KINETIC THEORY OF GASES

GAS LAWS

2011

1. A perfect gas at 27^0C is heated at constant pressure so as to double its volume. The increase in temperature of the gas will be

a) 600^0C b) 327^0C c) 54^0C d) 300^0C

2. Air inside a closed container is saturated with water vapour. The air pressure is p and the saturated vapour pressure of water is $\overline{p}$. If the mixture is compressed to one-half of its volume by maintaining temperature constant, the pressure becomes

a) $2(p+\overline{p})$ b) $2p+\overline{p}$ c) $(p+\overline{p})/2$ d) $p+2\overline{p}$

2010

3. If pressure of CO_2 (real gas) in a container is given by $p=\frac{RT}{2V-b}-\frac{9}{4b^2}$, then mass of the gas in container is

a) 11J b) 22 J c) 33 J d) 44 J

4. A closed vessel contains 8g of oxygen and 7g of nitrogen. The total pressure is 10 atm at a given temperature. If now oxygen is absorbed by introducing a suitable absorbent the pressure of the remaining gas (in atm) will be

a) 2 b) 10 c) 4 d) 5

5. Ideal gas and real gas have major different of

a) phase transition b) temperature
c) pressure d) none of these above

2009

6. By what percentage should the pressure of a given mass of a gas be increased, so as to decrease its volume by 10% at a constant temperature?

a) 5% b) 7.2% c) 12.5% d) 11.1%

7. When a van der Wall's gas undergoes free expansion, then its temperature

a) decreases b) increases
c) does not change d) depends upon the nature of the gas

8. An electron tube was sealed off during manufacture at a pressure of $1.2\times10^{-7}\,mm$ of mercury at 27^0C. Its volume is $100cm^3$. The number of molecules that remain in the tube is

a) 2×10^{16} b) 3×10^{15} c) 3.89×10^{11} d) 5×10^{11}

2008

9. At 10^0C the value of the density of a fixed mass of an ideal gas divided by its pressure is x. At 110^0C this ratio is

a) x b) $\frac{383}{283}x$ c) $\frac{10}{110}x$ d) $\frac{283}{383}x$

10. A balloon contains $500m^3$ of He at 27^0C and 1 atm pressure. The volume of He at -3^0C and 0.5 atm pressure will be

a) $700m^3$ b) $900m^3$ c) $1000m^3$ d) $500m^3$

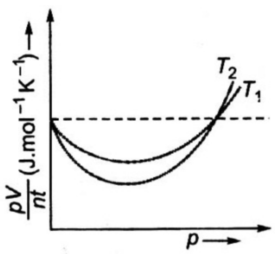
11. The phenomenon of Brownian movement may be taken as evidence of

a) Kinetic theory of matter b) EMT of radiation

c) Corpuscular theory of light d) photoelectric phenomenon

2007

12. The figure below shows the plot of $\frac{pV}{nT}$. Versus p for oxygen gas at two different temperatures



Read the following statements concerning the above curves

i) The dotted line corresponds to the 'ideal' gas behaviour

ii) $T_1 > T_2$

iii) The value of $\frac{pV}{nT}$ at the point where the curves meet on the y-axis is the same for all gases

Which of the above statements is true?

a) i only b) i and ii only c) all of these d) none of these

13. One litre of an ideal gas at 27^0C is heated at a constant pressure to 297^0C. Then, the final volume is approximately

a) 1.2 L b) 1.9L c) 19L d) 2.4L

2006

14. Two balloons are filled one with pure He gas and the other by air, respectively. If the pressure and temperature of these balloons are same then the number of molecules per unit volume is

a) more in the He filled balloon b) same in both balloons

c) more in air filled balloon d) in the ratio of 1 : 4

2005

15. Real gases obey ideal gas laws more closely at

a) low pressure and low temperature
b) low pressure and high temperature
c) high pressure and low temperature
d) low pressure and high temperature

2004

16. the equation of state for 5 g of oxygen at a pressure p and temperature T, when occupying a volume V, will be

a) pV = (5/32) RT
b) pV = 5RT
c) pV = (5/2) RT
d) pV = (5/16) RT

17. If a given mass of gas occupies a volume of 10cc at 1atm pressure and temperature 100^0C. What will be its volume at 4 atm pressure, the temperature being the same?

