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CHEMISTRY

TARGET : JEE Advanced - 2023

CAPS – 04
Gaseous State

SINGLE CHOICE QUESTIONS

1. Consider the following statements:

The coefficient B in the virial equation of state

$$PV_m = RT\left(1+\frac{B}{V_m}+\frac{C}{V_m^2}+......\right)$$

a: is independent of temperature

b: is equal to zero at Boyle temperature

c: has the dimension of molar volume

Which of the above statements are correct?

(A) a and b (B) a and c (C) b and c (D) a, b and c

2. The pressure of real gas is

(A) always greater than the pressure if it was an ideal gas

(B) generally less than the pressure if it was an ideal gas

(C) directly proportional to the intermolecular forces of attraction

(D) governed by Boyles law if temperature is fixed for a particular amount of the gas

3. The density of vapour of a substance (X) at 1 atm pressure and 500 K is 0.8 kg/m3. The vapour effuses through a small hole at a rate of 4/5 times slower than oxygen under the same condition. What is the compressibility factor (Z) of the vapour?

(A) 0.974 (B) 1.35 (C) 1.52 (D) 1.22

4. The number of effusion steps required to convert a mixture of H_2 and O_2 from 240 : 1600 (by mass) to 3072 : 20 (by mass) is

(A) 2 (B) 4 (C) 5 (D) 6

5. Correct option regarding a container containing 1 mol of a gas in 22.4 litre container at 273 K is

(A) If compressibility factor (z) > 1 then 'P' will be less than 1 atm.

(B) If compressibility factor (z) > 1 then 'P' will be greater than 1 atm.

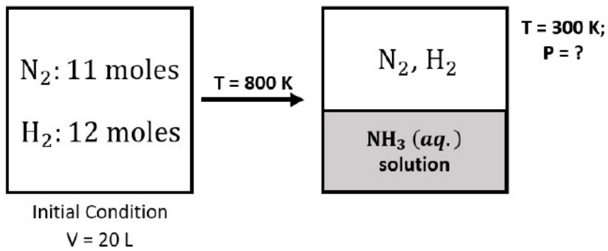
(C) If 'b' dominates, pressure will be less than 1 atm.

(D) If 'a' dominates, pressure will be greater than 1 atm.

6. 11 moles N_2 and 12 moles of H_2 mixture reacted in 20 litre vessel at 800 K. After equilibrium was reached, 6 mole of H_2 was present. 3.58 litre of liquid water is injected in equilibrium mixture and resultant gaseous mixture suddenly cooled to 300 K. What is the final pressure of gaseous mixture? Negative vapour pressure of liquid solution. Assume

(i) all NH_3 dissolved in water. (ii) no change in volume of liquid.

(iii) no reaction of N_2 and H_2 at 300.

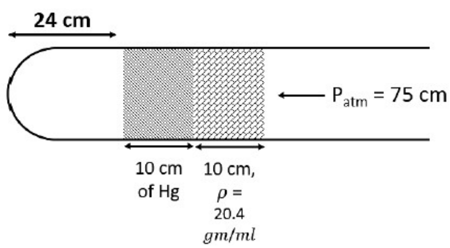


(A) 18.47 atm (B) 60 atm (C) 22.5 atm (D) 45 atm

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

(A) 80 (B) 257 (C) 255 (D) 256

8.

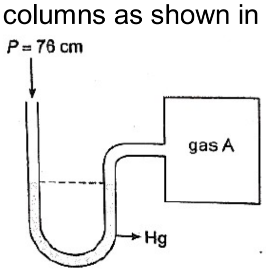


If above tube is placed vertically with the open end upward then the length of the air column will be (assume temperature remains constant)

(A) 20 cm (B) 36 cm (C) 18 cm (D) 15 cm

MULTIPLE CHOICE QUESTIONS

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



After sparking 'A' dissociates according to following reaction

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

If pressure of Gas "A" decreases to 0.9 atm, then (Assume temperature to the constant and is 300 K)

(A) total pressure increases to 1.3 atm

(B) total pressure increases by 0.3 atm

(C) total pressure increases by 22.3 cm of Hg

(D) difference in mercury level is 228 mm.

COMPREHENSION # 1 (FOR Q. 10 TO Q. 12)

The rate of change of pressure (p) of a gas at constant temperature and constant external pressure due to effusion of gas from a vessel of constant volume is related to rate of change of number of molecules present by

$$\frac{dp}{dt} = \frac{kT}{V}\frac{dN}{dt}$$

where k = Boltzmann constant, T = temperature, V = volume of vessel & N = No. of molecules and $\frac{dN}{dt} = \frac{-PA_0}{(2\pi mkT)^{1/2}}$ where A0 = area of orifice and m = mass of molecule.

