Class: 11
Subject: Physics
Topic: ASK15E11UT06
No. of Questions: 30

1: An ideal gas (γ = 1.5) is expanded adiabatically. How many times has the gas to be expanded to reduce the root mean square velocity of molecules 2.0 times

(A) 4 times (B) 16 times

(C) 8 times (D) 2 times

Ans. (B)

Solution:

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\therefore \quad V_{rms} \propto \sqrt{T}$$

V_{rms} is to reduce two times i.e, temperature of the gas will have to reduce four times or

$$\frac{T'}{T} = \frac{1}{4}$$

During adiabatic process

$$TV^{\gamma-1} = T'V'^{\gamma-1}$$

or, $$\frac{V'}{V} = \left(\frac{T}{T'}\right)^{\frac{1}{\gamma-1}} = (4)^{\frac{1}{1.5-1}} = 4^2 = 16$$

$$\therefore \quad V' = 16V$$

Hence, (B) is correct

2: A thin copper wire of length L increases in length by 1% when heated from $0^{o}C$ to $100^{o}C$. If a thin copper plate of area $2L \times L$ is heated from $0^{o}C$ to $100^{o}C$, the percentage increase in its area will be

(A) 1% (B) 2%

(C) 3% (D) 4%

Ans. (b)

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$L = L_o\,[1+\alpha\Delta\theta]$

$\Delta L = L_o\ \alpha\ \Delta\theta$

$\frac{\Delta L}{L_o} = \alpha\Delta\theta$

$\therefore\ \alpha\Delta\theta$ = percentage increase in length = $\frac{1}{100}$

$\therefore\ L = L_o\left(1+\frac{1}{100}\right)$

Hence $2L^2 = 2L_o{}^2\left(1+\frac{1}{100}\right)^2$

$2L^2 - 2L_o^2 \approx 2L_o^2 \times \frac{2}{100}$

or $\frac{\Delta A}{2L_o^2} = \frac{2}{100} = 2\%$

Hence, (B) is correct

3: Gas at pressure P_o is contained in a vessel. If the masses of all the molecules are doubled and their speed is halved, the resulting pressure P will be equal to

(A) $2P_o$ (B) $P_o/4$

(C) P_o (D) $P_o/2$

Ans. (d)

$P_o = \frac{1}{3}\left(\frac{mn}{v}\right)v_{rms}^2$

$P = \frac{1}{3}\left(\frac{m'n}{v}\right)v_{rms}'^2$

where $m' = 2m,\ v'_{rms} = \frac{v_{rms}}{2}$

putting the value

$$\therefore \qquad \frac{P}{P_o} = \frac{m'v'^2_{rms}}{mv^2_{rms}} = \frac{2m}{m}\frac{v^2_{rms}}{4 \times v^2_{rms}} = \frac{1}{2}$$

$P = P_o/2$

4: The molar heat capacity in a process of a diatomic gas if it does a work of Q/4, when Q amount of heat is supplied to it is

(A) $\frac{2}{5}R$ (B) $\frac{5}{2}R$

(C) $\frac{10}{3}R$ (D) $\frac{6}{7}R$

Ans. (C)

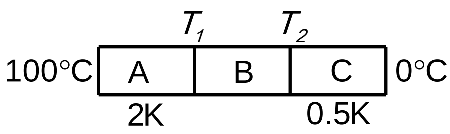
$dU = C_V\, dT = \left(\frac{5}{2}R\right)dT \Rightarrow dT = \frac{2(dU)}{5R}$

From 1st law of thermodynamics $dU = dQ - dW$ or $dU = Q - \frac{Q}{4} = \frac{3Q}{4}$

Now molar heat capacity $C = \frac{dQ}{dT} = \frac{Q}{2\left(\frac{dU}{5R}\right)} = \frac{5QR}{2\left(\frac{3Q}{4}\right)} = \frac{10}{3}R$

Hence (C) is correct

5. Three identical rods A,B and C of equal lengths and equal diameters are joined is series as shown in following fig. Their thermal conductivities are 2K,K and K/2 respectively. Calculate the temperature at two junction points.



