KINETIC THEORY

FACT/DEFINITION TYPE QUESTIONS

1. According to the kinetic theory of gases, the pressure exerted by a gas on the wall of the container is measured as
   (a) rate of change of momentum imparted to the walls per second per unit area.
   (b) momentum imparted to the walls per unit area
   (c) change of momentum imparted to the walls per unit area.
   (d) change in momentum per unit volume
2. According to kinetic theory of matter, a molecule is the smallest particle of a substance and it possesses
   (a) all the properties of the substance
   (b) some of the properties of the substance
   (c) none of the properties of the substance
   (d) either (b) or (c)
3. When a gas is in thermal equilibrium, its molecules
   (a) have the same average kinetic energy of molecules
   (b) have different energies which remain constant
   (c) have a certain constant energy
   (d) do not collide with one another
4. The pressure exerted on the walls of container by a gas is due to the fact that gas molecules are
   (a) losing their kinetic energy
   (b) sticking to the walls
   (c) changing their momenta due to collision with the walls
   (d) getting accelerated towards the wall
5. According to kinetic theory of gases, at absolute zero temperature
   (a) water freezes
   (b) liquid helium freezes
   (c) molecular motion stops
   (d) liquid hydrogen freezes
6. The temperature of a gas is a measure of
   (a) the average kinetic energy of the gaseous molecules
   (b) the average potential energy of the gaseous molecules
   (c) the average distance between the molecules of the gas
   (d) the size of the molecules of the gas
7. The absolute temperature of a gas determines
   (a) the average momentum of the molecule
   (b) the velocity of sound in the gas
   (c) the number of molecules in the gas
   (d) the mean square velocity of the molecules
8. At a given temperature the force between molecules of a gas as a function of intermolecular distance is
   (a) always constant
   (b) always decreases
   (c) always increases
   (d) first decreases and then increases
9. The temperature of gas is produced by
   (a) the potential energy of its molecules
   (b) the kinetic energy of its molecules
   (c) the attractive force between its molecules
   (d) the repulsive force between its molecules
10. Kinetic theory of gases provide a base for
    (a) Charle's law
    (b) Boyle's law
    (c) Both Charle's law and Boyle's law
    (d) None of these
11. In kinetic theory of gases, it is assumed that molecules
    (a) have same mass but can have different volume
    (b) have same volume but mass can be different
    (c) have different mass as well as volume
    (d) have same mass but negligible volume.
12. The internal energy of a gram-molecule of an ideal gas depends on
    (a) pressure alone
    (b) volume alone
    (c) temperature alone
    (d) both on pressure as well as temperature
13. The phenomenon of Browninan movement may be taken as evidence of
    (a) kinetic theory of matter
    (b) electromagnetic theory of radiation
    (c) corpuscular theory of light
    (d) photoelectric phenomenon

14. At 0K which of the following of a gas will be zero?
(a) Kinetic energy (b) Potential energy
(c) Vibrational energy (d) Density

15. Which of the following molecular properties is the same for all ideal gases at a given temperature
(a) momentum (b) rms velocity
(c) mean kinetic energy (d) mean free path

16. When do real gases approach the ideal gas behaviour ?
(a) At low pressure and low temperature
(b) At low pressure and high temperature
(c) At high pressure and high temperature
(d) At high pressure and low temperature

17. When temperature is constant, the pressure of a given mass of gas varies inversely with volume. This is the statement of
(a) Boyle's law (b) Charle's law
(c) Avogadro's law (d) None of these

18. The equation which should be satisfied exactly at all pressures and temperatures to be an ideal gas is
(a) $PV = \mu RT$ (b) $PV = k_B NT$
(c) $P = k_B nT.$ (d) All of these

19. In a diatomic molecules, the rotational energy at a given temperature
(a) obeys Maxwell's distribution
(b) have the same volue for all molecules
(c) equals the translational kinetic energy for each molecule.
(d) None of these

20. The average kinetic energy per molecule of any ideal gas is always equal to
(a) $\frac{2}{3}k_B T$ (b) $\frac{3}{4}k_B T$
(c) $\frac{3}{2}k_B T$ (d) $3k_B T$

21. In a mixture of gases at a fixed temperature
(a) heavier molecule has higher average speed
(b) lighter molecule has lower average speed
(c) heavier molecule has lower average speed
(d) None of these

22. The average kinetic energy of gas molecules depends upon which of the following factor?
(a) Nature of the gas (b) Temperature of the gas
(c) Volume of the gas (d) Both (b) & (c)

23. Cooking gas containers are kept in a lorry moving with uniform speed. The temperature of the gas molecules inside will.
(a) increase
(b) decrease
(c) remains the same
(d) decrease for some and increase for others

24. Molecules of a ideal gas behave like
(a) inelastic rigid sphere
(b) perfectly elastic non-rigid sphere
(c) perfectly elastic rigid sphere
(d) inelastic non-rigid sphere

25. If the pressure and the volume of certain quantity of ideal gas are halved, then its temperature
(a) is doubled (b) becomes one-fourth
(c) remains constant (d) is halved

26. In kinetic theory of gases, one assumes that the collisions between the molecules are
(a) perfectly elastic
(b) perfectly inelastic
(c) partly inelastic
(d) may be perfectly elastic or perfectly inelastic depending on nature of gas

27. Pressure exerted by a gas is
(a) independent of density of the gas
(b) inversely proportional to the density of the gas
(c) directly proportional to the square of the density of the gas
(d) directly proportional to the density of the gas

28. The internal energy of a gram-molecule of an ideal gas depends on
(a) pressure alone
(b) volume alone
(c) temperature alone
(d) both on pressure as well as temperature

29. The relation PV = RT can describe the behaviour of a real gas at
(a) high temperature and high pressure
(b) high temperature and low pressure
(c) low temperature and low pressure
(d) low temperature and high pressure

30. For Boyle's law to hold, the gas should be
(a) perfect and of constant mass and temperature
(b) real and of constant mass and temperature
(c) perfect and constant temperature but variable mass
(d) real and constant temperature but variable mass

31. Boyle' law is applicable for an
(a) adiabatic process. (b) isothermal process.
(c) isobaric process. (d) isochoric process

32. The deviation of gases from the behaviour of ideal gas is due to
(a) colourless molecules
(b) covalent bonding of molecules
(c) attraction of molecules
(d) absolute scale of temp.

