IDEAL GAS

1. The volume occupied by 4.75 g of acetylene gas at 50°C and 740 mmHg pressure is _____ L. (Rounded off to the nearest integer)
[Given R = 0.0826 L atm K^{-1} mol^{-1}]

2. A car tyre is filled with nitrogen gas at 35 psi at 27°C. It will burst if pressure exceeds 40 psi. The temperature in °C at which the car tyre will burst is _______. (Rounded-off to the nearest integer)

3. Five moles of an ideal gas at 293 K is expanded isothermally from an initial pressure of 2.1 MPa to 1.3 MPa against at constant external pressure 4.3 MPa. The heat transferred in this process is _______ kJ mol^{-1}. (Rounded-off to the nearest integer) [Use R = 8.314 J $mol^{-1}K^{-1}$]

4. A certain gas obeys $P(V_m - b) = RT$. The value of $\left(\frac{\partial Z}{\partial P}\right)_T$ is $\frac{xb}{RT}$. The value of x is_____.
(Integer answer) (Z : compressibility factor)

5. The pressure exerted by a non-reactive gaseous mixture of 6.4 g of methane and 8.8 g of carbon dioxide in a 10 L vessel at 27°C is _______ kPa.
(Round off to the Nearest Integer).
[Assume gases are ideal, R = 8.314 J mol^{-1} K^{-1}
Atomic masses : C : 12.0 u, H : 1.0 u, O : 16.0 u]

6. At 20°C, the vapour pressure of benzene is 70 torr and that of methyl benzene is 20 torr. The mole fraction of benzene in the vapour phase at 20°C above an equimolar mixture of benzene and methyl benzene is ________ $\times 10^{-2}$. (Nearest integer)

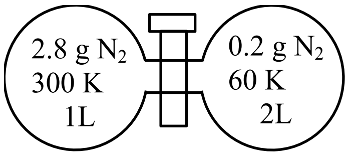
7. The vapour pressures of A and B at 25°C are 90 mm Hg and 15 mm Hg respectively. If A and B are mixed such that the mole fraction of A in the mixture is 0.6, then the mole fraction of B in the vapour phase is $x \times 10^{-1}$. The value of x is ______. (Nearest integer)

8. An LPG cylinder contains gas at a pressure of 300 kPa at 27°C. The cylinder can withstand the pressure of 1.2×10^6 Pa. The room in which the cylinder is kept catches fire. The minimum temperature at which the bursting of cylinder will take place is _________ °C. (Nearest integer)

9. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
The above reaction is carried out in a vessel starting with partial pressur $P_{SO_2} = 250\,m\,bar$, $P_{O_2} = 750m$ bar and $P_{SO_3} = 0$ bar. When the reaction is complete, the total pressure in the reaction vessel is _____ m bar. (Round off of the nearest integer).
$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

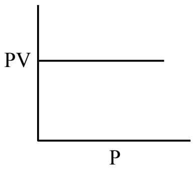
10. The unit of the van der Waals gas equation parameter 'a' in $\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$ is :
(1) kg m s^{-2} (2) dm^3 mol^{-1}
(3) kg m s^{-1} (4) atm dm^6 mol^{-2}

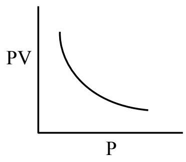
11. Two flasks I and II shown below are connected by a valve of negligible volume.

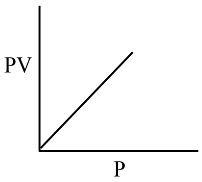


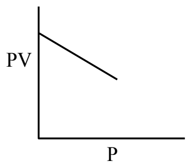
When the valve is opened, the final pressure of the system in bar is $x \times 10^{-2}$. The value of x is ______. (Integer answer)
[Assume–Ideal gas; 1 bar = 10^5 Pa; Molar mass of N_2 = 28.0 g mol^{-1}; R = 8.31 J $mol^{-1}K^{-1}$]

