Heat - Kinetic Theory of Gases : Objective Subjective Questions (Typical)

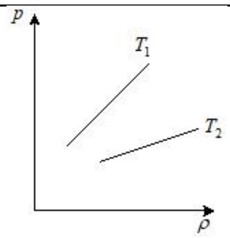
No of Questions: 87 **Time Allotted: 9 Hours**

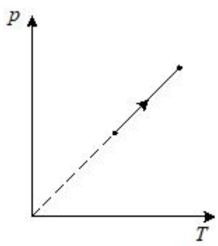
All questions are compulsory

[Note: Figures are conceptual only and not to the scale]

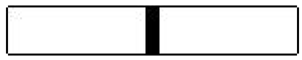
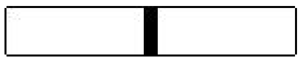
Guidelines:

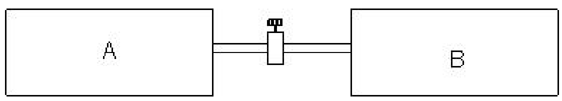
1. **Take questions in Three parts in different time slots of Three hours each, with proper refreshing break of minimum two hours**
2. **Part One – covers Q-01 to Q-30; Part Two – Covers Q-31 to Q-60 and Part Three – covers Q-61 to Q-87**

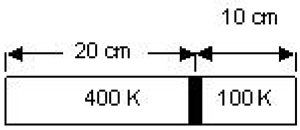
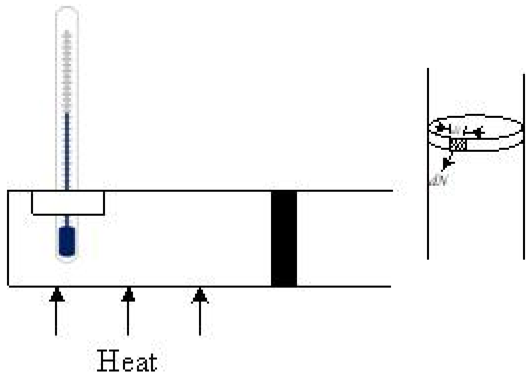
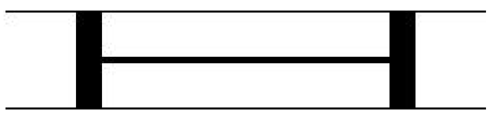
Q-01	Which of the following parameters is same for molecules of all gases at a given temperature? (a) Mass (b) Speed (c) Momentum (d) Kinetic Energy
Q-02	Gas behaves more closely as an ideal gas at (a) Low pressure and low temperature (b) Low pressure and high temperature (c) High pressure and low temperature (d) High pressure and high temperature
Q-03	The pressure of an ideal gas is written as $p = \frac{2E}{3v}$. Here, E refers to (a) Translational kinetic energy (b) Rotational kinetic energy (c) Vibrational kinetic energy (d) Total kinetic energy
Q-04	The energy of a given sample of an ideal gas depends on its (a) Volume (b) Pressure (c) Density (d) Temperature
Q-05	Which of the following gases has maximum rms speed at a given temperature ? (a) Hydrogen (b) Nitrogeen (c) Oxygen (d) Carbon dioxide
Q-06	From the given graph of pressure Vs density of an ideal gas at Two temperatures T_1 and T_2 (a) $T_1 > T_2$ (b) $T_1 = T_2$ (c) $T_1 < T_2$ (d) Any of these three is possible 
Q-07	The mean square speed of the molecules of a gas at absolute temperature T is proportional to (a) $\frac{1}{T}$ (b) $\sqrt{T}$ (c) T (d) T^2

