

## Kinetic Theory of Gases

 Self Evaluation Test -13

1. An ideal gas has an initial pressure of 3 pressure units and an initial volume of 4 volume units. The table gives the final pressure and volume of the gas (in those same units) in four, processes. Which processes start and end on the same isotherm

- (a) A  
(b) B  
(c) C  
(d) D

	A	B	C	D
P	5	4	12	6
V	7	6	1	3

2. Suppose ideal gas equation follows  $VP^3 = \text{constant}$ . Initial temperature and volume of the gas are  $T$  and  $V$  respectively. If gas expand to  $27V$  then its temperature will be come

- (a)  $T$  (b)  $9T$   
(c)  $27T$  (d)  $T/9$

3. One mole of a monoatomic ideal gas is mixed with one mole of a diatomic ideal gas. The molar specific heat of the mixture at constant volume is

- (a) 8 (b)  $\frac{3}{2}R$   
(c)  $2R$  (d)  $2.5R$

4. When the temperature of a gas is raised from  $27^\circ\text{C}$  to  $90^\circ\text{C}$ , the percentage increase in the *r.m.s.* velocity of the molecules will be

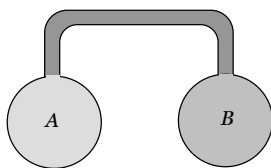
- (a) 10% (b) 15%  
(c) 20% (d) 17.5%

5. A gas is enclosed in a closed pot. On keeping this pot in a train moving with high speed, the temperature of the gas

- (a) Will increase  
(b) Will decrease  
(c) Will remain the same  
(d) Will change according to the nature of the gas

6. Two spherical vessel of equal volume, are connected by a narrow tube. The apparatus contains an ideal gas at one atmosphere and  $300\text{K}$ . Now if one vessel is immersed in a bath of constant temperature  $600\text{K}$  and the other in a bath of constant temperature  $300\text{K}$ . Then the common pressure will be

- (a) 1 atm  
(b)  $\frac{4}{5}$  atm  
(c)  $\frac{4}{3}$  atm  
(d)  $\frac{3}{4}$  atm



7. The *r.m.s.* velocity of a gas at a certain temperature is  $\sqrt{2}$  times than that of the oxygen molecules at that temperature. The gas can be

- (a)  $H_2$  (b) He  
(c)  $CH_4$  (d)  $SO_2$

8. At what temperature, the mean kinetic energy of  $O_2$  will be the same for  $H_2$  molecules at  $-73^\circ\text{C}$

- (a)  $127^\circ\text{C}$  (b)  $527^\circ\text{C}$   
(c)  $-73^\circ\text{C}$  (d)  $-173^\circ\text{C}$

9. The volume of a gas at pressure  $21 \times 10^4 \text{ N/m}^2$  and temperature  $27^\circ\text{C}$  is 83 litres. If  $R = 8.3 \text{ J/mol/K}$ , then the quantity of gas in *gm-mole* will be

- (a) 15 (b) 42  
(c) 7 (d) 14

10. The pressure and temperature of an ideal gas in a closed vessel are  $720 \text{ kPa}$  and  $40^\circ\text{C}$  respectively. If  $\frac{1}{4}$ th of the

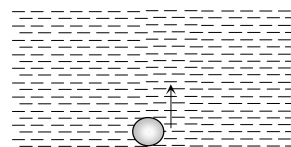
gas is released from the vessel and the temperature of the remaining gas is raised to  $353^\circ\text{C}$ , the final pressure of the gas is

[EAMCET (Med.) 2000]

- (a)  $1440 \text{ kPa}$  (b)  $1080 \text{ kPa}$   
(c)  $720 \text{ kPa}$  (d)  $540 \text{ kPa}$

11. An air bubble doubles its radius on raising from the bottom of water reservoir to be the surface of water in it. If the atmospheric pressure is equal to 10 m of water, the height of water in the reservoir is

- (a) 10 m  
(b) 20 m  
(c) 70 m  
(d) 80 m



12. If the *r.m.s.* velocity of a gas at a given temperature (Kelvin scale) is  $300 \text{ m/sec}$ . What will be the *r.m.s.* velocity of a gas having twice the molecular weight and half the temperature on Kelvin scale =

