PHYSICS

BOOKS - DC PANDEY ENGLISH

THERMOMETRY,THERMAL EXPANSION & KINETIC THEORY OF GASES

Example

1. Express a temperature of $60^\circ F$ in degrees Celsius and in kelvin.

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2. The temperature of an iron piece is heated from $30^\circ C \text{to} 90^\circ C$. What is the change in its temperature on the fahrenheit scale and on the kelvin scale?

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3. A steel ruler exactly $20cm$ long is graduated to give correct measurements at $20^\circ C$.

(a) Will it give readings that are too long or too short at lower temperatures?

(b) What will be that actual length of the ruler when it is used in the desert at a temperature of $40^{\circ} C$? $\alpha_{steel=1.2 \times 10^{-5}(.^{\circ} C)^{-1}}$.

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4. The scale on a steel meter stick is calibrated at $15^{\circ} C$. What is the error in the reading of $60 cm$ at $27^{\circ} C$? $\alpha_{steel} = 1.2 \times 10^{-5}(.^{\circ} C)^{-1}$.

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5. A second's pendulum clock has a steel wire. The clock is calibrated at $20^{\circ}C$. How much time does the clock lose or gain in one week when the temperature is increased to $30^{\circ}C$?

$\alpha_{steel} = 1.2 \times 10^{-5} (\hat{} \circ C)^{-1}$.

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6. A sphete of deamrter 7.0 cm and mass 266.5 g float in a bath of liquid. As the temperature is raised, the sphere begins to sink at a

temperature of $35^{\circ}C$. If the density of liqued is $1.527gcm^{-3}$ at$0^{\circ}C$, find the coeffiecient of cubical expamsion of the liquid. Neglect the expansion of the sphere.

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7. A glass beaker holds exactly $1L$at$0^{\circ}C$

(a) What is its volume at $50^{\circ}C$?

(b) If the beaker is filled with mercury at $0^{\circ}C$, what volume of mercury overflows ehen the temperature is $50^{\circ}C$?

$\alpha_g = 8.3 \times 10^{-6} per^\circ C$ and

$\gamma_{Hg} = 1.82 \times 10^{-4} per^\circ C.$

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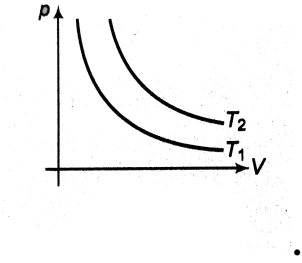
8. $p - V$ diagram of same mass of a gas are drawn at two different temperatures (T_1) and (T_2). Explain whether $T_1 > T_2$ or $T_2 > T_1$.



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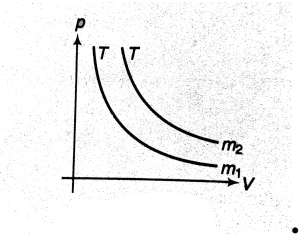
9. The $p - V$ diagram of two different masses m_1 and m_2 are drawn (as shown) at constant temperature (T). State whether $m_1 > m_2 \text{or} m_2 > m_2$.



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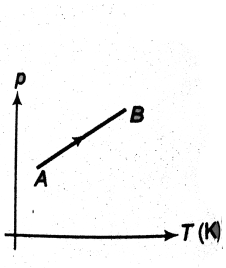
10. The p-T graph for the given mass of an ideal gas is shown in figure. What inference can be drawn regarding the change in volume

(whether it is constant, increasing or decreasing) ?

How to proceed Definitely, it is not constant. Because when volume of the gas is constant $p - T$ graph is a straight line passing through origin. The given line does not pass through origin, hence volume is not constant.



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$$V = (nR)\left(\frac{T}{P}\right)$$

Now, to see volume of the gas we will have to see whether $\frac{T}{P}$ is increasing or decreasing.

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11. A gas at $27^\circ C$ in a cylinder has a volume of 4 litre and pressure $100Nm^{-2}$.

(i) Gas is first compressed at constant temperature so that the pressure is $150Nm^{-2}$. Calaulate the change in volume.

(ii) It is then heated at constant volume so that temperature becomes $127^\circ C$. Calculate the new pressure.

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12. A balloon partially filled with helium has a volume of $30m^3$, at the earth's surface, where pressure is $76cm$ of (Hg) and temperature is $27^\circ C$ What will be the increase in volume of gas if balloon rises to a height, where pressure is $7.6cm$ of Hg and temperature is $-54^\circ C$?

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13. Find total internal energy of 3 moles of hydrogen gas at temperature T.

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14. Ten moles of (O_2) gas are kept at temperature T. At some higher temperature $2T$, fourty percent of molecular oxygen breaks into atomic oxygen. Find change in internal energy of the gas.

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15. At a given temperature internal energy of a monoatomic, diatomic and non - linear gas is

$(U_0$ each. Find their translational and rotiational kinetic energies separately.

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16. Two moles of helium (He) are mixed with four moles of hydrogen (H_2). Find

(a) $(C_V$ of the mixture

(b) $(C_P$ of the mixture and

(c) $(\gamma)$of the mixture.

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17. Temperature of two moles of a monoatomic gas is increased by $300K$ in the process $p \propto V$. Find

(a) molar heat capacity of the gas in the given process

(b) heat required in the given process.

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18. Find the rms speed of hydrogen molecules at room temperature $(= 300K)$.

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19. A tank used for filling helium balloons has a volume of $0.3m^3$ and contains (2.0) mol of helium gas at $20.0^\circ C$. Assuming that the helium behaves like an ideal gas.

(a) What is the total translational kinetic energy of the molecules of the gas ?

(b) What is the average kinetic energy per molecule ?