12. Which one of the following is the correct PV vs P plot at constant temperature for an ideal gas ? (P and V stand for pressure and volume of the gas respectively)

(1) 

(2) 

(3) 

(4) 

13. An empty LPG cylinder weighs 14.8 kg. When full, it weighs 29.0 kg and shows a pressure of 3.47 atm. In the course of use at ambient temperature, the mass of the cylinder is reduced to 23.0 kg. The final pressure inside of the cylinder is ______atm. (Nearest integer)

(Assume LPG of be an ideal gas)

SOLUTION

1. Official Ans. by NTA (5)

Sol. Given Mass = 4.75 g $\Rightarrow C_2H_2(g)$

$$\Rightarrow \text{Moles} = \frac{4.75}{26} \text{ mol}$$

Temp = 50 + 273 = 323 K

$$P = \frac{740}{760} \text{atm}$$

$$R = 0.0826 \frac{\ell \text{ atm}}{\text{mol K}}$$

$$\Rightarrow \quad V = \frac{nRT}{P} = \frac{4.75}{26} \times \frac{0.0826 \times 323}{\left(\frac{740}{760}\right)}$$

$$\Rightarrow \quad V = \frac{96314.078}{19240} = 5.0059\ell \simeq 5\ell$$

2. Official Ans. by NTA (70)

Sol. $P \propto T$

$$\frac{P_2}{P_1} = \frac{T_2}{T_1} \Rightarrow \frac{40}{35} = \frac{T_2}{300}$$

$T_2 = 342.854$ K

$= 69.70°C \simeq 70°C$

Hence answer is (70)

3. Official Ans. by NTA (15)

Sol. n = 5, T = 293K = const, $\Delta U = 0$,

$P_1 = 2.1$ MPa, $P_2 = 1.3$ MPa

$P_{ext} = 4.3$ MPa = const.

$$W = -P_{ext}(V_2 - V_1) = -P_{ext}\left(\frac{nRT}{P_2} - \frac{nRT}{P_1}\right)$$

$$\text{or, } W = -P_{ext}\, nRT\left(\frac{1}{P_2} - \frac{1}{P_1}\right)$$

$$= -4.3 \times 5 \times 8.314 \times 293\left(\frac{1}{1.3} - \frac{1}{2.1}\right)$$

$$= -4.3 \times 5 \times 8.314 \times 293\left(\frac{2.1-1.3}{1.3\times2.1}\right)$$

$$= -15347.7\text{J}$$

or, W = –15.35 kJ

$\Delta U^0 = q + W$

$\therefore\ q = -W$

or, q = 15.35 kJ (for 5 moles)

$$\therefore\ q/\text{mole} = \frac{15.35}{5} = 3\text{kJ mol}^{-1}$$

4. Official Ans. by NTA (1)

Sol. $Z = 1 + \frac{Pb}{RT}$

$$\left(\frac{\partial Z}{dP}\right)_T = 0 + \frac{b}{RT} \times 1$$

5. Official Ans. by NTA (150)

Sol. Total moles of gases, $n = n_{CH_4} + n_{CO_2}$

$$= \frac{6.4}{16} + \frac{8.8}{44} = 0.6$$

$$\text{Now, } P = \frac{nRT}{V} = \frac{0.6 \times 8.314 \times 300}{10 \times 10^{-3}}$$

$= 1.49652 \times 10^5$ Pa = 149.652 kPa

≈ 150 kPa

6. Official Ans. by NTA (78)

Sol. $P_B^o = 40$ $\quad P_T^o = 20$ $\quad K_B = 0.5 = K_T$

$$\text{Now} \quad y_B = \frac{K_B P_B^o}{K_B P_B^o + K_T P_T^o}$$

$$= \frac{70 \times 0.5}{70 \times 0.5 + 20 \times 0.5}$$

7. Official Ans. by NTA (1)

Sol. Given $P_A° = 90$ mm Hg, at 25°C

$P_B° = 15$ mm Hg

$$\text{and} \quad \left.\begin{matrix} X_A = 0.6 \\ X_B = 0.4 \end{matrix}\right\} P_T = X_A P_A^o + X_B P_B^o$$