a) 100 cc
b) 400 cc
c) 104 cc
d) 2.5 cc

18. Two gases of equal masses are in thermal equilibrium. If p_a , p_b and V_a, V_b are their respective pressure and volumes, then which relation is true

a) $2p_aV_a = p_bV_b$
b) $p_a \neq p_b, V_a \neq V_b$
c) $\frac{p_a}{V_a} = \frac{p_b}{V_b}$
d) $p_aV_a = p_bV_b$

Various Speeds of Gas

2010

19. The temperature of an ideal gas is increased from 120K to 480K. If at 120K, the root men square speed of gas molecules is v, then at 480K, it will be

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

20. At what temperature of an ideal gas is increased from 120K to 480K. If at 120K, the root mean square speed of gas molecules is v, then at 480K, it will be

a) 80K
b) -73K
c) 3K
d) 20K

2008

21. The speed of sound in hydrogen at NTP is $1270ms^{-1}$. Then, the speed in a mixture of hydrogen and oxygen in the ratio 4: 1 by volume will be

a) $317ms^{-1}$
b) $635ms^{-1}$
c) $830ms^{-1}$
d) $950ms^{-1}$

2006

22. Assertion (A): The root mean square and most probable speeds of the molecules in a gas are the same

Reason (R): The Maxwell distribution for the speed of molecules in a gas is symmetrical.

a) Both assertion and reason are true and reason is the correct explanation of assertion

b) Both assertion and reason are true but reason is not the correct explanation of assertion

c) Assertion is true but reason is false

d) Both assertion and reason are false

23. The temperature of H_2 at which the rms velocity of its molecules is seven times the rms velocity the molecules of nitrogen at 300 K is

a) 2100K b) 1700 K c) 1350 K d) 1050 K

24. If at NTP velocity of sound in a gas is $1150 ms^{-1}$, then the rms velocity of gas molecules at NTP is

a) $1600 ms^{-1}$ b) $1532.19 ms^{-1}$ c) $160 ms^{-1}$ d) zero

25. When temperature of an ideal gas is increased from $27^0 C$ to $227^0 C$, its rms speed is changed from $400 ms^{-1}$ to v_s. The v_s is

a) $516 ms^{-1}$ b) $450 ms^{-1}$ c) $310 ms^{-1}$ d) $746 ms^{-1}$

Pressure and Energy of Gas

2010

26. Assertion (A): If a gas container in motion is suddenly stopped, the temperature of the gas rises

Reason (R): The kinetic energy of ordered mechanical motion is converted into kinetic energy of random motion of gas molecules

a) Both assertion and reason are true and reason is the correct explanation of assertion

b) Both assertion and reason are true but reason is not the correct explanation of assertion

c) Assertion is true but reason is false

d) Both assertion and reason are false

27. The kinetic energy of 1g molecule of a gas at normal temperature and pressure is (R = 8.31 J/mol-K)

a) $1.3\times10^2 J$ b) $2.7\times10^2 J$ c) $0.56\times10^4 J$ d) $3.4\times10^3 J$

28. Which one of the following is not an assumption in the kinetic theory of gases

a) the volume occupied by the molecules of the gas is negligible

b) the force of attraction between the molecules is negligible

c) the collision between molecules are elastic

d) all molecules have some speed

2009

29. A sealed container with negligible coefficient of volumetric expansion contains helium (a monoatomic gas). When it is heated from 300K to 600K, the average KE of helium atoms is

a) halved
b) unchanged
c) doubled
d) increased by factor $\sqrt{2}$

2008

30. Two vessels A and B having equal volume contain equal masses of hydrogen in A and helium in B at 300K. Then, mark the correct statement

a) the pressure exerted by hydrogen is half to that exerted by helium
b) the pressure exerted by hydrogen is equal to that exerted by helium
c) average KE of the molecule of hydrogen is half the average KE of the molecules of helium
d) the pressure exerted by hydrogen is twice that exerted by helium

2007

31. Two cylinders fitted with pistons contain equal amounts of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of gas in A is 300K, then rise in temperature of gas in B is

a) 30K
b) 18K
c) 50K
d) 42K

2006

32. Pressured of an ideal gas is increased by keeping temperature constant. What is the on kinetic energy of molecules?

a) increase
b) decrease
c) no change
d) can't be determined

2004

33. At which of the following temperature would the molecules of gas have twice the average kinetic energy they have at 20^0C

a) 40^0C
b) 80^0C
c) 586^0C
d) 313^0C

Degrees of Freedom and Specific Heat

2010

34. Mean free path of gas molecule at constant temperature is inversely proportional to

a) p b) V c) m d) n (number density)