33. In Boyle's law what remains constant ?
(a) PV (b) TV
(c) $\frac{V}{T}$ (d) $\frac{P}{T}$

34. At a given temperature which of the following gases possesses maximum r.m.s. velocity?
(a) Hydrogen (b) Oxygen
(c) Nitrogen (d) Carbon dioxide

35. Pressure exerted by a perfect gas is equal to
(a) mean kinetic energy per unit volume
(b) half of mean kinetic energy per unti volume
(c) two third of mean kinetic energy per unit volume
(d) one third of mean kinetic energy per unit volume

36. The ratio of molar specific heat at constant pressure C_P, to molar specific heat at constant volume C_v for a monoatomic gas is
(a) $\frac{C_P}{C_V} = \frac{3}{5}$ (b) $\frac{C_P}{C_V} = \frac{5}{3}$
(c) $\frac{C_P}{C_V} = \frac{7}{9}$ (d) $\frac{C_P}{C_V} = \frac{9}{7}$

37. The average velocity of the molecules in a gas in equilibrium is proportional to
(a) $\sqrt{T}$ (b) T
(c) T^2 (d) $\frac{1}{\sqrt{T}}$

38. According to the kinetic theory of gases, the r.m.s. velocity of gas molecules is directly proportional to
(a) T (b) $\sqrt{T}$
(c) T^2 (d) $1/\sqrt{T}$

39. The average kinetic energy of a molecule of a perfect gas is
(a) (2/3) kT (b) 1.5 kT
(c) 2.5 kT (d) None of these

40. The internal energy of an ideal gas is
(a) the sum of total kinetic and potential energies.
(b) the total translational kinetic energy.
(c) the total kinetic energy of randomly moving molecules.
(d) the total kinetic energy of gas molecules.

41. The root mean square speed of a group of n gas molecules, having speed $v_1, v_2, v_3, \ldots, v_n$ is
(a) $\frac{1}{n}\sqrt{(v_1 + v_2 + v_3 + \ldots + v_n)^2}$
(b) $\frac{1}{n}\sqrt{(v_1^2 + v_2^2 + v_3^2 + \ldots + v_n^2)}$
(c) $\sqrt{\frac{1}{n}(v_1^2 + v_2^2 + v_3^2 + \ldots + v_n^2)}$
(d) $\sqrt{\left[\frac{(v_1 + v_2 + v_3 + \ldots v_n)^2}{n}\right]}$

42. The ratio of the molar heat capacities of a diatomic gas at constant pressure to that a constant volume is
(a) $\frac{7}{2}$ (b) $\frac{3}{2}$ (c) $\frac{3}{5}$ (d) $\frac{7}{5}$

43. The specific heat of a gas
(a) has only two values c_p and c_v
(b) has a unique value at a given temperature
(c) can have any value between 0 and ∞
(d) depends upon the mass of the gas

44. The mean kinetic energy of a perfect monatomic gas molecule at the temperature T°K is
(a) $\frac{1}{2}$kT (b) kT (c) $\frac{3}{2}$kT (d) 2kT

45. The total internal energy of one mole of rigid diatomic gas is
(a) $\frac{3}{2}$RT (b) $\frac{7}{2}$RT
(c) $\frac{5}{2}$RT (d) $\frac{9}{2}$RT

46. The specific heats at constant pressure is greater than that of the same gas at constant volume because
(a) at constant pressure work is done in expanding the gas
(b) at constant volume work is done in expanding the gas
(c) the molecular attraction increases more at constant pressure
(d) the molecular vibration increases more at constant pressure

47. If E is the translational kinetie energy, then which of the following relation holds good ?
(a) $PV = E$ (b) $PV = \frac{3}{2}E$
(c) $PV = 3E$ (d) $PV = \frac{2}{3}E$

48. Which of the following formula is wrong?
(a) $C_V = \frac{R}{\gamma - 1}$ (b) $C_P = \frac{\gamma R}{\gamma - 1}$
(c) $C_p / C_V = \gamma$ (d) $C_p - C_V = 2R$

49. As per the law of equi-partition of energy each vibrational mode gives how many degrees of freedom ?
(a) 1 (b) 2
(c) 3 (d) 0

50. A fly moving in a room has ...X... degree of freedom. Here, X refers to
(a) one (b) two
(c) three (d) four

51. The number of degrees of freedom for each atom of a monatomic gas is
(a) 3 (b) 5 (c) 6 (d) 1

52. The total number of degree of freedom of a CO_2 gas molecule is
(a) 3 (b) 6
(c) 5 (d) 4

53. A polyatomic gas with n degrees of freedom has a mean energy per molecule given by
(a) $\frac{nkT}{N}$ (b) $\frac{nkT}{2N}$
(c) $\frac{nkT}{2}$ (d) $\frac{3kT}{2}$

54. The degree of freedom of a molecule of a triatomic gas is
(a) 2 (b) 4
(c) 6 (d) 8

55. If a gas has 'n' degrees of freedom, the ratio of the specific heats γ of the gas is
(a) $\frac{1+n}{2}$ (b) $1+\frac{n}{2}$ (c) $1+\frac{1}{n}$ (d) $1+\frac{2}{n}$

56. How is the mean free path (λ) in a gas related to the interatomic distance ?
(a) λ is 10 times the interatomic distance
(b) λ is 100 times the interatomic distance
(c) λ is 1000 times the interatomic distance
(d) λ is $\frac{1}{10}$ times of the interatomic distance

57. Mean free path of a gas molecule is
(a) inversely proportional to number of molecules per unit volume
(b) inversely proportional to diameter of the molecule
(c) directly proportional to the square root of the absolute temperature
(d) directly proportional to the molecular mass

58. Maxwell's laws of distribution of velocities shows that
(a) the number of molecules with most probable velocity is very large
(b) the number of molecules with most probable velocity is very small
(c) the number of molecules with most probable velocity is zero
(d) the number of molecules with most probable velocity is exactly equal to 1

59. If the pressure in a closed vessel is reduced by drawing out some gas, the mean-free path of the molecules
(a) is decreased
(b) is increased
(c) remains unchanged
(d) increases or decreases according to the nature of the gas

STATEMENT TYPE QUESTIONS

60. In the kinetic theory of gases, which of these statements is/are true ?
I. The pressure of a gas is proportional to the mean speed of the molecules.
II. The root mean square speed of the molecules is proportional to the pressure.
III. The rate of diffusion is proportional to the mean speed of the molecules.
IV. The mean translational kinetic energy of a gas is proportional to its kelvin temperature.
(a) II and III only (b) I, II and IV
(c) I and III only (d) III and IV only

61. From the following statements, concerning ideal gas at any given temperature T, select the correct one(s)
I. The coefficient of volume expansion at constant pressure is same for all ideal gas
II. The average translational kinetic energy per molecule of oxygen gas is $3KT$ (K being Boltzmann constant)
III. In a gaseous mixture, the average translational kinetic energy of the molecules of each component is same
IV. The mean free path of molecules increases with decrease in pressure
(a) I, II and III (b) III and IV only
(c) I, III and IV (d) I, II, III and IV

62. Which of the given statement(s) is/are false ?
I. All molecules in a gas do not have same velocity.
II. For a gas there is distribution of velocities of the molecules.
III. There is no preferred direction of velocity of the molecules.
(a) I and II (b) II and III
(c) I and III (d) I, II and III

63. Which of the following statements is/are true ?
I. Average kinetic energy of a molecule is independent of the pressure of the gas.
II. Average kinetic energy of a molecule is independent of the volume of the gas.
III. Average kinetic energy of a molecule is independent of the nature of the gas.
(a) I and II (b) II and III
(c) I and III (d) I, II and III

64. For mean kinetic energy per molecule, a vessel filled with two different gases.
I. Mean kinetic energy per molecule for both gases will be equal
II. Mean kinetic energy per molecule of gas with higher mass will be more
III. Mean kinetic energy per moleculers of gas with lower mass will be more
Select the correct statement(s).
(a) I only (b) II only
(c) I and II (d) I, II and III

65. Consider the following statements and select the correct option from the following.

I. At room temperature the specific heats are independent of temperature.

II. At low temperature i.e. as $T \to 0$, specific heat approach zero.

III. At low temp, the degrees of freedom get frozen

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

(c) I and III (d) I, II and III

66. The root mean square value of the speed of the molecules in a fixed mass of an ideal gas is increased by increasing

I. the temperature while keeping the volume constant

II. the pressure while keeping the volume constant

III. the temperature while keeping the pressure constant

IV. the pressure while keeping the temperature constant.

Select the correct statements.

