, then post collision, kinetic energy of hydrogen molecule would increase and that of oxygen molecule would decrease. This is provided in Option (d). **Thus answer is option (c) and (d).**
I-19	As per kinetic theory of gases $pv=\frac{1}{3}mNv_{rms}{}^{2}$. For a certian volume force exerted by the molecule on the wall is $f_m=m(2v_{rms})\Delta t=\frac{2mv_{rms}}{\frac{2L}{v_{rms}}}=\frac{mv_{rms}{}^{2}}{L}$. Since force exerted by each molecule at certain temperature is same and hence for oxygen and hydrogen molecules $\frac{m_h v_{rms-h}{}^{2}}{L}=\frac{m_o v_{rms-o}{}^{2}}{L}\Rightarrow\frac{m_h}{m_o}=\frac{v_{rms-o}{}^{2}}{v_{rms-h}{}^{2}}\Rightarrow\frac{v_{rms-o}}{v_{rms-h}}=\sqrt{\frac{m_h}{m_o}}$. Molecular masx of oxygen is 32 while that of hydrogen is 2. Therefore, $\frac{v_{rms-o}}{v_{rms-h}}=\sqrt{\frac{32}{2}}\Rightarrow v_{rms-o}=\frac{v_{rms-h}}{4}$. Thus, rms speed of oxygen molecules is lesser than corresponding speed of oxygen molecules, i.e. $v_{rms-o}<v_{rms-h}$. Further, average speed $v_a=\frac{\sum_{i=1}^{N}v_i}{N}$ and $v_{rms}=\sqrt{\frac{\sum_{i=1}^{N}v_i{}^{2}}{N}}$. Numerically it is seen that if $v_{rms-1}>v_{rms-2}\Rightarrow v_{a-1}>v_{a-2}$. Accordingly, $v_{a-o}<v_{a-h}$ and it is in conformity with statement in option (b). **Thus, answer is (b).**
I-20	Mass of an ideal gas in equilibrium has Zero velocity. Thus despite, molecules performing brownian motion shall have average Zero velocity which is a vector quantity, In the given options kinetic energy, density and speed are scaler and non-zero. Thus, only option left out is $\vec{p}=m\vec{v}\Rightarrow\vec{p}=m\times 0=0$. It satisfies the requirement of the question and hence it is correct. **Hence, answer is (b).**
I-21	Ideal Gas equation is $pv=nRT$, given that number of moles (n), volume (v), and temperature (T) to be same it leads to $p=\frac{nRT}{v}$. In this R being Universal Gas Constant, in this expression RHS turns out to be constant, and hence pressure shall remain same. **Thus answer is option (c).**
I-22	Momentum of a molecule in a gas is $\vec{p}=m\vec{v}$. In an ideal gas average velocity of molecules is $\vec{v}_a=\frac{\sum_{i=1}^{N}\vec{v}_i}{N}=\frac{0}{N}=0$. From $pv=\frac{1}{3}mNv_{rms}{}^{2}$ and $pv=\frac{1}{3}nRT$, average rms speed is a function of scalar quantities viz. temperature i.e. $v_{rms}=f(T)$, number of moles (n) and volume (V), but momentum being a vectr can only depend on atleast onevector quantity, which is not specified and moreover average momentum is Zero. **Hence, answer is option (d).**
I-23	From kinetic theory of gases $pv=\frac{2}{3}mNE$ and as per Ideal Gas Equation $pv=nRT$, combining the two

	equations $\frac{2}{3}mNE = nRT \Rightarrow T \propto \frac{E}{n} \Rightarrow T \propto E\|_{n=1}$. Thus at same temperature for 1 mole of has is same for all gases. ***This makes option (a) to be correct.*** Number of molecules in 1 mole of gas is Abagadro's number $N_A = 6.02\times10^{23}\ \text{mol}^{-1}$. ***Therefore, option (c) is also correct.*** **Thus answer is option (a) and (c).**
I-24	From Ideal Gas Equation $pv = nRT = nN_AkT$. In the given expression $\frac{MkT}{pv} = \frac{(nN_Am)kT}{pv}$. It leads to $\frac{MkT}{pv} = \frac{(nN_Am)kT}{pv} = \left(\frac{nN_AkT}{pv}\right)m$. Using Ideal Gas Equation $\frac{MkT}{pv} = m$ i.e. mass of a molecule of a gas. This mass is characterstic to a gas and is indemendent of temperature, volume and pressure of gas. **Thus answer (d) is correct.**
I-25	As per ideal Gas Equation $pv = nRT \Rightarrow v = \frac{nRT}{p}$. At STP, Standard pressure is 1.0 atm = 760 mm Hg, Standard temperature is 273 K (I,e, 0^0C) and volume at 1 STP of 1 mol of gas is 22.4 L. Accordingly Universal Gas Constant $R = \frac{pv}{nT} = \frac{1\times22.4}{1\times273} = 8.2\times10^{-2}$ atm×L×mol^{-1}×K^{-1}. Therefore, volume of gas at given data would be $v = \frac{1\times(8.2\times10^{-2})\times273}{1} = 2238.6\times10^{-2}\ \text{L}$. In meter cube $1\text{m}^3 = (100\times100\times100)\text{cm}^3 = 10^6\ \text{cc} = 10^3\ \text{L}$, since $1\text{L} = 1000\text{cc}$. Accordingly, $v = \frac{2238.6}{1000}\times10^{-2}\ \text{m}^3 = 2.238.6\times10^{-2}\ \text{m}^3 \approx 2.24\times10^{-2}\ \text{m}^3$. **Hence, answer is $2.24\times10^{-2}\ \text{m}^3$.** **N.B.:** In this question, standard temperature and pressure have 3 SGs, and accordingly answer shall also have 3 SGs
I-26	From Iideal Gas Equation $v = \frac{nRT}{p}$. Volume is given to be $1.000\text{CC} = 1.000\times10^{-3}\ \text{L}$. Number of molecules in One Gram mole is Avagadro's Number $N_A = 6.023\times10^{23}$ and volume of gas at STP is $22.40\ \text{L}\cdot\text{mol}^{-1} = 22.40\times10^3\ \text{cc}\cdot\text{mol}^{-1}$.Therefore, number of molecules in 1.000 cc of gas is $N = \frac{N_A}{22.4\times10^3} = \frac{6.023\times10^{23}}{22.40\times10^3} = \frac{60.23}{22.40}\times10^{19} = 2.6888\times10^{19} = 2.689\times10^{19}$. **Hence, answer is 2.689×10^{19} molecules.** **N.B.:** Number of SGs is decided based on given volume of gas which has 4 SGs, and accordingly answer is given.
I-27	As per Ideal Gas Equation $pv = nRT \Rightarrow n = \frac{pv}{RT} \Rightarrow N = \left(\frac{pv}{RT}\right)N_A$, here $N = n\times N_A$. Given that pressure is $p = 10^{-5}$ mm of mercury, thus in MKS $p = \rho gh = (13.6\times10^3)\times(9.81)\times1\times10^{-8} = 1.33\times10^{-3}$ kg×m^{-3}. Substituting the values $N = \frac{(1.33\times10^{-3})\times(1\times10^{-6})}{8.314\times273}\times(6.02\times10^{23}) = \frac{1.33\times6.02}{8.314\times0.273}\times10^{11}$. It solves into $N = 3.527\times10^{11} = 3.53\times10^{11}$. **Hence, answer is 3.53×10^{11} molecules.** **N.B.:** Number of SGs is decided based on given volume and pressure of gas which has 3 SGs, and accordingly

