PHYSICS

BOOKS - DHANPAT RAI & CO PHYSICS (HINGLISH)

HEAT

Type A

1. A faulty thermometer has its fixed points marked as 5° and 95°. The temperature of a bady as measured by the faulty therature is 59°.

Find the correct temperature of the body on Celsisus scale.

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

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Example

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

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2. The triple point of neon and carbon dioxide are $24.57K$ and $216.55K$ respectively. Express these temperature on the Celsius and Fahrenheit scales.

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3. Two absolute scales A and B have triple points of water defined to be $200A$ and $350B$. What is the relation between T_A and T_B?

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4. A constant volume gas thermometer using helium records a pressure of $20.0kPa$ at the triple-point of water, and pressure of $14.3kPa$ at the temperature of 'dry ice' (solid CO_2). What is the temperature of 'dry ice' ?

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5. Two ideal gas thermometer A and B use oxygen and hydrogen respectively . The following observations are made:

Temperature, Pressure therometer A, Pressure therometer B

Triple point of water, $1.250 \times 10^5 Pa$, $0.200 \times 10^5 Pa$

Normal melting point of sulphur, $1.797 \times 10^5 Pa$,

$0.287 \times 10^5 Pa$

(a) What is the absolute temperature of normal melting point of sulphur as read by thermometers A and B ?

(b) What do you think is the reason for the slightly different answers from A and B ? (The thermometers are not faulty). what further procedure is needed in the experiment to reduce the discrepancy between the two readings.

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6. A plantinum wire has resistance of 10Ω at $0^\circ C$ and 20Ω at $273^\circ C$. Find the value of coefficient of resistance.

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7. The resistance of a resistance thermometer at $19^\circ C$ is 3.50Ω and at $99^\circ C$ is 3.66Ω. At what temperature will its resistance be $4.\ 30\Omega$?

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8. The electrical resistance in ohms of a certain thermometer varies with temperature ac cording to the approximate law: $R = R_0[1 + \alpha(T - T_0)]$ The resistances is 101.6Ω at the triple-point of water $273.16K$, and 165.5Ω at the normal melting point of lead $(600.5K)$. What is the temperature when the resistance is 123.4Ω?

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9. A hole is drilled in a copper sheet. The diameter of the hole is $4.24cm$ at $27.0^\circ C$. What is the change in the diameter of the hole when the sheet is heated to $227^{0}C$? α for copper $= 1.70 \times 10^{-5}K^{-1}$

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10. A steel tape $1m$ long is correctly calibrated for a temperature of $27.0^{\circ}C$. The length of a steel rod measured by this tape is found to be $63.0cm$ on a hot day when the temperature is $45^{\circ}C$. Coefficient of linear expansion of steel $= 1.20 \times 10^{-5}/K$. what is the actual length of the steel rod on that day?

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11. a large steel wheel is to be fitted on to a shaft of the same material. At $27^{\circ} C$, the outer diameter of the shaft is $8.70 cm$ and the diameter of the central hole in the wheel is $8.69 cm$. The shaft is cooled using 'dry ice' , At what temperature of the shaft does the wheel slip on the shaft? Assume coefficient of linear expansion of the steel to be constant over the required temperature range: $\alpha_{steel} = 1.20 \times 10^{-5} K^{-1}$.

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12. A brass rod of length 50 cm and diameter 3.0 mm is joined to a steel rod of the same length and diameter. What is the change in length of the combined rod at $250^{\circ} C$, if the original lengths are at $40.0^{\circ} C$? Is there a 'thermal stress' developed at the junction ? The ends of the rod are free to expand. Coefficient of linear expansion of brass $= 2.0 \times 10^{-5} . ^{\circ} C^{-1}$ and that of steel $= 1.2 \times 10^{-5} . ^{\circ} C^{-1}$.

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13. A steel scale measures the length of a copper wire as $80.0cm$ when both area at $20^{\circ}C$ (the calibration temperature for scale). What would be the scale read for the length of the wire when both are at $40^{\circ}C$? (Given $\alpha_{\text{steel}} = 11 \times 10^{-6} per^{\circ}C$ and $\alpha_{\text{copper}} = 17 \times 10^{-6} per^{\circ}C$)

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14. Railway lines are laid with gaps to allow for expansion. If the gap betweeen steel rails 60 m long be 3.60 cm at $10^{\circ}C$, then at what temperature will the lines just touch? Coefficient of linear expansion of steel $= 11 \times 10^{-6} . ^\circ C^{-1}$

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15. A brass wire $1.8m$ long at $27^\circ C$ is held taut with little tension between two rigid supports. If the wire cooled to a temperature of $-39^\circ C$, what is the tension developed in the wire, if its diameter is $2.0mm$? Coefficient of linear expansion of brass $= 2.0 \times 10^{-5} / ^\circ C$, Young's modulus of brass $= 0.91 \times 10^{11} Pa$.