(A) 85.7, 57.1°C (B) 80.85, 50.3°C

(C) 77.33, 48.3°C (D) 75.8,49.3°C

Solution: (A)

$i_{th\,1} = i_{th\,2} = i_{th\,3}$

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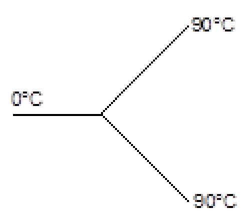
$$\frac{(100-T_1)2KA}{l} = \frac{(T_1-T_2)KA}{l} = \frac{(T_2-0)KA}{2l}$$

$(100 – T_1) = (T_1 – T_2) = \frac{T_2}{2}$ $\qquad T_1 = \frac{3T_2}{2}$

$(100 – T_1) = \frac{T_1}{3}$

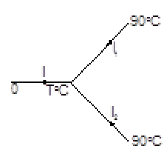
r $\qquad T_1 = \frac{600}{7} = 85.7°C$ and $T_2 = \frac{2T_1}{3} = \frac{2\times 85.7}{3} = 57.1°C$

6: Three rods made of the same material ane having the same cross-section have been joined as shown in. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of the junction of the three rods



(A) 45°C $\qquad$ (B) 60°C
(C) 30°C $\qquad$ (D) 20°C

Solution:



$I=I_1+I_2$

$$\frac{kA(90-T)}{l} + \frac{(90-t)kA}{l} = \frac{(t-0)kA}{l}$$

or $\qquad$ 3T = 180°C or T = 60°C

7: A solid copper sphere (density p and specific heat C) of radius r at an initial temperature 200 K is suspended inside a chamber whose walls are at almost 0 K. What is the required for temperature of the sphere to drop to 100 K?

(A) $\frac{7rpc\ ´\ 10^{-6}}{72es}$ $\qquad$ (B) $\frac{7rpc\ ´\ 10^{-8}}{72es}$

(C) $\frac{7rpc \times 10^{-10}}{72e\sigma}$ (D) $\frac{7rpc \times 10^{+6}}{72e\sigma}$

Solution: (A)

According to Stefan's law $P = eA\sigma T^4$

$$\frac{dQ}{dt} = \frac{-mcdT}{dt} = eA\sigma T^4 \text{ or } \frac{-dt}{dr} = \frac{-eA\sigma t^4}{mc}$$

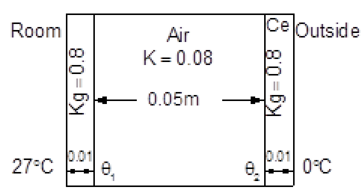
$$\frac{-dT}{dt} = \frac{e4\pi r^2\sigma T^4}{\frac{p4\pi rc^3}{3}} \text{ or } \frac{rpc}{3e\sigma}\int\frac{dT}{T^4} = \int_o^t dt$$

or $$t = \frac{rpc}{9e\sigma}\left|\frac{1}{T^3}\right|_{200}^{100} = \frac{7rpc \times 10^{-6}}{72e\sigma} \text{ seconds}$$

8: A double pane window used for insulating a room thermally from outside consists of two glass sheets each pf area 1 m^2 and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state the room glass interface and glass outdoor interface are at 27°C and 0°C respectively. Calculate the rate of flow of heat through the windowpane. Also find the flow of heat through the windowpane. Also find the temperature of other interface if, conductivities of glass and air are 0.8 and 0.08 $Wm^{-1} K^{-1}$ respectively.

(A) 0.72°C (B) 0.52°C
(C) 0.192°C (D) 0.32°C

Solution: (B)



$$\frac{dQ}{dt} = \frac{KA\Delta\theta}{L} = \frac{\Delta\theta}{R}$$

$$R_{eq} = \sum\frac{L}{KA} = \frac{1}{A}\left[\frac{0.01}{0.8}\times 2 + \frac{0.05}{0.08}\right]$$

$$A = 1\ m^2\ R_{eq} = \frac{1}{40} + \frac{5}{8} = \frac{26}{40}$$

$$\frac{dQ}{dt} = \frac{\Delta\theta}{R} = \frac{(27-0)\times 40}{26} = 41.5\ W$$

$$41.5 = 0.8 \times 1^2\ \frac{27-\theta_1}{0.01} \text{ or } \theta_1 = 26.48°C$$

$$41.5 = \frac{0.8\times 1^2(\theta_2 - 0)}{0.01} \text{ or } \theta_2 = 0.52°C$$

9: For an ideal gas:

(A) The change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to $nC_v (T_2 - T_1)$, where C_v is the molar specific heat at constant volume and n the number of moles of the gas.

(B) The change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process.

