THE GASEOUS STATE

IDEAL AND REAL GASES

Select the lettered item which best answers or completes each of the following :

1. Which two of the following are valid statements of Boyle's law ?
   (a) If the temperature of a given mass of gas is kept constant, its volume is inversely proportional to the pressure
   (b) $P_1V_1 = P_2V_2$
   (c) The volume of a gas sample is inversely proportional to the pressure, if the temperature is kept constant
   (d) $p/v = k$
   (e) $v = kp$

2. Which two of the following are valid statements of Charles Law ?
   (a) $\frac{V}{T} = k$
   (b) $V_1T_1 = V_2T_2$
   (c) the volume of a gas at constant pressure varies directly as the absolute temperature
   (d) the pressure of a gas varies directly as the absolute temperature

3. By what factor the pressure on a gas be decreased to triple the volume ?
   (a) 1/3 (b) 1/2
   (c) 3/1 (d) ¼

4. In the equation of state for an ideal gas, PV = nRT, the value of gas constant per degree per mole is
   (a) 0.0821 litre-atm (b) 8.314 Joules
   (c) 1.987 cals (d) all of these

5. By means of mercury vapour pump a vacuum of 10^{-7} mm Hg is obtained in a certain apparatus. Calculate the number of molecule which still remains in 1 cc. of the apparatus at 27ºC.
   (a) $\frac{\frac{10^{-7}}{760}\times\frac{1}{1000}}{0.0821\times300}\times6.0\times10^{23}$
   (b) $\frac{\frac{10^{-7}}{760}\times1}{0.0821\times300}\ 6.0\times10^{23}$
   (c) $\frac{\frac{10^{-7}}{760}\times1}{0.0821\times300}\times6.0\times10^{23}$
   (d) $\frac{\frac{10^{-7}}{760}\times\frac{1}{1000}}{1.987\times300}\times6.0\times10^{23}$

6. 1.35 g of phosphorus vapours occupy 500 ml at 300ºC and 750 mm of Hg pressure. What is the M.W. of phosphorus vapours ?
   (a) 62 (b) 31
   (c) 93 (d) 124

7. The density of a gas is found to be 2.07 g per litre at 30ºC and 2 atm, pressure. Its density at S.T.P. in grams per litre is
   (a) 4.14 (b) 1.15
   (c) 2.30 (d) 2.0

8. The density of a gas is 1.43 g/litre at S.T.P. At what temperature, its density is halved if pressure remains the same ?
   (a) 273ºC (b) 273 kelvin
   (c) 27ºC atom (d) none of these

9. The density of O_2 at 25ºC is 1.43 g/litre at 1 atm. Pressure. At what pressure will O_2 have a density twice this value ?
   Temperature is kept constant.
   (a) 1.5 atm (b) 3.0 atm
   (c) 2.0 atm (d) none of these

10. 2.8 g of N_2, 2.8 g of CO and 4.4 g of CO_2 are found to exert a pressure of 700 torr. The partial pressure of each gas in the mixture is
    (a) $\frac{1}{2}\times700$ (b) $\frac{1}{4}\times700$
    (c) $\frac{1}{3}\times700$ (d) none of these

11. A certain gas effuses through a small opening at a rate exactly one-fifth as great as helium. The M.W. of the gas is
    (a) 50 (b) 20
    (c) 100 (d) 200

12. How many formaldehyde molecules are there in a sample of gas which occupies 11.2 litres at S.T.P. ?
    (a) 6.0×10^{23} (b) 3.0×10^{23}
    (c) 1.5×10^{23} (d) none of these

13. A hydride of silicon (V.D. = 46.4) decomposes to give silicon and four times

its volume of hydrogen gas. The formula of hydride is
(a) SiH_4 (b) Si_2H_6
(c) Si_3H_8 (d) Si_4H_{10}

14. The product, PV, is a unit of
(a) entropy (b) force
(c) impulse (d) energy

15. Which of the following statements is false ?
(a) One mole of any gas contains a constant number of molecules ?
(a) At S.T.P. one mole of any gas occupies number of molecules
(c) Equal masses of the same gas at the same T & P occupy equal volumes
(d) Equal masses of different gases at the same T & P contain equal number of moles

