CHAPTER - 9
HEAT AND THERMODYNAMICS

SYNOPSIS

Temperature : Temperature of a body is that physical quantity which indicates degree of hotness or coldness of the body.

Heat : Heat is a form of energy. The natural flow of heat is from higher temperature to lower temperature.

Different types of temperature scales

Name of scale	Symbol	Lower fixed point	Upper fixed point	No. of divisions on the scale
Celsius	^0C	0^0C	100^0C	100
Fahrenheit	^0F	32^0F	212^0F	180
Kelvin	K	273 K	373K	100

Relationship between different scales $\frac{C}{100}=\frac{F-32}{180}=\frac{K-273}{100}$

At the following temperature different temperature scales have the same reading

$-40^0C = -40^0F$

$574.25^0F = 574.25K$

Celsius scale and Kelvin scale cannot have the same reading.

The Celsius and Kelvin scale have different zero points but the same size degrees.

Therefore any temperature difference is the same on the Celsius and Kelvin scales.

If f reading correspond to faulty thermometer and the true value then

$$\frac{t-\text{LFP of true scale}}{(\text{UFP}-\text{LFP})\text{ of true scale}}=\frac{f-\text{LFP of faulty scale}}{(\text{UFP}-\text{LFP})\text{ of faulty scale}}$$

Thermometry

A branch of science which deals with the measurement of temperature. The linear variation in some physical properties of a substance with change in temperature is the basic principle of thermometry and this properties are defined as thermometric property which are:

1. Volume of liquid - liquid thermometers
2. Pressure of a gas - constant volume gas thermometers
3. Electrical resistance - resistance thermometers
4. Thermoemf - thermoelectric thermometer

5. Intensity of light - radiation pyrometer
6. Magnetic property - magnetic thermometer

If X is the thermometric property then the unknown temperature $t = \left(\frac{X_t - X_0}{X_{100} - X_0}\right)$ x 100^0C

Thermal expansion in solids

The length, area and volume of a solid increases with increase in temperature as

$L_t = L_0(1+\alpha t)$ $\alpha \rightarrow$ coefficient of linear expansion

$A_t = A_0(1+\beta t)$ $\beta \rightarrow$ coefficient of superficial expansion

$V_t = V_0(1+\gamma t)$ $\gamma \rightarrow$ coefficient of cubical expansion

$\alpha:\beta:\gamma = 1:2:3$

For anisotropic solids $\gamma = \alpha_X + \alpha_Y + \alpha_Z$ where α_X, α_Y and α_Z represent coefficient of linear expansion along three mutually perpendicular directions.

For small change in temperature

$$\Delta L = L\alpha\Delta T,\ \Delta A = A\beta\ \Delta T,\ \Delta V = V\gamma\Delta T$$

Contraction on Heating

Some rubber like substances contract with rise in temperature because transverse vibration of atoms dominate over longitudinal vibrations which is responsible.

Effect of temperature on time period of pendulum

$$\frac{\Delta T}{T} = \frac{1}{2}\alpha\Delta t$$

If T = 1 sec Time loss/gain per day = $\frac{1}{2}\alpha\,\Delta t \times 86400\,\text{sec.}$

Thermal Stress in Rigid Fixed Rod

Thermal stress = $Y\ \alpha\Delta t$.

Thermal Expansion of Liquid

Since liquid can be heated only by heating the container along with the liquid the container also expands therefore apparent expansion of the liquid is not the real expansion. Thus a liquid has got 2 expansivities.

$$\gamma_r = \frac{\text{Real increase in volume}}{\text{Initial Volume} \times \text{change in temp.}} = \frac{(\Delta V)_r}{V \times \Delta\theta}$$

$$\gamma_a = \frac{\text{Apparent increase in volume}}{\text{Initial Volume} \times \Delta\theta} = \frac{(\Delta V)_a}{V \times \Delta\theta}$$

$$\gamma_r = \gamma_{app} + \gamma_{vessel}$$

Anomalous Expansion of Water

In the case of water it expands on heating if its temperature is greaten than 4°C. In the range 0°C to 4°C water contracts on heating and expands on cooling. This behaviour of water in the range of 0°C to 4°C is called anomalous expansion of water. Density of water is maximum a 4°C and volume minimum.

