CHAPTER

3

Gaseous State

EXERCISE I (JEE MAIN)

Gaseous Parameters and Gas Laws

1. The pressure outside a jet plane flying at high altitude falls considerably below atmospheric pressure at sea level. Therefore, the air inside the cabin must be pressurized to protect the passengers. What is the pressure (in atmosphere) in the cabin if the barometer reading is 688 mm of Hg?

(a) 0.905 atm (b) 6.88 atm
(c) 9.05 atm (d) Data, insufficient

2. Dibutylphthalate is often used as a monometer fluid. It has a density of 1.047 g/ml. How many torrs are represented by 1 mm of this fluid?

(a) 0.077 torr (b) 1 torr
(c) 12.98 torr (d) 760 torr

3. A liquid of density 1.70 g/ml is filled in the barometer, in place of mercury. What should be the length of liquid column, if another barometer filled with mercury is measuring 75 cm pressure?

(a) 75 cm (b) 600 cm
(c) 9.375 cm (d) 6000 cm

4. A barometer is placed in open space of laboratory of weather bureau. If the level of mercury in the barometer falls considerably, then it will represent

(a) normal weather
(b) very slow speed of wind after some time.
(c) very high speed of wind after some time.
(d) very high atmospheric pressure.

5. At a constant temperature, a gas occupies a volume of 200 ml at a pressure of 0.720 bar. It is subjected to an external pressure of 0.900 bar. What is the resulting volume of the gas?

(a) 160 ml (b) 320 ml
(c) 80 ml (d) 400 ml

6. A volume of 2.5 L of a sample of a gas at 27°C and 1 bar pressure is compressed to a volume of 500 ml keeping the temperature constant, the percentage increase in pressure is

(a) 100% (b) 400%
(c) 500% (d) 80%

7. When we inflate cycle tubes, the volume of tube as well as the pressure of air inside the tube increases.

(a) It is an exceptional case of Boyle's law.
(b) It happens because air is not ideal gas.
(c) It happens because mass of air is not constant.
(d) It happens because external force is applied in inflating the tubes.

8. The value of Boyle's law constant (in S.I. unit) for 200 ml of gas at 1.2 atm is about

(a) 240 atm-ml (b) 0.24 atm-l
(c) 24.3 J (d) 0.24 J

9. In the outer space, the pressure recorded is 5×10^{-4} torr. How much outer space could be compressed into 1 dm^3 box at a pressure of 1 atm?

(a) 1.52×10^6 dm^3 (b) 4.56×10^6 dm^3
(c) 2.28×10^6 dm^3 (d) 1.14×10^6 dm^3

10. What is the increase in volume, when the temperature of 600 ml of air increases from 27°C to 47°C under constant pressure?

(a) 50 ml (b) 60 ml
(c) 80 ml (d) 40 ml

11. The temperature of a certain mass of a gas is increased from 37°C to 38°C. The volume of the gas

(a) will decrease by $\frac{1}{273}$ of its volume at 37°C.
(b) will increase by $\frac{1}{273}$ of its volume at 273 K.
(c) will increase by $\frac{1}{273}$ of its volume at 310 K.
(d) will remain the same.

12. At 4°C, a gas occupies 200 ml and the same amount of gas at the same pressure occupies 300 ml at 144°C. The absolute zero from this data is

(a) −273°C (b) −276°C
(c) 276 K (d) −3°C

13. When a definite mole of different gases are heated from 20°C to 40°C at constant pressure, their volume

(a) becomes double.
(b) increases in the ratio of their molecular masses.
(c) increases to the same extent.
(d) decreases to the same extent.

14. A sample of gas at 35°C and 1 atmospheric pressure occupies a volume of 3.75 L. At what temperature should the gas be kept, if it is required to reduce the volume to 3.0 L at the same pressure?

(a) −26.6°C (b) 0°C
(c) 3.98°C (d) 28°C

15. A toy balloon can occupy 500 ml at 27°C. The maximum stretching capacity of the balloon is three times of the volume at 27°C. The temperature above which the balloon will burst, if pressure of the balloon does not change is

(a) 300 K (b) 900 K
(c) 625°C (d) 225°C

16. One day, when the temperature and pressure were 300 K and 760 mm, a mass of gas had a volume of 1200 ml. On the next day, the volume had changed to 1218 ml while the pressure was the same. What was the temperature on the next day?

(a) 546 K (b) 304.5 K
(c) 31.5 K (d) 300 K

17. If the pressure of a certain amount of a gas increases by 1% on heating by 1°C at constant volume, then its initial temperature must be

(a) 100 K (b) 100°C
(c) 250 K (d) 250°C

18. A gas has a volume of V cm^3 at 10°C. If the pressure is doubled, at what temperature will the volume still be V cm^3?

(a) 273°C (b) 300°C
(c) 283°C (d) 293°C

19. A quantity of 10 g of a gas at 1 atm pressure is cooled from 273°C to 273 K keeping its volume constant, the final pressure of the gas will be

(a) 273 atm (b) 0.5 atm
(c) 0.2 atm (d) 0.1 atm

20. A pre-weighed vessel was filled with oxygen at NTP and weighed. It was then evacuated, filled with SO_2 at the same temperature and pressure, and again weighed. The mass of oxygen will be

(a) the same as that of SO_2.
(b) half that of SO_2.
(c) twice that of SO_2.
(d) one-fourth of SO_2.

21. According to Avogadro's hypothesis, equal volumes of all gases under the same conditions of temperature and pressure will contain

(a) the same number of molecules.
(b) different number of molecules.
(c) the same number of molecules only if their molecular masses are equal.
(d) the same number of molecules if their densities are equal.

22. Four 1-L flasks are separately filled with the gas hydrogen, helium, oxygen and ozone at the same room temperature and pressure. The ratio of total number of atoms of these gases present in the different flasks would be

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

23. Reducing the pressure from 1.0 atm to 0.5 atm would change the number of molecules in one mole of ammonia to

(a) 75% of initial value.
(b) 50% of initial value.
(c) 25% of initial value.
(d) None of these

24. A closed container contains N molecules at P atm and T K. If the absolute temperature is doubled,

(a) The number of molecules present in the container will become $2N$.
(b) The number of molecules present in the container will become $N/2$.
(c) gas pressure becomes $2P$.
(d) gas pressure becomes $P/2$.

25. An empty bulb weighs 120.0 g. When it is filled by O_2 gas, it weighs 120.5 gm. Now, the bulb is evacuated and refilled by an unknown gas to the same pressure and temperature. If the bulb now weighs 120.75 g, then the molecular mass of unknown gas will be

(a) 32 (b) 48
(c) $\frac{64}{3}$ (d) 96

Ideal Gas Equation

26. Under what conditions will a pure sample of an ideal gas not only exhibit a pressure of 1 atm, also a concentration of 1 mole litre^{-1}?

(a) At STP
(b) When $V = 22.4$ L
(c) When $T \approx 12$ K
(d) Impossible under any condition.

27. The temperature of an ideal gas can be raised by

(a) decreasing the volume but keeping the quantity and pressure fixed.
(b) decreasing the quantity but keeping the pressure and volume fixed.
(c) decreasing the pressure but keeping the quantity and volume fixed.
(d) decreasing the pressure and volume but keeping the quantity fixed.

28. The approximate length of the side of a cube containing 850 million gas molecules at 0°C and 1 atm would be ($N_A = 6 \times 10^{23}$)

(a) 3.17×10^{-4} cm (b) 3.17×10^{-3} cm
(c) 1 mm (d) 5.25×10^{-4} cm

29. The pressure of interstellar space is about 4.0×10^{-22} atm. If the temperature is 3 K, then how many molecules are present per litre? ($R = 0.08$ L-atm/K-mol)

(a) 2000 (b) 1500
(c) 500 (d) 1000

30. The molar volume of CO_2 is maximum at

(a) 273 K and 1 atm (b) 546 K and 1 atm
(c) 273 K and 2 atm (d) 546 K and 2 atm

31. The volume occupied by 1.8 g H_2O at 4°C and 760 mm pressure is

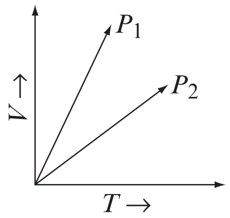
(a) 1.8 L (b) 1.8 ml
(c) 2.27 L (d) 2.98 ml

32. If air is pumped slowly but continuously into a metallic cylinder of strong wall, then what would happen to the air inside the cylinder?

(a) Temperature of air would increase.
(b) Pressure of air would increase.
(c) Pressure of air would decrease.
(d) Temperature and pressure of air would increase.

33. V vs. T curves at different pressures P_1 and P_2 for fixed amount of an ideal gas are shown below. Which one of the following is correct?

(a) $P_1 > P_2$
(b) $P_1 < P_2$
(c) $P_1 = P_2$
(d) Relation between P_1 and P_2 depends on the gas.



34. At which of the following four conditions, the density of an ideal gas will be maximum?

(a) 0°C and 0.1 atm.
(b) 0°C and 0.2 atm.
(c) 273°C and 0.1 atm.
(d) 273°C and 0.2 atm.

35. A vessel contains 1 mole of O_2 gas at a temperature T. The pressure of the gas is P. An identical vessel containing 1 mole of He gas at a temperature $2T$ has a pressure of

(a) $P/8$ (b) P
(c) $2P$ (d) $8P$

36. A 10 L bulb contains an ideal gas of molar mass 81 at 27°C. Some gas is removed from the bulb until the pressure of gas is decreased by 0.82 atm. The mass of gas removed is (R = 0.082 L-atm/K-mol)

(a) 27 g (b) 81 g
(c) 40.5 g (d) 54 g

37. A bulb with chlorine gas at ambient pressure contains 3.5 g at *t*°C. When the bulb is placed in a second thermostat at a temperature 30°C higher and the stopcock of the bulb temporarily opened (and closed again) to restore the initial pressure, the bulb is now found to contain 3.2 g of chlorine. What is the value of *t*°C?

(a) 47K (b) 14.1°C
(c) 320°C (d) 47°C

38. If the absolute temperature of an ideal gas having volume V cm^3 is doubled and the pressure is reduced to half, the final volume of gas will be

(a) $0.25V$ (b) $0.50V$
(c) $2V^2$ (d) $4V$

39. A 0.5 dm^3 flask contains gas A and 1 dm^3 flask contains gas B at the same temperature. If density of A is twice that of B and the molar mass of A is half of B, then the ratio of pressure exerted by gases is

(a) $P_A/P_B = 2$ (b) $P_A/P_B = 1$
(c) $P_A/P_B = 4$ (d) $P_A/P_B = 3$

40. Density of a gas is found to be 5.46 g/dm^3 at 27°C at 2 bar pressure. Its density at STP will be

(a) 1 g/dm^3 (b) 2 g/dm^3
(c) 3 g/dm^3 (d) 4 g/dm^3

41. A student forgot to add the reaction mixture to the round-bottomed flask at 27°C but put it on the flame. After a lapse of time, he realized his mistake. Using a pyrometer, he found the temperature of the flask as 477°C. What fraction of air would have been expelled out?

(a) 5/3 (b) 3/5
(c) 2/5 (d) 3/2

42. Pressure of 1 g of an ideal gas A at 27°C is found to be 2 bar. When 2 g of another ideal gas B is introduced in the same flask at same temperature the pressure becomes 3 bar. What is the relationship between their molecular masses?

(a) $2M_B = M_A$ (b) $M_B = M_A$
(c) $M_B = 4M_A$ (d) $M_B = 2M_A$

43. A compound exists in the gaseous phase both as monomer (A) and dimer (B). The molecular mass of A is 48. In an experiment, 96 g of the compound was confined in a vessel of volume 33.6 L and heated to 546 K. What is the pressure developed if the compound exists as dimer to the extent of 50% by weight under these conditions?

(a) 2 atm (b) 4 atm
(c) 3 atm (d) 0.5 atm

44. A 2.24 L cylinder of oxygen at 0°C and 1 atm 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

45. A container contains certain gas of mass *m* at high pressure. Some of the gas has been allowed to escape from the container. After some time, the pressure of the gas becomes half and its absolute temperature becomes two-third. The amount of the gas escaped is

(a) 2*m*/3 (b) *m*/2
(c) *m*/4 (d) *m*/6

46. A perfectly expandable balloon filled with helium gas at 27°C and a pressure of 720 mm of Hg has a volume of 100 L. The balloon rises to an altitude where the pressure is 420 mm of Hg and the temperature –63°C. What is the change in the volume of the balloon?

(a) 16 L (b) 20 L
(c) 48 L (d) 120 L

47. There is 10 L of a gas at STP. Which of the following changes keep the volume constant?

(a) 273 K and 2.0 bar pressure.
(b) 546 K and 2.0 bar pressure.
(c) 546 K and 0.5 bar pressure.
(d) 273 K and 0.5 bar pressure.

48. A certain mass of an ideal gas at 9 atm and 30°C is first heated to 131°C at constant volume and then the amount of the gas is increased by 50% at constant volume and temperature. The final pressure of the gas becomes

(a) 9 atm (b) 4.5 atm
(c) 18 atm (d) 13.5 atm

49. A quantity of 10 g of an ideal gas is expanded at constant temperature until its pressure becomes half of the initial pressure. The quantity of 1.25 g of the rarefied gas occupies 50 ml at the same final pressure and temperature. The initial volume of the gas was

(a) 200 ml (b) 400 ml
(c) 800 ml (d) 25 ml

50. One mole of N_2O_4(g) at 300 K is kept in a closed container under 1 atmospheric pressure. It is heated to 600 K when 20% by mass of N_2O_4(g) decomposes to NO_2(g). The resultant pressure is

(a) 1.2 atm (b) 2.4 atm
(c) 2.0 atm (d) 1.0 atm

Dalton's Law

51. Which of the following mixture of gases at room temperature follows Dalton's law of partial pressure?

(a) NH_3, HCl (b) H_2, O_2
(c) NO, O_2 (d) All of these

52. The partial pressures of N_2, O_2 and CO_2 in a vessel are 38 cm of Hg, 190 torr and 0.5 atm, respectively. The total pressure of the mixture at the same temperature is

(a) 0.96 atm (b) 1.02 atm
(c) 1.64 atm (d) 1.25 atm

53. Assume that air is 21% of O_2 and 79% of N_2 by volume. If the barometric pressure is 740 mm, then the partial pressure of O_2 is closest to which one of the following?

(a) 155 mm (b) 310 mm
(c) 580 mm (d) 740 mm

54. Equal masses of ethane and hydrogen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by hydrogen is

(a) 1 : 2 (b) 1 : 1
(c) 1 : 16 (d) 15 : 16

55. A mixture of hydrogen and oxygen at one bar pressure contains 20% by weight of hydrogen. The partial pressure of hydrogen will be

(a) 8 bar (b) 0.8 bar
(c) 4 bar (d) 6 bar

56. Quantities of 16 g of oxygen and 14 g of nitrogen are contained in a closed bottle. The pressure inside the bottle is 4 atm. Now, 8 g O_2 gas is removed from the bottle. What will be the new pressure inside the bottle?

(a) 2 atm (b) 4 atm
(c) 6 atm (d) 3 atm

57. The mass of pure CH_4 gas has to be mixed with 70 g of pure CO so that the partial pressure of CO is equal to the partial pressure of CH_4, is

(a) 40 g (b) 70 g
(c) 16 g (d) 28 g

58. A box of 1 L capacity is divided into two equal compartments by a thin partition, which is filled with 2 g hydrogen and 16 g methane, respectively. The pressure in each compartment is recorded as P atm. The total pressure when the partition is removed will be

(a) P atm (b) $2P$ atm
(c) $P/2$ atm (d) $P/4$ atm

59. A closed vessel contains equal number of nitrogen and oxygen molecules at a pressure of P mm. If nitrogen is removed from the system, then the pressure will be

(a) P mm (b) $2P$ mm
(c) $P/2$ mm (d) P^2 mm

60. A vessel is filled with a mixture of oxygen and nitrogen. At what ratio of partial pressures will the mass of gases be identical?

(a) $P(O_2) = 0.785\ P(N_2)$
(b) $P(O_2) = 8.75\ P(N_2)$
(c) $P(O_2) = 11.4\ P(N_2)$
(d) $P(O_2) = 0.875\ P(N_2)$

61. The volumes of the two vessels are in the ratio of 2 : 1. One contains nitrogen and the other oxygen at 800 mm and 680 mm pressure, respectively. Determine the resulting pressure when they are connected together.

(a) 760 mm (b) 670 mm
(c) 1140 mm (d) 1480 mm

62. What will be the pressure of the gas mixture when 0.5 L of H_2 at 0.8 bar and 2.0 L of oxygen at 0.7 bar are introduced in a 1 L vessel at 27°C?

(a) 3 bar (b) 1.8 bar
(c) 1 bar (d) 18 bar

63. A quantity of 4 g H_2 reacts with 9×10^{23} Cl_2 molecules and forms HCl gas. If the total pressure of the system after reaction is 700 mm, then what is the partial pressure of HCl? Assume complete reaction. ($N_A = 6 \times 10^{23}$)

(a) 200 mm (b) 350 mm
(c) 300 mm (d) 600 mm

64. A vessel has N_2 gas saturated with water vapours at a total pressure of 1 atm. The vapour pressure of water is 0.3 atm. The contents of this vessel are completely transferred to another vessel having one-third of the capacity of original volume, at the same temperature. The total pressure of this system in the new vessel is

(a) 3.0 atm (b) 1 atm
(c) 3.33 atm (d) 2.4 atm

65. There is some liquid in a closed bottle. The amount of liquid is continuously decreasing. The vapour in the remaining part

(a) must be saturated.
(b) must be unsaturated.
(c) must be super saturated.
(d) there will be no vapour.

66. A sample of air contains only N_2, O_2 and H_2O. It is saturated with water vapour and pressure is 640 torr. The vapour pressure of water is 40 torr and the molar ratio of $N_2 : O_2$ is 3 : 1. The partial pressure of N_2 in the sample is

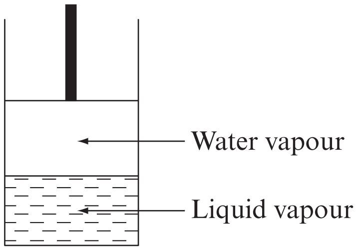
(a) 540 torr (b) 900 torr
(c) 480 torr (d) 450 torr

67. Oxygen gas is collected by downward displacement of water in a jar. The level of water inside the jar is adjusted to the height of water outside the jar. When the adjustment is made, the pressure exerted by the oxygen is

(a) Equal to the atmospheric pressure.
(b) Equal to the vapour pressure of oxygen at that temperature.
(c) Equal to atmospheric pressure plus aqueous tension at that temperature.
(d) Equal to atmospheric pressure minus aqueous tension at that temperature.

68. At 20°C, the vapour pressure of water is recorded as 22.57 mbar. What will be vapour pressure of water in the apparatus shown after the piston is lowered, thereby decreasing the volume of the gas above liquid to half of the original volume

(a) 45.14 mbar
(b) 22.57 mbar
(c) 11.28 mbar
(d) between 11.28 and 22.57 mbar



69. If the concentration of water vapour in the air is 1% and the total atmospheric pressure equals 1 atm, then the partial pressure of water vapour is

(a) 0.1 atm (b) 1 mm Hg
(c) 7.6 mm Hg (d) 100 atm

70. A volume of 190.0 ml of N_2 was collected in a jar over water at some temperature, water level inside and outside the jar standing at the same height. If barometer reads 740 mm Hg and aqueous tension at the temperature of the experiment is 20 mm Hg, the volume of the gas at 1 atm pressure and at the same temperature would be

(a) 185.0 ml (b) 180.0 ml
(c) 195.0 ml (d) 200 ml

Graham's Law

71. If helium and methane are allowed to diffuse out of the container under similar conditions of temperature and pressure, then the ratio of rate of diffusion of helium to methane is

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

72. An unknown gas 'X' has rate of diffusion measured to be 0.88 times that of PH_3 at the same conditions of temperature and pressure. The gas may be

(a) C_2H_6 (b) CO
(c) NO_2 (d) N_2O

73. A quantity of 2 g of hydrogen diffuses from a container is 10 minutes. How many grams of oxygen would diffuse through the same container in the same time under similar conditions?

(a) 0.5 g (b) 4 g
(c) 6 g (d) 8 g

74. A gas with formula C_nH_{2n+2} diffuses through the porous plug at a rate one-sixth of the rate of diffusion of hydrogen gas under similar conditions. The formula of gas is

(a) C_2H_6 (b) $C_{10}H_{22}$
(c) C_5H_{12} (d) C_6H_{14}

75. A class consists of 7 rows. The teacher releases laughing gas N_2O from the front row and a mischievous student releases a tear gas of molecular weight 176 from the rear end. The student of which row from the first will weep and smile simultaneously?

(a) Fifth (b) First
(c) Second (d) Third

76. A balloon is filled with N_2O is pricked with a sharp point and quickly plunged into a tank of CO_2 under the same pressure and temperature. The balloon will

(a) be enlarged
(b) shrink
(c) remain unchanged in size
(d) collapse completely

77. A certain gas diffuses from two different vessels A and B. The vessel A has a circular orifice while vessel B has square orifice of length equal to the radius of the orifice of vessel A. The ratio of the rates of diffusion of the gas from vessel A to vessel B, assuming same temperature and pressure is

(a) $\pi : 1$ (b) $1 : \pi$
(c) 1 : 1 (d) $2 : \pi$

78. A volume of 180 ml of hydrocarbon takes 15 minute to diffuse. Under the same conditions, 120 ml of sulphur dioxide takes 20 minutes. The molecular weight of hydrocarbon is

(a) 16 (b) 32
(c) 48 (d) 64

79. In a glass tube of 1 m length and uniform cross section, NH_3(g) from one end and BF_3(g) from the other end are sent at a time. The distance from the ammonia end where the addition compound, $BF_3 \cdot NH_3$ will first form is (B = 11; F = 19)

(a) 66.67 cm (b) 33.33 cm
(c) 50.00 cm (d) 60.00 cm

80. For 10 minutes each, at 27°C, from two identical holes nitrogen and an unknown gas are leaked into a common vessel of 3 L capacity. The resulting pressure is 4.15 bar and the mixture contains 0.4 mole of nitrogen. The molar mass of the unknown gas is (R = 0.083 L-bar/K-mol)

(a) 112 g mol^{-1} (b) 242 g mol^{-1}
(c) 224 g mol^{-1} (d) 448 g mol^{-1}

Kinetic Theory of Gases

81. The ratio of root mean square speed of H_2 at 50 K and that of O_2 at 800 K is

(a) 4 : 1 (b) 2 : 1

(c) 1 : 1 (d) 1 : 4

82. If only one gas molecule is taken in a container, the correct relation between average speed c, root mean square (RMS) speed u, and most probable speed α, becomes

(a) $\alpha < c < u$ (b) $\alpha = c = u$

(c) $c < u < \alpha$ (d) $u < c < \alpha$

83. The average speed of an ideal gas molecule at 27°C is 0.3 m/s. The average speed at 927°C will be

(a) 0.6 m/s (b) 0.3 m/s

(c) 0.9 m/s (d) 3.0 m/s

84. The molecules of a given mass of a gas have RMS speed of 200 m/s at 300 K and 1,00,000 bar pressure. When the absolute temperature is doubled and the pressure is halved, the RMS speed of molecules will become

(a) 200 m/s (b) 400 m/s

(c) 100 m/s (d) $200\sqrt{2}$ m/s

85. At STP, the order of the RMS speed of molecules of H_2, N_2, O_2 and HBr gases is

(a) $H_2 > N_2 > O_2 > HBr$

(b) $HBr > O_2 > N_2 > H_2$

(c) $HBr > H_2 > O_2 > N_2$

(d) $N_2 > O_2 > H_2 > HBr$

86. Two gases X and Y have their molecular speed in ratio of 3 : 1 at certain temperature. The ratio of their molecular masses M_x:M_y is

(a) 1 : 3 (b) 3 : 1

(c) 1 : 9 (d) 9 : 1

87. At what temperature will the total translational kinetic energy of 0.30 mole of He gas be the same as the total translational kinetic energy of 0.40 mol of Ar at 400 K?

(a) 533 K (b) 400 K

(c) 300 K (d) 266 K

88. The translational kinetic energy of N molecules of O_2 is x J at −123°C. Another sample of O_2 at 27°C has translational kinetic energy of $2x$ J. The latter sample contains

(a) N molecules of O_2.

(b) $2N$ molecules of O_2.

(c) $N/2$ molecules of O_2.

(d) $N/4$ molecules of O_2.

89. Helium atom is two times heavier than a hydrogen molecule. At 298 K, the average kinetic energy of a helium atom is

(a) two times that of hydrogen molecule.

(b) same as that of a hydrogen molecules.

(c) four times that of a hydrogen molecules.

(d) half that of a hydrogen molecule.

90. The translational kinetic energy of 10^{20} molecules of nitrogen at a certain temperature is 0.63 J. The temperature is ($N_A = 6 \times 10^{23}$)

(a) 23°C (b) 303.1°C

(c) 30.1°C (d) 43.3°C

91. Consider three identical flasks with different gases.

Flask A: CO at 760 torr and 273 K.

Flask B: N_2 at 250 torr and 273 K.

Flask C: H_2 at 100 torr and 273 K.

In which flask will the molecules have the greatest average kinetic energy per mole?

(a) A (b) B

(c) C (d) same in all

92. Maxwell and Boltzmann have shown that the actual distribution of molecular velocities in all molecules in a given gas depends on

(a) temperature and pressure.

(b) temperature and molecular mass.

(c) volume and temperature.

(d) pressure and molecular mass.

93. A gas container observes Maxwellian distribution law of speed. If the number of molecules between the speed 5.0 and 5.1 km per sec at 298 K is N, then what would be number of molecules between this range of speed if the total number of molecules in the vessel are doubled?

(a) $2N$ (b) N

(c) $2N^2$ (d) $N^2/2$

94. If X is the total number of collisions which a gas molecule registers with other molecules per unit time under particular conditions, then the collision frequency of the gas containing N molecules per unit volume is

(a) X/N (b) NX
(c) $2NX$ (d) $NX/2$

95. Which of the following gas molecule has the longest mean free path at the same pressure and temperature?

(a) H_2 (b) N_2
(c) O_2 (d) Cl_2

Real Gases

96. Consider an ideal gas contained in a vessel. If the intermolecular interactions suddenly begin to act, then which of the following will happen?

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

97. A real gas obeying van der Waals equation will resemble ideal gas if the constants

(a) a and b are small.
(b) a is large and b is small.
(c) a is small and b is large.
(d) a and b are large.

98. The behaviour of a real gas is usually depicted by plotting compressibility factor Z versus P at a constant temperature. At high temperature and high pressure, Z is usually more than 1. This fact can be explained by van der Waals equation when

(a) the constant a is negligible and not b.
(b) the constant b is negligible and not a.
(c) both constants a and b are negligible.
(d) both constants a and b are not negligible.

