Ideal Gas

U78-P4 What is meant by: (a) standard temperature and pressure (s.t.p.)?
(b) absolute gas scale of temperature?
Describe an experiment to obtain the absolute zero temperature by using a fixed mass of air at constant volume.
A fixed mass of air occupies 200 cm^3 at 25 °C and 755 mmHg. Calculate the volume of this fixed mass of air at s.t.p. [182.02 cm^3]

U82-8 Which of the following assumptions made about the nature and properties of the gas molecules is **wrong**?
A. The attractive and repulsive forces between the molecules are negligible.
B. The total volume of the molecules of the gas is equal to the volume of occupied by the gas.
C. The collisions of the molecules with one another and with the walls of the container are perfectly elastic.
D. By comparing to the time spent in free motion, the duration of the collision of the molecules is very short and therefore can be neglect.
E. The velocities of the gas molecules in free motion may be considered to be uniform i.e. without acceleration or retardation.

U82-10 What would be the length (l) of the air column as shown in Fig.U82-10(ii) when the same tube in Fig.U82-10(i) is inverted, assuming there is no change in temperature of the air in the tube and the existing pressure of the atmosphere is 760 mm of mercury throughout the experiment?
A. $\frac{760}{152}\times 200$ mm B. $\frac{760}{200}\times 152$ mm
C. $\frac{760+152}{760-152}\times 200$ mm D. $\frac{760-152}{760+152}\times 200$ mm
E. $\frac{760+152}{760+200}\times 200$ mm

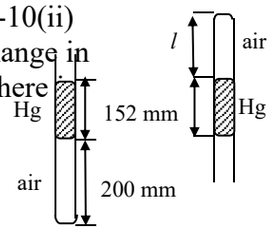


Fig.U82-10(i) Fig.U82-10(ii)

U83-13 Concerning the value of the 'constant' in the ideal gas equation, $\frac{PV}{T}=\text{constant}$, which of the following statements is **incorrect**?
A. If two ideal gases given are of the same gas and possess the same number of moles, then their 'constant' must be equal.
B. If two ideal gases given are of different gases but possess the same number of moles, them the 'constant' must be equal.
C. If two ideal gases given are in different states but are of the same gas and possess the same number of moles, then their 'constant' must be equal.
D. If two ideal gases given possess different mass but are of the same gas and in the same states of temperature and pressure, then their 'constant' must be equal.
E. Any ideal gas, as long as its temperature, pressure and volume are definite, would have a definite 'constant' value.

U85-P6 A thin glass tube, sealed at one end and with some air in it, is 105 cm long. When it is inverted and dipped into a trough of mercury, a small column of mercury rises in the tube, as shown in Fig.U85-P6.
(a) Find the pressure inside the tube, given that the existing atmospheric pressure is 760 mmHg. [56 cmHg]
(b) If the tube is slowly pulled up, what would happen to the height of the mercury column (originally 20 cm) in the tube? Why?
(c) How much should the value of h be adjusted (originally, h = 70 cm) so that the height of the column of mercury in the tube would drop to zero? [36.84 cmHg]

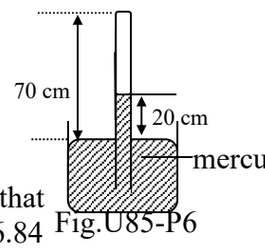


Fig.U85-P6

U87-12 An 8-litre gas cylinder contains neon gas at a pressure of 12 kPa. Another cylinder of 4-litre capacity and at the same temperature as the gas cylinder above contains neon gas at a pressure of 21 kPa. If these two cylinders are joined together so that the gas inside them can mix freely (their total capacity thus becomes 12 litres), what would be the resultant pressure of the gas, assuming that the temperature remains constant throughout?
A. 12 kPa B. 15 kPa C. 16.5 kPa D. 21 kPa E. N.O.T.A.

U84-6 If the temperature is constant, the graph of pressure and volume of an ideal gas is the positive portion of a/an _____.

A. straight line with a negative gradient B. parabola C. hyperbola
D. exponential curve E. curve with no fixed shape

U88-11 Which of the following statements concerning the physical meaning of the term 'constant' in the equation of state for ideal gases, $\frac{PV}{T} = \text{constant}$, is **correct**?

