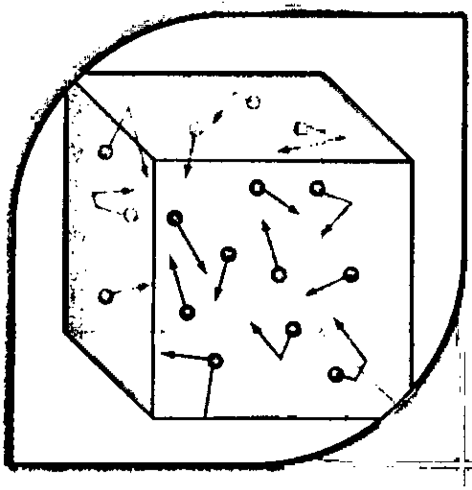


3

GASEOUS STATE

Gaseous State

The state is characterized by sensitivity of volume change with change of pressure and temperature. It is due to large distance between molecules as compared to their own dimensions. There exists weak vander Waal's forces.

Ideal Gas: A gas with no intermolecular attractions & having very negligible volume occupied by molecules when compared with volume of gas is termed as ideal gas. A theoretical concept which for gases present can be obtained only under certain condition.

Parameter associated with the ideal gas : P, V, T, n

where

P represents pressure exerted by the gas molecules on the walls of the container assuming negligible intermolecular attractions,

V represents free volume available for motion (equal to the volume of the container),

T represents absolute temperature, n represents no. of moles.

- **Conversion factors**

$$\text{Pressure : atm} = \,= 1.013\times10^{5}\ \text{Pa} = 760\ \text{mm of Hg} = 760\ \text{torr} = 1.013\ \text{bar}$$

$$\text{Volume : } 1\ \text{L} = 1\ \text{dm}^{3} = 10^{-3}\,\text{m}^{3} = 1000\ \text{mL} = 1000\,\text{cm}^{3}$$

$$\text{Temperature : } T_k = T_C^{\circ} + 273 = \frac{5}{9}T_F^{\circ} + 255.22$$

Instruments for Pressure Calculations

- **Barometer:** The instrument used for the measurement of atmospheric pressure is called a barometer.

$$P = \frac{A\times h\times d\times g}{A}$$

where d = density of fluid

h = vertical height

g = acceleration due to gravity

- **Manometer:** The instrument used for the measurement of the pressure of a gas is called a manometer. manometer are of two types
  (i) Open end (ii) Closed end

Experimental Gas Laws

I.	**Boyle's law**	$V \propto \frac{1}{P}$	(T & n constant)	$P_1V_1 = P_2V_2$
II.	**Charle's law**	$V \propto T$	(P & n constant)	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
III.	**Gay Lussac's law**	$P \propto T$	(V & n constant)	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
IV.	**Avogadro's law**	$V \propto n$	(T & P constant)	$\frac{V_1}{n_1} = \frac{V_2}{n_2}$

Combined Gas law : $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Equation of State: $PV = nRT$

$PV = \frac{w}{M}RT$ R is Universal Gas constant,

$R = 0.0821$ atm. L/K. mol $= 8.314$ Joule/K. Mol ≈ 2cal/ K.mol

density of gas $(d) = \frac{PM}{RT}$

- **Dalton's law of partial pressure:**

  $P_{\text{total}} = P_A + P_B + \ldots..$

  P_A, P_B are partial pressures; $P_A = \text{mole fraction}_A \times \text{Total pressure}$

  and % of gas in mixture $= \frac{\text{Partial pressure}}{\text{Total pressure}} \times 100$

  $P_{\text{wet gas}} = P_{\text{dry gas}} + P_{H_2O\text{ vapour}}$ (aqueous tension)

- **Amagat's law:** The total volume of a mixture of gases is equal to the sum of the partial volumes of the constituent gases, at same Temperature & Pressure.

- **Relative humidity:**

  $$\% \text{ Relative humidity} = \frac{\text{Partial pressure of } H_2O(g)}{\text{Vapour pressure of } H_2O(l)} \times 100$$

- **Graham's law of Diffusion or Effusion:**

  $$r \propto \frac{1}{\sqrt{d}} \text{ or } r \propto \frac{1}{\sqrt{M}} \quad r \propto \frac{P}{\sqrt{M}} \text{ [For gases effusing at different pressures]}$$

  r is rate of diffusion of any gas, d is density at same temperature.

  $$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}; \frac{V_1/t_1}{V_2/t_2} = \sqrt{\frac{M_2}{M_1}} = \frac{\text{Pressure drop I}}{\text{Pressure drop II}}$$

  $$r = \frac{\text{moles diffused}}{\text{time taken}} = \frac{\text{distance travelled in a narrow tube}}{\text{time taken}}$$

- **Isotopic Separation Factor:**

After x steps of separation, isotopic separation factor $(f) = \dfrac{(n_1/n_2)_{\text{final}}}{(n_1/n_2)_{\text{initial}}} = \left(\sqrt{\dfrac{M_2}{M_1}}\right)^x$

or
$$x = \frac{2\log f}{\log\left(\dfrac{M_2}{M_1}\right)}$$

Kinetic Theory of Gases

$$PV = \frac{1}{3} mNu^2 = \frac{1}{3}\text{M}\,u^2 \text{ (For 1 mole)}$$

Types of speeds:

- Mean square speed, $u^2 = \dfrac{u_1^2 + u_2^2 + \ldots + u_N^2}{N}$
- Root mean square speed, $u = \sqrt{\dfrac{3RT}{M}} = \sqrt{\dfrac{3PV}{nM}} = \sqrt{\dfrac{3P}{d}}$
- Average speed $= \dfrac{u_1 + u_2 + \ldots + u_N}{N} = \sqrt{\dfrac{8RT}{\pi M}} = \bar{u}$
- Most probable speed $= \sqrt{\dfrac{2RT}{M}} = u_{\text{mps}}$

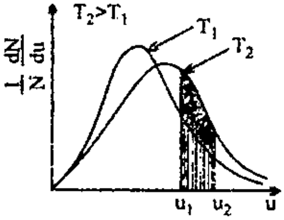
Relationship between three types of speeds

- Most probable: average : r.m.s. $= \sqrt{2} : \sqrt{\dfrac{8}{\pi}} : \sqrt{3} = 1:1.13:1.22$
- $u_{\text{rms}} > u_{\text{av}} > u_{\text{mp}}$
- Average kinetic energy of a single molecule $= \dfrac{3}{2}\cdot\dfrac{R}{N}\cdot T = \dfrac{3}{2}kT$

  where, k = Boltzman constant $= 1.3806 \times 10^{-16}$ erg deg^{-1}
- Total kinetic energy for **one mole** of a gas $= \dfrac{3}{2}RT$.
- Kinetic energy of **n moles** of a gas $= n \times \dfrac{3}{2}RT$

Maxwell speed distribution Law:

$$dN_u = 4\pi N\left(\frac{M}{2\pi RT}\right)^{3/2} \exp\left(-Mu^2/2RT\right) u^2 du$$
$$= 4\pi N\left(\frac{m}{2\pi kT}\right)^{3/2} \exp\left(-mu^2/2kT\right) u^2 du$$

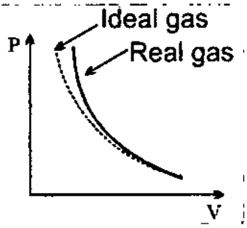


Real Gases

Real gases: Gases which do not obey perfect gas laws over a wide range of pressure and temperature are called real or non-ideal gases. These deviations are due to the interactions of molecules with each other and volume occupied by gas molecules. The repulsive forces between molecules assist expansion and attractive forces assist compression.

- **Deviation from ideal behaviour**

The curve for the real gas has a tendency to coincide with that of an ideal gas at low pressures when the volume is large. At higher pressures, however deviations are observed.



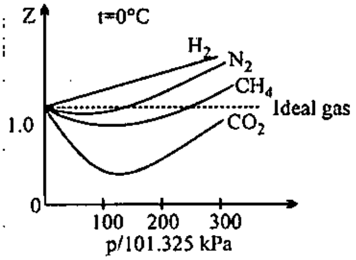
- **Vander Waals equation of state**

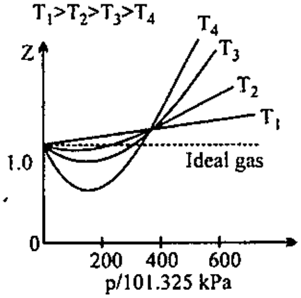
$$\left(P+\frac{an^2}{V^2}\right)(V-nb)=nRT$$

a, b are Vander Waals constants; different for each gas
unit of $a \longrightarrow$ atm L^2 mol^{-2} ; S.I. unit $\longrightarrow$ Pa m^6 mol^{-2}
unit of $b \longrightarrow$ L mol^{-1} ; S.I. unit $\longrightarrow$ m^3 mol^{-1}
greater the value of 'a' more easily the gas is liquefiable;
greater the value of 'b' greater the molecular size,

- **Compressibility factor**

$$Z=\frac{PV}{nRT}=\frac{\text{molar volume observed}}{\text{molar volume ideal}}$$





- **Interpretation of deviation from vander Waals equation**

(i) At low pressure $Z=\frac{PV}{RT}=1-\frac{a}{VRT}$

(ii) At high pressure $Z=\frac{PV}{RT}=1+\frac{Pb}{RT}$

(iii) At extremely low pressure $Z=\frac{PV}{RT}=1$; $PV=nRT$

- **Virial equation of state for 1 mole of gas**

$$Z=\frac{PV}{RT}=1+B\frac{1}{V}+C\frac{1}{V^2}+D\frac{1}{V^3}+\ldots.$$

$$\left.\begin{array}{l} B=\text{second virial coefficient}=b-\frac{a}{RT} \\ C=\text{third virial coefficient}=b^2 \end{array}\right]\text{gas dependent}$$

- **Boyle temperature (T_B):** The temperature at which a real gas obeys Boyle's law (*i.e.*, behaves as an ideal gas) in low pressure range.

$$T_B = \frac{a}{bR}$$

- **Inversion temperature:** The temperature at which a real gas show no Joule-Thomson effect is called its inversion temperature (T_i)

$$T_i = 2T_B = \frac{2a}{bR}$$

In Joule-Thomoson's effect, all gases except H_2 and He showed cooling effect while H_2 and He showed heating effect.

- **Critical constants**

(i) Critical temperature (T_c) : T_c is the maximum temperature at which a gas can be liquefied, *i.e.*, the temperature above which a liquid can not exist.

$$T_c = \frac{8a}{27Rb}$$

(ii) Critical pressure (P_c) : P_c is the minimum pressure required to cause liquefaction at the temperature T_c.

$$P_c = \frac{a}{27b^2}$$

(iii) Critical volume (V_c) : V_c is the volume occupied by one mole of gas at critical temperature and critical pressure.

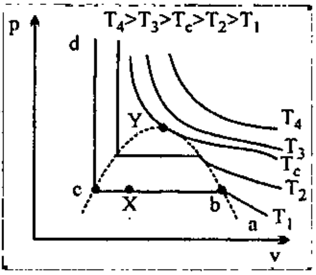
$$V_c = 3b$$

(iv) Compressibility factor under critical state of a gas

$$Z_c = \frac{P_c V_c}{RT_c}$$

Now substituting the values of P_c, V_c and T_c we get

$$Z_c = \frac{3}{8}$$



- **The law of corresponding states**

$$p_r = \frac{p}{p_c}, \quad T_r = \frac{T}{T_c} \quad \text{and } V_r = \frac{V_m}{V_c}$$

$$(p_r + 3/V_r^2)(3V_r - 1) = 8T_r$$

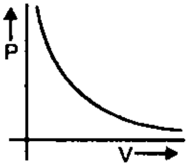
$$Z = \frac{pV_m}{RT} = \frac{(p_r p_c)(V_r V_c)}{R(T_r T_c)} = \frac{p_c V_c}{T_c}\left(\frac{p_r V_r}{T_r}\right) = \frac{3P_r V_r}{8T_r}$$

Level 1

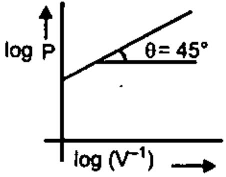
1. Which one of the following statements is not correct about the three states of matter *i.e.*, solid, liquid and gaseous ?
   (a) Molecules of a solid possess least energy whereas those of a gas possess highest energy
   (b) The density of solid is highest whereas that of gases is lowest
   (c) Gases and liquids possess definite volumes
   (d) Molecules of a solid possess vibratory motion

2. Which of the following curve does not represent Boyle's law?

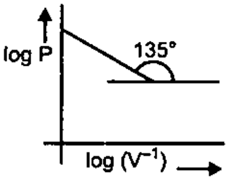
(a)



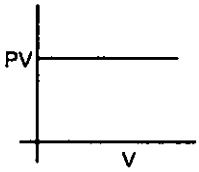
(b)



(c)



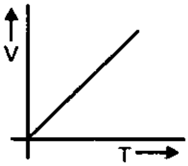
(d)



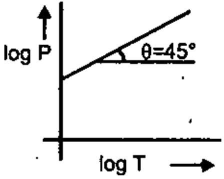
3. A certain sample of gas has a volume of 0.2 litre measured at 1 atm pressure and 0°C. At the same pressure but at 273°C, its volume will be:
   (a) 0.4 litre (b) 0.8 litre (c) 27.8 litres (d) 55.6 litres

4. Among the following curves, which is not according to Charle's law ?

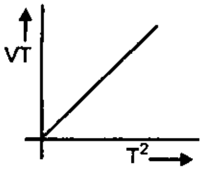
(a)



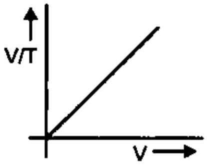
(b)



(c)

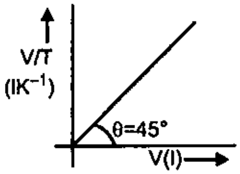


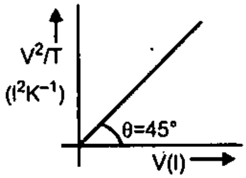
(d)

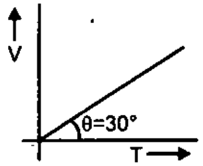


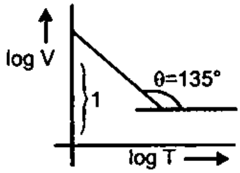
5. At what temperature, the sample of neon gas would be heated to double its pressure, if the initial volume of gas is reduced by 15% at 75°C ?
   (a) 319°C (b) 592°C (c) 128°C (d) 60°C

6. Which is correct curve for Charle's law, when the curve is plotted at 0.821 atm pressure for 10 mole ideal gas?

(a) 

(b) 

(c) 

(d) 

7. At constant volume, for a fixed number of moles of a gas, the pressure of the gas increases with increase in temperature due to:

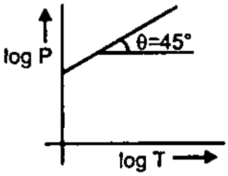
(a) Increase in the average molecular speed

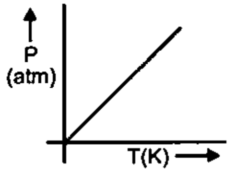
(b) Increase rate of collision amongst molecules

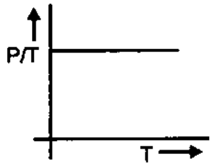
(c) Increase in molecular attraction

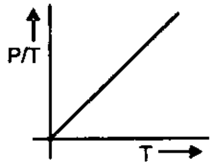
(d) Decrease in mean free path

8. Which in not correct curve for gay-lusacc's law ?

(a) 

(b) 

(c) 

(d) 

9. Three flasks of equal volumes contain CH_4, CO_2 and Cl_2 gases respectively. They will contain equal number of molecules if :

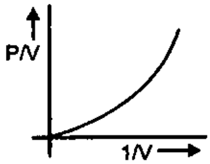
(a) the mass of all the gases is same

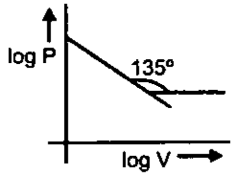
(b) the moles of all the gas is same but temperature is different

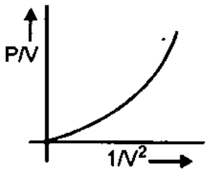
(c) temperature and pressure of all the flasks are same

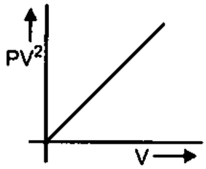
(d) temperature, pressure and masses same in the flasks

10. Which is **incorrect** curve for Boyle's law ?

(a) 

(b) 

(c) 

(d) 

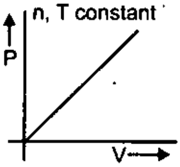
11. "Equal volumes of all gases at the same temperature and pressure contain equal number of particles." This statement is a direct consequence of :

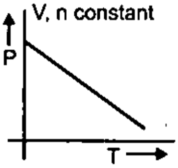
(a) Avogadro's law (b) Charle's law
(c) Ideal gas equation (d) Law of partial pressure

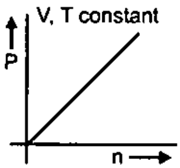
12. A 2.24L cylinder of oxygen at 1 atm and 273 K is found to develop a leakage. When the leakage was plugged the pressure dropped to 570 mm of Hg. The number of moles of gas that escaped will be :

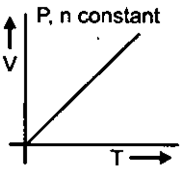
(a) 0.025 (b) 0.050 (c) 0.075 (d) 0.09

13. Which of the following curve is correct for an ideal gas ?

(a) 

(b) 

(c) 

(d) 

14. In the equation of state of an ideal gas $PV = nRT$, the value of the universal gas constant is not correct :

(a) 8.314 $JK^{-1}mol^{-1}$ (b) 0.0821 atm L $mol^{-1}K^{-1}$
(c) 0.8314 b L $mol^{-1}K^{-1}$ (d) 2 cal $mol^{-1}K^{-1}$

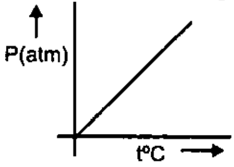
15. At 0°C and one atm pressure, a gas occupies 100 cc. If the pressure is increased to one and a half-time and temperature is increased by one-third of absolute temperature, then final volume of the gas will be:

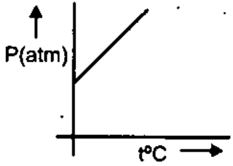
(a) 80 cc (b) 88.9 cc (c) 66.7 cc (d) 100 cc

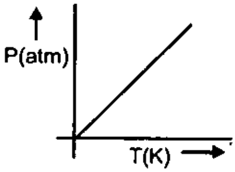
16. 10 gm of a gas at 1 atm and 273 K occupies 5 litres. The temperature at which the volume becomes double for the same mass of gas at the same pressure is:

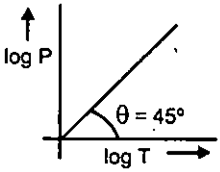
(a) 273 K (b) −273°C (c) 273°C (d) 546°C

17. Which of the following curve does not represent gay lusacc's law?

(a) 

(b) 

(c) 

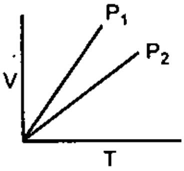
(d) 

18. Densities of two gases are in the ratio 1 : 2 and their temperatures are in the ratio 2 : 1, then the ratio of their respective molar mass at certain pressure is:
(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 4 : 1

19. Two separate bulbs contain ideal gases *A* and *B*. The density of gas *A* is twice that of gas *B*. The molecular mass of *A* is half that of gas *B*. The two gases are at the same temperature. The ratio of the pressure of *A* to that of gas *B* is :
(a) 2 (b) 1/2 (c) 4 (d) 1/4

20. Volume of the air that will be expelled from a vessel of 300 cm^3 when it is heated from 27°C to 37°C at the same pressure will be:
(a) 310 cm^3 (b) 290 cm^3 (c) 10 cm^3 (d) 37 cm^3

21. *V versus T* curves at constant pressure P_1 and P_2 for an ideal gas are shown in fig. Which is correct?
(a) $P_1 > P_2$ (b) $P_1 < P_2$
(c) $P_1 = P_2$ (d) All of these



22. Two flasks *A* and *B* of 500 mL each are respectively filled with O_2 and SO_2 at 300 K and 1 atm. pressure. The flasks will contain:
(a) The same number of atoms
(b) The same number of molecules
(c) More number of moles of molecules in flask *A* as compared to flask *B*
(d) The same amount of gases

23. 2.8 g of a gas at 1atm and 273K occupies a volume of 2.24 litres, the gas can not be:
(a) O_2 (b) CO (c) N_2 (d) C_2H_4

24. Five grams each of the following gases at 87°C and 750 mm pressure are taken. Which of them will have the least volume ?
(a) HF (b) HCl (c) HBr (d) HI

25. At what pressure a quantity of gas will occupy a volume of 60 mL, if it occupies a volume of 100 mL at a pressure of 720 mm (while temperature is constant) :
(a) 700 mm (b) 800 mm (c) 100 mm (d) 1200 mm

26. At 1 atm and 273 K the density of gas, whose molecular weight is 45, is:
(a) 44.8 g/L (b) 11.4 g/L (c) 2 g/L (d) 3 g/L

27. A small bubble rises from the bottom of a lake, where the temperature and pressure are 8°C and 6.0 atm, to the water's surface, where the temperature is 25°C and pressure is 1.0 atm. Calculate the final volume of the bubble if its initial volume was 2 mL.
(a) 14 mL (b) 12.72 mL (c) 11.31 mL (d) 15 mL

28. Argon is an inert gas used in light bulbs to retard the vaporization of the filament. A certain light-bulb containing argon at 1.25 atm and 18°C is heated to 85°C at constant volume. Calculate its final pressure.
(a) 1.53 atm (b) 1.25 atm (c) 1.35 atm (d) 2 atm

29. Calculate the volume of O_2 at 1 atm and 273 K required for the complete combustion of 2.64 L of acetylene (C_2H_2) at 1 atm and 273 K. $2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(l)$
(a) 3.6 L (b) 1.056 L (c) 6.6 L (d) 10 L

30. The density of O_2 (g) is maximum at :

(a) STP (b) 273 K and 2 atm

(c) 546 K and 1 atm (d) 546 K and 2 atm

31. At 27°C a sample of ammonia gas exerts a pressure of 5.3 atm. What is the pressure when the volume of the gas is reduced to one-tenth of the original value at the same temperature?

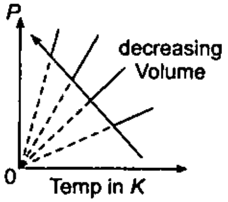
(a) 0.53 atm (b) 5.3 atm (c) 53 atm (d) None of these

32. A certain amount of gas at 25°C and at a pressure of 0.80 atm is contained in a glass vessel. Suppose that the vessel can withstand a pressure of 2.0 atm. How high can you raise the temperature of the gas without bursting the vessel?

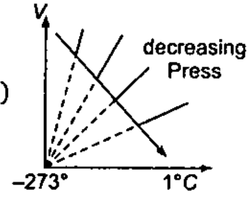
(a) 745°C (b) 472°C (c) 500°C (d) None of these

33. Which one of these graphs for an ideal gas, the arrow indication is incorrectly marked ?

(a)



(b)



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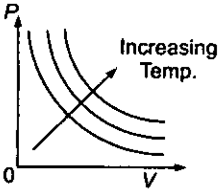
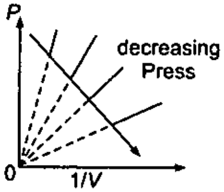


(d)



34. The pressure of sodium vapour in a 1.0 L container is 10 torr at 1000°C. How many atoms are in the container?

(a) 9.7×10^{17} (b) 7.6×10^{19}

(c) 4.2×10^{17} (d) 9.7×10^{19}

35. An ideal gaseous mixture of ethane (C_2H_6) and ethene (C_2H_4) occupies 28 litre at at 1 atm and 273 K. The mixture reacts completely with 128 gm O_2 to produce CO_2 and H_2O. Mole fraction at C_2H_4 in the mixture is :

(a) 0.6 (b) 0.4 (c) 0.5 (d) 0.8

36. A certain hydrate has the formula $MgSO_4 . xH_2O$. A quantity of 54.2 g of the compound is heated in an oven to drive off the water. If the steam generated exerts a pressure of 24.8 atm in a 2.0 L container at 120°C, calculate x.

(a) 2 (b) 5 (c) 6 (d) 7

37. Air entering the lungs ends up in tiny sacs called alveoli. It is from the alveoli that oxygen diffuses into the blood. The average radius of the alveoli is 0.0050 cm and the air inside contains 14 per cent oxygen. Assuming that the pressure in the alveoli is 1.0 atm and the temperature is 37°C, calculate the number of oxygen molecules in one of the alveoli.

(a) 6×10^{13} (b) 10^{24} (c) 1.7×10^{22} (d) 1.7×10^{9}

38. Nitrogen forms several gaseous oxides. One of them has a density of 1.33 g/L measured at 764 mmHg and 150°C. Write the formula of the compound.
(a) NO (b) N_2O (c) NO_2 (d) N_2O_5

39. Starting out on a trip into the mountains, you inflate the tires on your automobile to a recommended pressure of 3.21×10^5 Pa on a day when the temperature is – 5.0°C. You drive to the beach, where the temperature is 28.0°C. Assume that the volume of the tire has increased by 3%. What is the final pressure in the tyres?
(a) 350 Pa (b) 3500 Pa (c) 3.5×10^5 Pa (d) None of these

40. A compressed cylinder of gas contains 1.50×10^3 g of N_2 gas at a pressure of 2.0×10^7 Pa and a temperature of 17.1°C. What volume of gas has been released into the atmosphere if the final pressure in the cylinder is 1.80×10^5 Pa? Assume ideal behaviour and that the gas temperature is unchanged.
(a) 1260 L (b) 126 L (c) 12600 L (d) 45 L

41. A high-altitude balloon is filled with 1.41×10^4 L of hydrogen at a temperature of 21°C and a pressure of 745 torr. What is the volume of the balloon at a height of 20 km, where the temperature is – 48°C and the pressure is 63.1 torr?
(a) 1.274×10^5 L (b) 1.66×10^5 L (c) 1.66×10^4 L (d) None of these

42. The atmospheric pressure on Mars is 0.61 kPa. What is the pressure in mm Hg?
(a) 0.63 (b) 4.6 (c) 6.3 (d) 3.2

43. The density of liquid gallium at 30°C is 6.095 g/mL. Because of its wide liquid range (30 to 2400°C), gallium could be used as a barometer fluid at high temperature. What height (in cm) of gallium will be supported on a day when the mercury barometer reads 740 torr? (The density of mercury is 13.6 g/mL.).
(a) 322 (b) 285 (c) 165 (d) 210

44. A weather balloon is inflated with helium. The balloon has a volume of 100 m^3 and it must be inflated to a pressure of 0.10 atm. If 50 L gas cylinders of helium at a pressure of 100 atm are used, how many cylinders are needed? Assume that the temperature is constant.
(a) 2 (b) 3 (c) 4 (d) 1

45. A balloon contains 14.0 L of air at 760 torr. What will be the volume of the balloon when it is taken to a depth of 10 ft. in a swimming pool? Assume that the temperature of the air and water are equal. (density : Hg $= 13.6\,g/mL.$)
(a) 11.0 (b) 11.3 (c) 10 (d) 10.8

46. A 0.50 L container is occupied by nitrogen at a pressure of 800 torr and a temperature of 0°C. The container can only withstand a pressure of 3.0 atm. What is the highest temperature (°C) to which the container may be heated?
(a) 505 (b) 450 (c) 625 (d) 560

47. Equal volumes of oxygen gas and a second gas weigh 1.00 and 2.375 grams respectively under the same experimental conditions. Which of the following is the unknown gas?
(a) NO (b) SO_2 (c) CS_2 (d) CO

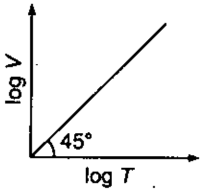
48. A high altitude balloon contains 6.81 g of helium in 1.16×10^4 L at – 23°C. Assuming ideal gas behaviour, how many grams of helium would have to be added to increase the pressure to 4.0×10^{-3} atm?
(a) 1.27 (b) 1.58 (c) 2.68 (d) 2.13

49. A 4.40 g piece of solid CO_2 (dry ice) is allowed to sublime in a balloon. The final volume of the balloon is 1.00 L at 300 K. What is the pressure (atm) of the gas?

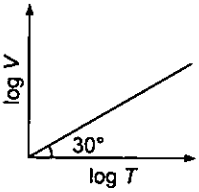
(a) 0.122 (b) 2.46 (c) 122 (d) 24.6

50. For a closed (not rigid) container containing $n = 10$ moles of an ideal gas fitted with movable, frictionless, weightless piston operating such that pressure of gas remains constant at 0.821 atm, which graph represents correct variation of log V *vs* log T where V is in litre and T in kelvin.

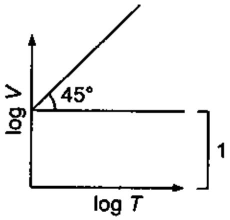
(a)



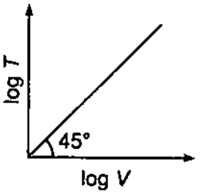
(b)



(c)



(d)



51. The intercept on y-axis and slope of curve plotted between P/T *vs.* T

For an ideal gas having 10 moles in a closed rigid container of volume 8.21 L. (P = Pressure in atm and T = Temp. in K, $\log_{10} 2 = 0.30$) are respectively :

(a) 0.01, 0 (b) 0.1, 0 (c) 0.1, 1 (d) 10, 1

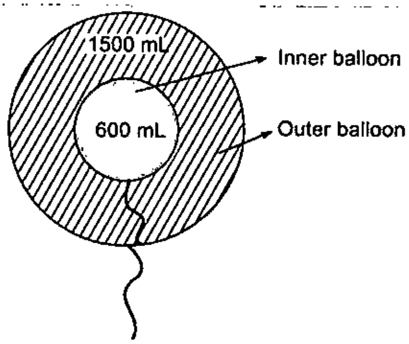
52. A He atom at 300 K is released from the surface of the earth to travel upwards, assuming that it undergoes no collision with other molecules, how high will it be before coming to the rest?

(a) 9.53 m (b) 95.3 m (c) 953 m (d) 9.53×10^4 m

53. The density of gas A is twice that to B at the same temperature the molecular weight of gas B is twice that of A. The ratio of pressure of gas A and B will be :

(a) 1 : 6 (b) 1 : 1 (c) 4 : 1 (d) 1 : 4

54. Two inflated ballons I and II (thin skin) having volume 600 mL and 1500 mL at 300 mL K are taken as shown in diagram. If maximum volume of inner and outer balloons are 800 mL and 1800 mL respectively then find the balloon which will burst first on gradual heating.



(a) inner balloon
(b) outer balloon
(c) both simultaneously
(d) unpredictable

55. An open flask containing air is heated from 300 K to 500 K. What percentage of air will be escaped to the atmosphere, if pressure is keeping constant?

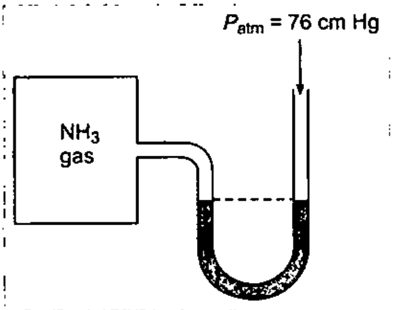
(a) 80 (b) 40 (c) 60 (d) 20

56. The value of universal gas constant R depends on :

(a) temperature of gas (b) volume of gas

(c) number of moles of gas (d) units of volume and pressure

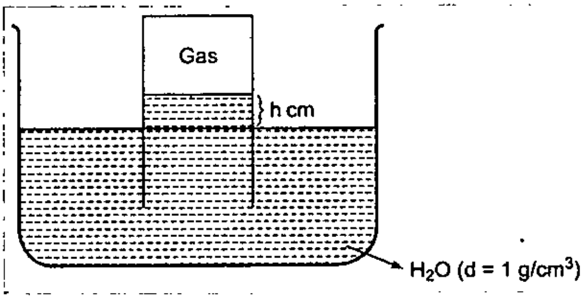
57. A manometer attached to a flask contains with ammonia gas have no difference in mercury level initially as shown in diagram. After sparking into the flask, ammonia is partially dissociated as $2NH_3\,(g) \longrightarrow N_2\,(g) + 3H_2\,(g)$ now it have difference of 6 cm in mercury level in two columns, what is partial pressure of $H_2\,(g)$ at equilibrium?



(a) 9 cm Hg (b) 18 cm Hg

(c) 27 cm Hg (d) None of these

58. An ideal gas is collected by downward displacement of water. Select the correct expression for P_{gas} according to the diagram $[d_{Hg} = 13.6 g/cm^3]$:



(a) $P_{gas} = P_{atmp} - \left[\text{aq. Tension} + \frac{h}{13.6}\right]$ (b) $P_{gas} = P_{atm} - hdg$

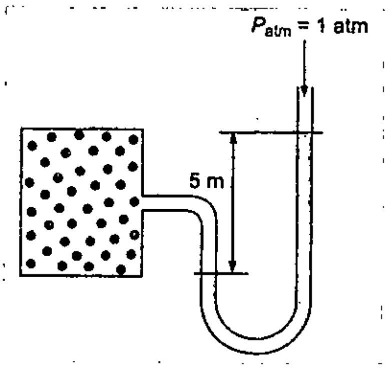
(c) $P_{gas} = P_{atmp} - \text{aq. Tension} + \frac{h}{13.6}$ (d) none of these

59. A bubble of gas released at the bottom of a lake increases to four times its original volume when it reaches the surface. Assuming that atmospheric pressure is equivalent to the pressure exerted by a column of water 10 m high, what is the depth of the lake?

(a) 20 m (b) 10 m (c) 30 m (d) 40 m

60. Calculate the number of moles of gas present in the container of volume 10 L at 300 K. If the manometer containing glycerin shows 5 m difference in level as shown diagram.

(Given : $d_{glycerin} = 2.72$ g/mL; $d_{mercury} = 13.6$ g/mL)



(a) 0.94 mole (b) 0.49 mole (c) 0.64 mole (d) none of these

61. A rigid vessel of volume 0.50 m^3 containing H_2 at 20.5°C and a pressure of 611×10^3 Pa is connected to a second rigid vessel of volume 0.75 m^3 containing Ar at 31.2°C at a pressure of 433×10^3 Pa. A valve separating the two vessels is opened and both are cooled to a temperature of 14.5°C. What is the final pressure in the vessels?

(a) 2×10^5
(b) 3.22×10^5 Pa
(c) 4840 Pa
(d) 4.84×10^5 Pa

62. Two glass bulbs *A* and *B* at same temperature are connected by a very small tube having a stop-corck. Bulb *A* has a volume of 100 cm^3 and contained the gas while bulb *B* was empty. On opening the stop-corck, the pressure fell down to 20%. The volume of the bulb *B* is :

(a) 100 cm^3
(b) 200 cm^3
(c) 250 cm^3
(d) 400 cm^3

63. A mixture of C_2H_2 and C_3H_8 occupied a certain volume at 80 mm Hg. The mixture was completely burnt to CO_2 and $H_2O(l)$. When the pressure of CO_2 was found to be 230 mm Hg at the same temperature and volume, the mole fraction of C_3H_8 in the mixture is :

(a) 0.125
(b) 0.875
(c) 0.6
(d) 0.8

64. The total pressure of a mixture of oxygen and hydrogen is 1.0 atm. The mixture is ignited and the water is removed. The remaining gas is pure hydrogen and exerts a pressure of 0.40 atm when measured at the same values of *T* and *V* as the original mixture. What was the composition of the original mixture in mole per cent?

(a) $x_{O_2} = 0.2$; $x_{H_2} = 0.8$
(b) $x_{O_2} = 0.4$; $x_{H_2} = 0.6$
(c) $x_{O_2} = 0.6$; $x_{H_2} = 0.4$
(d) $x_{O_2} = 0.8$; $x_{H_2} = 0.2$

65. Two closed vessel *A* and *B* of equal volume of 8.21 L are connected by a narrow tube of negligible volume with open valve. The left hand side container is found to contain 3 mole CO_2 and 2 mole of He at 400 K, what is the partial pressure of He in vessel *B* at 500 K?