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

(c) I and III (d) I, III and IV

67. Consider the following statements and select the correct option.

I. The ratio of C_P / C_V for a diatomic gas is more than that of a monoatomic gas.

II. The ratio of C_P / C_V is more for helium gas than for hydrogen

(a) I only (b) II only

(c) I and II (d) None of these

68. Choose the false statement(s) from the following.

I. $C_P - C_V = R$ is true for monoatomic gases only.

II. Specific heat of a gas at constant pressure is greater than specific heat at constant volume.

III. Mean free path of molecules of a gas decrease with increase in number density of the molecules.

(a) I only (b) II only

(c) I and II (d) I, II and III

69. Which of the following is/are incorrect statement(s) regarding the law of equipartition of energy ?

I. The gas possess equal energies in all the three directions x, y and z-axis.

II. The total energy of a gas is equally divided between kinetic and potential energies.

III. The total kinetic energy of a gas molecules is equally divided among translational and rotational kinetic energies.

(a) I only (b) II and III

(c) I and III (d) I, II and III

MATCHING TYPE QUESTIONS

70. Match the Column I and II.

Column I	Column II
(A) $P \propto T$	(1) Ideal gas equation
(B) $V \propto T$	(2) Boyle's law
(C) $PV = K_B NT$	(3) Charle's law
(D) $P = nRT / M$	(4) V - Constant

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)

(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)

(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (2)

71. Match **Column I** (Physical Variables) with **Column II** (Expressions) . (n = number of gas molecules present per unit volume, k = Boltzmann constant, T = absolute temperature, m = mass of the particle) :

Column I	Column II
(A) Most probable velocity	(1) nkT
(B) Energy per degree of freedom	(2) $\sqrt{(3kT/m)}$
(C) Pressure	(3) $\sqrt{(2kT/m)}$
(D) R.M.S. velocity	(4) $kT/2$

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)

(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (2)

72.

Column I	Column II
(A) Average speed v_{av}	(1) $\sqrt{\frac{3RT}{M}}$
(B) Root mean square speed v_{rms}	(2) $\sqrt{\frac{8RT}{\pi M}}$
(C) Most probable speed v_{mp}	(3) $\frac{\sqrt{\gamma Rt}}{M}$
(D) Speed of sound v_{sound}	(4) $\sqrt{\frac{2RT}{M}}$

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)

(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)

(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

73.

Column I	Column II
(A) An ideal gas obeys gas equation	(1) with decrease in pressure
(B) A real gas behaves as an ideal gas at low pressure	(2) at all temperature
(C) Mean free path of molecules increases	(3) at high temperature
(D) Charle's law	(4) pressure constant

(a) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2)

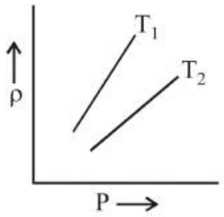
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)

(c) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (4)

(d) (A) → (2) ; (B) → (3) ; (C) → (1) ; (D) → (4)

DIAGRAM TYPE QUESTIONS

74. The density (ρ)versus pressuure (P) of a given mass of an ideal gas is shown at two temperatures T_1 and T_2



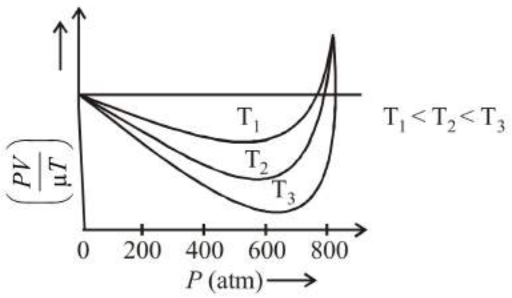
Then relation between T_1 and T_2 may be

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

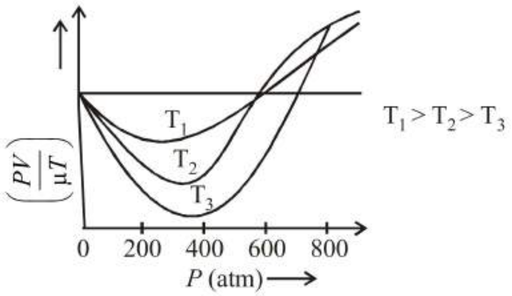
(c) $T_1 = T_2$ (d) All the three are possible

75. Which of the following graphs represents the real gas approaching ideal gas behaviour ?

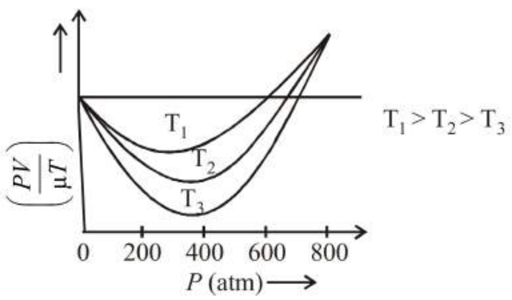
(a)



(b)

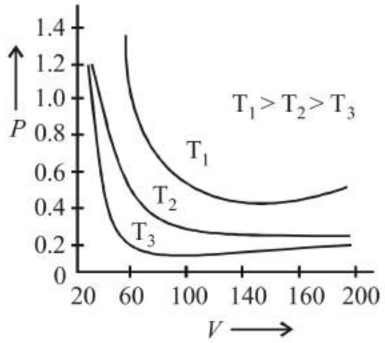


(c)



(d) None of these

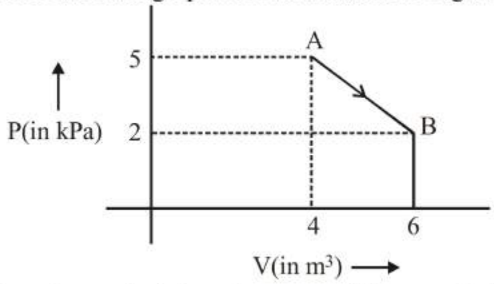
76. The given *P-V* curve is predicted by



(a) Boyle's law (b) Charle's law

(c) Avogadro's law (d) Gaylussac's law

77. One mole of an ideal diatomic gas undergoes a transition from A to B along a path AB as shown in the figure.

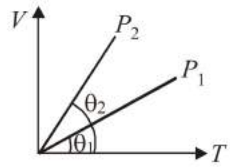


The change in internal energy of the gas during the transition is

(a) – 20 kJ (b) 20 J

(c) –12 kJ (d) 20 kJ

78. The figure shows the volume *V* versus temperature *T* graphs for a certain mass of a perfect gas at two constant pressures of P_1 and P_2. What inference can you draw from the graphs?