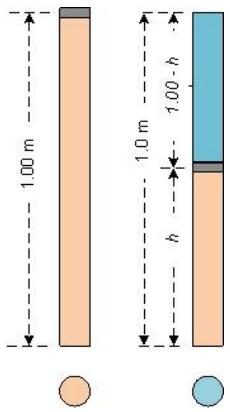
	answer is given.
I-28	From ideal gas Equation $pv = nRT \Rightarrow n = \frac{pv}{RT} = \frac{1\times1\times10^{-3}}{0.082\times273} = \frac{10^{-3}}{22.4}$. Since, pressure is given to be 1 atm, and not the absolute value and volume is $1\text{cc} = 1\times10^{-3}\text{L}$, hencee, value of R used is $= 8.2\times10^{-2}\ \text{atm}\times\text{L}\times\text{mol}^{-1}\times\text{K}^{-1}$. Accordingly, mass of gas is $m = nM = \frac{10^{-3}}{22.4}\times32 = 1.428\times10^{-3} = 1.43\times10^{-3}$ mg . **Hence, answer is 1.43 mg.** **N.B.: (a)** Number of SGs is decided based on given volume of gas which is given to be 0.001 L i.e. in 3 SGs, and accordingly answer is given. (b)Value of R in taken in unit $\text{atm}\times\text{L}\times\text{mol}^{-1}\times\text{K}^{-1}$ simplifies the calculations.
I-29	From ideal gas equation the two cases given in the question van be written as $p_1v_1 = n_1RT_1$ and $p_2v_2 = n_2RT_2$. Given that $v_1 = v_0$, $n_1 = n_2$ $T_1 = 300$ K, $v_2 = 2v_0$ and $T_2 = 600$ K. Substituting the given values in IGE for the two cases $\frac{p_1v_1}{p_2v_2} = \frac{n_1RT_1}{n_2RT_2} \Rightarrow \frac{p_1v_0}{p_2\times2v_0} = \frac{n_1R\times300}{n_1R\times600} \Rightarrow \frac{p_1}{2p_2} = \frac{1}{2} \Rightarrow p_1 : p_2 :: 1:1$. **Hence, answer is** $p_1 : p_2 :: 1:1$.
I-30	As per IGE $pv = nRT \Rightarrow n = \frac{pv}{RT}$ mol. Here, geven that $v = 250\,\text{cc} = 250\times10^{-6}\,\text{m}^3\Big\|_{1\text{cc}=10^{-6}\,\text{m}^3}$ and $p = 10^{-3}$ mm of mercury it calculates to $p = \rho gh = 13600\times10\times\left(10^{-3}\times10^{-3}\right)\Big\|_{1\text{mm}=10^{-3}\,\text{m}} = 1.36\times10^{-1}$. Accordingly, using the values $n = \frac{\left(1.36\times10^{-1}\right)\times\left(250\times10^{-6}\right)}{8.2\times\left(273+27\right)} = \frac{340\times10^{-7}}{8.2\times300} = 1.384\times10^{-7}$.mol. Therefore number of molecules will be $N = nN_A = \left(1.384\times10^{-7}\right)\times\left(6\times10^{23}\right) = 8.304\times10^{16} = 0.8\times10^{17}$ be. **Thus answer is** 8×10^{17}
I-31	The IGE for two cases can be written as $p_1v_1 = n_1RT_1$ and $p_2v_2 = n_2RT_2$. From the given data $p_1 = 8.0\times10^5\,\text{Pa}$, $p_2 = 1.0\times10^6\,\text{Pa}$ the maximum oressure capability beyond which the cylinder would break, $v_1 = v_2$ since change in volume of cylinder is neglected, $n_1 = n_2$ since, $T_1 = 300\,\text{K}$ and T_2 is to be determined. Thus, $\frac{p_1v_1}{p_2v_2} = \frac{n_1RT_1}{n_2RT_2} \Rightarrow \frac{8.0\times10^5}{1.0\times10^6} = \frac{300}{T_2} \Rightarrow T_2 = 300\times\frac{10}{8} = 375\,\text{K}$. **Thus answer is** $375\,\text{K}$
I-32	As per IGE, $pv = nRT \Rightarrow p = \frac{nRT}{v}$, given that cylinder is filled with 2 g of hydrogen. Since molecular weight of hydrogen is 2, hence gas filled inside cylinder is 1 mol, it implies $n = 1$. Therefore, $p = \frac{1\times8.31\times300}{0.02} = 1.246\times10^5 = 1.25\times10^5\,\text{N/m}^2$. Since 1Pa=1 N/m². therefore **answer can also be written as** 1.25×10^5 Pa .
I-33	As per IGE $pv = nRT \Rightarrow p = \frac{n}{v}RT = \frac{\frac{m}{M}}{v}RT = \frac{m}{v}\cdot\frac{RT}{M} = \rho\frac{RT}{M} \Rightarrow M = \frac{\rho RT}{p}$.Given thatdensity of gas is

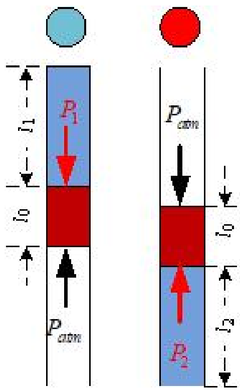
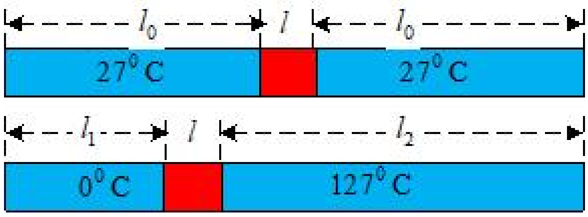
	$1.25\times10^{-3}\,\mathrm{g\cdot cm^{-3}} = 1.25\,\mathrm{kg\cdot m^{-3}}$ at standard temperature $T=273\mathrm{K}$, and in terms of mercury column standard pressure is $p=\rho\times g\times h=13600\times10\times0.76=1.03\times10^{5}\,\mathrm{N\cdot m^{-2}}$.Thus, $M=\frac{1.25\times8.31\times273}{1.03\times10^{5}}$ kg×mol^{-1} . It leads to $=2.835\times10^{-2}\mathrm{kg\cdot mol^{-1}}=28.4\,\mathrm{g\cdot mol^{-1}}$. **Thus answer is** $28.4\,\mathrm{gm\cdot mol^{-1}}$
I-34	Given that, at Simla $T_1=273+15=288\,\mathrm{K}$ and $p=\rho\times g\times h=0.72\rho g\,\mathrm{N\cdot m^{-2}}$ and at Kalka $T_2=273+35=308\,\mathrm{K}$ and $p_2=\rho\times g\times h=0.76\rho g\,\mathrm{N\cdot m^{-2}}$. As per IGE $pv=nRT\Rightarrow p=\frac{n}{v}RT=\frac{\frac{m}{M}}{v}RT=\frac{m}{v}\cdot\frac{RT}{M}=\rho\frac{RT}{M}\Rightarrow p\propto\rho T$. Since, R is Universal Gas Constant and M is molecular mass of gas which also constant for air. Thus in the gaven cases $\frac{p_1}{p_2}=\frac{\rho_1 T_1}{\rho_2 T_2}$. Substituting the given data $\frac{0.72}{0.76}=\frac{\rho_1\times288}{\rho_2\times308}\Rightarrow\frac{\rho_2}{\rho_1}=\frac{0.76\times288}{0.72\times308}=0.987$. **Hence, answer is 0.987.** **N.B.:** Here ratio that is asked has to be carefully noted and answered.
I-35	From the given data in the Two halves initial $p_{1i}=p_{2i}$, $v_{1i}=v_{2i}$ and $T_{1i}=T_{2i}$ Therefore as per ideal gas equation $pv=nRT$, gas content in mole is $n_1=n_2$; and it would remain despite slidding of piston to what ever position. The tube has adiabatic walls which means there will not be any heat transfer from tube to the environment. However piston is diathermic, which allows heat transfer but not mass transfer. Thus at equilibrium $T_{1f}=T_{2f}$.  Accodingly, after sliding piston dividing tube such that $\frac{v_{1f}}{v_{2f}}=\frac{1}{3}$, the gas equation shall be $\frac{p_{1f}v_{1f}}{p_{2f}v_{2f}}=\frac{n_1RT_{1f}}{n_2RT_{2f}}$, Using the given data it leads to $\frac{p_{1f}}{p_{2f}}.\frac{v_{1f}}{v_{2f}}=1\Rightarrow\frac{p_{1f}}{p_{2f}}=\frac{v_{2f}}{v_{1f}}=\frac{1}{\frac{v_{1f}}{v_{2f}}}=\frac{1}{\frac{1}{3}}=3$. **Thus answer is 3:1.**
I-36	From kinetic theory of gases $pv=\frac{1}{3}mNv_{rms}{}^2$ and as per Ideal Gas Equation $pv=nRT$. Combining the two equations $\frac{1}{3}mNv_{rms}{}^2=nRT$. Therefore for a given gas sample, m, N and n remain unchanged and theefore $v_{rms}{}^2\propto T$. Accordingly, $\frac{v_{rms-1}{}^2}{v_{rms-2}{}^2}=\frac{T_1}{T_2}$. Given that, $v_{rms-2}=2v_{rms-1}$, and $T_1=300\mathrm{K}$, therefore $T_2=T_1\times\frac{v_{rms\_2}{}^2}{v_{rms\_1}{}^2}=300\times\frac{(2\times v_{rms\_1})^2}{v_{rms\_1}{}^2}=300\times4=1200\mathrm{K}$ .This is part II of the answer. Taking 1 mol of gas from above Two equations $\frac{1}{3}mNv_{rms}{}^2=nRT\Rightarrow v_{rms\_1}=\sqrt{\frac{3RT_1}{mN}}=\sqrt{\frac{3RT_1}{M}}$. It reduces to $v_{rms\_1}=\sqrt{\frac{3\times8.31\times300}{2\times10^{-3}}}=\sqrt{374\times10^{4}}=19.33\times10^{2}\mathrm{m\times s^{-1}}$, i.e. rms speed $1933\,\mathrm{m\times s^{-1}}$. **Thus answers are** $1933\,\mathrm{m\times s^{-1}}$ **and** $1200\mathrm{K}$.