(a) 2.4 atm (b) 8 atm (c) 12 atm (d) None of these

66. At STP, a container has 1 mole of He, 2 mole Ne, 3 mole O_2 and 4 mole N_2. Without changing total pressure if 2 mole of O_2 is removed, the partial pressure of O_2 will be decreased by :

(a) 26%
(b) 40%
(c) 58.33%
(d) 66.66%

67. A 821 mL N_2 (g) was collected over liquid water at 300 K and 1 atm. If vapour pressure of H_2O is 30 torr then moles of N_2 (g) in moist gas mixture is :
(a) 0.39 (b) 0.032
(c) 0.96 (d) 0.0013

68. Let p and p_s be the partial pressure of H_2O (g) and vapour pressure of H_2O (l) respectively. Then the % relative humidity is given by:
(a) $\frac{p_s + p}{p_s} \times 100$ (b) $\frac{p}{p_s} \times 100$ (c) $\frac{p_s}{p} \times 100$ (d) $(p + p_s) \times 100$

69. The vapour pressure of water at 80°C is 355 mm of Hg. 1 L vessel contains O_2 at 80°C, saturated with water the total pressure being 760 mm of Hg. The contents of the vessel were pumped into 0.3 L vessel at the same temperature. What is the partial pressure of O_2?
(a) 1350 Hg (b) 2178.3 Hg (c) 121.5 Hg (d) 355 Hg

70. Which of the following gas mixture is not applicable for Dalton's law of partial pressure?
(a) SO_2 and Cl_2 (b) CO_2 and N_2 (c) CO and CO_2 (d) CO and N_2

71. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is:
(a) $\frac{2}{3}$ (b) $\frac{1}{3} \times \frac{273}{298}$ (c) $\frac{1}{3}$ (d) $\frac{1}{2}$

72. A box of 1 L capacity is divided into two equal compartments by a thin partition which are filled with 2g H_2 and 16 g CH_4 respectively. The pressure in each compartment is recorded as P atm. The total pressure when partition is removed will be:
(a) P (b) $2P$ (c) $P/2$ (d) $P/4$

73. If 10^{-4} dm^3 of water is introduced into a 1.0 dm^3 flask at 300 K, how many moles of water are in the vapour phase when equilibrium is established?
(Given : Vapour pressure of H_2O at 300 K is 3170 Pa; $R = 8.314\ JK^{-1}\ mol^{-1}$)
(a) 1.27×10^{-3} mole (b) 5.56×10^{-3} mole
(c) 1.53×10^{-2} mole (d) 4.46×10^{-2} mole

74. At room temperature Dalton's law of partial pressure is not applicable to :
(a) H_2 and N_2 mixture (b) H_2 and Cl_2 mixture
(c) H_2 and CO_2 mixture (d) none

75. 56 g of nitrogen and 96 g of oxygen are mixed isothermaly and at a total pressure of 10 atm. The partial pressures of oxygen and nitrogen (in atm) are respectively :
(a) 4, 6 (b) 5, 5 (c) 2, 8 (d) 6, 4

76. The closed containers of the same capacity and at the same temperature are filled with 44 g of H_2 in one and 44 g of CO_2 in the other. If the pressure of carbon dioxide in the second container is 1 atm. That of hydrogen in the first container would be :
(a) 1 atm (b) 10 atm (c) 22 atm (d) 44 atm

77. A jar contains a gas and a few drops of water. The pressure in the jar is 830 mm of Hg. The temperature of the jar is reduced by 1%. The vapour pressure of water at two temperatures are 30 and 25 mm of Hg. Calculate the new pressure in jar.
(a) 792 mm of Hg (b) 817 mm of Hg
(c) 800 mm of Hg (d) 840 mm of Hg

78. O_2 and SO_2 gases are filled in ratio of 1 : 3 by moles in a closed container of 3 L at temperature of 27°C. The partial pressure of O_2 is 0.60 atm, the concentration of SO_2 would be
(a) 0.36 (b) 0.036 (c) 3.6 (d) 36

79. A gaseous mixture contains three gases *A*, *B* and *C* with a total number of moles of 10 and total pressure of 10 atm. The partial pressure of *A* and *B* are 3 atm and 1 atm respectively and if *C* has molecular weight of 2 g/mol. Then, the weight of *C* present in the mixture will be :
(a) 8 g (b) 12 g (c) 3 g (d) 6 g

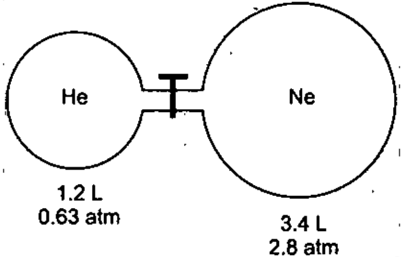
80. A rigid container containing 5 mole H_2 gas at same pressure and temperature. The gas has been allowed to escape by simple process from the container due to which pressure of the gas becomes half of its initial pressure and temperature become $(2/3)^{rd}$ of its initial. The mass of gas remaining is :
(a) 7.5 g (b) 1.5 g (c) 2.5 g (d) 3.5 g

81. Pressure of 1 g ideal gas *X* at 300 K is 2 atm. When 2 g of another gas *Y* is introduced in the same vessel at same temperature, the pressure become 3 atm then correct relationship between molar mass of *X* and *Y* is :
(a) $M_Y = 2M_X$ (b) $M_Y = 4M_X$
(c) $M_X = 4M_Y$ (d) None of these

82. Dry ice is solid carbon dioxide. A 0.050 g sample of dry ice is placed in an evacuated 4.6 L vessel at 30°C. Calculate the pressure inside the vessel after all the dry ice has been converted to CO_2 gas.
(a) 6.14 atm (b) 0.614 atm (c) 0.0614 atm (d) 6.14×10^{-3} atm

83. A mixture of helium and neon gases is collected over water at 28.0°C and 745 mmHg. If the partial pressure of helium is 368 mmHg, what is the partial pressure of neon? (Vapour pressure of water at 28°C = 28.3 mmHg)
(a) 348.7 mmHg (b) 377 mmHg (c) 384.7 mmHg (d) none of these

84. Consider the following apparatus. Calculate the partial pressure of helium after the opening valve. The temperature remains constant at 16°C.



(a) 0.164 atm (b) 1.64 atm (c) 0.328 atm (d) 1 atm

85. Oxygen gas generated by the decomposition of potassium chlorate is collected over water. The volume of oxygen collected at 24°C and atmospheric pressure of 760 mmHg is 128 mL. Calculate the mass of oxygen gas obtained. The pressure of the water vapour at 24°C is 22.4 mm Hg.
(a) 1.36 g (b) 1.52 g (c) 0.163 g (d) 1.63 g

86. The quantity $\frac{PV}{k_BT}$ represents the (k_B : Boltzmann constant)

(a) number of particles of the gas　　(b) mass of the gas
(c) number of moles of the gas　　(d) translation energy of the gas

87. Which of the following statements about kinetic energy (K.E.) is true?
(a) All objects moving with the same velocity have the same K.E.
(b) The K.E. of a body will quadruple if its velocity doubles
(c) As the velocity of a body increases, its K.E. decreases
(d) The K.E. of a body is independent of its mass

88. The Ne atom has 10 times the mass of H_2. Which of the following statements is true?

I. At 25°C they both have the same kinetic energy.

II. Ten moles of H_2 would have the same volume as 1 mole of Ne at same temp. and pr.

III. One mole of Ne exerts the same pressure as one mole of H_2 at STP.

IV. A H_2 molecule travels 10 times faster than Ne atom at same temperature.

V. At STP, one litre of Ne has 10 times the density of 1 litre of H_2.

(a) II, IV, V　　(b) I, III, V　　(c) I, II, III　　(d) I, II

89. Which of the following is NOT a postulate of the kinetic molecular theory of gases?
(a) The molecules possess a volume that is negligibly small compared to the container
(b) The pressure and volume of a gas are inversely related
(c) Gases consist of discrete particles that are in constant chaotic motion
(d) The average kinetic energy of the molecules is directly proportional to the temperature

90. Which one of the following relationships when graphed does not give a straight line for helium gas?

I. K.E. and T at constant pressure and volume

II. P v/s V at constant temperature for a constant mass

III. V v/s $1/T$ at constant pressure for a constant mass

(a) II　　(b) II and III　　(c) III　　(d) I

91. Consider three one-litre flasks labeled A, B and C filled with the gases NO, NO_2, and N_2O; respectively, each at 1 atm and 273 K. In which flask do the molecules have the highest average kinetic energy?

(a) Flask C　　(b) All are the same　　(c) Flask A　　(d) None

92. Which of the following statements is false?
(a) The product of pressure and volume of fixed amount of a gas is independent of temperature.
(b) Molecules of different gases have the same kinetic energy at a given temperature.
(c) The gas equation is not valid at high pressure and low temperature constant.
(d) The gas constant per molecule is known as Boltzmann's constant.

93. Which is not correct in terms of kinetic theory of gases?
(a) Gaseous particles are considered as point mass.
(b) The molecules are in random motion.
(c) When molecules collide, they lose energy.
(d) When the gas is heated , the molecules moves faster.

94. Two flasks A and B have equal volumes. A is maintained at 300 K and B at 600 K, while A contains H_2 gas, B has an equal mass of CO_2 gas. Find the ratio of total K.E. of gases in flask A to that of B.

(a) 1 : 2 (b) 11 : 1
(c) 33 : 2 (d) 55 : 7

95. Kinetic energy and pressure of a gas of unit are related as :

(a) $P = \frac{2}{3}E$ (b) $P = \frac{3}{2}E$ (c) $P = \frac{E}{2}$ (d) $P = 2E$

96. Two flask A and B of equal volumes maintained at temperature 300 K and 700 K contain equal mass of $He(g)$ and $N_2(g)$ respectively. What is the ratio of translational kinetic energy of gas in flask A to that of flask B?

(a) 1 : 3 (b) 3 : 1 (c) 3 : 49 (d) None of these

97. Which occurs when a substance X is converted from liquid to vapour phase at the standard boiling point?

I. Potential energy of the system decreases
II. The distance between molecules increases
III. The average kinetic energy of the molecules in both phases are equal

(a) I only (b) II only
(c) III only (d) II and III only

98. A mixture of Ne and Ar at 250 K has a total K.E. = 3 kJ in a closed vessel, the total mass of Ne and Ar is 30 g. Find mass % of Ne in gaseous mixture at 250 K.

(a) 61.63 (b) 38.37 (c) 50% (d) 28.3

99. In two vessels of 1 litre each at the same temperature 1g of H_2 and 1g of CH_4 are taken, for these:

(a) V_{rms} values will be same (b) Kinetic energy per mol will be same
(c) Total kinetic energy will same (d) Pressure will be same

100. Four particles have speed 2,3,4 and 5 cm/s respectively. Their rms speed is:

(a) 3.5 cm/s (b) (27/2) cm/s (c) $\sqrt{54}$ cm/s (d) $(\sqrt{54}/2)$ cm/s

101. A gaseous mixture contains 4 molecules with a velocity of 6 cm sec^{-1}, 5 molecules with a velocity of 2 cm sec^{-1} and 10 molecules with a velocity of 3 cm sec^{-1}. What is the RMS velocity of the gas:

(a) 2.5 cm sec^{-1} (b) 1.9 cm sec^{-1} (c) 3.6 cm sec^{-1} (d) 4.6 cm sec^{-1}

102. The ratio between the root mean square velocity of H_2 at 50 K and that of O_2 at 800 K is:

(a) 4 (b) 2 (c) 1 (d) 1/4

103. If C_1, C_2, C_3...represent the speeds of n_1, n_2, n_3...molecules respectively, then the root mean square speed will be:

(a) $\sqrt{\frac{n_1C_1^2 + n_2C_2^2 + n_3C_3^2 + \ldots}{n_1 + n_2 + n_3 + \ldots}}$ (b) $\sqrt{\frac{(n_1 + n_2 + n_3 + \ldots)^2}{n_1C_1^2 + n_2C_2^2 + n_3C_3^2 + \ldots}}$

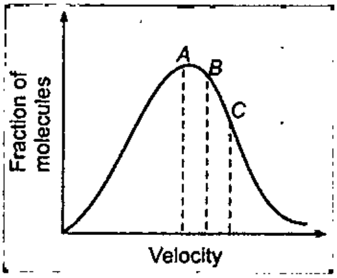
(c) $\sqrt{\frac{(n_1C_1)}{n_1} + \frac{(n_2C_2)}{n_2} + \frac{(n_3C_3)}{n_3}}$ (d) $\sqrt{\frac{(n_1C_1 + n_2C_2 + n_2C_3 + \ldots)^2}{n_1 + n_2 + n_3 + \ldots}}$

104. The root mean square velocity of hydrogen is $\sqrt{5}$ times than that of nitrogen. If T is the temperature of the gas, then :

(a) $T_{H_2} = T_{N_2}$ (b) $T_{H_2} > T_{N_2}$

(c) $T_{H_2} < T_{N_2}$ (d) $T_{H_2} = \sqrt{7}\, T_{N_2}$

105. At a definite temperature (T), the distribution of velocities is given by the curve. The curve that indicates that the velocities corresponding to points A, B and C are :



(a) most probable, average and root mean square

(b) average, root mean square and most probable

(c) root mean square, average and most probable

(d) most probable, root mean square and average

106. The most probable speed of 8 g of H_2 200 ms^{-1} average kinetic energy (neglect rotational and vibrational energy) of H_2 gas is :

(a) 480 J (b) 240 J (c) 120 J (d) none of these

107. At what temperature will average speed of the molecules of the second member of the series C_nH_{2n} be the same of Cl_2 at 627°C?

(a) 259.4 K (b) 400 K

(c) 532.4 K (d) None of these

108. If U_{RMS} of a gas is $30\,R^{1/2}$ ms^{-1} at 27°C then the molar mass of gas is :

(a) 0.02 kg/mol (b) 0.001 kg/mol

(c) 0.003 kg/mol (d) 1 kg/mol

109. 6×10^{22} gas molecules each of mass 10^{-24} kg are taken in a vessel of 10 litre. What is the pressure exerted by gas molecules? The root mean square speed of gas molecules is 100 m/s.

(a) 20 Pa (b) 2×10^4 Pa (c) 2×10^5 Pa (d) 2×10^7 Pa

110. At what temperature will most probable speed of the molecules of the second member of homologous series C_nH_{2n-2} be the same as that of SO_2 at 527°C.

(a) 500°C (b) 727°C (c) 227°C (d) None of these

111. The root mean square speed of 8 g of He is 300 ms^{-1}. Total kinetic energy of He gas is :

(a) 120 J (b) 240 J (c) 360 J (d) None of these

112. If T_1, T_2 and T_3 are the temperature at which the U_{RMS}, $U_{average}$, U_{MP} of oxygen gas are all equal to 1500 m/s then the correct statement is :

(a) $T_1 > T_2 > T_3$ (b) $T_1 < T_2 < T_3$

(c) $T_1 = T_2 = T_3$ (d) None of these

113. The density of a gas filled electric lamp is 0.75 kg/m^3. After the lamp has been switched on, the pressure in it increases from 4×10^4 Pa to 9×10^4 Pa. What is increases in U_{RMS}?

(a) 100 (b) 200 (c) 300 (d) None of these

114. The root mean sqaure velocity of an ideal gas at constant pressure varies with density (d) as :
(a) d^2 (b) d (c) $\sqrt{d}$ (d) $1/\sqrt{d}$

115. The ratio among most probable velocity, mean velocity and root mean square velocity is given by
(a) $1 : 2 : 3$ (b) $1 : \sqrt{2} : \sqrt{3}$
(c) $\sqrt{2} : \sqrt{3} : \sqrt{8/\pi}$ (d) $\sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$

116. The average speed at temperature T°C of $CH_4(g)$ is $\sqrt{\frac{28}{88}} \times 10^3\ ms^{-1}$. What is the value of T ?
(a) 240.55°C (b) – 32.45°C
(c) 3000°C (d) – 24.055°C

117. At what temperature most probable speed of O_2 molecules have the same value of root mean square speed of O_2 molecules at 300 K?
(a) 150 K (b) 600 K
(c) 750 K (d) 900 K

118. The rms speed of N_2 molecules in a gas is u. If the temperature is doubled and the nitrogen molecules dissociate into nitrogen atoms, the rms speed becomes:
(a) $u/2$ (b) $2u$ (C) $4u$ (D) $14u$

119. The rate of diffusion of a gas is proportional to:
(a) $\frac{P}{\sqrt{d}}$ (b) $\frac{P}{d}$ (c) $\sqrt{\frac{P}{d}}$ (d) $\frac{\sqrt{P}}{d}$

120. At constant volume and temperature conditions, the rates of diffusion r_A and r_B of gases A and B having densities ρ_A and ρ_B are related by the expression :
(a) $r_A = r_B \cdot (\rho_A/\rho_B)^2$ (b) $r_A = r_B(\rho_B/\rho_A)^{1/2}$
(c) $r_A = (r_B \cdot \rho_B/\rho_A)^{1/2}$ (d) $r_A = r_B(\rho_A/\rho_B)^{1/2}$

121. What is the ratio of diffusion rate of oxygen to hydrogen?
(a) 1 : 4 (b) 4 : 1 (c) 1 : 8 (d) 8 : 1

122. The molecular weight of a gas which diffuses through a porous plug at $1/6^{th}$ of the speed of hydrogen under identical conditions is:
(a) 27 (b) 72
(c) 36 (d) 48

123. X mL of H_2 gas effuses through a hole in a container in 5 seconds. The time taken for the effusion of the same volume of the gas specified below under identical condition is:
(a) 10 sec : He (b) 20 sec : O_2
(c) 25 sec : CO (d) 55 sec : CO_2

124. At identical temperature and pressure, the rate of diffusion of hydrogen gas is $3\sqrt{3}$ times that of a hydrocarbon having molecular formula C_nH_{2n-2}. What is the value of n?
(a) 1 (b) 4 (c) 3 (d) 8

125. Calculate relative rate of effusion of O_2 to CH_4 through a container containing O_2 and CH_4 in 3 : 2 mass ratio.
(a) $\frac{3\sqrt{2}}{4}$ (b) $\frac{3}{4\sqrt{2}}$ (c) $\frac{3}{2\sqrt{2}}$ (d) none of these

126. Calculate relative rate of effusion of SO_2 to CH_4, if the mixture obtained by effusing out a mixture with molar ratio $\frac{n_{SO_2}}{n_{CH_4}} = \frac{8}{1}$ for three effusing steps.

(a) 2 : 1 (b) 1 : 4
(c) 1 : 2 (d) none of these

127. A gaseous mixture containing He, CH_4 and SO_2 was allowed to effuse through a fine hole then find what molar ratio of gases coming out initially? If mixture contain He, CH_4 and SO_2 in 1 : 2 : 3 mole ratio.

(a) 2 : 2 : 3 (b) 6 : 6 : 1 (c) $\sqrt{2} : \sqrt{2} : 3$ (d) 4 : 4 : 3

128. 80 mL of O_2 takes 2 minute to pass through the hole. What volume of SO_2 will pass through the hole in 3 minute?

(a) $\frac{120}{\sqrt{2}}$ (b) $120 \times \sqrt{2}$ (c) $\frac{12}{\sqrt{2}}$ (d) None of these

129. When two cotton plugs, one moistened with ammonia and the other with hydrochloric acid, are simulataneously inserted into opposite ends of a glass tube 87.0 cm long, a white ring of NH_4Cl forms where gaseous NH_3 and gaseous HCl first come into contact.

$$NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$$

At what distance from the ammonia-moistened plug does this occur?