(a) $P_1 > P_2$

(b) $P_1 < P_2$

(c) $P_1 = P_2$

(d) No inference can be drawn due to insufficient information.

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

79. **Assertion:** On reducing the volume of the gas at constant temperature, the pressure of the gas increases.
Reason: It happens because on reducing the volume, the no. of molecules per unit volume increases and as a result more collisions with walls exert greater pressure on the walls.

80. **Assertion:** Internal energy of an ideal gas does not depend upon the volume of the gas.
Reason: Internal inergy of an ideal gas depends on temperature of the gas.

81. **Assertion:** At low temperature and high pressure, the real gases obey more strictly the gas equation $PV = RT$
Reason: At low temperature, the molecular motion ceases and due to high pressure, volume decreases and PV becomes constant.

82. **Assertion:** One mole of any substance at any temperature or volume always contains 6.02×10^{23} molecules.
Reason: One mole of a substance always refers to S.T.P. conditions.

83. **Assertion :** The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.
Reason : The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

84. **Assertion :** When we place a gas cylinder on a moving train, its internal kinetic energy increases.
Reason : Its temperature remains constant.

85. **Assertion :** If a gas container in motion is suddenly stopped, the temperature of the gas rises.
Reason : The kinetic energy of ordered mechanical motion is converted in to the kinetic energy of random motion of gas molecules.

86. **Assertion :** The internal energy of a real gas is function of both, temperature and volume.
Reason : Internal kinetic energy depends on temperature and internal potential energy depends on volume.

87. **Assertion :** Each vibrational mode gives two degrees of freedom
Reason : By law of equipartition of energy, the energy for each degree of freedom in thermal equilibrium is $2k_B T$.

88. **Assertion :** For an ideal gas, at constant temperature, the product of pressure and volume is constant.
Reason : The mean square velocity of the molecules is inversely proportional to mass.

89. **Assertion :** Air pressure in a car tyre increases during driving.
Reason : Absolute zero temperature is not zero energy temperature.

90. **Assertion :** A gas can be liquified at any temperature by increase of pressure alone.
Reason : On increasing pressure the temperature of gas decreases.

91. **Assertion :** At low density, variable of gases P, V and T follows the equation $PV = \mu RT$.
Reason : At low density real gases are more closely to ideal gases.

92. **Assertion :** A gas has unique value of specific heat.
Reason : Specific heat is defined as the amount of heat required to raise the temperature of unit mass of the substance through one degree centrigrade.

93. **Assertion :** Specific heat of a gas at constant pressure (C_p) is greater than its specific heat at constant volume (C_v).
Reason : At constnat pressure, some heat is spent in expansion of the gas.

94. **Assertion :** The ratio $\frac{C_V}{C_P}$ for a monatomic gas is less than for a diatomic gas.
Reason : The molecules of a monatomic gas have more degrees of freedom than those of a diatomic gas.

95. **Assertion :** For an atom the number of degrees of freedom is 3.
Reason : The ratio of specific heats at constant pressure and volume is a constant. i.e., $\frac{C_p}{C_v} = \gamma$.

96. **Assertion :** Maxwell speed distribution graph is symmetric about most probable speed
Reason : rms speed of ideal gas, depends upon it's type (monoatomic, diatomic and polyatomic)

97. **Assertion :** Mean free path of a gas molecules varies inversely as density of the gas.
Reason : Mean free path varies inversely as pressure of the gas.

CRITICALTHINKING TYPE QUESTIONS

98. A gas is enclosed in a cube of side l. What will be the change in momentum of the molecule, if it suffers an elastic collision with the plane wall parallel to yz-plane and rebounds with the same velocity ?
[(V_x, V_y & V_z) initial velocities of the gas molecules]
(a) mv_x (b) zero
(c) $-mv_x$ (d) $-2mv_x$.

99. A flask contains a monoatomic and a diatomic gas in the ratio of 4 : 1 by mass at a temperature of 300 K. The ratio of average kinetic energy per molecule of the two gases is
(a) 1 : 1 (b) 2 : 1
(c) 4 : 1 (d) 1 : 4

100. What will be the ratio of number of molecules of a monoatomic and a diatomic gas in a vessel, if the ratio of their partial pressures is 5 : 3 ?
(a) 5 : 1 (b) 3 : 1
(c) 5 : 3 (d) 3 : 5

101. If two vessels A and B contain the same gas but the volume of vessel A is twice that of B and temperature and pressure of gas A is twice that of gas in B, then the ratio of gas molecules in A and B is

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

102. At constant volume, temperature is increased then

(a) collision on walls will be less
(b) number of collisions per unit time will increase
(c) collisions will be in straight lines
(d) collisions will not change.

103. If a gas is heated at constant pressure, its isothermal compressibility

(a) remains constant
(b) increases linearly with temperature
(c) decreases linearly with temperature
(d) decreases inversely with temperature

104. A gas in a container A is in thermal equilibrium with antoher gas of the same mass in container B. If we denote the corresponding pressures and volumes by the suffixes A and B, then which of the following statement is most likely to be true?

(a) $P_A = P_B,\ V_A \neq V_B$ (b) $P_A \neq P_B,\ V_A = V_B$
(c) $P_A / V_A = P_B / V_B$ (d) $P_A V_A = P_B V_B$

105. In a cubical vessel are enclosed n molecules of a gas each having a mass m and an average speed v. If ℓ is the length of each edge of the cube, the pressure exerted by the gas will be

(a) $\frac{n m v^2}{\ell^3}$ (b) $\frac{n m^2 v}{2\ell^3}$ (c) $\frac{m n v^2}{3\ell^3}$ (d) $\frac{n m v}{2\ell}$

106. *P, V, T* respectively denote pressure, volume and temperature of two gases. On mixing, new temperature and volume are respectively *T and V*. Final pressure of the mixture is

(a) *P* (b) 2*P*
(c) zero (d) 3*P*

107. Gas at a pressure P_0 is contained in a vessel. If the masses of all the molecules are halved and their speeds are doubled, the resulting pressure *P* will be equal to

(a) $4P_0$ (b) $2P_0$
(c) P_0 (d) $\frac{P_0}{2}$

108. The temperature at which the average transitional kinetic energy of a gas molecule is equal to the energy gained by an electron in accelerating from rest through a potential difference of 1 volt is