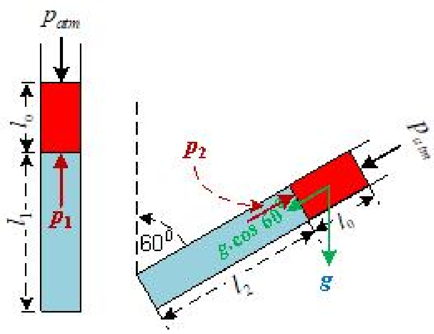
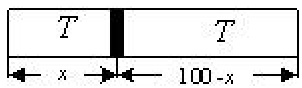
I-37	As per Kinetic Theory of gas $pv=\frac{1}{3}mNv_{rms}{}^2 \Rightarrow v_{rms}=\sqrt{\frac{3pv}{mN}}=\sqrt{\frac{3pv}{M}}$. Given data in SI mass of gas is $M=0.177g=0.177\times10^{-3}$ kg, volume of sample is $v=1000\,\text{cm}^3=1000\times10^{-6}\,\text{m}^3=1\times10^{-3}\,\text{m}^3$ and pressure is $p=1.03\,\text{N}\times\text{m}^{-2}$. Substituting the data $v_{rms}=\sqrt{\frac{3pv}{M}}=\sqrt{\frac{3\times(1.03\times10^5)\times(1\times10^{-3})}{0.177\times10^{-3}}}=\sqrt{1.746\times10^6}$. **Thus answer is** $v_{rms}=1.32\times10^3=1320\,\text{m}\times\text{s}^{-1}$
I-38	As per Kinetic Theory of Gases $pv=\frac{1}{3}mNv_{rms}{}^2=\frac{2}{3}N\left(\frac{1}{2}mv_{rms}{}^2\right)=\frac{2}{3}E_m$, and as per Ideal Gas Equation $pv=nN_akT=NkT$. Thus combining these two equations $\frac{2}{3}NE_m=NkT\Rightarrow T=\frac{2E_m}{3k}$. Here, $E=0.040\,\text{eV}=0.040\times1.6\times10^{-19}\,\text{J}$ and given that Boltzmann constant $k=1.38\times10^{-23}\,\text{JK}^{-1}$..Substituting the values $T=\frac{2\times(0.040\times1.6\times10^{-19})}{3\times(1.38\times10^{-23})}=0.0309\times10^4=310\,\text{K}$. **Thus answer is 310 K.** **N.B.:** The given data has 3 SGs and acciordingly answeris also in 3 SGs.
I-39	The problem requires to detrmine average time taken to travel a distance equal to diameter of earth $D=2\times R=2\times(6.4\times10^6)m$. This need average velocity of oxygen at 300 K which is $v_{avg}=\sqrt{\frac{8RT}{\pi M}}=\sqrt{\frac{8\times8.31\times300}{3.14\times0.032}}=445.5\,\text{m}\cdot\text{s}^{-1}$, here nolar mass of oxygen is $M=32\text{g}=0.032\,\text{kg}$ and $R=8.31$. Therefore average time would be $t=\frac{2\times6.4\times10^6}{445.5}\text{sec}=\frac{0.757\times10^6}{60\times60}\text{hrs}=7.98\,\text{hrs}=8\,\text{hrs}$. **Answer is 8 hrs.**
I-40	Magnitude of average linear momentum of a helium molecule $p=mv_{avg}$. Here, $v_{avg}=\sqrt{\frac{8RT}{\pi M}}=\sqrt{\frac{8(N_Ak)T}{\pi(N_Am)}}=\sqrt{\frac{8kT}{\pi m}}$. Therefore, $p=mv_{avg}=m\sqrt{\frac{8kT}{\pi m}}=\sqrt{\frac{8kmT}{\pi}}$. It solves into , $p=\sqrt{\frac{8\times(1.38\times10^{-23})\times(6.64\times10^{-27})\times273}{3.14}}=7.97\times10^{-24}\,\text{kg.m.s}^{-1}$. **Thus answer is** $7.97\times10^{-24}\,\text{kg.m.s}^{-1}$.
I-41	Mean speed of gaseous molecule , as per Maxwell-Boltzmann distribution is $v_{avg}=\sqrt{\frac{8RT}{\pi M}}$ For samples of hydrogen and helium is $v_{avg-H}=\sqrt{\frac{8RT_H}{\pi M_H}}$ and $v_{avg-He}=\sqrt{\frac{8RT_{He}}{\pi M_{He}}}$ it is given that $v_{avg-H}=v_{avg-He}$, it leads to $\sqrt{\frac{8RT_H}{\pi M_H}}=\sqrt{\frac{8RT_{He}}{\pi M_{He}}}\Rightarrow\frac{8RT_H}{\pi M_H}=\frac{8RT_{He}}{\pi M_{He}}\Rightarrow\frac{T_H}{T_{He}}=\frac{M_H}{M_{He}}=\frac{2}{4}\Rightarrow T_H:T_{He}::1:2$. **Thus answer is 1:2.**
I-42	Mean speed of a hydrogen molecule $v_{avg}=\sqrt{\frac{8RT}{\pi\times0.002}}$, since molar mass of hydrogen is

	$M_H = 2\,\text{g} = 0.002\,\text{kg}$ 2 g=0.002 kg. And escape velocity of hydrogen is determined from the potential energy of the molecule to displace it from earths surface to infinity. Accordingly, $\frac{1}{2}mv_{esc}^2 = \int_r^\infty \frac{GMm}{x^2}dx = GMm\left[-\frac{1}{x}\right]_r^\infty = -GMm\left[\frac{1}{\infty}-\frac{1}{r}\right] = \frac{GM}{r}m = \frac{GM}{r^2}rm = grm \Rightarrow v_{esc}^2 = 2gr \Rightarrow v_{esc} = \sqrt{2gr}$. **Thus answer is 11800 K.**
I-43	Mean speed of a a gas molecule $v_{avg} = \sqrt{\frac{8RT}{\pi \times M}}$. Molar mass of hydrogen $M_H = 2$ and $M_N = 28$ and hence $\frac{v_{avg-H}}{v_{avg-N}} = \frac{\sqrt{\frac{8RT}{\pi \times M_H}}}{\sqrt{\frac{8RT}{\pi \times M_N}}} \Rightarrow \frac{v_{avg-H}}{v_{avg-N}} = \sqrt{\frac{M_N}{M_H}} = \sqrt{\frac{28}{2}} = \sqrt{14} = 3.74$. **Hence the qnswer is 3.74.**
I-44	Given that in the vessel having two equal parts datherrmic separator are milled with separate molecules. Let part has gas of molar mass M_L and gas in right part has molar mass M_R seperated by As per KTG for left part $pv = \frac{1}{3}m_L N_L v_{rms}^2 = n_L N_A RT_L \Rightarrow v_{rms}^2 = \frac{3n_L N_A RT_L}{m_L N_L} = \frac{3n_L RT_L}{n_L M_L} \Rightarrow v_{rms} = \sqrt{\frac{3RT_L}{M_L}}$. And for right part mean speed of a molecule $v_{avg} = \sqrt{\frac{8RT_R}{\pi M_R}}$. Since seprator is diathermic hence temperatures in both parts will have same temperature i.e. $T_L = T_R = T$. Thus, together with the given condition it leads to $v_{rms} = v_{avg} \Rightarrow \sqrt{\frac{3RT}{M_L}} = \sqrt{\frac{8RT}{\pi M_R}} \Rightarrow \frac{M_L}{M_R} = \frac{3\pi}{8} = 1.18$. **Thus answer is 1.18.**
I-45	Number of collisions per second $f = \frac{1}{t}$, where mean time of collision is $t = \frac{l}{v_{avg}}$, here is $l = 1.38\times10^{-5}\,\text{cm} = 1.38\times10^{-7}\,\text{m}$ mean free opath and $v_{avg} = \sqrt{\frac{8RT}{\pi M}}$ is average velocity of gas molecule, where for hydrogen molar mass $M = 2\times10^{-3}$. Thus $f = \frac{\sqrt{\frac{8RT}{\pi M}}}{l}$. And on substituiting the given values (at STP $T = 273\,\text{K}$, we get $f = \frac{\sqrt{\frac{8\times8.31\times273}{3.14\times2\times10^{-3}}}}{1.38\times10^{-7}} = \frac{1}{1.38}\times\sqrt{\frac{4\times8.31\times27.3\times10^4}{3.14}}\times10^7 = 1.232\times10^{10}$. **Hence, answer is** 1.23×10^{10}**.**
I-46	Mean speed of the hydrogen molecule at 300 K is $v_{avg} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8\times8.31\times300}{3.14\times2\times10^{-3}}} = 1.78\times10^3\,\text{m}\times\text{s}^{-1}$. Since 1 atm $= 10^5\,\text{N.m}^2$. Force exerted by one molecule striking the wall at angle 45^0 with normal to the point of collision would also rebound at 45^0 with the normal, following laws of elastic collision. Thus change of momentum of molecule would be $\Delta p = m\left(v_{avg}\cos45^0 - \left(-v_{avg}\cos45^0\right)\right) = 2mv_{avg}\frac{1}{\sqrt{2}} = \sqrt{2}mv_{avg}$, here mass