16. 4.10 g of a gas contain at S.T.P. occupy 560 ml. Which of the following deductions is false ?
(a) The M.W. of the gas is 164
(b) The gas sample contains 1/40 of a mole
(c) If the temperature of this gas sample was held constant (at 0ºC) and the pressure is increased to 2.0 atm its density would be doubled
(d) Changing the volume of this gas sample, by altering the pressure or the temperature, would alter the number of moles present

17. 2.0 litres of O_2 at S.T.P. weigh 2.86 g which of the following conclusions is false ?
(a) The density of O_2 at S.T.P. is 1.43 g/litre
(b) The density of O_2 at 25ºC and 300 mm of Hg pressure is less than its density at S.T.P.
(c) The density of O_2 at 25ºC and 300 mm of Hg pressure is a greater than its density at S.T.P.
(d) none of these

18. A vessel initially at S.T.P. contains mixture of 0.70 g of CO and 1.4 g of N_2. Which of the following statements false ?
(a) There are in all 0.0575 moles of gas present
(b) If these gases were separated at constant J & P, the volume of would be twise that of CO
(c) The volume of the vessel is 1.12 litres
(d) If all the nitrogen were with drawn from the vessel and the temperature stayed constant at 0ºC, the pressure in the vessel would drop to 0.33 atm

19. The weaker inter-molecular forces of attraction due to induced-dipoles are called
(a) Ligancy forces
(b) H-bonding
(c) Vander Waal's forces
(d) Co-ordination forces

20. Assuming that at S.T.P. gas A has a density of 0.09 g per litre and gas B has a density of 1.43 g per litre, the relative rates of diffusion of gas A to that of gas B is
(a) 1 to 16 (b) 16 to 1
(c) 2 to 1 (d) 4 to 1

21. The rate of diffusion of H_2 is about
(a) one-half that of helium
(b) 1.41 times that of
(c) twice that of helium
(d) four times that of helium

22. The greatest amount of CO_2 can be dissolved in water under conditions of
(a) high T and high P
(b) high P and low T
(c) low P and low T
(d) low P and high T

23. A Dewar's flask is usually used to
(a) store liquid air
(b) measure the amount of liquid
(c) measure partial pressure of gas
(d) none

24. For a gas,
(a) the mean free path is very much larger than the molecular diameter
(b) the mean free path is less than the molecular diameter
(c) the mean free path is nearly equal to molecular diameter
(d) none of these

25. 0.3 grams of a volatile liquid, when vaporised in a Victor Mayer tube, displaced 40 ml of air at S.T.P. The M.W. was found to be
(a) 85 (b) 168
(c) 340 (d) 310

26. The weight in grams of nitrogen in 11.2 litres of NH_3 (at S.T.P.) is
(a) 7 (b) 8.5
(c) 14 (d) 3.5

27. One litre of gas, under standard conditions, weighs 1.16 grams. A possible formula for the gas is
(a) C_2H_2 (b) CO
(c) O_2 (d) NH_3

28. Two separate bulbs are filled with ideal gases A and B respectively. The density of gas A is three times that of gas B and the molecular weight of gas B is twice that of gas A. Calculate the ratio of the pressure of gas A to gas B if the gases are at the same temperature
(a) 3/2 (b) 2/3
(c) 6/1 (d) 1/6

29. Two samples of gases A and B are at the same temperature. The speed of molecules of A is 4 times that of molecules of A is 4 times that of molecules of B. The ratio of their masses (M_A/M_B) will be
(a) 16 (b) 4
(c) ¼ (d) 1.16

30. If 1000 ml of a gas A at 600 torr and 500 ml of gas B at 800 torr are placed in a 2 litre flask, the final pressure will be
(a) 500 torr (b) 1000 torr
(c) 850 torr (d) 2000 torr

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

32. Compute the weight of a gram molecular volume, 22.4 litres of air at S.T.P.
(a) 28.8 (b) $\frac{28.8}{22.4}$
(c) 28.8×22.4 (d) none of these