(a) 4.6×10^3 K (b) 11.6×10^3 K
(c) 23.2×10^3 K (d) 7.7×10^3 K

109. 4.0 g of a gas occupies 22.4 litres at NTP. The specific heat capacity of the gas at constant volume is $5.0 JK^{-1}$. If the speed of sound in this gas at NTP is 952 ms^{-1}, then the heat capacity at constant pressure is (Take gas constant R = 8.3 $JK^{-1} mol^{-1}$)

(a) 7.5 $JK^{-1} mol^{-1}$ (b) 7.0 $JK^{-1} mol^{-1}$
(c) 8.5 $JK^{-1} mol^{-1}$ (d) 8.0 $JK^{-1} mol^{-1}$

110. Two vessels separately contain two ideal gases A and B at the same temperature. The pressure of A being twice that of B. Under such conditions, the density of A is found to be 1.5 times the density of B. The ratio of molecular weight of A and B is :

(a) $\frac{3}{4}$ (b) 2
(c) $\frac{1}{2}$ (d) $\frac{2}{3}$

111. The ratio of the specific heats $\frac{C_p}{C_v} = \gamma$ in terms of degrees of freedom (n) is given by

(a) $\left(1+\frac{n}{3}\right)$ (b) $\left(1+\frac{2}{n}\right)$
(c) $\left(1+\frac{n}{2}\right)$ (d) $\left(1+\frac{1}{n}\right)$

112. For hydrogen gas $C_p - C_v = a$ and for oxygen gas $C_p - C_v = b$. So, the relation between a and b is given by

(a) a = 16 b (b) 16 a = b
(c) a = 4 b (d) a = b

113. The temperature at which protons in hydrogen gas would have enough energy to overcome Coulomb barrier of 4.14×10^{-14} J is
(Boltzmann constant = $1.38 \times 10^{-23} JK^{-1}$)

(a) 2×10^9 K (b) 10^9 K
(c) 6×10^9 K (d) 3×10^9 K

114. The temperature at which oxygen molecules have the same root mean square speed as that of hydrogen molecules at 300 K is

(a) 600 K (b) 2400 K
(c) 4800 K (d) 300 K

115. If the root mean square velocity of the molecules of hydrogen at NTP is 1.84 km/s. Calculate the root mean square velocity of oxygen molecule at NTP, molecular weight of hydrogen and oxygen are 2 and 32 respectively

(a) 1.47 km/sec (b) 0.94 km/s
(c) 1.84 km/s (d) 0.47 km/sec

116. The average transitional energy and the rms speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J and 484 m/s respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour)

(a) 12.42×10^{-21} J, 968 m/s (b) 8.78×10^{-21} J, 684 m/s

(c) 6.21×10^{-21} J, 968 m/s (d) 12.42×10^{-21} J, 684 m/s

117. If R is universal gas constant, the amount of heat needed to raise the temperature of 2 moles of an ideal monoatomic gas from 273 K to 373 K, when no work is done, is

(a) $100R$ (b) $150R$

(c) $300R$ (d) $500R$

118. One kg of a diatomic gas is at a pressure of 8×10^4 N/m^2. The density of the gas is 4 kg/m^3. What is the energy of the gas due to its thermal motion?

(a) 3×10^4 J (b) 5×10^4 J

(c) 6×10^4 J (d) 7×10^4 J

119. If C_P and C_V denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then

(a) $C_P - C_V = 28R$ (b) $C_P - C_V = R/28$

(c) $C_P - C_V = R/14$ (d) $C_P - C_V = R$

120. If one mole of monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ is mixed with one mole of diatomic gas $\left(\gamma = \frac{7}{5}\right)$, the value of γ for the mixture is

(a) 1.40 (b) 1.50

(c) 1.53 (d) 3.07

121. The molar specific heat at constant pressure of an ideal gas is (7/2)R. The ratio of specific heat at constant pressure to that at constant volume is

(a) 5/7 (b) 9/7 (c) 7/5 (d) 8/7

122. The molar specific heats of an ideal gas at constant pressure and volume are denoted by C_p and C_v, respectively. If $\gamma = \frac{C_p}{C_v}$ and R is the universal gas constant, then C_v is equal to

(a) $\frac{R}{(\gamma - 1)}$ (b) $\frac{(\gamma - 1)}{R}$

(c) γR (d) $\frac{1+\gamma}{1-\gamma}$

123. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_P}{C_V}$ of the mixture is

(a) 1.62 (b) 1.59

(c) 1.54 (d) 1.4

124. Half mole of helium gas is contained at STP. The heat energy needed to double the pressure of the gas keeping the volume constant (specific heat of the gas = 3J/g –K) is

(a) 3276 J (b) 1638 J

(c) 819 J (d) 409.5 J

125. A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats γ. It is moving with speed v and it suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by

(a) $\frac{(\gamma - 1)}{2\gamma R} Mv^2 K$ (b) $\frac{\gamma M v^2}{2R} K$

(c) $\frac{(\gamma - 1)}{2R} Mv^2 K$ (d) $\frac{(\gamma - 1)}{2(\gamma + 1)R} Mv^2 K$

126. A cylinder rolls without slipping down an inclined plane, the number of degrees of freedom it has, is

(a) 2 (b) 3

(c) 5 (d) 1

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** **2.** **(a)** **3.** **(a)** **4.** **(c)** **5.** **(c)**
6. **(a)** **7.** **(d)** **8.** **(d)** **9.** **(b)**
10. **(c)** Boyle's and Charle's law follow kinetic theory of gases.
11. **(d)** **12.** **(a)** **13.** **(a)** **14.** **(a)**
15. **(c)** $E = \frac{3}{2}RT$, so it is same for all ideal gases at same temperature.
16. **(b)** At low pressure and high temperature the molecules are far apart and molecular interactions are negligible. Without interactions the gas behaves like an ideal one.
17. **(a)**
18. **(c)** Perfect gas equation is $PV = \mu RT$.
μ is the number of moles, $R = N_A k_B$

$$\mu = \frac{M}{M_0} = \frac{N}{N_A}$$

$$\therefore \quad PV = k_B NT \quad \text{or} \quad P = k_B nT$$

19. **(a)**
20. **(c)** In equilibrium, the average kinetic energy of molecules of different gases will be equal. That is

$$\frac{1}{2}m_1\bar{v}_1^2 = \frac{1}{2}m_2\bar{v}_2^2 = \left(\frac{3}{2}k_BT\right)$$

21. **(c)** Lighter the molecule, higher the average speed.
22. **(b)** Average kinetic energy of gas molecues depends on the temperature of the gas as

$$\frac{1}{2}mv^2 = \frac{3}{2}k_BT$$

23. **(c)** The centre of mass of the gas molecules moves with uniform speed along with lorry. As there is no change in relative motion, the translational kinetic energy and hence the temperature of the gas molecules will remain same.
24. **(c)** molecules of ideal gas behaves like perfectly elastic rigid sphere.
25. **(b)** According to ideal gas law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \text{ or } T_2 = T_1\frac{P_2V_2}{P_1V_1}$$

$$\therefore T_2 = \frac{T\left(\frac{P}{2}\right)\left(\frac{V}{2}\right)}{PV} \quad T_2 = \frac{T}{4}$$