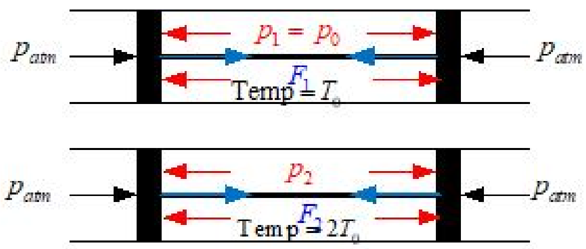
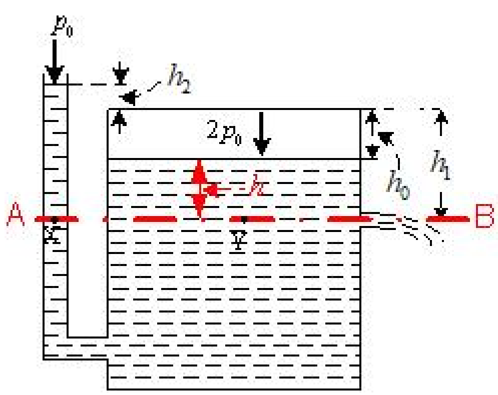
	of each molecule $m=\frac{M}{N_A}$, where M is molar mass and N_A Avagadror's Number Therefore, pressure $p=f\Delta p \Rightarrow f=\frac{p}{\Delta p}=\frac{10^5}{\sqrt{2}\frac{M}{N_A}v_{avg}}=\frac{10^5\times(6.02\times10^{23})}{\sqrt{2}\times(2\times10^{-3})\times(1.78\times10^3)}$. **It simplifies into an answer** $f=1.195\times10^{28}=1.20\times10^{28}$
I-47	From ideal gas equation $pv=nRT$. Given is data of two conditions for same mass and therefor IGE can be written as $\frac{pv}{T}=n\Rightarrow\frac{p_1v_1}{T_1}=\frac{p_2v_2}{T_2}$. Thus with the given data $\frac{(200\times10^3)v_1}{273+20}=\frac{p_2\times1.02v_1}{273+40}\Rightarrow p_2=\frac{200\times10^3\times313}{293\times1.02}$. . It leads to $p_2=209.4\times10^3\,\text{Pa}$ **Thus answer is 209 kPa.**
I-48	From ideal gas equation $pv=nRT\Rightarrow n=\frac{pv}{RT}$. Thus from the given data $n_1=\frac{p_1v_1}{RT_1}\Rightarrow m_1=n_1M=\frac{(1.5\times10^5)\times(1.0\times10^{-3})}{8.31\times400}\times32=1.44$. Likewise, after gas has leaked as per the given data $n_2=\frac{p_2v_2}{RT_2}\Rightarrow m_2=n_2M=\frac{(1.0\times10^5)\times(1.0\times10^{-3})}{8.31\times300}\times32=1.28$. Accordingly gas leaked out of the cylinder $\Delta m=m_1-m_2=1.44-1.28=0.16\,\text{g}$. **Thus answer is 0.16 g**
I-49	In the problem air filled inside a bubble, whether at bottom or at the surface of river, remains at ambient temperature i.e. $T_1=T_2=T$ and amount of gas also remains same $n_1=n_2=n$, At bottom of the river volume of the bubble $v_1=\frac{4}{3}\pi r_1^3$ and pressure $p_1=1\,\text{atm}+\rho gh=10^5+1000\times10\times3.3=1.33\times10^5\,\text{Pa}$. When, bubble reaches surface of the water its volume is $v_2=\frac{4}{3}\pi r_2^3$, here r_2 is to be determined, while $p_2=1\text{atm}=10^5\,\text{Pa}$. From ideal gas equation $pv=nRT\Rightarrow p_1v_1=p_2v_2$. Substituting values $(1.33\times10^5)\times\left(\frac{4}{3}\pi\times(2\times10^{-3})^3\right)=(1.0\times10^5)\times\left(\frac{4}{3}\pi\times r_2^3\right)\Rightarrow r_2^3=1.33\times8\times10^{-9}\Rightarrow r_2=(1.33\times8)^{\frac{1}{3}}10^{-3}=2.19\times10^{-3}\,\text{m}$. **Thus answer is 2.2 mm.**
I-50	In the problem let amonu of gas filled in the tube be n_1 moles, at pressure $p_1=2\,\text{atm}=2\times10^5\,\text{Pa}$ and volume of air at this pressure is $v_1=0.002\,\text{m}^3$. When tube get punctured its pressure comes to equilibrium with atmospheric pressure $p_1=1\text{atm}=10^5\,\text{Pa}$ and volume reduces to $v_1=0.0005\,\text{m}^3$ and let amount of air is n_2 moles. Further it is given that temperature remains same $T_1=T_2=300\,\text{K}$. Now as per ideal gas equation $pv=nRT$. Therefore, gas inside tube $n_1=\frac{p_1v_1}{RT}=\frac{(2\times10^5)\times0.002}{8.31\times300}=0.16\,\text{mol}$. And after leaking $n_2=\frac{p_2v_2}{RT}=\frac{(1\times10^5)\times0.0005}{8.31\times300}=0.02\,\text{mol}$. Therefore amount of gas leaked $\Delta n=n_1-n_2\,\text{mol}$. **Thus answer is** $0.16-0.02=0.14$ **mol**.

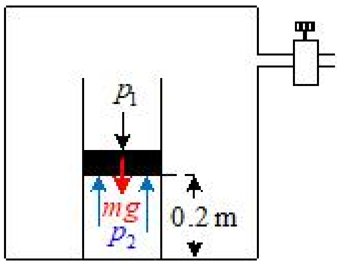
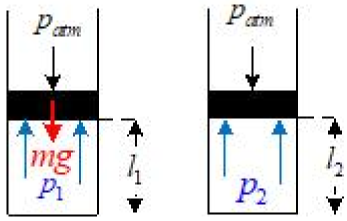
I-51	As per Kinetic Theory of Gases $pv = \frac{1}{3}mNv_{rms}^{2} = \frac{2}{3}\left(\frac{1}{2}mNv_{rms}^{2}\right) = \frac{2}{3}U$ and as per Ideal Gas Equation $pv = nRT$. Combining these two equations $\frac{2}{3}U = nRT$, here content of gHe in moles $n = \frac{m}{M} = \frac{0.040}{4} = 0.01$ Thus internal energy of the gas at 100^0C = 373 K is $U_1 = \frac{3}{2}n_1RT_1 = \frac{3}{2}\times 0.01\times 8.31\times 373 = 46.49\,\text{J}$. When internal energy of thegas is increased by 12 J, $U_2 = U_1 + 12 = 46,49 + 12.0 = 58.49 = 58.5\,\text{J}$. Accordingly, $U_2 = \frac{3}{2}n_2RT_2 = \frac{3}{2}\times 0.01\times 8.31\times T_2 = 58.5\,\text{J} \Rightarrow T_2 = \frac{58.5\times 2}{0.03\times 8.31} = 469.3\text{K}$. Thus increase in internal energy would require to bring the gas at temperature $469\text{K} \Rightarrow 469 - 273 = 196^0\,\text{C}$. **Thus answer is 196^{0}C.**
I-52	Given that the sample of gas is Ideal Gas and therefore as per Ideal Gas Equation $pv = nRT \Rightarrow \left(\frac{nRT}{v}\right)v^2 = \text{constant} \Rightarrow nRTv = \text{constant} \Rightarrow T_1v_1 = T_2v_2$. Given that $T_1 = T$, $v_1 = V, v_2 = 2V$ Accordingly, $TV = T_2 \times 2V \Rightarrow T_2 = \frac{T}{2}$. **Thus answer is $\frac{T}{2}$.**
I-53	As per Ideal Gas Equation $pv = nRT \Rightarrow p = \frac{m}{M}\times\frac{RT}{v}$. Volume occupied by oxygen and nitrogen is same i.e. $v = 0.166\,\text{m}^3$.Thus partial pressure exerted by oxygen is $p_{\text{O}} = \frac{1.6}{32}\times\frac{8.31\times 300}{0.166} = \frac{0.05\times 8.31\times 300}{0.166}$ and $p_{\text{H}} = \frac{2.8}{28}\times\frac{8.31\times 300}{0.166} = \frac{0.1\times 8.31\times 300}{0.166}$. Thus net pressure of the mixture shall be $p = p_{\text{O}} + p_{\text{H}}$. Accordingly, $p = \frac{0.05\times 8.31\times 300}{0.166} + \frac{0.1\times 8.31\times 300}{0.166} = 0.15\times\frac{8.31\times 300}{0.166} = 2252.7\text{N}\cdot\text{m}^2$.**Thus answer is** $2.25\times 10^3\,\text{N}\cdot\text{m}^2$.
I-54	Initially volume of the gas is $v_1 = 0.75\times A$, here A is cross-section of the tube.. Further, $h_0 = 75\text{cm} = 0.75\text{m}$ mercury corresponds to the atmospheric pressureair of air in the tube. Thus $p_{atm} = p_1 = \rho g h_0$. When mercury is gradually poured additional pressure on cork. In turn it compreses the air the tube, and at mercury column h m in the tube volume of compressed air is $v_2 = (1-h)\times A$. Here, Four points are to be noted; (1) since mercury is poured slowly and the cork piston is frictionless, and compression is isothermic, (2) as mercury is poured air is compressed but mercury can not be filled above the top of the tube that limits its height, (3) corck thickness is taken to be negligible, and (4) mercury meniscus is shown flat for simplification and is substantiated by the fact that diameter of the tube is not defined.  Thus at equilibrium $p_2 = p_{atm} + \rho gh = \rho g(h_0 + h)$. Now as per Ideal Gas Equation $pv = nRT \Rightarrow p_1v_1 = p_2v_2$. It leads to $(\rho g\times 0.75)\times(1\times A) = \rho g(0.75+h)\times((1-h)\times A)$. It further solves into Kkk $0.75 = 0.75 + 0.25h - h^2 \Rightarrow h^2 = 0.25h \Rightarrow h = 0.25\,\text{m}$. **Thus answer is 25 cm.**
I-55	As per Ideal Gas Equation $pv = nRT$. Accordingly, for vessel A , $p_Av = n_ART_A \Rightarrow \frac{n_A}{v} = \frac{RT_A}{p_A}$ and for vessel B ,