- (a)  $300 \text{ m/sec}$  (b)  $600 \text{ m/sec}$   
(c)  $75 \text{ m/sec}$  (d)  $150 \text{ m/sec}$

13. The ratio of two specific heats  $\frac{C_p}{C_v}$  of CO is

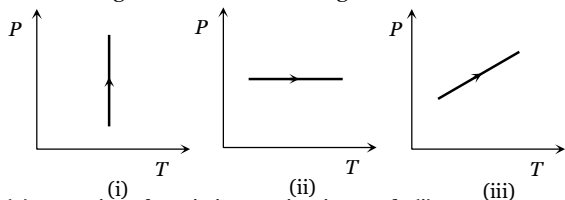
- (a) 1.33 (b) 1.40  
(c) 1.29 (d) 1.66

14. The energy of a gas/litre is 300 joules, then its pressure will be

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- (a)  $3 \times 10^5 \text{ N/m}^2$       (b)  $6 \times 10^5 \text{ N/m}^2$   
 (c)  $10^5 \text{ N/m}^2$       (d)  $2 \times 10^5 \text{ N/m}^2$

15. Pressure versus temperature graphs of an ideal gas are as shown in figure. Choose the wrong statement



- (a) Density of gas is increasing in graph (i)  
 (b) Density of gas is decreasing in graph (ii)  
 (c) Density of gas is constant in graph (iii)  
 (d) None of these

16. If pressure of  $\text{CO}_2$  (real gas) in a container is given by

$$P = \frac{RT}{2V-b} - \frac{a}{4b^2}$$

- (a) 11 gm      (b) 22 gm  
 (c) 33 gm      (d) 44 gm

17. A cylinder of fixed capacity 44.8 litre. contains a monatomic gas at standard temperature and pressure. The amount of heat required to cylinder by  $10^\circ\text{C}$  will be.

( $R$  = universal gas constant)

- (a)  $R$       (b)  $10R$   
 (c)  $20R$       (d)  $30R$

18. A pressure cooker contains air at 1 atm and  $30^\circ\text{C}$ . If the safety value of the cooler blows when the inside pressure  $\geq 3 \text{ atm}$ , then the maximum temperature of the air, inside the cooker can be

- (a)  $90^\circ\text{C}$       (b)  $636^\circ\text{C}$   
 (c)  $909^\circ\text{C}$       (d)  $363^\circ\text{C}$

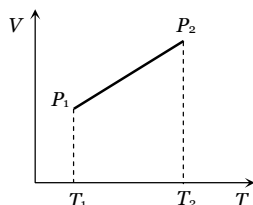
19. One mole of an ideal monatomic gas requires 210 J heat to raise the temperature by 10 K, when heated at constant temperature. If the same gas is heated at constant volume to raise the temperature by 10 K then heat required is

[Pb. PET 2000]

- (a) 238 J      (b) 126 J  
 (c) 210 J      (d) 350 J

20. From the following  $V$ - $T$  diagram we can conclude

- (a)  $P_1 = P_2$   
 (b)  $P_1 > P_2$   
 (c)  $P_1 < P_2$   
 (d) None of these



21. A cylinder contains 10 kg of gas at pressure of  $10^7 \text{ N/m}^2$ . The quantity of gas taken out of the cylinder,

if final pressure is  $2.5 \times 10^6 \text{ N/m}^2$ , will be (Temperature of gas is constant)

[EAMCET 1998; Pb. PMT 1999; 2003; DPMT 199, 2003]

- (a) 15.2 kg      (b) 3.7 kg  
 (c) Zero      (d) 7.5 kg

22. Certain amount of an ideal gas are contained in a closed vessel. The vessel is moving with a constant velocity  $v$ . The molecular mass of gas is  $M$ . The rise in temperature of the gas when the vessel is suddenly stopped is ( $\gamma = C_p / C_v$ )

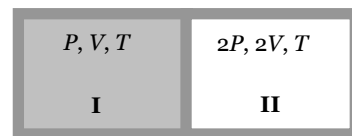
- (a)  $\frac{Mv^2}{2R(\gamma+1)}$       (b)  $\frac{Mv^2(\gamma-1)}{2R}$   
 (c)  $\frac{Mv^2}{2R(\gamma+1)}$       (d)  $\frac{Mv^2}{2R(\gamma+1)}$