A. For any two samples of an ideal gas, as long as their volume are equal, their constant must be equal.
B. For any two samples of an ideal gas, as long as they possess the same masses, their constant must be equal.
C. For any two samples of an ideal gas, as long as they possess the same moles, their constant must be equal.
D. The constant is a fixed value for all ideal gases, irrespective of their masses.
E. The constant is a fixed value for ideal gases of the same kind, irrespective of their masses.

U88-16 In Fig.U88-16, A and B are two containers filled with an ideal gas and joined by a thin pipe P. Container A and the gas inside it are maintained at a temperature of 250 K, while those of container B are maintained at 500 K. Given that the mass of the gas in A is m, what is the mass of the gas in B?

A. 2m B. 1.5m
C. 0.5m D. N.O.T.A.

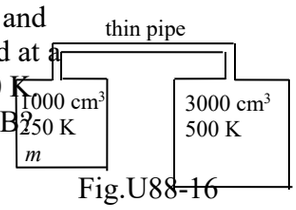


Fig.U88-16

U89-P5 One mole of an ideal gas, of volume 1 litre and temperature 27 °C in its initial state (state A) undergoes an isometric change so that its temperature is 327 °C when it reaches state B. From B, it undergoes an isobaric process whereby its volume is 2 litres when it reaches state C. Given that the universal gas constant R = 8.31 J mol^{-1} K^{-1}, find:

(a) the pressure of the ideal gas when it is in state A; [2.49×10^6 Pa]
(b) the pressure of the ideal gas when it is in state B; [4.99×10^6 Pa]
(c) the temperature of the ideal gas when it is in state C; [1200 K]
(d) draw a $V - T$ graph for the gas undergoing the isometric and isobaric processes as described above.

U90-18 Due to the pressure of a small trace of air inside the glass tube in the set-up as shown in Fig.U90-18, the difference in height of the mercury levels inside and outside the tube is h = 74.5 cmHg. If the glass tube is now slowly raised by means of an isothermal process, then _____.

A. the value of h would increase
B. the value of h would decrease
C. the value of h remain unchanged
D. the value of h would either increase or decrease
E. the variation of h could not be predicted, as the information given is not sufficient

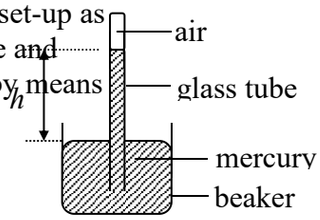


Fig.U90-18

U91-6 Which of the following statements concerning a certain change of states of an ideal gas of fixed mass is/are physically **unattainable**?

I. Decreasing its temperature to cause an increase in its pressure, while its volume remains unchanged.
II. Increasing its pressure to cause an increase in its temperature, while its volume remains unchanged.
III. Increasing its temperature to cause a decrease in its pressure, while its volume decreased
IV Increasing its temperature to cause a decrease in its pressure, while its volume increased.

A. I, III B. II, IV C. I, III, IV D. I, II, III, IV E. N.O.T.A.

U90-15 An air bubble rises to the water surface of a pond from a point 50 m below the surface. If the temperature of the water in the pond is uniform and constant throughout, and the existing atmospheric pressure is 10^5 Pa, then the volume of the bubble at the surface would be _____ times its volume when it is 50 m below. [Take g = 10 m s^{-2}]

A. 2 B. 4 C. 5 D. 6 E. 50

U91-15 The lower ends of two glass tubes A and B are connected by a rubber tubing, and all of them are filled with mercury, as shown in Fig.U91-15. The upper end of A is open to the atmosphere but that of B is closed, with a trace of air entrapped in it, and the difference of mercury levels in A and B is *h*. If the tube A is kept in position, while tube B is being slowly raised, then we would notice that

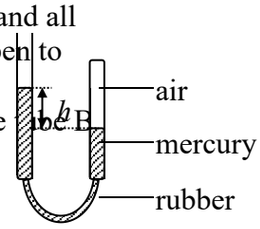


Fig.U91-15

A. the volume of air in tube B remains unchanged
B. the volume of air in tube B decreases
C. the volume of air in tube B increases
D. the value of *h* remains unchanged E. N.O.T.A.

U92-15 A bubble rises to the surface from the bottom of a pond 30 m deep. Given that the temperature at the bottom of the pond is 4°C and that at the water surface is 15 °C, then the volume of the bubble at the water surface would be approximately _____ times that at the bottom of the pond.
A. 2 B. 3 C. 4 D. 5

U92-P7b Sketch a graph showing how the product PV_1 varies with θ, where V_1 is the volume of one mole of an ideal gas at a pressure P and at a Celsius temperature θ.
With the aid of your graph, answer the following questions:
What are the gradient of the graph and the intercept of the graph on the temperature axis?
What are the physical interpretations of these values?