Variation of Density with Temperature

In the case of a substance it expands on heating therefore density decreases.

$$\rho = \frac{\rho_0}{1+\gamma\,\Delta\theta} = \rho_0\,(1-\gamma\,\Delta\theta)$$

Expansion of Gases

At constant pressure $V_t = V_0(1+\alpha t)$,

α Coefficient of volume expansion

At constant volume $P_t = P_0(1+\beta t)$,

β-Coefficient of pressure expansion

For an ideal gas $\alpha = \beta = \frac{1}{273}\,°C^{-1}$

Specific Heat C

It is the amount of heat required to raise the temperature of unit mass of a substance through 1°C or 1K expressed in J/kg°C or J/KgK

Sp: heat capacity of water = 4200/JKgK or 4.2J/gmK = 1cal/gm°C

Thermal capacity H

Amount of heat required to raise the temperature of a body by 1°C

H = mc J/°C

Water equivalent

The mass of water which has got the same thermal capacity as that of the substance

Water equivalent = $\frac{mc}{c_w}$

Dulong and petit law

Average molar sp:heat of all metals at room temperature is constant (except Be, B, C, Si)

Principle of mixtures

When two bodies at different temperature are placed in contact, heat will be transferred from a body at higher temperature to lower temperature until both reach a common temperature. Then

Heat lost by hot body = heat gained by cold body

Specific Heat of Gases (Molar Specific Heat)

Molar specific heat at constant volume C_V : The amount of heat required to raise the temperature of 1 mole of gas through 1°C or 1K keeping volume constant.

Molar specific heat at constant pressure C_p heat required to raise the temperature of 1 mole of gas through 1°C or 1K keeping pressure constant.

$C_P - C_V = R$ (Mayer's relation)

$$\frac{C_P}{C_V} = 1 + \frac{2}{f} = \gamma$$

f - degree of freedom

Latent heat

The Amount of heat required to change the state of unit mass of the substance

Latent heat of ice = 80 cal/g

Latent heat of steam = 536 cal/g

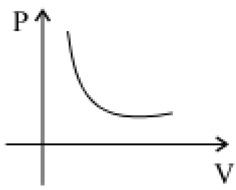
Solar constant : The amount of solar energy received in unit time by unit area of earth.

$S = 1400\ Wm^{-2}$

Kinetic theory of gases

Boyle's law

$V \alpha \frac{1}{P}$ at constant temperature for a given mass of ideal gas



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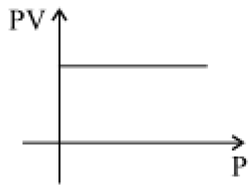
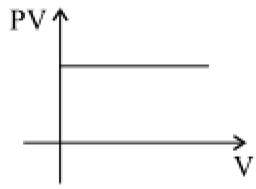
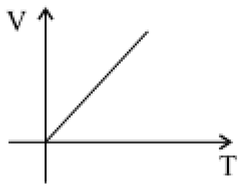




$P_1V_1 = P_2V_2$

Charle's Law

$V \alpha T$ at constant pressure for a given mass of ideal gas



For an ideal gas

$P\ \alpha T$ at constant volume

Avagadro's hypothesis

Equal volume of all gases under the same pressure and temperature contain equal no. of molecules.

Ideal gas equation

PV = nRT

$R = 8.31\ J\ mol^{-1}\ k^{-1} = 1.98\ cal\ mol^{-1}\ {}^0C^{-1} = 2\ cal\ mol^{-1}\ {}^0C^{-1}$

$\frac{R}{N} = k$

N $\rightarrow$ Avagadro number

R $\rightarrow$ universal gas constant

k $\rightarrow$ Boltzman's constant

Kinetic theory of gases

Root mean square velocity $C_{rms} = \sqrt{\dfrac{C_1^2 + C_2^2 + ...C_n^2}{n}}$

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

Average speed = $C_{av} = \dfrac{C_1 + C_2 + ... + C_n}{n}$; $C_{av} = \sqrt{\dfrac{8RT}{\pi M}}$

Most probable speed $C_{mp} = \sqrt{\dfrac{2RT}{M}}$

Mean free path $\lambda = \dfrac{1}{\sqrt{2}\pi d^2 n}$; $\lambda \ \alpha \dfrac{T}{P}$

d $\rightarrow$ diameter of molecule

n $\rightarrow$ no. of molecules per unit volume

Pressure exerted by a gas

$$P = \frac{1}{3}\rho C_{rms}^2$$

KE of a gas : - KE is equally divided between degree of freedoms (Equipartition theorem)

KE of a molecule / degree of freedom = $\dfrac{1}{2}kT$

KE of one mole / degree of freedom = $\dfrac{1}{2}RT$

Total kinetic energy for one molecule = $\dfrac{n}{2}kT$

Total kinetic energy for one mole = $\dfrac{n}{2}RT$

where 'n' is the no. of degrees of freedom.