(C) The internal energy does not change in an isothermal process.

(D) No heat is added or removed in an adiabatic process.

(A) A, B (B) A, B, C

(C) A, B, C, D (D) A, C

Solution: (C)

Change in internal energy depends only on change in temperature since internal energy is a function of state only i.e. $dU = nC_v, dT$.

In adiabatic process, $dQ = 0$,

Hence, $dU + dW = 0 \Rightarrow dU = -dW$

i.e. magnitude of change in internal energy is equal to magnitude of work done.

10: Heat is supplied to a diatomic gas at constant pressure. The ratio of $\Delta Q : \Delta U : \Delta W$ is

(A) 5:3:2 (B) 5:2:3

(C) 7:5:2 (D) 7:2:5

Ans. (C)

Solution:

$$\Delta Q = nC_P dT = \frac{7}{2}nR(\Delta T), \qquad \left[C_P = \frac{7}{2}R\right]$$

$\Delta U = nC_V \Delta T = \frac{5}{2} nR\Delta T$, $\left[C_V = \frac{5}{2}R\right]$

and $\Delta W = \Delta Q - \Delta U = nR\Delta T$

$\therefore \ \Delta Q : \Delta U : \Delta W = 7 : 5 : 2$

Hence, C is correct

11: Two mole of argon are mixed with one mole of hydrogen, then C_p/C_v for the mixture is nearly

(A) 1.2 (B) 1.3

(C) 1.4 (D) 1.5

Ans.(C)

Solution:

Average degree of freedom

$f_{av} = \frac{2 \times 3 + 1 \times 5}{2 + 3} = \frac{11}{5}$

$\gamma_{mix} = 1 + \frac{1}{f_{av}} = 1 + \frac{5}{11} = \frac{16}{11} = 1.4$

Hence, C is correct Answer.

12: An ideal gas is taken through the cycle A→ B→C→ A as shown in figure. If the net heat supplied to the gas in the cycle is 5J, the work done by the gas in the process C→A is,

(A) -5J (B) -10J

(C) -15J (D) -20J

Solution: (A)

$\Delta Q_{net} = \Delta W_{net} = \Delta W_{CA} + \Delta W_{AB}$

$5 = \Delta W_{CA} + 10 \times (2 - 1)$

$5 - 10 = \Delta W_{CA}$

$\Delta W_{CA} = -5$

13: When an ideal gas at pressure P, temperature T and volume V is isothermally compressed to a V/n, its pressure becomes P_i .If the gas is compressed adiabatically to V/n, its pressure becomes P_a. The ratio P_i / P_a is

(A) 1 (B) n

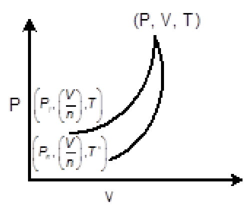
(C) n^{γ} (D) $n^{1-\gamma}$

Solution: (D)

For isothermal process, PV = constant. Therefore

$P_iV_i = PV$ or $P_i \frac{V}{n} = PV$ or $P_i = nP$ ……(i)

For adiabatic process, PV^{γ} = constant. Therefore



γ $P_a (V_a)^{\gamma} = PV^{\gamma}$ or $P_a\left(\frac{V}{n}\right)^{\gamma} = PV^{\gamma}$

or $P_a = n^{\gamma}P$ …..(ii)

From (i) and (ii) we get

$$\frac{P_i}{P_a} = \frac{n}{n^{\gamma}} = n^{(1-\gamma)}$$

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14 It is desired to put an iron rim on a wooden wheel. The diameter of the wheel is 1.1000m and the inside diameter of the rim is 1.0980 m. If the rim is at 20°C initially, to what temperature must it be heated to just fit onto the wheel?

(A) 52°C (B) 72°C
(C) 102°C (D) 152°C

Solution: (D)

α for iron is found to be 1.2×10^{-5} °C^{-1}.