(a) 51.7 cm from NH_3 end (b) 51.7 cm from HCl end
(c) 43.5 at mid point (d) None of these

130. Dimethyl ether decomposes as

$$CH_3OCH_3(g) \longrightarrow CH_4(g) + CO(g) + H_2(g)$$

When CH_3OCH_3 decomposes to 20% extent at certain fixed conditions, what is the ratio of diffusion of pure CH_3OCH_3 with methane?

(a) 0.59 : 1 (b) 1.18 : 1 (c) 2.36 : 1 (d) 1.77 : 1

131. 4 gm of sulphur dioxide gas diffuses from a container in 8 min. Mass of helium gas diffusing from the same container over the same time interval is :

(a) 0.5 gm (b) 1 gm (c) 2 gm (d) None of these

132. Under identical conditions of pressure and temperature, 4 L of gaseous mixture (H_2 and CH_4) effuses through a hole in 5 min whereas 4 L of a gas X of molecular mass 36 takes to 10 min to effuse through the same hole. The mole ratio of $H_2 : CH_4$ in the mixture is :

(a) 1 : 2 (b) 2 : 1 (c) 2 : 3 (d) 1 : 1

133. A balloon weighing 50 kg is filled with 685 kg of helium at 1 atm pressure and 25°C. What will be its pay load if it displaced 5108 kg of air?

(a) 4373 kg (b) 4423 kg
(c) 5793 kg (d) none of these

134. According to the law of equipartition of energy, the energy associated with each degree of freedom is :

(a) $\frac{1}{3}K_B T$ (b) $\frac{1}{2}K_B T$
(c) $K_B T$ (d) $\frac{3}{2}K_B T$

135. Calculate γ (ratio of C_p and C_v) for triatomic linear gas at high temperature. Assume that the contribution of vibrational degree of freedom is 75% :

(a) 1.222 (b) 1.121
(c) 1.18 (d) 1.33

136. If one mole each of a monoatomic and diatomic gases are mixed at low temperature then C_p/C_v ratio for the mixture is :

(a) 1.40 (b) 1.428
(c) 1.5 (d) 1.33

137. If one mole of a mono-atomic gas ($\gamma = 5/3$) is mixed with one mole of a diatomic gas ($\gamma = 7/5$), the value of γ for the mixture is :

(a) 1.4 (b) 1.5
(c) 1.53 (d) 3.07

138. Select the correct statement :

(a) internal energy of a real gas at a given temperature increases as the volume increases
(b) internal energy of an ideal gas at given temperature increase as the volume increases
(c) internal energy of an ideal gas molecules is not a function of temperature
(d) the internal energy of a real gas at a constant temperature is independent of change in volume

139. Which gas shows real behaviour?

(a) 16 g O_2 at STP occupies 11.2 L
(b) 1 g H_2 in 0.5 L flask exerts pressure of 24.63 atm at 300 K
(c) 1 mole NH_3 at 300 K and 1 atm occupies volume 22.4 L
(d) 5.6 L of CO_2 at STP is equal to 11 g

140. Consider a real gas placed in a container. If the intermolecular attractions are supposed to disappear suddenly which of the following would happen?

(a) The pressure decreases (b) The pressure increases
(c) The pressure remains unchanged (d) The gas collapses

141. The pressure of real gases is less than the pressure of an ideal gas because of :

(a) Increase in number of collisions (b) Finite size of molecule
(c) Increase in KE of molecules (d) Intermolecular forces of attraction

142. A gas behaves like an ideal gas at :

(a) high pressure and low temperature (b) low pressure and high temperature
(c) high pressure and high temperature (d) low pressure and low temperature

143. If temperature and volume are same, the pressure of a gas obeying Vander Waals equation is :

(a) Smaller than that of an ideal gas (b) Larger than that of an ideal gas
(c) Same as that of an ideal gas (d) None of these

144. 1 mole of each of X_1, X_2, X_3 with vander Waals constants a (in atm L^3 mol^{-2}) 1.0, 3.8, 2.1 respectively is kept separately in three different vessels of equal volume at identical temperature. Their pressures are observed to P_1, P_2, and P_3 respectively. On the basis of this data alone, select the correct option (neglect the effect of 'b'):

(a) $P_1 < P_2 < P_3$ (b) $P_2 < P_1 < P_3$
(c) $P_2 < P_3 < P_1$ (d) $P_1 = P_2 = P_3$

145. A gas obeys the equation of state $P(V-b)=RT$ (The parameter b is a constant). The slope for an isochore will be :

(a) Negative (b) Zero

(c) $R/(V-b)$ (d) R/P

146. van der Waals constant b of helium is 24 mL mol^{-1}. Find molecular diameter of helium.

(a) 1.335×10^{-10} cm (b) 1.335×10^{-8} cm

(c) 2.67×10^{-8} cm (d) 4.34×10^{-8} cm

147. Which of the following can be most readily liquefied?

(Given: value of 'a' for $NH_3 = 4.17$, $CO_2 = 3.59$, $SO_2 = 6.71$, $Cl_2 = 6.49$)

(a) NH_3 (b) Cl_2

(c) SO_2 (d) CO_2

148. For which of the following gases should the correction for the molecular volume be largest : CO, CO_2, NH_3 or SF_6?

(a) CO (b) CO_2

(c) NH_3 (d) SF_6

149. Under which of the following sets of conditions is a real gas expected to deviate from ideal behaviour?

(I) High pressure, small volume

(II) High temperature, low pressure

(III) Low temperature, high pressure

(a) only I (b) only II (c) only III (d) I and III both

150. For a certain gas which deviates a little from ideal behaviour. A plot between P/ρ vs P was found to be non-linear, the intercept on y-axis will be :

(a) $\frac{RT}{M}$ (b) $\frac{M}{RT}$ (c) $\frac{MZ}{RT}$ (d) $\frac{R}{TM}$

151. At low pressure, the van der Waals equation become :

(a) $PV_m = RT$ (b) $P(V_m - b) = RT$

(c) $\left(P + \frac{a}{V_m^2}\right)V_m = RT$ (d) $P = \frac{RT}{V_m} + \frac{a}{V_m^2}$

152. At low pressure, if $RT = 2\sqrt{a \cdot P}$, then the volume occupied by a real gas is :

(a) $\frac{2RT}{P}$ (b) $\frac{2P}{RT}$ (c) $\frac{RT}{2P}$ (d) $\frac{2RT}{P}$

153. For a gas deviation from ideal behaviour is maximum at :

(a) 0°C and 1.0 atm (b) 100°C and 2.0 atm

(c) – 13°C and 1.0 atm (d) – 13°C and 2.0 atm

154. At low pressures, van der Waals' equation is written as $\left(P + \frac{a}{V^2}\right)V = RT$. The compressibility factor is then equal to:

(a) $\left(1 - \frac{a}{RTV}\right)$ (b) $\left(1 - \frac{RTV}{a}\right)$

(c) $\left(1 + \frac{a}{RTV}\right)$ (d) $\left(1 + \frac{RTV}{a}\right)$

155. The compressibility factor for a real gas at high pressure is :

(a) 1
(b) $1+\frac{Pb}{RT}$
(c) $1-\frac{Pb}{RT}$
(d) $1+\frac{RT}{Pb}$

156. The compressibility of a gas is greater than unity at 1 atm and 273 K. Therefore :

(a) $V_m > 22.4$ L
(b) $V_m < 22.4$ L
(c) $V_m = 22.4$ L
(d) $V_m = 44.8$ L

157. At 273 K temp. and 9 atm pressure, the compressibility for a gas is 0.9. The volume of 1 milli-moles of gas at this temperature and pressure is :

(a) 2.24 litre
(b) 0.020 mL
(c) 2.24 mL
(d) 22.4 mL

158. The compressibility factor for nitrogen at 330 K and 800 atm is 1.90 and at 570 K and 200 atm is 1.10. A certain mass of N_2 occupies a volume of 1 dm^3 at 330 K and 800 atm. Calculate volume occupied by same quantity of N_2 gas at 570 K and 200 atm :

(a) 1 L
(b) 2 L
(c) 3 L
(d) 4 L

159. Consider the equation $Z=\frac{PV}{RT}$. Which of the following statements is correct?

(a) When $Z>1$, real gases are easier to compress than the ideal gas
(b) When $Z=1$, real gases get compressed easily
(c) When $Z>1$, real gases are difficult to compress
(d) When $Z=1$, real gases are difficult to compress

160. What is the compressibility factor (Z) for 0.02 mole of a van der Waals' gas at pressure of 0.1 atm. Assume the size of gas molecules is negligible.

Given : $RT = 20$ L atm mol^{-1} and $a = 1000$ atm L^2 mol^{-2}

(a) 2
(b) 1
(c) 0.02
(d) 0.5

161. Consider the following statements. If the van der Walls' parameters of two gases are given as

	a/dm^6 bar mol^{-2}	b/dm^3 mol^{-1}
Gas A	6.5	0.055
Gas B	2	0.01

then :

1. Critical volume of $A <$ Critical volume of B
2. Critical pressure $A >$ Critical pressure of B
3. Critical temperature of $A >$ Critical temperature of B

Which of the above statements is incorrect?

(a) 1 alone
(b) 1 and 2
(c) 1, 2 and 3
(d) 2 and 3

162. The van der Waals parameters for gases *W, X, Y* and *Z* are

Gas	a (atm L^2 mol^{-2})	b (L mol^{-1})
W	4.0	0.027
X	8.0	0.030
Y	6.0	0.032
Z	12.0	0.027

Which one of these gases has the highest critical temperature?

(a) W (b) X (c) Y (d) Z

163. Pressure remaining the same, the volume of a given mass of an ideal gas increases for every degree centigrade rise in temperature by definite fraction of its volume at:

(a) 0°C (b) Its critical temperature
(c) Absolute zero (d) Its Boyle temperature

164. The critical temperature of a substance is:

(a) The temperature above which the substance undergoes decomposition
(b) The temperature above which a substance can exist only in gaseous state
(c) Boiling point of the substance
(d) All are wrong

165. The excluded volume of a gas will be larger, if $\frac{T_C}{P_C}$ is :

(a) small (b) large
(c) equal to 1 (d) less than unity

166. Select incorrect statement :

(a) we can condense vapour simply by applying pressure
(b) to liquefy a gas one must lower the temperature below T_C and also apply pressure
(c) at T_C, there is no distinction between liquid and vapour state hence density of the liquid is nearly equal to density of the vapour
(d) However great the pressure applied, a gas cannot be liquified below it's critical temp.

167. The correct order of temperature of a real gas is :

(I) Boyle's temperature
(II) Critical temperature
(III) Inversion temperature

(a) III > I > II (b) I > II > III
(c) II > I > III (d) I > III > II

168. The temperature at which the second virial coefficient of real gas is zero is called :

(a) Critical temperature (b) Triple point
(c) Boiling point (d) Boyle's temperature

169. The van der Waals' equation for one mole may be expressed as

$$V_m^3 - \left(b + \frac{RT}{p}\right)V_m^2 + \frac{aV_m}{p} - \frac{ab}{p} = 0$$

where V_m is the molar volume of the gas. Which of the following is incorrect?

(a) For a temperature less than T_C, V has three real roots

(b) For a temperature less than T_C, V has three imaginary roots

(c) For a temperature equal to T_C all three roots of V are real and identical

(d) On increasing the temp. ($T < T_C$), the three roots become closer to one another

170. For a gas obeying the van der Waals' equation, at the critical temperature

(a) both $\left(\frac{\partial P}{\partial P}\right)_T$ and $\left(\frac{\partial^2 P}{\partial V^2}\right)_T$ are zero (b) both $\left(\frac{\partial P}{\partial V}\right)_T$ and $\left(\frac{\partial^2 P}{\partial V^2}\right)_T$ are not zero

(c) $\left(\frac{\partial P}{\partial P}\right)_T$ is zero but $\left(\frac{\partial^2 P}{\partial V^2}\right)_T$ is non-zero (d) $\left(\frac{\partial P}{\partial V}\right)_T$ is non-zero but $\left(\frac{\partial^2 P}{\partial V^2}\right)_T$ is zero

171. However great the pressure, a gas cannot be liquified above its :

(a) Boyle temperature (b) Inversion temperature

(c) Critical temperature (d) Room temperature

172. The temperature at which real gases obey the ideal gas laws over a wide range of low pressure is called:

(a) Critical temperature (b) Inversion temperature

(c) Boyle temperature (d) Reduced temperature

173. Inversion temperature $\left(T_i = \frac{2a}{Rb}\right)$ is defined as the temperature above which if gas is expanded adiabatically it gets warm up but if temperature of gas is lower than T_i then it will cool down. What will happen to a gas if it is adiabatically expanded at 600 K if its Boyle's temperature is 290 K?

(a) Heating (b) Cooling

(c) Constant (d) None

174. The van der Waals' equation of law of corresponding states for 1 mole of gas is :

(a) $\left(P_r + \frac{3}{V_r^2}\right)(3V_r - 1) = 8\,T_r$ (b) $\left(P_r - \frac{3}{V_r^2}\right)(3V_r - 1) = 8\,T_r$

(c) $\left(P_r + \frac{3}{V_r^2}\right)(3V_r + 1) = 8\,\pi T_r$ (d) $\left(P_r + \frac{3}{V_r^2}\right)(3V_r + 1) = 8$

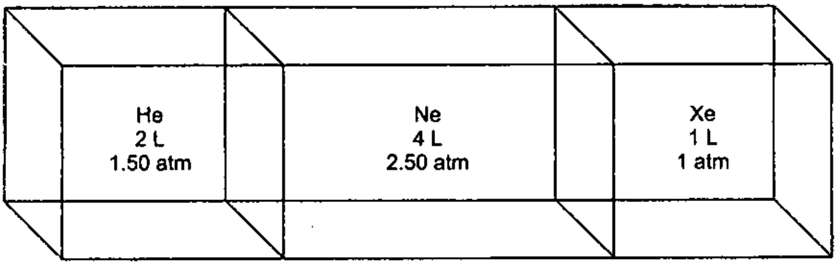
175. Calculate the volume occupied by 16 gram O_2 at 300 K and 8.31 MPa if $\frac{P_c V_c}{RT_c} = 3/8$ and $\frac{P_r V_r}{T_r} = 2.21$ (Given : $R = 8.314$ MPa/K- mol)

(a) 125.31 mL (b) 124.31 mL

(c) 248.62 mL (d) none of these

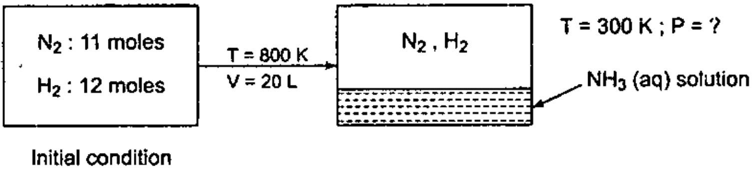
Level 2

1. Consider the composite system, which is held at 300 K, shown in the following figure. Assuming ideal gas behavior, calculate the total pressure if the barriers separating the compartments are removed. Assume that the volume of the barriers is negligible. (Given : $R = 0.082$ atm L/mol. K)



(a) 1 atm (b) 2 atm (c) 2.3 atm (d) 3.2 atm

2. 11 moles N_2 and 12 moles of H_2 mixture reacted in 20 litre vessel at 800 K. After equilibrium was reached, 6 mole of H_2 was present. 3.58 litre of liquid water is injected in equilibrium mixture and resultant gaseous mixture suddenly cooled to 300K. What is the final pressure of gaseous mixture? Neglect vapour pressure of liquid solution. Assume (i) all NH_3 dissolved in water (ii) no change in volume of liquid (iii) no reaction of N_2 and H_2 at 300 K



(a) 18.47 atm (b) 60 atm (c) 22.5 atm (d) 45 atm

3. Two vessels connected by a valve of negligible volume. One container (I) has 2.8 g of N_2 at temperature T_1(K). The other container (II) is completely evacuated. The container (I) is heated to T_2 (K) while container (II) is maintained at $T_2/3$ (K). volume of vessel (I) is half that of vessel (II). If the valve is opened then what is the weight ratio of N_2 in both vessel (W_I/W_{II})?

(a) 1 : 2 (b) 1 : 3 (c) 1 : 6 (d) 3 : 1

4. A mixture of $NH_3(g)$ and $N_2H_4(g)$ is placed in a sealed container at 300 K. The total pressure is 0.5 atm. The container is heated to 1200 K at which time both substances decompose completely according to the equations

$$2NH_3(g) \longrightarrow N_2(g) + 3H_2(g) \text{ and } N_2H_4(g) \longrightarrow N_2(g) + 2H_2(g)$$

After decomposition is complete, the total pressure at 1200 K is found to be 4.5 atm. Find the mole% of N_2H_4 in the original mixture :

(a) 20% (b) 25% (c) 50% (d) 75%

5. Correct expression for density of an ideal gas mixture of two gases 1 and 2, where m_1 and m_2 are masses and n_1 and n_2 are moles and M_1 and M_2 are molar masses.

(a) $d = \dfrac{(m_1 + m_2)}{(M_1 + M_2)}$ (b) $d = \dfrac{(m_1 + m_2)}{(n_1 + n_2)} \dfrac{P}{RT}$

(c) $d = \dfrac{(n_1 + n_2)}{(m_1 + m_2)} \times \dfrac{P}{RT}$ (d) None of these

6. Two closed vessel A and B of equal volume containing air at pressure P_1 and temperature T_1 are connected to each other through a narrow open tube. If the temperature of one is now maintained at T_1 and other at T_2 (where $T_1 > T_2$) then that what will be the final pressure?

(a) $\dfrac{T_1}{2P_1T_2}$ (b) $\dfrac{2P_1T_2}{T_1 + T_2}$ (c) $\dfrac{2P_1T_1}{T_1 - T_2}$ (d) $\dfrac{2P_1}{T_1 + T_2}$

7. A balloon containing 1 mole air at 1 atm initially is filled further with air till pressure increases to 4 atm. The initial diameter of the balloon is 1 m and the pressure at each stage is proportion to diameter of the balloon. How many no. of moles of air added to change the pressure from 1 atm to 4 atm.

(a) 80 (b) 257 (c) 255 (d) 256

8. If Pd v/s. P(where P denotes pressure in atm and d denotes density in gm/L) is plotted for He gas (assume ideal) at a particular temperature. If $\left[\dfrac{d}{dP}(Pd)\right]_{P = 8.21 \text{ atm}} = 5$, then the temperature will be

(a) 160 K (b) 320 K (c) 80 K (d) none of these

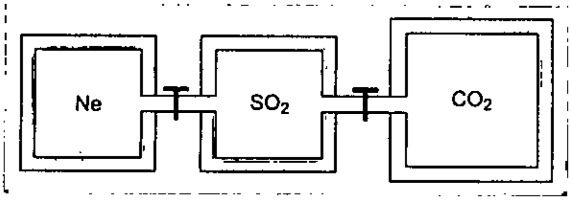
9. What is the density of wet air with 75% relative humidity at 1 atm and 300 K? Given : vapour pressure of H_2O is 30 torr and average molar mass of air is 29 g mol^{-1}.