THERMODYNAMICS

Thermodynamics deals with processes involving heat, work and internal energy.

System: It is a portion of matter under consideration.

Surroundings: Anything outside the system which has got some bearing on the behaviour of the system.

1. Open system $\rightarrow$ can exchange matter and energy with surroundings
2. Closed system $\rightarrow$ can exchange only energy
3. Isolated system $\rightarrow$ cannot exchange matter and energy.

First law of thermodynamics

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

$\Delta Q \rightarrow$ heat absorbed or released

$\Delta U \rightarrow$ change in internal energy

$\Delta W \rightarrow$ work done

$\rightarrow$ work done by the system is taken as positive

$\rightarrow$ work done on the system is taken as negative

$\rightarrow$ heat absorbed is taken as positive

$\rightarrow$ heat released is taken as negative

Work done by a thermodynamic system

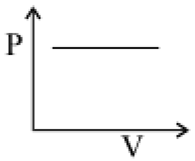
$$W = \int_{V_1}^{V_2} PdV$$

Thermodynamic Processes

Thermodynamic equilibrium $\rightarrow$ If the system is in mechanical equilibrium, thermal equilibrium and chemical equilibrium it is said to be in thermodynamic equilibrium.

Quasistatic Process $\rightarrow$ A process in which all the states through which the system passes can be considered as thermodynamic equilibrium is known as a quasistatic process.

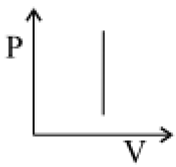
Isobaric Process - Constant Pressure



$$W = P(V_2 - V_1)$$

Isochoric Process - Constant Volume

Work Done = 0

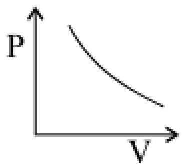


Isothermal Process - Constant Temperature

$\Delta U = 0$

$\Delta Q = W$

PV = constant

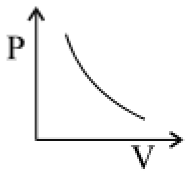


$$W = 2.303nRT\log\left(V_2/V_1\right) = 2.303nRT\log\left(P_1/P_2\right)$$

Isothermal bulkmodulus of elasticity = P

Adiabatic Process $\rightarrow$ No heat exchange between system and surroundings.

$\Delta Q = 0$, $\Delta U = -W$



equation of state

$PV^{\gamma} = \text{constant}$

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

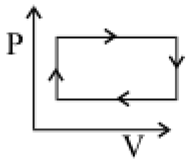
$T^{\gamma}P^{1-\gamma} = \text{constant}$

Work done $W = \frac{nR}{\gamma - 1}(T_1 - T_2)$

→ The slope of adiabatic is γ times that of isothermal.

→ Adiabatic bulkmodulus of elasticity = γP

Cyclic Process



$\Delta U = 0; \quad \Delta Q = W$

Work done in cyclic process is the area of cyclic loop.

Critical temperature: Temperature below which alone the gas can be liquified by the mere application of pressure.

Critical Pressure: The minimum pressure that should be applied to the gas at its critical temperature in order to liquify it.

Critical Volume: Volume at critical temperature and pressure.

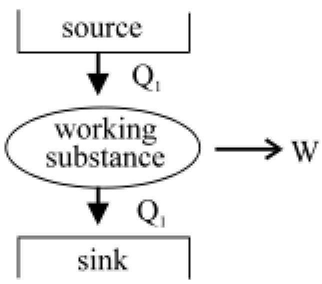
Triple point → It is a point on the P - T plane at which the solid, liquid and vapour states of a substance co exist in dynamic equilibrium.