$\Delta L = 1.1000 - 1.0980 = 0.0020 \text{ m} = \alpha L \, \Delta t$

$0.0020 = (1.2 \times 10^{-5})(1.098) \, \Delta t$

$\Delta t + 20 = 172°C$

$\Delta t = 152°C$

15. Find the coefficient of volume expansion for an ideal gas at constant pressure.

(A) $\gamma = \frac{1}{T}$ (B) $g = T$
(C) $g = \frac{1}{T^2}$ (D) $g = \frac{1}{T^3}$

Solution: (A)

For an idea gas PV= nRT

As P is constant, we have

P.dV = nRdT

$$\frac{dV}{dT} = \frac{nR}{P}$$

$$\gamma = \frac{1}{V}\frac{dV}{dT} = \frac{nR}{PV} = \frac{nR}{nRT} = \frac{1}{T}$$

$$\gamma = \frac{1}{T}$$

16. What should be the lengths of steel and copper rod so that the length of steel rod is 5cm longer then the copper rod at all the temperatures. Coefficients of linear expansion for copper and steel are 1.7 and 1.1

(A) 2.17, 14.17 cm (B) 9.17, 14.17 cm
(C) 9.17, 18.17 cm (D) 3.17, 5.17 cm

Solution: (B)

It is given that the difference in length of the two rods is always 5 cm. Thus the expansion in both the rods must be same for all temperatures. Thus we can say that at all temperature differences, we have

$\Delta L_{Cu} = \Delta L_{steel}$

or $\alpha_{Cu} l_1 \Delta t = \alpha_{st} l_2 \Delta t$ [If l_1 and l_2 are the initial lengths of Cu and steel rods]

or $\alpha_{Cu} l_1 = \alpha_{st} l_2$

or $1.7 l_1 = 1.1 l_2$ .....(1)

It is given that $l_2 - l_1 = 5\text{cm}$ ....(2)

$\left(\frac{1.7}{1.1} - 1\right) l_1 = 5\text{cm}$

or $l_1 = \frac{5 \times 1.1}{0.6} = 9.17\text{cm}$

Now from equation (2) $l_2 = 14.17$ cm

17. A steel wire of cross-sectional area 0.5 mm^2 is held between two rigid clamps so that it is just taut at 20^oC. Find the tension in the wire at 0^oC. Given that Young's modulus of steel is $Y_{st} = 2.1 \times 10^{12}$ dynes / cm^2 and coefficient of linear expansion of steel is $\alpha_{st} = 1.1 \times 10^{-5}\ {}^oC$.

(A) 2.31×10^{-4} (B) 2.31×10^{-2}
(C) 9.31×10^{-6} (D) 2.31×10^{-6}

Solution: (D)

We know that due to drop in temperature, then tension increment in a clamped wire is

$T = YA\ \alpha\Delta T = 2.1 \times 10^{12} \times 0.5 \times 10^{-2} \times 1.1 \times 10^{-5} \times 20 = 2.31 \times 10^{-6}$

18. Two bodies have the same heat capacity. If they are combined to form a single composite body, show that the equivalent specific heat of this composite body is independent of the masses of the individual bodies.

(A) $\frac{2s_1 s_2}{s_2 - s_1}$ (B) $\frac{s_1 s_2}{s_2 + s_1}$

(C) $\frac{2s_1s_2}{s_2+s_1}$ (D) $\frac{s_2}{s_2+s_1}$

Solution: (C)

Let the two bodies have masses m_1, m_2 and specific heats s_1 and s_2 then

$m_1s_1 = m_2s_2$

or $m_1/m_2 = s_2/s_1$

Let s = specific heat of the composite body.

Then $(m_1 + m_2)\, s = m_1s_1 + m_2s_2 = 2m_1s_1$

$$s = \frac{2m_1s_1}{m_1+m_2} = \frac{2m_1s_1}{m_1+m_1(s_1/s_2)} = \frac{2s_1s_2}{s_2+s_1}$$

19: When an ideal monatomic gas is heated at constant pressure, the fraction of heat energy supplied which increases the internal energy of the gas is

(A) 2/5 (B) 3/5

(C) 3/7 (D) 3/4

Solution: (B)

$$\Delta U = \frac{nR\Delta T}{\gamma - 1}$$

$$\Delta U = \frac{\Delta w}{\gamma - 1} \qquad [\Delta w = nR\Delta T]$$

$$= \frac{\Delta Q - \Delta U}{\gamma - 1} \qquad [\because \Delta Q = \Delta W + \Delta U]$$

$$\Delta U(\gamma - 1) = \Delta Q - \Delta U$$

$$\Delta U[\gamma - 1 + 1] = \Delta Q$$

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$$\frac{\Delta U}{\Delta Q} = \frac{1}{\gamma} = \frac{3}{5}$$ [for monoatomic gas $\gamma = 5/3$]