U92-P8a Explain clearly what you understand by **ideal gas**.
Under what conditions will a real gas such as nitrogen obey the ideal gas law?
(b) Shows that, for a pure gas of density ρ and molecular weight M, $P = \frac{\rho RT}{M}$, where P and T are the pressure and absolute temperature of the gas respectively and R is the universal gas constant.
(c) 4.30 g of a mono-atomic gas has a volume of 3.0×10^{-3} m^3 when its temperature is 0 °C and its pressure is 8.0×10^5 Pa. What type of gas is it? [He]
(d) A car tyre is filled to a pressure of 200 kPa when the temperature is 20 °C. After the car has been running at high speed, the temperature of the tyre rises to 68 °C. Find the new pressure within the tyre if the volume of the tyre does not change? [2.33 × 10^5 Pa]

U94-13 Two glass tubes are standing upright in two separate identical water troughs, both of water, as shown in Fig.U94-13. If part of the air in each tube is withdrawn, causing the water in the trough to rise up the tubes, it is found that the right tube has a water level higher than that of the left tube. Now of the two tubes are connected by means of a rubber tube in a manner as shown by the dotted lines in the diagram, how will the water flow between the two tubes?

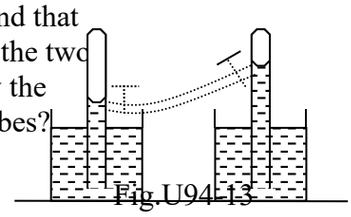


Fig.U94-13

A. water will flow from the left tube to the right tube.
B. water will flow from the right tube to the left tube.
C. No water will flow between the two tubes.
D. This cannot be ascertained, as the information provided is insufficient.

U96-P6a What is the **equation of state of ideal gas**?
(b) Name the three laws and write down the related equations included in the equation of state of ideal gas.
(c) Fig.U96-P6 is the *P* –*V* diagram of a fixed quantity of ideal gas in which CD is an isobaric line and AD and BC are the isothermals. The temperature of AD is 250 K.
(i) Find the temperature and pressure in state B.
(ii) Draw the *P* – *T* diagram and *V* – *T* diagram of the changes of states of the gas. [500 K, 4×10^5 Pa]

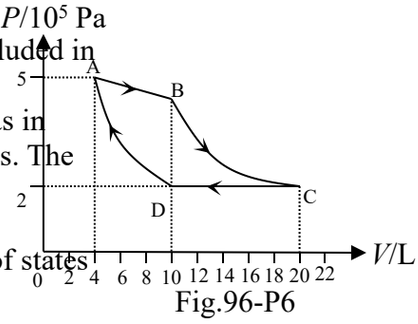


Fig.96-P6

U93-15 Which of the curves shown in Fig.93-15 most **correctly** expresses the Pressure Law?

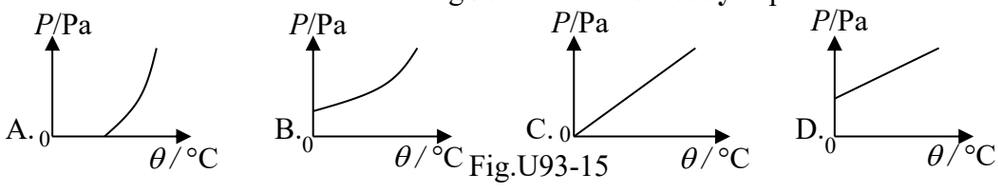


Fig.U93-15

U98-14 A fixed mass of an ideal gas of volume V at pressure P undergoes changes as shown in Fig.U98-14. Which is the **lowest** temperature point and which is the **highest**?