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20. Consider an 1100 particels gas system with speeds distribution as follows :

1000 particles each with speed $100m/s$

2000 particles each wityh speed $200m/s$

4000 particles each with speed $300m/s$

3000 particles each with speed $400m/s$ and

1000 particles each with speed $500m/s$

Find the average speed, and rms speed.

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21. Calculate the change in internal energy of 3.0 mol of helium gas when its temperature is increased by $2.\ 0K$.

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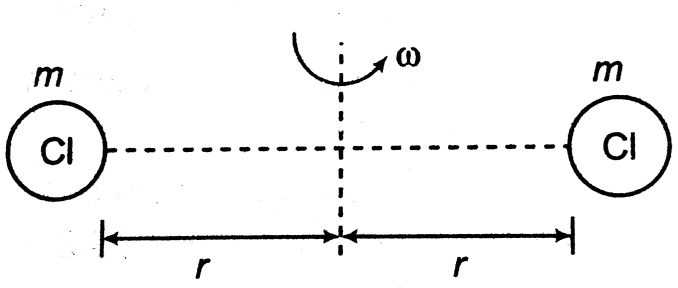
22. In a crude model of a rotating diatomic molecule of chlorine (Cl_2), the two (Cl) atoms are $2.0 \times 10^{-10}m$ apart and rotate about their centre of mass withb angular speed $\omega = 2.0 \times 10^{12}\text{rad}/s$. What is the rotational kinetic energy of one molecule of

Cl_2 , Which has a molar mass of $70.0 g / mol$?



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23. Prove that the pressure of an ideal gas is numerically equal to two third of the mean translational kinetic energy per unit volume of the gas.

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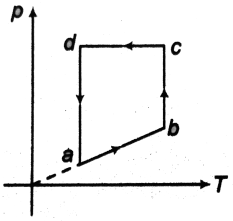
Example Type 1

1. 

Corresponding to (p - T) graph as shown in figure, draw

(a) P - V graph

(b) V - T graph

(c) ρ - T graph and

(d) U - T graph.

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Example Type 2

1. An insulated box containing a monoatomic gas of molar mass (M) moving with a speed v_0 is suddenly stopped. Find the increment is gas temperature as a result of stopping the box.

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Example Type 3

1. A cubical box of side $1m$ contains helium gas (atomic weight 4) at a pressure of $100N/m^2$. During an observation time of $1\,\mathrm{sec}\,ond$, an atom travelling with the root - mean - square speed parallel to one of the edges of the cube, was found to make $500hits$ with a particular wall, without any collision with other atoms . Take

$R = \frac{25}{3} j/mol - K$ and $k = 1.38 \times 10^{-23} J/K$

.

(a) Evalite the temperature of the gas.

(b) Evaluate the average kinetic energy per atom.

(c) Evaluate the total mass of helium gas in the box.

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2. $1g$ mole of oxygen at $27^{\circ}C$ and (1) atmosphere pressure is enclosed in a vessel.

(a) Assuming the molecules to be moving with $(v_{rms}$, find the number of collisions per second which the molecules make with one square

metre area of the vessel wall.

(b) The vessel is next thermally insulated and moves with a constant speed $(v_0$. It is then suddenly stoppes. The process results in a rise of temperature of the temperature of the gas by $1^\circ C$. Calculate the speed v_0. $\left[k = 1.38 \times 10^{-23} J/K \text{ and } N_A = 6.02 \times 10^{23}/mol\right]$.

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Miscellaneous Example

1. An ideal diatomic gas with $C_V = \frac{5R}{2}$ occupies a volume $(V_i$ at a pressure $(P_i$. The gas undergoes a process in which the pressure is proportional to the volume. At the end of the process, it is found that the rms speed of the gas molecules has doubles from its initial value. Determine the amount of energy transferred to the gas by heat.

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2. Given, Avogadro's number $N = 6.02 \times 10^{23}$ and Boltzmann's constant $k = 1.38 \times 10^{-23} J/K.$

(a) Calculate the average kinetic energy of translation of the molecules of an ideal gas at $0^{\circ} C$ and $at 100^{\circ} C.$

(b) Also calculate the corresponding energies per mole of the gas.

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3. An air bubble starts rising from the bottom of a lake. Its diameter is $3.6mm$ at the bottom and $4mm$ at the surface. The depth of the lake is $250cm$ and the temperature at the surface is $40^\circ C$. What is the temperature at the bottom of the lake? Given atmospheric pressure = $76cmofHg$ and $g = 980cm/s^2$.

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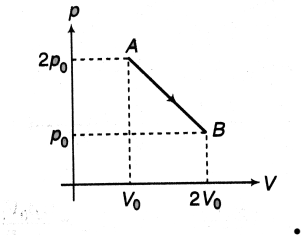
4. (p - V) diagram of (n) moles of an ideal gas is as shown in figure. Find the maximum

temperature between (A) and (B).



How to proceed For given number of moles of a gas,

$T \propto pV (pV = nRT)$

Although

$(pV)_A = (pV)_B = 2p_0V_0$ or $T_A = T_B$, yet it is not an isothermal process. Because in isothermal process (p- V) graph is a rectangular hyperbola while it is a straight line. So, to see the behaviour of temperature,

First we will find either (T - V) equation or (T _ p) equation and from that equation we can judge how the temperature baries. From the graph, first we will write)p V) equation, then we will convert it either in (T - V) equation or in (T - p) quation with the help of equation, (pV = nRT).

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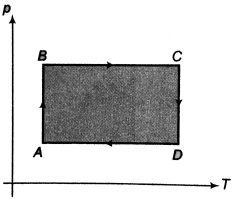
5. Plot (p - V),(V - T) and (ρ - T) graph corresponding to the (p - T) graph for an ideal

gas shown in figure. 