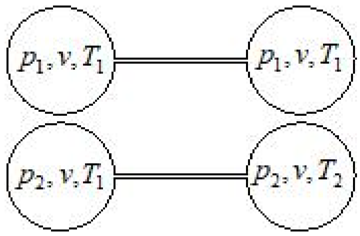
	$\frac{n_B}{v}=\frac{RT_B}{p_B}$. When the two vessels are connected then at equlibrium $\frac{n_A+n_B}{2v}=\frac{RT}{p}\Rightarrow\frac{n_A}{v}+\frac{n_B}{v}=\frac{2RT}{p}$. Sunbstituting the values determined earlier, on L.H.S, $\frac{RT_A}{p_A}+\frac{RT_B}{p_B}=\frac{2RT}{p}\Rightarrow\frac{T}{p}=\frac{1}{2}\left(\frac{T_A}{p_A}+\frac{T_B}{p_B}\right)$. **Hence proved.**
I-56	As per ideal gas equation $pv=nRT\Rightarrow pv=\frac{m}{M}RT\Rightarrow m=\frac{pvM}{RT}$. Substituting values it leads to $m=\frac{10^5\times\left(50\times10^{-6}\right)\times\left(28.8\times10^{-3}\right)}{8.31\times T}\text{kg}=\frac{0.0173}{T}\text{kg}=\frac{17.3}{T}\text{g}$. Accordingly, mass of gas in equilibrium in ice bath is $m=\frac{17.3}{273}=0.063\text{g}$. **This is part (a) of the answer.** When container is placed in water boiling at 100^0C, $m=\frac{17.3}{273+100}=\frac{17.3}{373}=0.046\text{g}$ **This is part (a) of the answer.** In part (c) of the question, bottle in equilibrium at 100^0C is sealed and placed back in ice bath. Hence, pressure in the bottle as per IGE would be $p=\frac{mRT}{vM}$. Since given value of M and value of m in part (b) are in grams and both appear in numerator and denominator, they can be used as such with other quantities in SI and accordingly $p=\frac{0.046\times8.31\times273}{\left(50\times10^{-6}\right)\times28.8}=72.47\times10^3\text{kPa}$. **Hence answer for part (c) is 72.5 kPa**
I-57	Let A be the cross-sectional area of the tube. When tube is inverted, i.e. closed end at the top, equation for equlibrium of mercury pallet is $p_{atm}=p_1+\rho gl_0$. And when tube is held with open end at the top then equation of equilibrium of mercury pallet is $p_{atm}+\rho gl_0=p_2$. As per Ideal Gas Equation $pv=nRT$. It is given that $n_1=n_2=n$, $l_0=0.1\text{m}$, $l_1=0.2\text{m}$ and $T_1=T_2=T$. From geometry of the tube $p_{atm}=0.75\rho g$, $v_1=l_1A=0.2A$, $v_2=l_2A$, here $l_2$is top be determined, Therefore, $p_1v_1=p_2v_2$. It leads to $\left(p_{atm}-\rho gl_0\right)\times l_1A=\left(p_{atm}+\rho gl_0\right)\times l_2A\Rightarrow l_2=\frac{\left(p_{atm}-\rho gl_0\right)}{\left(p_{atm}+\rho gl_0\right)}\times l_1$. On substituting values $l_2=\frac{\left(0.75\rho g-\rho g\left(0.1\right)\right)}{\left(0.75\rho g+\rho g\left(0.1\right)\right)}\times\left(0.2\right)=\frac{0.65}{0.85}\times0.2=0.153\text{m}$. **Thus answer is 15 cm.** 
I-58	In initial case on both sides of the mercury pallet, at the centre of the tube pressure $\left(p_0=\rho g\times0.76=0.76\rho g\right)$, temperature $\left(T_0=27^0\text{C}=273+27=300\text{K}\right)$,volume of the gas $\left(v_0=l_0A=\frac{1-0.10}{2}=0.45\text{m}\right)$ here A is the cross-sectional area of the tube,and hence number of moles of gas (n) are also equal. By geometry, volume of air at 0^0C is $v_1=l_1A$ and $v_2=l_2A$. Further in case of equilibrium of the mercury pallet when both sides are maintained at different temperatures. $p_1=p_2=p$ 

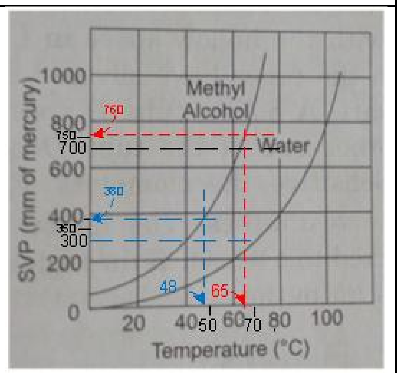
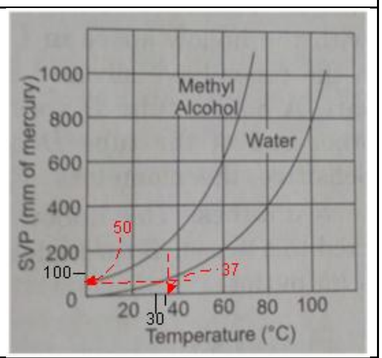
	As per Ideal Gas Equation $pv = nRT \Rightarrow \frac{pv_1}{T_1} = \frac{pv_2}{T_2} \Rightarrow \frac{0.76\rho g \times 0.45\,\text{A}}{273+27} = \frac{p \times l_1\,\text{A}}{273+0} = \frac{p \times l_2\,\text{A}}{273+127}$. It leads to $1.14\times10^{-3} \times \rho g = \frac{p \times l_1}{273} = \frac{p \times l_2}{400}$. Thus $\frac{l_2}{l_1} = \frac{400}{273} \Rightarrow \frac{l_2 + l_1}{l_1} = \frac{400+273}{273}$. Since mercury is incompressible and hence $l_1 + l_2 = 2l_0 = 2\times0.45 = 0.90$m. Therefore, $\frac{l_1}{2l_0} = \frac{273}{673} \Rightarrow l_1 = \frac{0.9\times273}{673} = 0.365$m. **Hence answer is 36.5 cm.** **N.B.**: It is given that change in volume of mercury and glass are negligible, therefore for any variation in pressure due to volume in the sealed tube shall always be $l_1 + l_2 = 1.0 - 0.1 = 0.90$ m. It is enough to lead to the answer. Thus applying IGE for base case is not required.
I-59	When tube is held vertical length of air column in tube air trapped between closed end and mercury has volume $v_1 = l_1 A$ where A is the cross-sectional area of the tube then pressure equation in a state of equlibrium would be $p_1 = \rho gh + \rho g l_0 = \rho g\left(h + l_0\right)$. When tube is tilted through an angle θ, the pressure equation would be determined based on principle that air exert uniform pressure in all directions but pressure exerted by liquid is based on vertical height of liquid column which changes with angle, despite length of liqiuid column remaining unchanged. Accordingly, $p_1 = \rho gh + \rho\left(g\sin\theta\right)l_0$ here $\theta = 60^0$.  Since, amount of gas trapped is same and hence number of moles in the tube in both cases would be same say n moles. So also tempertaure of the gas is given to be constant. Thus as per Boyle's Law $p_1v_1 = p_2v_2$, On substituting values $\rho g\left(h + l_0\right)\times Al_1 = \rho g\left(h + l_0\cos\theta\right)\times Al_2 \Rightarrow l_2 = \frac{\left(h+l_0\right)\times0.43}{h + l_0\sin\theta} = \frac{\left(0.76+0.20\right)\times0.43}{0.76+0.20\sin60^0}$. It solves into $l_2 = 0.48\text{m} = 48$ cm.. **Thus answer is 48 cm**.
I-60	During initial equilibrium condition pressure exerted by gas in two parts would be same despite temperature and volume of gas are different and hence number of moles of gas would laso be different. Thus as per IGE $pv = nRT \Rightarrow \frac{p}{R} = \frac{nT}{v}$. Thus initially for Two chambers  $\frac{n_1T_1}{v_1} = \frac{n_2T_2}{v_2} \Rightarrow \frac{n_1T_1}{l_1A} = \frac{n_2T_2}{l_2A} \Rightarrow \frac{n_1T_1}{l_1} = \frac{n_2T_2}{l_2}$. It leads to $\frac{n_1}{n_2} = \frac{l_1T_2}{l_2T_1}$. Since seperator is weekly conducting, and seperator can slide, gradually temperature and pressure in the two chambers would equalize while ratio of gas content $\left(\frac{n_1}{n_2}\right)$ would remain same and in turn seperator would reposition. Let the final temperature be T. Therefore, $\frac{n_1}{n_2} = \frac{xT}{\left(L-x\right)T} = \frac{x}{\left(L-x\right)}$. Equaliting the two expressions for $\left(\frac{n_1}{n_2}\right)$ it simplifies into $\frac{l_1T_2}{l_2T_1} = \frac{x}{\left(L-x\right)}$. Substituiting the values $\frac{0.2\times100}{0.1\times400} = \frac{x}{\left(0.3-x\right)} \Rightarrow 20\left(0.3-x\right) = 40x \Rightarrow 60x = 6 \Rightarrow x = 0.1\text{m=10 cm}$. **Thus answer is 10 cm from Left end.**
I-61	Let at any instant t volume, pressure and quantity of gas in the vessel be $v\,\text{m}^3, p\,\text{N}\times\text{m}^2$ and n moles respectively. As per IGE $pv = nRT \Rightarrow pdv + V_0dp = RTdn$. Given that in the vessel v, T and as rate of