Second law of thermodynamics

Kelvin statement: It is impossible to get a continuous supply of work from a body by cooling it to a temperature lower than its surroundings.

Clausius statement: It is impossible for a self acting machine to transfer heat from a body at a lower temperature to a body at a higher temperature.

Carnot's heat engine

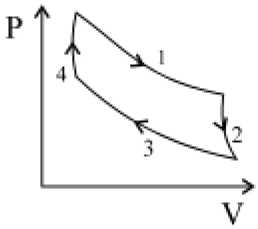


$W = Q_1 - Q_2$

$\eta = \frac{W}{Q_1} = 1 - \frac{Q_2}{Q_1}$

$\eta = 1 - \frac{T_2}{T_1}$

Carnot's cycle:



1. Isothermal expansion
2. Adiabatic expansion
3. Isothermal compression
4. Adiabatic compression

Refrigerator

Coefficient of performance $\beta=\frac{Q_2}{W}=\frac{T_2}{T_1-T_2}$

Heat Transfer

There are three modes of heat transfer

1. Conduction 2. Convection 3. Radiation

Conduction

In conduction heat flows from a region of high temperature to a region of low temperature with out the transport of matter. Heat imparted to any part of a body sets the molecules of that part into more energetic vibrations. These molecules transmit the vibrations to their neighbours and heat travels along the body from molecules to molecules.

Convection :

Heat flows along with the transport of matter. It is possible only in fluids. Trade winds, Land breeze and sea breeze and monsoon are due to convection.

Radiation :

In radiation heat does not require any material medium. It travels in the form of electromagnetic radiation

Law of heat conduction

$$\frac{\Delta Q}{\Delta t}=kA\left(\frac{\Delta T}{\Delta x}\right)$$

A $\rightarrow$ cross sectional area of the slab

$\Delta x \rightarrow$ thickness of slab

$\Delta T \rightarrow$ difference in temperature between ends

$\frac{\Delta Q}{\Delta t} \rightarrow$ rate of heat flow

k $\rightarrow$ thermal conductivity

$\frac{\Delta T}{\Delta x} \rightarrow$ temperature gradient

Thermal conductance = $\frac{KA}{l}$; Thermal resistance = $\frac{l}{KA}$

If two conductors are connected in series equivalent thermal resistance $R = R_1 + R_2$

Connected in parallel $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$

Properties of heat radiations

$\rightarrow$ Radiant heat travels with the speed of light

$\rightarrow$ It travels along a straight line

$\rightarrow$ It can be reflected as well as refracted like light rays

$\rightarrow$ Intensity of heat radiations decreases in inverse square proportionality with distance

$\rightarrow$ It shows the phenomenon of interference, diffraction and polarisation

Perfectly black body : A body which absorbs all radiation incident on it.

Absorptive power (a) : The ratio of radiant energy absorbed to the total energy incident on it.

$a \leq 1$

a = 1 for perfectly black body

Emissive power : Energy emitted per unit area per unit time by a body

Kirchoff's law :

$$\frac{\text{emissive power}}{\text{absorptive power}} = \text{constant} \Rightarrow \text{ a good emitter is a good absorber}$$

Stefan's law

Radiant energy emitted by a black body per unit area per second is proportional to fourth power of absolute temperature T.

$E \; \alpha \; T^4$; $E = \sigma T^4$

$\sigma = 5.68 \times 10^{-8}\, Wm^{-2}K^{-4}$

Stefan - Boltzman law

Net radiant energy lost from a black body per unit area per unit time, $E\,\alpha\left(T^4 - T_0^4\right)$, $T_0 \rightarrow$ temp of surroundings

Wien's displacement law

The wavelength of maximum spectral intensity is inversely proportional to the absolute temperature of the body

$\lambda_m \alpha \frac{1}{T}$; $\lambda_m T = b$ Wien's constant

b = 0.29 cm K

Newton's law of cooling

When the temperature difference between the body and its surroundings is not very large, then the rate of cooling is directly proportional to the temperature difference.

$$\frac{\theta_1 - \theta_2}{t} \alpha \left(\frac{\theta_1 + \theta_2}{2}\right) - \theta_0$$