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16. The design of some physical instrument requires that there be a constant difference in length of 10 cm between an iron rod and a copper cylinder laid side by side at all temperature find their lengths

$$\left(\alpha_{Fe} = 11 \times 10^{6} .^{\circ} C^{-1}, \alpha_{Cu} = 17 \times 10^{-6} .^{\circ} C^{-1}\right)$$

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17. A metal ball $0.1m$ in radius is heated from 273 to 348 K. calculate the increase in surface area of the ball. Given coefficient of superficial expansion $= 0.000034K^{-1}$.

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18. An iron sphere has a radius of 10 cm at a temperature of $0^\circ C$. Calculate the change in the volume of the sphere, if it is heated to $100^\circ C$. Coefficient of linear expansion of iron $= 11 \times 10^{-6} . ^\circ C^{-1}$.

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19. On heating a glass block of $10,000 cm^3$ from $25^\circ C$ to $40^\circ C$, its volume increase by $4 cm^3$. Calculate coefficient of linear expansion of glass.

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20. The volume of a block of a metal changes by 0.12% when it is heated through $20^\circ C$. The coefficient of linear expansion of the metal is

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21. The coefficient of volume expansion of glycerine is $49 \times 10^{-5} / ^{\circ} C$. What is the fractional change in its density (approx.) for $30^{\circ} C$ rise in temperature?

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22. A piece of metal weighs 46 g in air and 30 g in lipuid of density $1.24 \times 10^{3} kgm^{-3}$ kept at $27^{0} C$. When the temperature of the liquid is raised to $42^{0} C$ the metal piece weights 30.5 g . The density of the liqued at $42^0 C$ is $1.20 \times 10^3 kgm^{-3}$.

Calculate the coefficient of linear expandsion of the metal.

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23. A hollow sphere and a solid sphere of equal radii and of same material are heated to raise their temperature by equal amounts. How will the change in their volume expansion be related?

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24. Density ρ, mass m and volume V are related as $\rho = m / V$. Prove that

$$\gamma = -\frac{1}{\rho}\frac{d\rho}{dT}.$$

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25. In a Joule's experiment, two weights of 5 kg each fall through a height of 3m and rotate a paddle wheel which stirs 0.1 kg water. What is the change in the temperature of the water ?

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26. A heavy box having a mass of 300 kg is moved along the floor for a distance of 10m. If the coefficient of sliding friction is 0.2m how many kcal of heat are produced ?

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27. A lead bullet weighing 20 g and moving with a velocity of $100ms^{-1}$ comes to rest in a fixed block of wood. Calculate the heat developed and the rise in temperature of the bullet assuming that the half of the heat is absorbed by the bulley. The specific heat of lead is $0.03 cal g^{-1} . ^{\circ} C^{-1}$.

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28. The height of Niagra falls is 50 m. Calculate the difference in temperature of water at the top and at the bottom of fall, if $J = 4.2 J cal^{-1}$.

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29. In Joule's experiment, a mass of 0.8 kg was allowed to fal through a height of 75 cm. The process was repeated 150 times and rise of temperature of $2.1^{\circ}C$ was observed. If the water equivalent of the calorimeter and its contents is 100g, find the value of J.

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30. How much height can a 60 kg mass climb by using energy from a slice of bread which produces 100,000cal ? Assume the efficiency of human body is 28%.

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31. During the Indo-Pakistan war, a soldier observed that the lead bullet fired by him just melted, when stopped by an obstacle. Assuming that whole of the kinetic energy of bullet got converted into heat energy, calculate the velocity of the bullet. Given that initial temperature of the bullet $= 47.6^\circ C$. Melting point of lead $321^\circ C$, specific heat of lead $= 0.3 cal g^{-1} . ^\circ C^{-1}$, latent heat of lead $= 6 cal g^{-1}$ and $J = 4.2 \times 10^7 erg cal^{-1}$.

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32. A closed card board tube is 50 cm in length an contains 200g of lead shots which occupy 2 cm of the length of the tube when it is held vertically. The tube is inverted quickly so that the end which was previously above is now below. This process is repeated 400 times. If the specific heat of lead is $0.32 cal g^{-1} . ^{\circ} C^{-1}$, calculate the rise in temperature of the lead shots.

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33. How much work in joule is done in producing heat necessary to convert 10g of ice at $-5^{\circ} C$

into steam at $100^{\circ} C$? Given specificheat of ice $= 0.5 cal g^{-1} . ^{\circ} C^{-1}$, latent heat of steam $= 540 cal g^{-1}$.

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34. A $10 kW$ drilling machine is used to drill a bore in a small aluminium block of mass $8.0 kg$. How much is the rise in temperature of the block in 2.5 minutes, assuming 50% of power is used up in heating the machine itself or lost to the surrounding? Specific heat of aluminium $= 0.91 J/g^{\circ} C$.