23. Air is filled at  $60^\circ\text{C}$  in a vessel of open mouth. The vessel is heated to a temperature  $T$  so that  $1/4$ th part of air escapes. Assuming the volume of the vessel remaining constant, the value of  $T$  is [MP PET 1996, 99]

- (a)  $80^\circ\text{C}$       (b)  $444^\circ\text{C}$   
 (c)  $333^\circ\text{C}$       (d)  $171^\circ\text{C}$

24. A partition divides a container having insulated walls into two compartments I and II. the same gas fills the two compartments. The ratio of the number of molecules in compartments I and II is

- (a) 1 : 6  
 (b) 6 : 1  
 (c) 4 : 1  
 (d) 1 : 4



25. Considering the gases to be ideal, the value of  $\gamma = \frac{C_p}{C_v}$  for a gaseous mixture consisting of = 3 moles of carbon dioxide and 2 moles of oxygen will be ( $\gamma_{\text{O}_2} = 1.4, \gamma_{\text{CO}_2} = 1.3$ )

[UPSEAT 2000; Pb. PET 2004]

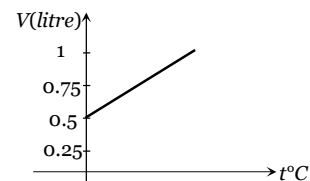
- (a) 1.37      (b) 1.34  
 (c) 1.55      (d) 1.63

26. A jar has a mixture of hydrogen and oxygen gas in the ratio of 1 : 5. The ratio of mean kinetic energies of hydrogen and oxygen molecules is

- (a) 1 : 16      (b) 1 : 4  
 (c) 1 : 5      (d) 1 : 1

27. Graph between volume and temperature for a gas is shown in figure. If  $\alpha$  = volume coefficient of gas =  $\frac{1}{273}$  per  $^\circ\text{C}$ , then what is the volume of gas at a temperature of  $819^\circ\text{C}$

- (a)  $1 \times 10^{-3} \text{ m}^3$   
 (b)  $2 \times 10^{-3} \text{ m}^3$   
 (c)  $3 \times 10^{-3} \text{ m}^3$   
 (d)  $4 \times 10^{-3} \text{ m}^3$



# AS Answers and Solutions

(SET -13)

1. (c) For same isotherm ;  $T \rightarrow$  constant

$$\therefore P \propto \frac{1}{V} \Rightarrow P_1 V_1 = P_2 V_2$$

2. (b)  $VP^3 = \text{constant} = k \Rightarrow P = \frac{k}{V^{1/3}}$

$$\text{Also } PV = \mu RT \Rightarrow \frac{k}{V^{1/3}} \cdot V = \mu RT \Rightarrow V^{2/3} = \frac{\mu RT}{k}$$

$$\text{Hence } \left(\frac{V_1}{V_2}\right)^{2/3} = \frac{T_1}{T_2} \Rightarrow \left(\frac{V}{27V}\right)^{2/3} = \frac{T}{T_2} \Rightarrow T_2 = 9T$$

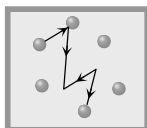
3. (c)  $(C_V)_{\text{mix}} = \frac{\mu_1 C_{V1} + \mu_2 C_{V2}}{\mu_1 + \mu_2} = \frac{1 \times \frac{3}{2}R + 1 \times \frac{5}{2}R}{1+1} = 2R$

$$\left( (C_V)_{\text{mono}} = \frac{3}{2}R, (C_V)_{\text{di}} = \frac{5}{2}R \right)$$

4. (a)  $v_{\text{rms}} = \sqrt{\frac{3RT}{M}} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{(273+90)}{(273+30)}} = 1.1$

$$\% \text{ increase} = \left(\frac{v_2}{v_1} - 1\right) \times 100 = 0.1 \times 100 = 10\%$$

5. (c) Temperature of the gas is concerned only with its disordered motion. It is no way concerned with its ordered motion.