99. The van der Waals equation for (½) mole of a gas is

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

(b) $\left(P+\frac{a}{4V^2}\right)\left(V-\frac{b}{2}\right)=\frac{RT}{2}$

(c) $\left(P+\frac{a}{4V^2}\right)\left(\frac{V-b}{2}\right)=RT$

(d) $\left(P+\frac{a}{4V^2}\right)\left(\frac{V-b}{2}\right)=2RT$

100. The numerical value of a, the van der Waals constant, is maximum for

(a) He (b) H_2
(c) O_2 (d) NH_3

101. The molecular radius for a certain gas = 1.25 Å. What is the reasonable estimate of the magnitude of the van der Waals constant b, for the gas?

(a) 0.98×10^{-2} litre/mole
(b) 1.43×10^{-2} litre/mole
(c) 1.97×10^{-2} litre/mole
(d) 3.33×10^{-2} litre/mole

102. What is the pressure exerted by 32 g of methane in a 250 ml vessel at 300 K using van der Waals equation. Given that $a = 2.5$ atm L mol^{-2} and $b = 0.05$ L mol^{-1}.

(a) 227.54 atm (b) 299.64 atm
(c) 168.4 atm (d) 328.4 atm

103. van der Waals constant b for a gas is 0.0391 L mole^{-1}. What is the radius of the gas molecule?

(a) 3.8765 Å (b) 1.5708 Å
(c) 8.3675 Å (d) 5.8075 Å

104. When there is more deviation in the behaviour of a gas from the ideal gas equation $PV = nRT$?

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

105. The PV–P isotherms of 1 mole of different gases at 273 K, if the limit of pressure tending to zero, converge to a value of $PV =$

(a) 11.2 L atm (b) 22.4 L atm
(c) Zero (d) 22.4 L

Liquefaction of Gases

106. Only the vapours of a liquid exist

(a) below boiling point.
(b) below critical temperature.
(c) below inversion temperature.
(d) above critical temperature.

107. Van der Waals constants *b* and the corresponding values of critical temperature for three gases P, Q and R are given below

Gas	Critical temperature	van der Waals constant *b*
P	−200°C	0.03 L/mol
Q	−100°C	0.02 L/mol
R	+50°C	0.01 L/mol

Which of the gases are liquefiable at a temperature −110°C by application of increasing pressure?

(a) P, Q, R (b) P, Q
(c) Q, R (d) None of these

108. For a certain gas obeying van der Waals equation, the critical temperature is 305.5 K and the critical pressure is 48.2 atm. The critical volume is

(a) 0.098 L/mol (b) 0.195 L/mol
(c) 0.231 L/mol (d) 0.321 L/mol

109. The van der Waal's parameters for gases W, X, Y and Z are as follows.

Gas	*a* (atm l^2/mol^2)	*b* (l/mol)
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

110. The critical constants P_C and T_C for four gases are as follows.

Gas	Critical temperature	Critical pressure
O_2	153 K	50 bar
Cl_2	417 K	76 bar
H_2	33.9 K	13.5 bar
He	5.12 K	2.2 bar

The gas with the smallest value of van der Waals constant *b* is

(a) O_2 (b) Cl_2
(c) H_2 (d) He

111. Under critical conditions, the compressibility factor for a gas is

(a) 3/8 (b) 8/3
(c) 1 (d) 1/4

112. The behaviour of temporary gases like carbon dioxide approaches that of permanent gases, such as nitrogen, oxygen, etc., as we go

(a) below critical temperature.
(b) above critical temperature.
(c) above absolute zero.
(d) below absolute zero.

113. The van der Waals constants for three gases R, S and T are given below.

Gas	*a* (atm L^2/mol^2)	*b* (l/mol)
R	5.2	0.420
S	3.8	0.038
T	2.3	0.032

The correct sequence of placing the easily liquefiable gas last and the one difficult to liquefy first is

(a) R, S, T (b) S, T, R
(c) T, S, R (d) S, R, T

114. The correct order of the values of critical temperature, T_C; Boyle temperature, T_B and inversion temperature, T_i of a real gas is

(a) $T_C < T_B < T_i$ (b) $T_B < T_i < T_C$
(c) $T_B < T_C < T_i$ (d) $T_C < T_i < T_C$

115. The critical temperature and critical pressure of a gas obeying van der Waals equation are 27°C and 82.1 atm, respectively. Its van der Waals constant *b* (in litres mol^{-1}) is

(a) 0.500 (b) 0.30
(c) 0.075 (d) 0.0375

EXERCISE II (JEE ADVANCED)

Section A (Only one Correct)

1. A manometer is connected to a gas containing bulb. The open arm reads 53.3 cm, whereas the arm connected to the bulb reads 15.6 cm. If the barometric pressure is 763 mm mercury, then what is the pressure of gas in atm?

(a) 1.05 atm (b) 1.5 atm

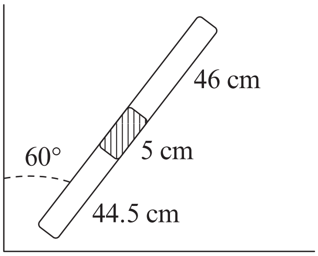
(c) 0.51 atm (d) 1.91 atm

2. A diver ascends quickly to the surface from the bottom of a lake of depth H metre. During this period, he neither exhales nor inhales air. Assuming constant temperature, what would be the fractional increase in volume of his lungs? The atmospheric pressure is $7H$ metre of water.

(a) $\frac{1}{8}$ (b) $\frac{7}{8}$

(c) $\frac{8}{7}$ (d) $\frac{1}{7}$

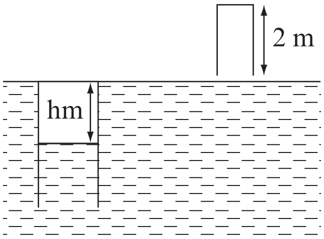
3. A thin tube of uniform cross section has trapped air columns of lengths 46 and 44.5 cm above and below a middle pellet of mercury 5 cm in length (see figure) when held at an angle of 60° to the vertical. When placed horizontally, the columns are equal in length. The temperature is 27°C. The pressure of air columns, in cm Hg, when the tube is horizontal, is



(a) 76.0 cm (b) 71.7 cm

(c) 73.2 cm (d) 75.4 cm

4. A 2 m long tube closed at one end is lowered vertically into water until the closed end is flushed with the water surface. See figure. Calculate the water level height in the tube, h. (Barometric pressure = 1 atm = 10 m of hydrostatic water head. Temperature = 25°C, density of water + 1.00 g/ml. Neglect water vapour pressure)



(a) 1.01 m (b) 0.29 m

(c) 1.71 m (d) 0.92 m

5. For which state of matter, the coefficient of cubic expansion is independent to chemical composition?

(a) Solid (b) Liquid

(c) Gas (d) All of these

6. When the volume of a fixed mass of a gas (Y–axis) is plotted against temperature in °C (X–axis) at constant pressure of 5 atm, the graph is straight line with slope 0.08 L/°C cutting the volume axis at V_0. The value of V_0 is

(a) 21.84 L (b) 0.08 L

(c) 19.04 L (d) 19.04 ml

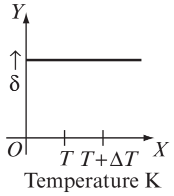
7. At 0°C and a pressure of 1000 mm, a given weight of nitrogen occupies a volume of 1.0 L. At −100°C, the same weight of gas under the same pressure occupies a volume of 0.6 L. What is the value of absolute zero in degree celsius?

(a) −250°C (b) 250°C

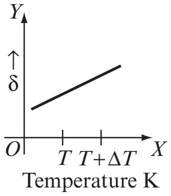
(c) −273°C (d) 273°C

8. An ideal gas is initially at temperature T and volume V. Its volume increases by ΔV due to an increase in temperature of ΔT, pressure remaining constant. The quantity $\delta = \frac{\Delta V}{V \Delta T}$ varies with temperature as

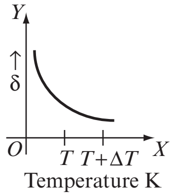
(a)



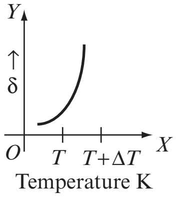
(b)



(c)



(d)



9. A sample of gas has a volume of V_1 L at temperature t_1°C. When the temperature of the gas is changed to t_2°C at constant pressure, the volume of the gas was found to increase by 10%. The percentage increase in temperature (in °C) is

(a) 10%
(b) $(10 + 2730 t_1^{-1})$
(c) 37.3%
(d) $(0.1 + t_1^{-1})$

10. Two flasks A and B of 1 L capacity each contains SO_2 and Br_2 gases, respectively, maintained at 340 K and pressure of 1.5 atm. If the number of Br_2 molecules in flask B is N, then the total number of atoms in flask A will be

(a) N
(b) $2N$
(c) $N/2$
(d) $3N$

11. A volume of 1 litre of N_2 and 7/8 L of O_2 at the same temperature and pressure were mixed together. What is the relation between the masses of the two gases in the mixture?

(a) $M_{N_2} = 3M_{O_2}$
(b) $M_{N_2} = 8M_{O_2}$
(c) $M_{N_2} = M_{O_2}$
(d) $M_{N_2} = 16M_{O_2}$

12. The diameter of a balloon filled by 8 moles of He gas is 10 cm. If 7 moles of He gas effuses out in the night, then what should be the diameter of balloon in the next morning? Assume constant pressure and temperature for the gas.

(a) 5 cm
(b) $\left(\frac{7}{8}\right)^{1/3} \times 5$ cm
(c) $\left(\frac{8}{7}\right)^{1/3} \times 5$ cm
(d) 20 cm

13. A quantity of 22 g dry ice is taken in an open bottle of one litre capacity and the bottle is then closed properly. If the temperature of bottle is maintained at 27°C for long time, in which all the CO_2 is sublimed, then the pressure in bottle is (Ambient condition is 1 atm and 27°C)

(a) 13.315 atm
(b) 12.315 atm
(c) 11.315 atm
(d) 1.0 atm

14. The volume of a filled balloon of mass 20 g is 40 L. The density of gas filled in the balloon is 0.6 g/L and the density of air is 1.3 g/L. The balloon

(a) will not lift upward.
(b) will lift upward with pay load zero.
(c) will lift upward with pay load 6 g.
(d) will lift upwards with pay load 8 g.

15. If the intermolecular forces vanish away, the volume occupied by the molecules contained in 4.5 kg water at 0°C and 1 atm will be given by

(a) 4.5 m^3
(b) 5.6 m^3
(c) 11.2 m^3
(d) 11.2 litre

16. A mixture of CO and CO_2 has a density of 1.5 g/L at 27°C and 760 mm pressure. If 1 L of the mixture is exposed to alkali, then what would be the pressure of the remaining gas at the same volume and temperature?

(a) 533 mm
(b) 473 mm
(c) 335 mm
(d) 595 mm

17. By what factor does water expand when converted into vapour at 100°C and 1 atm pressure? The density of liquid water at 100°C and 1 atm is 0.96 g cm^{-3}?

(a) 815
(b) 1.63
(c) 1633
(d) 1042

18. The circulation of blood in human body supplies O_2 and releases CO_2. It results the variation in concentration of O_2 and CO_2 in the body. But in an average, blood contains 0.32 g of O_2 and 0.88 g of CO_2 per litre. What should be the volume occupied by O_2 and CO_2, as gas, at 1 atm and at body temperature 37°C, assuming 10 litre blood in human body?

(a) 2.545 L, 2.545 L
(b) 5.09 L, 2.545 L
(c) 2.545 L, 5.09 L
(d) 2.545 L, 7.635 L

19. A bottle of cold drink has 200 ml of liquid in which the concentration of CO_2 is 0.1 M. If CO_2 behaves as ideal gas, the volume of CO_2 at 0°C and 1 atm equivalent to the one in cold drink is

(a) 0.224 L (b) 0.448 L
(c) 0.112 L (d) 4.48 L

20. A plot of the density versus the pressure for air at 27°C has the limiting slope = 1.2×10^{-5} kg $m^{-3}Pa^{-1}$. The composition of air (contains only N_2 and O_2) in volume ratio of N_2 and O_2 is (R = 8.0 J/K-mol)

(a) 80:20 (b) 90:10
(c) 50:50 (d) 60:40

21. A quantity of 4 g of oxygen occupies 10 L at a particular pressure and temperature. If the pressure of gas is doubled and absolute temperature is halved, in order to maintain constant volume,

(a) 3 g gas should be removed from the container.
(b) 3 g gas should be added in the container.
(c) 16 g gas should be added in the container.
(d) 12 g gas should be added in the container.

22. If at the top of a hill 2000 m above sea level, the atmospheric pressure is 50 cm of Hg and at the sea level, the atmospheric pressure is 74.5 cm of Hg, and you need as much oxygen to breath at sea level as on the top of the hill, then how much faster do you need to breathe at the top of the hill?

(a) 2.44 times (b) 1.49 times
(c) 5 times (d) 7 times

23. At 0°C the density of nitrogen at 1 atm is 1.25 kg/m^3. The nitrogen which occupied 1500 ml at 0°C and 1 atm was compressed at 0°C and 575 atm and the gas volume was observed to be 3.92 ml, in violation of Boyle's law. What was the final density of this non-ideal gas?

(a) 278 kg/m^3 (b) 378 kg/m^3
(c) 478 kg/m^3 (d) 578 kg/m^3

24. A spherical air bubble is rising from the depth of a lake where pressure is P atm and temperature is T K. The percentage increase in its radius when it comes to the surface of a lake will be (Assume temperature and pressure at the surface to be respectively $2T$ K and $P/4$)

(a) 100% (b) 50%
(c) 40% (d) 200%

25. An ideal gas expands according to the law P^2V = constant. On expansion, the temperature

(a) decreases (b) increases
(c) remains constant (d) None of these

26. The ratio of universal gas constant and molar mass of gas is called molar gas constant. The value of molar gas constant is greater for

(a) He (b) N_2
(c) H_2 (d) Same for all

27. The pressure exerted on walls of a 3 L flask when 7 g of N_2 is introduced into it at 300 K, should be (assume ideal behaviour of gas)

(a) zero (b) 2.05 atm
(c) 4.10 atm (d) 207.85 atm

28. An amount of 1 mole of a gas is changed from its initial state (20 L, 2 atm) to final state (4 L, 10 atm), respectively. If the change can be represented by a straight line in P–V curve, then the maximum temperature achieved by the gas in the process is (R = 0.08 L-atm/K-mol)

(a) 900°C (b) 900 K
(c) 627 K (d) 1173°C

29. The drain cleaner called 'Drainex' contains small bits of aluminium which react with caustic soda to produce hydrogen. What volume of hydrogen at 27°C and 0.831 bar will be released when 0.15 g of aluminium reacts? (Al = 27)

(a) 250 ml (b) 150 ml
(c) 500 ml (d) 125 ml

30. A vessel of 5.0 L capacity contains 1.4 g nitrogen at 1800 K. Assuming that at this temperature, 40% of molecules are dissociated into atoms and the gas is ideal, what is the gas pressure?

(a) 2.07 atm (b) 1.476 atm
(c) 1.05 atm (d) 2.67 atm

31. A steel rigid vessel of volume 1 L is filled with a mixture of methane and oxygen at a total pressure of one atm at 27°C. The gas mixture is exploded. What would be the final pressure of the products at 127°C? Aqueous tension at 27°C = 0.04 atm.

(a) 3.13 atm (b) 1.33 atm
(c) 1.29 atm (d) 1.37 atm

32. A gaseous mixture of three gases A, B and C has a pressure of 10 atm. The total number of moles of all the gases is 10. If the partial pressures of A and B are 3.0 and 1.0 atm, respectively, and if C has molecular mass of 2.0, then what is the mass of C, in g, present in the mixture?

(a) 6 (b) 8
(c) 12 (d) 3

33. A quantity of 5.0 g of a mixture of He and another gas occupies a volume of 2.4 L at 300 K and 760 mm Hg. The gas freezes at 270 K. At 15 K, the pressure of the gas mixture is 19 mm Hg (at the same volume). What is the molecular mass of the gas?

(a) 96 (b) 4.0
(c) 48 (d) 192

34. A volume of 10 ml of ethane gas is mixed with 40 ml of oxygen gas in an eudiometer tube at 30°C and fired. When the resulting gases are cooled to 30°C, the volume of eudiometer becomes 26 ml. What is the vapour pressure of water at 30°C? Neglect the volume occupied by liquid water. Pressure is 1 atm and constant throughout.

(a) 1 atm (b) 29.23 mm Hg
(c) 26 mm Hg (d) 32.55 mm Hg

35. On a certain day, the vapour pressure is 24 mm of Hg for water vapour in air at 300 K. The saturated vapour pressure is 26.463 mm. How many moles of water vapour per litre of air would be required to saturate the air at this temperature?

(a) 0.1 (b) 0.0132
(c) 1.32×10^{-4} (d) 7.60

36. A volume of 50 L of dry N_2 is passed through 36 g of water at 300 K. After the passage of gas, there is a loss of 1.20 g in water. The vapour pressure of water at 300 K is

(a) 0.033 mm Hg (b) 24.96 mm Hg
(c) 16.05 mm Hg (d) 38.73 mm Hg

37. Suppose the inhaled air has partial pressure of water vapour of 5 mm Hg and exhaled air is nearly saturated at body temperature (310 K) with water vapour. The mass of water lost per day by a person assuming that the normal man breaths 10,000 litre per day. Saturated vapour pressure of water at 310 K is 45 mm Hg.

(a) 20.68 g (b) 372.23 g
(c) 418.76 g (d) 46.53 g

38. If saturated vapours are compressed slowly and isothermally to half of the initial volume, then the pressure exerted by the vapours will

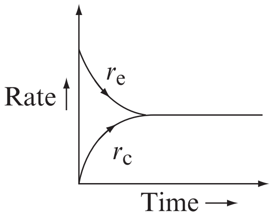
(a) become four times (b) become double
(c) remain unchanged (d) become half

39. Vapour is injected at a uniform rate in a closed vessel which was initially evacuated. The pressure in the vessel

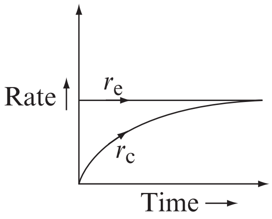
(a) increases continuously.
(b) decreases continuously.
(c) first increases and then decreases.
(d) first increases and then becomes constant.

40. Some liquid is taken in an evacuated vessel and the vessel is sealed. Which of the following graph will correctly represent the achievement of equilibrium of liquid with its vapour at constant temperature? (r_e = rate of evaporation, r_c = rate of condensation)

(a)



(b)



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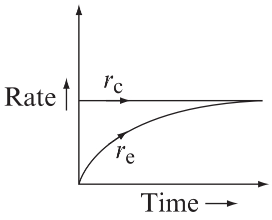

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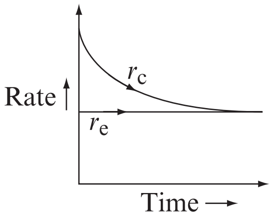


41. The rate of diffusion of two gases X and Y is in the ratio 1 : 5 and that of Y and Z is in the ratio of 1:6. The ratio of the rate of diffusion of Z with respect to X is

(a) 30/1 (b) 1/30
(c) 5/6 (d) 6/5

42. At room temperature, NH_3(g) and HX(g) are passed into a 1 m long tube from two opposite ends at the same pressure. The formation of NH_4X (s) will be closest from the injection of HX end when HX is

(a) HF (b) HCl
(c) HBr (d) HI

43. At 20°C, two balloons of equal volumes and porosity are filled to a pressure of 2 atm, one with 14 kg N_2 and other with 1 kg of H_2. The N_2 balloon leaks to a pressure of half atm in 1 hr. How long will it take for H_2 balloon to reach a pressure of half atm?

(a) 1 hour (b) 30 minutes
(c) 16 minutes (d) 3.74 hours

44. Which among the following has rate of effusion less than the moist air?

(a) He (b) Dry air
(c) NH_3 (d) Heavy hydrogen

45. A mixture of CH_4 and HBr in a vessel is allowed to effuse out through a small hole at the same temperature. What is the mole fraction of CH_4 if the initial rates of effusion are the same for both gases?

(a) 0.31 (b) 0.44
(c) 0.5 (d) 0.16

46. In a glass tube of uniform cross section, a mixture of HCl and He gases are sent from one end and a mixture of NH_3 and Ar gases are sent from the another end at the same time. The white fumes of NH_4Cl will appear first

(a) at the middle of the tube.
(b) closer to NH_3 end.
(c) closer to HCl end.
(d) at the NH_3 end.

47. If Avogadro's number were to tend to infinity, the phenomenon of Brownian motion in gas molecules would

(a) remain completely unaffected.
(b) become more vigorous than that observed with the present finite value of Avogadro's number for all sizes of the Brownian particles.
(c) become more vigorous than that observed with the present finite value of Avogadro's number only for relatively large Brownian particles.
(d) become practically unobservable as the molecular impact would tend to balance one another for practically all sizes of Brownian particles.

48. A sample of gas in a closed container of fixed volume is at 250 K and 400 mm of Hg pressure. If the gas is heated to 375 K, then its pressure increases to 600 mm of Hg. By what factor will be the average speed of the molecules increases?

(a) 1.22 (b) 1.50
(c) 2.25 (d) 2.00

49. The RMS speed of oxygen molecules in a gas is V. If the absolute temperature is doubled and the oxygen molecules are dissociated into oxygen atoms, then the RMS speed will become

(a) V (b) $\sqrt{2}\,V$
(c) $2V$ (d) $4V$

50. Three closed vessels A, B and C are at the same temperature and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only O_2, B only N_2, and C, a mixture of equal quantities of O_2 and N_2. If the average speed of the O_2 molecules in vessel A is V_1, then that of the N_2 molecules in vessel B is V_2, the average speed of the O_2 molecules in vessel C is

(a) $(V_1 + V_2)/2$ (b) V_1
(c) $\sqrt{V_1V_2}$ (d) $\sqrt{3kT/M}$

Here, M is the mean molar mass of the mixture.

51. When temperature is increased, the difference between most probable velocity, RMS velocity and average velocity

(a) increases (b) decreases
(c) remains the same (d) None of these

52. Two flasks X and Y have capacity 1 and 2 L, respectively, and each of them contains 1 mole of a gas. The temperature of the flask is so adjusted that average speed of molecules in X is twice as those in Y. The pressure in flask X would be

(a) same as that in Y. (b) half of that in Y.
(c) twice of that in Y. (d) 8 times of that in Y.

53. When 1 g of an ideal gas A is introduced into an evacuated vessel at 300 K, the pressure was found to be 1 atm. Two grams of another ideal gas B is then added to A and the pressure is now found to be 1.5 atm. What is the ratio between the average speeds of A and B at the same temperature?

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

54. For two gases, A and B with molecular weights M_A and M_B, it is observed that at a certain temperature T, the mean velocity of A is equal to the root mean square velocity of B. Thus, the mean velocity of A can be made equal to the mean velocity of B, if

(a) A is at temperature T, and B at T', $T > T'$.
(b) A is lowered to a temperature $T' < T$ while B is at T.
(c) both A and B are raised to a higher temperature.
(d) both A and B are placed at lower temperature.

55. The number of gas molecules effusing per second unit area through an orifice on the wall of the container is $\frac{1}{4}.N^*.u_{av}$, where N^* is the number of molecules per unit volume. What is this number under STP conditions for nitrogen gas?

(a) 1.53×10^{24} m^{-2}s^{-1} (b) 1.03×10^{22} m^{-2}s^{-1}
(c) 3.05×10^{27} m^{-2}s^{-1} (d) 3.05×10^{21} m^{-2}s^{-1}

56. The RMS speed of a sample of ozone is 'v' m/s at 27°C. When the temperature is increased to 327°C, all the ozone molecules are dissociated into oxygen molecules. What is the RMS speed of new gas sample?

(a) $\sqrt{\frac{2}{3}}v$ m/s (b) $\frac{1}{\sqrt{3}}v$ m/s
(c) $\frac{1}{\sqrt{2}}v$ m/s (d) $\sqrt{3}v$ m/s

57. Which of the following gas will have the highest value for translational kinetic energy per g at the same temperature?

(a) Methane (b) Helium
(c) Nitrogen (d) Same for all

58. If for two gases of molecular weights M_A and M_B at temperature T_A and T_B, $T_A M_B = T_B M_A$, then which property has the same magnitude for both the gases?

(a) Density (b) Pressure
(c) K.E. per mole (d) RMS speed

59. At what temperature does the average translational K.E. of a molecule in a gas becomes equal to the K.E. of an electron accelerated through a potential density of 3 V?

(a) 232 K (b) 2320 K
(c) 23,200 K (d) 2,32,000 K

60. Which of the following statements is not true?

(a) The ratio of the mean speed to the RMS speed is independent of temperature.
(b) The square of mean speed of the molecules is equal to the mean square speed at the same temperature.
(c) Mean kinetic energy of the gas molecules at any given temperature is independent of the mean speed.
(d) The difference between RMS speed and mean speed at any temperature for different gases decreases as larger and yet larger molar masses are considered.

61. The number of collisions of Ar atoms with the walls of container per unit time, keeping the partial pressure of Ar constant,

(a) increases when the temperature increases.
(b) remains the same when CO_2 is added to the container at constant temperature.
(c) increases when CO_2 is added to the container at constant temperature.
(d) decreases when the average kinetic energy per molecule is decreased.

62. The ratio of the RMS speeds of CH_4 at T and SO_2 at 300 K is 4 : 1. The average kinetic energy per mole of CH_4 is

(a) 3600 cal (b) 1200 cal
(c) 900 cal (d) 2400 cal

63. How many times the average speed of the molecules in a gas becomes when the temperature is raised from 27°C to 159°C?

(a) 1.2 (b) 1.44
(c) 5.89 (d) 2.43

64. In a closed flask of 5 L, 1.0 g H_2 is heated from 300 to 600 K. Which of the following statement is not correct?

(a) Pressure of the gas increases.
(b) The rate of collision increases.
(c) The number of moles of gas increases.
(d) The energy of gas molecules increases.

65. When the temperature of an ideal gas is increased at constant pressure,

(a) The collision number increases.
(b) The collision frequency increases.
(c) The mean free path increases.
(d) The number of molecules per unit volume increases.

66. Modern vacuum pumps permit the pressures down to 4.1×10^{-14} atm to be reached at room temperature (27°C). Assuming that the gas exhausted is nitrogen, find the mean distance between the gas molecules remained at this pressure. Diameter of nitrogen molecule is 1.5 Å

(a) 1×10^{7} m (b) 1×10^{-7} m
(c) 0.01 cm (d) 1×10^{7} cm

67. A vessel contains only two gas molecules. Which of the following relation is correct for RMS speed (u), average speed (c) and most probable speed (α) for the molecules?