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35. In an experiment to determine the specific heat of a metal,a $0.20kg$ block of the metal at $150.^{\circ} C$ is dropped in a copper calorimeter (of water equivalent $0.025kg$) containing $150cm^3$ of water at $27.^{\circ} C$. The final temperature is $40.^{\circ} C$. The specific heat of the metal is.

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36. A child running a temperature of 101^{F} is given and antipyrin (i.e. a madicine that lowers fever) which cause an increase in the rate of evaporation of sweat from his body. If the fever is brought down to $98^{\circ}F$ in 20 min., what is the averatge rate of extra evaporation caused, by the drug ? Assume the evaporation mechanism to the only way by which heat is lost. The mass of the child is 30 kg. The specific heat of human body is approximately the same as that of water and latent heat of evaporation of water at that temperature is about $580 cal. g^{-1}$.

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37. A copper block of mass $2.5 kg$ is heated in a furnace to a temperature of $500^{\circ} C$ and then placed on a large ice block. What is the maximum amount (approx.) of ice that can melt? (Specific heat copper $= 0.39 J / g^{\circ} C$ heat of fusion of water $= 335 J / g$).

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38. A thermally isolated vessel contains 100g of water at $0^{\circ} C$ when air above the water is

pumped out, some of the water freezes and some evaporates at $0^{\circ} C$ itself. Calculate the mass at $0^{\circ} C = 2.10 \times 10^{6} j / kg$ and latent heat of fusion of ice $= 3.36 \times 10^{5} j / kg.$

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39. A cylinder of fixed capacity 44.8 litre contains helium gas at standard temperature and pressure. What is the amount of heat needed to raise the temperature of the gas in the cylinder by $15.0^{\circ} C$? $\left[R = 8.31 J mol^{-1} K(-1)\right]$

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40. Calculate the specific heat capacity at constant volume for a gas. Given specific heat capacity at constant pressure is $6.85 cal mol^{-1} K^{-1}, R = 8.31 J mol^{-1} K^{-1}$.

$J = 4.18 J cal^{-1}$.

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41. Calculate the difference between the two principal specific heats of 1g of helium gas at

S.T.P. Given atomic weight of helium = 4 and $J = 4.186 J cal^{-1}$ and $R = 8.31 J mol^{-1} K^{-1}$.

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42. For a gas, difference between two specific heats is 5000 J/ mole°C. If the ratio of specific heats is 1.6, the two specific heats in J/mole-°C are

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43. Specific heat of argon at constant pressure is $0.125 cal. g^{-1} K^{-1}$, and at constant volume

$0.075 cal. g^{-1} K^{-1}$. Calculate the density of argon at N.T.P. Given $J = 4.18 \times 10^7$ erg cal^{-1} and normal pressure = 1.01×10^6 dyne cm^{-2}.

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44. Calculate the value of c_v for air, given that $c_p = 0.23$ calorie $g^{-1} K^{-1}$. Density of the air at S.T.P. is 1.293 $glitre^{-1}$ and $J = 4.2 \times 10^7$ erg cal or ie^{-1}.

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45. For air, specific heat at constant pressure is $0.273 cal g^{-1} . ^{\circ} C^{-1}$ and specific heat at constant volume is $0.169 cal g^{-1} . ^{\circ} C^{-1}$, density of air $= 0.001293 g cm^{-3}$ at S.T.P. Calculate the value of J.

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46. Calculate the two specific heats of nitrogen from the following data : $\gamma = c_p / c_v = 1.51$ density of nitrogen at N.T.P $= 1.234 g litre^{-1}$ and $J = 4.2 \times 10^7 erg cal^{-1}$.

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47. An ideal gas has a molar heat capacity at constant pressure of $Cp = 2.5R$. The gas is kept in a closed vessel of volume $0.0083m^3$, at a temperature of $300K$ and a pressure of $1.6 \times 10^6 Nm^{-2}$. An amount $2.49 \times 10^4 J$ of heat energy is supplied to the gas. Calculate the final temperature and pressure of the gas.

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48. Calculate the internal energy of 1 gram of oxygen at NTP.

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49. Hydrogen is heated in a vessel to a temperature of 10,000K. Let each molecule posses an average energy E_1. A few molecules escape into the atmosphere at 300 K. Due to collisions, their energy changes to E_2. Calculate ratio E_1 / E_2.

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50. How many degrees of freedom are associated with 2 gram of helium at NTP ? Calculate the amount of heat energy required to raise the temp. Of this amount from $27^{\circ} C \rightarrow 127^{\circ} C$. Given Boltzmann constant $k_B = 1.38 \times 10^{-23}$ erg $\text{molecule}^{-1} K^{-1}$ and Avogadro's number $= 6.02 \times 10^{23}$.