	Lowest Temp.	**Highest Temp.**
A.	X	Y
B.	Y	Z
C.	Z	X
D.	Z	Y

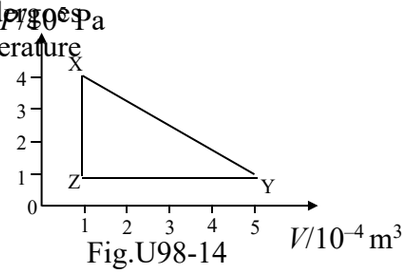


Fig.U98-14

U99-P5 A uniform glass tube of 20 cm in length is closed at one end and opened at the other end. When the glass tube is placed horizontally, the air column enclosed by a 5 cm mercury column is $l_0 = 8$ cm, as shown in Fig.U99-P4(i). Given that the pressure of the air column is $P_0 = 1.0\times10^5$ Pa. Neglecting the air resistance and the viscosity between the mercury and the glass tube, find the lengths of the air column in the three cases below:

(a) A shown in Fig.U99-P4(ii), the glass tube is placed vertically with the open end upwards. Find l_2. [7.50 cm]

(b) As shown in Fig.U99-P4(iii), the glass tube with its open end downwards sinks vertically into the water until the whole tube is just under water. Find l_2. [8.50 cm]

(c) As shown in Fig.U99-P4(iv), the glass tube is horizontally placed on a trolley with the open end to the end to left while the trolley moves to the right with an acceleration of 5 m s^{-2}. Find l_3. [8.28 cm]

[Note: take $g = 10$ m s^{-2}, $\rho_w = 1000$ kg m^{-3}, $\rho_{Hg} = 13600$ kg m^{-3}]

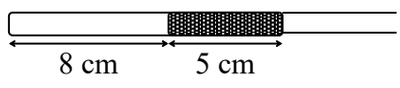


Fig.U99-P4(i)

Fig.U99-P4(ii)

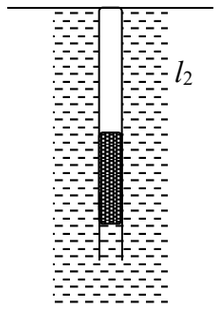


Fig.U99-P4(iii)

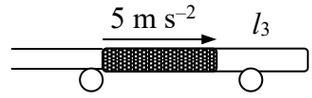


Fig.U99-P4(iv)

U2k2-11 At a constant temperature, the pressure of a fixed mass of gas increases as the volume decreases. This is because _____

A. the number of gas molecules increases
B. the total internal energy of the gas molecules increases
C. the gas molecules collide with the walls of the container more frequently
D. the mass of the gas molecules increases as their surface area decreases

U2k2-12 An air column is enclosed by a small column of mercury in a long straight uniform glass tube with one end closed and the other end open. The glass tube is then inverted with the open end downwards. When the glass tube is changed from its upright position to a slanting position, assuming the temperature remains unchanged, _____

A. both the pressure and the density of the enclosed air column increase
B. the volume of the enclosed air column increases but pressure decreases
C. the volume of the enclosed air column increases but density decreases
D. the pressure, volume and density of the enclosed air column remain unchanged

U2k2-P5 (a) What is an ideal gas?

What is the relationship between the volume, the temperature and the pressure of an ideal gas?

(b) In Fig.U2k2-P5b, the frictionless piston of a gas cylinder is connected to a spring balance and remains in equilibrium. At that moment, the reading of the spring balance is 10 N, and the temperature of the gas in the cylinder is 27 °C while the pressure is 1.2×10^5 Pa.

(i) What is the weight of the piston, if the cross-sectional area of the piston is 1.0×10^{-3} m^2, and the atmospheric pressure is 1.0×10^5 Pa?

(ii) What is the temperature in Celsius of the gas in the cylinder, if the gas is heated until the reading of the spring balance becomes zero? Assume the gas

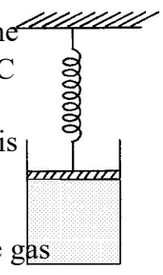


Fig.U2k02-P5

in the cylinder undergoes an isochoric process and the atmospheric pressure remains unchanged. [30 N; 325 K]

U2k03-11 A long, thin uniform glass tube with one end open contains a mercury thread of 20 cm in length and an air column of 22 cm is trapped in its lower part, as shown in Fig.U2k03-11. Given that the prevailing atmospheric pressure is p_0 = 76 cmHg, find the total pressure of the air column when the tube is moving upwards with a uniform velocity of 9 m s^{-1}.

A. 76 cmHg B. 96 cmHg
C. 106 cmHg D. 128 cmHg

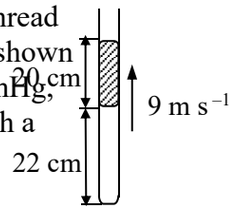


Fig.U2k03-11

U2k04-P5a A student intends to verify the Boyles' law in the laboratory. Please tell him
(i) how to set up the apparatus;
(ii) how to make the measurement in order to get some readings and come to a conclusion.