— Motion of train (order of motion)

— Motion of molecule (Disordered motion)

6. (c)  $\mu = \mu_1 + \mu_2$

$$\frac{P(2V)}{RT_1} = \frac{P'V}{RT_1} + \frac{P'V}{RT_2} \Rightarrow \frac{2P}{RT_1} = \frac{P'}{R} \left[ \frac{T_2 + T_1}{T_1 T_2} \right]$$

$$P' = \frac{2PT_2}{(T_1 + T_2)} = \frac{2 \times 1 \times 600}{(300 + 600)} = \frac{4}{3} \text{ atm}$$

7. (c)  $v_{\text{rms}} \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$

$$\therefore \frac{1}{\sqrt{2}} = \sqrt{\frac{M_2}{32}} \Rightarrow M_2 = 16. \text{ Hence the gas is } CH_4.$$

8. (c) Mean kinetic energy of molecule depends upon temperature only. For  $O_2$  it is same as that of  $H_2$  at the same temperature of  $-73^\circ C$ .

9. (c)  $PV = \mu RT \Rightarrow \mu = \frac{PV}{RT} = \frac{21 \times 10^4 \times 83 \times 10^{-3}}{8.3 \times 300} = 7$

10. (b)  $P_1 = 720 \text{ kpa}, T_1 = 40^\circ C = 273 + 40 = 313 \text{ K}$

$$P \propto mT \Rightarrow \frac{P_2}{P_1} = \frac{m_2 T_2}{m_1 T_1} = \frac{3}{4} \times \frac{626}{313} = 1.5$$

$$\Rightarrow P_2 = 1.5 P_1 = 1.5 \times 720 = 1080 \text{ kPa}$$

11. (c) According to Boyle's law  $(P_1 V_1)_{\text{bottom}} = (P_2 V_2)_{\text{top}}$

$$(10+h) \times \frac{4}{3} \pi r_1^3 = 10 \times \frac{4}{3} \pi r_2^3 \quad \text{but } r_2 = 2r_1$$

$$\therefore (10+h)r_1^3 = 10 \times 8r_1^3 \Rightarrow 10+h=80 \quad \therefore h=70 \text{ m}$$

12. (d)  $v_{\text{rms}} = \sqrt{\frac{3RT}{M}} \Rightarrow v_{\text{rms}} \propto \sqrt{\frac{T}{M}}$

$$\frac{v_2}{v_1} = \sqrt{\frac{M_1 \times T_2}{M_2 \times T_1}} = \sqrt{\frac{1 \times \frac{1}{2}}{2 \times \frac{1}{2}}} \Rightarrow v_2 = \frac{v_1}{2} = \frac{300}{2} = 150 \text{ m/sec}$$

13. (bc) Co is diatomic gas, for diatomic gas

$$C_P = \frac{7}{2}R \text{ and } C_V = \frac{5}{2}R \Rightarrow \gamma_{\text{di}} = \frac{C_P}{C_V} = \frac{7R/2}{5R/2} = 1.4$$

14. (d) Energy = 300 J / litre = 300  $\times 10^3$  J / m<sup>3</sup>

$$P = \frac{2}{3}E = \frac{2 \times 300 \times 10^3}{3} = 2 \times 10^5 \text{ N/m}^2$$

15. (c)  $\rho = \frac{PM}{RT}$

Density  $\rho$  remains constant when  $P/T$  or volume remains constant.

In graph (i) Pressure is increasing at constant temperature hence volume is decreasing so density is increasing. Graphs (ii) and (iii) volume is increasing hence, density is decreasing. Note that volume would had been constant in case the straight line in graph (iii) had passed through origin.

16. (b) Vander wall's gas equation for  $\mu$  mole of real gas

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

on comparing the given equation with this standard

equation we get  $\mu = \frac{1}{2}$ . Hence  $\mu = \frac{m}{M} \Rightarrow$  mass of gas

$$m = \mu M = \frac{1}{2} \times 44 = 22 \text{ gm.}$$

17. (d) As we know 1 mol of any ideal gas at STP occupies a volume of 22.4 litres.

$$\text{Hence number of moles of gas } \mu = \frac{44.8}{22.4} = 2$$

Since the volume of cylinder is fixed,

$$\text{Hence } (\Delta Q)_V = \mu \omega \Delta T$$

$$= 2 \times \frac{3}{2} R \times 10 = 30 R \quad \left( \because (C_V)_{\text{mono}} = \frac{3}{2} R \right)$$