(a) 1.614 g/L (b) 0.96 g/L (c) 1.06 g/L (d) 1.164 g/L

10. 7 moles of a tetra-atomic non-linear gas 'A' at 10 atm and T K are mixed with 6 moles of another gas B at $\dfrac{T}{3}$ K and 5 atm in a closed, rigid vessel without energy transfer with surroundings. If final temperature of mixture was $\dfrac{5T}{6}$ K, then gas B is? (Assuming all modes of energy are active)

(a) monoatomic (b) diatomic (c) triatomic (d) tetra atomic

11. Three closed rigid vessels, A, B and C without energy transfer with surroundings, which initially contain three different gases at different temperatures are connected by tube of negligible volume. The vessel A contain 2 mole Ne gas, at 300 K, vessel 'B' contain 2 mole SO_2 gas at 400 K and vessel 'C' contain 3 mole CO_2 gas at temperature 500 K. What is the final pressure (in atm) attained by gases when all valves of connecting three vessels are opened and additional 15.6 kcal heat supplied to vessel through valve. The volume of A, B and C vessel is 2, 2 and 3 litre respectively



Given : $R = 2$ calorie/mol-K; C_v (Ne) $= 3/2\,R$, C_v (CO) $= 5/2\ R$ and C_v $(SO_2) = 3\,R$

(a) 73.89 atm (b) 67.31 atm (c) 80 atm (d) none of these

12. Gas molecules each of mass 10^{-26} kg are taken in a container of volume 1 dm^3. The root mean square speed of gas molecules is 1 km sec^{-1}. What is the temperature of gas molecules.

(Given : $N_A = 6 \times 10^{23}$; $R = 8$ J/mol. K)

(a) 298 K (b) 25 K (c) 250 K (d) 2500 K

13. A balloon of diameter 21 meter weight 100 kg. Calculate its pay-load, if it is filled with He at 1.0 atm and 27°C. Density of air is 1.2 kg m^{-3}. (Given : $R = 0.082$ L atm $K^{-1}mol^{-1}$)

(a) 4952.42 kg (b) 4932.42 kg (c) 493.242 kg (d) none of these

14. A given volume of ozonised oxygen (containing 60% oxygen by volume) required 220 sec to effuse which an equal volume of oxygen took 200 sec only under the conditions. If density of O_2 is 1.6 g/L then find density of O_3.

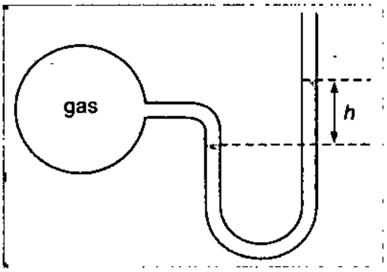
(a) 1.936 g/L (b) 2.16 g/L (c) 3.28 g/L (d) 2.24 g/L

15. If 250 mL of N_2 over water at 30°C and a total pressure of 740 torr is mixed with 300 mL of Ne over water at 25°C and a total pressure of 780 torr, what will be the total pressure if the mixture is in a 500 mL vessel over water at 35°C.

(Given : Vapour pressure (Aqueous tension) of H_2O at 25°C, 30°C and 35°C are 23.8, 31.8 and 42.2 torr respectively. Assume volume of $H_2O(l)$ is negligible in final vessel)

(a) 760 torr (b) 828.4 torr (c) 807.6 torr (d) 870.6 torr

16. A bulb of constant volume is attached to a manometer tube open at other end as shown in figure. The manometer is filled with a liquid of density $(1/3)^{rd}$ that of mercury. Initially h was 228 cm.



Through a small hole in the bulb gas leaked assuming pressure decreases as $\frac{dp}{dt} = -kP$.

If value of h is 114 cm after 14 minutes. What is the value of k (in $hour^{-1}$)?

[Use : $\ln(4/3) = 0.28$ and density of Hg $= 13.6$ g/mL.].

(a) 0.6 (b) 1.2 (c) 2.4 (d) none of these

17. A mixture of nitrogen and water vapours is admitted to a flask at 760 torr which contains a sufficient solid drying agent after long time the pressure reached a steady value of 722 torr.

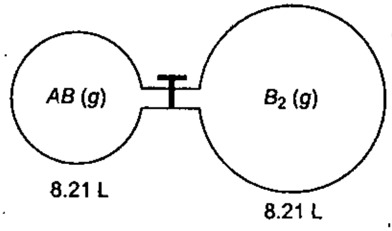
If the experiment is done at 27°C and drying agent increases in weight by 0.9 gm, what is the volume of the flask? Neglect any possible vapour pressure of drying agent and volume occupied by drying agent.

(a) 443.34 L (b) 246.3 L (c) 12.315 L (d) 24.63 L

18. At room temperature following reaction goes to completion

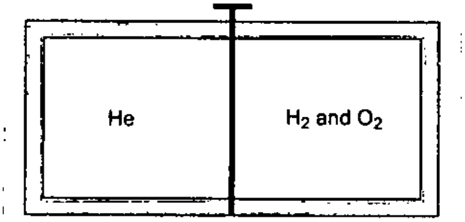
$$2AB(g) + B_2(g) \longrightarrow 2AB_2(g)$$

AB_2 is solid with negligible vapour pressure below 0°C. At 300 K, the AB in the smaller flask exerts a pressure of 3 atm and the larger flask exerts a pressure of 1 atm at 400 K when they are separated out by a close valve. The gases are mixed by opening the stop cock and after the end of the reaction the flask are cooled to 250 K



(a) 0.156 atm
(b) 0.3125 atm
(c) 0.625 atm
(d) 3.2 atm

19. A vessel of uniform cross-section of length 500 cm as shown in figure is divided in two parts by a weightless and frictionless piston one part contains 5 moles of He(g) and other part 2 moles of $H_2(g)$ and 4 mole of $O_2(g)$ added at the same temperature and pressure, in which reaction takes place finally vessel cooled to 300 K and 1 atm. What is the length of He compartment? (Assume volume of piston and vol. of $H_2O(l)$ formed are negligible)



At initial stage

(a) 187.5
(b) 300 atm
(c) 312.5 cm
(d) none of these

20. For a real gas (mol. mass = 60) if density at critical point is 0.80 g/cm^3 and its $T_c = \dfrac{4\times10^5}{821}$ K, then van der Waals' constant a (in atm L^2 mol^{-2}) is

(a) 0.3375
(b) 3.375
(c) 1.68
(d) 0.025

21. The van der Waals' constant 'b' of a gas is $4\pi\times10^{-4}$ L/mol. How near can the centres of the two molecules approach each other? [Use : $N_A = 6\times10^{23}$]

(a) 10^{-7} m
(b) 10^{-10} m
(c) 5×10^{-11} m
(d) 5×10^{-9} m

22. The density of vapour of a substance (X) at 1 atm pressure and 500 K is 0.8 kg/m^3. The vapour effuses through a small hole at a rate of 4/5 times slover than oxygen under the same condition. What is the compressibility factor (Z) of the vapour?

(a) 0.974
(b) 1.35
(c) 1.52
(d) 1.22

23. Vander Waal's gas equation can be reduced to virial equation and virial equation (in terms of volume) is $Z = A + \frac{B}{V_m} + \frac{C}{V_m^2} + \ldots\ldots$

where A = first virial coefficient, B = second virial coefficient, C = third virial coefficient. The third virial coefficient of Hg(g) is 625 $(\text{cm}^2/\text{mol})^2$. What volume is available for movement of 10 moles He(g) atoms present in 50 L vessel?

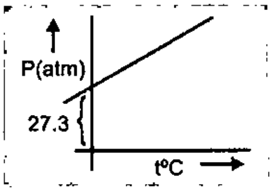
(a) 49.75 L (b) 49.25 L (c) 25 L (d) 50 L

24. If the slope of 'Z' (compressibility factor) v/s 'P' curve is constant $\left(\text{slope} = \frac{\pi}{492.6}\ \text{atm}^{-1}\right)$ at a particular temperature (300 K) and very high pressure, then calculate diameter of the molecules.

(Given : $N_A = 6.0 \times 10^{23}$, $R = 0.0821$ atm. lit $\text{mol}^{-1}\ \text{K}^{-1}$)

(a) 7.5 Å (b) 5 Å (c) 2.5 Å (d) 1.25 Å

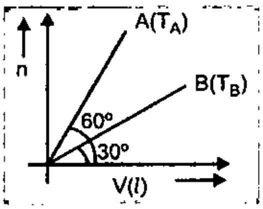
25. A graph is plotted between P (atm) *vs* t°C for 10 mol of an ideal gas as follows:



then slope of curve and volume of container (L) respectively, is:

(a) 0.1, 8.21 (b) 8.21, 0.1
(c) 27.3, 8.21 (d) 8.21, 27.3

26. For two samples A and B of ideal gas following curve is plotted between n *vs* V (volume of container) at 16.42 atm pressure as follows, then temperature of A and B respectively are:



(a) $\frac{200}{\sqrt{3}}$ K, $200\sqrt{3}$ K (b) $\frac{200}{\sqrt{3}}$ °C, $(200\sqrt{3})$ °C

(c) $200\sqrt{3}$ K, $\frac{200}{\sqrt{3}}$ K (d) 200 K, $\frac{\sqrt{3}}{200}$ K

27. At a constant pressure, what should be the percentage increase in the temperature in kelvin for a 10% increase in volume:

(a) 10% (b) 20% (c) 5% (d) 50%

28. 6 litre H_2O is placed in a closed room of volume 827 L at the temperature of 300 K. If vapour pressure of liquid water is 22.8 mm of Hg at 300 K and its density is 1 g/cm^3:
[Given : $R = 0.0821$ atm. L $\text{mol}^{-1}\ \text{K}^{-1}$, Assuming volume of liquid water to be constant]

	Column-I		Column-II
(P)	Mass of H_2O in gaseous form (in gm)	**(1)**	6
(Q)	Moles of H_2O in gaseous state (in moles)	**(2)**	18
(R)	Approximate mass of water left in liquid state (in kg)	**(3)**	3
(S)	Total number of moles of all atoms in vapour form	**(4)**	1

Codes :

	P	Q	R	S
(a)	1	2	4	3
(b)	4	3	2	1
(c)	2	3	1	4
(d)	1	2	3	4

29. Match the items of columns I and II.

Column-I		**Column-II**	
(P)	Z for ideal gas behaviour	**(1)**	3/8
(Q)	Z for real gas at low pressure	**(2)**	$\left(1+\frac{Pb}{RT}\right)$
(R)	Z for real gas at high pressure	**(3)**	1
(S)	Z for critical state	**(4)**	$\left(1-\frac{a}{RTV}\right)$

Codes :

	P	Q	R	S
(a)	1	2	4	3
(b)	4	3	2	1
(c)	2	1	4	3
(d)	1	2	3	4

30.

List-I (Conditions for real gas)		**List-II**	
(P)	If force of attraction among gas particles are negligible	**(1)**	$PV_m = RT$
(Q)	At 1 atm and 273 K	**(2)**	$PV_m = RT - \frac{a}{V_m}$
(R)	If the volume of gas particles is negligible	**(3)**	$\left(P+\frac{a}{V_m^2}\right)(V_m - b) = RT$
(S)	At low pressure and high temperature	**(4)**	$PV_m = RT + Pb$

Codes :

	P	Q	R	S
(a)	4	1	3	2
(b)	4	3	2	1
(c)	2	1	4	3
(d)	1	2	3	4

Level 3

PASSAGE 1

van der Waals' equation for calculating the pressure of a nonideal gas is

$$\left(P+\frac{an^2}{V^2}\right)(V-nb)=n\,RT$$

van der Waals' suggested that the pressure exerted by an ideal gas, P_{ideal}, is related to the experimentally measured pressure, P_{real} by the equation

$$P_{\text{ideal}} = \underset{\substack{\uparrow\\ \text{observed}\\ \text{pressure}}}{P_{\text{real}}} + \underset{\substack{\uparrow\\ \text{correction}\\ \text{term}}}{\frac{an^2}{V^2}}$$

Constant **a** is measure of intermolecular interaction between gaseous molecules that gives rise to nonideal behavior depends on how frequently any two molecules approach each other closely. Another correction concerns the volume occupied by the gas molecules. In the ideal gas equation, V represents the volume of the container. However, each molecule does occupy a finite, although small, intrinsic volume, so the effective volume of the gas becomes $(V-nb)$, where n is the number of moles of the gas and b is a constant. The term nb represents the volume occupied by n moles of the gas.

Having taken into account the corrections for pressure and volume, we can rewrite the ideal gas equation as follows :

$$\underset{\substack{\text{corrected}\\ \text{pressure}}}{\left(P+\frac{an^2}{V^2}\right)}\quad \underset{\substack{\text{corrected}\\ \text{volume}}}{(V-nb)}=nRT$$

1. At relatively high pressures, the van der Waals' equation of state reduces to
(a) $PV=RT-a/V$ (b) $PV=aRT/V^2$ (c) $P=RT-a/V^2$ (d) $PV=RT+Pb$

2. For non-zero value of force of attraction between gas molecules for large volume, gas equation will be :
(a) $PV=nRT-\frac{n^2a}{V}$ (b) $PV=nRT+nbP$ (c) $P=\frac{nRT}{V-b}$ (d) $PV=nRT$

3. The van der Waals' constant 'a' for CO_2 gas is greater than that of H_2 gas. Its mean that the
(a) strength of van der Waals' force of CO_2 gas is less than that of H_2 gas
(b) strength of van der Waals' force of CO_2 gas is equal to that of H_2 gas
(c) CO_2 gas can be more easily liquified
(d) H_2 gas can be more easily liquified

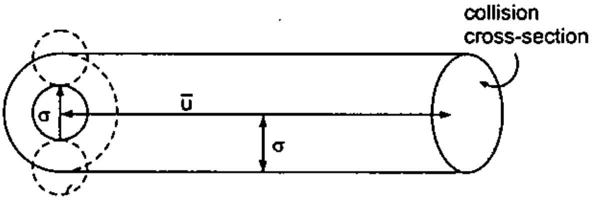
4. Using van der Waals' equation, find the constant 'a' (in atm L^2 mol^{-2}) when two moles of a gas confined in 4 L flask exerts a pressure of 11.0 atmospheres at a temperature of 300 K. The value of b is 0.05 L mol^{-1}. (R = 0.082 atm. L/K mol)

(a) 2.62 (b) 2.64 (c) 6.24 (d) 6.46

PASSAGE 2

Collision cross-section is an area of an imaginary sphere of radius σ around the molecule within which the centre of another molecule cannot penetrate.

The volume swept by a single molecule in unit time is



$$V = (\pi\sigma^2)\bar{u} \quad \text{where } \bar{u} \text{ is the average speed}$$

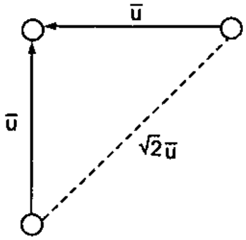
If N^* is the number of molecules per unit volume, then the number of molecules within the volume V is

$$N = VN^* = (\pi\sigma^2\bar{u})N^*$$

Hence, the number of collision made by a single molecule in unit time will be

$$Z = N = (\pi\sigma^2\bar{u})N^*$$

In order to account for the movements of all molecules, we must consider the average velocity along the line of centres of two colliding molecules instead of the average velocity of a single molecule. If it is assumed that, on an average, molecules collide while approaching each other perpendicularly, then the average velocity along their centres is $\sqrt{2}\,\bar{u}$ as shown below.



Number of collision made by a single molecule with other molecules per unit time is given by

$$Z_1 = \pi\sigma^2(\bar{u}_{rel})N^* = \sqrt{2}\,\pi\sigma^2\,\bar{u}N^*$$

The total number of bimolecular collisions Z_{11} per unit volume per unit time is given by

$$Z_{11} = \frac{1}{2}(Z_1N^*) \text{ or } Z_{11} = \frac{1}{2}(\sqrt{2}\pi\sigma^2\bar{u}N^*)\,N^* = \frac{1}{\sqrt{2}}\,\pi\sigma^2\bar{u}N^{*2}$$

If the collision involve two unlike molecules then the number of collisions Z_{12} per unit volume per unit time is given as

$$Z_{12} = \pi\sigma_{12}^2\left(\sqrt{\frac{8kT}{\pi\mu}}\right)N_1N_2$$

where N_1 and N_2 are the number of molecules per unit volume of the two types of molecules, σ_{12} is the average diameter of the two molecules and μ is the reduced mass.

The mean free path is the average distance travelled by a molecule between two successive collisions. We can express it as follows :

$$\lambda = \frac{\text{Average distance travelled per unit time}}{\text{No. of collisions made by a single molecule per unit time}} = \frac{\bar{u}}{Z_1}$$

or $$\lambda = \frac{\bar{u}}{\sqrt{2}\,\pi\sigma^2\bar{u}N^*} \Rightarrow \frac{1}{\sqrt{2}\,\pi\sigma^2 N^*}.$$

1. For a given gas the mean free path at a particular pressure is

(a) Independent of temperature (b) Decreases with rise in temperature

(c) Increases with rise in temperature (d) Directly proportional to T^2

2-3 Three ideal gas samples in separate equal volume containers are taken and following data is given :

	Pressure	Temperature	Mean free paths	Mol. wt.
Gas A	1 atm	1600 K	0.16 nm	20
Gas B	2 atm	200 K	0.16 nm	40
Gas C	4 atm	400 K	0.04 nm	80

2. Calculate ratio of collision frequencies (Z_{11}) ($A : B : C$) of following for the three gases.

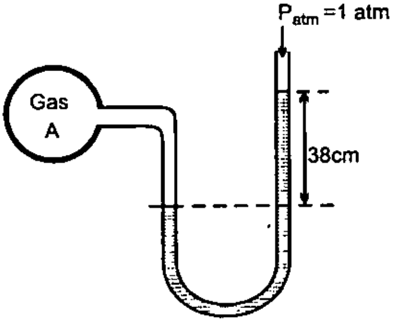
(a) 1 : 2 : 4 (b) 4 : 2 : 1 (c) 1 : 4 : 16 (d) 16 : 4 :1

3. Calculate number of collision by one molecule per sec (Z_1).

(a) 4 : 1 : 4 (b) 1 : 4 : 4 (c) 4 : 3 : 2 (d) 1 : 2 : 4

PASSAGE 3

A manometer contains a liquid of density 5.44 g/cm3 is attached to a flask containing gas 'A' as follows



1. If the same liquid is used in Barometer to measure the atmospheric pressure, then what will be the length of the liquid column, which exerts pressure equal to 1 atm ? (density of Hg = 13.6 g/cm^3)

(a) 190 cm (b) 76 cm (c) 30.4 cm (d) 266 cm

2. The initial pressure of gas A in the flask is:

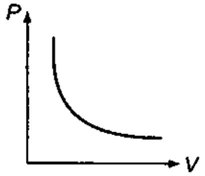
(a) 1.5 atm (b) 1 atm (c) 1.3 atm (d) 1.2 atm

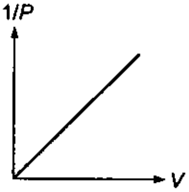
3. If gas A undergoes 30% trimerisation $[3A(g) \rightleftharpoons A_3(g)]$ then the difference in height of the liquid level in two columns is:

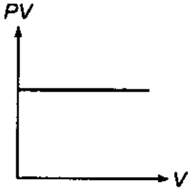
(a) 38 cm (b) 7.6 cm (c) 3.04 cm (d) 15.1 cm

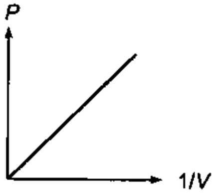
ONE OR MORE ANSWERS IS/ARE CORRECT

1. Which of the following curves represent(s) Boyle's law?

(a)


(b)


(c)


(d)


2. If a gas expands at constant temperature:

(a) the pressure decreases

(b) the kinetic energy of the molecules remains the same

(c) the K.E. of the molecules decrease

(d) the number of molecules of the gas increase

3. Which of the following statements are correct?

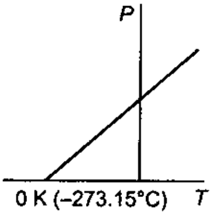
(a) It is not possible to compress a gas at a temperature below T_C

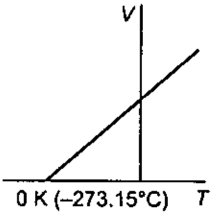
(b) At a temperature below T_C, the molecules are close enough for the attractive forces to act, and condensation occurs

(c) No condensation takes place above T_C

(d) Due to higher kinetic energy of the gas molecules above T_C, it is considered as super critical fluid.