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Exercise 20 1

1. What is the value of.

(a) $0^{\circ} F$ in Celsius scale ?

(b) $0K$ on Fahrenheit scale ?

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2. At what temperature is the Fahrenheit scale reading equal to

(a) twice (b) half of Celsius ?

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3. A faulty thermometer reads $5^{\circ}C$ melting ice and $99^{\circ}C$ in steam. Find the correct temperature in $\hat{}\circ C$ when this faulty thermometer reads $52^{\circ}C$.

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4. At what temperature the Fahrenheit and kelvin scales of temperature give the same reading ?

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5. At what temperature the Fahrenheit and Celsius scales of temperature give the same reading ?.

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Exercise 20 2

1. Take the values of (prop) from table 20.2.

A pendulum clock of time period $2s$ gives the correct time at $30^{\circ}C$. The pendulum is made of iron. How many seconds will it lose or gain per day when the temperature falls tp $0^{\circ}C$? $\alpha_{Fe} = 1.2 \times 10^{-5}(.^{\circ}\ C)^{-1}$.

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2. A block of wood is floating in water at $0^\circ C$. The temperature of water is slowly raised from $0^\circ C$ to $10^\circ C$. How will the precentage of volume of block above water level change with rise in temperature?

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3. A piece of metal floats on mercury. The coefficient of volume expansion of metal and mercury are γ_1 and γ_2, respectively. if the temperature of both mercury and metal are

increased by an amount ΔT, by what factor does the frection of the volume of the metal submerged in mercury changes ?

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4. A brass disc fits snugly in a hole in a steel plate. Should you heat or cool the system to loosen the disc from the hole ? given that $\alpha_b > \alpha_F e.$

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5. An iron ball has a diameter of $6cm$ and is $0.010mm$ too large to pass through a hole in a brass plate when the ball and plate are at a temperature of $30^\circ C$. At what temperature, the same for ball and plate, will the ball just pass through the hole?

Take the values of (prop) from Table 20.2.

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6. (a) An alumunium measuring rod which is correct at $5^\circ C$, measures a certain distance as

$88.42cmat35^\circ C$. determine the error in measuring hr distance due to the expansion of the rod. (b) If this aluminium rod measures a length of steel as $88.42cmat35^\circ C$, what is the correct length of the steel at $35^\circ C$?

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7. A steel tape is callibrated at $20^\circ C$. On a cold day when the temperature is $-15^\circ C$, what will be the percentage error in the tape ?

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Exercise 20 3

1. From the graph for an ideal gas, state whether m_1 or m_2 is greater.

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2. A vessel is filled with an ideal gas at a pressure of $20atm$ and is a temperature of $27^\circ C$ One - half of the mass is removed from

the vessel and the temperature of the remaining gas is increased to $87^{\circ}C$. At this temperature, Find the pressure of the gas.

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3. A vessel contains a mixture of $7g$ of nitrogen and $11g$ carbon dioxide at temperature $T = 290K$. If pressure of the mixure is $1atm\left(= 1.01 \times 10^5 N/m^2 \right)$, calculate its dencity $(R = 8.31J/mol - K)$.

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4. An electric bulb of volume 250cc was sealed during manufacturing at a pressure of $10^{-3}mm$ of mercury at $27^{\circ}C$. Compute the number of air molecules contained in the bulb. Avogadro constant $= 6 \times 10^{23}mol^{-1}$, density of mercury $= 13600kgm^{-3}$ and $g = 10ms^{-2}$.

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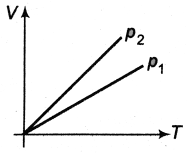
5. State whether $(p_1 > p_2$ or $p_2 > p_1)$ for given mass of a gas ?



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6. For a given mass of a gas what is the shape of (p) versus $\left(\frac{1}{V}\right)$ graph at constant temperature ?

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7. For a given mass of a gas, what is the shape of (pV) versus (T) graph on isothermal process ?

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Exercise 20 4

1. A gas mixture coinsists of (2) moles of oxygen and (4) moles of argon at temperature

(T). Neglecting all vibrational modes, the total internal energy of the system is (jee 1999)

(a) 4 RT (b) 15 RT (c) 9 RT (d) 11 RT.

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2. The average translational kinetic energy of O_2 (molar mass 32) molecules at a particular temperature is $0.048eV$. The translational kinetic energy of N_2 (molar mass 28) molecules in (eV) at the same temperature is

(JEE 1997)

(a) 0.0015 (b) 0.003 (c) 0.048 (d) 0.768

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3. At a given temperature, rotational kinetic energy of diatomic gas is K_0. Find its translational and total kinetic energy.

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Exercise 20 5

1. Calculate the root mean square speed of hydrogen molecules at $373.15K$.

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2. Five gas molecules chosen at random are found to have speed of $500, 600, 700, 800 \text{ and } 900 m/s$. Find the rms speed. Is it the same as the average speed ?

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3. The average speed of all the molecules in a gas at a given instant is not zero, whereas the average velocity of all the molecules is xero. Explain why ?

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4. A sample of helium gas is at a temperature of $300K$ and a pressure of $0.5atm$. What is the average kinetic energy of a molecule of a gas ?

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5. A sample of helium and neon gases has a temperature of $300K$ and pressure of $1.0atm$. The molar mass of helium is $4.0g/mol$ and that of neon is $20.2g/mol$.

(a) Find the rms speed of the helium atoms and of the neon atoms.

(b) What is the average kinetic energy per atom of each gas ?

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6. At what temperature will the particles in a sample of helium gas have an rms speed of $1.0 km / s$?

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7. For any distribution of speeds $v_{rms} \geq v_{av}$ Is this statement true or false ?