26. **(a)** According to kinetic theory of gases there is no loss of energy during the collisions between the molecules. Therefore, collision between the molecules is perfectly elastic.
27. **(d)** Pressure exerted by a gas is given by

$$P = \frac{1}{3}\frac{mn}{V}v^2$$

$$\text{or} \quad P = \frac{1}{3}\rho\bar{v}^2 \quad \therefore \quad P \propto \rho$$

Therefore, pressure exerted by a gas is directly proportional to the density of the gas.
28. **(c)** **29.** **(b)** **30.** **(a)**
31. **(b)** According to boyle's law, at constant temperature.

$$P \propto \frac{1}{V} \quad \text{or} \quad P_1V_1 = P_2V_2$$

32. **(c)**
33. **(a)** According to Boyle's law PV = constant.
34. **(a)** $V_{rms} = \sqrt{\frac{3RT}{M}}$ M is least for hydrogen among the hydrogen, oxygen, nitrogen and carbon dioxide.
35. **(c)** Pressure, $P = \frac{2E}{3}$
36. **(b)** For a monoatomic gas, the average energy of a molecule at temperature T is $\frac{3}{2}k_BT$.

$$\therefore \quad \text{Internal energy } U = \frac{3}{2}RT$$

$$C_V = \frac{dU}{dT} = \frac{3}{2}R$$

For an ideal gas, $C_P - C_V = R$

$$\therefore \quad C_P = \frac{5}{2}R \text{ and } \gamma = \frac{C_P}{C_V} = \frac{5}{3}$$

37. **(a)** Average velocity $v_{avg.} = \sqrt{\frac{8kT}{\pi m}}$
38. **(b)** RMS velocity $V_{rms} = \sqrt{\frac{3RT}{M}}$
39. **(b)** **40.** **(d)** **41.** **(c)**
42. **(d)** For a diatomic gas,
Molar heat capacity at constant pressure,

$$C_P = \frac{7}{2}R$$

Molar heat capacity at constant volume,

$$C_V = \frac{5}{2}R \quad \therefore \quad \frac{C_P}{C_V} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5}$$

43. (c) $C = \frac{Q}{m\Delta T}$; If $\Delta T = 0$, $C = \infty$ and if $Q = 0$, then $C = 0$

44. (c)

45. (c) A rigid diatomic molecule has 5 degrees of freedom total internal energy of one mole of rigid diatomic gas is

$$U = \frac{5}{2}k_B T \times N_A = \frac{5}{2}RT \qquad (\because R = k_B N_A)$$

46. (a) Work done is to be done in expanding the gas at constant pressure.

47. (d) Translational kinetic enegy $E = \frac{3}{2}k_B NT$

$$\therefore \quad PV = \frac{2}{3}E \qquad [\because k_B NT = PV]$$

48. (d) The difference of C_P and C_V is equal to R, not $2R$.

49. (b) Law of equipartition of energy states that the energy for each degree of freedom in thermal equilibrium is $\frac{1}{2}k_B T$. Thus each vibrational mode gives 2 degrees of freedom (kinetic and potential energy modes) corresponding to the energy $2\times\frac{1}{2}k_B T = k_B T$

50. (c) A fly moving in a room has three degrees of freedom, because it is free to move in space.

51. (a) 52. (c)

53. (c) According to law of equipartition of energy, the energy per degree of freedom is $\frac{1}{2}kT$.

For a polyatomic gas with n degrees of freedom, the mean energy per molecule $= \frac{1}{2}nkT$

54. (c) No. of degree of freedom $= 3K - N$

where K is no. of atom and N is the number of relations between atoms. For triatomic gas,

$K = 3, N = {}^3C_2 = 3$

No. of degree of freedom $= 3(3) - 3 = 6$

55. (d)

56. (b) Mean free path in a gas is 100 times the interatomic distance.

57. (a) Mean free path, $\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$

where,
n = number of molecules per unit volume,
d = diameter of the molecules

58. (a) Based on Maxwell's velocity distribution curve.

59. (b)

STATEMENT TYPE QUESTIONS

60. (d)

61. (c) Coefficient of volume expansion at constant pressure is $\frac{1}{273}$ for all gases. The average transnational K.E. is same for molecules of all gases and for each molecules it is $\frac{3}{2}kT$

Mean free path $\lambda = \frac{kT}{\sqrt{2}\,\pi d^2 P}$ (as P decreases, λ increases)

62. (d) 63. (d)

64. (a) Mean kinetic energy per molecule will be equal for both the gases because it depends only upon the temperature. ($E = \frac{3}{2}k_B T$)

65. (d) 66. (c)

67. (b) Helium is monoatomic and hydrogen is diatomic. Helium has smaller number of degrees of freedom than hydrogen. So C_P / C_V for helium is more than that for hydrogen.

68. (a) $C_P - C_V = R$ is true for any gas.

69. (b) In all the three directions x, y and z gas possess equal energies.

MATCHING TYPE QUESTIONS

70. (c) (A)→(4) ; (B)→(3) ; (C)→(1) ; (D)→(2)

71. (a) (A)→(3) ; (B)→(4) ; (C)→(1) ; (D)→(2)

72. (c) (A)→(2); (B)→(1); (C)→(4) ; (D)→(3)

73. (d) (A)→(2) ; (B)→(3) ; (C)→(1) ; (D)→(4)

DIAGRAM TYPE QUESTIONS

74. (b) According to ideal gas equation

PV = nRT

$$PV = \frac{m}{M}RT,\ P = \frac{\rho}{M}RT \text{ or } \frac{\rho}{P} = \frac{M}{RT} \text{ or } \frac{\rho}{P} \propto \frac{1}{T}$$

Here, $\frac{\rho}{P}$ represent the slope of graph

Hence $T_2 > T_1$

75. (c) 76. (a)

77. (a) Change in internal energy from A → B

$$\Delta U = \frac{f}{2}nR\Delta T = \frac{f}{2}nR(T_f - T_i)$$

$$= \frac{5}{2}\{P_f V_f - P_i V_i\}$$

(As gas is diatomic $\therefore$ f = 5)

$= \frac{5}{2}\{2\times10^3\times6-5\times10^3\times4\}$

$= \frac{5}{2}\{12-20\}\times10^3\text{ J} = 5\times(-4)\times10^3\text{ J}$

$\Delta U = -20$ KJ

78. **(a)** $\because \theta_1 < \theta_2 \Rightarrow \tan\theta_1 < \tan\theta_2 \Rightarrow \left(\frac{V}{T}\right)_1 < \left(\frac{V}{T}\right)_2$

From $PV = \mu RT$; $\frac{V}{T} \propto \frac{1}{P}$

Hence $\left(\frac{1}{P}\right)_1 < \left(\frac{1}{P}\right)_2 \Rightarrow P_1 > P_2$.