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51. Calculate the limiting ratio of the internal energy possessed by helium and hydrogen gases at 10,000K.

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Type B

1. A steel bridge 200 m long exists in a locality, where temperature varies from 243 K to 313 K. Find the change in length of the bridge for this variation in temperature. Coefficient of linear expansion of steel is $11 \times 10^{-6} K^{-1}$.

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2. How much should the temperature of a brass rod be increased so as to increase its length by 1% ? Given α for brass is $0.00002 .^{\circ} C^{-1}$.

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Type C

1. A sheet of brass is 50 cm long and 10 cm broad at $0^\circ C$. The area of the surface increases by $1.9 cm^2$ at $100^\circ C$. Find the coefficient of linear expansion of bras.

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2. The original area of a metal plate is $100 cm^2$ at $20^\circ C$. If β for the metal is $0.000032^\circ C^{-1}$, then what is the area of the plate at $200^\circ C$?

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Type D

1. What is the horse power applied by a person while chewing 100g of ice per minute ? Given $J = 4.2$ joule per calorie.

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2. Calculate the horse power of a man who can chew ice at the rate of $60g \min .^{-1}$. Given $J = 4.2Jcal^{-1}$ and altent heat of ice $= 80calg^{-1}, 1hp = 746W$.

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Type E

1. A geyser heats water flowing at the rate of 3.0 litre per minute from $27^{\circ}C$ to $77^{\circ}C$. If the geyser operates on a gas burner and its heat of combustion is $4.0 \times 10^4 J/g$, then what is the rate of combusion of fuel (approx.)?

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Type F

1. What amount of heat must be supplied to $2 \times 10^{-2} Kg$ of nitrogen at room temperature to rise its temperature by $45^{\circ} C$ at constant pressure? Given molecular mass of nitrogen is 28 and $R = 8.3 J mole^{-1} K^{-1}$

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Type G

1. Calculate the number of degrees of freedom of molecules of hydrogen in 1 cc of hydrogen gas at NTP.

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Problem

1. A gas thermometer is used as a standard thermometer for measurement of temperature. When the gas container of the thermometer is immersed in water at its triple point $273.16K$, the pressure in the gas thermometer reads $3.0 \times 10^4 N/m^2$. When the gas container of the same thermometer is immersed in another system, the gas pressure reads $3.5 \times 10^4 N/m^2$. The temperature of this system is therefore __________. $^\circ C$.

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2. (a) The brass scale of a barometer gives correct reading at $0^\circ C$. Coefficient of linear expansion of brass is $2.0 \times 10^{-5} / ^\circ C$. The barometer reads $75 cm$ at $27^\circ C$. What is the atmospheric pressure at $27^{\circ} C$?

(b) A barometer reads $75.0 cm$ on a steel scale. The room temperature is $30^{\circ} C$. The scale is correctly graduated for $0^{\circ} C$. The coefficient of linear expansion of steel is $\alpha = 1.2 \times 10^{-5} / ^{\circ} C$ and the coefficient of volume expansion of mercury is $\gamma = 1.8 \times 10^{-4} / ^{\circ} C$. Find the correct atmospheric pressure.

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

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4. Two rods each of length L_2 and coefficient of linear expansion α_2 each are connected freely to a third rod of length L_1 and coefficient of expansion α_1 to form an isoscles triangle. The arrangement is supported on a knife-edge at the midpoint of L_1 which is horizontal. what relation must exist between L_1 and L_2 so that the apex of the isoscles triangle is to remain at a constant height from the knife edge as the temperature changes ?

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5. Two rods of equal cross sections, one of copper and the other of steel, are joined to form a composite rod of length 2.0 m at $20^\circ C$, the length of the copper rod is 0.5 m. When the temperature is raised to $120^\circ C$, the length of composite rod increases to 2.002m. If the composite rod is fixed between two rigid walls and thus not allowed to expand, it is found that the lengths of the component rods also do not change with increase in temperature. Calculate Young's moulus of steel. (The coefficient of linear expansion of copper, $\alpha_c = 1.6 \times 10^{-5 \circ} C$ and Young's modulus of copper is $1.3 \times 10^{13} N / m^2$).

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6. Water at Bhakra dam falls through a height of 210 m. Assuming that the whole of the energy due to fall is converted into heat, calculate the rise in temperature of water. Take $J = 4.2 J cal^{-1}$ and $g = 9.8 m s^{-2}$.

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7. The temperature of 100 g of water is to be raised from $24^{\circ} C$ to $90^{\circ} C$ by adding steam to it. Calculate the mass of the steam required for this purpose.