Hint and note on Lifting power of Ballons : A ballon will float in air when the weight of the object is less than the weight of the air the object displaces. The net lifting power of a balloon is the weight that must be added to make the balloon and its contents weigh exactly the same as an equal volume of air.

wt. of air displaced – wt. of balloon and its gas = lifting power

33. At S.T.P. 22.4 litres of H_2 weigh 2.0 g and its displaces 1 GMV of air or 28.8 g. The lifting power of a 22.4 litre balloon filled with H_2 at S.T.P. is
(a) 28.8 (b) 26.8
(c) 2.0 (d) none of these

34. A 100 litre balloon weighing 25 g is filled with He at S.T.P. How much additional weight it will lift ? One mole of helium (M.W. = 4) will lift 24.8 g (28.8 – 4 = 24.8)
(a) 111 (b) 25
(c) 86 (d) 4.47

35. A balloon of diameter 20 m weighs 100 kg. Calculate its pay-load if it is filled with He at 1.0 atm and 27ºC. Density of air is 1.2 kg m^{-3} ($R = 0.082\ dm^3\ atm\ k^{-1}\ mole^{-1}$)

Volume of balloon,

$$V = \frac{4}{3}\pi r^3 = \frac{4}{3} \times 3.14 \times 10^3 = 4.183 \times 10^3\ m^3$$

Mass of air displaced = (4.187×10^3) (1.22) = 5108 kg

Moles of gas present V = 4187 m^3,

P = 1 atm, T = 300 k

$$n = \frac{PV}{RT} = \frac{1 \times 4187 \times 10^3}{0.082 \times 300}$$

$= 171.3 \times 10^3$ moles

since the balloon is filled with He, mass of He = $171.3 \times 10^3 \times 4 = 685.2$ kg

Mass of balloon + Helium gas = 100 + 685.2 = 785.2 g

Pay load or net lift power = mass of air displaced = Total mass of balloon

= 5180 – 785.2

= 4322.8

36. The ratio of rates of diffusion of SO_2, O_2 and CH_4 is
(a) $1:\sqrt{2}:2$ (b) 1 : 2 : 4
(c) $2:\sqrt{2}:1$ (d) $1:2:\sqrt{2}$

37. A weather balloon filled with H_2 at 1 atm and 27ºC has volume equal to 12000 litres. On ascending it reaches a place when temperature is –23ºC and pressure is 0.5 atm. The volume of the balloon is (in litres)
(a) 24000 (b) 20000
(c) 10,000 (d) 12000

38. The pressure of mixture of equal weights of two gases of M.W. 4 and 40 is 1.1 atm. The partial pressure of the lighter gas is the mixture is
(a) 0.55 atm (b) 0.11 atm
(c) 1 atm (d) 0.1 atm

39. For a gas, maximum deviation from ideal gas behaviour is observed at
(a) 0ºC and 1.0 atm
(b) 100ºC and 2.0 atm
(c) –100ºC and 2.0 atm
(d) –100ºC and 5.0 atm

40. At 750 torr and 27ºC, 0.60 gram of a certain gas occupies 0.50 litre. Calculate its M.W.
(a) 30 (b) 60
(c) 90 (d) 120

41. If 12.0 g of N_2, 0.40 g of H_2 and 9.0 g of O_2 are put into a 1.0 litre container at 27ºC, what is the total pressure in the container ?
(a) 22.4 atm (b) 11.2 atm
(c) 44.8 atm (d) 5.6 atm

42. The S.I. units of the Vander Waal's constant b are
(a) m^3 mole (b) m^2 $mole^{-1}$
(c) m^3 $mole^{-1}$ (d) m^2 mole

43. The temperature of a sample of SO_2 is raised from 27 to 327ºC. The average K.E. of the gas molecules is
(a) doubled
(b) raised to power 2
(c) halved
(d) multiplied by a factor of 327/27

44. For one mole gas, the total K.E. is equal to
(a) RT (b) 3/2 RT
(c) 2/3 KT (d) $(C_p - C_v)RT$

45. For a given mass of gas, if pressure is reduced to half and temperature is doubled, then volume V will become
(a) 4V (b) $2V^2$
(c) V/4 (d) 8V