ASSERTION- REASON TYPE QUESTIONS

79. **(a)** **80.** **(d)**

81. **(d)** The real gases obey the gas equation at low pressure and high temperature as, at high temperature the intermolecular force is negligible due to increased volume of the gas.

82. **(c)** The number 6.02×10^{23} is Avogadro's number and one mole of a substance contains Avogadro's number of molecules.

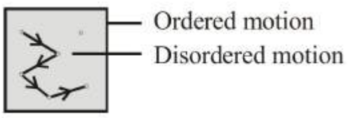
83. **(b)** Total translational kinetic energy $= \frac{3}{2}nRT = \frac{3}{2}PV$

In an ideal gas all molecules moving randomly in all direction collide and their velocity changes after collision.

84. **(c)** Internal energy can be increased when molecules of gas will get greater velocity w.r.t. container.

85. **(a)** The motion of the container is known as the ordered motion of the gas and zigzag motion of gas molecules within the container is called disordered motion

When the container suddenly stops, ordered kinetic energy gets converted into disordered kinetic energy which is turn increases the temperature of the gas.



86. **(a)** In real gas, intermolecular force exist. Work has to be done in changing the distance between the molecules. Therefore, internal energy of real gas is sum of internal kinetic and internal potential energy which are function of temperature and volume respectively. Also change in internal energy of a system depends only on initial and final sates of the system.

87. **(c)** By law of equipartition of energy, the energy for each degree of freedom in thermal equilibrium is $\frac{1}{2}k_BT$. Each quadratic term form in the total energy expression of a molecules is to be counted as a degree of freedom. Thus each vibrational mode gives 2 degree of freedom i.e, kinetic and potential energy modes, corresponding to the energy $2\left(\frac{1}{2}k_BT\right) = k_BT$.

88. **(b)** $PV = \text{constant}$ and $v_{rms} = \sqrt{\frac{3kT}{m}}$

89. **(b)** When a person is driving a car then the temperature of air inside the tyre is increased because of motion. From the Gay Lussac's law,

$P \propto T$

Hence, when temperature increases the pressure also increase.

90. **(d)** A vapour above the critical temperature is a gas and gas below the critical temperature for the substance is a vapour. As gas cannot be liquidfied by the application of pressure alone, how so ever large the pressure may be while vapour can be liquified under pressure alone. To liquify a gas it must be cooled upto or below its critical temperature.

91. **(a)** At high temperature and low pressure (low density), real gas behaves like an ideal gas.

92. **(d)** The specific heat of a gas can be from 0 to ∞.

93. **(a)** C_v is used in increasing the internal energy of the gas while C_p is used in two ways (i) to change the internal energy and (ii) to do expansion of gas. Hence $C_p > C_v$.

94. **(c)** For monatomic gas, f = 3,

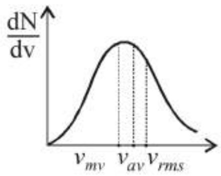
$C_V = \frac{3R}{2}, C_p = \frac{5R}{2}$; $\frac{C_V}{C_p} = \frac{3}{5}$

For diatomic gas, f = 5

$C_V = \frac{5R}{2}, C_p = \frac{7R}{2}$; $\frac{C_V}{C_p} = \frac{5}{7}$

95. **(b)** An atom can have only translatory motion, so its degrees of freedom can be $\frac{1}{2}mv_x^2, \frac{1}{2}mv_y^2, \frac{1}{2}mv_z^2$.

96. **(d)** Maxwell speed distribution graph is asymmetric graph, because it has a long 'tail' that extends to infinity. Also U_{rms} depends upon nature of gas and it's temperature.



97. **(a)** The mean free path of a gas molecule is the averge distance between two successive collisions. It is represented by λ.

$\lambda = \frac{1}{\sqrt{2}}\frac{kT}{\pi\sigma^2 P}$ and $\lambda = \frac{m}{\sqrt{2}\cdot\pi\sigma^2 d}$

Here, $\sigma = 0$ diameter of molecule and

k = Boltzmann's constant.

$\Rightarrow \lambda \propto 1/d,\ \lambda \propto T$ and $\lambda \propto 1/P$.

Hence, mean free path varies inversely as density of the gas. It can easily proved that the mean free path varies directly as the temperature and inversely as the pressure of the gas.

CRITICALTHINKING TYPE QUESTIONS

98. (d) Since it hits the plane wall parallel to y z – plane and it rebounds with same velocity, its y and z components of velocity do not change, but the x-component reverses the sign.
$\therefore$ Velocity after collision is $(-v_x, v_y \text{ and } v_z)$.
The change in momentum is
$-mv_x - mv_x = -2mv_x$

99. (a) The average kinetic energy per molecule of any ideal gas is always equal to $\left(\frac{3}{2}\right)k_BT$. It depends only on the temperature and is independent of the mass and nature of the gas.

100. (c) V and T will be same for both gases.
$P_1V = \mu_1RT$ and $P_2V = \mu_2RT$

$$(P_1/P_2) = \frac{5}{3} \qquad \therefore \left(\frac{\mu_1}{\mu_2}\right) = \frac{5}{3}$$

By definition, $\mu_1 = \frac{N_1}{N_A}$ and $\mu_2 = \frac{N_2}{N_A}$

$$\therefore \frac{N_1}{N_2} = \frac{\mu_1}{\mu_2} = \frac{5}{3}$$

101. (d) $V_A = 2V_B$; $T_A = 2T_B$; $P_A = 2P_B$

$$\frac{P_AV_A}{TA} = \frac{P_BV_B}{T_B} = n_AR = n_BR$$

$$\therefore \frac{\eta_A}{\eta_B} = \frac{P_AV_AT_B}{P_BV_BT_A}$$

$$= \frac{(2P_B)(2V_B)(T_B)}{P_B\,V_B\,(2T_B)} = 2$$

102. (b) As the temperature increases, the average velocity increases. So, the collisions are faster.

103. (a)

104. (d) Apply Boyle's law, at constant temperature

$$P \propto \frac{1}{V}$$

105. (c)

106. (b) Let n_1 and n_2 be the number of moles of each gas. Then

$$n_1 = \frac{PV}{RT} \text{ and } n_2 = \frac{PV}{RT}$$

When the two gases are mixed, total number of moles,
$n = n_1 + n_2$

$$\Rightarrow \frac{P'V}{RT} = \frac{PV}{RT} + \frac{PV}{RT}$$

(where P' is the pressure of the mixture.)
$\Rightarrow P' = 2P$

107. (b) $P_0 = \frac{1}{3}\frac{mnc^2}{V}$ and $P' = \frac{1}{3}\left(\frac{m}{2}\right) \times n \times (2c)^2 = 2P_0$.

108. (d)

$$1\,\text{eV} = \frac{3}{2}kT$$

or $1.6 \times 10^{-19} = \frac{3}{2} \times 1.38 \times 10^{-23}T$

$\therefore T = 7.7 \times 10^3$ K.