	evacuation of gas at instantaneous internal pressure p of the vessel i.e. $\frac{dv}{dt}=r$ are constant. This leads to rewriting the partial derivative of IGE as $p\frac{dv}{dt}+V_0\frac{dp}{dt}=RT\frac{dn}{dt}\Rightarrow pr+V_0\frac{dp}{dt}=RT\frac{dn}{dt}$. In an infitesimal time $\Delta t\to 0$ taking $\Delta n\to 0$ the partial derivative equation can be written as $\frac{dp}{p}=-\frac{rdt}{V_0}$. Integrating both sides $\int_{p_0}^{p}\frac{dp}{p}=-\int_0^t\frac{rdt}{V_0}\Rightarrow[\log p]_{p_0}^{p}=-\frac{r}{V_0}[t]_0^t\Rightarrow\log\frac{p}{p_0}=-\frac{r}{V_0}t\Rightarrow p=p_0e^{-\frac{r}{V_0}t}$. **This is part (a) of the answer.** Since, volume and temperature are same and therefore as per ideal gas equation $\frac{p_1V_0}{p_2V_0}=\frac{n_1RT}{n_2RT}\Rightarrow\frac{p_1}{p_2}=\frac{n_1}{n_2}$. Therefore, when half of of the original gas is pumped out remaoning gas would $n=\frac{n_0}{2}$, here n_0 moles is the gas at pressure p_0. Accordingly as per IGE, pressure at $\frac{n_0}{2}$ moles gas in the vessel $p=\frac{p_0}{2}$. It leads to $\frac{p_0}{2}=p_0e^{-\frac{rt}{V_0}}\Rightarrow e^{-\frac{rt}{V_0}}=\frac{1}{2}\Rightarrow e^{\frac{rt}{V_0}}=2\Rightarrow\frac{rt}{V_0}=\ln 2\Rightarrow t=\frac{V_0\ln 2}{r}$. **This is part (b) of the answer.** **N.B.:** It is to be remembered that $\ln 2=\log_e 2$ and $\log 2=\log_{10} 2$
I-62	As per IGE $pv=nRT$, therefore as per given process on a one Mole of gas at $v=v_0$ the process equation shall be $\frac{p_0}{1+\left(\frac{v_0}{v_0}\right)^2}v_0=nRT\Rightarrow T=\frac{p_0v_0}{2nR}\text{K}$. Since n in moles appears in the denominator in the final expression and given that $n=1\,\text{mol}$. **Hence answer is** $\frac{p_0v_0}{2R}\text{K}\times\text{mol}^{-1}$.
I-63	As per IGE $pv=nRT$. It is given that inside room as temperature changes pressure remains constant. Since inside room volume of air is constant and decided by the geometry of the room, therefore $pv=n_1RT_1=n_2RT_2$. And as per KTG $pv=\frac{1}{3}mNv_{rms}^2=\frac{2}{3}\left(\frac{1}{2}mnN_Av_{rms}^2\right)=\frac{2}{3}\left(\frac{1}{2}nMv_{rms}^2\right)=\frac{2}{3}nU$, here M is the molar mass of the gas. Combining the two relations of pv it deduces to $\frac{2}{3}nU=nRT\Rightarrow U=\frac{3}{2}RT$. Since T is given to be constant and hence internal energy of the air is also contant. **Hence proved**.
I-64	In this question Three important concepts apply – (a) Tight-fit Cork would experience frictional force when internal pressure of the gas in the tube exceeds atmospheric pressure and tends to move it out. The cork would pop out only $p-p_{atm}\to> f_{\lim}$. Here, $f_{\lim}=\mu\left(2\pi r\frac{dN}{dl}\right)$, here $\mu=0.2$ is frictional coefficient between cork and tube and $r=5\,\text{cm}=0.05\,\text{m}$ is internal radius of the tube. (b) It is given that cork pops out when temperature of the gas reaches to 600 K, until then volume of air in the tube remains constant as per (a) above. Therefore as per Charle's Pressure $\frac{p_1}{T_1}=\frac{p_2}{T_2}\Rightarrow p_2=\frac{T_2}{T_1}p_1=\frac{600}{300}p_{atm}=2p_{atm}$.

	(c) It is given that temperature of gas remains constant at any instant. This can happen only when cork starts poping out the process is conservative., i.e. work done, during displacement $\Delta x \to 0$ is, by internal pressure of gas is equal to work done by frictional force. Thus $\Delta p dv = f_{\lim} dx \Rightarrow \Delta p\left(Adx\right) = f_{\lim} dx \Rightarrow \Delta pA = f_{\lim}$. Combining the stipulations at (a) and (b) above, $\mu\left(2\pi r\frac{dN}{dl}\right) = \left(2p_{atm} - p_{atm}\right)\times A \Rightarrow 2\pi r\mu\frac{dN}{dl} = \Delta pA$. In this firal form of equation substituting the given data and quantities derived at (a), (b) and (c) above in the final expression $2\pi r\mu\frac{dN}{dl} = \Delta pA \Rightarrow 2\times\pi\times r\times 0.2\frac{dN}{dl} = 10^5\times\pi r^2 \Rightarrow \frac{dN}{dl} = \frac{r10^5}{0.4} = \frac{0.05\times 10^5}{0.4} = 1.25\times 10^4\ \mathrm{N\cdot m^{-1}}$. **Thus answer is** $1.25\times 10^4\ \mathrm{N\cdot m^{-1}}$ N.B.: (a) This problem is an excellent example of integration of concepts. (b) This problem is a good example of solving it algebraically, in the process most of variables cancel out. Thus use numerical values in last step simplify solution and improve probability of accuracy. (c) The data on length of the cylindrical tube is not required to be used in solution. Hence it is redundant and should not be confused
I-65	In initial condition at temperature and pressure T_0 and p_0 respectively of the gas trapped between two pistons connected a metallic wire given that $p_0 = p_{atm}$. Therefore, both pistons would remain in equilibrium and would continue to remain there wherever they are. Therefore, $p_0\times A - F = p_{atm}\times A$, thus from given value of p_0, tensile forced in the metallic wire $F = \left(p_0 - p_{atm}\right)A = 0\times A = 0$. **This is part (a) of the answwer.**  When temperature of the gas is raised to $2T_0$ volumetric expansion of the gas trapped between two pistos, connected by metallic wire, will be negligible since thermal expansion and tensile alongation of the gas is taken to be negligible. This premise is based on the fact that no dat is given either of thermal expansion or related to tensile alongation of the wire. Thus volume of the gas v_0 and quantity of gas n moles would remain constant. Therefore from IGE $pv = nRT \Rightarrow \frac{p}{T} = \frac{nR}{v}$. It leads to $\frac{p_1}{T_1} = \frac{p_2}{T_2} \Rightarrow p_2 = \frac{T_2}{T_1}p_1$. On substituting the values from the given data $p_2 = \frac{2T_0}{T_0}p_0 = 2p_0$. Accordingly, $p_2\times A - F_2 = p_0\times A \Rightarrow F_2 = \left(p_2 - p_0\right)\times A = \left(2p_0 - p_0\right)\times A$. **Thus** $F_2 = p_0 A$ **is part (b) of the answer.**
I-66	Initially pressure exerted by air trapped inside tank above water surface is $2p_0$ where p_0 is the atmospheric pressure. It is required to determine height of water level h_2, above the top of the water tank, in long tube connected to the tank. This can be determined by the equilibrium of hydrostatic pressure above any line say AB passing through center of hole. Taking points X and Y in the tank where $p_X = p_0 + \rho g\left(h_2 + h_0 + h\right)$ and $p_Y = 2p_0 + \rho g\left(h\right)$, here ρ is density of water. Thus, at equilibrium $p_X = p_y$ which leads to $p_0 + \rho g\left(h_2 + h_0 + h\right) = 2p_0 + \rho g\left(h\right)$. It, further, solves into $\rho g\left(h_2 + h_0\right) = p_0 \Rightarrow h_2 = \frac{p_0}{\rho g} - h_0$. **This is the part (a) of the** 