46. Gases deviate from the ideal gas behaviour because molecules
(a) are colourless
(b) attract each other
(c) contain covalent bonds
(d) show Brownian motion

47. Which set of conditions represents the easiest way to liquify a gas ?
(a) low T and high P
(b) low T and low P
(c) high T and high P
(d) high T and low P

48. Which molecular property tends to produce large deviations from ideal gas behaviour ?
(a) high molecular speed
(b) small molecular weight
(c) large molecular volume
(d) weak inter-molecular attraction

49. Vander Waal's constant "b" has units of volume (litres mole-1), the constant "a" is expressed in
(a) atm-$litre^2$/$mole^2$
(b) 1-atom/mole
(c) litre-atm/$mole^2$
(d) $litre^2$ – atm/mole

50. For a Vander Waal's fluid, a/b has the dimensions of
(a) atm per litre
(b) energy per $(litre)^2$
(c) energy per mole
(d) energy per degree per mole

51. At relatively high pressure, the Vander Waal's equation reduces to ($\frac{a}{V^2}$ is negligible compared to P)
(a) PV = RT – (a/v)
(b) PV = RT + Pb
(c) $P = RT - \left(\frac{a}{V^2}\right)$
(d) $PV = \frac{aRT}{V^2}$

52. At relative low pressure (b is negligible compared to v) and Vander Waal's Equation reduces to
(a) $PV = RT - \frac{a}{V}$
(b) PV = RT + Pb
(c) $P = RT - \frac{a}{V^2}$
(d) $PV = \frac{aRT}{V^2}$

53. At very low pressures
(a) $\frac{a}{V^2}$ approaches zero
(b) b is negligible compared to V
(c) Vander Waal's equation reduces to PV
(d) all the above

54. The translational energy of 1 mole of ideal gas at 25ºC is nearly
(a) 600 J (b) 1250 J
(c) 2500 J (d) 3750 J

55. Three molecules have velocities 100 msec[1], 200 $msec^{-1}$ and 300 $msec^{-1}$. The root mean square velocity is
(a) 190 $msec^{-1}$ (b) 200 $msec^{-1}$
(c) 216 $msec^{-1}$ (d) 400 $msec^{-1}$

56. Compared with molecular diameter, the mean free path is greater in the case of
(a) gases
(b) liquids
(c) solids
(d) Vander Waal's fluids

57. Calculate the average K.E. of gas molecules at 0ºC
(a) K.E. = $\frac{3}{2}\times\frac{R}{N}T$
(b) K.E. = $\frac{3}{2}kT$
(c) K.E. = $\frac{3}{2}\times\frac{8.31}{6.0\times10^{23}}\times273J$
(d) all of these

58. The r.m.s. velocity of H_2 molecules at 0ºC
(a) $C_{(r.m.s.)} = \sqrt{\frac{3RT}{M}}$
(b) $C_{rms} = \sqrt{\frac{3(8.31\times10^{7}\ ergs)\ 273}{2g}} cm\ s^{-1}$
(c) $\sqrt{\frac{3\times8.3\ J\times273}{2\times10^{-3}\ kg}}\ m\ sec^{-1}$
(d) all of these

59. The ratio of rates of effusion of H_2 and O_2 both at 0ºC and 1 atm pressure is
(a) 1 : 4 (b) 4 : 1
(c) 1 : 2 (d) 2 : 1

60. The ratio of rates of thermal diffusion of $^{238}U\ F_6$ to $^{235}U\ F_6$ is
(a) 10085 : 1 (b) 1 : 1.0085
(c) 2 : 3 (d) 2 : 1

61. According to Maxwell Boltzmann distribution law of gases, the average translational K.E. is
(a) 1/2 kT per molecule
(b) kT per molecule
(c) 3/2 kT per molecule
(d) RT per molecule

62. Which one of the following gases is most difficult to liquify ? Vander Waal's constant for He, Ne, H_2, N_2 is 0.341, 0.2107, 0.244 and 1.39 $\frac{litre^2-atm}{mole^2}$ respectively.
(a) He
(b) Ne
(c) H_2
(d) N_2