(b) In a mercury barometer, the height of the glass tube is 1 m above the mercury level in the trough, as shown in Fig.U2k04-P5b. As some air escapes into the glass tube, the readings of barometer become inaccurate. At the temperature of 27 °C, the barometer reads 70 cmHg as the reading of the standard barometer is 76 cmHg.
(i) What is the pressure of the gas in column AB of the glass tube?
(ii) What is the actual pressure if the reading of the barometer is 68 cmHg at the same temperature?
(iii) What is the actual pressure if the temperature lowers to –3 °C and the reading of the barometer remains at 70 cmHg?
[6 cmHg; 73.6 cmHg; 75.4 cmHg]

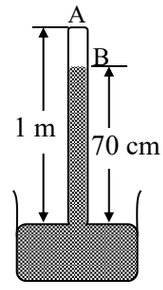


Fig.U2k04-P5b

U2k05-P5 (a) What is ideal gas? Write out the equation of state of an ideal gas. [3%]

(b) As shown in U2k05-P5b, a leveled container is divided into 3 sections by a movable piston. Section I and Section II are containing gases and Section III is vacuum. When the temperature of gas in Section I is 27 ºC and that in Section II is 127 ºC, l_1 = 35 cm and l_2 = 70 cm. The piston is at rest. If the sliding friction between the piston and the wall of container is neglected, then
(i) what is the ratio of number of substance of gas in Section I and Section II? [3%]
(ii) which direction shall the piston move if the temperatures of the gases in Section I and Section II are raised to 57 ºC and 277 ºC respectively? [2%]
(iii) how far shall the piston move before it comes to rest again under state as in (ii) [2%]
[2: 3; towards left; 5 cm]

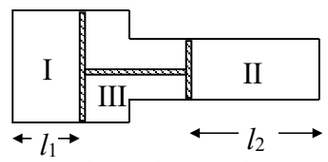


Fig.U2k05-P5b

U2k06-17 A fixed mass of gas has 3 parameters *P*, *V* and *T*. Will the situation where either one parameter will change but the other two remain unchanged occur?

A. Never B. Possibly C. Certainly D. Possibly not

U2k07-11 A sample of oxygen occupies 2.8×10^{-3} m^3 at a pressure of 1.5 atmospheres and the temperature of 69 °C. Calculate the volume of the oxygen at 1 atmosphere and at 0 °C. (1 atm = 1.0×10^5 Pa)

A. 1.12×10^{-3} m^3 B. 2.23×10^{-3} m^3 C. 3.35×10^{-3} m^3 D. 4.31×10^{-3} m^3

U2k08-15 A small amount of air is trapped inside a capillary tube by a thread of mercury of length 5 cm. Fig.U2k08-15a shows the capillary tube in a vertical position with its opened end facing upwards. Fig.U2k08-15b shows the capillary tube in a vertical position with its opened end facing downwards. Calculate the length of the air column, *y*, in Fig.U2k08-15. (Atmospheric pressure = 76 cmHg)

A. 5.3 cm B. 5.7 cm
C. 14.9 cm D. 16.0 cm

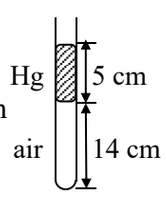


Fig.U2k08-15a

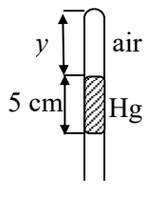
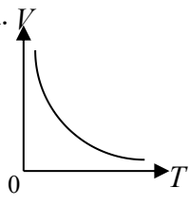
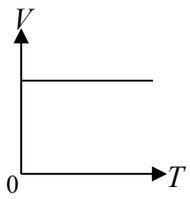
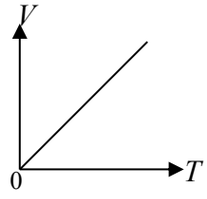


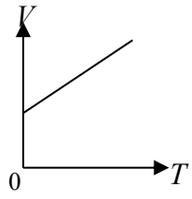
Fig.U2k08-15b

U2k09-14 Which of the following graphs represents **correctly** the relationship between volume V and absolute temperature T of an ideal gas at constant pressure?

A. 

B. 

C. 

D. 

U2k09-P4(a) State Boyle's law, and draw a $P.V.$ diagram to illustrate it.