	answer. As regards part (b) velocity would be determined by the kinetic energy of water as per principle of conservation of energy at the outlet i.e. equating total energy at incoming water which is pressure energy and it is $TE_i = 2p_0 + (h_1 - h_0)gh$ and total energy at at outlet which sum of kinetic energy and pressure energy and it is $TE_o = \frac{1}{2}\rho v^2 + p_0$. Accordingly, $KE = PE \Rightarrow \frac{1}{2}\rho v^2 + p_0 = 2p_0 + \rho g(h_1 - h_0) \Rightarrow v^2 = \frac{2[p_0 + \rho g(h_1 - h_0)]}{\rho}$. It leads to $v = \sqrt{\frac{2[p_0 + \rho g(h_1 - h_0)]}{\rho}}\ \text{m} \times \text{s}^{-1}$. **This is part (b) of the answer.** As regards part (c) of the answer for water to stop coming at outlet kinetic energy is Zero. This can happen when $v = \sqrt{\frac{2[p_0 + \rho g(h_1 - h_0)]}{\rho}} = 0 \Rightarrow p_0 + \rho g(h_1 - h_0) = 0 \Rightarrow \rho g h_0 = p_0 + \rho g h_1 \Rightarrow h_0 = h_1 + \frac{p_0}{\rho g}$. Substituting this value of h_0 in the answer of part (a) above, $h_2 = \frac{p_0}{\rho g} - \left(h_1 + \frac{p_0}{\rho g}\right) = \left(\frac{p_0}{\rho g} - \frac{p_0}{\rho g}\right) - h_1 = -h_1$ **This is part (c) of the answer.**
I-68	Intially volume of the gas in the cylinder is $v_1 = l_1 A = 0.2 \times (10 \times 10^{-4}) = 2 \times 10^{-4}$.  Forces equation in initial equilibrium of the piston $p_2 A = p_1 A + mg$. It is given that weight of the piston is 1 kg; since weight is a force whose unit is N and while unit of mass is kg. Hence, weight stated in the problem, as per unit, is mass $m = 1\text{kg}$ and shall be used accordingly. It is also given that $p_1 = 100\,\text{kPa} = 10^5\,\text{kPa}$. After air in the chamber is completely evacuated pressure of air on the piston shall be $p_1' = 0$, accordingly when piston moves to a state of equilibrium equation of forces shall be $p_2' A = mg$. Further it is given that temperature of the gas remains constant throughout the process, moreover gas filled inside the cylinder remains same. Therefore, as per Boyle's Law $p_2 v_2 = p_2' v_2' \Rightarrow \left(p_1 + \frac{mg}{A}\right) A l_1 = \frac{mg}{A} \times A l_1'$, Here, $l_1 = 0.2\text{m}$ is the length of gas column pre-evacuation, and l' is the length post-evauation, required to be determined. It is reduced to $\frac{mg}{A} \times l_1' = \left(p_1 + \frac{mg}{A}\right) l_1 \Rightarrow l_1' = \left(\frac{p_1}{mg} + \frac{1}{A}\right) l_1 A$. On substituting the given values $l' = \left(\frac{10^5}{1 \times 10} + \frac{1}{10^{-3}}\right) \times 0.2 \times 10^{-3} = (10 + 1)0.2 = 2.2\,\text{m}$. **Hence, answer is 2.2 m.**
I-69	Gas filled in the cylinder, as shown in the figure, is under pressure $p_1 = p_{atm} + \frac{mg}{A}$, mass of the piston though referred to as weight is not force and $m = 10\text{kg}$ and area of cross-section of piston over which pressure is exerted on the piston is $A = 10\,\text{cm}^2 = 10 \times 10^{-4}\text{m}^2$. Given that $p_{atm} = 10^5\,\text{Pa}$,  When the cylinder is taken to the spaceship revolving aronud the earth, force exerted by piston is neutralized by centripetal and centrifugal forces. The only force exerted is due air pressure maintained in the spaceship such that $p_2 = 100\,\text{kPa} = 10^5\,\text{Pa}$. Since the question does not make any mention of the temperature, it is taken to be constant. Thus as per Boyle's Law

	$p_1v_1 = p_2v_2 \Rightarrow \left(p_{atm}+\frac{mg}{A}\right)\times\left(A\times l_1\right) = p_{atm}\times\left(A\times l_2\right)$. Here, given that $l_1 = 20\,\text{cm} = 0.2\text{ m}$. Accordingly- $p_1v_1 = p_2v_2 \Rightarrow \left(10^5+\frac{1\times10}{10\times10^{-4}}\right)\times\left(\left(10\times10^{-4}\right)\times0.2\right) = 10^5\times\left(\left(10\times10^{-4}\right)\times l_2\right) \Rightarrow 22 = 100\times l_2 \Rightarrow l_2 = 0.22\,\text{m}$. **Thus answer is 22 cm.** **N.B.:** The equation $p_1 = p_{atm}+\frac{mg}{A}$ is valid only when the cylinder is vertical. Though this is not mentioned explicitly but the problem states "… length of the gas column in the vessel is 20 cm..". In this statement the word column implies that the vessel is held vertically. The Column word is for vertical formation and beam is forhorizontal formation.
I-70	Initially both bulbs of equal volume are at ame temperature and pressure. When one bulb is placed in hot water bath at $T_2 = 62^0$ C while the other is maintained at same temperature $T_1 = 0^0$C, pressure in hot bulb increases and through narrow tube pressure in Two bulbs at different temperatures is equalized to a new value say p.  As per IGE initial mass of gas in each bulb iss equal to $pv = nMRT \Rightarrow nM = m = \frac{p_1 v}{RT_1}$. When one of the bulb is heated to $T_2 = 62^0$, as per Charles Pressure Law pressure is built inside it $\frac{p_2}{T_2} = \frac{p_1}{T_1} \Rightarrow p_2 = \frac{T_2}{T_1}p_1$. Since the two bulbs are connected by a narrow tube, the pressure in two bulbs would slowly equalize to a new value $p_1 < p < p_2$ with unequal mass of the gas in Two bulbs $m_1 = \frac{pv}{RT_1}$ and $m_2 = \frac{pv}{RT_2}$ such that $m_1 + m_2 = 2m \Rightarrow \frac{pv}{RT_1} + \frac{pv}{RT_2} = 2\frac{p_1 v}{RT_1} \Rightarrow p\left(\frac{T_1+T_2}{T_1T_2}\right) = 2\frac{p_1}{T_1} \Rightarrow p = \frac{2T_2}{T_1+T_2}p_1$. Substituting the values given $p = \frac{2(273+62)}{273+(273+62)}\times76 = \frac{2\times335}{608}\times76 = 83.75$ cm Hg. **Hence answer is 84 cm Hg** based on SGs in the given data. **N.B.:** Since pressure is given in Cm of Hg and answer asked is also pressure, and hence the pressure is not converted to Pa.
I-71	As per definition relative humidity is – $RH = \frac{\text{Amount of water vapour in a given volume of air at a given temperature}}{\text{Amount of water vapour requiored tosaturate the same volume of air at a given temperature}}$. And dew point is that temperature at which vapour present in air is enough to to cause RH = 100%. From the given weather data at 20^{0}C , RH = 100% and **hence Dew Point is 20^{0}C, and is the answer.**
I-72	As per definition of relative humidity, $RH = \frac{VP}{SVP}$ at temperature here is VP Vapour pressure and SVP saturated vapour pressure at any T temperature . Therefore, in an atmosphere at 25^{0}C at pressure 104 kPa, $RH = 60\%$ pressure of vapour is $VP = RH \times SVP = 0.6\times3.2 = 1.92$ kPa. As per partial pressure $p = p_a + p_v$. Here, $p = 104$ kPa as given. p_a partial pressure of dry air and vapour pressure as caluclated is $p_v = 1.9$ kPa. Accordingly, after evacuation water vapour remain air is dry and shall have pressure

	$p_a = p - p_v = 104 - 1.92 = 102.08 = 102$ kP. **Thus answer is 102 kPa.**
I-73	Dew point is that temperature at which oressure of vapour present in air turns saturated.. In the given conditions there is drop of tempertaure, without any change in constent of vapour in the air. Therefore Dew Point would remain at 10^0C, despite drop of temperature. **Hence answer is 10^0C,**
I-74	As per definition of Relative Humidity, $RH = \frac{VP}{SVP}$, and SVP is dependent upon Temperature and hence $p_1 = VP = RH \times SVP \Rightarrow p_1 = 0.4 \times SVP$. When air is compressed isothermally, its SVP would remain temperature since in isothermal process temperature does not change. Further, as per Boyle's Law $p_1 v_1 = p_2 v_2$. Pressure p_2 at which vapour trapped in the vessel starts condensing $p_2 = SVP$ at the tempertaure. Therefore, extending Boyle's Law, $v_2 = \frac{p_1 v_1}{p_2} = \frac{(0.4 \times SVP) \times v_1}{SVP} = 0.4 v_1$. Substituting, given data, $v_2 = 0.4 \times 10\,\text{cm}^3 = 4\,\text{cm}^3$. **Hence, answer is 4.0 cm^3**
I-75	Atmospheric pressure $p_{atm} = 76$cm of Hg. When a small quanity of water is introduced height of mercury columns drop to $p = 75.4$cm of Hg. This drop in height of percury column is due to vapour pressure (VP) created by evaporation pressure in space above mercury, which was initially vacuum. Thus $p_{atm} = p + VP \Rightarrow VP = p_{atm} - p = 76 - 75.4 = 0.6$ cm. It is also given that at room temperature $SVP = 1$cm.. Therefore as per definition $RH = \frac{VP}{SVP} \times 100 = \frac{0.6}{1} \times 100 = 60\%$. **Thus answer is 60%.**
I-76	Given data is plotted on the graph and accordigly tempertaure corresponding to atmospheric pressure (=76 cm) is 65^0C. Likewise at 0.5 atm = $0.5\,\text{atm} = 0.5 \times 760 = 380\,\text{mm}$, corresponding temperature is 48^0C. **Thus answer is 65^0C and 48^0C.** 
I-77	Temperature of human body is given in Ferenheight while in the graph given graph temperature is in Centigrade thefore as per conversion formula $\frac{C}{5} = \frac{F-32}{9} \Rightarrow C = \frac{(98-32)\times 5}{9} = \frac{66 \times 5}{9} = 36.7 = 37^0$Cs. Therefore, SVP at 37^0C from the given graph is 50 mm of HG. **Hence answer is 50 mm of mercury.** 
I-78	From definition of relative humidity $RH = \frac{VP}{SVP} \times 100$. From the given data dew point is 10^0C and corresponding vapour pressure $VP = 8.9$mm of Hg. The room temperature 20^0C corresponds to boiling point of water at pressure 17.5 mm Hg. Therefore, at room temperature $SVP = 17.5$ mm of Hg. Thus, $RH = \frac{8.9}{17.5} \times 100$