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Level 1 Assertion And Reason

1. Assertion: Straight line on (p - T) graph for an ideal gas represents isochoric process.

Reason: If $p \propto T, V = cons\tan t.$

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: D

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2. Vibrational kinetic energy is insignificant at low temperatures.

Interatomic forces are responsible for vibrational kinetic energy.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: B

3. In the formula $p = \frac{2}{3}E$, the term (E) represents translational kinetic energy per unit volume of gas.

In case of monoatomic gas, translational

kinetic energy and total kinetic energy are equal.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: B

4. If a gas container is placed in a moving train, the temperature of gas will increase.

Kinetic energy of gas molecules will increase.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: D

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5. According to the law of equipartition of energy, internal energy of an ideal gas at a given temperature, is equally distributed in translational and rotational kinetic energies. Rotational kinetic energy of a monoatomic gas is zero.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: D

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6. Assertion: Real gases behave as ideal gases most closely at low pressure and high temperature.

Reason: Intermolecular force between ideal gas molecules is assumed to be zero. Choose the appropriate option:

a) If both Assertion and Reason are true and the reason is correct explanation of the

Assertion.

b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

c) If Assertion is true, but the Reason is false.

d) If Assertion is false but the Reason is true.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct

explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: B

7. Assertion: A glass of water is filled at $4^{\circ}C$. Water will overflow, if temperature is increased or decreased. (Ignore expansion of glass).

Reason: Density of water is minimum at $4^{\circ}C$.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: C

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8. If pressure of an ideal gas is doubled and volume is halved, then its internal energy will remain unchanged.

Internal energy of an ideal gas is a function of only temperature.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: B

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9. In equation $p = \frac{1}{3}\alpha v_{rms}^2$, the term (prop) represents dencity of gas.

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

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: B

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10. Assertion: In isobaric process, (V - T) graph is a straight line passing through origin. Slope of this line is directly proportional to mass of the gas. (V) is taken on (y - axis).

Reason: $V = \left(\frac{nR}{p}\right)T$

$\therefore$ Slope $\propto n$

or $\text{slope} \propto m$.

A. If both Assertion and Reason are true and the reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: A

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Level 1 Objective

1. The average velocity of molecules of a gas of molecular weight (M) at temperature (T) is

A. $\frac{\sqrt{3RT}}{M}$.

B. $\frac{\sqrt{8RT}}{\pi M}$.

C. $\frac{\sqrt{2RT}}{M}$.

D. zero

Answer: B

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2. Four particles have velocities $1, 0, 2, \text{ and } 3m/s$. The root mean square velocity of the particles (definition wise) is.

A. $3.5m/s$.

B. $\sqrt{3.5m/s}$.

C. $1.5m/s$

D. $\sqrt{\frac{14}{3}}m/s.$

Answer: B

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3. The temperature of an ideal gas is increased from $27^\circ C$ to $927^\circ C$. The rms speed of its molecules becomes.

A. twice

B. half

C. four times

D. one - fourth

Answer: A

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4. In case of hydrogen and oxygen at (NTP), which of the following is the same for both ?

A. Average linear momentum per molecule.

B. Average (KE) per molecule.

C. (KE) per unit volume

D. (KE) per unit mass

Answer: B

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5. The average kinetic energy of the molecules of an ideal gas at $10^{\circ}C$ has the value (E). The temperature at which the kinetic energy of the same gas becomes (2 E) is.

A. $5^{\circ} C$

B. $10^{\circ} C$

C. $40^{\circ} C$

D. None of these

Answer: D

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6. A polyatomic gas with (n) degress of freedom has a mean energy per molecule given by.

A. $\frac{n}{2}RT$

B. $\frac{1}{2}RT$

C. $\frac{n}{2}kT$

D. $\frac{1}{2}kT$

Answer: C

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7. In a process, the pressure of a gas remains constant. If the temperature is doubles, then the change in the volume will be.

A. $100\ \%$

B. $200\ \%$

C. $50\ \%$

D. $25\ \%$

Answer: A

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8. A steel rod of length $1m$ is heated from $25^\circ \text{to} 75^\circ C$ keeping its length constant. The longitudinal strain developed in the rod is (

Given, coefficient of linear expansion of steel = $12 \times 10^{-6} / {}^{\circ} C$).

A. 6×10^{-4}

B. -6×10^{-5}

C. -6×10^{-4}

D. zero

Answer: C

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9. The coefficient of linear expansion of steel and brass are $11 \times 10^{-6}/^{\circ}C$ and $19 \times 10^{-6}/^{\circ}C$, respectively. If their difference in lengths at all temperature has to kept constant at $30cm$, their lengths at $0^{\circ}C$ should be

A. $71.25cm$ and $41.25cm$

B. $82cm$ and $52cm$

C. $92cm$ and $62cm$

D. $62.25cm$ and $32.25cm$

Answer: A

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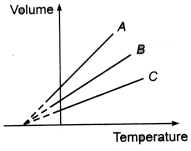
10. The expansion of an ideal gas of mass (m) at a constant pressure (p) is given by the straight line (B) Then, the expansion of the same ideal gas of mass $2m$ at a pressure $2p$ is given by the straight line.



A. (C)

B. (A)

C. (B)

D. data insufficient

Answer: C

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Level 1 Subjective

1. Change each of the given temperature to the Celsius and Kelvin scales : $68^\circ F, 5^\circ F$ and $176^\circ F$.

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2. Change each of the given temperature to the Fahrenheit and Reaumur scale : $30^\circ C, 5^\circ C$ and $-20^\circ C$.

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3. At what temperature do the Celsius and Fahrenheit readings have the same numerical value ?

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4. You work in a materials testing lab and your boss tells you to increase the temperature of a sample by $40.0^{\circ} C$. The only thermometer you can find at your workbench reads in $\hat{} \circ C$. If the initial temperature of the sample is $68.2^{\circ} C$. What is its temperature in $\hat{} \circ C$

when the desired temperature increase has been achieved ?