Q-08	Suppose a container is evacuated to leave just one molecule of a gas in it. Let v_a and v_{rms} represent the average speed and rms speed of the gas (a) $v_a > v_{rms}$ (b) $v_a < v_{rms}$ (c) $v_a = v_{rms}$ (d) v_{rms} is undefined (b)
Q-09	The rms speed of oxygen at room temperature is about $500\,\text{m.s}^{-1}$. The rms speed of hydrogen at the same temperature is about (a) $125\,\text{m.s}^{-1}$ (b) $2000\,\text{m.s}^{-1}$ (c) $8000\,\text{m.s}^{-1}$ (d) $31\,\text{m.s}^{-1}$
Q-10	Pressure of a gas kept in an isothermal container is 200 kPa. Half the gas is removed from it, the pressure will be – (a) 100 kPa (b) 200 kPa (c) 400 kPa (d) 800 kPa
Q-11	The rms speed of oxygen molecule in a gas is v. If the temperature is doubled and the oxygen molecules dissociate in oxygen atoms , the rms speed will become (a) v (b) $v\sqrt{2}$ (c) $2v$ (d) $4v$
Q-12	The quantity $\frac{pv}{kT}$ represents (a) Mass of the gas (b) Kinetic energy of the gas (c) Number of moles of the gas (d) Number of molecules in the gas
Q-13	The process on an ideal gas shown in the figure is (a) Isothermal (b) Isobaric (c) Isochoric (d) None of these 
Q-14	There is some liquid in a closed bottle. The amount of liquid is continuously decreasing. The vapour in the remaining part (a) Must be saturated (b) Must be unsaturated (c) May be saturated (d) There will be no vapour
Q-15	There is some liquid in a closed bottle. The amount iof liquid remains constant as time passes. The vapour in remaining part (a) Must be saturated (b) Must be unsaturated (b) May be saturated (d) There will be no vapour
Q-16	Vapour is injected at a uniform rate in a closed vessel which was initially evacuated. The pressure in the vessel (a) Increases continuously (b) Decrease continuously (c) First increase and then decrease (d) First increase and then becomes constant
Q-17	A vessel *A* has volume *V* and a vessel *B* has volume *2V*. Both contain some water which has a constant volume. The pressure in the space above water is p_a for vessel *A* and p_b for vessel *B* (a) $p_a = p_b$ (b) $p_a = 2p_b$ (c) $p_b = 2p_a$ (d) $p_b = 4p_a$
Q-18	Consider a collison between an oxygen molecule and a hydogen molecule in a mixture of oxygen and hydrogen kept at room temperature. Which of the following are possible? (a) The kinetic energy of both the molecules increase. (b) The kinetic energy of both the molecules decrease. (c) Kinetic energy of the oxygen molecules increase and that of the hydrogen molecule decrease (d) Kinetic energy of the hydrogen molecules increase and that of the oxygen molecule decrease

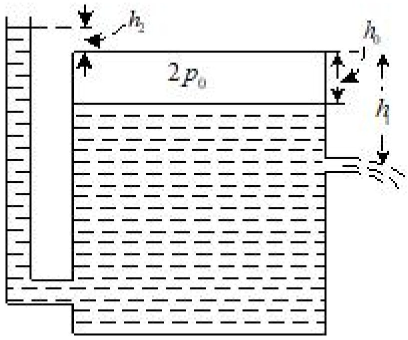
Q-19	Consider a mixture of oxygen and hydrogen kept at room temperature. As compared to a hydrogen molecule an oxygen molecule hits the wall. (a) With greater average speed (b) With smaller average speed (c) With greater average kinetic energy (d) With smaller average kinetic energy
Q-20	Which of the following quantities is zero on an average for molecules of an ideal gas in equilibrium? (a) Kinetic Energy (b) Momentum (c) Density (d) Speed
Q-21	Keeping the number of moles, volume and temperature the same, which of the following are same for all ideal gases? (a) Rms speed of a molecule (b) Density (c) Pressure (d) Average magnitude of momentum
Q-22	The average momentum of a molecule in a sample of an ideal gas depends on (a) Temperature (b) Number of moles (c) Volume (d) None of these
Q-23	Which of the following quantities is the same for all gases at the same temperature? (a) Kinetic energy of 1 mole (b) Kinetic energy of 1 g (c) Number of molecules in 1 mole (d) Number of molecules in 1 g
Q-24	Consider the quantity $\frac{MkT}{pv}$ of an ideal gas where M is the mass of the gas. It depends on the (a) Temperature of the gas (b) Volume of the gas (c) Pressure of the gas (d) Nature of the gas
Q-25	Calculate the volume of 1 mole of an ideal gas at STP.
Q-26	Find the number of molecules of an ideal gas at STP in a volume of $1.000\ \text{cm}^3$
Q-27	Find number of molecules in 1cm^3 of an ideal gas at 0^0C and at a pressure of 10^{-5} mm of mercury.
Q-28	Calculate mass of 1cm^3 of oxygen kep at STP
Q-29	Equal masses of air are sealed in two vessels, one of volume V_0 and other of volume $2V_0$. If the first vessel is maintained at a temperature $300\,\text{K}$ and other at $600\,\text{K}$, find ratio of pressure in the two vessels.
Q-30	An electric bulb of volume 250 cc was sealed during manufacturing at a pressure of 10^{-3} mm of mercury at 27^0C. Compute the number of air molecules contained in the bulb. Avogadros constant $=6\times10^{23}\ \text{mol}^{-1}$, density of mercury $=13600\,\text{kg}\cdot\text{m}^{-3}$ and $g=10\,\text{m}\cdot\text{s}^{-2}$.
Q-31	A gas cylinder has walls that can bear a maximum pressure of 1.0×10^6 Pa. It contains a gas at 8.0×10^5 Pa and $300\,\text{K}$. The cylinder is steadily heated. Neglecting any change in volume, calculate the temperature at which cylinder would break.