18. (b) Since volume is constant,

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$$\text{Hence } \frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{1}{3} = \frac{(273 + 30)}{T_2}$$

$$\Rightarrow T_2 = 909 \text{ K} = 636^\circ\text{C}$$

19. (b)  $(\Delta Q)_P = \mu C_P \Delta T$  and  $(\Delta Q)_V = \mu C_V \Delta T$

$$\Rightarrow \frac{(\Delta Q)_V}{(\Delta Q)_P} = \frac{C_V}{C_P} = \frac{\frac{3}{2}R}{\frac{5}{2}R} = \frac{3}{5}$$

$$\left[ \because (C_V)_{\text{mono}} = \frac{3}{2}R, (C_P)_{\text{mono}} = \frac{5}{2}R \right]$$

$$\Rightarrow (\Delta Q)_V = \frac{3}{5} \times (\Delta Q)_P = \frac{3}{5} \times 210 = 126 \text{ J}$$

20. (b) In case of given graph,  $V$  and  $T$  are related as  $V = aT - b$ , where  $a$  and  $b$  are constants.

From ideal gas equation,  $PV = \mu RT$

$$\text{We find } P = \frac{\mu RT}{aT - b} = \frac{\mu R}{a - b/T}$$

Since  $T_2 > T_1$ , therefore  $P_2 < P_1$ .

21. (d)  $PV = \mu rT \Rightarrow P \propto m$  [ $\because V, r, T \rightarrow \text{constant}$ ]

$$\Rightarrow \frac{m_1}{m_2} = \frac{P_1}{P_2} \Rightarrow \frac{10}{m_2} = \frac{10^7}{2.5 \times 10^6} \Rightarrow m_2 = 2.5 \text{ kg.}$$

Hence mass of the gas taken out of the cylinder

$$= 10 - 2.5 = 7.5 \text{ kg.}$$

22. (b) If  $m$  is the total mass of the gas then its kinetic energy  $= \frac{1}{2}mv^2$

When the vessel is suddenly stopped then total kinetic energy will increase the temperature of the gas. Hence  $\frac{1}{2}mv^2 = \mu C_V \Delta T = \frac{m}{M} C_V \Delta T$  [As

$$C_V = \frac{R}{\gamma - 1}]$$

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

23. (d) For open mouth vessel, pressure is constant. Volume is also given constant

$$\text{Hence from } PV = \mu RT = \left(\frac{m}{M}\right)RT \Rightarrow T \propto \frac{1}{m} \Rightarrow$$

$$\frac{T_1}{T_2} = \frac{m_2}{m_1}$$

$\therefore \frac{1}{4}$ th part escapes, so remaining mass in the vessel

$$m_2 = \frac{3}{4}m_1 \Rightarrow \frac{(273 + 60)}{T} = \frac{3/4 m_1}{m_1}$$

$$\Rightarrow T = 444 \text{ K} = 171^\circ\text{C}$$

24. (d)  $n = \frac{PV}{kT}$  Now,  $n' = \frac{(2P)(2V)}{kT} = 4 \frac{PV}{kT} = 4n$  or  $\frac{n}{n'} = \frac{1}{4}$ .

$$25. (b) \gamma_{\text{mix}} = \frac{\frac{\mu_1 \gamma_1}{\gamma_1 - 1} + \frac{\mu_2 \gamma_2}{\gamma_2 - 1}}{\frac{\mu_1}{\gamma_1 - 1} + \frac{\mu_2}{\gamma_2 - 1}} = \frac{\frac{3 \times 1.3}{(1.3 - 1)} + \frac{2 \times 1.4}{(1.4 - 1)}}{\frac{3}{(1.3 - 1)} + \frac{2}{(1.4 - 1)}} = 1.33$$

26. (d) In mixture gases will acquire thermal equilibrium (i.e., same temperature) so their kinetic energies will also be same.

27. (b)

$$V_t = V_0(1 + \alpha t) = 0.5 \left( 1 + \frac{1}{273} \times 819 \right) = 2 \text{ litre} = 2 \times 10^{-3}$$

$$m^3$$

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