109. (d) Molar mass of the gas = 4g/mol
Speed of sound

$$V = \sqrt{\frac{\gamma RT}{m}} \Rightarrow 952 = \sqrt{\frac{\gamma \times 3.3 \times 273}{4 \times 10^{-3}}}$$

$$\Rightarrow \gamma = 1.6 = \frac{16}{10} = \frac{8}{5}$$

Also, $\gamma = \frac{C_P}{C_V} = \frac{8}{5}$

So, $C_P = \frac{8 \times 5}{5} = 8JK^{-1}mol^{-1}$ [$C_V = 5.0\,JK^{-1}$ given]

110. (a) From PV = nRT

$$P_A = \frac{\rho_A M_A}{RT} \text{ and } P_B = \frac{\rho_B M_B}{RT}$$

From question,

$$\frac{P_A}{P_B} = \frac{\rho_A}{\rho_B}\frac{M_A}{M_B} = 2\frac{M_A}{M_B} = \frac{3}{2}$$

So, $\frac{M_A}{M_B} = \frac{3}{4}$

111. (b) Let 'n' be the degree of freedom

$$\gamma = \frac{C_p}{C_v} = \frac{\left(\frac{n}{2}+1\right)R}{\left(\frac{n}{2}\right)R} = \left(1 + \frac{2}{n}\right)$$

112. (d) Both are diatomic gases and $C_p - C_v = R$ for all gases.

113. (a) $\frac{3}{2}k_BT = K_{av}$ ...(i)
where K_{av} is the average kinetic energy of the proton.

$$\therefore T = \frac{2K_{av}}{3k_B}$$

$$T = \frac{2 \times 4.14 \times 10^{-14}\,J}{3 \times 1.38 \times 10^{-23}JK^{-1}} = 2 \times 10^9 K.$$

114. (c) According to given problem
$(v_{rms})_{O_2} = (v_{rms})_{H_2}$

$$\sqrt{\frac{3RT_{O_2}}{M_{O_2}}} = \sqrt{\frac{3R(300)}{M_{H_2}}}$$

$$T_{O_2} = 300 \times \frac{M_{O_2}}{M_{H_2}} = 300 \times \frac{32}{2} = 4800\text{ K}$$

115. (d) $(c_{rms})_{H_2} = 1.84$ km/s, $(c_{rms})_{O_2} = ?$

$M_{H_2} = 2,\ M_{O_2} = 32$

$\Rightarrow$ Rms velocity,

$$c_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\therefore\ \frac{c_{H_2}}{c_{O_2}} = \sqrt{\frac{M_{O_2}}{M_{H_2}}}$$

$$\Rightarrow \frac{1.84}{C_{O_2}} = \sqrt{\frac{32}{2}} = 4$$

$$\Rightarrow C_{O_2} = \frac{1.84}{4} = 0.46\ \text{km/s}$$

116. (d) $E = \frac{3}{2} \times 300;\ E' = \frac{3}{2}R(600) = 2E = 2 \times 6.21 \times 10^{-21}$

$= 12.42 \times 10^{-21}$ J.

$$v_{rms} = \sqrt{\frac{3R \times 300}{M}};\ v'_{rms} = \sqrt{\frac{3R \times 600}{M}} = \sqrt{2}\ v_{rms}$$

$= 682.44$ m/s

117. (c) If a gas is heated at constant volume then no work is done. The heat supplied is given by

$dQ = nC_v dT$

But $C_v = \frac{f}{2}R$ where f is the degree of freedom of the gas

$$\therefore\ dQ = \frac{nfRdT}{2}$$

$$= \frac{2 \times 3 \times R \times (373 - 273)}{2} = 300\ R$$

118. (b) For 1kg gas energy, $E = \frac{f}{2}rT$

As $P = \rho rT$ therefore $rT = P/\rho$

$E = \frac{5}{2} \times \frac{8 \times 10^4}{4}$ [$f = 5$ for diatomic gas]

$E = 5 \times 10^4$ Joule.

119. (b) According to Mayer's relationship

$C_p - C_v = R$

$$\therefore\ \frac{C_p}{M} - \frac{C_v}{M} = \frac{R}{M}$$

Here M = 28.

120. (b)
$$\frac{n_1 + n_2}{\gamma - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}$$

or
$$\frac{2}{\gamma - 1} = \frac{1}{\frac{5}{3} - 1} + \frac{1}{\frac{7}{5} - 1}$$

$$\therefore\ \gamma = \frac{3}{2}.$$

121. (c) Molar specific heat at constant pressure $C_P = \frac{7}{2}R$

Since, $C_P - C_V = R \Rightarrow C_V - C_P - R = \frac{7}{2}R - R = \frac{5}{2}R$

$$\therefore\ \frac{C_P}{C_V} = \frac{(7/2)R}{(5/2)R} = \frac{7}{5}.$$

122. (a) $C_p - C_v = R \Rightarrow C_p = C_v + R$

$$\because\ \gamma = \frac{C_p}{C_v} = \frac{C_v + R}{C_v} = \frac{C_v}{C_v} + \frac{R}{C_v}$$

$$\Rightarrow \gamma = 1 + \frac{R}{C_v} \Rightarrow \frac{R}{C_v} = \gamma - 1 \Rightarrow C_v = \frac{R}{\gamma - 1}$$

123. (a) For mixture of gas,

$$C_v = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2}$$

$$= \frac{4 \times \frac{3}{2}R + \frac{1}{2} \times \frac{5}{2}R}{\left(4 + \frac{1}{2}\right)} = \frac{6R + \frac{5}{4}R}{\frac{9}{2}}$$

$$= \frac{29R \times 23}{9 \times 4} = \frac{29R}{18}$$

and
$$C_p = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{(n_1 + n_2)} = \frac{4 \times \frac{5R}{2} + \frac{1}{2} \times \frac{7R}{2}}{\left(4 + \frac{1}{2}\right)}$$

$$= \frac{10R + \frac{7}{4}R}{\frac{9}{2}} = \frac{47R}{18}$$

$$\therefore\ \frac{C_p}{C_v} = \frac{47R}{18} \times \frac{18}{29R} = 1.62$$

124. (b) $C_v = Mc_v = 4 \times 3 = 12$ J/mol-K

To doubling the pressure, the temperature will be doubled, so

$\Delta T = T_2 - T_1 = 273\ K$

Thus $Q = nC_v \Delta T = \frac{1}{2} \times 12 \times 273 = 1638$ J

125. (c) As no heat is lost,

Loss of kinetic energy = gain of internal energy of gas

$$\frac{1}{2}mv^2 = nC_V \Delta T \Rightarrow \frac{1}{2}mv^2 = \frac{m}{M} \cdot \frac{R}{\gamma - 1}\Delta T$$

$$\Rightarrow \Delta T = \frac{mv^2(\gamma - 1)}{2R}K$$

126. (a) As degree of freedom is defined as the number of independent variables required to define body's motion completely. Here f = 2(1 Translational + 1 Rotational).