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8. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300K. The ratio of the average rorational kinetic energy per O_2 molecules to that per N_2 molecules is

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9. A gas mixture consists 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

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10. Two perfect gases at absolute temperature T_1 and T_2 are mixed. There is no loss of energy. The masses of the molecules are m_1 and m_2. The number of molecules in the gases are n_1 and n_2. The temperature of the mixture is

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11. One mole of a monoatomic gas is mixed with three moles of a diatomic gas. What is the

molecular specific heat of mixture at constant volume? $R = 8.31 J mol^{-1} K^{-1}$.

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12. $(1/2)$ mole of helium is contained in a container at STP how much heat energy is needed to double the pressure of the gas, keeping the volume constant? Heat capacity of gas is $3 J g^{-1} K^{-1}$.

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13. A gaseous mixture enclosed in a vessel consists of one gram mole of a gas A with $\gamma = \left(\frac{5}{3}\right)$ and some amount of gas B with $\gamma = \frac{7}{5}$ at a temperature T.

The gases A and B do not react with each other and are assumed to be ideal. Find the number of gram moles of the gas B if γ for the gaseous mixture is $\left(\frac{19}{13}\right)$.

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14. About 0.014 kg nitrogen is enclosed in a vessel at temperature of $27^{\circ} C$ How much heat has to be transferred to the gas to double the rms speed of its molecules ? $(R = 2cal / molK)$

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Problem For Self Practice

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

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2. An ungraduated thermometer of uniform bore is attached to a centimeter scale and is found to read $10.3cm$ in melting ice, 26.8 cm in boiling water and 6.5 cm in freezing mixture. Calculate the temperature of the freezing mixture.

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3. The normal temperature of the human body is $98.4^\circ F$.Calculcate this temperature on celsius scale and absolute scale.

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4. What is the triple point of water on a Fahrenheit scale ? What is the absolute zero on this scale ?

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5. when a thermometer is taken from the melting ice to a warm liquid, the mercury level rises to $\frac{2}{5}th$ of the distance between the lower and the upper fixed points. Find the temperature of liquid in $.^\circ C$ and K.

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6. The pressure of air in the bulb of constant volume air thermometer is 75 cm of mercury at $0^\circ C, 100cm$ at $100^\circ C$ and 80 cm at the room temperature. Calculate the room temperature.

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

(a) twice (b) half of Celsius ?

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

(a) twice (b) half of Celsius ?

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9. A constant volume thermometer registers o pressure of 1.500×10^4 Pa at the triple point of water and a pressure of 1.500×10^4 Pa at the normal boiling point. What is the temperature at the normal boiling point?

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10. The resistance of a certain platinum resistance thermometer is found to be 2.56Ω at $0^\circ C$ and 3.56Ω at $100^\circ C$. When the

thermometer is immersed in a given liquid, its resistance is observed to be 5.06Ω. The temperature of the liquid

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11. The resistances of a platinum resistane thermometer are $2.5\Omega, 4.0\Omega,$ and 7.3Ω at $0^{\circ}C, 100^{\circ}C$ at $t^{\circ}C$ respectively. Calculate t.

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12. The temperature coefficient of resistance of the material of a wire is $0.00125^\circ C^{-1}$. Its resistance at $27^\circ C$ is 1Ω. At what temperature will its resistance be 2Ω ?

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13. The resistance of a platinum resistance thermometer is 3.14Ω at $40^\circ C$ and 3.76Ω at $100^\circ C$. Calculate the temperature coefficient of resistance of platinum. What will be its resistance when the thermometer is immersed in melting ice ?

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14. A platinum resistancethermometer reads 0^0at the ice point and boiling point of water respectively. The resistance of a platnum wire varies with Celsius temperature θ as $R_t = R_0(1 + \alpha\theta + \beta\theta^2)$, where $\alpha = 3.8 \times 10^{-3} \, \hat{} \, 0C^{-1}$ and $\beta = -5.6 \times 10^{-7} \, \hat{} \, 0C^{-2}$. What will be the reading of this thermometer if it is pleaced in a liquid bath maintained at $50^0 C$?

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15. A copper bar is 80 cm long at $15^\circ C$. What is the increase in length, when heated to $35^\circ C$? The coefficient of linear expansion for copper is $1.7 \times 10^{-5} .^\circ C^{-1}$

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16. A metal rod measures 50 cm in length at $20^\circ C$. When it is heated to $95^\circ C$, the length becomes $50.06 cm$. What is the coefficient of linear expansion of rod ? What will be the length of the rod at $-20^\circ C$?