4. What conclusion would you draw from the following graphs for an ideal gas?





(a) As the temperature is reduced, the volume as well as the pressure increase

(b) As the temperature is reduced, the volume becomes zero and the pressure reaches infinity

(c) As the temperature is reduced, the pressure decrease

(d) A point is reached where, theoretically, the volume become zero

5. At Boyle temperature:

(a) the effects of the repulsive and attractive intermolecular forces just offset each other

(b) the repulsive intermolecular forces are greater than the attractive intermolecular forces

(c) the repulsive intermolecular forces are less than the attractive intermolecular forces

(d) $b - \frac{a}{RT} > 0$

6. Indicate the correct statement for equal volumes of $N_2(g)$ and $CO_2(g)$ at 25°C and 1 atm.

(a) The average translational K.E. per molecule is the same for N_2 and CO_2

(b) The rms speed remains same for both $N_2$and CO_2

(c) The density of N_2 is less than that of CO_2

(d) The total translational K.E. of both N_2 and CO_2 is the same

7. Which of the following is correct for critical temperature?

(a) It is the highest temperature at which liquid and vapour can coexist

(b) Beyond this temperature, there is no distinction between the two phases and a gas cannot be liquefied by compression.

(c) At this temperature, the gas and the liquid phases have different critical densities

(d) All are correct

8. Consider the following statement regarding Maxwell's distribution of velocities. The correct statement(s) is/are :

(a) As temperature increases, the peak (maxima) of a curve is shifted towards right side

(b) As temperature increases, the most probable velocity of molecules increases but fraction of molecules of maximum velocity decreases

(c) The area under the curve at all the temperatures is the same because it represents the number of gaseous molecules

(d) The fractions of molecules having different velocities are different at a given temperature

9. If a gas expands at a constant pressure by providing heat :

(a) the temperature increases

(b) the kinetic energy of the gaseous molecules remains same

(c) the kinetic energy of gaseous molecules decreases

(d) the number of molecules of the gas decreases

10. Select incorrect statement(s) :

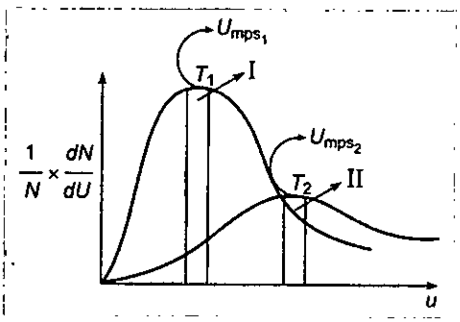
(a) the product of pressure and volume of fixed amount of a gas is independent of temperature

(b) the value of universal gas constant depends upon temperature, volume and number of gaseous molecules

(c) the gas constant also know as Boltzmann's constant

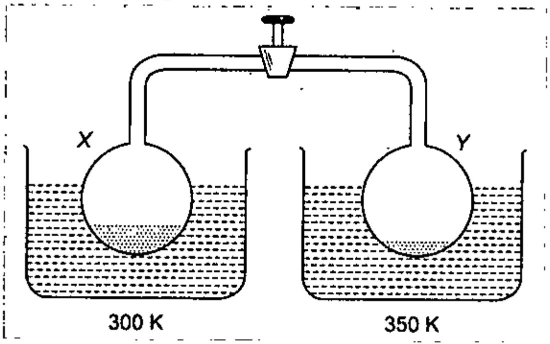
(d) the average kinetic energy of molecules depends only on temperature

11. Following represents the Maxwell distribution curve for an ideal gas at two temperature T_1 and T_2. Which of the following option(s) are true?



(a) Total area under the two curves is independent of moles of gas
(b) U_{mps} decreases as temperature decreases
(c) $T_1 > T_2$ and hence higher the temperature, sharper the curve
(d) The fraction of molecules having speed $= U_{mps}$ decreases as temperature increases

12. Two container each containing liquid water are connected as shown in diagram.



Given that vapour pressure of $H_2O(l)$ at 300 K and 350 K are 22 torr and 40 torr. Select write statement(s) :

(a) The final pressure in each container if valve is opened while keeping the containers at the given temperature is 22 torr
(b) The final pressure in each container if valve is opened while keeping the containers at the given temperature is 40 torr
(c) Mass of $H_2O(l)$ is decreased in vessel X
(d) Mass of $H_2O(l)$ is decreased in vessel Y

13. Select the correct statement(s) :

(a) At Boyle's temperature a real gas behaves like an ideal gas at low pressure
(b) Above critical conditions, a real gas behave like an ideal gas
(c) For hydrogen gas '*b*' domainates over '*a*' at all temperature
(d) At high pressure van der Waals' constant '*b*' domainates over '*a*'

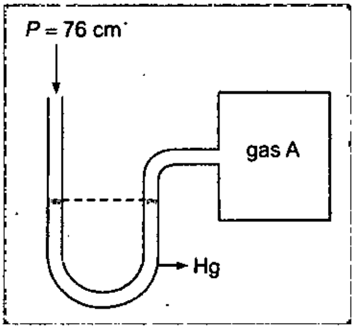
14. Select the correct statement :

(a) The value of compressibility factor '*Z*' for H_2 gas is greater than one at room temperature and pressure
(b) The real gas behaves as an ideal gas at Boyle's temperature.

(c) For a real gas following van der Waals' equation of state, the expression of critical temperature is $\frac{8a}{27R.b}$

(d) At low pressure, the compressibility factor 'Z' $= 1 + \frac{P.b}{RT}$ for a van der Waals' gas.

15. A open ended mercury manometer is used to measure the pressure exerted by a trapped gas as shown in the figure. Initially manometer shows no difference in mercury level in both columns as shown in diagram.



After sparking 'A' dissociates according to following reaction

$$A(g) \longrightarrow B(g) + 3C(g)$$

If pressure of Gas "A" decreases to 0.9 atm. Then (Assume temperature to be constant and is 300 K)

(a) total pressure increased to 1.3 atm

(b) total pressure increased by 0.3 atm

(c) total pressure increased by 22.3 cm of Hg

(d) difference in mercury level is 228 mm.

16. Select incorrect statements for real gas:

(a) Gases have only attraction forces in low pressure region

(b) Volume of gas particles is not negligible in low pressure

(c) Gases behaves as an ideal gas at low pressure

(d) In high pressure region attractive forces dominates

17. Select correct statements:

(a) A real gas can be liquified at critical temperature

(b) Critical pressure is the maximum pressure at which substance present in its liquid state at T_C

(c) Ideal gas can be liquified below T_C

(d) Critical volume is the molar volume of substance in gaseous state at T_C and P_C

18. Which is/are correct for real gases?

(a) $\underset{P \to 0}{Lt}(PV_m)$ = constant at constant high temperature

(b) $\underset{V_m \to 0}{Lt}(PV_m)$ = constant at constant low temperature

(c) $\underset{P\to 0}{Lt}\left(\frac{PV_m}{RT}\right) = 1$ at high temperature

(d) $\underset{V\to 0}{Lt}\left(\frac{PV_m}{RT}\right) = R$

19. Select incorrect statement(s)
(a) At very low pressure real gases show minimum deviation from ideal behaviour.
(b) The compressibility factor for an ideal gas is zero.
(c) At Boyle temperature real gas behave as ideal gas in high pressure region.
(d) Real gas show maximum deviation at high pressure and low temperature.

20. If an ideal gas is heated at constant pressure:
(a) The volume increases
(b) The mass of gas remains same
(c) The kinetic energy of the molecules increases
(d) Attraction forces between gas particles increases

MATCH THE COLUMN

Column-I and **Column-II** contains four entries each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

1.

Column I	**Column II**
(A) Boyle's temperature	(P) a/Rb
(B) Inversion temperature	(Q) $8a/27Rb$
(C) Critical temperature	(R) $2a/Rb$
(D) Critical pressure	(S) $a/27b^2$

2.

Column I	**Column II**
(A) Root mean square velocity	(P) $\frac{3}{2}RT$
(B) Most probable velocity	(Q) $\sqrt{\frac{8P}{\pi d}}$
(C) Average velocity	(R) $\sqrt{\frac{3P}{d}}$
(D) K.E. of gas mol^{-1}	(S) $\sqrt{\frac{2RT}{M}}$

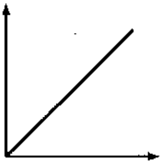
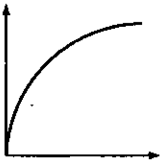
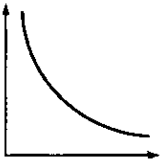
3.

Column I	Column II
(A) If force of attraction among the gas molecules be negligible	(P) $\left(P+\frac{a}{V^2}\right)(V-b)=RT$
(B) If the volume of the gas molecules be negligible	(Q) $PV=RT-\frac{a}{V}$
(C) At STP	(R) $PV=RT+Pb$
(D) At low pressure and at high temperature	(S) $PV=RT$

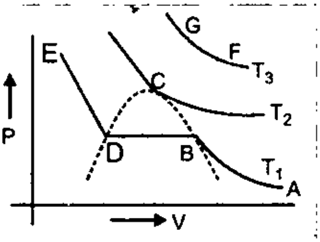
4. Match gases under specified conditions listed in Column I with their properties/laws in Column II.

Column I	Column II
(A) Hydrogen gas ($P=200$ atm, $T=273$K)	(P) Compressibility factor $\neq 1$
(B) Hydrogen gas ($P\sim 0$, $T=273$ K)	(Q) Attractive forces are dominant
(C) CO_2 ($P=1$ atm, $T=273$ K)	(R) $PV=nRT$
(D) Real gas with very large molar volume	(S) $P(V-nb)=nRT$

5.

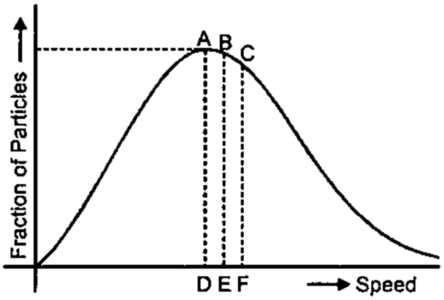
Column I	Column II
(A) $\frac{1}{V^2}$ vs. P for ideal gas at constant T and n.	(P) 
(B) V vs. $\frac{1}{T}$ for ideal gas at constant P and n	(Q) 
(C) PT vs. T^2 for ideal gas at constant T and n.	(R) 
(D) V vs. $\frac{1}{p^2}$ for ideal gas at constant T and n.	(S) 

6. Match the correct column from list-1 to list-2 on the basis of following Andrews isotherm of Real gas.



Column-I	Column-II
(A) Substance exist in both liquid and gas state	(P) At AB part
(B) Only liquid state exist	(Q) At BD part
(C) Substance exist in gas state only	(R) At DE part
(D) Real gas is called super critical fluid	(S) At point C
	(T) At GF curve

7.



Column-I	Column-II
(A) Speed at point 'A' is	(P) $\sqrt{\frac{8RT}{\pi M}}$
(B) Speed at point 'B' is	(Q) $\sqrt{\frac{3RT}{M}}$
(C) Speed at point 'C' is	(R) U_{rms}
(D) The speed possessed by maximum fraction of the gas particles	(S) $\sqrt{\frac{2RT}{M}}$

ASSERTION-REASON TYPE QUESTIONS

Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason).

Examine the statements carefully and mark the correct answer according to the instructions given below

(A) If both the statement are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1

(B) If both the statement are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT-1

(C) If STATEMENT-1 is TRUE and STATEMENT-2 is FALSE

(D) If STATEMENT-1 is FALSE and STATEMENT-2 is TRUE

1. **STATEMENT-1 :** The heat absorbed during the isothermal expansion of an ideal gas against vacuum is zero.
   STATEMENT-2 : The volume occupied by the molecules of an ideal gas is zero.
2. **STATEMENT-1 :** A lighter gas diffuses more rapidly than a heavier gas.
   STATEMENT-2 : At a given temperature, the rate of diffusion of a gas is inversely proportional to the density.
3. **STATEMENT-1 :** The value of the van der Waals' constant 'a' is larger for ammonia than for nitrogen.
   STATEMENT-2 : Hydrogen bonding is present in ammonia.
4. **STATEMENT-1 :** Helium shows only positive deviation from ideal behaviour at room temperature.
   STATEMENT-2 : Helium is an inert gas.
5. **STATEMENT-1 :** CH_4, CO_2 has value of Z (compressibility factor) less than one at 0°C.
   STATEMENT-2 : $Z < 1$ is due to the attractive forces dominate among the molecules.
6. **STATEMENT-1 :** The Joule-Thomson coefficient for an ideal gas is zero.
   STATEMENT-2 : There are no intermolecular attractive forces in an ideal gas.
7. **STATEMENT-1 :** The average translational kinetic energy per molecule of the gas per degree of freedom is 1/2 KT.
   STATEMENT-2 : For every molecule there are three rotational degree of freedom.
8. **STATEMENT-1 :** On increasing the temperature, the height of the peak of the Maxwell distribution curve decreases.
   STATEMENT-2 : The fraction of molecules is very less at the higher velocities.
9. **STATEMENT-1 :** The gases He and H_2 are very different in their behaviour at any temperature and pressure but their compressibility factors are nearly the same at the critical point.
   STATEMENT-2 : They have nearly the same critical constant.

10. STATEMENT-1 : Most probable velocity is the velocity possessed by maximum fraction of molecules at the same temperature.

STATEMENT-2 : On collision, more and more molecules acquire higher velocity at the same temperature.

11. STATEMENT-1 : Plot of P *vs* $1/V$ (volume) is a straight line for an ideal gas.

STATEMENT-2 : Pressure is directly proportional to volume for an ideal gas.

12. STATEMENT-1 : 1 mol of H_2 and O_2 each occupy 22.7 L of volume at 0°C and 1 bar pressure, considering ideal behaviour.

STATEMENT-2 : Molar volume for all ideal gases at the same temperature and pressure are equal.

13. STATEMENT-1 : Reacting gases react to form a new gas having pressure equal to the sum of their partial pressure.

STATEMENT-2 : Pressure exerted by a mixture of non-reacting gases present in a container is equal to the sum of their partial pressures.

14. STATEMENT-1 : $1/4^{th}$ of the initial mole of the air is expelled, if air present in an open vessel is heated from 27°C to 127°C.

STATEMENT-2 : Rate of diffusion of a gas is inversely proportional to the square root of its molecular mass.

15. STATEMENT-1 : Compressibility factor for hydrogen varies with pressure with positive slope at all pressures at 0°C.

STATEMENT-2 : Even at low pressures, Repulsive forces dominate hydrogen gas at 0°C.

16. STATEMENT-1 : Wet air is heavier than dry air.

STATEMENT-2 : The density of dry air is less than the density of water at 1 atm and 273K.

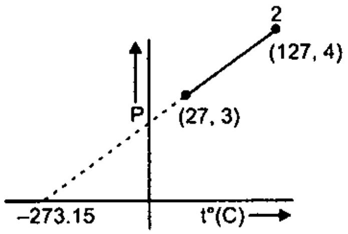
SUBJECTIVE PROBLEMS

1. Collapsible balloon is inflated to a volume of 10 L at a pressure of 1 atm. When the balloon is immersed to the bottom of a lake, its volume reduce to 1.25 L. Assuming atmospheric pressure to be equivalent to 10 m column of water and no change in temperature. If the depth of the lake is $x \times 10^3$ cm, what is the value of x ?

2. A gaseous mixture containing equal moles of H_2, O_2 and He is subjected to series of effusion steps. The composition (by moles) of effused mixture after 4 effusion steps is $x:1:y$ respectively. Then find the value of $\left(\frac{x}{y}\right)$.

3. One mole of a gas changed from its initial state (15 L, 2 atm) to final state (4 L, 10 atm) reversibly. If this change can be represented by a straight line in $P-V$ curve maximum temperature (approximate), the gas attained is $x \times 10^2$ K. Then find the value of x.

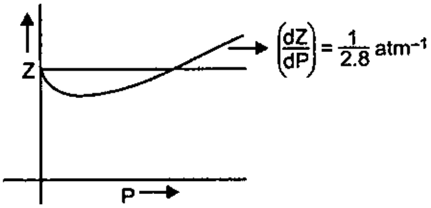
4. Two moles of an ideal gas undergoes the following process. Given that $\left(\frac{\partial P}{\partial T}\right)_V$ is $x \times 10^{-y}$, then calculate the value of $(x+y)$



5. If 1 mole of a diatomic gas present in 10 L vessel at certain temperature exert a pressure of 0.96 atm. Under similar conditions an ideal gas exerted 1.0 atm pressure. If volume of gas molecule is negligible. Then find the value of van der Waals' constant "a" (in atm L^2/mol^2).