2009

35. At ordinary temperature, the molecules of an ideal gas have only translational and rotational kinetic energies. At high temperatures they may also have vibrational energy. As a result of this at higher temperature (C_V = molar heat capacity at constant volume)

a) $C_V = \frac{3}{2}$ R for a monoatomic gas b) $C_V > \frac{3}{2}$ R for a monoatomic gas

c) $C_V < \frac{5}{2}$ R for a diatomic gas d) $C_V = \frac{5}{2}$ R for a diatomic gas

2008

36. A given mass of a gas is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its original volume is restored and its pressure is then found to be 0.75 of its initial pressure. The ratio of the specific heat of the gas is approximately

a) 1.20 b) 1.41 c) 1.67 d) 1.83

37. Assertion (A) : Mean free path a gas molecules varies inversely as density of the gas

Reason (R) : Mead free path varies inversely as pressure of the gas

a) Both assertion and reason are true and reason is the correct explanation of assertion

b) Both assertion and reason are true but reason is not the correct explanation of assertion

c) Assertion is true but reason is false d) Both assertion and reason are false

2007

38. The degrees of freedom of a molecule of a tri-atomic gas are

a) 2 b) 4 c) 6 d) 8

KEY

1) **d**	2) **b**	3) **b**	4) **d**	5) **c**	6) **d**	7) **a**	8) **c**	9) **d**	10) **b**
11) **a**	12) **c**	13) **b**	14) **b**	15) **b**	16) **a**	17) **d**	18) **d**	19) **b**	20) **d**
21) **b**	22) **d**	23) **d**	24) **b**	25) **a**	26) **a**	27) **d**	28) **d**	29) **c**	30) **d**
31) **d**	32) **c**	33) **d**	34) **d**	35) **a**	36) **b**	37) **b**	38) **c**		

HINTS

Gas Law

1. $V \propto T$

Here, $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

$V_1 = V$ then $V_2 = 2V$ and $T_1 = 300K$

$\therefore \frac{1}{2} = \frac{300}{T_2}$

$T_2 = 600K$

$T_2 = 327^0 K$

So, $\Delta t = 327 - 27$

$= 300^0 C$

3. $\left(p + \frac{\mu^2 a}{V^2}\right)(V - \mu b) = \mu RT$

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

Given equation, $p = \left(\frac{RT}{2V - b} - \frac{a}{4b^2}\right)$

On comparing the given equation with this standard equation, we get

$\mu = \frac{1}{2}$ d

Hence, $\mu = \frac{m}{M} \Rightarrow$ mass of gas

$m = \mu M = \frac{1}{2} \times 44 = 22g$

4. $p_{mix} = p_1 + p_2$

$= \frac{\mu_1 RT}{V} + \frac{\mu_2 RT}{V}$

$= \frac{m_1}{M_1} . \frac{RT}{V} + \frac{m_2}{M_2} . \frac{RT}{V}$

$= \frac{8}{32} . \frac{RT}{V} + \frac{7}{28} . \frac{RT}{V} = \frac{RT}{2V}$

$10 = \frac{RT}{2V}$ …………………..(i)

When oxygen is absorbed then for nitrogen by pressure

$$p = \frac{7}{28}\frac{RT}{V}$$

$$p = \frac{RT}{4V} \text{ ....(ii)}$$

From eqs (i) and (ii) we get

Pressure of the nitrogen p = 5 atm

9. pV = nRT

or $pV = \frac{m}{M}RT$

or $\frac{pV}{m} = \frac{1}{M}RT$ or $\frac{p}{\rho} = \frac{RT}{M}$

or $\frac{\rho}{p} = \frac{1}{T}$

$\therefore \frac{\rho_1 / p_1}{\rho_2 / p_2} = \frac{T_2}{T_1} \Rightarrow \frac{x}{(\rho_2 / p_2)} = \frac{383}{283}$