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5. The steam point and the ice point of a Mercury thermometer are marked as 80^0 and 20^0. What will be the temperature in centigrade mercury scale when this thermometer reads 32^0?

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6. A platinum resistance thermometer reads $0^\circ C$ when its resistance is 80Ω and $100^\circ C$ when its resistance is 90Ω. Find the temperature at which the resistance is 86Ω.

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7. The steam point and the ice point of a mercury thermometer are marked as 80° and 10°. At what temperature on centigrade scale the reading of this thermometer will be 59° ?

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8. Find the temperature at which oxygen molecules would have the same rms speed as of hydrogen molecules at $300K$.

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9. Find the mass (in kilogram) of an ammonia molecule NH_3.

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10. Three moles of an ideal gas having $\gamma = 1.67$ are mixed with 2 moles of another ideal gas having $\gamma = 1.4$. Find the equivalent value of γ for the mixture.

Watch Video Solution

11. How many degress of freedom have the gas molecules, if under standard conditions the gas density is $\rho = 1.3kg/m^3$ and velocity of sound propagation o it is $v = 330m/s$?

Watch Video Solution

12. $4g$ hydrogen is mixed with 11.2 litre of He at (STP) in a container of volume 20 litre. If the final temperature is $300K$, find the pressure.

Watch Video Solution

13. One mole of an ideal monoatomic gas is taken at a temperature of $300K$. Its volume is

doubled keeping its pressure constant. Find the change in internal energy.

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14. Two perfect monoatomic gases at absolute temperature T_1 and T_2 are mixed. There is no loss of energy. Find the temperature of the mixture if the number of moles in the gases aren_1 and n_2.

Watch Video Solution

15. If the water molecules in $1.0g$ of water were distributed uniformly over the surface of earth, how many such molecules would there be in $1.0cm^2$ of earth's surface ?

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16. If the kinetic energy of the molecules in 5 litre of helium at 2 atm is (E). What is the kinetic energy of molecules in 15 litre of oxygen at 3 atm in terms of (E) ?

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17. At what temperature is the "effective" speed of gaseous hydrogen molecules (molecular weight = 2) equal to that of oxygen molecules (molecular weight = 32) at $47^{\circ} C$?

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18. At what temperature is v_{rms} of H_2 molecules equal to the escape speed from earth's surface. What is the corresponding

temperature for escape of hydrogen from moon's surface ? Given $g_m = 1.6m/s^2, R_e = 6367km \text{and} R_m = 1750km$.

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19. The pressure of the gas in a constant volume gas thermometer is 80cm of mercury in melting ice at $1atm$. When the bulb is placed in a liquid, the pressure becomes

$160cm$ of mercury. Find the temperature of the liquid.

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20. The resistances of a platinum resistance thermometer at the ice point, the steam point and the boiling point of sulphur are $2.50, 3.50 \text{ and } 6.50(\Omega)$ respectively. Find the boiling point of sulphur on the platinum scale. The ice point and the steam point measure $0^\circ \text{ and } 100^\circ$, respectively.

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21. In a constant volume gas thermometer, the pressure of the working gas is measured by the differenced in the levels of mercury in the two arms of a U-tube connected to the gas at one end. When the bulb is placed at the room temperature 27.0^0C, the mercury column in the arm open to atmosphere stands $5.00cm$ above the level of mercury in the other arm. When the bulb is placed in a hot liquid, the difference of mercury levels becomes

$45. .0Cm$. Calculate the temperature of the liquid. (Atmospheric pressure $= 75.0cm$ of mercury).

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22. A steel wire of $2.0mm^2$ cross- section is held straight(but under no tension) by attaching it firmly to two points a distance $1.50m$ apart at $30^\circ C$. If the temperature now decreases to $-10^\circ C$ and if the two points

remain fixed, what will be the tension in the wire ? For steel, $Y = 20.0000MPa$.

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23. A metallic bob weights $50g$ in air. If it is immersed in a liquid at a temperature of $25^\circ C$, it weights $45g$. When the temperature of the liquid is raised to $100^\circ C$, it weights $45.1g$. Calculate the coefficient of cubical expansion of the liquid. Given that coefficient of cubical expansion of the metal is $12 \times 10^{-6}.^\circ C^{-1}$.

Watch Video Solution

24. An ideal gas exerts a pressure of $1.52MP$a when its temperature is $298.15K$ and its volume is $10^{-2}m^3$. (a) How many moles of gas are there ? (b) What is the mass density if the gas is molecular hydrogen ? (c) What is the mass density if the gas is oxygen ?

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25. A compressor pumps $70L$ of air into a $6L$ tank with the tempertaure remaining unchanged. If all the air is originally at $1atm$. What is the fianl absolute pressure of the air in the tank ?

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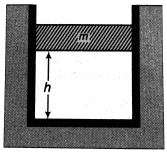
26. A partially inflated balloon contains $500m^3$ of helium at $27^\circ C$ and $1atm$ pressure. What is the volume of the helium at an altitude of

$18000 ft$, where the pressure is $0.5 atm$ and the temperature is $-3^{\circ} C$?

Watch Video Solution

27. A cylinder whose inside diameter is $4.00 cm$ contains air compressed by a piston of mass $m = 13.0 kg$ which can slide freely in the cylinder. The entire arrangement is immersed in a water bath temperature can be controlled. The system is initially in equilibrium at temperature $t_i = 20^{\circ} C$. The initial height of

the piston above the bottom of the cylinder is $h_i = 4.00cm$. The temperature of the water bath is gradually increased to afinal temperature $t_f = 100^\circ C$. Calculate the final height h_f of the piston.