6. The graph of compressibility factor (Z) vs. P for one mole of a real gas is shown in following diagram. The graph is plotted at constant temperature 273 K. If the slope of graph at very high pressure $\left(\frac{dZ}{dP}\right)$ is $\left(\frac{1}{2.8}\right)$ atm^{-1}, then calculate volume of one mole of real gas molecules (in L /mol)

Given : $N_A = 6 \times 10^{23}$ and $R = \frac{22.4}{273}$ L atm $K^{-1} mol^{-1}$

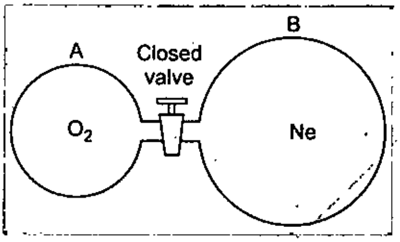


7. Under the identical conditions of temperature, the density of a gas X is two times to that of gas Y while molecular mass of gas Y is three times that of X. Calculate the ratio of pressure of X and Y.

8. The time taken for a certain volume of a certain gas to diffuse through a small hole was 2 min. Under similar conditions an equal volume of oxygen took 5.65 min to pass. What is the molecular mass of gas (in amu) ?

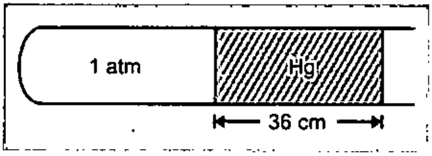
9. If excess $F_2(g)$ reacts at 150°C and 1.0 atm pressure with $Br_2(g)$ to give a compound BrF_n, if 423 mL of $Br_2(g)$ at the same temperature and pressure produced 4.2 g of BrF_n, what is n ? [Atomic mass Br = 80, F = 19]

10. Initially bulb "A" contained oxygen gas at 27°C and 950 mm of Hg and bulb "B" contained neon gas at 27°C and 900 mm of Hg. These bulbs are connected by a narrow tube of negligible volume equipped with a stopcock and gases were allowed to mix-up freely. Then obtain pressure in the combined system was found to be 910 mm of Hg.



If volume of bulb *B* was measured to be 10 L. Then find the mass of oxygen gas present initially in bulb "*A*".

11. Air is trapped in a horizontal glass tube by 40 cm mercury column as shown below :



If the tube is held vertical keeping the open end up, length of air column shrink to 19 cm. What is the length (in cm) by which the mercury column shifts down?

12. A flask containing air at 107°C and 722 mm of Hg is cooled to 100 K and 760 mm of Hg. If density in the initial condition 1 g/cm^3, then what is the final density (g/cm^3)?

13. If an ideal gas at 100 K is heated to 109 K in a rigid container, the pressure increases by X%. What is the value of *X*?

14. The vander Waal's constants for a gas are $a = 3.6$ atm L^2 mol^{-2}, $b = 0.6 L.mol^{-1}$. If $R = 0.08$ L atm K^{-1} mol^{-1}. If the Boyle's temperature (K) is T_B of this gas, then what is the value of $\frac{T_B}{15}$?

15. A flask has 10 gas particles out of which four particles are moving at 7 ms^{-1} and the remaining are moving at the same speed of '*X*' ms^{-1}. If the r.m.s. of the gas is 5 ms^{-1}, what is the value of *X* ?

ANSWERS

Level 1

1. (c)	2. (c)	3. (a)	4. (d)	5. (a)	6. (b)	7. (a)	8. (d)	9. (c)	10. (c)
11. (a)	12. (a)	13. (c)	14. (c)	15. (b)	16. (c)	17. (a)	18. (a)	19. (c)	20. (c)
21. (b)	22. (b)	23. (a)	24. (d)	25. (d)	26. (c)	27. (b)	28. (a)	29. (c)	30. (b)
31. (c)	32. (b)	33. (b)	34. (b)	35. (a)	36. (d)	37. (d)	38. (c)	39. (c)	40. (a)
41. (a)	42. (b)	43. (c)	44. (a)	45. (d)	46. (a)	47. (c)	48. (d)	49. (b)	50. (a)
51. (b)	52. (d)	53. (c)	54. (b)	55. (b)	56. (d)	57. (a)	58. (a)	59. (c)	60. (a)
61. (d)	62. (d)	63. (b)	64. (a)	65. (b)	66. (c)	67. (b)	68. (b)	69. (a)	70. (a)
71. (c)	72. (a)	73. (a)	74. (b)	75. (d)	76. (c)	77. (b)	78. (b)	79. (b)	80. (a)
81. (b)	82. (d)	83. (a)	84. (a)	85. (c)	86. (a)	87. (b)	88. (b)	89. (b)	90. (b)
91. (b)	92. (a)	93. (c)	94. (b)	95. (a)	96. (b)	97. (d)	98. (d)	99. (b)	100. (d)
101. (c)	102. (c)	103. (a)	104. (c)	105. (a)	106. (b)	107. (c)	108. (d)	109. (b)	110. (c)
111. (c)	112. (b)	113. (b)	114. (d)	115. (d)	116. (b)	117. (d)	118. (b)	119. (a)	120. (d)
121. (a)	122. (b)	123. (b)	124. (b)	125. (b)	126. (c)	127. (d)	128. (a)	129. (a)	130. (c)
131. (b)	132. (d)	133. (a)	134. (b)	135. (c)	136. (c)	137. (b)	138. (a)	139. (c)	140. (b)
141. (d)	142. (b)	143. (a)	144. (c)	145. (c)	146. (c)	147. (c)	148. (d)	149. (d)	150. (a)
151. (c)	152. (c)	153. (d)	154. (a)	155. (b)	156. (a)	157. (c)	158. (d)	159. (c)	160. (d)
161. (d)	162. (d)	163. (a)	164. (b)	165. (b)	166. (d)	167. (a)	168. (d)	169. (b)	170. (a)
171. (c)	172. (c)	173. (a)	174. (a)	175. (b)					

Level 2

1. (b)	2. (c)	3. (c)	4. (b)	5. (b)	6. (b)	7. (c)	8. (a)	9. (d)	10. (b)
11. (a)	12. (c)	13. (b)	14. (d)	15. (d)	16. (b)	17. (d)	18. (c)	19. (c)	20. (b)
21. (b)	22. (c)	23. (a)	24. (b)	25. (b)	26. (c)	27. (a)	28. (c)	29. (b)	30. (b)

Level 3

Passage–1 1. (d) 2. (a) 3. (c) 4. (d)

Passage–2 1. (c) 2. (c) 3. (a)

Passage–3 1. (a) 2. (d) 3. (b)

One or More Answers is/are correct

1. (a,b,c,d) 2. (a,b) 3. (b,c,d) 4. (c,d) 5. (a) 6. (a,c,d) 7. (a,b) 8. (a,b,c,d)
9. (a) 10. (a,b,c) 11. (a,b,d) 12. (a,d) 13. (a,b,d) 14. (a,b,c) 15. (a,b,d) 16. (a,b,c)
17. (a,d) 18. (a,c) 19. (b,c) 20. (a,b,c)

Match the Column

1. A → P; B → R; C → Q; D → S
2. A → R; B → S; C → Q; D → P
3. A → R; B → Q; C → P; D → S
4. A → P, S; B → R; C → P, Q; D → R
5. A → R; B → S; C → P; D → Q
6. A → Q, S; B → R; C → P, T; D → T
7. A → S; B → P; C → Q, R; D → S

Assertion-Reason Type Questions

1. (B) 2. (C) 3. (A) 4. (B) 5. (A) 6. (A) 7. (C) 8. (B) 9. (C) 10. (C)
11. (C) 12. (A) 13. (D) 14. (B) 15. (A) 16. (D)

Subjective Problems

1. 7 2. 4 3. 7 4. 3 5. 4 6. 2 7. 6 8. 4 9. 5 10. 4
11. 9 12. 4 13. 9 14. 5 15. 3

Hints and Solutions

Level 1

27. (b) The moles of the gas in the bubble remains constant, so that $n_1 = n_2$. To calculate the final volume, V_2,

$$V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1}$$

$$= 2.0 \text{ mL} \times \frac{6.0 \text{ atm}}{1.0 \text{ atm}} \times \frac{298 \text{ K}}{281 \text{ K}}$$

$$= 12.72 \text{ mL}$$

39. (c) Because the number of moles is constant.

$$\frac{P_iV_i}{T_i} = \frac{P_fV_f}{T_f}; \quad P_f = \frac{P_iV_iT_f}{V_fT_i}$$

$$P_f = \frac{P_iV_iT_f}{V_fT_i}$$

$$= 3.21 \times 10^5 \text{ Pa} \times \frac{V_i}{1.03\,V_i} \times \frac{(273 + 28.0)}{(273 - 5.00)}$$

$$= 3.50 \times 10^5 \text{ Pa}$$

51. (b) Intercept on y-axis

$$= \log_{10} \frac{nR}{V} = \log_{10} \frac{10 \times 0.0821}{8.21} = -1.0$$

$\frac{P}{T}$ v/s curve $\frac{P}{T} = \frac{nR}{V}$

$$\text{Intercept} = \frac{nR}{V}$$

$$= \frac{10 \times 0.0821}{8.21} = 0.1, \quad \text{slope} = 0$$

53. (c) $d_A = 2d_B$; $3M_A = M_B$; $PM = dRT$

$$= \frac{P_A}{P_B} \times \frac{M_A}{M_B} = \frac{d_A}{d_B} \times \frac{RT}{RT}$$

$$= \frac{P_A}{P_B} \times \frac{1}{2} = 2$$

$$\frac{P_A}{P_B} = \frac{4}{1}$$

54. (b) Case I—Suppose inner balloon burst first

$$\frac{600}{300} = \frac{800}{T_2} \Rightarrow T_2 = 400 \text{ K}$$

Case II—Suppose outer balloon burst first

$$\frac{1500}{300} = \frac{1800}{T_2}; \quad T_2 = 360 \text{ K}$$

55. (b) $V_1 = V, T_1 = 300$ K, $T_2 = 500$ K, $V_2 = ?$

At constant pressure $V_1T_2 = V_2T_1$

$$\therefore \quad V_2 = \frac{V_1T_2}{T_1} = \frac{V \times 500}{300} = \frac{5\,V}{3}$$

$\therefore$ Volume of air escaped

= final volume − initial volume

$$= \frac{5\,V}{3} - V = \frac{2\,V}{3}$$

$$\therefore \ \% \text{ of air escaped} = \frac{2\,V/3}{5\,V/3} \times 100 = 40\%$$

57. (a)

	$2NH_3(g)$	$\longrightarrow$	$N_2(g)$ +	$3H_2(g)$
Before sparking	76		0	0
After sparking at eqm	$76 - 2x$		x	$3x$

Increase in pressure $2x = 18$; $x = 9$ cm Hg

Partial pressure of $H_2 = 3 \times 3 = 9$ cm Hg

60. (a) $h_g d_g = h_{Hg} d_{Hg}$; $5 \times 2.72 = 13.6\, h_{Hg}$

$h_{Hg} = 1$ m

$P_{gas} = 0.76$ dg + 1 dg = 1760 mm of Hg

$$\frac{1760}{760} \times 10 = n \times R \times 300$$

$$n = 0.94 \text{ mole}$$

65. (b) $P_1 = \frac{5 \times RT}{V}$; p.pr. of He $= \frac{2}{5} \times \left(\frac{5RT}{V}\right)$

$$= \frac{2 \times 0.0821 \times 400}{8.21}$$

$$= 8 \text{ atm}$$

66.(c) $$P_{O_2} = \frac{3}{10} \times P_T;$$

After removing 2 mole of O_2,

$$P'_{O_2} = \frac{1}{8} \times P_T$$

$$\text{Decreasing in p.pr. of } O_2 = \frac{\frac{3P_T}{10} - \frac{P_T}{8}}{\frac{3P_T}{10}} \times 100$$

$$= 58.33$$

67. (b) $P_{total} = P_{N_2} + P_{H_2O}$; $P_{N_2} = 730$ torr;

$$n_{N_2} = \frac{\left(\frac{730}{760}\right) \times 0.821}{0.0821 \times 300} = 0.032$$

69. (a) Volume of $O_2 = 1$ L

and $p_{O_2} = 760 - 355 = 405$ mm Hg

Since, the temperature is constant, using Boyle's law we get

$$1 \text{ L} \times 405 \text{ mm} \equiv 0.3 \text{ L} \times p'_{O_2}$$

$$\therefore \quad p'_{O_2} = 1350 \text{ mm Hg}$$

77. (b) $P_{gas} = P_{dry\,gas} + P_{moisture}$ at T K

or $P_{dry} = 830 - 30 = 800$

Now at $T_2 = 0.99\,T_1$;

at constant volume $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$$P_{dry} = \frac{800 \times 0.99\,T}{T} = 792 \text{ mm}$$

$$\therefore \quad P_{gas} = P_{dry} + P_{moisture}$$

$$= 792 + 25 = 817 \text{ mm}$$

78. (b) We have $P_{O_2} = X_{O_2} \times P_{total}$

$$\therefore \quad 0.60 = \frac{n_{O_2}}{n_{O_2} + n_{SO_2}} \times P_{total}$$

Let no. of moles of O_2 are x;

$$0.60 = \frac{x/32}{x/32 + 3x/64} \times P_{total}$$

$$\therefore 0.60 = 0.4 \times P_{total}$$

$$\therefore \quad P_{total} = \frac{0.60}{0.4} = 1.5 \text{ atm}$$

$$\because \quad P_{O_2} + P_{SO_2} = 1.5 \text{ atm}$$

$$\Rightarrow P_{SO_2} = 1.5 - P_{O_2} = 1.5 - 0.60 = 0.9 \text{ atm}$$

$$\therefore \text{Concentration of } SO_2 = \frac{0.9}{0.0821 \times 300}$$

$$= 0.036$$

79. (b) Given $P = 10$ atm,

total numbers of moles; $n_A + n_B + n_C = 10$

$P_A = 3$ atm, $P_B = 1$ atm, $n_A = 3$, $n_B = 1$

$$\because \quad P_A = x_A \times P_{(total)} = \frac{n_A}{n_A + n_B + n_C} \times 10$$

$$= \frac{n_A}{10} \times 10 \; n_A = 3$$

Similarly, $P_B = x_B \times P_{(total)}$

So, $n_B = 1$

$$\therefore \quad n_C = 10 - (n_A + n_B) = 10 - 4 = 6$$

Weight of C $= 6 \times 2 = 12$ g

80. (a)
$$PV = \frac{10}{M} RT \qquad \ldots(1)$$

Let x g of the gas remain in the flask when final press $\frac{P}{2}, \frac{2T}{3}$

$$\therefore \quad \left(\frac{P}{2}\right) V = \left(\frac{x}{M}\right) R \left(\frac{2T}{3}\right) \qquad \ldots(2)$$

$$(1)/(2) \Rightarrow \quad 2 = \frac{10}{x} \times \frac{3}{2}$$

$$x = \frac{3 \times 10}{4} = 7.5 \text{ g}$$

85. (c) From the total pressure and the vapour pressure of water we can calculate the partial pressure of O_2.

$$P_{O_2} = P_T - P_{H_2O}$$

$$= 760 - 22.4$$

$$= 737.6 \text{ mm Hg}$$

From the ideal gas equation we write

$$m = \frac{PVM}{RT}$$

$$= \frac{(0.974 \text{ atm})(0.128 \text{ L})(32.0 \text{ g/mol})}{(0.0821 \text{ L atm/K mol})(273 + 24) \text{ K}}$$

$$= 0.163 \text{ g}$$

96. (b) Moles ratio $= \frac{n_{He}}{n_{N_2}} = \frac{w/4}{w/28} = \frac{7}{1}$

$$\text{Ratio of translational K.E.} = \frac{n_{He} \cdot T_{He}}{n_{N_2} \cdot T_{N_2}}$$

$$= \frac{7}{1} \times \frac{300}{700} = 3:1$$

104. (c) $V_{rms} = \sqrt{\frac{3RT}{M}} = \frac{(V_{rms})_{H_2}}{(V_{rms})_{N_2}} = \sqrt{\frac{T_{H_2}}{M_{H_2}} \times \frac{M_{N_2}}{T_{N_2}}}$;

$$(V_{rms})_{H_2} = \sqrt{5}\,(V_{rms})_{N_2}$$

$$\therefore \quad \frac{(V_{rms})_{H_2}}{(V_{rms})_{H_2}} \times \sqrt{5} = \sqrt{\frac{T_{H_2}}{T_{N_2}} \times \frac{28}{2}}$$

$$= \frac{\sqrt{5}}{1} = \sqrt{\frac{T_{H_2}}{T_{N_2}} \times 14}$$

$$= 5 = \frac{T_{H_2}}{T_{N_2}} \times 14$$

$$T_{N_2} \times 5 = T_{H_2} \times 14$$

$$\therefore \quad T_{N_2} > T_{H_2}$$

106. (b) $200 = \sqrt{\dfrac{2RT}{2 \times 10^{-3}}} = RT = 40$

$$\text{Average K.E.} = \frac{3}{2}nRT = \frac{3}{2} \times \frac{8}{2} \times 40$$

$$= 240 \text{ J}$$

107. (c) Second member of C_nH_{2n} series

$$= C_3H_6 = 42$$

$$= \sqrt{\frac{8RT_1}{\pi M_1}} = \sqrt{\frac{8RT_2}{\pi M_2}} = \frac{900}{71} = \frac{T_2}{42}$$

$$T_2 = 532.4 \text{ K}$$

109. (b) $P = \dfrac{1}{3}\dfrac{nmc^2}{V}$

$$= \frac{1}{3} \times \frac{6 \times 10^{22} \times 10^{-24} \times (100)^2}{10 \times 10^{-3}}$$

$$= 2 \times 10^4 \text{ Pa}$$

110. (c) Second member is C_3H_4;

$$\sqrt{\frac{2RT_1}{M_1}} = \sqrt{\frac{2RT_2}{M_2}}$$

$$T_1 = T_2\left(\frac{M_1}{M_2}\right) = 800\left(\frac{40}{64}\right) \text{K}$$

$$= 500 \text{ K} \quad \text{or} \quad 227°\text{C}$$

111. (c) $300 = \sqrt{\dfrac{3RT}{4 \times 10^{-3}}}; \quad RT = 120$

$$\text{Total K.E. of He gas} = \frac{3}{2}nRT$$

$$= \frac{3}{2} \times \frac{8}{4} \times 120 \text{ J}$$

$$= 360 \text{ J}$$

113. (b) $U_1 = \sqrt{\dfrac{3P_1}{d_1}}$

$$\therefore \quad \Delta U_{\text{rms}} = \sqrt{\frac{3}{d}}\,(\sqrt{P_2} - \sqrt{P_1})$$

$$= \sqrt{\frac{3}{0.75}}\,(300 - 200)$$

$$= \sqrt{4} \times 100 = 200$$

115. (d) $\alpha : v : u = \sqrt{2} : \sqrt{\dfrac{8}{\pi}} : \sqrt{3}$

116. (b) $\sqrt{\dfrac{8RT}{\pi M}} = \sqrt{\dfrac{28}{88}} = \sqrt{\dfrac{7}{22}}$

$$\frac{8 \times 8.314 \times T}{\pi \times 16 \times 10^{-3}} = \frac{7}{22} \times 10^6$$

$$T = \frac{1000 \times 2}{8.314} = 240.55 \text{ K}$$

$$T\,°\text{C} = 240.55 - 273 = -32.45°\text{C}$$

117. (d) $\sqrt{\dfrac{2RT}{M_{SO_2}}} = \sqrt{\dfrac{3R \times T_1}{M_{O_2}}} \Rightarrow \dfrac{2 \times T}{64} = \dfrac{3 \times 300}{32}$

$$T = 900 \text{ K}$$

119. (a) Rate of diffusion $\propto \dfrac{1}{\sqrt{d}} \propto P$

$$\therefore \quad \text{Rate of diffusion} \propto \frac{P}{\sqrt{d}}$$

125. (b) $\dfrac{r_{O_2}}{r_{CH_4}} = \dfrac{n_{O_2}}{n_{CH_4}} = \sqrt{\dfrac{M_{CH_4}}{M_{O_2}}}$

$$= \frac{3}{2} \times \frac{16}{32} \times \sqrt{\frac{16}{32}} = \frac{3}{4\sqrt{2}}$$