(b) A fixed amount of ideal gas undergoes an isochoric process, and its temperature rises from 14 °C to 15 °C. How many times is the increase in pressure as compared to its pressure at 0 °C?

(c) As shown in Fig.U2k09-P4c, under isothermal conditions, a glass tube sealed at the top and of length 100 cm is inserted vertically into a mercury trough. The distance from its mouth to the mercury surface in the tough is half its length. If the atmospheric pressure is 75 cm of mercury, find the length h of the mercury column in the tube.

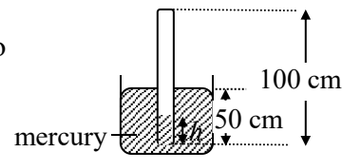


Fig.U2k09-P4c

(d) A container of volume 56.6 litres contains oxygen gas at pressure 1.37×10^7 Pa and temperature 27 °C. What is the mass of oxygen gas in kg in the container? (the moral mass of oxygen is 32 g mol^{-1})
[1/273; 25 cm; 9.95 kg]

U2k11-12 Fig. U2k11-12 shows a uniform glass tube of length 50 cm, with one end open and the other end closed. When the glass tube is placed with its open end vertically downwards, the 15 cm mercury column enclosed an air column of 12 cm at its top. If the glass tube falls freely with its open end downwards vertically, what is the length of the air column in the tube during the free fall? (Assume the temperature remains unchanged and the atmospheric pressure remains at 75 cmHg during the fall.)

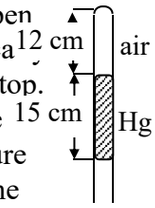


Fig.U2k11-12

A. 8.0 cm B. 9.6 cm C. 12.0 cm D. 14.4 cm

U2k11-P5a What is meant by ideal gases?

(b) The state changes of 0.5 mol of an ideal gas is as shown in Fig.U2k11-P5b. If its volume at state A is 1.2 m^3, find its volume and pressure at state B. [944.8 Pa]

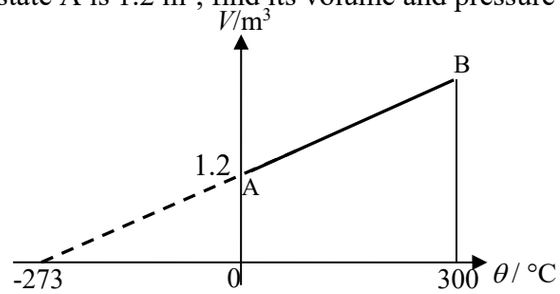


Fig.U2k11-P5b

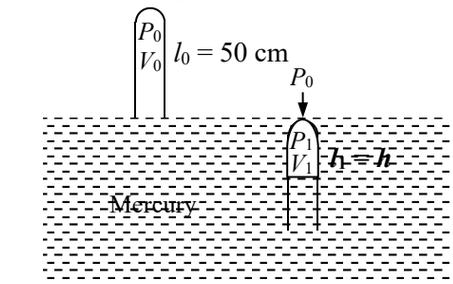


Fig.U2k11-P5c

(c) As shown in Fig.U2k11-P5c, a glass tube is 50 cm in length and one of its ends is closed. Under the conditions of 30 °C and one atmospheric pressure (76 cmHg), the tube is filled with nitrogen gas. With the open end downwards, it is then pressed into a mercury tank until the closed end is at the same level as mercury level in the tank. If the atmospheric pressure and the temperature remain unchanged, find:
(i) the height h of the nitrogen gas in the tube;
(ii) the pressure p_1 of nitrogen gas. [34.4 cm; 110.4 cmHg]

U2k15-13 The value of pressure p and volume V of four ideal gases, with the same number of mole, are given below. Which of them has the highest temperature?

	p / 10^5 Pa	V / cm^3
A	4	1
B	3	3
C	2	5
D	1	7

U2k14-13 In Fig.U2k14-13, a gas of fixed mass, undergoes three different process from initial states *a*, *b*, *c*, respectively to the same final state *d*. Which of the following statements regarding its changes in pressure are **true**?

I. $a \rightarrow d$, pressure increased.
II. $b \rightarrow d$, pressure increased.
III. $c \rightarrow d$, pressure decreased.