63. Which of the following gases is capable of being easily liquified ?
(a) C_2H_4
(b) CO_2
(c) NH_3
(d) H_2O

64. According to Maxwell Baltzmann law of distribution of molecular velocities, the curve in the graph shows that most molecules possess
(a) most probable velocities
(b) root mean square velocity
(c) average velocity
(d) none of these

65. The number of molecules in 1 c.c. of H_2 gas at S.T.P. is
(a) 2.68×10^{19}
(b) 1.12×10^{23}
(c) 6.0×10^{23}
(d) 1×10^{24}

66. The ratio of K.E. at 35ºC and 25ºC is
(a) 1.03
(b) 10
(c) 2
(d) none of these

67. At what temperature H_2 molecules have the same r.m.s. velocity as N_2 molecules have at 27ºC ?
(a) 21.4ºk
(b) 42.8ºk
(c) 10.7ºk
(d) 85.6ºk

68. The density of helium at 500ºC and 100 torr in grams per litre is
(a) 0.18
(b) 0.09
(c) 0.083
(d) none of these

69. 10 g of H_2 and 64 g of O_2 are contained in a 10 litre flask at 200ºC. Calculate the total pressure of the mixture

(a) 2.7 atm (b) 27 atm
(c) 13.5 atm (d) 0.23 atm

70. If a shark ignites the mixture (refer to Q. 69) what will be the fluid pressure ?
(a) 1.9 atm (b) 19 atm
(c) 9.5 atm (d) 0.19 atm

71. Equal weights of ethane and H_2 are mixed in an empty container at 25ºC. The fraction of total pressure exerted by H_2 is
(a) 1 : 2 (b) 1 : 1
(c) 1 : 16 (d) 15 : 16

72. The maximum possible number of hydrogen bonds in a water molecule can form is
(a) 2 (b) 4
(c) 3 (d) 1

73. At constant volume, for a fixed number of moles of gas the pressure of the gas increases with rise of temperature due to
(a) increase in average molecular speed
(b) increased rate of collisions amongst molecules
(c) increase in molecular attraction
(d) decrease in mean free path

74. According to kinetic theory of gases for a diatomic molecule
(a) the pressure exerted by the gas is proportional to the mean velocity of the molecules
(b) the pressure exerted by the gas is proportional to the r.m.s. velocity of the molecule
(c) the r.m.s. velocity of the molecules is inversely proportional to the temperature
(d) the mean translational K.E. of the molecule is proportional to the temperature

75. The density of neon will be highest at
(a) S.T.P (b) 0ºC, 2 atm
(c) 273ºC, 1 atm (d) 273ºC, 2atm

76. The rate of diffusion of CH_4 at a given temperature is twice that of a gas (x). The M.W. of gas (x) is
(a) 64.0 (b) 32.0
(c) 4.0 (d) 8.0

77. The value of Vander Waal's constant "a" for the gases O_2, N_2, NH_3 and CH_4 are 1.360, 1.390, 4.170 and 2.253 litre^2 atm mole^{-2} respectively. The gas which can be most easily liquified is
(a) O_2 (b) N_2
(c) NH_3 (d) CH_4

78. In Vander Waals equation of state for a non-ideal gas, the term that accounts for inter molecular attraction is
(a) (V – b) (b) RT
(c) $\left(P + \frac{a}{V^2}\right)$ (d) $[RT]^{-1}$

79. If a gas is expanded at constant temperature,
(a) the pressure decreases
(b) the K.E. of the molecules remains the same
(c) the K.E. of the molecules decrease
(d) the number of molecules of gas increases

80. When an ideal gas under gas unrestrained expansion, no cooling occurs because the molecules
(a) are above the inversion temperature
(b) exert no attractive force on each other
(c) do work equal to loss in K.E.
(d) collide without loss of energy

81. The average velocity of an ideal gas molecule at 27ºC is 0.3 m/sec. The average velocity at 927ºC will be
(a) 0.6 m/sec (b) 0.3 /sec
(c) 0.9 m/sec (d) 3.0 m/sec