126. (c) $\dfrac{\dfrac{n^3_{SO_2}}{n^3_{CH_4}}}{8/1} = \left(\dfrac{16}{64}\right)^{3/2} = \dfrac{1}{1};$

$$\frac{r_{SO_2}}{r_{CH_4}} = \frac{1}{1} \cdot \sqrt{\frac{16}{64}} = \frac{1}{2}$$

127. (d) $\dfrac{n'_{He}}{n'_{CH_4}} = \dfrac{1}{2}\sqrt{\dfrac{16}{4}} = \dfrac{1}{1}$

$$\frac{n'_{He}}{n'_{SO_2}} = \frac{1}{3}\sqrt{\frac{64}{4}} = \frac{4}{3}$$

$$n'_{He} : n'_{CH_4} : n'_{SO_2} = 4 : 4 : 3$$

128. (a) $\dfrac{r_1}{r_2} = \dfrac{V_1/t_1}{V_2/t_2} = \dfrac{V_1 \times t_2}{V_2 \times t_1} = \sqrt{\dfrac{M_2}{M_1}};$

$$\frac{80 \times 3}{V_2 \times 2} = \sqrt{\frac{64}{32}} = \sqrt{2}; \quad V_2 = \frac{120}{\sqrt{2}}$$

130. (c) $\dfrac{r_{CH_3OCH_3}}{r_{CH_4}} = \sqrt{\dfrac{M_{CH_4}}{M_{CH_3OCH_3}}} \times \dfrac{P_{CH_3OCH_3}}{P_{CH_4}}$

$$= \sqrt{\frac{16}{46}} \times \frac{0.8}{0.2} = 2.36 : 1$$

131. (b) $\dfrac{n_1 \cdot t_2}{n_2 \cdot t_1} = \sqrt{\dfrac{M_2}{M_1}}; \quad \dfrac{w_1}{M_1} \times \dfrac{M_2}{w_2} = \sqrt{\dfrac{M_2}{M_1}}$

$$\frac{w_1}{w_2} = \sqrt{\frac{M_1}{M_2}}; \quad \frac{w_1}{4} = \sqrt{\frac{4}{64}}$$

$$\Rightarrow \quad w_1 = 1 \text{ gm}$$

132. (d) $\dfrac{r_{\text{mix}}}{r_x} = \dfrac{4/5}{4/10} = 2 = \sqrt{\dfrac{M_x}{M_{\text{Mix}}}}$

$$\Rightarrow M_{\text{mix}} = 9$$

$$M_{\text{mix}} = M_{H_2}X_{H_2} + M_{CH_4}X_{CH_4}$$
$$= 2X_{H_2} + 16\,(1 - X_{H_2}) = 9$$
$$\Rightarrow \qquad X_{H_2} = 0.5$$

133. (a) Mass of the filled balloon = 50 + 685

= 735 kg

Pay load = Mass of displaced air − Mass of balloon

$\therefore$ = 5108 − 735 = 4373 kg

135. (c) $C_v = \frac{3}{2}R + R + 4R \times \frac{3}{4} = \frac{11}{2}R$;

$$C_p = \frac{11}{2}R + R = \frac{13}{2}R$$
$$\frac{C_p}{C_v} = \frac{13}{11} = 1.18$$

136. (c) $C_v = \dfrac{\left(\frac{3}{2}R + \frac{5}{2}R\right)}{2} = 2R$

$$C_p = \frac{\left(\frac{5}{2}R + \frac{7}{2}R\right)}{2} = 3R$$
$$\frac{C_p}{C_v} = 1.5$$

137. (b) $\left.\begin{array}{l} C_v = \frac{3}{2}RT \\ C_p = \frac{5}{2}RT \end{array}\right\}$ for monoatomic gas;

$\left.\begin{array}{l} C_v = \frac{5}{2}2RT \\ C_p = \frac{7}{2}RT \end{array}\right\}$ for diatomic gas

Thus, for mixture of 1 mole each,

$$C_v = \frac{\frac{3}{2}RT + \frac{5}{2}RT}{2}$$

and $$C_p = \frac{\frac{5}{2}RT + \frac{7}{2}RT}{2}$$

Thus, $\dfrac{C_p}{C_v} = \dfrac{3RT}{2RT} = 1.5$

145. (c) $P(V - b) = RT$; $P = \dfrac{RT}{(V - b)}$;

$$P = \left(\frac{R}{(V - b)}\right)T + 0$$

146. (c) $b = 4 \times$ volume occupied by molecules of 1 mol of a gas,

or $\qquad b = 4N_A\left(\frac{4}{3}\pi r^3\right)$

or $\qquad r = \left(\dfrac{3b}{16N_A\pi}\right)^{1/3}$

$$= \left[\frac{3 \times 24}{16 \times 6.023 \times 10^{23} \times 3.14}\right]^{1/3} \text{cm}$$
$$= 1.355 \times 10^{-8} \text{ cm}$$

Now, molecular diameter, $d = 2r$

$= 2.67 \times 10^{-8}$ cm

152. (c) At low pressure,

$$\left(P + \frac{a}{V^2}\right)(V) = RT$$

i.e., $\qquad PV^2 - RTV + a = 0$

$$V = \frac{RT \pm \sqrt{R^2T^2 - 4Pa}}{2P} = \frac{RT}{2P}$$

$(\because\ 4a{\cdot}P = R^2T^2)$

154. (a) $\dfrac{PV}{RT} = Z \quad \therefore\ Z = 1 - \dfrac{a}{VRT}$

155. (b) van der Waals' equation for one mole of a real gas is

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

or $\qquad PV = RT + Pb + \dfrac{ab}{V^2} - \dfrac{a}{V}$

At high pressures, the van der Waals' gas equation reduces to $PV = RT + Pb$

or $\qquad \dfrac{PV}{RT} = 1 + \dfrac{Pb}{RT}$

$\therefore$ Compressibility factor $Z = \dfrac{PV}{RT} = 1 + \dfrac{Pb}{RT}$

157. (c) $Z = \dfrac{PV}{nRT} = \dfrac{V}{n} = \dfrac{0.9 \times 0.0821 \times 273}{9}$

= 2.24 litre/mol

$\therefore$ Volume of 1 milli-mole of gas = 2.24 mL

158. (d) $Z = \dfrac{PV}{nRT}$; $\quad 1.90 = \dfrac{1 \times 800}{n \times R \times 330}$;

$$n = \frac{1 \times 800}{1.90 \times R \times 330}$$
$$Z = 1.10 = \frac{V \times 200}{n \times R \times 570};$$

$$1.10 = \frac{V \times 200 \times 1.90 \times R \times 330}{800 \times R \times 570}$$

$$V = 4\ \text{L}$$

160. (d) $\left(0.1 + \dfrac{1000 \times (0.02)^2}{V^2}\right) V = 20 \times 0.02$

$$= 0.1\,V^2 - 0.4\,V + 0.4 = 0$$

$$= V^2 - 4V + 4 = 0$$

$$\Rightarrow \quad V = 2\,\text{L}$$

$$Z = \frac{PV}{nRT} = \frac{0.1 \times 2}{20 \times 0.02} = 0.5$$

174. (a) The van der Waals' equation for 1 mole of gas is

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

if we put, $P_r = \dfrac{P}{P_C}$, $V_r = \dfrac{V_m}{V_C}$ and $T_r = \dfrac{T}{T_C}$;

$$\left(\because\ P_C = \frac{a}{27b^2},\ V_C = 3b \text{ and } T_C = \frac{8a}{27Rb}\right)$$

$$\left(P_r\left(\frac{a^2}{27b^2}\right) + \frac{a}{V_r^2\,(3b)^2}\right)(V_r(3b) - b) = RT_r\left(\frac{8a}{27Rb}\right)$$

This equation is called van der Waals' equation of law of corresponding states.

175. (b) $\dfrac{PV_m}{RT} = \dfrac{3}{8} \times 2.21;\quad V_m = \left(\dfrac{3}{8} \times 2.21\right) \times \dfrac{RT}{P};$

$$V_m = \frac{3}{8} \times 2.21 \times \frac{8.314 \times 300}{8.314}$$

$$= 248.625\ \text{mL;}$$

$$V_{O_2} = \frac{16}{32} = 248.625 = 124.31\ \text{mL}$$

Level 2

1. (b) The number of moles of He, Ne and Xe is given by

$$n_{He} = \frac{PV}{RT} = \frac{3}{RT};\quad n_{Ne} = \frac{PV}{RT} = \frac{10}{RT};$$

$$n_{Xe} = \frac{PV}{RT} = \frac{1}{RT}$$

$$n = n_{He} + n_{Ne} + n_{Xe} = \frac{(3 + 10 + 1)}{RT}$$

The total pressure is given by

$$P = \frac{(n_{He} + n_{Ne} + n_{Xe})\,RT}{V}$$

$$P_{total} = \frac{(3 + 10 + 1)}{RT} \times \frac{RT}{7} = 2\ \text{atm}$$

2. (c) $\qquad N_2 + 3H_2 \rightleftharpoons 2NH_3$

Initial moles 11 12 0

at equilibrium 9 6 4

moles of N_2 and H_2 present at equilibrium

$$= 15$$

after addition of water

$$NH_3(g) + H_2O(l) \longrightarrow NH_4OH(l)$$

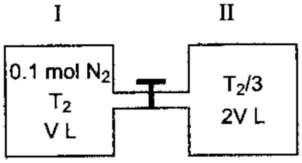
Volume of vessel available for gaseous mixture of N_2 and H_2 = 20 − 3.58

$$\Rightarrow \qquad 16.42\ \text{L}$$

Pressure exerted by gaseous mixture at

$$300\ \text{K} = \frac{15 \times 0.821 \times 300}{16.42} \Rightarrow 22.5\ \text{atm}$$

3. (c)



Let x mole of N_2 present into vessel II and P is final pressure of N_2

$P(2V) = xR(T_2/3)$ and $P(V) = (0.1 - x)RT_2$

$$\Rightarrow \qquad 2 = \frac{x}{3(0.1 - x)}$$

$$\Rightarrow \qquad x = 0.6/7\ \text{mole;}$$

$$\frac{0.6}{7} \times 28 \Rightarrow 2.4\ \text{g}\ N_2$$

II has 2.4 g N_2 and I has 0.4 g of N_2;

$$\frac{W_I}{W_{II}} = \frac{0.4}{2.4} \Rightarrow 1:6$$

4. (b) Let initial mixture contains n_1 and n_2 moles of NH_3 and N_2H_4 respectively

Total moles of gases originally present

$$= n_1 + n_2$$

Total moles of gases after decomposition of gases = $2n_1 + 3n_2$

$$0.5 \times V = (n_1 + n_2)\,R \times 300$$

$$4.5 \times V = (2n_1 + 3n_2)\,R \times 1200$$

$$\frac{2n_1 + 3n_2}{n_1 + n_2} = \frac{9}{4}$$

$$\frac{n_1}{n_2} = \frac{1}{3}$$

$$\frac{n_2}{n_1 + n_2} \times 100 = 25\%$$

26. (c) $n = \left(\frac{P}{RT}\right) V$

$$\text{Slope of line } = \frac{P}{RT} = \tan\theta$$

$$\Rightarrow \quad T = \frac{P}{R\tan\theta} = \frac{16.42}{0.0821\tan\theta}$$

For A, $\quad T = 200\sqrt{3}\,K$

For B, $\quad T = \frac{200}{\sqrt{3}}K$

Level 3

Passage-2

2 & 3. Let σ_A, σ_B and σ_C be collision diameters of A, B and C

$$\lambda = \frac{kT}{\sqrt{2}\pi\sigma^2 P}, \text{ i.e., } \sigma \propto \sqrt{\frac{T}{\lambda P}}$$

$$\therefore \quad \sigma_A : \sigma_B : \sigma_C$$

$$= \sqrt{\frac{1600}{0.16\times 1}} : \sqrt{\frac{200}{0.16\times 2}} : \sqrt{\frac{400}{0.04\times 4}}$$

$$= 4 : 1 : 2$$

2. (c) $Z_{11} \propto \frac{\sigma^2 P^2}{\sqrt{m}T^{3/2}}$

$$\Rightarrow A : B : C = \frac{16\times 1}{\sqrt{20}\times(1600)^{3/2}} : \frac{1\times 4}{\sqrt{40}\times(200)^{3/2}} : \frac{4\times 16}{\sqrt{80}\times(400)^{3/2}}$$

$$= 1 : 4 : 16$$

3. (a) $Z_1 \propto \frac{(\sigma^2)P}{\sqrt{MT}}$

$$\Rightarrow A : B : C = \frac{0.6\times 1}{\sqrt{20\times 1600}} : \frac{1\times 2}{\sqrt{40\times 200}} : \frac{4\times 4}{\sqrt{80\times 400}}$$

$$= 4 : 1 : 4$$

Passage-3

1. (a) $h_L d_L = h_{Hg} d_{Hg}$

$$h_L = \frac{76\times 13.6}{5.44} = 190 \text{ cm}$$

2. (d) $P_{Gas} = P_{Atm} + P_L = 1 + \frac{38}{190} = 1.2$

3. (b) $\quad 3A(g) \rightleftharpoons A_3 g$

$$\begin{array}{lll} t = 0 & 1.2 \text{ atm} & A_3(g) \\ t = t_{eq} & 1.2 - 0.36 & \frac{1}{3}(0.36) = 0.12 \text{ atm} \end{array}$$

$\therefore \quad P_T = 1.2 - 0.36 + 0.12 = 0.96$ atm

$\therefore \quad$ Pressure difference in column

$$= 1 - 0.96 = 0.04 \text{ atm}$$

$\therefore$ The difference in height of the liquid level in two columns $= 0.04 \times 190 = 7.6$ cm

One or More Answers is/are Correct

11. (a,b,d)

(A) $\because$ area under the curve gives fraction of molecules and total area is constant.

(B) U_{mps} decreases with decrease in temperature.

(C) T_2 is higher temperature

(D) As seen from graph; $\therefore$ A, B, D

15. (a,b,d)

$P_T = (1 + 3x) = 1 + 3\times 0.1 = 1.3$ atm.

$\Delta P = 0.2$ atm or 76×0.3 cm of Hg

or 760×0.3 mm of Hg

18. (a,c)

Low P and high temperature gas behaves as an ideal gas.

$\therefore \quad PV = $ constant and $\frac{PV_m}{RT} = 1$.

Match the Column

5. $y = \frac{1}{V^2}$ or $\sqrt{y} = \frac{1}{V}$

$P = x$ and $P = \frac{\text{constant}}{V}$

(A) $x = (k)\sqrt{y} \Rightarrow y = k^1 x^2$

(B) $V = kT; \quad y = V \;\&\; \frac{1}{T} = x \quad \therefore y = \frac{k}{x}$

(C) $P = kT; \quad PT = kT^2$ or $y = kx$

(D) $v = \frac{c}{p} \Rightarrow y = c\sqrt{x}; y^2 = cx$

Subjective Problems

11. $P_f = 1 + \frac{36}{76} = \frac{112}{76}$ atm. Final height = 19 cm

$P_i = 1$ atm, initial length $= h_i$ cm

$\therefore$ Boyle's law $\quad P_iV_i = P_fV_f$

$$1 \times h_i A = \frac{112}{76} \times 19A$$

$$h_i = 28\text{ cm}$$

$\therefore$ The length by which the Hg column shifts down $= h_i - h_f$

12. $P_i = 722\text{ mm}$ $\qquad P_f = 760\text{ mm}$

$T_i = 107 + 273 = 380\text{ K}$ $\qquad T_f = 100\text{ K}$

$d_i = 1_g/\text{cm}^3$ $\qquad d_f = ?$

$$\frac{d_i T_i R}{P_i} = \frac{d_f T_f R}{P_f}$$

$$\Rightarrow d_f = \left(\frac{P_f}{P_i}\right)\left(\frac{T_i}{T_f}\right) d_i = \left(\frac{760}{722}\right)\left(\frac{380}{100}\right) \times 1\,g/\text{cm}^3$$

$$= 4\,g/\text{cm}^3$$

$$= 28 - 19 = 9\text{ cm}$$

13. V, n constant.

$$\frac{P_i}{T_i} = \frac{P_f}{T_f} \Rightarrow P_f = \frac{T_f}{T_i} P_i = \left(\frac{109}{100}\right) P_i$$

$$\Rightarrow P_{\text{increases}}\, \Delta P = P_f - P_i = \frac{9}{100} P_i$$

$\therefore$ % Pressure increases

$$= \frac{\Delta P_f}{P_i} \times 100 = \frac{9P_i}{100P_i} \times 100\%$$

$$X\% = 9\%$$

$$X = 9$$

14. $T_B = \dfrac{a}{Rb} = \dfrac{3.6}{0.08 \times 0.6} = 75\text{ K}, \dfrac{75}{15} = 5\text{ K}$

15. 3 ms^{-1}

$$u_{\text{rms}} = \sqrt{\frac{u_1^2 N_1 + u_2^2 N_2}{N_1 + N_2}} \Rightarrow u_{\text{rms}}^2 = \frac{u_1^2 N_1 + u_2^2 N_2}{N_1 + N_2}$$

$$25 = \frac{4 \times 7^2 + 64_2^2}{10} \Rightarrow u_2 = \sqrt{\frac{54}{6}} = 3\text{ ms}^{-1}$$