A. I, II B. I, III
C. II, III D. I, II, III

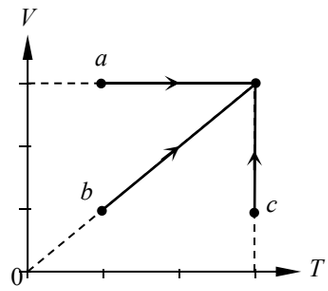


Fig.U2k14-13

U2k16-13 A fixed quantity of ideal gas at 20 °C and 150 kPa occupies a volume of 2.0 m^3. What will be the volume of the gas if its pressure is raised to 250 kPa and its temperature is increased to 30 °C? (Assume no leakage of the gas)

A. 0.25 m^3 B. 1.24 m^3 C. 2.40 m^3 D. 3.50 m^3

U2k16-P5(b) Fig.U2k16-P5b shows two air containers, A and B, joined by a narrow tube which contains a mercury column. When the temperature of the a is 27 °C, and that of B is 7 °C, the mercury column remains stationary A and B are heated, causing a rise in temperature of 15 °C in A and 10 B, explain the movement of the mercury column in the tube. Justify you answer with calculation. [moves from A to B, to the right]

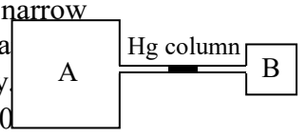


Fig.U2k16-P5b

U2k17-14 Which of the following changes is true for an ideal gas with constant mass and constant volume when its absolute temperature is increased.

A. The pressure of the gas will increase.
B. The density of the gas will increase.
C. The intermolecular force between gas molecules will increase.
D. The average kinetic energy of gas will decrease.

U2k17-12 In Fig.U2k17-12, the three capillary tubes are identical. Compare the length of the air columns *x*, *y* and *z* which are being trapped respectively by a 4 cm length of mercury thread.

A. $x > y > z$
B. $x > z > y$
C. $y > z > x$
D. $y > x > z$

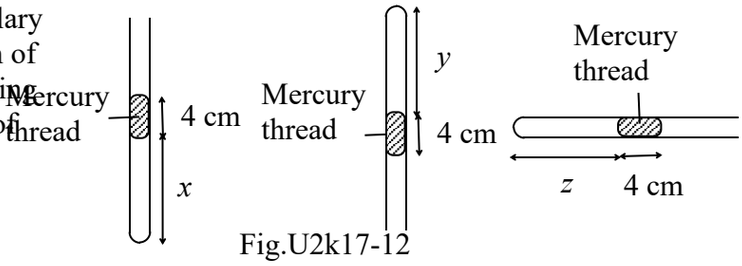


Fig.U2k17-12

U2k18-11 A uniform U-shaped tube ABCD with both ends open, consists of a horizontal tube BC of length 14 cm. The tube is placed vertically with an air column of length 8 cm, being trapped in the horizontal tube by mercury column. At equilibrium, the height of each mercury column is 2 cm, as shown in Fig.U2k18-11. Given that the atmospheric pressure is 76 cmHg, and the initial temperature of the air column is 273 K. What is the temperature of the air column when the length of the air column increases to 12 cm?

A. 256 K B. 280 K
C. 349 K D. 420 K

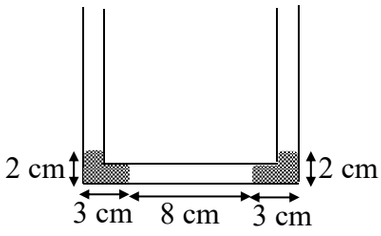


Fig.U2k18-11

U2k19-13 A container contains *n* mol of an ideal gas at pressure 152.3 kPa and temperature 80 °C. In order to reduce the pressure of the gas, the cover of the container is opened for a short duration to release some gas. If the pressure and temperature of the gas drop to 101.3 kPa and 40 °C respectively, how many moles of the gas will be released?

A. 1.33*n* B. 0.75*n* C. 0.50*n* D. 0.25*n*

Saturated Vapour Pressure

U87-9 The pressure exerted by a vapour in contact with its own liquid in a closed container at a given temperature will be constant when _____.

A. as many molecules leave the liquid as those return to it in a given time
B. no more molecules return to the liquid
C. no more molecules leaves the surface of the liquid
D. all the molecules have left the liquid

U87-10 A container contains a mixture of an ideal gas and some saturated water vapour. What happen to the gas pressure and vapour pressure if the temperature of the gas and vapour in the container are raised to twice their original values?

	Gas pressure	Vapour pressure
A.	doubled	doubled
B.	remains the same	doubled
C.	remains the same	increased
D.	doubled	increased
E.	decreased	increased