Q-32	2g of hydrogen is sealed in a vessel of volume $0.02\,\text{m}^3$ and is maintained at $300\,\text{K}$. Calculate pressure in the vessel.
Q-33	Density of an ideal gas is $1.25\times10^{-3}\ \text{g}\cdot\text{cm}^{-3}$ at STP. Calculate molecular weight of the gas.
Q-34	Temperature and pressure at Simla are 15.0^0C and $72.0\,\text{cm}$ of mercury and at Kalka these are 35.0^0C and $76.0\,\text{cm}$ of mercury. Find the ratio of air density at Kalka and Simla.
Q-35	Figure shows a cylindrical tube with adiabatic walls and fitted a diathermic seperator. The seperator can slid in the tube by an external mechanism. An ideal gas is injected into the two sides at equal pressures and equal temperatures. The seperator remains in equilibrium at the middle. It is now slid to a position wher it divides the tube in the ratio $1:3$. Find the ratio of the pressures in the Two parts of the vessel. 
Q-36	Find the rms speed of the hydrogen molecules in a sample of hydrogen gas at $300\,\text{K}$. Find the temperature at which the rms speed is double the speed calculated at $300\,\text{K}$.
Q-37	A sample of $0.177\,\text{g}$ of an ideal gas occupies $1000\,\text{cm}^3$ at STP. Calculate the rms speed of the gas molecules.
Q-38	The average translational kinetic energy of air molecules is $0.040\,\text{eV}\left(1\text{eV}=1.6\times10^{-19}\ \text{J}\right)$. Calculate the temperature of the air. Boltzmann constant $k=1.38\times10^{-23}\ \text{JK}^{-1}$.
Q-39	Consider a sample of oxygen at $300\,\text{K}$. Find the average time taken by a molecule to travel a distance equal to the diameter of the earth.
Q-40	Find average magnitude of linear momentum of a helium molecule in a sample of helium gas at $0^0\ \text{C}$. Mass of a helim molecule $=6.64\times10^{-27}\ \text{kg}$ and Boltzmann constant $k=1.38\times10^{-23}\ \text{JK}^{-1}$.
Q-41	The mean speed of molecules of a hydrogen sample equals the mean speed of the molecules ofa helium sample. Calculate the ratio of the temperature of the hydrogen sample to the tempertaure of the helium sample
Q-42	At what temperature the mean speed of the molecules of hydrogen gas equals the escape speed from the earth?
Q-43	Find the ratio of the mean speed of hydrogen molecules to the mean speed of nitrogen molecules in a sample containing a mixture of the two gases.
Q-44	Figure shows a vessel partitioned by a fixed dathermic separator. Different ideal gases are filled in the two parts. The rms speed of the molecules in the left part equals the mean speed of the molecules in the right part. Calculate the ratio of the mass of a molecule in left part to the mass of the molecule in right part. 
Q-45	Estimate the number of collisons per second suffered by a molecule in a sample of hydrogen at STP. The mean free path (average distance covered by a molecule between successive collisions is $1.38\times10^{-5}\ \text{cm}$).
Q-46	Hydogen gas is contained in a closed vessel at 1 atm (100 kPa) and 300 K. (a) Calculate the mean speed of the molecules, (b) suppose the molecules strike the wall with this speed making an average angle 45^0 with it. How many molecules strike each square metre of the wall per second?
Q-47	Air is pumped into an automobile tyre's tube upto a pressure of 200 kPa in the morning when air temperature is 20^0C. During the day the temperature rises to 40^0C and the tube expands by 2%. Calculate the pressure of the air