	i.e. $RH = 50.8\% = 51\%$, considering SGs. **Hence answer is 51%** .
I-79	Volume of saturated vapour at 30^0C is 50 m^3. Therefore, mass of vapour as per given data is $m_1 = V \times SVP_{30}$ g. When the saturated vapour is cooled down to 20^0C, mass of vapour shall be $m_2 = V \times SVP_{20}$. Thus, the mass of vapour condensed into water shall be $m = m_1 - m_2 = V \times SVP_{20} - V \times SVP_{10} = V\left(SVP_{20} - SVP_{10}\right)$. On sunstituting the values $m = 50(30-16) = 700$ g. **Thus answer is 700 g.**
I-80	Correct reading of atmospheric pressure by a barometer is $p_1 = 76.0$ cm of Hg. When water is slowly introduced by a dropper in barometer tube, it will first rise above mercury level. Then, it will start evaporating until space in the tube above mercury attains SVP corresponding to room temperature and let atmospheric pressure measured in this faulty state be p_2. Accordingly, $p_1 = p_2 + SVP \Rightarrow p_2 = p_1 - SVP \Rightarrow 76.0 - 0.80 = 75.2$ cm of Hg. **Thus answer is 75.2 of Hg.**
I-81	As per principle of barometer when water level in the jar is same as that outside, then pressure inside jar is equal to atmospheric pressure. Further, in a state of equiilibrium Oxygen in jar will contain saturated vapour; and as per principle of partial pressure $p_{atm} = p_{O_2} + VP \Rightarrow 99.4 = p_{O_2} + 3.4 \Rightarrow p_{O_2} = 99.4 - 3.4 = 96$ kPa. Now applying Ideal gas equation $pv = nRT \Rightarrow n = \frac{pv}{RT}$. On substituiting the given data $n = \frac{4.8}{8.3 \times 300} = 1.927 \times 10^{-3} = 1.9 \times 10^{-3}$ moles. **Hence, answer is** 1.93×10^{-3} **moles**.
I-82	As per principle of partial pressure, above mercury mercury level in faulty barometer is $p = p_{air} + VP$, therefore air pressure would be $p_{air} = p - VP$. Therefore, as per principle of barometer $p_{atm} = p + \rho gh$. Since all pressures are given in terms of height of mercury column therefore the equation can be written as $p_{atm} = p + h$. Accordingly, in two cases as given air temperature is not stated and hence it taken to be the same. Therefore vapour pressure corresponding to the air temperature is $VP = 1.0$ Hg. This leads to Two equations $p_{atm-1-c} = p_{atm-1-e} + p_{e-1} \Rightarrow p_{e-1} = p_{atm-1-c} - p_{atm-1-e} = 76.0 - 74.0 = 2.0$ cm, Therefore air pressure would be $p_{air-1} = p_{e-1} - VP = 2 - 1 = 1$ cm. Likewise, in case 2, $p_{atm-2-c} = p_{atm-2-e} + p_{e-2}$. Hence, $p_{e-2} = p_{atm-2-c} - p_{atm-2-e} \Rightarrow p_{air-2} = p_{e-2} - VP$ and air pressure would be , $p_{e-2} = p_{air-2} = 74.0 - 72.10 - 1 = 0.9$. Now, the pressure exerted by air would change as per Boyle's Law since temperature is same. Accordingly, $p_{e-1} \times v_1 = p_{e-2} \times v_2 \Rightarrow p_{e-1} \times A\left(l - h_1\right) = p_{e-2} \times A\left(l - h_1\right) \Rightarrow_{e-1} \times \left(l - h_1\right) = p_{e-2} \times \left(l - h_1\right)$. Substituting the values of p_{e-1} and p_{e-2}, and the given data $1.0 \times \left(l - 74.0\right) = 0.9 \times \left(l - 72.1\right) \Rightarrow l = \frac{74.0 \times 1.0 - 72.1 \times 0.9}{1.0 - 0.9} = 91.1$ cm. **Hence, answer is 91.1 cm.**
I-83	By definition of relative humdity $RH = \frac{VP}{SVP} \Rightarrow VP = SVP \times RH$. Accordingly, vapour pressure in ambient air at 0^0C from given data would be $VP_{amb} = 0.46 \times \frac{40}{100} = 0.184$ cm. The ambient air enter room of Volume V and heated to temperature 20^0C. This condition as per Charle's law would cause change in pressure of air and VP together. Accordingly change in VP at 20^0C in the room would be $\frac{VP_{amb}}{VP_{room}} = \frac{T_{amb}}{T_{room}} \Rightarrow VP_{room} = VP_{amb} \times \frac{T_{room}}{T_{amb}}$ cm.

	Therefore, relative humidity inside the room shall be $RH_{room}=\frac{VP_{amb}\times\frac{T_{room}}{T_{amb}}}{SVP_{room}}$. On substituting the values $RH_{room}=\frac{0.184}{1.8}\times\frac{273+20}{273+0}=\frac{0.184}{0.18}\times\frac{293}{273}\times 100\%=10.97\%$. **Hence, answer is 11.0%**
I-84	As per definition of Relative Humidity $RH=\frac{VP}{SVP}\Rightarrow VP=SVP\times RH$. Therefore, amount of vapour to be added to saturate 1 m^3 of air corresponds to $\Delta VP=SVP-VP\Rightarrow SVP(1-RH)$. As per ideal gas equation $pv=nRT\Rightarrow n=\frac{\Delta pv}{R\times T}\rightarrow\frac{SVP\left(1-\frac{RH}{100}\right)\times 1}{8.31\times(273+27)}=\frac{(3.6\times 10^3)\times\left(1-\frac{50}{100}\right)}{8.31\times 300}=\frac{1.8}{2.493}=0.72$ mole. Molecular mass of water vapour is $M=18$ g, hence water vapour to be added is $m=nM=0.72\times 18=12.96=13$ g. **Hence, answer is 13 g.**
I-85	As per definition of Relative Humidity $RH=\frac{VP}{SVP}\Rightarrow VP=SVP\times RH$. Therefore as per Ideal Gas Equation $pv=nRT\Rightarrow(VP)v=n\times R\times T\Rightarrow n=\frac{(SVP\times RH)v}{R\times T}=\left(\frac{(3.3\times 10^3)\times\frac{20}{100}}{8.31\times 300}\right)\times 50=13$ moles. There mass of water vapour present in air $m=nM=13\times 18=238$ g. **Hence, answer is 238 g.**
I-86	As per definition of Relative Humidity $RH=\frac{VP}{SVP}\Rightarrow VP=SVP\times RH$. Therefore as per Ideal Gas Equation $pv=nRT\Rightarrow(VP)v=nR\times T\Rightarrow n=\frac{(SVP\times RH)v}{R\times T}=\left(\frac{(3.3\times 10^3)\times\frac{20}{100}}{8.31\times 300}\right)\times 50=13$ moles. There mass of water vapour present in air $m=nM=13\times 18=238$ g. Now 500 g equivalent to $\Delta n=\frac{500}{18}=27.8$ moles of water sticking on floor on drying will add to vapour pressure in the room and in turn change relative humidity of the room. Thus finally total vapour in the room is $n'=n+\Delta n=13+27.8=40.8$ moles. Thus using formula derived from IGE it leads to $RH=\frac{n'RT}{SVP\times v}\times 100=\frac{40.8\times 8.31\times 300}{(3.3\times 10^3)\times 50}\times 100=61.65=62\%$. **Thus, answer is 62%**
I-87	As per definition of Relative Humidity $RH=\frac{VP}{SVP}\Rightarrow VP=SVP\times RH$. As per Ideal Gas Equation $pv=nRT$ accordingly amount of vapour present in air in the room of size 50 m^3 at 15^0C and 40 % relative humidity would $(VP)v=nR\times T\Rightarrow n=\frac{(SVP\times RH)v}{R\times T}=\left(\frac{(1.6\times 10^3)\times\frac{40}{100}}{8.31\times(273+15)}\right)\times 50=13.37$. Accordingly, the extent to which water will continue to evaporate is till vapour attains SVP at the room temperature. Thus

	$\frac{n}{n+\Delta n}=\frac{RH}{100}\Rightarrow \Delta n\times RH=n\times(100-RH)\Rightarrow \Delta n=\frac{n\times(100-RH)}{RH}=\frac{13.37\times 60}{40}=20.06$ moles. Therefore amount of water epavporated from bucket to saturate the air is $\Delta m=\Delta n\times M=20.06\times 18=361$. **This is part (a) of the answer.** If temperature is increased by 5^0C i.e. from 15^0C to 20^0C the change in SVP is $\Delta SVP=2.4-1.6=0.8\,\text{kPa}$. Therefore using IGE, the additional mass of vapour that would saturate the air in the room is $\Delta m'=\frac{\Delta SVP\times v\times M}{R\times T}=\frac{(0.8\times 10^3)\times 50\times 18}{8.31\times(273+20)}=295.7=296\,\text{g}$. **This is part (b) of the answer.** **N.B.:** It is to be noted that part (b) of the answer requires additional amount of water to attain SVP of the given volume of air initially saturated at 15^0C to that when it is saturated at 20^0C.

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