10. Time required for pressure inside vessel to reduce to 1/e of its initial value in (ln e = 1)

(A) $\left(\frac{2\pi m}{kT}\right)^{1/2}\frac{V}{A_0}$ (B) $\left(\frac{kT}{2\pi m}\right)^{1/2}\frac{V}{A_0}$

(C) $\left(\frac{2\pi mkT}{A_0}\right)^{1/2}$ (D) $\frac{2\pi m}{kT}\frac{V}{A_0}$

11. If the gas inside the vessel had molecular weight 9 times the gas in previous example and area of orifice was doubled and temperature maintained at 4T, time required for pressure to fall to 1/e times of its initial value would be (t = answer of previous option)

(A) 1.33 t (B) 4.24 t (C) 0.75 t (D) 1.125 t

12. The incorrect statement (s) is/are.

[I] Pressure will not fall to zero in infinite time.

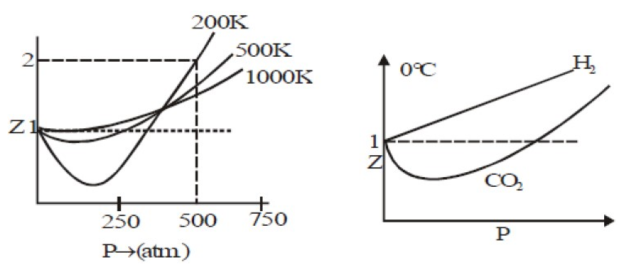
[II] Time required for pressure to decrease to half its initial value is independent of initial pressure.

[III] The relations given above are true for real gases also.

(A) I (B) II (C) III (D) I and III

COMPREHENSION # 2 (FOR Q.13 TO Q.14)

Sketch shows the plot of Z v/s P for a hypothetical gas for one mole at three distinct temperature.



Boyle's temperature is the temperature at which a gas shows ideal behavior over a pressure range in the low-pressure region. Boyle's temperature $(T_b) = \frac{a}{Rb}$. If a plot is obtained at temperatures well below Boyle's temperature then the curve will show negative deviation, in low pressure region and positive deviation in the high-pressure region. Near critical temperature the curve is more likely as CO_2 and the temperature well above critical temperature curve is more like H_2 at 0°C as shown above. At high pressure suppose all the constant temperature curve varies linearly with pressure according to the following equation

$$Z = 1 + \frac{Pb}{RT}\left(R = 2\text{cal mol}^{-1}\text{K}^{-1}\right)$$

13. For 500 K plot value of Z changes from 2 to 2.2 if pressure is varied from 1000 atm to 1200 atm (high pressure) then the value of $\frac{b}{RT}$ will be

(A) 10^{-3} atm^{-1} (B) 2 x 10^{-3} atm^{-1} (C) 5 x 10^{-4} atm^{-1} (D) 10^{-4} atm^{-1}

14. In very high-pressure region if Z v/s P is plotted at 1200 K for the above gas then it will have greatest slope.

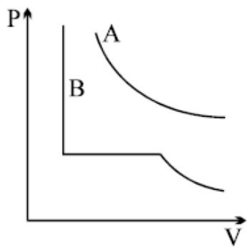
(A) true (B) false

(C) can't say (D) not related to the paragraph

COMPREHENSION # 3 (FOR Q.15 TO Q.16)

For two gases A and B, P v/s V isotherms are drawn at T K as shown.

TA & TB are critical temperatures of A & B respectively



15. Which of following is true?

(A) TA < T < TB (B) TA > T > TB (C) TA > TB > T (D) none of above

16. The correct statement(s) is/are

(I) Pressure correction term will be more negligible for gas B at T K.

(II) The curve for gas 'B' will be of same shape as for gas A if T > TB

(III) Gas 'A' will show same P v/s V curve as of gas 'B' if T > TA

(A) III only (B) II and III (C) II only (D) All

NUMERIC ANSWER TYPE

17. Pure O_2 diffuses through an aperture in 224 sec, whereas mixture of O_2 and another gas containing 80% O_2 diffuses from the same in 234 sec. What is molecular weight of the gas.

18. The compressibility factor for N_2 at –50°C and 800 atm pressure is 1.95 and at 100°C and 200 atm, it is 1.10. A certain mass of nitrogen occupied one litre at –50°C and 800 atm. Calculate the volume occupied by the same quantity of N_2 at 100°C and 200 atm.

19. During one of his adventure, Chacha chaudhary got trapped in an underground cave which was sealed two hundred year back. The air inside the cave was poisonous, having some amount of carbon monoxide in addition to O_2 and N_2. 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 filled his lung with cave air and exhaled it out in the surroundings. In the mean-time fresh air from surrounding effused into the cave till the pressure was again one atmosphere. Each time sabu sucked out some air, the pressure in the cave dropped to half of its initial value of one atmosphere.