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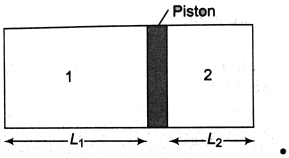
28. The closed cylinder shown in figure has a freely moving piston separating chambers 1

and 2. Chamber 1 contains $25mg$ of N_2 and chamber 2 contains $40mg$ of helium gas. When equilibrium is established what will be the ratio L_1 / L_2 ? What is the ratio of the number of moles of N_2 to the number of moles of He ? (Molecular weights of N_2 and He are 28 and 4.



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29. Two gases occupy two containers (A) and (B). The gas in (A) of volume $0.11m^3$ experts a

pressure of $1.38Mpa$. The gas in (B) of volume $0.16m^3$ experts a pressure of `0.69 Mpa. Two containers are united by a tube of negligible volume and the gases are allowed to intermingle. What is the final pressure in the container if the temperature remains constant ?

Watch Video Solution

30. A glass bulb of volume $400cm^3$ is connected to another bulb of volume $200cm^3$

by means of a tube of negligible volume. The bulbs contain dry air and are both at a common temperature and pressure of $20^{\circ}C$ and 1.000 atm, respectively. The larger bulb is immersed in steam at $100^{\circ}C$ and the smaller in melting ice at 0°. Find the final common pressure.

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31. The condition called standard temperature and pressure (STP) for a gas is defined as

temperature of $0^{\circ}C = 273.15K$ and a pressure of $1atm = 1.013 \times 10^{5} Pa$. If you want to keep a mole of an ideal gas in your room at (STP), how big a container do you need ?

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32. A large cylindrical tank contains $0.750m^{3}$ of nitrogen gas at $276 \circ C$ and $1.50 \times 10^{5} Pa$ (absolute pressure). The tank has a tightfitting piston that allows the volume to be changed.

What will be the pressure if the volume is decreased to $0.480m^3$ and the temperature is increased to $157^\circ C$.

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33. A vessel of volume 5 litres contains $1.4g$ of N_2 and $0.4g$ of He at $1500K$. If $30\,\%$ of the nitrogen molecules are dissociated into atoms then find the gas pressure.

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34. Temperature of diatomic gas is $300K$. If moment of intertia of its molecules is $8.28 \times 10^{-38} g - cm^2$. Calculate their root mean square angular velocity.

Watch Video Solution

35. Find the number of degrees of freedom of molecules in a gas. Whose molar heat capacity

(a) at constant pressure $C_p = 29 Jmol^{-1} K^{-1}$

(b) $C = 29 Jmol^{-1} K^{-1}$ in the process (pT) = constant.

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36. In a certain $\left(\frac{2}{5}\right)th$ of the energy of molecules is associated with the ratation of molecules and the rest of it is associated with the motion of the centre of mass.

(a) What is the average translational energy of one such molecule when the temperature id $27^{\circ}C$?

(b) How much energy must be supplied to one mole of thsi gas constant volume to raise the temperature by $1^{\circ}C$?

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37. A mixture contains 1 mole of helium $(C_p = 2.5R, C_v = 1.5R.)$ and 1 mole of hydrogen $(C_p = 3.5R, C_v = 2.5R,)$. Calculate the values of C_p, C_v and γ for the mixture.

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38. An ideal gas $\left(\frac{C_p}{C_v} = \gamma\right)$ is taken through a process in which the pressure and volume vary as $\left(p = aV^b\right)$. Find the value of b for which the specific heat capacity in the process is zero.

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39. An ideal gas is taken through a process in which the pressure and the volume are changed according to the equation $p = kv$.

Show that the molar heat capacity of the gas for the process is given by $\left(C = C_v + \frac{R}{2}\right)$.

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40. The pressure of a gas in a $100mL$ container is $200kPa$ and the. Average translational kinetic energy of each gas particle is $6 \times 10^{-21} J$. Find the number of gas particles in the container. How many moles are there in the container ?

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41. One gram mole $NO_2 \text{at} 47^\circ C$ and 2 atm pressure in kept in a vessel. Assuming the molecules to be moving with (rms) velocity. Find the number of collisions per which the molecules make with one square metre area of the vessel wall.

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42. A $2.00mL$ volume container contains $50mg$ of gas at a pressure of $100kPa$. The mass of

each gas particle is $8.0 \times 10^{-26} kg$. Find the average translational kinetic energy of each particle

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43. Call the (rms) speed of the molecules in an ideal gas V_0 at temperature T_0 and pressure p_0. Find the speed if (a) the temperature id raised from $T_0 = 293K \text{to} 573K$ (b) the pressure is doubled and $T = T_0$ (c) the

molecular weight of each of the gas molecules is tripled.

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44. (a) What is the average translational kinetic energy of a molecule of an ideal gas at temperature of $276 \circ C$?

(a) What is the total random translational kinetic energy of the molecules in one mole of this gas ?

(c) What is the rms speed of oxygen molecules at this temperature ?

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45. At $0^\circ C$ and $1.0 atm \left(= 1.01 \times 10^5 N/m^2 \right)$ pressure the densities of air, oxygen and nitrogen are $1.284 kg/m^3$, $1.429 kg/m^3$ and $1.251 kg/m^3$ respectively. Calculate the percentage of

nitrogen in the air from these data, assuming only these two gases to be present.

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46. An air bubble of $20cm^3$ volume is at the bottom of a lake $40m$ deep where the temperature is $4^\circ C$. The bubble rises to the surface which is at a temperature of $20^\circ C$. Take the temperature to be the same as that of the surrounding water and find its volume just before it reaches the surface.

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47. For a certain gas the heat capcity at constant pressure is greater than that at constant volume by $29.1 J / K$.