(a) $\alpha < c < u$
(b) $c < u$, α cannot be predicted
(c) $c = u$, α cannot be predicted
(d) $\alpha = c = u$

68. Average velocity of molecules of a gas in a container moving only in one dimension is

(a) $\sqrt{\dfrac{8RT}{\pi M}}$ (b) $\dfrac{1}{3} \cdot \sqrt{\dfrac{8RT}{\pi M}}$
(c) Zero (d) Infinite

69. The most probable kinetic energy of gas molecule is

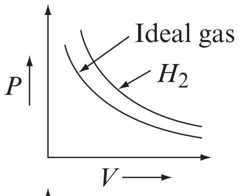
(a) $kT/2$ (b) $3kT/2$
(c) kT (d) $kT/4$

70. The assumptions of the kinetic theory of gases are most likely to be incorrect for gases under which of the following conditions?

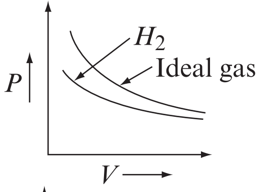
(a) High temperature and high pressure.
(b) High temperature and low pressure.
(c) Low temperature and low pressure.
(d) Low temperature and high pressure.

71. Which of the following graph is correct for hydrogen gas at 0°C?

(a)



(b)



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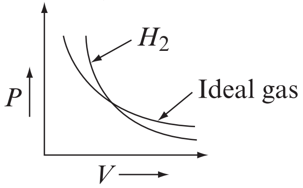

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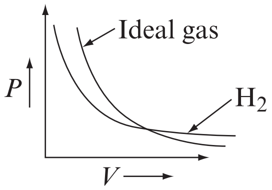
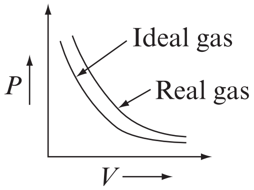


72. Which of the following graph is correct for real gases other than hydrogen and helium at 0°C?

(a)



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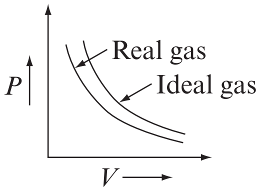

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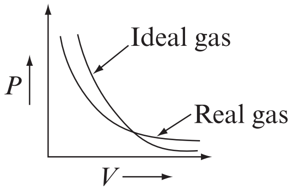
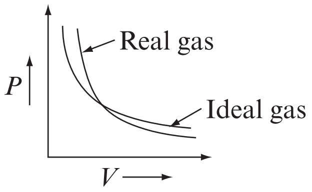


(d)



73. In the case of positive deviation from an ideal gas

(a) Interactions in molecules, $\frac{PV}{nRT} > 1$

(b) Interactions in molecules, $\frac{PV}{nRT} < 1$

(c) Finite size of molecules, $\frac{PV}{nRT} > 1$

(d) Finite size of molecules, $\frac{PV}{nRT} < 1$

74. *n* moles of He gas is placed in a vessel of volume *V* L at *T* K. If V_1 is free volume of He, then the diameter of He atom is

(a) $\left(\frac{3V_1}{2\pi N_A n}\right)^{\frac{1}{3}}$ (b) $\left(\frac{3(V-V_1)}{2\pi N_A n}\right)^{\frac{1}{3}}$

(c) $\left(\frac{6(V-V_1)}{\pi N_A n}\right)^{\frac{1}{3}}$ (d) $\left(\frac{6V_1}{\pi N_A n}\right)^{\frac{1}{3}}$

75. One mole of each gases A, B, C and D with van der Waals constant (atm L^2 mol^{-2}) 1.348, 6.823, 4.390 and 2.438, respectively, are kept separately in four different vessels of equal volumes at identical temperature. Their pressures are observed to be P_A, P_B, P_C and P_D, respectively. On the basis of this data alone, the order of pressure of gases is (assume other van der Waals constant to be nearly same for all gases)

(a) $P_A < P_B < P_C < P_D$

(b) $P_B < P_C < P_D < P_A$

(c) $P_B < P_A < P_C < P_D$

(d) $P_C < P_B < P_D < P_A$

76. Van der Waals constants for neon and helium are (a_1, b_1) and (a_2, b_2), respectively. The maximum moles of helium which will form a homogeneous mixture with one mole of neon at *T* K and *P* atm pressure is

(a) $\frac{4Pb_2^2}{a_2}$ (b) $\frac{27Pb_2^2}{a_2}$

(c) $\frac{4Pb_1^2}{a_1}$ (d) Infinite

77. When the pressure of a sample of gas is increased from 0.50 to 100 atm at constant temperature, then its volume decreases from 2.0 L to 13 ml. What could cause the deviation from Boyle's law?

(a) Volume of the gas molecules is a significant fraction of the volume of container at higher pressure.

(b) The force of attraction between the gas molecules is greater when the pressure is higher.

(c) The molecules are dimerized at higher pressure.

(d) The collision of the molecules on the walls of the container are no longer elastic at higher pressure.

78. At 320 K and 16 atm, the molar volume of ammonia gas is about 10% less than the molar volume of an ideal gas. The reason that the actual volume is less than the ideal volume is that

(a) the force of attraction between ammonia molecules is significant at this temperature and pressure.

(b) the volume occupied by the ammonia molecules themselves is a significant fraction of the volume of the container at this temperature and pressure.

(c) ammonia molecules move more slowly than predicted by the kinetic theory at this pressure and temperature.

(d) at 16.0 atm, ammonia molecules no longer move randomly.

79. The equation of state for a van der Waal gas can be expressed as $Z = 1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \ldots$. If the van der Waal constants *a* and *b* are 1.344 litre^2 atm/mol^2 and 0.03 litre mol^{-1}, respectively, then the value of second virial coefficient (in litre/mol) for oxygen gas at 0°C is

(a) –0.03 (b) +0.03

(c) –0.09 (d) +0.09

80. The equation of state for a gas is $P(V - nb) = nRT$, where *b* and *R* are constants. If the pressure and temperature are such that $V_m = 10$ b, then what is the compressibility factor of gas in this condition?

(a) $\frac{10}{9}$ (b) $\frac{9}{11}$

(c) $\frac{11}{10}$ (d) $\frac{10}{11}$

81. Under what pressure will carbon dioxide have the density of 2.2 g/litre at 300 K? For CO_2, $a = 3.6$ atm L^2 mol^{-2} and $b = 0.05$ mol^{-1}L.

(a) 1.23 atm (b) 1.28 atm
(c) 2.46 atm (d) 0.64 atm

82. The virial form of van der Waals gas equation is $PV_m = RT\left(1+\frac{B}{V_m}+\frac{C}{V_m^2}+\ldots\right)$. The second virial coefficient of argon gas at 262.5 K is –1 L mol^{-1}. What is the density of argon gas at 262.5 K and 1 atm? Neglect all the terms after second term in the virial forms, under these conditions. ($R = 0.08$ L-atm/K-mol, Ar = 40)

(a) 2.0 g/L (b) 1.905 g/L
(c) 1.818 g/L (d) 1.964 g/L

83. Dieterici's equation of state is $P \cdot e^{a/VRT}(v-b) = RT$, where V is the molar volume of gas. What is the pressure exerted by one mole of the gas in a vessel of 410.5 L capacity at 27°C, if $P \to 0$?

(a) 0.06 atm (b) Zero
(c) 60 atm (d) 6×10^{-5} atm

84. One mole of a gas occupies 0.5 L at 27°C. The compressibility factor of gas at this temperature is 0.8. If $b = 0.04$ L mol^{-1}, then what is the value of Van der Waals constant a for the gas? (R = 0.08 L-atm/K-mol)

(a) 3.44 atm L^2 mol^{-2} (b) 2.87 atm L^2 mol^{-2}
(c) 4.14 atm L^2 mol^{-2} (d) 3.82 atm L^2 mol^{-2}

85. At moderate pressure, the compressibility factor for a gas is given as $Z = 1 + 0.35P - \frac{168}{T}.P$, where P is in bar and T is in Kelvin. What is the Boyle's temperature of the gas?

(a) 168 K (b) 480 K
(c) 58.8 K (d) 575 K

86. Above Boyle's temperature, a gas

(a) may be liquefied by suitable pressure.
(b) shows positive deviation at all pressure.
(c) shows negative deviation at low pressure and positive deviation at high pressure.
(d) shows positive deviation at low pressure and the deviation continuously increases with increase in temperature.

87. The expression for compressibility factor for one mole of a van der Waals gas at Boyle temperature is

(a) $1+\frac{b^2}{V(V-b)}$ (b) $1+\frac{b^2}{V^2}$
(c) $1+\frac{b}{V}$ (d) $1-\frac{b^2}{V^2}$

88. For an ideal gas, the critical temperature is

(a) 0°C (b) 0 K
(c) Infinite (d) Undefined

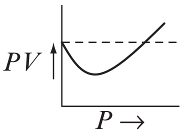
89. Critical temperatures of NO, CO_2 and CCl_4 are 178 K, 304 and 550 K, respectively. Which gas is more close to ideal behaviour at 600 K?

(a) NO (b) CO_2
(c) CCl_4 (d) Unpredictable

90. Gases do not liquefy above the critical temperature because above the critical temperature,

(a) the gases become ideal.
(b) the intermolecular attraction vanishes.
(c) the kinetic energy of molecules become so large that the attractive forces become unable to hold the molecules together.
(d) the repulsive forces dominates in the molecules.

91. At critical temperature, which of the following graphs is correct?

(a)


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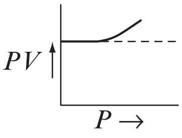

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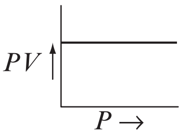

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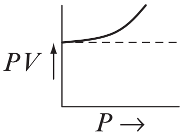


92. CO_2 and CH_4 have critical temperatures of 304 K and 190 K, respectively. The value of P_C for CO_2 = 72 atm and P_C for CH_4 = 45 atm. The ratio of $b_{CO_2} : b_{CH_4}$ is

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

93. A gas can never be liquefied at

(a) $T = T_C$ and $P = P_C$
(b) $T < T_C$ and $P = P_C$
(c) $T < T_C$ and $P < P_C$
(d) $T > T_C$ and $P >> P_C$

94. Consider the following statements.

1. Molecules of different ideal gases have the same translational kinetic energy at a given temperature.
2. The total translational kinetic energy for two moles of an ideal gas is equal to $3RT$.
3. At critical temperature, the intermolecular forces between gas molecules vanishes.
4. The gas with a larger value of the ratio of critical temperature to critical pressure will have larger value of excluded volume.

(a) 1, 3 and 4 are correct.
(b) 1, 2 and 3 are correct.
(c) 2, 3 and 4 are correct.
(d) 1, 2 and 4 are correct.

95. The critical pressure and temperature of a Van der Waal gas are 41.05 atm and 128 K, respectively. The critical volume of the gas is

(a) 0.096 L/mol (b) 0.192 L/mol
(c) 0.683 L/mol (d) 0.118 L/mol

Section B (One or More than one Correct)

1. The value of Boyle's law constant for an ideal gas at a certain temperature depends on

(a) pressure of the gas.
(b) volume of the gas.
(c) amount of the gas.
(d) temperature of the gas.

2. Two identical containers, each of volume V_o are joined by a small pipe of negligible volume. The containers contain identical gases at temperature T_o and pressure P_o. One container is heated to temperature $2T_o$ while maintaining the other at the same temperature, T_o. The common pressure of the gas is P and n is the number of moles of gas in container at temperature $2T_o$, then

(a) $P = 2P_o$ (b) $P = 4P_o/3$
(c) $n = 2P_oV_o/3RT_o$ (d) $n = 3P_oV_o/2RT_o$

3. A vessel of volume 10 L is evacuated by means of a piston air pump. One piston stroke captures the volume 1 L. The process is assumed to be isothermal and the gas is ideal. The initial pressure of gas in the vessel was 24.2 atm. Select the correct statement(s) from the following.

(a) The pressure of gas remained in the vessel after first stroke is 22 atm.
(b) The pressure of gas remained in the vessel after second stroke is 20 atm.
(c) The number of strokes needed to reduce the pressure in the vessel η times is $\frac{\ln \eta}{\ln 1.1}$.
(d) The pressure of gas remained in the vessel after 'n' strokes is $24.2 \times \left(\frac{10}{11}\right)^n$ atm.

4. As a gas (insoluble in liquid) is bubbled through a liquid, part of the liquid vaporizes and these vapours are carried off with the gas. As a sample of dry nitrogen gas is bubbled through a liquid, it is found that under identical conditions of temperature and pressure, a definite volume of wet nitrogen gas weighs more than the equal volume of dry nitrogen gas. Hence, the liquid through which dry nitrogen gas was passed may be

(a) water (b) benzene
(c) CCl_4 (d) heavy water

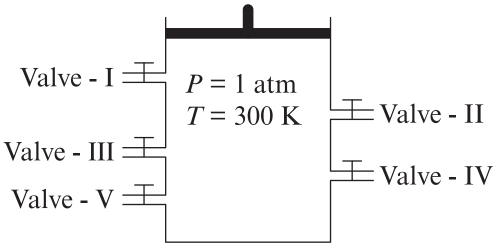
5. A vessel contains a mixture of H_2 and D_2 gases. If a pin hole is made in the vessel, then

(a) the mole fraction of H_2 in the gas remaining in the vessel will increase with time.
(b) the mole fraction of D_2 in the gas remaining in the vessel will increase with time.
(c) the average molecular weight of gas remaining in the vessel will increase with time.
(d) the partial pressure of H_2 in the gas remaining in the vessel will increase with time.

6. One mole of helium and one mole of neon are taken in a vessel. Which of the following statements are correct?

(a) Molecules of helium strike the wall of vessel more frequently.
(b) Molecules of neon apply more average force per collision on the wall of vessel.
(c) Molecules of helium have greater average molecular speed.
(d) Helium exerts higher pressure than neon.

7. A container (cylindrical, base area $= 821\ \text{cm}^2$) fitted with frictionless, massless piston consist of five valves, such as I, II, III, IV and V. The distance of valves from the initial position of piston is 15, 30, 40, 45 and 50 cm, respectively. The initial height of piston from the base of container was 60 cm. These valves open automatically if pressure exceeds over 1.5, 2.2, 2.5, 4.4 and 4.8 atm, respectively. Under the given conditions (shown in the diagram), the system is in state of equilibrium. The piston is now compressed (moved downward) slowly and isothermally. Neglect the volumes of valve connectors.



(a) Value - II will be opened first.
(b) As the piston crosses the value which will be opened first, the remaining number of moles in the container are $\frac{5}{3}$.
(c) Value – V will be the second value, which open.
(d) Number of moles will be zero as the piston crosses value – V.

8. Which of the following does not change during compression of a gas at constant temperature?

(a) Density of a gas.
(b) Molecular distance.
(c) Average speed of molecules.
(d) Number of collisions in a gas.

9. The RMS speeds of the molecules of two gases A and B are in the ratio $\sqrt{3} : 2$ at 27°C for A and 127°C for B. Gases A and B may be

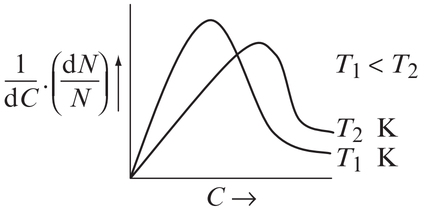
(a) N_2 and CO
(b) O_2 and N_2H_4
(c) N_2O and CO_2
(d) SO_2 and SO_3

10. The volume of a gas is held constant while its temperature is raised. The pressure the gas exerts on the walls of container increases because

(a) the masses of the molecules increases.
(b) each molecule loses more kinetic energy when it strikes the wall.
(c) the molecules collide with the wall with relatively greater momentum.
(d) the molecules strike the walls more often.

11. Which of the following graphs are correct for ideal gases?

(a)



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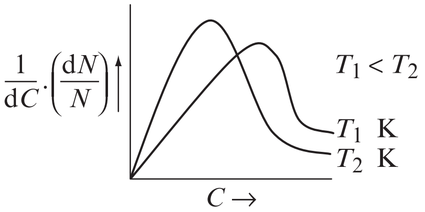

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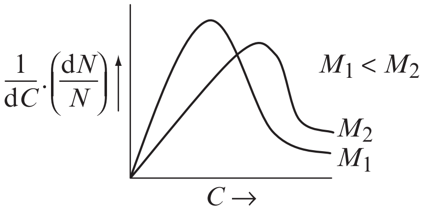
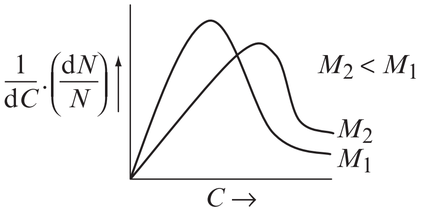


(d)



12. Which of the following statement(s) is/are true?

(a) Rise in compressibility factor with increasing pressure is due to b.
(b) Average velocity of molecules of an ideal gas in a container moving only in one dimension will be zero.
(c) The fraction of molecules having speeds in the range of u to $u + du$ of a gas of molar mass M at temperature T is the same as that of the gas of molar mass $M/2$ at temperature $T/2$.
(d) Near critical condition, gases behave ideally.

13. At very high pressure, the compressibility factor of 1 mole of a van der Waals gas can be given as

(a) $Z = 1 + \frac{bP}{RT}$
(b) $Z = \frac{V}{V - b}$
(c) $Z = \frac{V + b}{V}$
(d) $Z = 1 - \frac{a}{VRT}$

14. N_2 gas behaves ideally at its Boyle temperature in the pressure range from 0 to 50 atm. The critical temperature of N_2 gas is −177°C. Assume that the gas obeys van der Waals equation in the entire range of pressure and temperature. Which of the following statement(s) must be incorrect regarding the molar volume of the gas at the given conditions?

(a) 9.6 L at 0.821 atm and −177°C.
(b) 40 L at 0.821 atm and 127°C.
(c) 310 ml at 82.1 atm and 51°C.
(d) 32.4 ml at 0.821 atm and 51°C.

15. van der Waals constant '*a*' can be expressed as

(a) $\frac{9RT_CV_C}{8}$ (b) $3P_CV_C^{\,2}$
(c) $\frac{3}{8}\cdot\frac{P_CV_C}{T_C}$ (d) $\frac{27}{64}\cdot\frac{R^2T_C^{\,2}}{P_C}$

16. The critical temperature and pressure of a gas are 340 K and 42 atm, respectively. The gas can be liquefied at

(a) 340 K and 45 atm. (b) 340 K and 40 atm.
(c) 350 K and 100 atm. (d) 320 K and 42 atm.

17. The van der Waals equation for a real gas may be rearranged to give

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

where V_m is the molar volume of the gas. Indicate the correct statement(s) amongst the following.

(a) At temperature greater than T_C, there are three values of V_m, one real and two imaginary.
(b) At temperature T_c, the three real values of V_m are identical.
(c) At temperature less than T_c there are three real values of V_m.
(d) At any temperature, there are three values of V_m, Where one is real and two are imaginary.

18. For a real gas (van der Waals gas), behaving ideally, the pressure may be

(a) $a\cdot b\cdot V_m$ (b) $\frac{V_m}{a\cdot b}$
(c) $\frac{a}{V_m\cdot b}$ (d) $\frac{b}{a\cdot V_m}$

19. If the van der Waals equation is represented as $Z=\frac{PV_m}{RT}=1+B'P+C'P^2+\ldots$, in place of $Z=\frac{PV_m}{RT}=1+\frac{B}{V_m}+\frac{C}{V_m^2}+\ldots$, the correct relation(s) is/are

(a) $B=B'RT$ (b) $B=B'/RT$
(c) $C=B^2+C'(RT)^2$ (d) $C'=C/(RT)^2$

20. Which of the following statement(s) is/are correct?

(a) The physical state of the system at critical condition cannot be defined.
(b) All the physical properties of liquid and gaseous state of a substance become identical at critical condition.
(c) For a gas, there is no distinction between liquid and vapour state at critical condition.
(d) Easily liquefiable gases have higher Boyle's temperature while the gases difficult to liquefy have lower Boyle's temperature.

Section C (Comprehensions)

Comprehension I

A pumped-up bicycle tire has a volume of about 1 litre and when properly inflated, it is at a total pressure of about 8 bar. A typical hand bicycle pump has a piston cross section area of 4 cm^2 and a stroke length of 25 cm. The atmospheric pressure is 1 bar ($g = 10$ ms^{-2}).

1. How many strokes of the hand pump assuming no leakage or heating effects would be needed to inflate the tire?

(a) 40
(b) 50
(c) 80
(d) 100

2. What force would have to be applied to the hand pump to reach the final pressure?

(a) 160 N
(b) 320 N
(c) 80 N
(d) 640 N

3. If this force were exerted by the weight of an object placed on the pump handle, which is an unusual procedure, then what would be the mass of this object?

(a) 16 kg
(b) 3200 kg
(c) 32 kg
(d) 64 kg

Comprehension II

Recent communications with the inhabitants of Neptune have revealed that they have a Celsius type temperature scale, but it is based on the melting point (0°N) and boiling point (100°N) of their most common substance, hydrogen. Further communications have revealed that the Neptunians know about perfect gas behaviour and that they find in the limit of zero pressure, the value of PV_m is 28 L – atm at 0°N and 40 L – atm at 100°N.

4. What is the value of the absolute zero of temperature on their temperature scale?

(a) 233.33°C
(b) –233.33°C
(c) –233.33°N
(d) 233.33°N

5. What is the value of universal gas constant?

(a) 0.082 L – atm /K – mol
(b) 0.12 L – atm /K – mol
(c) 0.4 L – atm /K – mol
(d) Infinite

6. What is the volume occupied by 2 moles of a perfect gas at 2 atm and 66.67°N?

(a) 36 L
(b) 24.6 L
(c) 20.0 L
(d) 8.0 L

Comprehension III

A glass tube AD of uniform cross section of length 100 cm contains two columns of air (assume ideal behaviour) AB and CD, separately by a column of mercury (BC) of length 20 cm. When the tube is horizontal, AB = 20 cm and CD = 60 cm. When the tube is held vertically with the end 'A' up, the mercury column moves down 10 cm.

7. Which of the following information regarding the tube is correct?

(a) Its both ends are open.
(b) Only end A is closed.
(c) Only end D is closed.
(d) Its both ends are closed.

8. What is the pressure of air in the air columns, when the tube was horizontal?

(a) $P_{AB} = 3 \times P_{CD} = 37.5$ cm Hg
(b) $P_{AB} = P_{CD} = 37.5$ cm Hg
(c) $P_{CD} = 3 \times P_{AB} = 37.5$ cm Hg
(b) $P_{AB} = P_{CD} = 20$ cm Hg

9. What will be the length of the gas column AB when the tube is held vertically with the end D up?

(a) 30 cm
(b) 10 cm
(c) 15.33 cm
(d) 13.88 cm

Comprehension IV

Chemical explosions are characterized by the instantaneous release of large quantities of hot gases, which set up a shock wave of enormous pressure (up to 70,000 atm) and velocity (up to 32,000 km/h). For example, the explosion of nitroglycerine ($C_3H_5N_3O_9$) releases four gases, such as A, B, C and D.

$$n\ C_3H_5N_3O_9 \rightarrow a\ A(g) + b\ B(g) + c\ C(g) + d\ D(g)$$

Assume that the explosion of 1 mol of nitroglycerine releases gases with a temperature of 1727°C and a volume of 2.9 L at 410.5 atm pressure.

10. How many moles of hot gases are released by the explosion of 0.04 mole of nitroglycerine?

(a) 7.25
(b) 0.29
(c) 2.9
(d) 0.58

11. When the products released by explosion of 0.04 mole of nitroglycerine were placed in a 821 ml flask and the flask was cooled to –23°C, product 'A' gets solidified and the pressure inside the flask was 4.75 atm. How many moles of A were present and what is its likely identity? Neglect the volume of solid formed.

(a) 0.1 mol, H_2
(b) 2.5 mol, H_2O
(c) 0.1 mol, H_2O
(d) 0.1 mol, CO_2

12. When gases B, C and D were passed through a tube of powdered Li_2O, gas B reacted to form Li_2CO_3. The remaining gases, C and D, were collected in another 821 ml flask and found to have a pressure of 2.1 atm at 27°C. How many moles of B were present and what is its likely identity?

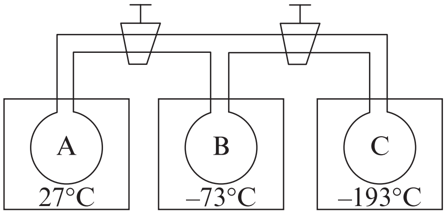
(a) 3.0 mol, CO_2
(b) 0.12 mol, CO_2
(c) 3.0 mol, CO
(d) 0.12 mol, CO

13. When gases C and D were passed through a hot tube of powdered copper, gas C reacted to form CuO. The remaining gas D was collected in a third 821 ml flask and it was found to have a mass of 1.68 g and a pressure of 1.8 atm at 27°C. How many moles each of C and D were present and what are their likely identities?

(a) C : 0.01 mol O_2, D : 0.06 mol N_2
(b) C : 0.06 mol O_2, D : 0.01 mol N_2
(c) C : 0.02 mol O_2, D : 0.06 mol N_2
(d) C : 0.07 mol O_2, D : 0.06 mol N_2

Comprehension V

The apparatus shown consists of three temperature jacketed 1.642 L bulbs connected by stopcocks. Bulb A contains a mixture of $H_2O(g)$, $CO_2(g)$ and $N_2(g)$ at 27°C and a total pressure of 570 mm Hg. Bulb B is empty and held at a temperature of −73°C. Bulb C is also empty and is held at a temperature of −193°C. The stopcocks are closed and the volume of the lines connecting the bulbs is zero. CO_2 sublimes at −78°C and N_2 boils at −196°C. Neglect the volume of any solid, if formed.



14. The stopcock between A and B is opened and the system is allowed to come to equilibrium. The pressure in A and B is now 0.21 atm. What do bulbs A and B contain?

(a) **A:** $CO_2(g)$,
B: $N_2(g)$, $H_2O(s)$
(b) **A:** $N_2(g)$,
B: $CO_2(g)$, $N_2(g)$, $H_2O(s)$
(c) **A:** $CO_2(g)$, $N_2(g)$,
B: $CO_2(g)$, $N_2(g)$, $H_2O(s)$
(d) **A:** $CO_2(g)$, $N_2(g)$, $H_2O(l)$,
B: $CO_2(g)$, $N_2(g)$

15. How many moles of H_2O are in the system?

(a) 0.0075
(b) 0.015
(c) 0.05
(d) 0.035

16. Both stopcocks are opened and the system is again allowed to come at equilibrium. The pressure throughout the system is 22.8 mm Hg. What do bulbs A, B and C contain?