Or $\frac{\rho_2}{p_2} = \frac{283}{383}x$

10. $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$

Or $V_2 = \frac{p_1V_1T_2}{p_2T_1}$

$\therefore V_2 = \frac{1\times500\times(273-3)}{0.5\times(273+27)}$

$V_2 = \frac{1\times500\times270}{0.5\times300}$

$V_2 = 900m^3$

13. $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

So, $V_2 = \frac{V_1T_2}{T_1}$

$\therefore V_2 = 1\times\frac{(297+273)}{(27+273)}$

$\Rightarrow V_2 = \frac{570}{300}$

$\Rightarrow V_2 = 1.9L$

16. No. of moles $n = \frac{m}{molecular\ weight} = \frac{5}{32}$

pV = nRT

$\Rightarrow pV = \frac{5}{32}RT$

17. $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$

Here $T_1 = T_2$

And $p_1 = 1atm$, $V_1 = 10cc$, $p_2 = 4atm$

Now from eq (i) $p_1V_1 = P_2V_2$

$10 \times 1 = 4 \times V_2$

$V_2 = 2.5cc$

Various Speeds of Gas

19. $v_{rms} = \sqrt{\frac{3RT}{M}}$

So, $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

Now, $T_1 = 120K$, $T_2 = 480K$, $v_1 = v$

So, $\frac{v_1}{v_2} = \sqrt{\frac{120}{480}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

$\Rightarrow \frac{v}{v_2} = \frac{1}{2}$

$\Rightarrow v_2 = 2v$

20. $C = \sqrt{\frac{3RT}{M}}$

$\frac{T}{M} = \text{constant}$

$\frac{T}{2} = \frac{273+47}{32}$

Or $\frac{T}{2} = \frac{320}{32} = 10$

Or T = 20 K

21. Density of mixture $\rho_m = \frac{4V \times 1 + V \times 16}{5V}$

As $v \propto \left(\frac{1}{\rho}\right)^{1/2}$

$\therefore$ Velocity in mixture $= \frac{1270}{(4)^{1/2}} = 635 ms^{-1}$

23. $v_{rmp} = \sqrt{\frac{3RT}{m}}$

$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{M_1} \times \frac{M_2}{T_2}}$

$\frac{v_H}{v_N} = \sqrt{\frac{T_H}{M_H} \times \frac{M_N}{T_N}}$

$7 = \sqrt{\frac{T_H \times 28}{2 \times 300}}$

$49 = \frac{T_H \times 28}{600}$

$T_H = \frac{49 \times 600}{28} = 1050K$

24. $R = \frac{8.3}{4.2} cal\, g\, mol^{-1} - K^{-1}$

$C_V = C_P - R = \left(4.8 - \frac{8.3}{4.2}\right) = 2824$

$\gamma = \frac{C_p}{C_v} = \frac{4.8}{2.824} = 1.69$

Since, $v = \sqrt{\left(\frac{3}{\gamma}\right)} v_s = \sqrt{\frac{3}{1.69}} \times 1150 = 1532.19 ms^{-1}$

25. $v_{rms} \propto \sqrt{T}$

Hence, $\frac{v_{rms(1)}}{v_{rms(2)}} \propto \sqrt{\frac{T_1}{T_2}}$

$\frac{400}{v_{rms(2)}} = \frac{\sqrt{27+273}}{\sqrt{227+273}} = \sqrt{\frac{300}{500}}$

$v_{rms(2)} = v = \sqrt{\frac{500}{300}} \times 400 \approx 516 ms^{-1}$

Pressure and Energy of Gas

27. $E = \frac{f}{2}RT$

$E_{trans} = \frac{3}{2}RT = \frac{3}{2}\times 8.31\times(273+0) = 3.4\times10^3 J$

31. $E = \frac{3}{2}kT$ or $E \propto T$

$\frac{E_1}{E_2} = \frac{T_1}{T_2}$ or $\frac{E_1}{2E_1} = \frac{273+20}{T_2}$

Or $T_2 = 2\times293 = 586K = 586-273 = 313^0 C$

Degrees of Freedom and Specific Heat

36. $p \propto \frac{1}{V}$

$\Rightarrow \frac{p_2}{p_1} = \frac{V_1}{V_2}$

$\Rightarrow \frac{2p}{p} = \frac{V_1}{V_2}$

$\therefore \frac{V_1}{V_2} = 2$

$pV^{\gamma} =$ Constant

$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^{\gamma}$

$\Rightarrow \frac{2p}{0.75p} = \left(\frac{2}{1}\right)^{\gamma}$

$\Rightarrow \log\left(\frac{8}{3}\right) = \gamma \log 2$

$\Rightarrow \log 8 - \log 3 = \gamma \log 2$

$\therefore \gamma = 1.41$