If the initial sample of air from the cave contain 5% by volume CO.

If the safe level of CO in the atmosphere is less than 0.001% by volume how many times does Sabu need to such out air to save Chacha choudhary.

20. A closed vertical cylinder is divided into two parts by a frictionless piston, each part contains 1 mole of air. At 27°C the volume of the upper part is 4 times than that of the lower part. Calculate the temperature when volume of the upper part will be three times that of the lower part.

21. Calculate the volume occupied by 14.0 g N_2 at 200 K and 8.21 atm pressure if $\frac{P_cV_c}{RT_c} = \frac{3}{8}$ and $\frac{P_rV_r}{T_r} = 2.2$

22. While resting, the average human male use 0.2 dm3 of O_2 per hour at STP for each kg of body mass. Assume that all this O_2 is used to produce energy by oxidising glucose in the body. What is the mass of glucose required per hour by a resting male having mass 60 kg. What volume, at STP of CO_2 would be produced.

23. At 27°C, hydrogen is leaked through a tiny hole into a vessel for 20 min. Another unknown gas at the same T & P as that of H_2, is leaked through the same hole for 20 min. After the effusion of the gases the mixture exerts a pressure of 6 atm. The hydrogen content of the mixture is 0.7 mole. If the volume of the container is 3 litre, what is molecular weight of unknown gas. (Use R = 0.0821 L atm K^{-1} $mole^{-1}$)

24. Find the number of diffusion steps required to separate the isotopic mixture initially containing some amount of H_2 gas and 1 mol of D_2 gas in a container of 3 lit capacity maintained at 24.6 atm & 27 °C to the final mass ratio D_2 and H_2 gas is 1 : 4.

25. One mole of an ideal gas is subjected to a process in which $P = \frac{V}{8.21}$ where P is in atm & V in litre. If the process is operating from 1 atm to finally 10 atm (no higher pressure achieved during the process) then what would be the maximum temperature obtained & at what instant will it occur in the process.

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

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

27. Match the columns

	Column-I		**Column-II**
(A)	$P_1V_1 = P_2V_2 = P_3V_3 = ...$	(p)	Dalton's law of partial pressures at constant temperature.
(B)	$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3}$ = at constant pressure.	(q)	Kinetic equation of ideal gases
(C)	$r \propto \sqrt{\frac{l}{d}}$	(r)	22.4 litre
(D)	$P = P_1 + P_2 + P_3 + ...$	(s)	Isotherm

(E) $(V-b)\left(P+\frac{a}{V^2}\right)=RT$	(t) Isobar
(F) R/N	(u) Charles' law
(G) Molar volume	(v) Graham's law
(H) $KE=\frac{3}{2}RT$	(w) Boyle's law
(I) Graph between P and V at constant temperature	(x) Equation for real gases
(J) Graph between V and T at constantpressure.	(y) Boltzmann's constant

(A) (A) – w, (B) – u, (C) – v, (D) – p, (E) – x, (F) – y, (G) – r, (H) – q, (I) – s, (J) – t

(B) (A) – p, (B) – q, (C) – r, (D) – s, (E) – t, (F) – u, (G) – v, (H) – w, (I) – x, (J) – y

(C) (A) – v, (B) – w, (C) – x, (D) – y, (E) – p, (F) – q, (G) – r, (H) – s, (I) – t, (J) – u

(D) (A) – y, (B) – x, (C) – w, (D) – v, (E) – u, (F) – t, (G) – s, (H) – r, (I) – q, (J) – p

SUBJECTIVE ANSWER TYPE

28. A gas present in a container connected to frictionless, weightless piston operating always at one atmosphere pressure such that it permits flow of gas outside (with no adding of gas). The graph of n vs T (Kelvin) was plotted & was found to be a straight line with coordinates of extreme points as (300, 2) & (200, 3). Calculate:

(i) relationship between n & T

(ii) relationship between V & T

(iii) Maxima or minima value of 'V'

29. Find the critical constant (P_c, V_c and T_c) in terms of A and B, also find compressibility factor (z) for the following equation of state.

$$PV = RT - \frac{A}{V} + \frac{2B}{V^2}$$

where A and B are constant, P = pressure and V = molar volume.

30. A 50 litre vessel is equally divided into three parts with the help of two stationary semi permeable membrane (SPM). The vessel contains 60 g H_2 gas in the left chamber, 160 g O_2 in the middle & 140 g N_2 in the right one. The left SPM allows transfer of only H_2 gas while the right one allows the transfer of both H_2 & N_2. Calculate the final ratio of pressure in the three chambers.