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17. Railway lines are laid with gaps to allow for expansion. If the gap betweeen steel rails 60 m long be 3.60 cm at $10^\circ C$, then at what temperature will the lines just touch? Coefficient of linear expansion of steel $= 11 \times 10^{-6} . ^{\circ} C^{-1}$

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18. A brass disc has a hole of diameter 2.5 cm at $27^{\circ} C$. Find the change in the diameter of the hole of the disc when heated to $327^{\circ} C$. Given coefficient of linear expansion of brass = $1.9 \times 10^{-5} . ^{\circ} C^{-1}$

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19. 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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20. A steel scale measures the length of a copper wire as $80.0cm$ when both area at $20^\circ C$ (the calibration temperature for scale). What would be the scale read for the length of the wire when both are at $40^\circ C$? (Given

$\alpha_{\text{steel}} = 11 \times 10^{-6} per^{\circ} C$ and

$\alpha_{\text{copper}} = 17 \times 10^{-6} per^{\circ} C$)

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21. A steel metre scale is to be ruled so that the millimetre intervals are accurate to within about 5×10^{-5}mm at a certain temperature. What is the maximum temperature variation allowable during the rulting ? Given α for steel $= 1.1 \times 10^{-5} .^{\circ} C^{-1}$.

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22. A steel scale is correct at $0^\circ C$. The length of a brass tube measured by it at $40^\circ C$ is $4.5m$. The correct length of the tube at $0^\circ C$ is (Coefficients of linear expansion of steel and brass are $11 \times 10^{-6 / \circ} C$ and $19 \times 10^{-6 / \circ} C$ respectively).

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23. If a cylinder of diameter $1.0cm$ at $30^\circ C$ is to be slid into a hole of diameter $0.9997cm$ in a steel plate at the same temperature, the minimum required rise in the temperature of the plate is: (Coefficient of linear expansion of steel

$= 12 \times 10^{-6 / \circ} C$)

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24. What should be the length of steel and copper rods at $0^\circ C$ that the length of steel rod is 5 cm longer than copper at all termperature?

Given $\alpha_{Cu} = 1.7 \times 10^5 . ^\circ C^{-1}$ and

$\alpha_{steel} = 1.1 \times 10^5 . ^\circ C^{-1}$.

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25. A clock while keeps correct time at $30^{\circ} C$ has a pendulum rod made of brass. The number of seconds it gains (or) looses per second when the temperature falls to $10^{\circ} C$ is [α of brass $= 18 \times 10^{-6 / \circ} C$]

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26. A steel wire 2mm in diameter is stretched between two clamps, when its temperature is $40^{\circ} C$ Calculate the tension in the wire, when its temperature falls to $30^{\circ} C$ Given, coefficient Y for steel $= 21 \times 10^{11} dyne / cm^2$, coefficient for steel= 11 x 10^(-6).

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27. A steel wire of length 20 cm and uniform cross-section $1mm^2$ is tied rigidly at both the ends. If the temperature of the wire is altered from $40^\circ C$ to $20^\circ C$, the change in tension. [Given coefficient of linear expansion of steel is $1.1 \times 10^5 .^\circ C^{-1}$ and Young's modulus for steel is $2.0 \times 10^{11} Nm^{-2}$]

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28. A sheet of brass is 40 cm long and 8 cm broad at $0^{\circ}C$. If the area at $100^{\circ}C$ is $320.1m^2$, calculate the coefficient of linear expansion of brass.

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29. A solid occupies 1000ml at $20^{\circ}C$. Its volume becomes 1016.2ml at $320^{\circ}C$. What is the value of coefficient of cubical and linear expansion ?

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30. The volume of a lead ball is 100 cc at 273K and 100.85cc at 273K. Calculate coefficient of cubical expansion.

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31. An iron sphere has a radius of 10 cm at a temperature of $0^{\circ} C$. Calculate the change in volume of the sphere if it is heated to $100^{\circ} C$. Given $\alpha_{Fe} = 1.1 \times 10^{-6} .^{\circ} C^{-1}$

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32. The volume of a metal sphere is increased by 1% of its original volume when it is heated from 320 K to 522 K. calculate the coefficients of linear, superficial and cubical expansion of the metal.

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33. The density of mercury is $13.6 gcm^{-3}$ at $0^{\circ} C$ and its coefficient of cubical expansion is $1.82 \times 10^{-4} . {}^{\circ} C^{-1}$. Calculate the density of merucury at $50^{\circ} C$.

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34. A glass flask of volume one litre at $0^{\circ}C$ is filled, level full of mercury at this temperature. The flask and mercury are now heated to $100^{\circ}C$. How much mercury will spill out if coefficient of volume expansion of mercury is $1.82 \times 10^{-4} / {}^{\circ}C$ and linear expansion of glass is $0.1 \times 10^{-4} / {}^{\circ}C$ respectively?

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35. A one litre flask contains some mercury. It is found that at different temperatures the volume of air inside the flask remains the same. The volume of mercury in the flask is $(\alpha_{glass} = 9 \times 10^{-6} / ^{\circ} C, \gamma_{Hg} = 180 \times 10^{-6} / ^{\circ} C)$

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36. From what height must a block of ice be dropped in order that it may melt completely. It is assumed that the whole of energy is retained by ice. Given that latent heat of ice $= 80 cal g^{-1}$.