(a) How many moles of the gas are there ?

(b) if the gas is monatomic, what are heat capacities at constant volume and pressure ?

(c) If the gas molecules are diatomic which rotate but do nit vibrate, what are heat capacities at constant volume and at constant pressure.

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48. The heat capacity at constant volume of a monoatomic gas is $35j/K$. Find

(a) the number of moles

(b) the internal energy at $0^\circ C$.

(c) the molar heat capacity at constant pressure.

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Level 2 Single Correct

1. Two thermally insulated vessel 1 and 2 are filled with air at temperature (T_1T_2), $volume(V_1V_2)$ and pressure (P_1P_2) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be

A. $T_1 + T_2$

B. $(T_1 + T_2)/2$

C. $\dfrac{T_1T_2(V_1 + V_2)}{p_1V_1T_2 + p_2V_2T_1}$.

D. $\dfrac{T_1T_2(p_1V_1 + p_2V_2)}{p_1V_1T_2 + p_2V_2T_1}$.

Answer: C

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2. Two marks on a glass rod $10cm$ apart are found to increase their distance by $0.08mm$ when the rod is heated from $0^\circ C\text{to}100^\circ C$. A flask made of the same glass as that of rod measures a volume of $100\text{at}0^\circ C$. The volume it measures at $100^\circ C$ in (cc) is.

A. 100.24

B. 100.12

C. 100.36

D. 100.48

Answer: A

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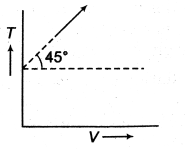
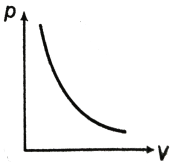
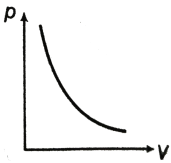
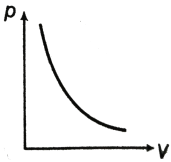
3. The given curve represents the variation of temperatue as a function of volume for one mole of an ideal gas. Which of the following curves best represents the variation of

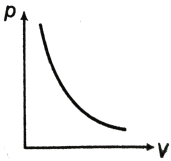
pressure as a function of volume ?



A. (a) 

B. (a) 

C. (a) 

D. (a) 

Answer: A

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4. A gas is found to be obeyed the law $p^2V = cons\tan t$. The initial temperature and volume are T_0 and V_0. If the gas expands to a volume $3V_0$, then the final temperature becomes.

A. $\sqrt{3}T_0$

B. $\sqrt{2}T_0$.

C. $\frac{T_0}{\sqrt{3}}$.

D. $\frac{T_0}{\sqrt{2}}$.

Answer: A

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5. Air fills a rooms in winter at $7^\circ C$ and in summer st $37^\circ C$. If the pressure is the same in winter and summer, the ratio of the weight of the air filled in winter and that in summer is.

A. 2.2

B. 1.75

C. 1.1

D. 3.3

Answer: C

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6. Three closed vessels A, B and C are at the same temperature T and contain gasses which obey the Maxwellian distribution of velocities. Vessel A contain only O_2 and N_2. If the

average speed of the O_2 molecules in vessel A is v_1 that of the N_2 molecules in vessel B us v_2, the average speed of the O_2 molecules in vessel C is

A. $\frac{(v_1 + v_2)}{2}$

B. V_1

C. $\sqrt{v_1 v_2}$

D. None of these

Answer: B

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7. In a very good vacuum system in the laboratory, the vacuum attained was $10^{-13} atm$. If the temperature of the system was $300K$, the number of molecules present in a volume of $1cm^3$ is.

A. 2.4×10^6

B. 24

C. 2.4×10^9

D. zero

Answer: A

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8. If nitrogen gas molecule goes straight up with its rms speed at $0^{\circ}C$ from the surface of the earth and there are no collisions with other molecules, then it will rise to an approximate height of.

A. $8km$

B. $12km$

C. $12m$

D. $8m$

Answer: B

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9. The given (p - U) graph shows the variation of internal energy of an ideal gas with increase in pressure. Which of the following pressure - volume graph is equivalent to this graph ?

A. (a)

(##DCP_V03_C20_E01_106_Q01##).

B. (b)

(##DCP_V03_C20_E01_106_Q01##).

C. (c)

(##DCP_V03_C20_E01_106_Q01##).

D. (d)

(##DCP_V03_C20_E01_106_Q01##).

Answer: B

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10. $28g \text{of} N_2$ gas is contained in a flask at a pressure of $10atm$ and at a temperature of $57^\circ C$. It is found that due to leakage in the flask, the pressure is reduced to half and the temperature to $27^\circ C$. The quantity of N_2 gas that leaked out is.

A. $11/20g$

B. $20/11g$

C. $5/63g$

D. $63/5g$

Answer: D

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11. A mixture of $4g$ of hydrogen and $8g$ of helium at (NTP) has a dencity about.

A. $0.22kg/m^3$

B. $0.62kg/m^3$

C. $1.12kg/m^3$

D. $0.13 kg / m^3$

Answer: D

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12. The pressure (p) and the dencity ρ of given mass of a gas expressed by Boyle's law, $p = K\rho$ holds true.

A. for any gas under any condition

B. for same gas under any condition

C. Only if the tamperature is kept constant.

D. None of these

Answer: C

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Level 2 More Than One Correct

1. During an experiment, an ideal gas is found to obey a condition $\frac{p^2}{\rho} = \text{constant}$. ($\rho$ = density of the gas). The gas is initially at

temperature (T), pressure (p) and density ρ. The gas expands such that density changes to $\rho/2$.