$\theta_1 \rightarrow$ initial temperature of the body

$\theta_2 \rightarrow$ final temperature of the body

$t \rightarrow$ time taken to cool from θ_1 to θ_2

$\theta_0 \rightarrow$ temperature of surroundings

PART I - JEEMAIN

SECTION - I - Straight objective type questions

1. An iron piece is heated from 30^0C to 90^0C. Find the change in its temperature on the Fahrenheit and the kevlin scale.
   1) 108 and 60 2) 60 and 108 3) 100 and 50 4) 50 and 40

2. An isosceles triangle is formed with a rod of length l_1 and coefficient of linear expansion α_1 for the base and two thin rods each of length ℓ_2 and coefficient of linear expansion α_2 for the two pieces, if the distance between the apex and the midpoint of the base remain unchanged as the temperature is varied, then $\frac{\ell_1}{\ell_2} =$

1) $2\frac{\alpha_2}{\alpha_1}$ 2) $2\sqrt{\frac{\alpha_2}{\alpha_1}}$ 3) $\sqrt{\frac{\alpha_1}{\alpha_2}}$ 4) $4\sqrt{\frac{\alpha_1}{\alpha_2}}$

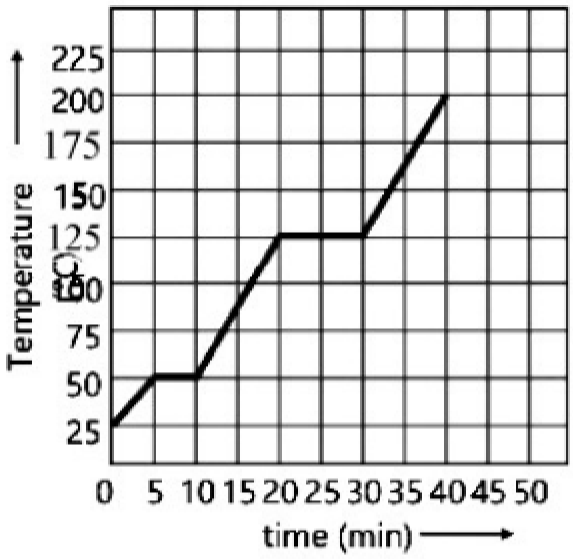
3. A glass flask of volume 1 litre at 0^0C is filled, level full of mercury at this temperature. The flask and mercury are now heated to 100^0C. How much mercury will spill out, if coefficient of volume expansion of mercury is $1.82\times10^{-4}/{}^0C$ and linear expansion of glass is $0.1\times10^{-4}/{}^0C$ respectively?

1) 21.2 cc 2) 15.2 cc 3) 1.52 cc 4) 2.12 cc

4. Two liquids are at temperature 20^0C and 40^0C when same mass of both of them is mixed, the temperature of the mixture is 32^0C. What is the ratio of their specific heat:

1) $\frac{1}{3}$ 2) $\frac{2}{3}$ 3) $\frac{1}{5}$ 4) $\frac{2}{5}$

5. The graph shown in the figure represent change in the temperature of 5kg of a substance as it absorbs heat at a constant rate of 63 kJ min^{-1}. The latent heat of vaporization of the substance is:

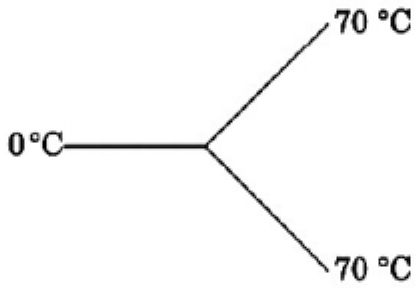


1) 630 kJ kg^{-1} 2) 126 kJ kg^{-1} 3) 84 kJ kg^{-1} 4) 12.6 kJ kg^{-1}

6. 10 kg of ice at -10^0C is mixed with 40 kg of water at 45^0C. The final temperature of mixture is: (specific heat of ice = 2100 J/kg -k)

1) 19^0C 2) 17^0C 3) 15^0C 4) 13^0C

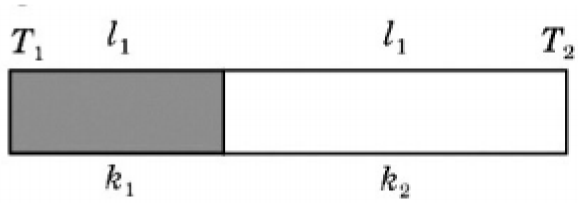
7. Three rods of same material and of equal cross sectional area and length have been connected together as shown in the figure.