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37. Calculate the difference in temperature of water at the top and the bottom of a water fall of 150 m height.

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38. From what height must a hailstone at $0^{\circ} C$ fall in order that it may melt on reaching the ground, assuming that 7% energy is lost during fal.

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39. Calculate the rise in temperature of water, which falls from a height of 100m. Assume that 80% of the energy due to fall is converted into heat and is retaied by the water. $J = 4.2 \times 10^7 ergcal^{-1}$.

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40. A lead bullet of mass 50g moving with a velocity of $100ms^{-1}$ strikes a target. If 40% of

the heat produced is retained by the bullet, calculate the rise in its temperature. Specific heat of lead $= 0.03 cal g^{-1} K^{-1}$ and $J = 4.2 J cal^{-1}$

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41. A lead bullet strikes a target with a velocity of $500 ms^{-1}$ and the bullet falls dead. Calculate the rise in temperature of the bullet assuming that 40% of the heat produced is used in heating the bullet. Given specific heat of lead $= 0.03 cal g^{-1} . ^{\circ} C^{-1}, J = 4.2 J cal^{-1}$.

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42. Calculate the velocity with which a piece of ice at - $5^{\circ}C$ be thrown against a wall so that its entire mass melts upon contact. Latent heat of ice = 80 cal g^{-1}, specific heat of ice = 0.5 cal $g^{-1}.^{\circ}C^{-1}$. And $J = 4.2 \times 10^7$ erg cal^{-1}.

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43. A heavy box having a mass of 2 quintal is pulled along the floor for 8 metre. If coefficient of sliding friction is 0.2, how much heat is developed ? Given $J = 4.2 \times 10^3 Jkcal^{-1}$

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44. In the Joule experiment, a mass of 20 kg falls through 1.5m at a constant velocity to stir the water in a calorimeter. If the calorimeter has a water equivalent of 2 g and contains 12 g of water, what is f, the mechanical equivalent of heat, for a temperature rise of $5.0^\circ C$?

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45. A body of mass 25 kg is dragged on a horizontal rough road with a constant speed of $20 km h^{-1}$. If the coefficient of friction is 0.5, find the heat generated in one hour. If 50% of the heat is absorbed by the body, find the rise in temperature. Specific heat of the material of the body is 0.1 cal $g^{-1} . ^{\circ} C^{-1}$.

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46. A worker eats a dish of icecream which funishes 200 kcal of heat. If the efficiency of the body is 25%, then calculate the height to which the worker can carry a weight of 56 kg using the energy of icecream. Worker's own weight is 70 kg. Given $J = 4.2 J cal^{-1}$.

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47. When water is boiled at 2 atm pressure the latent heat of vaporization is $2.2 \times 10^6 J / kg$ and the boiling point is $120^\circ C$ At 2 atm pressure 1 kg of water has a volume of $10^{-3} m^{-3}$ and 1 kg of steam has volume of $0.824 m^3$. The increase in internal energy of 1 kg of water when it is converted into steam at 2 atm pressure and $120^\circ C$ is [1 atm pressure $= 1.013 \times 10^5 N/m^2$]

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48. When 10 g of coal is burnt, it raises the temperature of 2 litres of water from $20^\circ C$ to $55^\circ C$. Calculate the heat of combustion of fuel.

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49. A person weighing 60 kg takes in 2000 kcal diet in a day. If this energy were to be used in heating the person without any losses, his rise in temperature would be nearly (Given sp. Heat of human body is $0.83 cal g^{-1}, .^{\circ} C^{-1}$

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50. 0.75 gram of petroleum was burnt in a bomb calorimeter which contains 2 kg of water and has a water equivalent 500 gram. The rise in temperature was $3^{\circ} C$. Determine the calorific value of petroleum.

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51. The heat of combustion of ethane gas at 373 k cal per mole. Assume that 50% of heat is useful, how many be burnt litres to convert 60 kg of water at $20^{\circ} C$ to steam at $100^{\circ} C$? One mole of gas occupies 22.4 litre at S.T.P. Latent heat of steam = $2.25 \times 10^{6} Jkg^{-1}$.

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52. A refrigeratior converts 50 gram of water at $15^{\circ} C$ intoice at $0^{\circ} C$ in one hour. Calculate the quantity of heat removed per minute. Take specific heat of water $= 1$ cal $g^{-1}.^{\circ}C^{-1}$ and latent heat of ice $= 80$ cal g^{-1}

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53. 1.50 gram of ice is mixed in 300 gram of water at $50^{\circ}C$. Determine the resulting temperature. Given heat of fusion of ice = 336 Jg^{-1}.