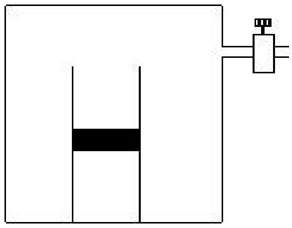
	in the tube at this temperature.
Q-48	Oxygen is filled in a closed metal jar of volume $1.0\times10^{-3}\ \text{m}^3$ at a pressure $1.5\times10^5\ \text{Pa}$ and temperature 400 K. The jar has leak in it. The atmospheric pressure is $1.0\times10^5\ \text{Pa}$ and the temperature is 300 K. Find mass of the gas that leaks out by the time the pressure and temperature inside the jar equalise with the surrounding.
Q-49	An air bubble of radius 2.0 mm is formed at the bottom of a 3.3 m deep river. Calculate the radius of the bubble as it comes to the surface. Atmospheric pressure is $1.0\times10^5\ \text{Pa}$ and density of water is $1000\,\text{kg}\times\text{m}^{-3}$.
Q-50	Air is pumped into the tube of a cycle rikshaw at a pressure 2 atm. The volume of each tube at this pressure is 0.002 m^3. One of the tube gets punctured and the volume of the tube reduces to 0.0005 m^3. How many moles of air have leaked out? Assume that the temperature remains constant at 300 K and that the air behaves as an ideal gas.
Q-51	0.040 g He is kept in a closed container initially at 100.0^{0}C. The container is now heated. Neglecting the expansion of the container, calculate the temperature at which the internal energy is increased by 12 J.
Q-52	During an experiment, an ideal gas is found to obey $pv^2=\text{constant}$. The gas is initially at a tempertaure T and volume v. Find the temperature at which it expands to volume $2v$.
Q-53	A vessel contains 1.60 g of oxygen and 2.80 g of nitrogen. The tempertaure is maintained at 300 K and volume of the vessel is 0.166 m^3. Find pressure of the mixture.
Q-54	A vertical cylinder of height 100 cm contains air at a constant temperature. The top is closed by a frictionless light piston. The atmospheric pressure is equal to 75 cm of mercury. Mercury is slowly poured over the piston. Find the maximum height of the mercury column that can be put on the piston.
Q-55	Figure shows two vessels A and B with rigid walls containing ideal gases. The two vessels contains gas at pressure, temperature and volume at p_A, T_A, v and p_B, T_B, v respectively. The vessels are now connected through a small tube. Show that at equilibrium pressure (p) and temperature (T) in the two vessels shall be such that $\frac{p}{T}=\frac{1}{2}\left(\frac{p_A}{T_A}+\frac{p_B}{T_B}\right)$ 
Q-56	A container of volume 50 cc contains air (mean molecular weight = 28.8 g) and is open to atmosphere where the pressure is 100 kPa. The container is kept in a bath containing melting ice at 0^{0}C, (a) Find the mass of the air in the container when thermal equilibrium is reached. (b) The container is now placed in another bath containing boiling water at 100^{0}C. (c) The coantainer is now closed and placed in melting-ice bath. Find the pressure of the air when thermal equilibrium is reached.
Q-57	A uniform tube closed at one end, contains a pellet of mercury 10 cm long. When the tube is kept vertically with the closed-end upward, the length of the air column traped is 20 cm. Find the length of the air column trapped when the tube is inverted so that the closed-end goes down. Atmospheric pressure is 75 cm of mercury,
Q-58	A glass tube, sealed at both ends, is 100 cm long. It lies horizontally with the middle 10 cm containing mercury. The two ends of the tube contain air at 27^{0}C and at a pressure of 76 cm of mercury. The air column on one side is maintained at 0^{0}C and the other side is maintained at 127^{0}C. Calculate the length of the air column on the cooler side. Neglect the changes in the volume of the mercury and of the glass.
Q-59	An ideal gas is trapped between a mercury column and the closed-end of a narrow vertical tube of uniform base containing the column. The upper end of the tube is open to the atmosphere. The atmoshperic pressure is 76 cm