The temperature of the junction of the rods approximately is

1) 35^0C 2) 47^0C 3) 51^0C 4) 57^0C

8. One end of a thermally insulated rod is kept at a temperature T_1 and the other at T_2. The rod is composed of two sections of lengths l_1 and l_2 and thermal conductivities k_1 and k_2 respectively. The temperature at the interface of the two sections is



1) $(k_2l_2T_1 + k_1l_1 T_2) / (k_1l_1 + k_2l_2)$ 2) $(k_2l_2T_1 + k_1l_1T_2)/(k_2l_1 + k_1l_2)$
3) $(k_1l_2T_1 + k_2l_1T_2)/ (k_1l_2 + k_2l_1)$ 4) $(k_1l_1T_1 + k_2l_2T_2)/(k_1l_1 + k_2l_2)$

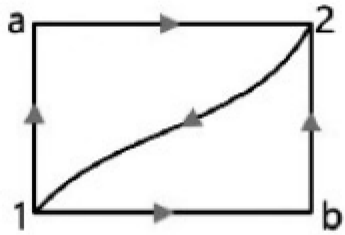
9. Hot water cools from 60^0C to 50^0C in the first 10 minutes and to 42^0C in the next 10 minutes. The temperature of the surroundings is:

1) 25^0C 2) 10^0C 3) 15^0C 4) 20^0C

10. The power radiated by a black body is P and it radiates maximum energy at wavelength λ_0. If the temperature of the blackbody is now changed so that it radiates maximum energy at wavelength $\frac{3}{4}\lambda_0$, the power radiated by it becomes nP. The value of *n* is

1) $\frac{256}{81}$ 2) $\frac{4}{3}$ 3) $\frac{3}{4}$ 4) $\frac{81}{256}$

11. When a system is taken from state 1 to 2 along the path 1a2 it absorbes 50 cal of heat and work done is 20 cal. Along the path 1b2, Q=36 cal. What is the wotk done along 1b2?

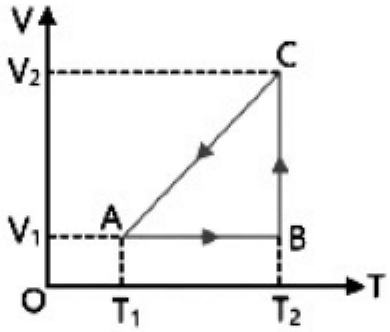


1) 56 cal 2) 66 cal 3) 16 cal 4) 6 cal

12. The ratio of work done by an ideal diatomic gas to the heat supplied by the gas in an isobaric process is

1) $\frac{5}{7}$ 2) $\frac{3}{5}$ 3) $\frac{2}{5}$ 4) $\frac{5}{3}$

13. A cyclic process for 1 mole of an ideal gas is shown in figure in the V-T, diagram. The work done in AB, BC and CA respectively



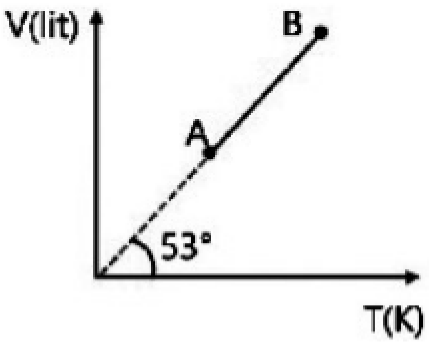
1) $0, RT_2 \ln\left(\frac{V_1}{V_2}\right), R(T_1 - T_2)$ 2) $R(T_1 - T_2), 0, RT_1 \ln\frac{V_1}{V_2}$

3) $0, RT_2 \ln\left(\frac{V_2}{V_1}\right), R(T_1 - T_2)$ 4) $0, RT_2 \ln\left(\frac{V_2}{V_1}\right), R(T_2 - T_1)$

14. The volume of a poly-atomic gas $\left(\gamma = \frac{4}{3}\right)$ compressed adiabatically to $\frac{1}{8}^{th}$ of the original volume. If the original pressure of the gas is P_0 the new pressure will be:-