A. The pressure of the gas changes to $\sqrt{2}p$.

B. The temperature of the gas changes to $\sqrt{2}T$

C. The graph of the above process on (p - T) diagram is parabola.

D. The graph of the above process on (p - T) diagram is hyperbola.

Answer: B::D

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2. During an experiment, an ideal gas is found to obey a condition $Vp^2 =$ constant. The gas is initially at a temperature (T), pressure (p) and volume (V). The gas expands to volume (4V).

A. The pressure of gas changes to $\frac{p}{2}$

B. The temperature of the gas changes to $4T$

C. The graph of the above process on (p - T) diagram is parabola.

D. The graph of the above process on (p - T) diagram is hyperbola.

Answer: A::D

Watch Video Solution

3. find the correct options.

A. Ice point in Fahrenheit scale is $32^\circ F$

B. Ice point in Fahrenheit scale is $98.8^\circ F$

C. Steam point in Fahrenheit scale is $212^\circ F$

D. Steam point in Fahrenheit scale is $252^\circ F$

Answer: A::C

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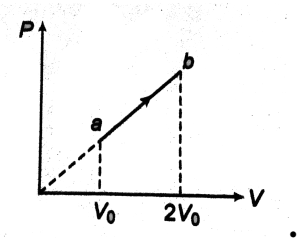
4. In the (p - V) diagram shown in figure, choose the correct options for the the process (a - b) :



A. debsity of gas reduced to half

B. temperature of gas has increased to two times.

C. internal energy of gas has increased to four times

D. (T - V)graph is a parabola passing thriugh origin

Answer: A::C::D

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5. Choose the wrong options

A. Translational kinetic energy of all ideal gases at same temperature is same.

B. In one degree of freedom all ideal gases has interal energy = $\frac{1}{2}RT$

C. Translational degree of freedom of all ideal gases is three

D. Translational kinetic energy of one mole of all ideal gases is $\frac{3}{2}RT$

Answer: A::B

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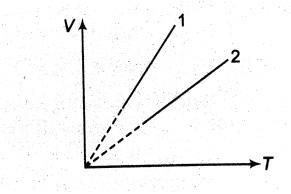
6. Along the line - 1, mass of gas m_1 and pressure is p_1. Along the line - 2 mass of same gas is m_2 and pressure is p_2. Choose the correct options.



A. m_1 may be less than m_2

B. $m_2 maybe \leq ssthan$m_(1)`

C. p_1 may be less than p_2

D. p_2 may be less than p_1

Answer: A::B::C::D

Watch Video Solution

7. Choose the correct options.

A. In $p = \frac{m}{M}RT$, (m) is mass of gas per unit volume.

B. In $pV = \frac{m}{M}RT$, (m) is mass of one molecule of gas.

C. In $p = \frac{1}{3}\frac{mN}{V}v_{rms}^2$, (m) is total mass of gas.

D. In $v_{rms} = \frac{\sqrt{3kT}}{m}$, (m) is mass of one molecule of gas.

Answer: A::D

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Level 2 Subjective

1. Show that the volume thermal expansion coefficient for an ideal gas at constant pressure is $\frac{1}{T}$.

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2. The volume of a diatomic gas $(\gamma = 7/5)$ is increased two times in a polytropic process with molar heat capacity $C = R$. How many times will the rate of collision of molecules against the wall of the vessel be reduced as a result of this process?

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3. A perfectly conducting vessel of volume $V = 0.4m^3$ contains an ideal gas at constant temperature $T = 273K$. A portion of the gas is let out and the pressure of the falls by $\Delta p = 0.24atm$. (Density of the gas at (STP) is $\rho = 1.2kg/m^3$). Find the mass of the gas which escapes from the vessel.

Watch Video Solution

4. A thin - walled cylinder of mass (m), height (h) and cross- sectional area (A) is filled with a gas and floats on the surface of water. As a result of leakage from the lower part of the cylinder, the depth of its submergence has increased by Δh. Find the initial pressure p_1 of the gas in the cylinder if the atmospheric pressure is p_0 and the temperature remains constant.

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5. find the minimum attainable pressure of an ideal gs in the process $T = t_0 + \propto V^2$, where $T_0 n$ and α are positive constants and (V) is the volume of one mole of gas.

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6. A solid body floats in a liquid at a temperature $t = 50^\circ C$ being completely submerged in it. What percentage of the volume of the body is submerged in the liquid after it is cooled to $t_0 = 0^\circ C$, if the coefficient

of cubic expansion for the solid is $\gamma_s = 0.3 \times 10^{-5}.^\circ C^{-1}$ and of the liquid $\gamma_l = 8 \times 10^{-5}.^\circ C^{-1}$.

Watch Video Solution

7. Two vessel connected by a pipe with a sliding plug contain mercury. In one vessel, the height of murcury column is $39.2cm$ and its temperature is $0^\circ C$, while in the other, the height of mercury column is $40cm$ and its temperature is $100^\circ C$. Find the coefficient if

cubical expansion for mercury. The volume of the connecting pipe should be neglected.

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8. Two steel rods and an aluminium rod of equal length l_0 and equal cross- section are joined rigidly at their ends as shown in the figure below. All the rods are in a state of zero tension at $0^\circ C$. Find the length of the system when the temperature is raised to θ. Coefficient of linear expansion of aluminium

and steel are α_a and α_s respectively. Young's modulus of aluminium is Y_a and of steel is Y_s.

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9. A metal rod (A) of $25cm$ length expands by $0.050cm$ when its temperature is raised from $0^\circ C$ to $100^\circ C$. Another rod (B) of a different metal of length $40cm$ expamds by $0.040cm$ for the same rise in temperature. A third rod (C) of $50cm$ length is made up of pieces of rods (A) and (B) placed end to end expands by

$0.03cm$ on heating from $0^\circ C$. Find the lengths of each portion of the composite rod.

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