(a) **A:** $N_2(g)$,
B: $N_2(g)$, $H_2O(s)$,
C: $N_2(g)$, $H_2O(s)$, $CO_2(s)$

(b) **A:** $N_2(g)$,
B: $N_2(g)$, $H_2O(s)$,
C: $N_2(g)$, $CO_2(s)$

(c) **A:** $N_2(g)$,
B: $N_2(g)$, $H_2O(s)$, $CO_2(s)$,
C: $N_2(g)$, $H_2O(s)$, $CO_2(s)$

(d) **A:** $N_2(g)$,
B: $N_2(g)$, $H_2O(s)$, $CO_2(g)$,
C: $N_2(g)$, $H_2O(s)$, $CO_2(s)$

17. How many moles of CO_2 are in the system?

(a) 0.0125 (b) 0.015
(c) 0.0225 (d) 0.0375

Comprehension VI

A closed rigid bulb contains 0.01 mole of inert helium gas and a sample of solid white ammonium chloride, NH_4Cl. Assume that the volume of the solid NH_4Cl is negligible compared to the volume of the bulb. The pressure of He is measured at 300 K and is found to be 114 mm Hg. The bulb is then heated to 600 K. All the NH_4Cl decomposes to $NH_3(g)$ and HCl(g). The final total pressure in the bulb after complete decomposition of the solid is 908 mm Hg. Assume ideal behaviour for all gases.

18. The approximate mass of NH_4Cl present initially in the bulb is

(a) 0.8 g (b) 1.6 g
(c) 0.4 g (d) 2.4 g

19. The final partial pressure of NH_3 gas in the bulb is

(a) 908 mm Hg (b) 454 mm Hg
(c) 680 mm Hg (d) 340 mm Hg

20. The capacity (volume) of bulb is

(a) 2.24 L (b) 1.642 L
(c) 0.821 L (d) 3.284 L

Comprehension VII

A quantity of 5.0 kg liquid water is poured in an evacuated room of capacity 40 m^3 maintained at 300 K. Assume ideal gas behaviour for water vapour. The vapour pressure of water at 300 K is 0.04 atm ($R = 0.08$ L-atm/K-mol).

21. What percentage of liquid water will vaporize?

(a) 2.4% (b) 24%
(c) 36% (d) 12%

22. What should be the minimum volume of the room, if no liquid water is to be present finally in the room?

(a) 166.67 L (b) 16.67 L
(c) 166.67 m^3 (d) 16.67 m^3

Comprehension VIII

The leak rate, $-\frac{dp}{dt}$, of a gas is directly proportional to the difference in pressure of the gas in the cylinder and the external pressure. Some ideal gas is taken in a cylinder of 10 L capacity at 20 atm and 300 K. The proportionality constant is 0.001 sec^{-1}. The constant external pressure is 1 atm ($\ln 38 = 3.6$, $\ln 2 = 0.7$, $\ln 10 = 2.3$).

23. What is the pressure of gas in the cylinder after 1 hour?

(a) 0 (b) 0.5 atm
(c) 1.5 atm (d) 0.526 atm

24. How many balloons of capacity 2.0 dm^3 can be filled at 1 atm and 27°C by using the gas effused out in 1 hour?

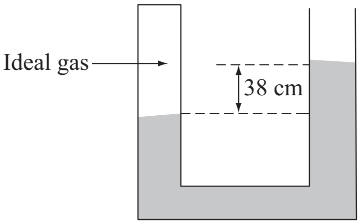
(a) 90 (b) 92
(c) 93 (d) 97

25. In what time, the pressure of gas in the cylinder becomes 2 atm?

(a) 2900 s (b) 2300 s
(c) 3500 s (d) 3200 s

Comprehension IX

A U-shaped tube partly filled by mercury is taken as shown in the figure. The cross section area of closed arm is A cm^2 and that of open arm is 2A cm^2. A pin hole is now made at the top of the closed arm by which leakage of gas starts. The leak rate $-\frac{dP}{dt}$ is directly proportional to the pressure of remaining gas inside the tube over mercury. The proportionality constant is Ks^{-1}.



26. What will be the expression for pressures of gas above mercury in the closed arm at any time, t?

(a) 1.5 atm
(b) 1.5 e^{-kt} atm
(c) 1.5 (e^{-kt} – 1) atm
(d) 1.5 (1 – e^{-kt}) atm

27. What will be the increase in level of mercury in the closed arm at any time, t?

(a) 38 (1 – e^{-kt}) cm
(b) 76 (1 – e^{-kt}) cm
(c) (1 – e^{-kt}) cm
(d) 152(1 – e^{-kt}) cm

28. What will be the decrease in level of mercury in the open arm at any time, t?

(a) 38 (1 – e^{-kt}) cm
(b) 76 (1 – e^{-kt}) cm
(c) (1 – e^{-kt}) cm
(d) 152 (1 – e^{-kt}) cm

Comprehension X

According to Maxwell's distribution law, the fraction of molecules per unit change in speed [velocity distribution function, $f(c)$], traveling with the speed from C to $C + dC$ is given as: $f(c) = \frac{1}{dC}\cdot\left(\frac{dN}{N}\right) = 4\pi.\left(\frac{M}{2\pi RT}\right)^{3/2}.C^2.e^{-MC^2/2RT}$.

($R = 8.0$ J/K-mol, ln 2 = 0.7)

29. At what temperature, the velocity distribution function for the oxygen molecules will have maximum value at the speed 400 m/s?

(a) 34.9°C
(b) 47°C
(c) 320°C
(d) –31.3°C

30. At what temperature, the RMS speed of hydrogen molecules exceeds their most probable speed by 400 m/s? ($\sqrt{6} = 2.45$)

(a) 127°C
(b) 108.6°C
(c) 400°C
(d) 381.6°C

31. At what temperature, the speeds of nitrogen gas molecules at C_1 = 300 m/s and C_2 = 600 m/s are associated with equal value of Maxwell distribution function $f(c)$?

(a) 337.5°C
(b) 402°C
(c) 64.5°C
(d) –95.75°C

32. At what speed of the molecules, the value of the Maxwell distribution function $f(c)$ for the temperature T will be the same as that of the temperature n times higher?

(a) $\sqrt{\frac{3RT\ \ln n}{M(n-1)}}$

(b) $\sqrt{\frac{3RT\ n\ln n}{M(n-1)}}$

(c) RMS speed

(d) Most probable speed

33. On increasing the temperature of a gas, the fraction of molecules having speed equal to most probable speed at that temperature

(a) increases
(b) decreases
(c) remains unchanged
(d) increases or decreases, depending on gas.

34. On increasing the molecular mass of gaseous sample at constant temperature, the fraction of molecules having speed equal to most probable speed at that molecular mass

(a) increases
(b) decreases
(c) remains unchanged
(d) increases or decreases, depending on gas.

35. What is the ratio of the number of molecules having speeds in the range of $2u_{mp}$ and $2u_{mp} + du$ to the number of molecules having speeds in the range of u_{mp} and $u_{mp} + du$?

(a) $4.e^{-3}$ (b) e^{-3}
(c) $4.e^{3}$ (d) 2

Comprehension XI

Three flasks A, B and C have equal volumes. A is maintained at 300 K, B at 600 K and C at 900 K. Flask A contains H_2 gas, flask B contains CH_4 gas and flask C contains O_2 gas, and the masses of all gases are same. Assume ideal behaviour of gases.

36. Flask containing greater number of molecules is

(a) A (b) B
(c) C (d) Same in all flask

37. Flask with greater number of collisions with the walls per unit area per unit time is

(a) A (b) B
(c) C (d) same for all

38. Flask with greater mean free path for the molecules $(r_{H_2} : r_{CH_4} : r_{O_2} = 1:2:2)$ is

(a) A (b) B
(c) C (d) Same for all

39. Flask with greater total translational kinetic energy is

(a) A (b) B
(c) C (d) same for all

40. Flask with greater compressibility factor of gas is

(a) A (b) B
(c) C (d) same fo all

41. Flask with greater collision number of the molecules is

(a) A (b) B
(c) C (d) same for all

42. Flask with greater average speed for the molecules is

(a) A (b) B
(c) C (d) same for all

Comprehension XII

The equation of state for a gas is $P = \frac{RT}{V-b} - \frac{a}{T.V^2}$, where V is the molar volume of the gas and a and b are constants different than van der Waals constant.

43. The temperature above which the gas cannot be liquefied at any pressure is

(a) $\frac{8a}{Rb}$ (b) $\frac{a}{Rb}$
(c) $\frac{8a}{27Rb}$ (d) $\sqrt{\frac{8a}{27Rb}}$

44. The minimum pressure needed for liquefaction of gas at the temperature calculated above is

(a) $\frac{a}{27b^2}$ (b) $\sqrt{\frac{a}{27b^2}}$
(c) $\sqrt{\frac{aR}{216b^3}}$ (d) $\sqrt{\frac{aR}{216b^2}}$

45. The molar volume of the system at the temperature and pressure calculated above is

(a) $3b$ (b) $2b$
(c) $4b$ (d) zero

Section D (Assertion – Reason)

The following questions consist of two statements. Mark

- **(a)** If both statements are CORRECT, and **Statement II** is the CORRECT explanation of **Statement I**.
- **(b)** If both statements are CORRECT, and **Statement II** is NOT the CORRECT explanation of **Statement I**.
- **(c)** If **Statement I** is CORRECT, but **Statement II** is INCORRECT.
- **(d)** If **Statement I** is INCORRECT, but **Statement II** is CORRECT.

1. **Statement I:** Under identical conditions of temperature and pressure, equal number of molecules of different gases occupies the same volume.

Statement II: The distance between gas molecules is much larger than the actual dimensions of molecules.

2. **Statement I:** The ratio of volume and absolute temperature is constant for a fixed amount of gas at constant pressure.

Statement II: At constant pressure, the volume of a given mass of a gas increases or decreases by $\frac{1}{273}$ of its volume at 0°C, for each 1°C rise or fall in temperature, respectively.

3. **Statement I:** At constant temperature, if pressure on the fixed mass of a gas is doubled, its density is doubled.

Statement II: At constant temperature, the molecular mass of a gas is directly proportional to the density and inversely proportional to pressure.

4. **Statement I:** If H_2 and Cl_2 is enclosed separately in the same vessel exert pressures of 100 and 200 mm respectively, then their mixture in the same vessel at the same temperature will exert a pressure of 300 mm.

Statement II: Dalton's law of partial pressure states that the total pressure is the sum of partial pressures.

5. **Statement I:** On increasing the surface area of any liquid at constant temperature, the rate of evaporation increases.

Statement II: Increase in surface area at constant temperature increases the escaping tendency of molecule of liquid at surface.

6. **Statement I:** Graham's law is a limiting law, i.e., it is best applied at low pressures for gases.

Statement II: Graham's law is valid only for ideal gases.

7. **Statement I:** At constant volume, the pressure of a fixed amount of an ideal gas is proportional to its absolute temperature.

Statement II: Frequency of collisions and their impact both increases in proportion to the square root of absolute temperature.

8. **Statement I:** Absolute zero is a theoretically possible temperature at which the volume of the gas becomes zero.

Statement II: The total kinetic energy of the molecules is zero at absolute zero.

9. **Statement I:** In kinetic theory of gases, the volume occupied by the gas molecules is considered negligible in comparison to the volume of gas.

Statement II: The volume of an ideal gas should be only that volume which is available for the gas molecules.

10. **Statement I:** The average speed of gas molecules decreases with increase in molar mass of gas at constant temperature.

Statement II: The average kinetic energy per mole of all the gases is same and it is independent of their molar masses.

11. **Statement I:** The total kinetic energy of vapours formed over liquid water in closed container A and B having free space 1 L and 2 L, respectively, over water at the same temperature is in the ratio 1 : 2, assuming ideal behaviour of vapours.

Statement II: Vapour pressure of a pure substance depends only on temperature.

12. **Statement I:** On increasing the temperature, the fraction of molecules possessing the most probable speed increases.

Statement II: On increasing the temperature, the most probable speed of a gas increases.

13. **Statement I:** If the intermolecular attraction between gas molecules in a vessel of fixed volume vanishes at constant temperature, then the pressure of gas will increase.

Statement II: The speed at which the gas molecules are colliding at the walls will increase due to the disappearance of attractive forces.

14. **Statement I:** Excluded volume or co-volume equals to $(V - nb)$ for n moles.

Statement II: Co-volume depends on the effective size of gas molecules.

15. **Statement I:** Critical temperature is the temperature at which the intermolecular attraction in gas molecules vanishes.

Statement II: At critical point, the density of substance in gaseous and liquid states becomes same.

16. **Statement I:** For a fixed amount of a gas, the product PV is always constant.

Statement II: Gases deviate more from ideal behaviour at high pressure and low temperature.

17. **Statement I:** At 273 K, hydrogen and helium gases have positive slope at all pressure in PV vs. P graph.

Statement II: The Boyle temperature of hydrogen and helium gases is less than 273 K.

18. **Statement I:** For a Van der Waals gas, the constants ‘a’ and ‘b’ are independent of temperature.

Statement II: The gases obeying Van der Waals equation in all the conditions of pressure and temperature are called Van der Waals gases.

19. **Statement I:** At Boyle temperature, the compressibility factor of a real gas, $Z \geq 1$.

Statement II: All the gases tend to approach a value $Z = 1$, when the pressure of gas approaches to zero value at any temperature.

20. **Statement I:** Above critical temperature, a substance cannot exist in liquid state.

Statement II: Above critical temperature, the average kinetic energy of gas molecules is always greater than the maximum kinetic energy of a molecule possible in liquid state.

Section E (Column Match)

1. Match the columns.

Column I	Column II
(A) Boyle’s law	(P) $\left(\frac{dP}{dV}\right)_T = -\frac{P}{V}$
(B) Charle’s law	(Q) $\left(\frac{dV}{dT}\right)_P = \frac{V}{T}$
(C) Avogadro’s law	(R) $\left[\frac{d(PV)}{dP}\right]_T = 0$
(D) Graham’s law	(S) $\left(\frac{dV}{dn}\right)_{P,T} = \frac{RT}{P}$
	(T) $-\frac{dP}{dt} = \frac{k}{\sqrt{d}}$

2. Match the columns.

Column I	Column II
(A) H_2 gas at 300 K	(P) Maximum translational K.E. per mol.
(B) CH_4 gas at 400 K	(Q) Maximum translational K.E. per gram.
(C) O_2 gas at 900 K	(R) Minimum translational K.E. per mol.
(D) He gas at 600 K	(S) Minimum translational K.E. per gram.

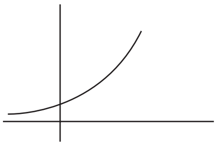
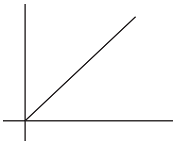
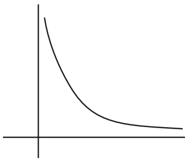
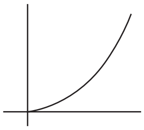
3. Van der waals constant for three different gases are given as follows.

Gas	a (atm L^2/mol^2)	b (L/mol)
X	3.0	0.025
Y	10.0	0.030
Z	6.0	0.035

Which of the following is correctly matched?

Column I	Column II
(A) X	(P) Maximum critical temperature
(B) Y	(Q) Maximum critical volume
(C) Z	(R) Least deviation from ideal behaviour
	(S) Maximum critical pressure

4. Match the description in Column I with graph in Column II for n moles of an ideal gas at constant temperature.

Column I	Column II
(A) $\frac{P}{V}$ vs. P	(P) 
(B) $\frac{P}{V}$ vs. V	(Q) 
(C) $\frac{V}{P}$ vs. $\frac{1}{P^2}$	(R) 
(D) $\frac{P}{V}$ vs. $\log P$	(S) 

5. A volume of 6 L H_2O is placed in a closed evacuated room of volume 827 L at the temperature of 300 K. The density of liquid water at 300 K is 1.0 g/ml. The vapour pressure of water at 300 K is 22.8 mm Hg. Neglect the change in volume of liquid water by vaporization.

Column I	Column II
(A) Mass of water vapour formed (in g)	(P) 6
(B) Moles of water vapour formed	(Q) 18
(C) Approximately mass of liquid water left (in kg)	(R) 3
(D) Total moles of atoms in vapour form	(S) 1

6. Van der Waals constant a and b for a gas are 4.0 atm L^2/mol^2 and 0.05 L/mol, respectively. If 80 g of the gas (molecular mass = 16) is placed in a 10 L vessel at 300 K, then

Column I	Column II
(A) Pressure correction (in atm)	(P) 0.0625
(B) Ideal volume of gas (in L)	(Q) 1
(C) Actual volume occupied by molecules (in L)	(R) 9.75
(D) Volume correction (in L)	(S) 0.25

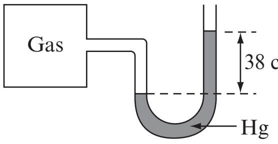
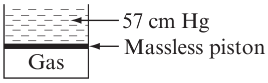
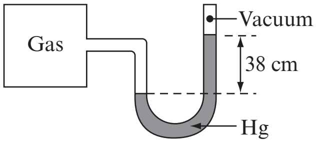
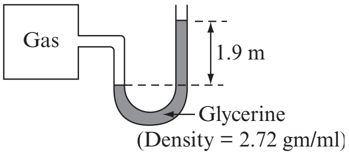
7. Match Column I with Column II for a van der Waals gas.

Column I	Column II
(A) Free volume	(P) Depends upon nature of gas.
(B) Critical temperature	(Q) Constant for a particular gas.
(C) Boyle's temperature	(R) Depends upon pressure for a particular gas.
(D) Compressibility factor	(S) Depends upon the radius of gas molecule.

8. A container contains 2 moles of an ideal gas at 27°C. It is heated to 327°C. Match Column I (parameters) with Column II (increases by a factor).

Column I	Column II
(A) Mean free path, λ	(P) 1 (at constant volume)
(B) Collision number, Z_1	(Q) $\sqrt{2}$ (at constant volume)
(C) Collision frequency, Z_{11}	(R) $\frac{1}{\sqrt{2}}$ (at constant pressure)
	(S) 2 (at constant pressure)

9. Match the columns.

Column I (Pressure exerted by gas in figures)	**Column II (Consider atmospheric pressure equal to 1 atm and density of mercury = 13.6 g/ml, if needed)**
(A) 1.50 atm	(P) 
(B) 1.75 atm	(Q) 
(C) 0.50 atm	(R) 
	(S) 

10. The critical temperature and pressure of a Van der Waals gas is –177°C and 20 atm, respectively. At Boyle's temperature, the gas behaves ideally up to 50 atm. If 0.2 moles of this gas is taken at the temperature and pressure given in Column I, then match with the expected volume of system in Column II ($R = 0.08$ L-atm/K-mol).

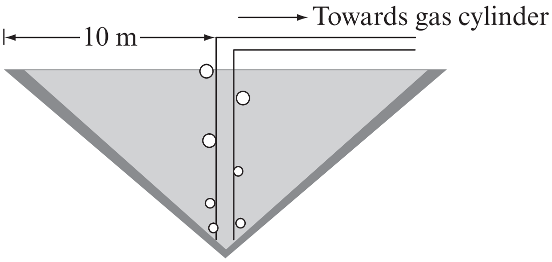
Column I	**Column II**
(A) −177°C, 20 atm	(P) 821 ml
(B) 51°C, 6.48 atm	(Q) 28.8 ml
(C) 77°C, 7.0 atm	(R) 760 ml
(D) 27°C, 6.0 atm	(S) 800 ml
(E) 51°C, 64.8 atm	(T) 85 ml

Section F (Subjective)

Single-digit Integer Type

1. A gas is confined in a graduated cylinder enclosed by a movable piston. When the temperature of the room is 27°C, the volume of the gas at atmospheric pressure is found to be 45 ml. The cylinder is then immersed in a bath containing a mixture of liquid and solid benzene, maintained at the normal freezing point of benzene. The piston moves to maintain constant atmospheric pressure. The volume of the gas at the freezing point of benzene is 42 ml. The freezing point of benzene (in °C) is

2. A swimming pool (Figure) is conical in shape of diameter 20 m. To measure the depth of the pool, a pipe line having cross sectional area of π mm^2 has been introduced through the base centre to the depth of the pool. The other end of the pipeline is connected with the gas cylinder. When gases are passed through the pipeline, it has been measured that the volume of each bubble across the pipeline at the surface of the pool is 2π mm^3. Assume the temperature of water to be same as that of atmosphere and 1 atm pressure is equal to 10 m of water column. If the water holding capacity of the swimming pool is V m^3, then the value of $\frac{3V}{100\,\pi}$ is



3. An iron meteorite was analysed for its isotopic argon content. The amount of Ar^{36} was 1.911 mm^3 (STP) per kg of meteorite. If each Ar^{36} atom had been formed by a single cosmic event, then how many such events must there have been per kg of meteorite? If the answer is X, then the value of $\frac{X}{10^{16}}$ is ($R = 8.4$ J/K-mol, $N_A = 6.0 \times 10^{23}$)

4. What will be the temperature difference (in °C) needed in a hot air balloon to lift $\frac{10.0}{8.314}$ kg of mass? Assume that the volume of the balloon is 91.0 m^3, the temperature of the ambient air is 17°C, the pressure is 1.0 bar, and air is an ideal gas with an average molar mass of 29 g/mole.

5. A vessel of volume 3.0 L contains ideal gas at the temperature 0°C. After a portion of the gas has been let out, the pressure in the vessel decreases by 0.8 atm (the temperature remaining constant). The gas density under the normal condition (0°C and 1 atm) is 1.25 g/L. The mass of released gas in (g) is

6. Two identical vessels are connected by a tube with a valve letting the gas to pass from one vessel into the other if the pressure difference $\Delta P \geq 2.0$ atm. Initially, there was a vacuum in one vessel while the other contained ideal gas at a temperature 300 K and pressure 4.0 atm. Then both vessels were heated to a temperature 600 K. Up to what value will be the pressure (in atm) in the first vessel (which had a vacuum initially) increase?

7. A 5.0 L box contains 28.4 g of mixture of gases C_xH_8 and C_xH_{10}. The pressure of the gas mixture at 300 K is 2.46 atm. The analysis of the gas mixture shows that carbon is 84.5% by mass. The value of x is

8. An ideal gas, X_n, is taken in a container connected to frictionless, massless piston. The pressure of gas is constant (always equal to the atmospheric pressure). The expected graph for the variation of volume of gas with the change in temperature should be like as shown in Fig. I, but the actual graph is like Fig. II. The deviation was attributed to dissociation of gas as $X_n(g) \rightarrow n\,X(g)$. If the yield of this reaction is only 60%, then the value of n is

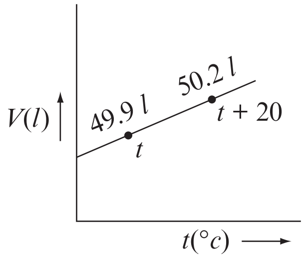


Fig. I

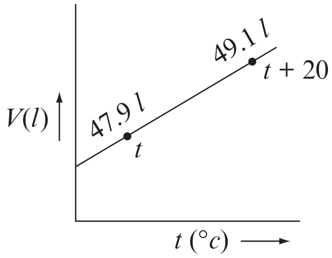


Fig. II

9. A mixture of H_2 and O_2 in 2 : 1 mole ratio is used to prepare water vapour by the following reaction.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

The total pressure of gases in the container is 4.5 atm at 57°C before the reaction. The final total pressure of gases (in atm) at 127°C after reaction assuming 80% yield of water vapour is

10. What would be the final pressure of O_2 in the following experiment? A collapsed polyethylene bag of 30 L capacity is partially blown up by the addition of 10 L of N_2 at 0.9 atm at 298 K. Subsequently, enough O_2 is pumped into the bag so that at 298 K and external pressure of 1.1 atm, the bag contains full 30 L. If the answer is x atm, then the value of $10x$ is

11. Pure water vapour is trapped in a vessel of volume 10 ml. The relative humidity is 40%. The vapour is compressed slowly and isothermally. The volume of vapour (in ml) at which first drop of liquid will form is

12. A container with a volume of 20.0 L holds N_2 (g) and H_2O (l) at 300 K. The pressure is found to be 1.0 atm. The water is then split into hydrogen and oxygen by electrolysis. After the reaction is complete, the pressure is 1.86 atm. What mass (in g) of water was present initially in the container? The aqueous tension of water at 300 K is 0.04 atm. ($R = 0.08$ L-atm/K-mol)

13. Find the number of diffusion steps required to separate the isotopic mixture initially containing some mass of hydrogen gas and 1 mole of deuterium gas in a 3 litre container maintained at 24.63 atm and 300 K to the final mass ratio of hydrogen to deuterium gas equal to 1 : 4.

14. The equation of state for a certain gas is $P = \frac{RT}{V_m - b} - \frac{a}{V_m}$, where *a* and *b* are constants distinct from zero. Ascertain whether the gas has a critical point or not. Answer as **1** if the gas has critical point and as **2**, if no critical point.

15. The Van der Waals constants *a* and *b* for a gas of molar mass 164.2 g/mol are 4.105 atm-L^2/mol^2 and 0.1 L/mol, respectively. The density (in kg/m^3) of the gas at 2 atm and 500 K is

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Four-digit Integer Type

1. A faulty barometer has some trapped air above the mercury column due to which it does not give the correct reading. When the atmospheric pressure is 760 mm Hg, the barometer reads 750 mm Hg and when the pressure is 800 mm Hg, the barometer reads 770 mm Hg. The actual pressure (in mm Hg) when the barometer reads 760 mm Hg is

2. Liquefied natural gas (LNG) is mainly methane. A 10.0 m^3 tank is constructed to store LNG at −164°C and 1 atm pressure, under which conditions its density is 416 kg/m^3. The volume (in m^3) of a storage tank capable of holding the same mass of LNG as a gas at 27°C and 1.642 atm pressure is

3. An unspecified quantity of an ideal gas was at initial pressure of 5 atm and temperature of 303 K. The gas is expanded at 303 K until the volume has increased by 60% of the initial value. Next, the quantity of the gas in the vessel is increased by 20% of the initial value while the volume is maintained constant. Finally, the temperature is adjusted at constant volume until the gas pressure is again 5 atm. What is the final temperature in Kelvin?