1) $8P_0$ 2) $16 P_0$ 3) $6P_0$ 4) $2P_0$

15. V-T curve for 2 moles of a gas is straight line as shown in the graph here. Find the pressure of gas at A.



1) 125 N/m^2 2) $1.25 \times 10^4 N/m^2$ 3) 225 N/m^2 4) $2.25 \times 10^4 N/m^2$

SECTION - II
Numerical Type Questions

16. The density of upper atmosphere is very low of the order of $10^{14}m^{-3}$. Assuming the average diameter of air molecule as $\sqrt{\frac{35}{\pi}}\overset{0}{A}$, the approximate mean free path of air molecules in (in km)

17. A vessel contains 28gm of N_2 and 32 gm of O_2 at temperature T = 1800K and pressure 2atm. Find the pressure if N_2 dissociates 30% and $)_2$ dissociates 50% if temperature remains constant. (in atm)

PART - II (JEE ADVANCED)

SECTION - III (Only one option correct type)

18. A faulty thermometer has the fixed points marked as 10^0 and 90^0. Temperature of a body as measured by the faulty thermometer is the correct temperature of the body on celsius scale. The temperature of body is

A) 60^0C B) 55^0C C) 50^0C D) 52^0C

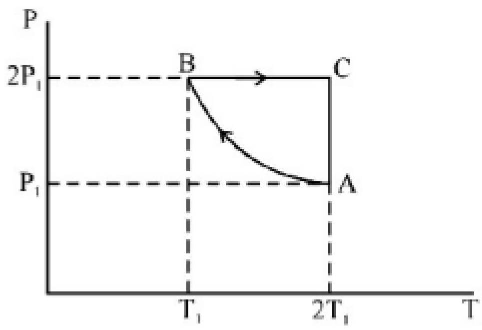
19. A vertical U-tube contains a liquid. When the two arms are maintained at different temperature 50^0C and 60^0C, the levels of liquid in the two arms are 49 cm and 50 cm respectively. The coefficient of volume expansion of the liquid is

A) $1.2\times10^{-3}\ {}^0C^{-1}$ B) $1.4\times10^{-3}\ {}^0C^{-1}$ C) $2.3\times10^{-3}\ {}^0C^{-1}$ D) $1.8\times10^{-3}\ {}^0C^{-1}$

20. 2 kg of ice at -20 ^0C is mixed with 5kg of water at 20 ^0C in an insulating vessel having a negligible heat capacity. Assuming that the specific heat of water, ice and latent heat of ice respectively are 1 $kcalkg^{-1}$ $(^0C^{-1})$, 0.5 $kcalkg^{-1}$ $(^0C^{-1})$ and 80 $kcalkg^{-1}$, then the final mass of water (in kg) left in the container is

A) 2 B) 3 C) 0 D) 12

21. Two moles of an ideal monoatomic gas is taken through a cycle ABCA as shown. During process AB, pressure and temperature of the gas vary such that PT = a constant.

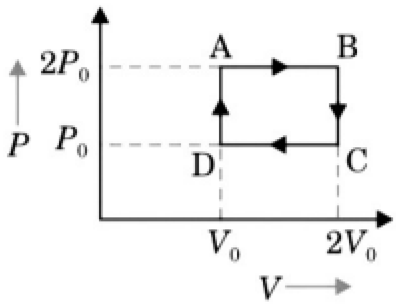


i) Work done during process AB is $-4RT_1$

ii) Heat energy released/absorbed in process AB is $7RT_1$

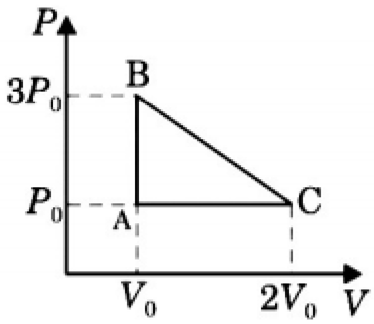
A) only i is correct B) only ii is correct C) both are correct D) both are incorrect

22. Helium gas goes through a cycle ABCDA (consisting of two isochoric and two isobaric lines) as shown in figure. Efficiency of this cycle is nearly:



A) 12.5% B) 15.4% C) 9.1 % D) 10.5%

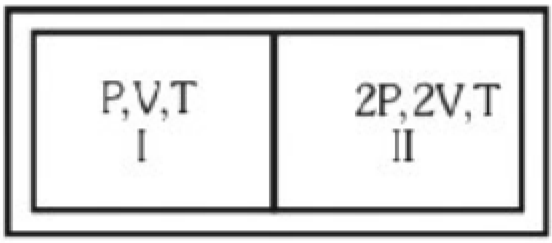
23. One mole of an ideal monoatomic gas is taken along the path ABCA as shown in the PV diagram. The maximum temperature attained by the gas along the path BC is given by



A) $\frac{25}{4}\frac{P_0V_0}{R}$ B) $\frac{5}{8}\frac{P_0V_0}{R}$ C) $\frac{25}{8}\frac{P_0V_0}{R}$ D) $\frac{25}{16}\frac{P_0V_0}{R}$

SECTION - IV (More than one correct answer)

24. A parition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameter are given. The parition is a conducting wall which can move freely without friction. Which of the following statements is/are correct with reference to the final equilibrium position?



A) The pressure in the two compartments are equal

B) Volume of compartment I is $\frac{3V}{5}$

C) Volume of compartment II is $\frac{12V}{5}$

D) Final pressure in compartment I is $\frac{5P}{3}$

25. A closed vessel contains a mixture of two diatomic gases A and B. Molar mass of A is 16 times that of B and mass of gas A, contained in the vessel is 2 times that of B. Which of the following statements is/are correct?

A) Average kinetic energy per molecule of A is equal to that of B

B) Root mean square value of translational velocity of B is four times that of A

C) Pressure exerted by B is eight times of that exerted by A

D) Number of molecules of B in the cylinder is eight times that of A

26. A container holds 10^{26} molecule.m^3, each of mass $3\times10^{-27}\,kg$. Assume that $\frac{1}{6}$ of the molecules move with velocity 2000 ms^{-1} directly toward one wall of the container while the remaining $\frac{5}{6}$ of the molecules move either away from the wall or in perpendicular direction, and all collisions of the molecules with the wall are elastic:

A) Number of molecules hitting 1m^2 of the wall every second is $\frac{1}{3}\times10^{29}$

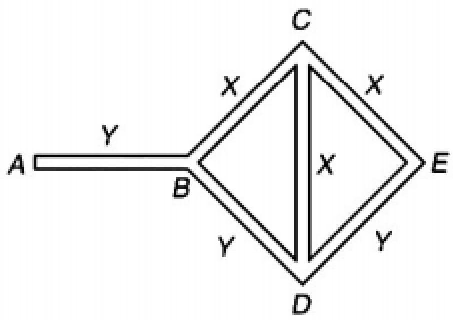
B) Number of molecules hitting 1m^3 of the wall every second is 2×10^{29}

C) Pressure exerted on the wall by molecules is $24\times10^{5}\,Nm^{-2}$

D) Pressure exerted on the wall by molecules is $4\times10^{5}\,Nm^{-2}$

SECTION - V (Numerical Type - Upto two decimal place)

27. Three rods of material X and three rods of material Y are connected as shown in figure.



All rods have Identified lengths and cross-sectional areas. If the end A is maintained at 60^{0}C and the junction L at 10^{0}C, calculate the temperature of junction B. The thermal conductivity of X is $9.2\times10^{-2}\,kcalm^{-1}s^{-1}C^{-1}$ and that of Y is $4.6\times10^{-2}\ kcalm^{-1}s^{-1}\ {}^0C^{-1}$

28. A block having some emissivity is maintained at 500K temperature in a surrounding of 300K temperature. It is observed that, to maintain the temperature of the block, 210W external power is required to be supplied to it. If instead of this block is black body of same geometry and size is used, 700W external power is required for the same. Calculate the emissivity of the material of the block

29. 1 mole of an ideal monoatomic gas is expanded till the temperature of the gas is doubkled under the process V^2T = constant. The initial temperature of the gas is 400K. Calculate the total work done in the process is given by -nR, then n is

30. A uniform tube closed at one end, contains a pallet of mercury 10cm long. When the tube is kept vertically wiht the closed end of teh tube upward, the length of air column trapped by mercury and the closed end of the tube is 20cm. If the tube is inverted so that its open end becomes upward. Find the final length of the air column trapped. Take atmospheric pressure to be 76 cm of *Hg*.