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54. How many grams of ice at $-14.^{\circ}C$ are needed to cool 200 gram of water form $25.^{\circ}C$

to $10.^\circ C$? Take specific heat of ice $= 0.5 cal g^{-1} . ^\circ C^{-1}$ and latant heat of ice = $80 cal g^{-1}$.

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55. Calculate the heat required to convert 3 kg of ice at $-12^\circ C$ kept in a calorimeter to steam at $100^\circ C$ at atmospheric pressure. Given,

specific heat capacity of ice = $2100 J kg^{-1} K^{-1}$

specific heat capicity of water = $4186 J kg^{-1} K^{-1}$

Latent heat of fusion of ice = $3.35 \times 10^5 J kg^{-1}$

and latent heat of steam = $2.256 \times 10^6 J kg^{-1}$.

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56. A piece of iron of mass $100g$ is kept inside a furnace for a long time and then put in a calorimeter of water equivalent $10g$ containing $240g$ of water at $20^\circ C$. The mixture attains an equilibrium temperature of $60^\circ C$. Find the temperature of the furnace.

Specific heat capacity of iron $= 470Jkg^{-1}.^\circ C^{-1}$

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57. An electric heater of power 100 W raises the temperature of 5 kg of a liquid from $25^\circ C$ to $31^\circ C$ in 2 minutes. Calculate the specific heat of the liquid.

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58. Calculate the two specific heats of nitrogen from the following data : $\gamma = c_p / c_v = 1.51$ density of nitrogen at N.T.P $= 1.234 g litre^{-1}$ and $J = 4.2 \times 10^7 erg cal^{-1}$.

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59. Calculate the two specific heats of nitrogen from the following data : $\gamma = c_p / c_v = 1.51$ density of nitrogen at N.T.P $= 1.234 glitre^{-1}$ and $J = 4.2 \times 10^7 ergcal^{-1}$.

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60. Calculate the specific heat capacity at constant volume for a gas. Given specific heat capacity at constant pressure is $6.85 calmol^{-1} K^{-1}$, $R = 8.31 Jmol^{-1} K^{-1}$. $J = 4.18 Jcal^{-1}$.

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61. Calculate difference in specific heats for 1 gram of air at $N.T.P.$ Given density of air at N.T.P. is $1.293 g litre^{-1}, j = 4.2 \times 10^7 \text{ erg } cal^{-1}$.

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62. Calculate C_P for air, given that $C_v = 0.162 cal g^{-1} K^{-1}$ and density of air at S.T.P is 0.001293 g cm^{-3}.

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63. For air, specific heat at constant pressure is $0.273 cal g^{-1}.^{\circ}C^{-1}$ and specific heat at constant volume is $0.169 cal g^{-1}.^{\circ}C^{-1}$, density of air $= 0.001293 g cm^{-3}$ at S.T.P. Calculate the value of J.

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64. Calculate the ratio of specific heats for nitrogen. Given that the specific heat of nitrogen

at cinstant pressure $= 0.236$ cal $g^{-1} K^{-1}$ and density at S.T.P. is $0.001234 g / cc$. Atmospheric pressure $= 1.01 \times 10^6 dyne / cm^2$.

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65. If for hydrogen $C_P - C_V = m$ and for nitrogen $C_P - C_V = n$, where C_P and C_V refer to specific heats per unit mass respectively at constant pressure and constant volume, the relation between m and n is (molecular weight of hydrogen = 2 and molecular weight or nitrogen = 14)

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66. The specific heats of argon at constant pressure and constant volume are $525 J/kg$ and $315 J/kg$, respectively. Its density at NTP will be\

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67. One mole of oxygen is heated at constant pressure starting at $0^{\circ} C$. How much heat energy must be added to the gas to double its volume ?

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68. Calculate the total number of degree of freedom for a mole of diatomic gas at STP.

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69. Calculate the number of degrees of freedom in $10cm^3$ of O_2 at N.T.P.

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70. Calculate the number of degree of freedom in 15 c.c. Of nitrogen at N.T.P.?

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71. The specific heat of argon at constant volume is $0.075 kcal kg^{-1} K^{-1}$. Calculate its atomic weight. $Take R = 2 cal mol^{-1} K^{-1}$.

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72. A certain gas possessess 3 degree of freedom corresponding to the translational motion and 2 degrees of freedom corresponding to rotational motion. (i) What is the kinetic energy of translational motion of one such molecule of gas at 300 K ? (ii) If the temperature is raised by $1^{\circ}C$, what energy must be supplied to the one molecule of the gas. Given Avogadro's number N = $6.023 \times 10^{23} mol^{-1}$ and Boltzmann'a constant $k_B = 1.38 \times 10^{-23} Jmo \leq \underline{ce}^{-1} K^{-1}$.

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