4. A cylinder contains 64 g of an ideal gas (M = 64) at 27°C and 3 atm. In transportation, the cylinder fell down and a dent was created, i.e., the effective volume of the cylinder decreases. But the valve attached to the cylinder cannot keep the pressure greater than 3 atm, so 8 g of gas was leaked out. The volume of the cylinder before and after the dent was *a* L and *b* L, respectively. If the valve was pretty strong, the pressure of gas in the cylinder after incurring a dent was $\frac{cd}{7}$ atm. Temperature remained constant during this process. The value of *abcd* is (R = 0.08 L-atm/K-mol)

5. A vertical cylinder closed from both ends is equipped with an easily moving piston dividing the volume into two parts, each containing one mole of air. In equilibrium at 320 K, the volume of the upper part is 4.0 times greater than that of the lower part. At what temperature (in kelvin), the volume of upper part becomes 3.0 times than that of lower part?

6. An LPG (liquefied petroleum gas) cylinder weighs 14.8 kg when empty. When full, it weighs 28.8 kg and shows a pressure of 35 atm. In the course of use at 300 K, the weight of the full cylinder is reduced to 23.2 kg. Assume LPG to be *n*-butane with normal boiling point of 273 K. If

$ab = \frac{1}{100} \times$ the volume (in litre) of the gas used up at the normal usage conditions, and

cd = final pressure (in atm) inside the cylinder

then the value of *abcd* is (R = 0.08 L-atm/K-mol)

7. At room temperature, the following reaction goes to completion.

$$2\,NO + O_2 \rightarrow 2\,NO_2 \rightarrow N_2O_4$$

Dimer N_2O_4 at 262 K is solid. A 750 ml flask and a 250 ml flask are separated by a stopcock. At 300 K, the nitric oxide in the longer flask exerts a pressure of 1.6 atm and the smaller contains oxygen at 1.2 atm. The gases are mixed by opening the stopcock. After the completion of reaction, the flasks are cooled to 200 K. Neglect the vapour pressure of dimer ($R = 0.08$ L-atm/K-mol)

a = 1 (if the gas remaining at 200 K is NO) or 2 (if the gas remaining at 200 K is O_2) or 3 (if the gas remaining at 200 K is NO_2) or 4 (if the gas remaining at 200 K is N_2O_4)

bc = millimole of gas remaining at 200 K

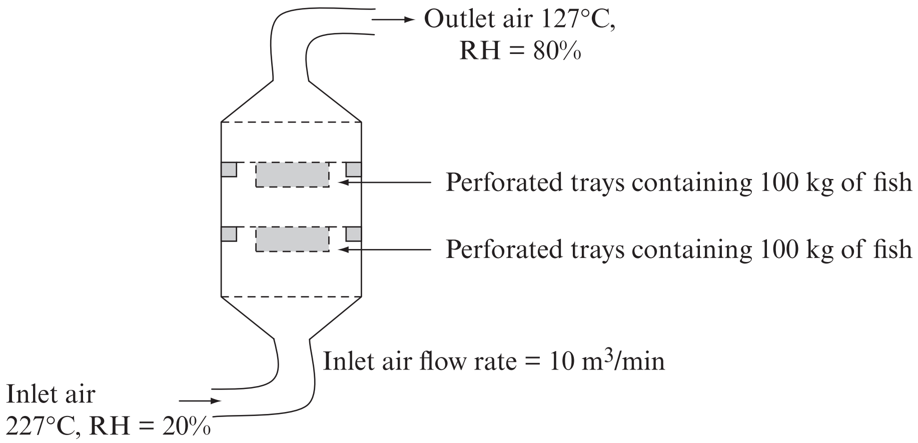
d = 10 × the pressure (in atm) of gas remaining at 200 K.

The value of *abcd* is

8. A barometer tube contains a mixture of air and saturated water vapour in the space above the mercury column. If it reads 70 cm when the actual atmospheric pressure is 76 cm of Hg, then the saturation vapour pressure at room temperature is 1.0 cm of Hg. The tube is now lowered in the reservoir till the space above the mercury column is reduced to half of its original volume. The reading of barometer (in cm) is (Assume that the temperature remains constant)

9. Temperature and relative humidity of air are 27°C and 75% on a certain day. Vapour pressure of water at 27°C and 7°C are 24.0 mm and 8.4 mm Hg, respectively. If the fraction of the mass of water vapour that will condense, if the temperature falls to 7°C is x, then the value of $1000x$ is

10. Suppose you are a manger of a fish drying unit. You have to dry 200 kg of fish containing 36% water on wet basis. The drier specification is mentioned in the figure.



Saturation vapour pressure at 227°C = 38 mm of Hg
Saturation vapour pressure at 127°C = 19 mm of Hg
What is the process time of the drier (in hr)? (R = 0.08 L-atm/K-mol)

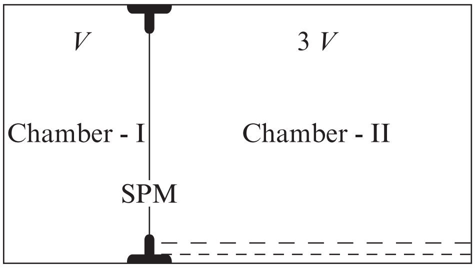
11. A diver at a depth of 10 m exhales some air by which a bubble of air of volume 24.0 ml is formed. The bubble catches an organism which survives on the exhaled air trapped in the bubble. The organism just inhales the air at the rate of 0.05 millimoles/min and exhales nothing. The atmospheric pressure is 1 atm and the temperature of water is throughout 300 K. The density of water is 1.013 g/ml (R = 0.08 L-atm/K-mol, g = 10 ms^{-2}),

ab = volume (in ml) of bubble when it reaches the surface after 10 minutes,

cd = average rate (in 10^{-5} mole/min) at which the organism should inhale air so that the volume of bubble remains the same at the depth and at the surface.

The value of $abcd$ is

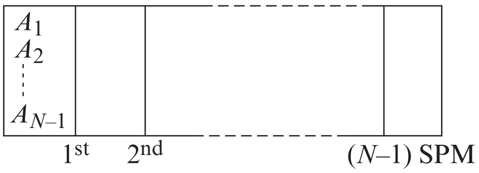
12. A container is divided into two parts in the ratio 1 : 3, by a fixed semipermeable membrane (SPM), which permits the movement of NO_2 gas only. At T K, Chamber – I contains only N_2O_4 gas at 20 mm Hg pressure and Chamber – II contains small amount of liquid water, but it is sufficient to maintain equilibrium with vapours at any temperature. Now, both the chambers are heated to '1.2T' K at which 50% of N_2O_4 is dissociated into NO_2. The vapour pressure of water at T K and '1.2T' K are 20 and 30 mm Hg, respectively. If ab and cd are the final pressures (in mm Hg) of gases in chambers I and II, respectively, then the value of $abcd$ is



13. During one of his adventure, Chacha Chaudhary got trapped in an underground cave which was sealed two hundred years back. The air inside the cave was poisonous, having some amount of CO (5.0%, by volume) in addition to O_2 and N_2. The safe limit of CO in the atmosphere is less than 0.001% by volume. Sabu, being huge, could not enter into the cave, so in order to save Chacha Choudhary, he started sucking the poisonous air out of the cave by mouth. Each time, he fills his lungs with the cave air and exhaled it out in the surroundings. In the meantime, fresh air from surrounding effused into the cave till the pressure becomes again 1 atm. If each time, Sabu sucked out half of the air present in the cave, then how many times does Sabu need to suck out air in order to safe Chacha Chaudhary?

14. A 50 litre vessel is equally divided into three parts with the help of two stationary (fixed) semi-permeable membranes (SPM). The vessel contains 60 g H_2 in the left chamber, 160 g O_2 in the middle and 140 g N_2 in the right chamber. The left SPM allows transfer of only H_2 gas while the right SPM allows the transfer of both H_2 and N_2. If the ratio of final total pressures in the three chambers is $x : y : 5$, then the value of $(5 \times x \times y)$ is

15. A very long rectangular box is divided into N equal compartments with $(N - 1)$ fixed semipermeable membranes (SPM) numbered from 1 to $(N - 1)$ as shown in the figure. The gases are initially present in only the first compartment and they can pass through only those SPM whose number is less than or equal to their subscript. For example, gas A_1 can pass through only first SPM, gas A_2 can pass only through first and second SPM, and so on. If initially all gases have same moles and after a long time, the ratio of partial pressures of gas A_4 in third compartment to that of gas A_{N-1} in first compartment is 3, then the value of N is



16. A volume of 100 ml of hydrogen were confined in a diffusion tube and exposed to air and at equilibrium a volume of 26 ml of air was measured in the tube. Again, when 100 ml of an unknown gas were placed in the same tube and exposed to air, 130 ml of air were measured in the tube at the equilibrium. The molecular mass of the unknown gas is

17. An argon atom is released from the surface of the earth to travel upwards at 300 K. Assuming that it undergoes no collisions with other molecules, how long (in metre) will it travel before coming to rest? Atomic mass of Ar = 40, $g = 10\ ms^{-2}$, $R = 8.4$ J/K-mol).

18. The second virial coefficient of methane can be approximate by the empirical equation,

$$B = a + b \cdot e^{-C/T^2}$$

where $a = -0.2\ bar^{-1}$, $b = 0.22\ bar^{-1}$, and $c = 950K^2$. What is the value of the Boyle temperature of methane (in K)? ($ln1.1 = 0.095$)

19. For a Van der Waals gas, the critical pressure and temperature are 73.89 atm and 27°C, respectively. What is the volume (in ml) occupied only by the molecules in a sample of gas containing its 24 moles?

20. The density of a gas (in g/litre) depends on pressure (in atm) at 300 K as

$$d = 4P + 0.02P^2 + 0.001P^3 + \ldots$$

The molar mass of gas (in g/mol) is ($R = 0.08$ L-atm/K-mol)

Answer Keys — Exercise I

Gaseous Parameters and Gas Laws

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

Ideal Gas Equation

26. (c) 27. (b) 28. (a) 29. (d) 30. (b) 31. (b) 32. (b) 33. (b) 34. (b) 35. (c)
36. (a) 37. (d) 38. (d) 39. (c) 40. (c) 41. (b) 42. (c) 43. (a) 44. (a) 45. (c)
46. (b) 47. (b) 48. (c) 49. (a) 50. (b)

Dalton's Law

51. (b) 52. (d) 53. (a) 54. (d) 55. (b) 56. (d) 57. (a) 58. (a) 59. (c) 60. (d)
61. (a) 62. (b) 63. (d) 64. (d) 65. (b) 66. (d) 67. (d) 68. (b) 69. (c) 70. (b)

Graham's Law

71. (a) 72. (d) 73. (d) 74. (c) 75. (a) 76. (c) 77. (a) 78. (a) 79. (a) 80. (d)

Kinetic Theory of Gases

81. (c) 82. (b) 83. (a) 84. (d) 85. (a) 86. (c) 87. (a) 88. (a) 89. (b) 90. (c)
91. (d) 92. (b) 93. (a) 94. (d) 95. (a)

Real Gases

96. (a) 97. (a) 98. (a) 99. (b) 100. (d) 101. (c) 102. (c) 103. (b) 104. (b) 105. (b)

Liquefaction of Gases

106. (d) 107. (c) 108. (b) 109. (d) 110. (d) 111. (a) 112. (b) 113. (c) 114. (a) 115. (d)

Answer Keys — Exercise II

Section A (Only one Correct)

1. (b) 2. (d) 3. (d) 4. (c) 5. (c) 6. (c) 7. (a) 8. (c) 9. (b) 10. (d)
11. (c) 12. (a) 13. (a) 14. (d) 15. (b) 16. (c) 17. (c) 18. (c) 19. (b) 20. (a)
21. (d) 22. (b) 23. (c) 24. (a) 25. (b) 26. (c) 27. (b) 28. (b) 29. (a) 30. (a)
31. (b) 32. (c) 33. (a) 34. (b) 35. (c) 36. (b) 37. (b) 38. (c) 39. (d) 40. (b)
41. (a) 42. (d) 43. (c) 44. (b) 45. (a) 46. (c) 47. (b) 48. (a) 49. (c) 50. (b)
51. (a) 52. (d) 53. (a) 54. (b) 55. (c) 56. (d) 57. (b) 58. (d) 59. (c) 60. (b)
61. (b) 62. (a) 63. (a) 64. (c) 65. (c) 66. (a) 67. (b) 68. (c) 69. (a) 70. (d)
71. (a) 72. (d) 73. (c) 74. (b) 75. (b) 76. (d) 77. (a) 78. (a) 79. (a) 80. (a)
81. (a) 82. (a) 83. (a) 84. (a) 85. (b) 86. (b) 87. (a) 88. (d) 89. (a) 90. (c)
91. (a) 92. (b) 93. (d) 94. (d) 95. (a)

Section B (One or More than one Correct)

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

Section C

Comprehension I

1. (c) 2. (b) 3. (c)

Comprehension II

4. (c) 5. (b) 6. (a)

Comprehension III

7. (d) 8. (b) 9. (d)

Comprehension IV

10. (b) 11. (c) 12. (b) 13 (a)

Comprehension V

14. (c) 15. (b) 16. (a) 17. (c)

Comprehension VI

18. (a) 19. (d) 20. (b)

Comprehension VII

21. (b) 22. (c)

Comprehension VIII

23. (c) 24. (b) 25. (a)

Comprehension IX

26. (b) 27. (b) 28. (a)

Comprehension X

29. (b) 30. (a) 31. (c) 32. (b)
33. (b) 34. (a) 35. (a)

Comprehension XI

36. (a) 37. (a) 38. (c) 39. (a)
40. (d) 41. (a) 42. (a)

Comprehension XII

43. (d) 44. (c) 45. (a)

Section D (Assertion – Reason)

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

Section E (Column Match)

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

Section F (Subjective)

Single-digit Integer Type

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

Four-digit Integer Type

1. (0775) 2. (3900) 3. (0404) 4. (8724) 5. (0450)
6. (2421) 7. (1254) 8. (0065) 9. (0500) 10. (0320)
11. (3610) 12. (1836) 13. (0013) 14. (0140) 15. (0015)
16. (0050) 17. (9450) 18. (0100) 19. (0250) 20. (0096)

HINTS AND EXPLANATIONS

EXERCISE I (JEE MAIN)

Gaseous Parameters and Gas Laws

1. $P = \frac{688}{760} = 0.905$ atm

2. $\rho_1 h_1 = \rho_2 h_2$

or $1.047 \times 1 = 13.6 \times h_2 \Rightarrow h_2 = 0.077$ mmHg.

3. $\rho_1 h_1 = \rho_2 h_2$

or $13.6 \times 75 = 1.7 \times h_2 \Rightarrow h_2 = 600$ cm

4. As the pressure in that area is low, there must be storm.

5. $P_1V_1 = P_2V_2 \Rightarrow 0.72 \times 200 = 0.90 \times V_2$

$\Rightarrow V_2 = 160$ ml.

6. $P_1V_1 = P_2V_2 \Rightarrow 1 \times 2500 = P_2 \times 500 \Rightarrow P_2 = 5$ bar.

$\therefore$ % Increase in pressure $= \frac{5-1}{1} \times 100 = 400\%$

7. Theory based

8. Boyle's law constant $= PV = \left(1.2 \times 1.013 \times 10^5 \frac{\text{N}}{\text{m}^2}\right)$

$$\times \left(200 \times 10^{-6}\,\text{m}^3\right)$$

$$= 24.3\ \text{J}$$

9. $P_1V_1 = P_2V_2 \Rightarrow 5 \times 10^{-4} \times V_1 = 760 \times 1$

$\Rightarrow V_1 = 1.52 \times 10^6$ dm^3.

10. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{600}{300} = \frac{V_2}{320} \Rightarrow V_2 = 640$ ml.

$\therefore$ Increase in volume = 640 – 600 = 40 ml.

11. Theory based

12. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{200}{x+4} = \frac{300}{x+144} \Rightarrow x = 276.$

$\therefore$ Absolute zero $= -276°$C.

13. $V \propto T$

14. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{3.75}{308} = \frac{3.0}{T_2} \Rightarrow T_2 = 246.4\ \text{K} = -26.6°\text{C}.$

15. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V}{300} = \frac{3V}{T_2} \Rightarrow T_2 = 900$ K.

16. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{1200}{300} = \frac{1218}{T_2} \Rightarrow T_2 = 304.5$ K.

17. $\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{100}{T} = \frac{101}{T+1} \Rightarrow T = 100$ K.

18. $\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{P}{283} = \frac{2P}{T_2} \Rightarrow T_2 = 566\ \text{K} = 293°\text{C}.$

19. $\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{1}{546} = \frac{P_2}{273} \Rightarrow P_2 = 0.5$ atm.

20. $n_{O_2} = n_{SO_2} \Rightarrow \frac{m_{O_2}}{32} = \frac{m_{SO_2}}{64} \Rightarrow m_{O_2} = \frac{1}{2} \times m_{SO_2}$

21. Theory based

22. The number of molecules will be the same. Hence, the ratio of number of atoms = 2 : 1 : 2 : 3.

23. Number of molecules in a mole will remain equal to Avogadro's number.

24. The number of molecules in a closed container will not change, but the pressure of gas becomes double ($P \propto$ T when 'n' and 'V' are constant).

25. $n_{O_2} = n_{\text{gas}} \Rightarrow \frac{0.5}{32} = \frac{0.75}{\text{M}} \Rightarrow \text{M} = 48.$

Ideal Gas Equation

26. $PV = nRT \Rightarrow P = \frac{n}{V}RT = CRT$

$\therefore$ $1 \text{ atm} = 1\frac{\text{mol}}{\text{litre}} \times 0.0821\frac{\text{L-atm}}{\text{K.mol}} \times \text{T} \Rightarrow \text{T} \simeq 12.2 \text{ K}.$

27. Theory based

28. Volume of cube, $l^3 = n \times 22.4 \text{ L}$

$$= \frac{850 \times 10^6}{6 \times 10^{23}} \times 22.4 \times 10^3 \text{ cm}.$$

$\therefore\ l = 3.17 \times 10^{-4}$ cm.

29. $PV = nRT$

or $4 \times 10^{-22} \times 1 = \frac{N}{6 \times 10^{23}} \times 0.08 \times 3 \Rightarrow N = 1000.$

30. $V = \frac{nRT}{P} \Rightarrow$ For $V_{\max}$, T should be high and P should be low.

31. At 4°C, H_2O is a liquid with density = 1.0 g/ml.

Hence, $V = \frac{M}{d} = \frac{1.8}{1.0} = 1.8$ ml.

32. As metallic cylinder is a good conductor of heat, the temperature will remain constant. But the pressure will increase due to increase in mole.

33. $V = \frac{nR}{P} \cdot \text{T}$

Slope will be smaller at higher 'P'.

34. $d = \frac{PM}{RT} \Rightarrow$ For maximum density, 'P' should be high and 'T' should be low.

35. $PV = nRT \Rightarrow P \propto \text{T} \Rightarrow \left(\frac{P}{T}\right)_{v_2} = \left(\frac{P}{T}\right)_{\text{H}_\text{e}}$

$\Rightarrow \frac{P}{T} = \frac{P_{\text{He}}}{2T} \Rightarrow P_{\text{He}} = 2$

36. $n_{\text{removed}} = n_{\text{taken}} - n_{\text{remained}}$

or $\frac{w}{81} = \frac{P \times 10}{0.082 \times 300} - \frac{(P - 0.82) \times 10}{0.082 \times 300} \Rightarrow w = 27 \text{ g}.$

37. $PV = \frac{w}{M}RT \Rightarrow w_1T_1 = w_2T_2$

or $3.5 \times (273 + t) = 3.2 \times (303 + t) \Rightarrow t = 47°\text{C}.$

38. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{P \times V}{T} = \frac{\frac{P}{2} \times V_2}{2T} \Rightarrow V_2 = 4V.$

39. $d = \frac{PM}{RT} \Rightarrow \frac{PM}{d} = \text{Constant} \Rightarrow \frac{P_AM_A}{d_A} = \frac{P_BM_B}{d_B}$

or $\frac{P_A \times \frac{M_B}{2}}{2 \times d_B} = \frac{P_B \times M_B}{d_B} \Rightarrow \frac{P_A}{P_B} = \frac{4}{1}.$

40. $\frac{d_1T_1}{P_1} = \frac{d_2T_2}{P_2} \Rightarrow \frac{5.46 \times 300}{2} = \frac{d_2 \times 273}{1}$

$\Rightarrow d_2 = 3.0 \text{ gm/dm}^3.$

41. $n_1T_1 = n_2T_2 \Rightarrow n_1 \times 300 = n_2 \times 750 \Rightarrow \frac{n_2}{n_1} = \frac{2}{5}.$

$\therefore$ Fraction of air escaped $= 1 - \frac{n_2}{n_1} = \frac{3}{5}.$

42. $2 \times V = \frac{1}{M_A} \times RT$ and $3 \times V = \left(\frac{1}{M_A} + \frac{2}{M_B}\right) \times RT$

$\therefore\ \frac{M_A}{M_B} = \frac{1}{4}.$

43. $P = 33.6 = \left(\frac{48}{48} + \frac{48}{96}\right) \times 0.0821 \times 546 \Rightarrow P = 2 \text{ atm}.$

44. $n_{\text{escaped}} = n_{\text{taken}} - n_{\text{remained}}$

$$= \frac{1 \times 2.24}{0.0821 \times 273} - \frac{\frac{570}{760} \times 2.24}{0.0821 \times 273} = 0.025.$$

45. $\frac{n_1T_1}{P_1} = \frac{n_2T_2}{P_2} \Rightarrow \frac{n_1 \times T}{P} = \frac{n_2 \times \frac{2}{3}T}{\frac{P}{2}} \Rightarrow n_2 = \frac{3}{4}n_1$

$\therefore$ Mass of gas escaped $= m - \frac{3}{4}m = \frac{m}{4}.$

46. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{720\times 100}{300} = \frac{420\times V_2}{210} \Rightarrow V_2 = 120$ L.

$\therefore$ Increase in volume $= 120 - 100 = 20$ L.

47. $V = \frac{nRT}{P} \Rightarrow$ For constant volume, $\frac{T}{P}$ should be the same.

48. $\frac{P_1}{n_1T_1} = \frac{P_2}{n_2T_2} \Rightarrow \frac{9}{n\times 303} = \frac{P_2}{1.5n\times 404} \Rightarrow P_2 = 18$ atm.

49. $\frac{P_1V_1}{m_1} = \frac{P_2V_2}{m_2} \Rightarrow \frac{P\times V_1}{10} = \frac{\frac{P}{2}\times 50}{1.25}$

$\therefore\ V_1 = 200$ ml.

50. $N_2O_4 \rightarrow 2NO_2$

Initial	1 mole	0
Final	1 – 0.2 = 0.8	2 × 0.2 = 0.4

Now, $\frac{P_1}{n_1T_1} = \frac{P_2}{n_2T_2} \Rightarrow \frac{1}{1\times 300} = \frac{P_2}{1.2\times 600}$
$\Rightarrow P_2 = 2.4$ atm.

Dalton's Law

51. H_2 and O_2 gases are unreactive in normal condition.

52. $P_{\text{total}} = P_{N_2} + P_{O_2} + P_{CO_2} = \frac{38}{76} + \frac{190}{760} + 0.5$
$= 1.25$ atm.

53. $P_{O_2} = X_{O_2} \cdot P_{\text{total}} = \frac{21}{100}\times 740 = 155.4$ mmHg.

54. $\frac{P_{H_2}}{P_{\text{total}}} = X_{H_2} = \frac{n_{H_2}}{n_{H_2} + n_{C_2H_6}} = \frac{\frac{w}{2}}{\frac{w}{2} + \frac{w}{30}} = \frac{15}{16}.$

55. $P_{H_2} = X_{H_2} \cdot P_{\text{total}} = \frac{\frac{20}{2}}{\frac{20}{2} + \frac{80}{32}} \times 1 = 0.8$ bar.

56. $\frac{n_1}{P_1} = \frac{n_2}{P_2} \Rightarrow \frac{\frac{16}{32} + \frac{14}{28}}{4} = \frac{\frac{8}{32} + \frac{14}{28}}{P_2} \Rightarrow P_2 = 3$ atm.

57. $P_{CO} = P_{CH_4} \Rightarrow n_{CO} = n_{CH_4} \Rightarrow \frac{70}{28} = \frac{w}{16} \Rightarrow w = 40$ g.

58. $n_{\text{total}} = n_{H_2} + n_{CH_4} \Rightarrow \frac{P_f\times 2V}{RT} = \frac{P\times V}{RT} + \frac{P\times V}{RT}$
$\Rightarrow P_f = P.$

59. $\frac{P_1}{n_1} = \frac{P_2}{n_2} \Rightarrow \frac{P}{n+n} = \frac{P_2}{n} \Rightarrow P_2 = \frac{P}{2}$ mm.

60. $\frac{P_{O_2}}{P_{N_2}} = \frac{n_{O_2}}{n_{N_2}} = \frac{w/32}{w/28} = \frac{7}{8}$

$\therefore\ P_{O_2} = 0.875\times P_{N_2}.$

61. $n_{\text{total}} = n_{N_2} + n_{O_2} \Rightarrow \frac{P.3V}{RT} = \frac{800\times 2V}{RT} + \frac{680\times V}{RT}$

$\therefore\ P = 760$ mm.

62. $n_{\text{total}} = n_{H_2} + n_{O_2}$

or $\frac{P\times 1}{RT} = \frac{0.8\times 0.5}{RT} + \frac{0.7\times 2.0}{RT} \Rightarrow P = 1.8$ bar.

63. $H_2 + Cl_2 \Rightarrow 2HCl$

Initial mole	$\frac{4}{2} = 2$	$\frac{9\times 10^{23}}{6\times 10^{23}} = 1.5$	0
Final moles	0.5	0	3.0

Now, $P_{HCl} = X_{HCl} \times P_{\text{total}} = \frac{3.0}{3.5}\times 700 = 600$ mm

64. For N_2 gas, $P_1V_1 = P_2V_2 \Rightarrow (1 - 0.3)\times V = P_2 \times \frac{V}{3}$
$\Rightarrow P_2 = 2.1$ atm.

$\therefore$ Final pressure $= P_{N_2} + V.P. = 2.1 + 0.3 = 2.4$ atm.

65. Rate of evaporation is greater than the rate of condensation.

66. $P_{N_2} = X_{N_2} \times P_{\text{total}} = \frac{3}{4} \times (640 - 40) = 450$ Torr.

67. P_{O_2} + Vapour pressure of water = External pressure.

68. Vapour pressure depends only on temperature.

69. $P_{H_2O} = \frac{1}{100} \times 760$ mmHg = 7.6 mmHg.

70. $P_1V_1 = P_2V_2 \Rightarrow (740 - 20) \times 190 = 760 \times V_2$
$\Rightarrow V_2 = 180$ mm.

Graham's Law

71. $\frac{r_{H_e}}{r_{CH_4}} = \sqrt{\frac{M_{CH_4}}{M_{H_e}}} = \sqrt{\frac{16}{4}} = \frac{2}{1}$.