$= (0.6 \times 90) + (0.4 \times 15)$

$= 54 + 6 = 60$ mm

Now mol fraction of B in the vapour phase

$$\text{i.e.} \quad Y_B = \frac{P_B}{P_T} = \frac{X_B P_B^o}{60} = 0.1 = 1 \times 10^{-1}$$

therefore: x = 1

8. Official Ans. by NTA (927)

Sol. $\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow \frac{300 \times 10^3}{300} = \frac{1.2 \times 10^6}{T_2}$

$\Rightarrow$ $T_2 = 1200$ K

$T_2 = 927°C$

9. Official Ans. by NTA (875)

Sol.	$2SO_2\,(g)$ +	$O_2\,(g)$ $\rightarrow$	$2SO_3\,(g)$
Initial	250 m bar (L. R.)	750 m bar	O
Final	–250 m bar	– 125 m bar	250 m bar
	0	625 m bar	250 m bar

$\therefore$ Final total pressure = 625 + 250 = 875 m bar

10. Official Ans. by NTA (4)

Sol. $\frac{an^2}{V^2} = \text{atm} \Rightarrow a = \text{atm} \times \frac{\text{dm}^6}{\text{mol}^2}$

11. Official Ans. by NTA (84)

Sol. Applying ; $(n_I + n_{II})_{initial} = (n_I + n_{II})_{final}$

$\Rightarrow$ Assuming the system attains a final temperature of T (such that 300 < T < 60)

$$\Rightarrow \begin{pmatrix} \text{Heat lost by} \\ N_2 \text{ of container} \\ \text{I} \end{pmatrix} = \begin{pmatrix} \text{Heat gained by} \\ N_2 \text{ of container} \\ \text{II} \end{pmatrix}$$

$\Rightarrow n_I C_m (300–T) = n_{II} C_m (T–60)$

$$\Rightarrow \left(\frac{2.8}{28}\right)(300 - T) = \frac{0.2}{28}(T - 60)$$

$\Rightarrow$ 14(300–T) = T–60

$$\Rightarrow \frac{(14 \times 300 + 60)}{15} = T$$

$\Rightarrow$ T = 284 K (final temperature)

$\Rightarrow$ If the final pressure = P

$$\Rightarrow (n_I + n_{II})_{final} = \left(\frac{3.0}{28}\right)$$

$$\Rightarrow \frac{P}{RT}(V_I + V_{II}) = \frac{3.0\text{gm}}{28\text{gm / mol}}$$

$$P = \left(\frac{3}{28}\text{mol}\right) \times 8.31 \frac{J}{\text{mol} - K} \times \frac{284K}{3 \times 10^{-3} m^3} \times 10^{-5} \frac{\text{bar}}{\text{Pa}}$$

$\Rightarrow$ 0.84287 bar

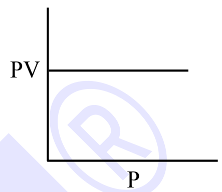
$\Rightarrow 84.28 \times 10^{-2}$ bar

$\Rightarrow$ 84

12. Official Ans. by NTA (1)

Sol. PV = nRT (n,T constant)

PV = constant



13. Official Ans. by NTA (2)

Sol. Initial mass of gas = 29 –14.8 = 14.2 Kg

mass of gas used = 29 –23 = 6 Kg

gas left = 14.2 – 6 = 8.2 Kg

$$(1)\ 3.47 \times V = \left(\frac{14.2 \times 10^3}{M}\right) \times R \times T$$

$$(2)\ p \times V = \left(\frac{8.2 \times 10^3}{M}\right) \times R \times T$$

Divide :

$$\frac{(1)}{(2)} \Rightarrow \frac{3.47}{P} = \frac{14.2}{8.2}$$

P = 2.003