20: A monatomic ideal gas, initially at temperature T_1 is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then T_1/T_2 is given by

(A) $(L_1/L_2)^{2/3}$ (B) L_1/L_2

(C) L_2/L_1 (D) $(L_2/L_1)^{2/3}$

Solution: (D)

$$TV^{\gamma-1} = constant$$

Initial position $T_1(L_1A)^{\gamma-1}$ = constant

Final position $T_2\,(L_2A)^{\gamma-1}$ = constant

$$\therefore\ \frac{T_1}{T_2}\left(\frac{L_1}{L_2}\right)^{\gamma-1} = 1$$

$$\frac{T_1}{T_2} = \left(\frac{L_2}{L_1}\right)^{\gamma-1}$$

$$= \left(\frac{L_2}{L_1}\right)^{5/3-1}$$ [for monoatomic gas $\because\ \gamma = 5/3$]

$$= \left(\frac{L_2}{L_1}\right)^{2/3}$$

21: An ideal mono atomic gas at 300K expands adiabatically to twice its volume. What is the fine temperature

(A) 189K (B) 289K

(C) 30Kj (D) Non of these

Solution: (A)

$$TV^{\gamma-1} = constant$$

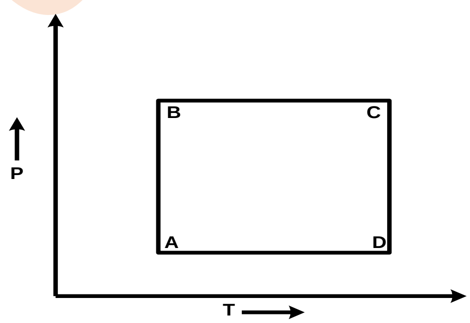
$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$300\,V_1^{\gamma-1} = T_2\left(2V_1\right)^{\gamma-1}$$

$$300 = T_2 \times 2^{\gamma-1}$$

$$T_2 = \frac{300}{2^{\gamma-1}} = \frac{300}{2^{5/3-1}} = \frac{300}{2^{2/3}} = \frac{300}{1.587} \approx 189K$$

22: What will be P-V graph corresponding to the P-T graph (process AB) for an ideal gas shown in figure



(A) Hyperbolic (B) Circle

(C) Straight line (D) Elliptical

Solution: (A)

23: One mole of argon is heated using $PV^{5/2}$ = const. By which amount of heat is obtained by the process when the temperature change by ΔT = -26K.

(A) 100J (B) 200J

(C) 108J (D) 208J

Solution: (C)

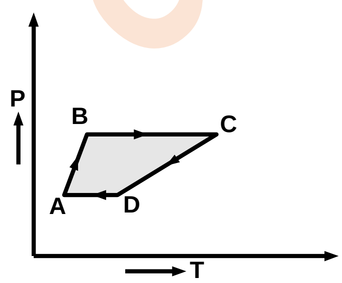
Here n = 1

$$C = \frac{R}{\gamma - 1} + \frac{R}{1 - x} \qquad [For\ polytropic\ process]$$

$$C = \frac{R}{5/3 - 1} + \frac{R}{\left(1 - \frac{3}{2}\right)}$$

$$\Delta Q = nC\Delta T = 1\left(\frac{3}{2}R - 2R\right)(-26) = 108J$$

24: 3 moles of an ideal monoatmic gas performs a cycle as shown in the fig. The gas temperatures T_1 = 400K, T_2 = 800K, T_3 = 2400K, T_4 = 1200K. What will be the net work done.



(A) 20J (B) 20000J

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(C) 200J (D) 2000J

Solution: (B)

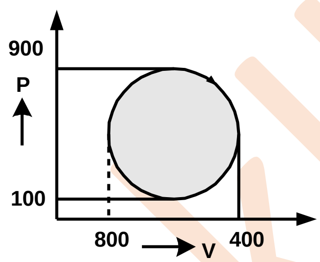
$W_{AB} = C_{CD} = 0$, because process is isochoric.