72. $\frac{r_X}{r_{PH_3}} = \sqrt{\frac{M_{PH_3}}{M_X}} \Rightarrow 0.88 = \sqrt{\frac{34}{M_X}} \Rightarrow M_X = 43.9$.

Gas may be $N_2O(M = 44)$

73. $\frac{r_{O_2}}{r_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} \Rightarrow \frac{n_{O_2}/t}{n_{H_2}/t} = \sqrt{\frac{2}{32}} \Rightarrow n_{O_2} = \frac{1}{4} \times n_{H_2}$.

or $\frac{w_{O_2}}{32} = \frac{1}{4} \times \frac{2}{2} \Rightarrow w_{O_2} = 8$ g.

74. $\frac{r_{C_nH_{2n+2}}}{r_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{C_n}H_{2n+2}}} \Rightarrow \frac{1}{6}\sqrt{\frac{2}{14n+2}} \Rightarrow n = 5$.

75. $\frac{r_{N_2O}}{r_{\text{tear gas}}} = \sqrt{\frac{M_{\text{tear gas}}}{M_{N_2O}}} \Rightarrow \frac{x/t}{8 - x/t} = \sqrt{\frac{176}{44}}$
$\Rightarrow x = 5.33$

76. $M_{N_2O} = M_{CO_2} \Rightarrow r_{N_2O} = r_{CO_2}$

77. $\frac{r_A}{r_B} = \frac{\text{Area}_A}{\text{Area}_B} = \frac{\pi r^2}{r^2} = \frac{\pi}{1}$.

78. $\frac{r_{HC}}{r_{SO_2}} = \sqrt{\frac{M_{SO_2}}{M_{HC}}} \Rightarrow \frac{180/15}{120/20} = \sqrt{\frac{64}{M_{HC}}}$
$\Rightarrow M_{HC} = 16$.

79. $\frac{r_{NH_3}}{r_{BF_3}} = \sqrt{\frac{M_{BF_3}}{M_{NH_3}}} \Rightarrow \frac{x/t}{(100 - x)/t} = \sqrt{\frac{68}{17}}$
$\Rightarrow x = 66.67$ cm.

80. $n_{\text{total}} = \frac{PV}{RT} = \frac{4.15 \times 3}{0.083 \times 300} = 0.5$

$\therefore\ n_{\text{gas}} = 0.5 - n_{N_2} = 0.5 - 0.4 = 0.1$.

Now, $\frac{r_{N_2}}{r_{\text{gas}}} = \sqrt{\frac{M_{\text{gas}}}{M_{N_2}}} \Rightarrow \frac{0.1/t}{0.4/t} = \sqrt{\frac{M_{\text{gas}}}{28}}$
$\Rightarrow M_{\text{gas}} = 448$

Kinetic Theory of Gases

81. $\frac{u_{\text{rms},H_2}}{u_{\text{rms},O_2}} = \frac{\sqrt{\frac{3R \times 50}{2}}}{\sqrt{\frac{3R \times 800}{32}}} = \frac{1}{1}$

82. $\alpha = c = u$

83. $u_{av} \propto \sqrt{T} \Rightarrow \frac{u_2}{u_1} = \sqrt{\frac{T_2}{T_1}} \Rightarrow \frac{u_2}{0.3} = \sqrt{\frac{1200}{300}}$
$\Rightarrow u_2 = 0.6$ m/s

84. $u_{\text{rms}} \propto \sqrt{T} \Rightarrow u_2 = \sqrt{2} \times u_1$

85. $u_{\text{rms}} \propto \frac{1}{\sqrt{M}} \Rightarrow H_2 > N_2 > O_2 > HBr$.

86. $u \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{u_1}{r_2} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{3}{1} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{M_1}{M_2} = \frac{1}{9}$.

87. $E_T = \frac{3}{2}nRT \Rightarrow \frac{3}{2}\times 0.3\times RT = \frac{3}{2}\times 0.4\times R\times 400$

$\Rightarrow T = \frac{1600}{3}$

88. $x = \frac{3}{2}\times\frac{N}{N_A}\times R\times 150$ and $2x = \frac{3}{2}\times\frac{N^1}{N_A}\times R\times 300$

$\therefore N^1 = N$

89. $Av.$K.E. $\propto T$

90. $E_T = \frac{3}{2}nRT \Rightarrow 0.63 = \frac{3}{2}\times\frac{10^{20}}{6\times 10^{23}}\times 8.314\times T$

$\Rightarrow T = 303.1 = \text{K} = 30.1°\text{C}$

91. $Av.$K.E. $\alpha\ T$

92. Theory based

93. Fraction of molecule remains the same.

94. $Z_{11} = Z_1.\frac{N^*}{2} = X.\frac{N^*}{2}$

95. $\lambda = \frac{RT}{\sqrt{2\pi}\sigma^2.P.N_A} \Rightarrow \lambda\,\alpha\,\frac{1}{\sigma^2}$

$\therefore$ Smaller the size of molecule, larger is λ.

Real Gases

96. Theory based

97. Theory based

98. $Z = 1 + \frac{P.b}{RT}$

99. $\left(P + \frac{a.n^2}{V^2}\right)(V - nb) = nRT \Rightarrow \left(P + \frac{a}{4V^2}\right)\left(V - \frac{b}{2}\right)$

$= \frac{RT}{2}.$

100. Greater the intermolecular forces, greater is 'a'.

101. $b = 4\times$ Volume of a molecule$\times \text{N}_A$

$= 4\times\frac{4}{3}\pi\times\left(1.25\times10^{-8}\text{ cm}\right)^3\times 6.022\times10^{23}$

$= 19.7\,\text{cm}^3/\text{mol} = 1.97\times10^{-2}\,\text{L}/\text{mol}.$

102. $P = \frac{nRT}{V-nb} - \frac{an^2}{v^2} = \frac{2\times0.0821\times300}{0.25 - 2\times0.05} - \frac{2.5\times2^2}{(0.25)^2}$

$= 168.4$ atm.

103. $b = 4\times\frac{4}{3}\pi r^3 N_A$

or, $0.0391\times10^3 = 4\times\frac{4}{3}\pi r^3\times 6.022\times10^{23}$

$\Rightarrow r = 1.57\times10^{-8}$ cm

104. Theory based

105. When $P \to 0$, gases behave ideally. $PV = nRT$.

Liquefaction of Gases

106. Theory based

107. $-\underset{P}{200°C} < -110°C < -\underset{Q}{100°C} < +\underset{R}{50°C}$

Gases cannot be liquefied above critical temperature (T_c).

108. $P_C V_C = \frac{3}{8}R.T_C \Rightarrow V_C = \frac{3}{8}\times\frac{0.0821\times305.5}{48.2}$

= 0.195 L/mol.

109. $T_C = \frac{8a}{27Rb}$ and $\frac{a}{b}$ is maximum for Z.

110. $T_C = \frac{8a}{27Rb}$ and $P_C = \frac{a}{27b^2} \Rightarrow b = \frac{R.T_c}{8.P_C}$ and $\frac{T_C}{P_C}$ is minimum for He.

111. $Z_C = \frac{P_C.V_C}{R.T_C} = \frac{\frac{a}{27b^2} \times 3b}{R \times \frac{80}{27Rb}} = \frac{3}{8}.$

112. Gases cannot be liquefied above Tc.

113. Gases with higher ‘a’ value are easily liquefiable.

114. $T_c = \frac{8}{27}.\frac{a}{Rb}$; $T_B = \frac{a}{Rb}$; $T_i = 2.\frac{a}{Rb}.$

115. $b = \frac{R.T_c}{8.P_c} = \frac{0.0821 \times 300}{8 \times 82.1} = 0.0375$ L/mol.

EXERCISE II (JEE ADVANCED)

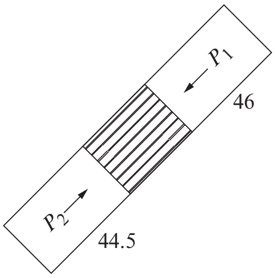
Section A (Only one Correct)

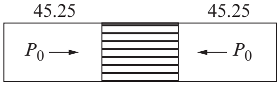
1. $P_{\text{gas}} + 15.6 = 53.3 + 76.3 \Rightarrow P_{\text{gas}} = 114$ cm Hg = 1.5 atm

2. Fractional increase $= \frac{V_2 - V_1}{V_1} = \frac{V_2}{V_1} - 1 = \frac{P_1}{P_2} - 1$

$$= \frac{H + 7H}{7H} - 1 = \frac{1}{7}$$

3.





$P_0 \times 45.25 = P_1 \times 46 = P_2 \times 44.5$

$P_1 + 5 \sin 30° = P_2$

$$\frac{P_0 \times 45.25}{46} + 5 \times \frac{1}{2} = \frac{P_0 \times 45.25}{44.5}$$

$$\Rightarrow P_0 = 75.4 \text{ cm Hg}$$

4. $P_1V_1 = P_2V_2 \Rightarrow 10 \times 2A = (10 + h) \times hA$

$\Rightarrow h = 1.71$ m

5. Theory based

6. $\frac{dv}{dt} = \frac{V_0}{273} = 0.08 \Rightarrow V_0 = 21.84$ L

7. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{1.0}{x+0} = \frac{0.6}{x+(-100)}$

$\Rightarrow x = 250 \Rightarrow 0$ K $= -250$°C

8. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V}{T} = \frac{V + \Delta V}{T + \Delta T}$

$\Rightarrow \frac{\Delta V}{V.\Delta T} = \frac{1}{T} \Rightarrow y = \frac{1}{x}$

9. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V_1}{273 + t_1} = \frac{1.1 V_1}{273 + t_2}$

∴ Percentage increase in temperature

$$= \frac{t_2 - t_1}{t_1} \times 100 = (10 + \frac{2730}{t_1})\ \%$$

10. Number of SO_2 molecules = $N \Rightarrow$ Number of atoms = 3N

11. $\frac{n_{N_2}}{n_{O_2}} = \frac{V_{N_2}}{V_{O_2}} \Rightarrow \frac{m_{N_2}/28}{m_{O_2}/32} = \frac{1}{7/8} \Rightarrow \frac{m_{N_2}}{m_{O_2}} = \frac{1}{1}$

12. $\frac{V_1}{n_1} = \frac{V_2}{n_2} \Rightarrow \frac{4/3\pi(10/2)^3}{8}$

$$= \frac{4/3\pi(d/2)^3}{1} \Rightarrow d = 5 \text{ cm}$$

13. $P = P_{CO_2} + P_{\text{air}} = \frac{0.5 \times 0.0821 \times 300}{1} + 1 = 13.315$ atm

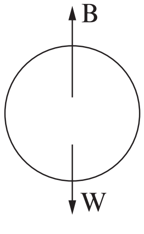
14. Weight of filled balloon,

W = 20 g + 40 × 0.6 = 44 g

Weight of displaced air,

B = 40 × 1.3 = 52 g

∴ Balloon will lift upward with pay load = 52 – 44 = 8 g



15. Water will behave like ideal gas on disappearance of intermolecular forces.

$$V = \frac{nRT}{P} = \frac{4.5\times10^3}{18} \times (22.4\times10^{-3})\ \text{m}^3 = 5.6\ \text{m}^3$$

16. $$d = \frac{m}{v} \Rightarrow 1.5 = \frac{n_{co}\times28 + n_{co_2}\times44}{(n_{co}+n_{co_2})\times\frac{0.0821\times300}{1}}$$

$$\Rightarrow n_{co} = \frac{7.055}{8.945}\ n_{co_2}$$

Alkali will absorb all CO_2. Hence, final pressure is due to CO.

$$P_{co} = \frac{n_{co}}{n_{co}+n_{co_2}} \times P_{total} = \frac{7.055}{7.055+8.945}\times760\ \text{mm}$$

$$= 335.1\ \text{mm}$$

17. $$\frac{V_{\text{water vapour}}}{V_{\text{water}}} = \frac{\left(\frac{1\times0.0821\times373}{1}l\right)}{\left(\frac{18}{0.96}ml\right)} = 1633.24$$

18. $$V_{O_2} = \frac{\frac{3.2}{32}\times0.0821\times310}{1} = 2.5451\ \text{L}$$

$$V_{CO_2} = \frac{\frac{8.8}{44}\times0.0821\times310}{1} = 5.0902\ \text{L}$$

19. $$n_{CO_2} = \frac{200\times0.1}{1000} = 0.02$$

$$\therefore\ V_{CO_2} = 0.02\times22.4 = 0.448\ \text{L}$$

20. $$\frac{d(d)}{d\rho} = \frac{M}{RT} = 1.2\times10^{-5}\ \text{Kg m}^{-3}\,\text{Pa}^{-1}$$

$$\Rightarrow \frac{M}{8.314\times300} = 1.2\times10^{-5}$$

$$\therefore\ M_{air} = 0.03\ \text{Kg/mol} = 30\ \text{gm/mol}$$

Now, $$30 = \frac{n_{N_2}\times28 + n_{O_2}\times32}{n_{N_2}+n_{O_2}} \Rightarrow n_{N_2}:n_{O_2} = 1:1$$

21. $$\frac{m_1 T_1}{P_1} = \frac{m_2 T_2}{P_2} \Rightarrow \frac{4\times T}{P} = \frac{m_2\times\frac{T}{2}}{2P}$$

$$\Rightarrow m_2 = 16\ \text{gm}$$

Hence, (16 – 4) = 12 gm gas should be added.

22. $$\frac{74.5}{50} = 1.49\ \text{times}$$

23. $$V_1d_1 = V_2d_2 \Rightarrow 1500\times1.25 = 3.92\times d_2$$
$$\Rightarrow d_2 = 478.3\ \text{kg/mol}$$

24. $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow \frac{P\times\frac{4}{3}\pi r_1^3}{T} = \frac{\frac{P}{4}\times\frac{4}{3}\pi r_2^3}{2T}$$

$$\Rightarrow r_2 = 2r_1$$

$$\therefore\ \%\ \text{Increase in radius} = \frac{r_2 - r_1}{r_1}\times100 = 100\%$$

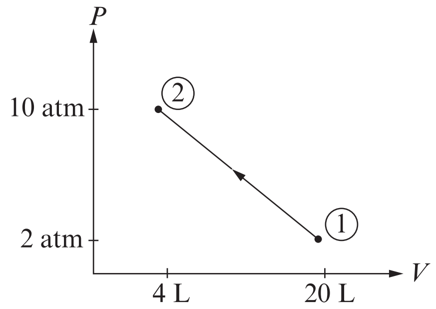
25. $$\text{Constant} = P^2V = \left(\frac{nRT}{V}\right)^2 V \Rightarrow \frac{T^2}{V} = \text{Constant}$$

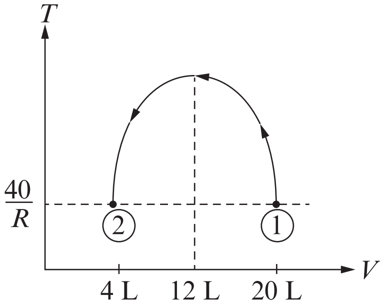
∴ On expansion, temperature will increase.

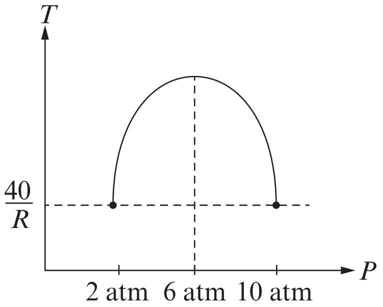
26. $$r = \frac{R}{M} \Rightarrow r_{n_2} > r_{H_e} > r_{N_2}$$

27. $$P\times3 = \frac{7}{28}\times0.0821\times300 \Rightarrow 2.0525\ \text{atm}$$

28.







For T_{max}, $V = 12$ L and $P = 6$ atm and hence,

$$T_{max} = \frac{6\times12}{1\times0.08} = 900\ \text{K}.$$

29. $2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

2 mole 3 mole

$\therefore \frac{0.15}{27}$ mole $\frac{3}{2}\times\frac{0.15}{27}$ mole

$\therefore V_{H_2} = \frac{1.5\times0.15}{27}\times\frac{0.0831\times300}{0.831} = 0.25L$

30. $N_2 \rightarrow 2N$

Initial mole $a = \frac{1.4}{28}$ 0

Final mole $a - 0.4a$ $2\times0.4a$

$= 0.6a$ $= 0.8a$

Final total moles $= 0.6a + 0.8a = 1.4\times\frac{1.4}{28} = 0.07$

$\therefore P = \frac{0.07\times0.0821\times1800}{5} \simeq 2.07$ atm

31. $CH_4 (g) + 2O_2 (g) \xrightarrow{127°C} CO_2 (g) + 2H_2O (g)$

As there is no change in mole of gases,

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{1}{300} = \frac{P_2}{400} \Rightarrow P_2 = 1.33 \text{ atm}$$

32. $P_c = X_c\, P_{\text{total}} \Rightarrow 10 - (1 + 3) = \frac{n_C}{10}\times10 \Rightarrow n_c = 6$

$\therefore$ Mass of $C = 6\times2 = 12$ gm

33. $\frac{x}{4} + \frac{5-x}{M} = \frac{760\times2.4}{R\times300}$ and $\frac{x}{4} = \frac{19\times2.4}{R\times15}$

$\therefore M = 96$

34. $C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O(l)$

1 vol $\frac{7}{2}$ vol 2 vol 0 vol

$\therefore$ 10 ml 35 ml 20 ml 0

Final volume should be 20 + (40 – 35) = 25 ml but it is 26 ml. Hence, volume occupied by water vapour is (26 – 25) = 1 ml.

$\therefore$ Vapour pressure of water $= \frac{1}{26}\times 1 \text{ atm} = \frac{760}{26}$

$= 29.23$ mm Hg

35. n_{H_2O} vapour needed $= \frac{(26.463 - 24)\times1}{760\times0.0821\times300}$

$= 1.32\times10^{-4}$

36. $P = \frac{1.2\times0.0821\times300}{18\times50}\times760 = 24.96$ mm Hg

37. Mass of water lost per day $= \frac{\Delta P.V}{RT}\times M$

$$= \frac{\frac{(45-5)}{760}\times10000}{0.0821\times310}\times18 = 372.23 \text{ gm}$$

38. Vapour pressure is a function of temperature only

39. After achievement of equilibrium with its liquid form which will form on continuous injection of vapour, the pressure due to vapours become constant.

40. Rate of evaporation will remain constant throughout because neither surface area nor temperature are changing

41. $\frac{r_x}{r_y} = \frac{1}{5}$ and $\frac{r_y}{r_z} = \frac{1}{6} \Rightarrow \frac{r_z}{r_x} = \frac{30}{1}$

42. Smaller the rate of diffusion of HX, more closer to the HX end, NH_4X will form.

43. $\frac{r_{N_2}}{r_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{N_2}}} \Rightarrow \frac{\Delta P/60}{\Delta P/t} = \sqrt{\frac{2}{28}}$

$\Rightarrow t = 16.04$ min

44. $M_{\text{dry air}} > M_{\text{moist air}}$

45. $\frac{r_{CH_4}}{r_{HBr}} = \frac{P_{CH_4}}{P_{HBr}}\sqrt{\frac{M_{HBr}}{M_{CH_4}}} \Rightarrow \frac{1}{1} = \frac{n_{CH_4}}{n_{HBr}}\sqrt{\frac{81}{16}}$

$\Rightarrow \frac{n_{CH_4}}{n_{HBr}} = 0.4$

$\therefore X_{CH_4} = \frac{n_{CH_4}}{n_{CH_4} + n_{HBr}} = 0.31$

46. As HCl will diffuse slowly, white fumes will form closer to HCl end.

47. In gases, the intermolecular distance is much higher than the size of molecules.

48. $\frac{u_{av,2}}{u_{av,1}} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{375}{250}} = 1.22$

49. $\frac{u_{rms,\,O}}{u_{rms,\,O_2}} = \frac{\sqrt{\frac{3R\times2T}{16}}}{\sqrt{\frac{3RT}{32}}}\ \frac{2}{1} \Rightarrow u_{rms,\,o} = 2\,V$

50. Average speed for a gas depends on temperature and it is independent from the presence of other gas.

51. Difference in any two kind of speed, $\Delta u = K \times \sqrt{T}$

Now, $\dfrac{d(\Delta u)}{dT} = \dfrac{\mathrm{K}}{2\sqrt{\mathrm{T}}}$

$\Rightarrow$ On increasing temperature, Δu decreases.

52. $\dfrac{u_{av,\,x}}{u_{av,\,y}} = \dfrac{2}{1} = \sqrt{\dfrac{T_X}{T_Y}} \Rightarrow \dfrac{T_X}{T_Y} = \dfrac{4}{1}$

Now, $\dfrac{P_X}{P_Y} = \dfrac{nRT_X/V_X}{nRT_Y/V_Y} = \dfrac{T_X}{T_Y}\times\dfrac{V_Y}{V_X} = \dfrac{4}{1}\times\dfrac{2}{1} = \dfrac{8}{1}$

53. $1 \times V = \dfrac{1}{M_A} \times R \times T \Rightarrow \dfrac{M_B}{M_A} = \dfrac{4}{1}$

$0.5 \times V = \dfrac{2}{M_B} \times RT$

$\therefore\ \dfrac{u_{av,\,A}}{u_{av,\,B}} = \sqrt{\dfrac{M_B}{M_A}} = \dfrac{2}{1}$

54. $u_{av,\,A} = u_{av,\,B} \Rightarrow \sqrt{\dfrac{8RT_A}{\pi M_A}} = \sqrt{\dfrac{3RT}{M_B}} \Rightarrow \dfrac{M_B}{M_A} = \dfrac{3\pi}{8}$

Now, $u_{av,\,A} = u_{av,\,B} \Rightarrow \sqrt{\dfrac{8RT_A}{\pi M_A}} = \sqrt{\dfrac{8RT_B}{\pi M_B}}$

$\Rightarrow \dfrac{T_A}{T_B} = \dfrac{M_A}{M_B} = \dfrac{8}{3\pi} < 1$

55. $\dfrac{1}{4}\ .\ N^{*}.u_{\text{av}} = \dfrac{1}{4}\times\dfrac{6\times10^{23}}{22.4\times10^{-3}}\times\sqrt{\dfrac{8\times8.314\times273}{\pi\times28\times10^{-3}}}$

$= 3.05 \times 10^{27}\,\text{m}^{-2}\text{s}^{-1}$

56. $\dfrac{u_{\text{rms},O_2}}{u_{\text{rms},O_3}} = \sqrt{\dfrac{3R\times600}{32}\times\dfrac{48}{3R\times300}} = \sqrt{3}$

$\Rightarrow u_{\text{rms},\text{O}_2} = \sqrt{3}$ v m/s

57. Average translational K.E. per gm $= \dfrac{3}{2}\ \dfrac{RT}{M}$

58. $\dfrac{T_A}{M_A} = \dfrac{T_B}{M_B} \Rightarrow u_{\text{rms}} = \sqrt{\dfrac{3RT}{M}}$ = Same for both

59. $\dfrac{3}{2}\ \text{KT} = \text{qV} \Rightarrow \dfrac{3}{2}\times\dfrac{8.314}{6.022\times10^{23}}\times T$

$= 1.602 \times 10^{-19} \times 3$

$\Rightarrow T = 23207.2$ K

60. $u^2_{\text{rms}} \neq u^2_{\text{av}}$

61. $Z_w = \dfrac{1}{4}\ .\ N^{*}.\ u_{\text{av}} = \dfrac{1}{4}\times\dfrac{P.N_A}{RT}\times\sqrt{\dfrac{8RT}{\pi M}}$

$\Rightarrow Z_w \propto \dfrac{1}{\sqrt{T}}$

62. $\dfrac{u_{\text{rms, CH}_4}}{u_{\text{rms, SO}_2}} = \sqrt{\dfrac{3R\times T}{16}\times\dfrac{64}{3R\times300}} = \dfrac{4}{1}$

$\Rightarrow T = 1200$ K

$\therefore$ Average K.E. per mole $= \dfrac{3}{2}RT = \dfrac{3}{2}\times2\times1200$

$= 3600$ cal

63. $u_{\text{av}} \propto \sqrt{T} \Rightarrow \dfrac{u_2}{u_1} = \sqrt{\dfrac{432}{300}} = 1.2$

64. Mole of gas cannot change.

65. Collision number, $\text{Z}_1 = \sqrt{2}\,\pi\sigma^2.u_{\text{av}}.N^{*}$

$= \sqrt{2}\,\pi\sigma^2\,.\sqrt{\dfrac{8RT}{\pi M}}\times\left(\dfrac{PN_A}{RT}\right)$

$\therefore\ Z_1 \propto \dfrac{1}{\sqrt{T}}$

Collision frequency, $Z_{11} = \dfrac{1}{\sqrt{2}}\,\pi\sigma^2\,u_{\text{av}}.N^{*2}$

$= \dfrac{1}{\sqrt{2}}\,\pi\sigma^2\,.\sqrt{\dfrac{8RT}{\pi M}}\times\left(\dfrac{PN_A}{RT}\right)^2$

$\therefore\ Z_{11} \propto \dfrac{1}{T^{3/2}}$

Mean free path, $\lambda = \dfrac{1}{\sqrt{2}\pi\sigma^2 N^{*}} = \dfrac{RT}{\sqrt{2}\pi\sigma^2.PN_A}$

$\Rightarrow \lambda \propto T$

66. $\lambda = \dfrac{RT}{\sqrt{2}\pi\sigma^2\times PN_A}$

$= \dfrac{8.314\times300}{\sqrt{2}\pi\times(1.5\times10^{-10})^2\times(4.1\times10^{-14}\times1.013\times10^{5})\times(6.022\times10^{23})}$

$= 1.0 \times 10^{7}$ m

67. Theory based

68. Velocity is a vector quality.

69. $\dfrac{dN}{N} = 4\pi\left(\dfrac{m}{2\pi KT}\right)^{3/2}\times u^2\times e^{-\frac{mu^2}{2KT}}\times du$

$= \dfrac{2}{\sqrt{\pi}}\left(\dfrac{1}{KT}\right)^{3/2}\times\sqrt{E}\times e^{-E/KT}\times dE$

For most probable K.E., $\frac{d(dN/N)}{dE} = 0$

$\Rightarrow E = \frac{1}{2}KT$

70. Deviation from ideal behavior is maximum at low temperature and high pressure.

71. $Z > 1$ for H_2 at 0°C at all pressure.

72. $Z < 1$ at low pressure and $Z > 1$ at high pressure.

73. Theory based

74. $V_1 = V - nb \Rightarrow b = \frac{V - V_1}{n}$

$\Rightarrow 4\times\frac{\pi}{6}d^3 \times N_A = \frac{V - V_1}{n}$

$\therefore d = \left(\frac{3(V - V_1)}{2\pi n N_A}\right)^{1/3}$

75. $P_\text{i} = P + \frac{an^2}{V^2} \Rightarrow P = \left(P_i + \frac{an^2}{V^2}\right)$

Greater the value of 'a', smaller will be 'P'.