	of mercury. The length of the mercury column and trapped air column are 20 cm and 43 cm respectively. What will be the length of the air column when the tube is tilted slowly in a vertical plane at an angle of 60^0 ? Assume temperature to remain constant.
Q-60	Figure shows a cylindrical tube of length 30 cm which is partitioned by tight-fit seperator. The seperator is very weakly conducting and can freely slide along the tube. Ideal gases are filled in the two parts of the vessel. In the beginning, the temperature in the parts A and B are 440 K and 100 K respectively. The seperator slides to a momentary equilibrium. Position shown in the figure. Find the final equilibrium position of the separator, reached after along time. 
Q-61	A vessel of volume v_0 contains an ideal gas at pressure p_0 and temperature T. Gas is continuously pupmed out of this vessel at a constant volume-rate $\frac{dv}{dt} = r$ keeping the the temperature constant. The pressure of the gas being taken out equals the the pressure inside the vessel. Find (a) the pressuire of the gas as a function of time, (b) the time taken before half the original gas is pumped out.
Q-62	One mole of an ideal gas undergoes a process $p = \frac{p_0}{1+\left(\frac{v}{v_0}\right)^2}$ where p_0 and v_0 are constants. Find the temperature of the gas when $v = v_0$.
Q-63	Show that the internal energy of the air (treated as an ideal gas) contained in a room remains constant as the temperature changes between day and night. Assume that the atmospheric pressure around remains constant and the air in the room maintains this pressure by communicating with the surrounding through the window, doors etc.
Q-64	Figure shows a cylindrical tube of radius 5 cm and length 20 cm. It is closed by a tight-fit cork. The friction coefficient between cork and the tube is 0.20. The tube contains an ideal gas at a pressure of 1 atm and a temperature 300 K. The tube is slowly heated and it is found that the cork pops out when the temperature reaches 600K. Let dN denote the normal contact force exerted by a small length dl of the cork along the periphery as shown in the figure. Assuming that the temperature of the gas is uniform at any instant, calculate $\frac{dN}{dl}$. 
Q-65	Figure shows a cylindrical tube of cross-sectional area A fitted with two frictionless pistons. The pitsons are connected to each other by a metallic wire. Initially the temperature of the gas is T_0 and its pressure is p_0 which equals the atmoshperic pressure. (a) What is the tension in the wire ? (b) What will be the tension if temperature is increased to $2T_0$? 

Q-66 Figure shows a large closed cylindrical tank containing water. Initially the air is trapped above the water surface has a height h_0 and pressure $2p_0$, where p_0 is the atmospheric pressure. There is a hole in the wall of the tank at a depth h_1, below the top from which water comes out. A long vertical tube is connected as shown. (a) Find the height h_2 of the water in the long tube above the top initially. (b) Find the speed with which water comes out of the hole. (c) Find the height of the water in the long tube above the top when water stops coming out of the hole.



Q-67 An ideal gas is kept in a long cylindrical vessel fitted with a frictionless piston of cross-sectional area 10 cm^2 and weight 1 kg as shown in the figure. The vessel itself is kept in a big chamber containing air at atmospheric pressure 100 kPa. The length of the gas column is 20 cm. If the chamber is now completely evacuated by an exhaust pump, what will be the length of the gas column? Assume the temperature to remain constant throughout the process.



Q-69 An ideal gas is kept in long cylinderical vessel fitted with frictionless piston of cross-sectional area of 10 cm^2 and weight 1 kg. The length of the gas column in the vessel is 20 cm. The atmospheric pressure is 100 kPa. The vessel is now taken into spaceship revolving round the earth as a satellite. The air prerssure in the spaceship is maintained at 100 kPa. Find the length of the gas column in the cylinder.

Q-70 Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0^0C at a pressure of 76 cm of mercury. One of the bulb is then placed in melting ice and the other is placed in a water bath maintained at 62^0C. What is the new value of the pressure inside the bulb when equilibrium is reached? The volume of the connecting tube is negligible.

Q-71 The weather report reads "Temperature 20^0C, Relative humidity 100%". What is the dew point?

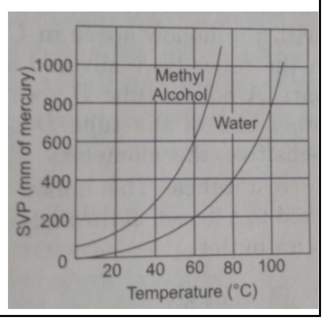
Q-72 The condition of air in a closed room is described as follows. Temperature = 25^0C, relative humidity = 60%, pressure = 104 kPa. If all the water vapour is removed from the room without changing the temperature, what will be the new pressure? The saturation vapour pressure at 25^0C – 3.2 kPa.