$W_{AD} = nR\Delta T = 3R(T_A - T_B) = 3 \times 8.31\ (2400 - 800) = 39884$

$\therefore$ Total work done $W_{AD} + W_{BC} = 39888 - 19944 = 20 \times 10^3 J = 19944$

$\approx 20 \times 10^3 J$

25: How much heat is absorbed by the system in going through the process shown in the fig. (consider that value is taken in SI system)



(A) 20.4×10^4 J (B) 30.4×10^4 J

(C) 21.4×10^4 J (D) 25.12×10^4 J

Solution: (D)

Work done = Area of PV diagram

$= \frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$

$= \frac{\pi}{4}(800)400$

$= 800 \times 100 \times 3.14$

$= 8 \times 10^4 \times 3.14$

$= 25.12 \times 10^4$

26: 3000J of heat is given to a gas at constant pressure of 2×10^5 N/m^2. If its volume increases by 10 litres during the process, what will be the change in the internal energy of the gas

(A) 1000J (B) 100J

(C) 200J (D) 2000J

Solution: (A)

$\Delta Q = 3000J$

$P = 2 \times 10^5 = V_i$

$V_f = (V_i + 10 \times 10^{-3})$

$W = Pdv$

$W = 2 \times 10^5 \times 10 \times 10^{-3} = 2 \times 10^3$

$\Delta Q = \Delta W + \Delta U$

$3000 = 2 \times 10^3 + \Delta U$

$\Delta Q = 1000$

27: A gas at atmospheric pressure is contained in a cylinder of volume 80 litre. When it is compressed adiabatically to 20 litre its pressure rises to 7 atm. What will be the ratio of specific heats of the gas

(A) 1.33 (B) 1.4

(C) 1.67 (D) 1.5

Solution: (B)

P_i = 1atm = 1×10^5 N/m^2

$V_i = 80 \times 10^{-3}$m^3

$V_f = 20 \times 10^{-3}$ m^3

P_f = 7atm = 7×10^5 N/m^2

$P_iV_i^\gamma = P_fV_f^\gamma$

$1 \times 10^5 \times (80 \times 10^{-3})^\gamma = (7 \times 10^5)(20 \times 10^{-3})^\gamma$

$$\left(\frac{80\times10^{-3}}{20\times10^{-3}}\right)^\gamma = 7$$

$$(4)^\gamma = 7$$

$$\gamma\log 4 = \log 7$$

$$\gamma = \frac{\log 7}{\log 4} = 1.40$$

28 A gas consisting of rigid diatomic molecules was initially under standard conditions. Then gas was compressed adiabatically to one fifth of its initial volume. What will be the mean kinetic energy of a rotating molecule in the final state?

(A) 1.44 J (B) 4.55J

(C) 787.98×10^{-23} (D) 757.3×10^{-23}J

Solution: (C)

$$\gamma = 1.4$$

$$TV^{\gamma-1} = \text{constant}$$

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$(300)V_1^{7/5-1} = T_2\left(\frac{V_1}{5}\right)^{\frac{7}{5}-1}$$

$$T_2 = \frac{300\times V_1^{2/5}}{V_1^{2/5}\times\left(\frac{1}{5}\right)^{2/5}} = \frac{300}{5^{-2/5}} = 300\times5^{2/5} = 300\times(1.903) = 571$$

Mean kinetic energy of rotating molecules = KT = $1.38 \times 10^{-23} \times 571$

KT = 787.98×10^{-23}

29 Immediately after the explosion of an atom bomb, the ball of fire produced has a radius of 100m and a temperature 105K . What will be the approximate temperature when the ball expands adiabatically to a radius of 1000m (suppose mono atomic gas is there)

(A) 1000K (B) 100K

(C) $105 \times (10^{-3})^{2/3}$ (D) 200K

Solution: (C)

r = 100 m

$\Rightarrow \quad V_i = \frac{4}{3}\pi(100)^3$

T_i = 105 K

after explosion r = 1000 m, $\Rightarrow$ $V_f = \frac{4}{3}\pi(1000)^3$

$$T_i V_i^{\gamma-1} = T_f V_f^{\gamma-1}$$

$$T_f = T_i\left(\frac{V_i}{V_f}\right)^{\gamma-1}$$

$$T_f = 105\left(\frac{\frac{4}{3}\pi(100)^3}{\frac{4}{3}\pi(1000)^3}\right)^{\frac{5}{3}-1}$$

$= 105 \times (10^{-3})^{2/3}$

= 1.05 K

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30. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic. Then

(A) $W_2 > W_1 > W_3$ (B) $W_2 > W_3 > W_1$

(C) $W_1 > W_2 > W_3$ (D) $W_1 > W_3 > W_2$

Solution: (A)