76. Gaseous mixture is always homogeneous.

77. $P_1V_1 = P_2V_2 \Rightarrow 0.5 \times 2000 = 100 \times V_2$

$\Rightarrow V_2 = 10$ ml < 13 ml

As the real volume is greater than ideal, the volume occupied by the molecule is significant.

78. When attractive forces are dominant, $V_\text{real} < V_\text{ideal}$.

79. $B = b - \frac{a}{RT} = 0.03 - \frac{1.344}{0.0821\times 273} = -\,0.03$ l/mol

80. $Z = \frac{PV_m}{RT} = \frac{V_m}{V_m - b} = \frac{10b}{10b - b} = \frac{10}{9}$

81. $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$ may be expressed as

$\left(P + \frac{a.d^2}{M^2}\right)\left(\frac{M}{d} - b\right) = RT$ as $d = \frac{m}{v} = \frac{n\times m}{v}$

Now, $\left[P + \frac{3.6\times(2.2)^2}{(44)^2}\right]\left[\frac{44}{2.2} - 0.05\right] = 0.0821 \times 300$

$\Rightarrow P = 1.226$ atm

82. $B = b - \frac{a}{RT} = -1.0$ L/mol

Now, $PV_m = RT\left(1 + \frac{B}{V_m}\right)$ and $d = \frac{M}{V_m}$

Hence, $\frac{PM}{d} = RT\left(1 + \frac{B\times d}{M}\right)$

or, $\frac{1\times 40}{d} = 0.08 \times 262.5\left[1 + \frac{(-1.0)\times d}{40}\right]$

$\therefore d = 2.005$ g/L

83. When $P \to 0$, $V \to \infty$ and hence $e^{a/VRT} \to 1$ and $(V - b) \to V$. Hence, $P = \frac{RT}{V} = \frac{0.0821\times 300}{410.5} = 0.06$ atm

84. For a van der Waals gas, $Z = \frac{V_m}{V_m - b} - \frac{a}{V_mRT}$

or, $0.8 = \frac{0.5}{0.5 - 0.04} - \frac{a}{0.5\times 0.08\times 300}$

$\Rightarrow a = 3.44$ atm L^2/mol^2

85. At Boyle's temperature, $\frac{dz}{dp} = 0 \Rightarrow T = \frac{168}{0.35} = 480$ K

86. Theory based.

The initial slope of Z vs. P curve increases with increase in temperature, above Boyle's temperature, only upto $2\times T_B$. Then, the slope starts decreasing.

87. For van der Waals gas, $Z = \frac{V_m}{V_m - b} - \frac{a}{V_m \times RT}$

At Boyle's temperature, $Z = \frac{V_m}{V_m - b} - \frac{a}{V_m \times R \times \left(\frac{a}{Rb}\right)}$

$= 1 + \frac{b^2}{V_m(V_m - b)}$

88. Ideal gas can never be liquified.

89. For ideal behavior, Boyle's temperature should be closer to 600 K.

90. Theory based

91. $T_c < T_B$

92. $\frac{T_c}{P_c} = \frac{8a/27Rb}{a/27b^2} = \frac{8b}{R}$

$\therefore \frac{\left(\frac{T_c}{P_c}\right)_{CO_2}}{\left(\frac{T_c}{P_c}\right)_{CH_4}} = \frac{b_{CO_2}}{b_{CH_4}} = \frac{304/72}{190/45} = \frac{1}{1}$

93. At $T > T_c$, the gas can never be liquified.

94. Theory based

95. $P_c V_c = \frac{3}{8} R T_c \Rightarrow V_c = \frac{3}{8} \times \frac{0.0821 \times 128}{41.05}$

$= 0.096$ L/mol

Section B (One or More than one Correct)

1. Boyle's law constant $= PV = nRT$

2. $\frac{P_0 V_0}{RT_0} + \frac{P_0 V_0}{RT_0} = \frac{P V_0}{R \times 2T_0} + \frac{P V_0}{RT_0} \Rightarrow P = \frac{4}{3} P_0$

and $n = \frac{\frac{4}{3} P_0 \times V_0}{R \times 2T_0} = \frac{2 P_0 V_0}{3 R T_0}$

3. $P_f = P_i \left(\frac{V}{V + \Delta V} \right)^n$

(a) $P_f = 24.2 \times \left(\frac{10}{10+1} \right)^1 = 22$ atm

(b) $P_f = 24.2 \times \left(\frac{10}{10+1} \right)^2 = 20$ atm

(c) $\frac{P}{\eta} = \text{P} \left(\frac{10}{10+1} \right)^n \Rightarrow n = \frac{\ln \eta}{\ln 1.1}$

(d) $P_f = 24.2 \times \left(\frac{10}{10+1} \right)^n$ atm

4. As the average molar mass increases, the molar mass of vapours must be greater than that of N_2.

5. $r_{H_2} > r_{D_2}$

6. (a) Number of molecules colliding at the wall per unit time per unit area, $Z_w = \frac{1}{4} .u_{av}.N^*$

N^* is same for both but $u_{av,\,He} > u_{av,\,Ne}$

(b) Average force per collision $\propto$ Change in momentum $\propto \sqrt{M}$

7. **At valve – I:** $P_1 V_1 = P_2 V_2 \Rightarrow 1 \times 60 \text{ A} = P_2 \times 45 \text{ A}$
$\Rightarrow P_2 = 1.33 \text{ atm} < 1.5 \text{ atm}$

Hence, valve – I will not open.

At valve – II: $P_1 V_1 = P_2 V_2 \Rightarrow 1 \times 60 \text{ A} = P_2 \times 30 \text{ A}$
$\Rightarrow P_2 = 2 \text{ atm} < 2.2 \text{ atm}$

Hence, valve – II will not open.

At valve – III: $P_1 V_1 = P_2 V_2 \Rightarrow 1 \times 60 \text{ A} = P_2 \times 20 \text{ A}$
$\Rightarrow P_2 = 3 \text{ atm} > 2.5 \text{ atm}$

Hence, valve – III will open first. As the piston will reach at valve – III, the gas will come out till the pressure of gas becomes 2.5 atm. Now,

$$2.5 \times \frac{20 \times 821}{1000} = n \times 0.0821 \times 300$$

$\Rightarrow$ Moles of gas remained, $n = \frac{5}{3}$

At valve – IV: $P_1 V_1 = P_2 V_2 \Rightarrow 2.5 \times 20 \text{ A} = P_2 \times 15 \text{ A}$
$\Rightarrow P_2 = 3.33 \text{ atm} < 4.4 \text{ atm}$

Hence, valve - IV will not open.

At valve – V: $P_1 V_1 = P_2 V_2 \Rightarrow 2.5 \times 20 \text{ A} = P_2 \times 10 \text{ A}$
$\Rightarrow P_2 = 5 \text{ atm} > 4.8 \text{ atm}$

Hence, valve – V will open until the gas pressure becomes 4.8 atm.

8. $u_{av} \propto \sqrt{T}$

9. $\frac{u_{\text{rms, A}}}{u_{\text{rms, B}}} = \sqrt{\frac{3R \times 300}{M_A} : \frac{M_B}{3R \times 400}} = \frac{\sqrt{3}}{2}$

$\Rightarrow M_A = M_B$

10. On increasing the temperature at constant volume, the average speed of molecules as well as number of molecular collisions at wall increases.

11. Theory based

12. Theory based

13. At very high pressure, $\left(P + \frac{a}{V^2} \right) \simeq P$

$$\Rightarrow Z = 1 + \frac{b.P}{RT}$$

and $Z = \frac{PV}{RT} \Rightarrow \frac{P}{RT} = \frac{Z}{V} \Rightarrow Z = \frac{V}{V - b}$

14. $T_c = 273 + (-177) = 96\text{ K}$

$$\Rightarrow T_B = \frac{27}{8} \times 96 = 324\text{K} = 51°\text{C}$$

$$\text{(a) } Z = \frac{P.V_m}{RT} = \frac{0.821 \times 9.6}{0.0821 \times 96} = 1$$

But at $T = T_c$, $Z < 1$ at low pressure

$$\text{(b) } Z = \frac{P.V_m}{RT} = \frac{0.821 \times 40}{0.0821 \times 400} = 1$$

But at $T > T_B$, $Z > 1$ at all pressure

$$\text{(c) } Z = \frac{P.V_m}{RT} = \frac{82.1 \times 0.310}{0.0821 \times 324} = 0.96 < 1$$

But at $T = T_B$ and $P > 50$ atm, $Z > 1$

$$\text{(d) } Z = \frac{P.V_m}{RT} = \frac{0.821 \times 32.4 \times 10^{-3}}{0.0821 \times 324} = 10^{-3} < 1$$

But at $T = T_c$ and $P < 50$ atm, $Z = 1$

15. a. $$\frac{9R \times \frac{8a}{27Rb} \times 36}{8} = a$$

b. $$3 \times \frac{a}{27b^2} \times (3b)^2 = a$$

c. $$\frac{3}{8} \times \frac{\frac{a}{27b^2} \times 36}{\frac{8a}{27Rb}} \neq a$$

d. $$\frac{27}{64} \times \frac{R^2 \times \left(\frac{8a}{27Rb}\right)^2}{\frac{a}{27b^2}} = a$$

16. Theory based

17. Theory based

18. Real gas may behave ideally at Boyle's temperature.

$$P = \frac{RT}{V_m} = \frac{R \times \frac{a}{Rb}}{V_m} = \frac{a}{b.Vm}$$

19. $$Z = \frac{PV_m}{RT} = 1 + B'.P + C'.P^2 + \ldots \qquad (1)$$

$$Z = \frac{PV_m}{RT} = 1 + \frac{B}{Vm} + \frac{C}{V_m^2} + \ldots \qquad (2)$$

$$\text{Or, } P = \frac{RT}{V_m}\left(1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \ldots\right)$$

Substituting this value in Equation (1), we get:

$$Z = 1 + B'.\left\{\frac{RT}{V_m}\left(1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \ldots\right)\right\} + C'.\left\{\frac{RT}{V_m}\left(1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \ldots\right)\right\}^2 + \ldots$$

$$= 1 + \frac{B'RT}{V_m} + \frac{B'RT.B + C'(RT)^2}{V_m^2} + \ldots$$

Comparing this with Equation (2), we get:
$B'RT = B$ and $B'RT.B + C.(RT)^2 = C$

20. Theory based

Section C (Comprehensions)

Comprehension – I

1. Number of strokes $= \dfrac{(8\text{ bar}) \times (1000\text{ cm}^3)}{(1\text{ bar}) \times (25 \times 4\text{ cm}^3)} = 80$

2. $\text{F} = \text{P.A} = \left(8 \times 10^5 \dfrac{N}{m^2}\right) \times (4 \times 10^{-4}\text{ m}^2) = 320\text{ N}$

3. $m = \dfrac{F}{g} = \dfrac{320}{10} = 32\text{ kg}$

Comprehension – II

4. $PV_m = RT$ (Let 0K = $-x$°N)

$28 = R(0 + x)$ $x = 233.33$

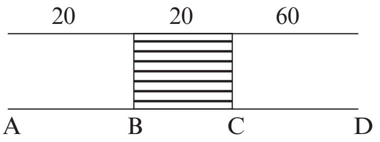
$40 = R(100 + x)$ $\therefore$ 0K = -233.33°N

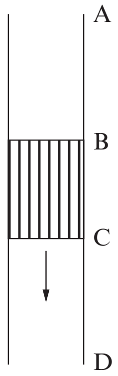
5. $R = \dfrac{28}{x} = 0.12$ L – atm/K-mol

6. $V = \dfrac{nRT}{P} = \dfrac{2\times0.12\times(66.67+233.33)}{2} = 36$ L

Comprehension – III

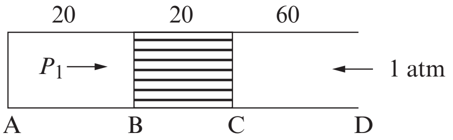
7. **A**

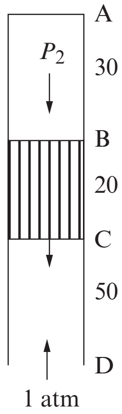




If both ends are open, then mercury will fall down.

B





For AB column:

$P_1 = 1$ atm $= 76$ cm Hg

$V_1 = 20$ A cm^3

$P_2 = 1$ atm $- 20$ cm Hg

$= 76 - 20$

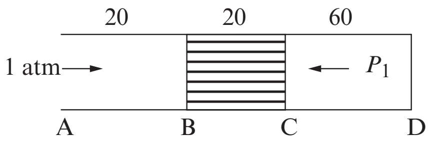
$= 56$ cm Hg

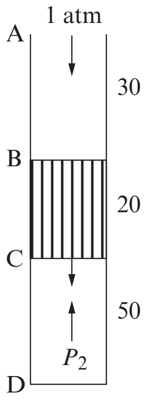
$V_2 = 30$ A cm^3

Now, $P_1V_1 \neq P_2V_2$

Hence, only end A is not closed.

C





For CD column:

$P_1 = 1$ atm $= 76$ cm Hg

$V_1 = 60$ A cm^3

$P_2 = 1$ atm $+ 20$ cm Hg

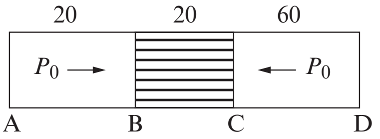
$= 76 + 20$

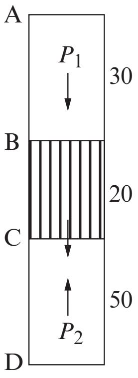
$= 96$ cm Hg

$V_2 = 50$ A cm^3

As $P_1V_1 \neq P_2V_2$, only end D is not closed.
Hence, both the ends are closed.

8.





For AB column:

$P_0 \times 20 = P_1 \times 30$

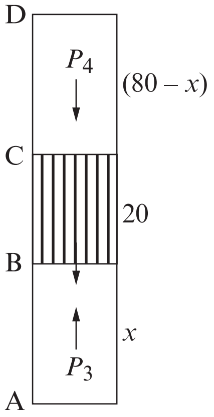
For CD column:

$P_0 \times 60 = P_2 \times 50$

As $P_1 + 20$ cm Hg $= P_2$

or, $\dfrac{20P_0}{30} + 20$ cm Hg $= \dfrac{60P_0}{50} \Rightarrow P_0 = 37.5$ cm Hg

9. **D**



$P_4 + 20$ cm Hg $= P_3$

or, $\dfrac{60P_0}{(80-x)} + 20 = \dfrac{20P_0}{x} \Rightarrow x = 13.88$

Comprehension – IV

10. Total moles of product gases = $\frac{PV}{RT}$

$= \frac{410.5\times 2.9}{0.0821\times 2000} = 7.25$

∴ Moles of gases per 0.04 mole of nitroglycerine $= 0.04\times 7.25 = 0.29$

11. Moles of gases except A = $\frac{4.75\times 0.821}{0.0821\times 250} = 0.19$

'A' must be H_2O because it solidifies at –23°C and its mole = 0.29 – 0.19 = 0.10.

12. Moles of gases C and D = $\frac{2.1\times 0.821}{0.0821\times 300} = 0.07$

∴ Mole of gas 'B', which is CO_2 = 0.19 – 0.07 = 0.12

13. The gas remained, D must be N_2 and its mole $= \frac{1.8\times 0.821}{0.0821\times 300} = 0.06$

and gas 'C' is O_2 and its mole = 0.07 – 0.06 = 0.01.

Comprehension – V

14. All $H_2O(g)$ will solidify in bulb 'B'.

15. $n_{H_2O} + n_{CO_2} + n_{N_2} = \frac{570\times 1.642}{760\times 0.0821\times 300} = 0.05$

$n_{CO_2} + n_{N_2} = \frac{0.21\times 1.642}{0.0821\times 300} + \frac{0.21\times 1.642}{0.0821\times 200} = 0.035$

$\therefore\ n_{H_2O} = 0.05 - 0.035 = 0.015$

16. $H_2O(g)$ will solidify in 'B' as well as 'C' but $CO_2(g)$ will solidify only in 'C'.

17. $n_{N_2} = \frac{22.8\times 1.642}{760\times 0.0821}\left[\frac{1}{300}+\frac{1}{200}+\frac{1}{80}\right] = 0.0125$

$\therefore\ n_{CO_2} = 0.035 - 0.0125 = 0.0225$

Comprehension VI

18. Let x mole, NH_4Cl was present initially.

$$NH_4Cl(s) \rightarrow \underset{x\ \text{mole}}{NH_3(g)} + \underset{x\ \text{mole}}{HCl(g)}$$

Now, $PV = nRT$

$114 \times V = 0.01 \times R \times 300$

and $908 \times V = (0.01 + 2x) \times R \times 600$

$\therefore\ x \approx 0.015$

∴ Mass of $NH_4Cl = x \times 53.5 \approx 0.8$ gm

19. $P_{NH_3} = \frac{908 - 114\times 2}{2}$ 340 mm Hg

20. $V = \frac{0.01\times 0.0821\times 300\times 760}{114} = 1.642$ L

Comprehension – VII

21. Water will vaporize till $P_{H_2O} = 0.04$ atm

Now, $PV = nRT \Rightarrow 0.04 \times (40\times 10^3) = \frac{w}{18} \times 0.08 \times 300$

or $w = 1200 = 1.2$ kg

∴ Percentage of water vaporized $= \frac{1.2}{5}\times 100 = 24\%$

22. $V = \frac{nRT}{P} = \frac{\frac{5000}{18}\times 0.08\times 300}{0.04} = 1.67\times 10^5$ L

Comprehension – VIII

23. $\frac{-dP}{dt} = K(P - P_0) \Rightarrow -\int_{P_1}^{P_2} \frac{dP}{P - P_0} = K\int_0^t dt$

$\Rightarrow \ln\frac{P_1 - P_0}{P_2 - P_0} = Kt$

or, $\ln\frac{20 - 1}{P_2 - 1} = 0.001 \times 3600 = \ln 38 \Rightarrow P_2 = 1.5$ atm

24. Number of balloons $= \frac{(20 - 1.5)\times 10}{1\times 2} = 92.5 \approx 92$

25. $\ln\frac{P_1 - P_0}{P_2 - P_0} = Kt \Rightarrow \ln\frac{20 - 1}{2 - 1} = 0.001 \times t$

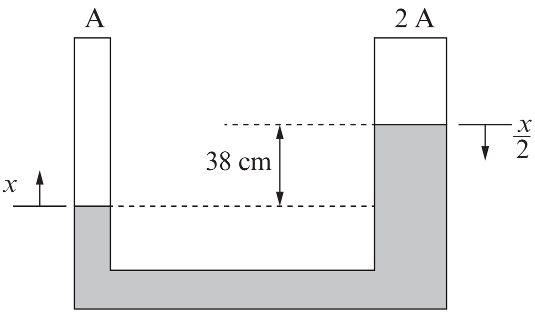
$\Rightarrow t = 2900$ sec

Comprehension – IX

26. $-\dfrac{dP}{dt} = \text{K.P} \Rightarrow -\displaystyle\int_{1.5\,\text{atm}}^{P} \dfrac{dP}{P} = K\int_{0}^{t} dt$

$\Rightarrow P = (1.5\text{ atm}).e^{-Kt}$

27.



The pressure of gas in closed arm,

$P = 1\text{ atm} + \left(38 - \dfrac{3x}{2}\right)\text{ cm}$

$= \left(114 - \dfrac{3x}{2}\right)\text{ cm Hg}$

Now, $\left(114 - \dfrac{3x}{2}\right) = 114 \times e^{-kt}$

$\Rightarrow x = 76\ (1 – e^{-kt})\text{ cm Hg}$

28. $\dfrac{x}{2} = 38(1 - e^{-kt})\text{ cm Hg}$

Comprehension – X

29. $u_{\text{mp}} = \sqrt{\dfrac{2RT}{M}} \Rightarrow T = \dfrac{M \times u_{\text{mp}}^2}{2R}$

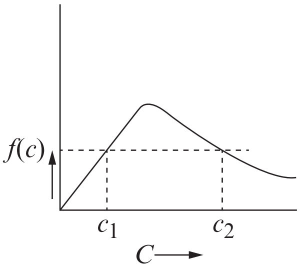
$= \dfrac{(32\times10^{-3})\times(400)^2}{2\times8} = 320\text{K} = 47°\text{C}$

30. $u_{\text{rms}} - u_{\text{mp}} = 400\text{ m/s} \Rightarrow \sqrt{\dfrac{3RT}{M}} - \sqrt{\dfrac{2RT}{M}} = 400\text{ m/s}$

or, $T = \left(\dfrac{400}{\sqrt{3}-\sqrt{2}}\right)^2 \times \dfrac{M}{R}$

$= \dfrac{(400)^2}{3+2-2\sqrt{6}} \times \dfrac{2\times10^{-3}}{8} = 400\text{ K} = 127°\text{C}$

31.



$4\pi\left(\dfrac{M}{2\pi RT}\right)^{3/2} \times C_1{}^2 \times e^{\frac{-MC_1^2}{2RT}}$

$= 4\pi\left(\dfrac{M}{2\pi RT}\right)^{3/2} \times C_2{}^2 \times e^{\frac{-MC_2^2}{2RT}}$

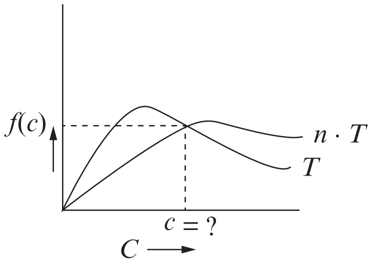
or, $\dfrac{C_1^2}{C_2^2} = e^{\frac{M(C_1^2-C_2^2)}{2RT}}$

or, $\dfrac{M(C_1^2-C_2^2)}{2RT} = 2\ln\left(\dfrac{C_1}{C_2}\right)$

$\therefore\ T = \dfrac{M(C_1^2-C_2^2)}{4R.\ln\left(\frac{C_1}{C_2}\right)} = \dfrac{(28\times10^{-3})(300^2-600^2)}{4\times8\times\ln\left(\frac{300}{600}\right)}$

$= 337.5\text{ K} = 64.5°\text{C}$

32.



$4\pi\left(\dfrac{M}{2\pi RT}\right)^{3/2} \times c^2 \times e^{-\frac{MC^2}{2RT}}$

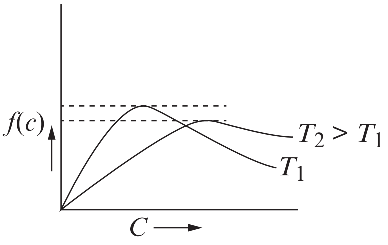
$= 4\pi\left(\dfrac{M}{2\pi RT.n}\right)^{3/2} \times c^2 \times e^{-\frac{MC^2}{2RT.n}}$

or, $n^{3/2} = e^{\frac{MC^2}{2RT}\left(1-\frac{1}{n}\right)}$

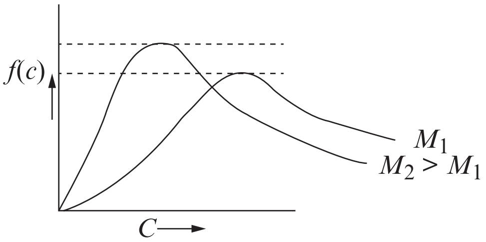
or, $\dfrac{3}{2}\ln n = \dfrac{MC^2}{2RT} \times \dfrac{n-1}{n}$

$\therefore\ C = \sqrt{\dfrac{3nRT\ln n}{M(n-1)}}$

33.



34.



35. $\dfrac{(dN)_1}{(dN)_2} =$

$$\frac{4\pi\times\left(\dfrac{M}{2\pi RT}\right)^{3/2}\times(2u_{\text{mp}})^2\times e^{-\frac{M(2u_{\text{mp}})^2}{2RT}}\times du\times N}{4\pi\times\left(\dfrac{M}{2\pi RT}\right)^{3/2}\times u_{\text{mp}}^2\times e^{-\frac{M\times u_{\text{mp}}^2}{2RT}}\times du\times N}$$

$$= 4\times e^{-\frac{Mu_{mp}^2}{2RT}(4-1)} = 4.e^{-3}$$

Comprehension – XI

36. $n_A = \dfrac{m}{2}, n_B = \dfrac{m}{16}, n_C = \dfrac{m}{32}$

37. $Z_W = \dfrac{1}{4}\times u_{av}\times N^* = \dfrac{1}{4}\sqrt{\dfrac{8RT}{\pi M}}\times N^*$

$\Rightarrow Z_W \propto \dfrac{N^*}{\sqrt{M}}$

38. $\lambda = \dfrac{1}{\sqrt{2\pi\sigma^2 N^*}} \Rightarrow \lambda_A : \lambda_B : \lambda_C$

$= \dfrac{1}{1^2\times\dfrac{m}{2}} : \dfrac{1}{2^2\times\dfrac{m}{16}} : \dfrac{1}{2^2\times\dfrac{m}{32}}$

$= 1 : 2 : 4$

39. $E_{\text{total}} = \dfrac{3}{2}$nRT and n_{max} for A

40. $Z = 1$ for all (Ideal behaviour)

41. $Z_1 = \sqrt{2}\,\pi\,\sigma^2\,u_{av}\times N^*$

$Z_A : Z_B : Z_C = 1^2\times\dfrac{1}{\sqrt{2}}\times\dfrac{m}{2} : 2^2\times\dfrac{1}{\sqrt{16}}\times\dfrac{m}{16} :$

$2^2\times\dfrac{1}{\sqrt{32}}\times\dfrac{m}{32}$

$= \dfrac{1}{2\sqrt{2}} : \dfrac{1}{64} : \dfrac{1}{128\sqrt{2}}$

42. $u_{av} \propto \dfrac{1}{\sqrt{M}}$

Comprehension – XII

For critical point, $\dfrac{dP}{dV} = 0$ and $\dfrac{d^2P}{dV^2}$

Now, $\dfrac{dP}{dV} = 0 \Rightarrow -\dfrac{RT}{(V-b)^2} + \dfrac{2a}{T.V^3} = 0$

$$\Rightarrow \frac{RT}{(V-b)^2} = \frac{2a}{T.V^3} \qquad (1)$$

and $\dfrac{d^2P}{dV^2} = 0 \Rightarrow \dfrac{2RT}{(V-b)^3} - \dfrac{6a}{T.V^4} = 0$

$$\Rightarrow \frac{2RT}{(V-b)^3} = \frac{3a}{T.V^4} \qquad (2)$$

From (1) ÷ (2) : $V - b = \dfrac{2V}{3} \Rightarrow V_C = 3b$

Eq 1 : $\dfrac{RT}{(3b-b)^2} = \dfrac{2a}{T.(3b)^3} \Rightarrow T_C = \sqrt{\dfrac{8a}{27Rb}}$

and $P_C = \dfrac{RT}{V-b} - \dfrac{a}{T.V^2} = \sqrt{\dfrac{aR}{216b^3}}$

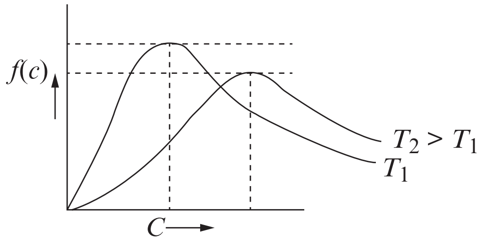
43. $T_C = \sqrt{\dfrac{8a}{27Rb}}$

44. $P_C = \sqrt{\dfrac{aR}{216b^3}}$

45. $V_C = 3b$

Section D (Assertion – Reason)

1. Avogadro's hypothesis is valid only for gases due to large intermolecular distance.
2. Charle's law
3. $d = \dfrac{PM}{RT}$ but M is independent from d, P or T.
4. H_2 and Cl_2 are reactive gases.
5. Escaping tendency increases only on increasing the energy of molecules.
6. Graham's law is valid for ideal as well as non-ideal gases.
7. Theory based
8. Theory based
9. Volume of ideal gas should be the total volume minus the volume occupied by gas molecules.
10. As the average K.E. is same, increase in mass decreases their speed.
11. Total K.E. = $\dfrac{3}{2}$nRT

    As the pressure exerted by the vapour is same in both but volume is in 1 : 2 ratio, the moles is also in 1 : 2 ratio.
12. 