Q-73 The temperature and dew point in an open room are 20^0C and 10^0C. If the room tempearture drops to 15^0C what will be the new dew point?

Q-74 Pure water vapour is trapped in a vessel of volume 10 cm^3. The relative humidity is 40%. The vapour is compressed slowly and isothermally. Find the volume of the vapour at which it will start condensing.

Q-75 A barometer tube is 80 cm long (above the mercury reservoir). It reads 76 cm on a particular day. A small amount of water is introduced in the tube and the reading drops to 75.4 cm. Find relative humidity in the space above the mercury column if the saturation vapour pressure at room temperature is 1.0 cm.

Q-76 Using given figure, find the boiling point of methyl alcohol at 1 atm (760 cm of mercury) and at 0.5 atm.



Q-77	The human body has an average temperature of 98^0F. Assume that vapour pressure of the blood in the veins behaves like that of pure water. Find the minimum atmospheric pressure which is necessary to prevent the blood from boiling. Use figure given in Q-76 for the vapour pressure.
Q-78	A glass contains some water at room temperature 20^0C. Refrigearted water is added to it slowly. When the temperature of the glass reaches 10^0C, small droplets condense on the outer surface. Calculate the relative humidity of the room. The boiling point of water at a pressure of 17.5 mm of mercury is 20^0C and at 8.9 mm of mercury it is 10^0C.
Q-79	50 m^3 of saturated vapour is cooled down from 30^0C to 20^0C. Find the mass of the water condensed. The absolute humidity of saturated water vapour is 30 g.m^3 at 30^0C and 16 g.m^3 at 20^0C.
Q-80	A barometer correctly reads the atmospheric pressure as 76 cm of mercury. Water droplets are solwly introduced into barometer tube by a dropper. The height of the mercury column first decreases and then becomes constant. If saturated vapour pressure at the atmospheric temperature is 0.80 cm of mercury, find the height of the mercury column when it reaches its minimum value.
Q-81	50 cc of oxygen is collected in an inverted gas jar over water. The atmospheric pressure is 99.4 kPa and the room temperature is 27^0C. The water level in the jar is same as the level outside. The saturated vapour pressure at 27^0C is 3.4 kPa. Calculate the number of moles of oxygen collected in the jar.
Q-82	A faulty barometer contains certain amount of air and saturated water vapour. It reads 74.0 cm when the atmospheric pressure is 76.0 cm of mercury and reads 72.10 cm when atmospheric pressure is 74.0 cm of mercury. Saturated vapour pressure at the air temperature = 1.0 cm of mercury. Find length of the barometer tube above the mercury level in the reservoir.
Q-83	On a winter day, the outside temperature is 0^0C and relative humidity 40%. The air from outside comes into a room heated to 20^0C. What is the relative humidity in the room? The saturated vapour pressure at 0^0C is 4.6 mm of mercury and at 20^0C it is 18 mm of mercury.
Q-84	The temperature and humidity of air are 27^0C and 50% on a particular day. Calculate the amount of vapour that should be added to 1 cubic meter of air to saturate it. The saturated vapour pressure at 27^0C =3600 Pa.
Q-85	The temperature and relative humidity in a room are 300 K and 20% respectively. The volume of the room is 50 m^3. The saturated vapour pressure at 300 K is 3.3 kPa. Calculate the mass of the water vapour present in the room.
Q-86	The temperature and relative humidity are 300 K and 20% in a room of volume 50 m^3. The floor is washed with water, 500 g of water sticking on the floor. Assuming no communication with the surrounding, find the relative humidity when the floor dries. The changes in temperature and pressure may be neglected. Saturated vapour pressure at 300 K= 3.3 kPa.
Q-87	A bucket full of water is placed in a room at temperature 15^0C with initial relative humidity 40%. The volume of the room is 50 m^3. (a) How much water will evaporate? (b) If the room temperature is increased by 5^0C, how much more water will evaporate? The saturated vapour pressure of water at 15^0C and 20^0C are 1.6 kPa and 2.4 kPa respectively.

—00—