82. Diagrams of distribution of velocities it can be concluded that
(a) increasing the temperature increases K.E. of the molecules
(b) a greater fraction of molecules would have higher velocities at higher temperature
(c) the fraction of molecules having velocities lower the most probable velocity decrease
(d) all of these

83. The kinetic energy of the molecules of a gas is
(a) directly proportional to the absolute temperature
(b) inversely proportional to the volume
(c) inversely proportional to the absolute temperature

84. The total average K.E. in kilo joules of 2 moles of an ideal gas at 127ºC is
(a) 8.33 (b) 24.94
(c) 7.48 (d) 9.98

85. The S.I. units of Vander Waal's constants "a" are
(a) Pa m^2 $mole^{-2}$ (b) Nm^6 $mole^{-2}$
(c) Jm^6 $mole^{-2}$ (d) Pa m^6 $mole^{-2}$

86. The specific heats at constant volume and constant pressure for a gas X are respectively 0.095 and 0.120 cals per gram. What is the M.W. of the gas ?
(a) 40 (b) 60
(c) 80 (d) 120

87. At what temperature would N_2 molecules have the same average speed as Helium molecules at 300ºK ?
(a) 2100 k (b) 1100 k
(c) 420 k (d) none of these

88. The most probable velocity of CO_2 molecules at 27ºC in cm per sec is
(a) 3.38×10^4 (b) 1.69×10^2
(c) 3.8×10^4 (d) 4.13×10^4

89. The ratio between the most probable velocity, average velocity and root mean square velocity is given by
(a) $\sqrt{2} : \frac{\sqrt{8}}{\pi} : \sqrt{3}$ (b) 1 : 2 : 3
(c) $\sqrt{2} : \sqrt{3} : \frac{\sqrt{8}}{\pi}$ (d) $1 : \frac{\sqrt{8}}{\pi} : \sqrt{3}$

90. The pressure of real gases is less than the pressure of an ideal gas because of
(a) increase in the number of collissions
(b) finite size of molecules
(c) increase in the K.E. of the molecules
(d) inter-molecular forces

91. The temperature at which a real gas obeys the ideal gas law over an appreciable range of pressure range is called the
(a) critical temperature
(b) inversion temperature
(c) Boyle's temperature
(d) reduced temperature

92. Real gases approach the behaviour of an ideal gas at
(a) lot T and high P
(b) high T and low P
(c) low T and low P
(d) high T and high P

93. For a reaction of the type A(g) $\rightleftharpoons$ B(b) + C(g), Calculate the degree of dissociation if 2.0 grams of A(M.W. = 60) exert a pressure of 8.40 atm. When vaporised in a 0.5 litre flask at 1000ºC
(a) 0.200
(b) 0.100
(c) 0.400
(d) 0.050

94. According to the equipartition principle, an energy of _____ per mole is associated with each term to describe the translation, rotational and vibrational energy of the molecules
(a) 1/2 kT (b) 1/2 RT
(c) 3/2 kT (d) 3/2 RT

95. When temperature is increased, the difference between most probable velocity of molecules of gas, r.m.s. velocity and average velocity
(a) increases
(b) decreases
(c) remains the same
(d) none of these

96. Average K.E. per molecules of an ideal gase at 0ºC is expressed by
(a) 3/2 kT (b) $\frac{3}{2} \times \frac{R}{N} T$
(c) $\frac{3}{2}\left(\frac{8.314}{6.0 \times 10^{23}}\right)(273)$ (d) all of these

97. Average K.E. of 8g of CH_4 (0.5 moles CH_4) at 0ºC is given by
(a) 3/2 nRT
(b) $3/2 \times 0.5 \times 8.31 \times 273$
(c) 1.7025 kJ
(d) all of these

98. At what temperature will H_2 molecules have the same r.m.s. speed as N_2 molecules at 35ºC ?
(a) 22 K (b) 11 K
(c) 35 K (d) 308 K

99. At room temperature, the translational energy of a mole of gas is about
(a) 1 cal (b) 2 cals
(c) 4 kJ (d) 8×10^7 ergs

100. In a mixture of H_2, He and Ne at 25°C, the molecules moving with the greatest speed are
(a) H_2
(b) He
(c) Ne
(d) all speeds are the same