13. Concept based
14. Excluded volume is 'nb'.
15. $T_C < T_B$ and hence, attractive forces are dominant.
16. PV is constant at constant temperature.
17. Above Boyle's temperature, gases show positive deviation.
18. Theory based
19. Theory based
20. K.E. of molecules is the function of T.

Section E (Column Match)

1. Boyle's law : $PV = K \Rightarrow \left(\dfrac{dP}{dV}\right)_T = -\dfrac{K}{V^2} = -\dfrac{P}{V}$

And $\left[\dfrac{d(PV)}{dP}\right]_T = 0$

Charle's law $\dfrac{V}{T} = K \Rightarrow \left(\dfrac{dV}{dT}\right)_P = K = \dfrac{V}{T}$

Avogadro's law : $\dfrac{V}{n} = K = \dfrac{RT}{P}$

$\Rightarrow \left(\dfrac{dV}{dn}\right)_{P,T} = \dfrac{RT}{P}$

Graham's law $r = \left(-\dfrac{dP}{dt}\right) \propto \dfrac{1}{\sqrt{d}}$

2. Average translational K.E. per mole = $\dfrac{3}{2}$RT

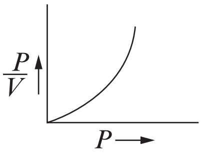
Average translational K.E. per gram = $\dfrac{3}{2}\dfrac{RT}{M}$

3. $T_C = \dfrac{8a}{27Rb}$ $\left(\dfrac{a}{b}\right)_X = 120$, $\left(\dfrac{a}{b}\right)_Y = 333.33$, $\left(\dfrac{a}{b}\right)_Z = 171.4$

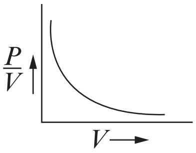
$V_C = 3b$

$P_C = \dfrac{a}{27b^2}$, $\left(\dfrac{a}{b^2}\right)_X = 4800$, $\left(\dfrac{a}{b^2}\right)_Y = 11111.11$, $\left(\dfrac{a}{b^2}\right)_Z = 4898$

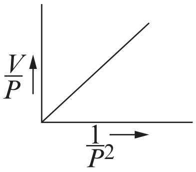
4. A. $\dfrac{P}{V} = \dfrac{P}{\left(\dfrac{nRT}{P}\right)} = \dfrac{P^2}{nRT}$



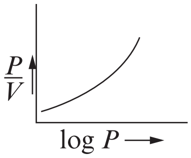
B. $\frac{P}{V} = \frac{nRT/V}{V} = \frac{nRT}{V^2}$



C. $\frac{V}{P} = \frac{nRT}{P^2}$



D. $\frac{P}{V} = \frac{P^2}{nRT} = \frac{10^{2\log P}}{nRT}$



5. Moles of water vapour formed, $n = \frac{PV}{RT}$

$= \frac{22.8\times(827-6)}{760\times 0.0821\times 300} = 1$

6. Pressure correction $= \frac{a.n^2}{V^2} = \frac{4\times 5^2}{10^2} = 1$ atm

Ideal volume $= V - nb = 10 - 5\times 0.05 = 9.75$ L

Volume occupied by molecules $= \frac{nb}{4} = \frac{0.25}{4}$

$= 0.0625$ L

Volume correction $= nb = 0.25$L

7. Theory based

8. (A) $\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 N^*} = \frac{RT}{\sqrt{2}\pi\sigma^2 PN_A}$

At constant volume, N^* = constant $\Rightarrow \frac{\lambda_2}{\lambda_1} = 1$

At constant pressure, $\lambda \propto T \Rightarrow \frac{\lambda_2}{\lambda_1} = 2$

(B) $Z_1 = \sqrt{2}\,\pi\sigma^2 \times u_{av} \times N^*$

$= \sqrt{2}\;\pi\sigma^2 \times \sqrt{\frac{8RT}{\pi M}}\left(\frac{PN_A}{RT}\right)$

At constant volume : $Z_1 \propto \sqrt{T} \;\Rightarrow\; \frac{Z_{1,2}}{Z_{1,1}} = \sqrt{2}$

At constant pressure : $Z_1 \propto \frac{1}{\sqrt{T}} \;\Rightarrow\; \frac{Z_{1,2}}{Z_{1,1}} = \frac{1}{\sqrt{2}}$

(C) $Z_{11} = \frac{1}{\sqrt{2}}\pi\sigma^2.u_{av}.N^{*2} = \frac{1}{\sqrt{2}}\pi\sigma^2\sqrt{\frac{8RT}{\pi M}}\left(\frac{PN_A}{RT}\right)^2$

At constant volume : $Z_{11} \propto \sqrt{T} \;\Rightarrow\; \frac{Z_{11,2}}{Z_{11,1}} = \sqrt{2}$

At constant pressure : $Z_{11} \propto \frac{1}{(T)^{3/2}} \;\Rightarrow\; \frac{Z_{11,2}}{Z_{11,1}}$

$= \frac{1}{2\sqrt{2}}$

9. A. $P = 1$ atm + 38 cm Hg = 1.5 atm

Q. $P = 1$ atm + 57 cm Hg = 1.75 atm

R. $P = 38$ cm Hg = 0.5 atm

S. $P = 1$ atm + 1.9 m glycerine $= 1 + \frac{190\times 2.72}{13.6\times 76}$

= 1.5 atm

10. $T_C = 273 + (-177) = 96$ K $= -177$°C

$T_B = \frac{27}{8}\times 96 = 324$ K $= 51$°C

A. $V_i = \frac{0.2\times 0.08\times 96}{20}\times 10^3 = 76.8$ ml

But $V_{\text{real}} < V_{\text{ideal}}$ in given condition $\Rightarrow V_r < 76.8$ ml

B. $Z = 1 \Rightarrow V_r = V_i = \frac{0.2\times 0.08\times 324}{6.48}\times 10^3 = 800$ ml

C. Above Boyle's temperature, $Z > 1$

$\therefore\; V_r > V_i = \frac{0.2\times 0.08\times 350}{7}\times 10^3 = 800$ ml

D. Below Boyle's temperature, $Z < 1$

$\therefore\; V_r < V_i = \frac{0.2\times 0.08\times 300}{6}\times 10^3 = 800$ ml

E. $T = T_B$ but $P > 50$ atm $\Rightarrow Z > 1$

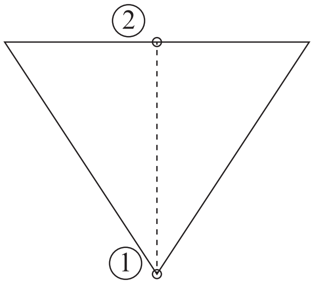
$\therefore V_r > V_i = \frac{0.2\times 0.08\times 324}{64.8}\times 10^3 = 80$ ml

Section F (Subjective)

Single-digit Integer Type

1. $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{45}{300} = \frac{42}{T_2} \Rightarrow T_2 = 280$ K $= 7$°C

2.



$P_1 = 1 \text{ atm} + hm \text{ water} = (10 + h) \text{ m water}$

$V_1 = \frac{4}{3}\pi\ (1 \text{ mm})^3 \qquad A = \pi r^2 = \pi \text{ mm}^2$

$\therefore r = 1 \text{ mm}$

$P_2 = 1 \text{ atm} = 10 \text{ m water}$

$V_2 = 2\pi \text{ mm}^3$

Now, $P_1V_1 = P_2V_2 \Rightarrow (10 + h) \times \frac{4}{3}\pi = 10 \times 2\pi$

$\Rightarrow h = 5 \text{ m}$

Hence, water holding capacity of pool, $V = \frac{1}{3}\pi r^2 h$

$= \frac{1}{3}\pi (10 \text{ m})^2 \times 5 \text{ m} = \frac{500\pi}{3} \text{ m}^3$

3. Number of cosmic events = Number of Ar-atoms

$= \frac{1.911\times10^{-6} l}{22.7 l} \times 6 \times 10^{23} = 5.05 \times 10^{16}$

4. For lifting of balloon, $B > W$

or, $(V \times \rho_{\text{outside air}} \times g) > (V \times \rho_{\text{inside air}} + m_{\text{additional}})g$

or, $V(\rho_{\text{outside air}} - \rho_{\text{inside air}}) > m_{\text{additional}}$

or, $91\left(\frac{1\times29}{0.08314\times290} - \frac{1\times29}{0.08314\times T}\right) > \frac{10}{8.314}$

$\therefore T > 293.22$

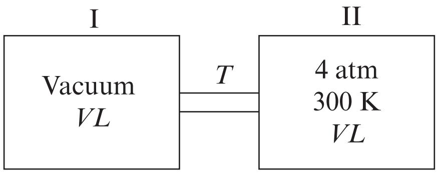
Hence, difference in temperature, $\Delta T > 3.22 \approx 4$ K.

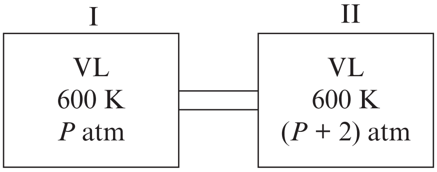
5. $n_{\text{released gas}} = n_{\text{taken}} - n_{\text{remained}}$

or, $\frac{m}{22.4\times1.25} = \frac{P\times3}{0.0821\times273} - \frac{(p-0.8)\times3}{0.0821\times273}$

$\Rightarrow m = 3$ gm

6.





Final moles of gases in vessel I and II = Initial mole in vessel II

or, $\frac{P\times V}{R\times600} + \frac{(P+2)\times V}{R\times600} = \frac{4\times V}{R\times300} \Rightarrow P = 3 \text{ atm}$

7. Let the mixture contains a moles C_xH_8 and b moles C_xH_{10}.

Now, $a \times (12x + 8) + 6 \times (12x + 10) = 28.4$ (1)

$a + b = \frac{PV}{RT} = \frac{2.46\times5}{0.082\times300} = 0.5$ (2)

and $28.4 \times \frac{84.5}{100} = a \times 12x + b \times 12x$ (3)

On solving, $x \approx 4$

8. From $PV = nRT$, $V = \frac{nR}{P}.T$

As the pressure is constant, the change in slope is only due to change in moles.

	X_n	$\rightarrow$ nX
Initial	a mole	o
Final	$a - 0.6a$ $= 0.4a$	$0.6axn$

Now, $\frac{a}{0.4a + 0.6an} = \frac{(50.2-49.9)/20}{(49.1-47.9)/20} \Rightarrow n = 6$

9. $2H_2 \quad + \quad O_2 \quad \rightarrow \quad 2H_2O$

	$2H_2$	O_2	$2H_2O$
	2a	a	0
Final	2a – 1.6a = 0.4a	a – 0.8a = 0.2a	1.6a

Now, $\frac{P}{nT} = \frac{R}{V} = \text{Constant} \Rightarrow \frac{P_1}{n_1T_1} = \frac{P_2}{n_2T_2}$

$\Rightarrow \frac{4.5}{3a\times330} = \frac{P_2}{2.2a\times400} \quad \therefore P_2 = 4 \text{ atm}$

10. $n_{\text{total}} = n_{O_2} + n_{N_2}$

or, $\frac{1.1\times30}{RT} = \frac{Po_2\times30}{RT} + \frac{0.9\times10}{RT}$

$\Rightarrow P_{O_2} = 0.8$ atm

11. $P_{H_2O} = \frac{40}{100} \times (\text{V.P.})$

First drop of liquid will form when P = V.P.

Now, $P_1V_1 = P_2V_2 \Rightarrow \dfrac{40}{100} \times (\text{V.P.}) \times 10$

$= (\text{V.P.}) \times V_2$

$\therefore\ V_2 = 4$ ml

12. $H_2O(l) \quad \rightarrow \quad H_2(g) \quad + \quad \dfrac{1}{2}\, O_2(g)$

a mole $\qquad 0 \qquad 0$

Final $\quad 0 \qquad a$ mole $\qquad 0.5\,a$ mole

Δ P.V = $\Delta\, n$.RT

or, $(1.86 - 0.96) \times 20 = (1.5a) \times 0.08 \times 300 \Rightarrow a = 0.5$

$\therefore$ Mass of water present initially = $0.5 \times 18 = 9$ gm

13. Initial total moles $= \dfrac{PV}{RT} = \dfrac{24.63 \times 3}{0.0821 \times 300} = 3$

$\therefore$ Initial mole of $H_2 = 3 - 1 = 2$

Final mole ratio, $\dfrac{n_{H_2}}{n_{D_2}} = \dfrac{1/2}{4/4} = \dfrac{1}{2}$

Now, $\dfrac{n^f{}_{H_2}}{n^f{}_{D_2}} = \dfrac{n^i{}_{H_2}}{n^i{}_{D_2}} \times \left(\sqrt{\dfrac{M_{D_2}}{M_{H_2}}}\right)^n$

or, $\dfrac{1}{2} = \dfrac{2}{1} \times \left(\sqrt{\dfrac{4}{2}}\right)^n \Rightarrow n = 4$

14. For critical point, $\dfrac{dP}{dV_m} = 0$ and $\dfrac{d^2P}{dV_m^2} = 0$

On solving, $b = 0$. But $b \neq 0$ from question. Hence, the gas does not have critical condition.

15. Boyle's temperature:

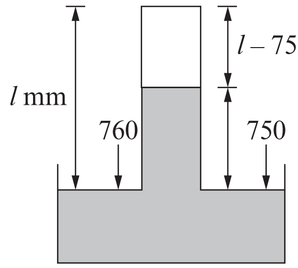
$$T_B = \frac{a}{Rb} = \frac{4.105}{0.0821 \times 0.1} = 500\,\text{K}$$

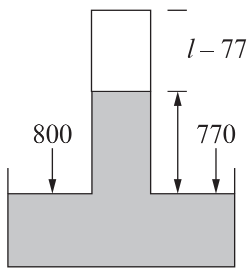
Hence, at 500 K, the gas will behave ideally.

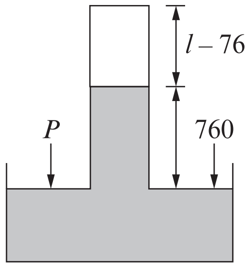
Not, $d = \dfrac{PM}{RT} = \dfrac{2 \times 164.2}{0.0821 \times 500} = 8$ g/L = 8 kg/m^3

Four-digit Integer Type

1.







$(760 - 750) \times (l - 750) = (800 - 770) \times (l - 770) = (P - 760) \times (l - 760)$

$\therefore\ P = 775$ mm Hg

2. Mass of LNG = 10 m$^3 \times 416$ kg/m$^3 = 416 \times 10^4$ gm

$\therefore$ Moles of $CH_4 = \dfrac{916 \times 10^4}{16} = 26 \times 10^4$

Now, $V = \dfrac{nRT}{P} = \dfrac{26 \times 10^4 \times 0.021 \times 300}{1.692} = 3.9 \times 10^6$ L

$= 3900$ m^3

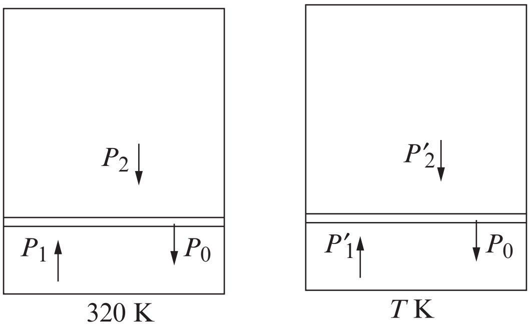
3. $\dfrac{V_1}{n_1T_1} = \dfrac{V_2}{n_2T_2} \Rightarrow \dfrac{V}{n \times 303} = \dfrac{1.6V}{1.2n \times T_2} \Rightarrow T_2 = 404$ K

4. $V_{\text{initial}} = a = \dfrac{nRT}{P} = \dfrac{64 \times 0.08 \times 300}{64 \times 3} = 8$ L

$V_{\text{initial}} = b = \dfrac{nRT}{P} = \dfrac{(64 - 8) \times 0.08 \times 300}{64 \times 3} = 7$ L

$P = \dfrac{nRT}{V} = \dfrac{64 \times 0.08 \times 300}{64 \times 7} = \dfrac{24}{7}$ atm

5.



$P_2 + P_0 = P_1$ $\qquad$ $P'_2 + P_0 = P'_1$

$P_0 = P_1 - P_2 = P'_1 - P'_2$

or,

$$\frac{n\times R\times 320}{\left(\frac{V}{5}\right)} - \frac{n\times R\times 320}{\left(\frac{4V}{5}\right)} = \frac{n\times R\times T}{\left(\frac{V}{4}\right)} - \frac{n\times R\times T}{\left(\frac{3V}{4}\right)}$$

$\therefore\ T = 450$ K

6. Mass of gas used = 28.8 – 23.2 = 5.6 kg

Volume of gas used up,

$$V = \frac{nRT}{P} = \frac{(5.6\times 10^3)\times 0.08\times 300}{56\times 1}$$

= 2400 L

Now, $\frac{P_1}{M_1} = \frac{P_2}{M_2} \Rightarrow \frac{35}{(28.8-14.8)} = \frac{P_2}{(23.2-14.8)}$

$\Rightarrow P_2 = 21$ atm

7. $n_{NO} = \frac{1.6\times 0.75}{0.08\times 3.00} = 0.05$

$n_{O_2} = \frac{1.2\times 0.25}{0.08\times 3.00} = 0.0125$

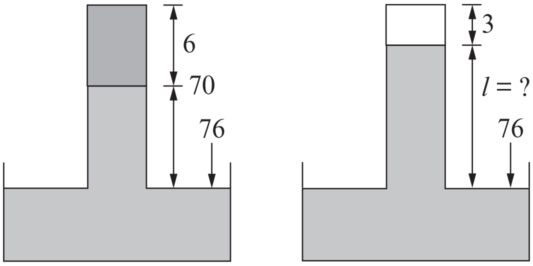
$$\begin{array}{lcccc} & 2NO & + \ O_2 & \rightarrow\ 2NO_2 & \rightarrow\ N_2O_4 \\ & 0.05 & 0.0125 & 0 & 0 \\ \text{Final} & \frac{-0.025}{0.025} & \frac{-0.0125}{0} & \frac{0}{0} & \frac{0.0125}{0.0125} \end{array}$$

But at 200 K, N_2O_4 is solid. Hence, the only gas is NO.

Millimoles of NO remained = 0.025 × 1000 = 25

Now, $P = \frac{0.025\times 0.08\times 200}{(0.75+0.25)} = 0.4$ atm

8.



$P_1 = (6 - 1) = 5$ cm Hg $\qquad$ $P_2 = ?$

$V_1 = 6$ A cm^3 $\qquad$ $V_2 = 3$ A cm^3

$P_2 = \frac{5\times 6A}{3A} = 10$ cm Hg

Hence, final total pressure in table above mercury = 10 + 1 = 11 cm Hg

$\therefore$ Barometer reading

= 76 – 11 = 65 cm

9. Mass of water vapour present initially,

$$m_1 = \frac{\left(\frac{756}{100}\times\frac{24}{760}\right)\times V}{R\times 300}\times 18$$

Mass of water vapour finally remained,

$$m_2 = \frac{\frac{8.4}{760}\times V}{R\times 280}\times 18$$

$\therefore$ Fraction of water condensed = $\frac{m_1 - m_2}{m_1} = 0.5$

10. Let the process time = t min

Mass of water vapour in inlet air,

$$m_1 = \frac{\left(\frac{20}{100}\times\frac{38}{760}\right)\times\left(10t\times 10^3\right)}{0.08\times 500}\times 18 \text{ gm } = 2.5\,t \text{ gm}$$

Mass of water vapour in outlet air,

$$m_2 = \frac{\left(\frac{80}{100}\times\frac{19}{760}\right)\times\left(10t\times 10^3\right)}{0.08\times 400}\times 18 \text{ gm} = 6.25\,t \text{ gm}$$

From question, $m_1 + 200 \text{ kg}\times\frac{36}{100} = m_2$

$\Rightarrow t = 19200$

11. At a depth of 10 m, P_1 = 1 atm + 10 m water

$= 1 + \frac{1.013\times1000\times1000}{1.013\times10^6} = 2$ atm

$V_1 = 24$ ml

$n_1 = \frac{2\times24\times10^{-3}}{0.08\times300} = 2\times10^{-3}$

At surface, $P_2 = 1$ atm, $V_2 = ?$,

$n_2 = 2\times10^{-3} - 0.05\times10^{-3}\times10$

$= 1.5\times10^{-3}$

Now, $\frac{P_1V_1}{n_1} = \frac{P_2V_2}{n_2} \Rightarrow \frac{2\times24}{2\times10^{-3}} = \frac{1\times V_2}{1.5\times10^{-3}} \Rightarrow V_2$

= 36 ml

For volume remaining uncharged, $\frac{P_1}{n_1} = \frac{P_2}{n_2}$

or, $\frac{2}{2\times10^{-3}} = \frac{1}{2\times10^{-3} - r\times10} \Rightarrow r = 10^{-4}$ mol/min

12.

$$\begin{array}{lcc} & N_2O_4 & \rightarrow \quad 2NO_2 \\ \text{Initial mole} & \frac{20\times V}{RT} & 0 \\ \text{Final mole} & \frac{20\times V}{RT} - \frac{10V}{RT} & \frac{20V}{RT} \\ & = \frac{10V}{RT} & \end{array}$$

NO_2 will effuse through SPM till its pressure becomes same in both chamber and hence, mole ratio of NO_2 in chamber-I and II should be 1 : 3.

Final moles in chamber-I = $\frac{10V}{RT}$ of N_2O_4 and $\frac{5V}{RT}$ of NO_2

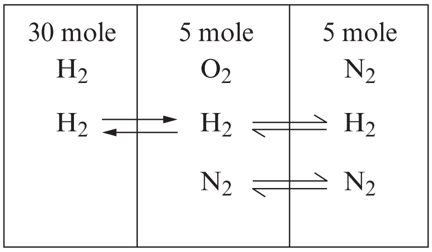
Final moles in chamber-II except H_2O vapour = $\frac{15V}{RT}$ of NO_2

$\therefore$ Pressure of gas in chamber-I = $\frac{\frac{15V}{RT}\times R\times1.2T}{V}$
= 18 mm

and pressure of gases in chamber-II = $\frac{\frac{15V}{RT}\times R\times1.2T}{3V}$ + 30 = 36 mm

13. $\frac{5}{2^n} \le 0.01 \Rightarrow n \ge 12.28$

14.



Inital

H_2 = 10 mole	H_2 = 10 mole O_2 = 5 mole N_2 = 2.5 mole	H_2 = 10 mole N_2 = 2.5 mole

Final

$P_1 : P_2 : P_3 = 10 : 17.5 : 12.5 = 4 : 7 : 5$

15.

$A_1 = \frac{n}{2}$	$A_1 = \frac{n}{2}$			--------
$A_2 = \frac{n}{3}$	$A_2 = \frac{n}{3}$	$A_2 = \frac{n}{3}$		
$A_3 = \frac{n}{4}$	$A_3 = \frac{n}{4}$	$A_3 = \frac{n}{4}$	$A_3 = \frac{n}{4}$	--------

$\therefore \frac{P_{A_4}}{P_{A_{N-1}}} = \frac{n/5}{n/N} = 3 \Rightarrow N = 15$

16. $\frac{r_{H_2}}{r_{air}} = \sqrt{\frac{M_{air}}{M_{H_2}}} \Rightarrow \frac{100/t}{26/t} = \sqrt{\frac{M_{air}}{2}}$

and $\frac{r_{gas}}{r_{air}} = \sqrt{\frac{M_{air}}{M_{H_2}}} \Rightarrow \frac{100/t}{130/t} = \sqrt{\frac{M_{air}}{M_{gas}}}$

$\therefore M_{gas} = 50$

17. $\frac{3}{2}$ kT = mgh $\Rightarrow \frac{3}{2}\times\frac{8.4}{N_A}\times300 = \frac{(40\times10^{-3})}{N_A}\times10\times h$

$\therefore h = 9450$ m

18. At Boyle's temperature, the second virial coefficient is zero.

$B = a + b\,.\,e^{c/T^2} = 0$

or, $e^{-c/T^2} = -\frac{a}{b} \Rightarrow e^{-950/T^2} = -\frac{-0.02}{0.22} \Rightarrow T = 100$ k

19. $P_c = 73.89 \text{ atm} = \dfrac{a}{27b^2}$ and $T_c = 300 \text{ k} = \dfrac{8a}{27Rb}$

$\therefore \dfrac{300}{73.89} = \dfrac{8b}{R} \Rightarrow b = 0.0416 \text{ l mol}^{-1}$

$b = 4 \times$ Volume occupied by molecules per mole

$\therefore$ Volume occupied by molecules in 24 moles

$= \dfrac{b}{4} \times 24$

= 0.25 L = 250 ml

20. $\dfrac{d(d)}{dP} = 4 + 0.02 \times 2\text{P} + \ldots$

$\therefore \left(\dfrac{d(d)}{dP}\right)_{P\to 0} = 4 = \dfrac{M}{RT}$

$\Rightarrow M = 4 \times 0.08 \times 300 = 96$