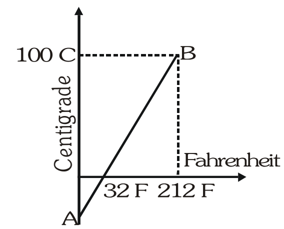
EXERCISE–01 CHECK YOUR GRASP

SELECT THE CORRECT ALTERNATIVE (ONLY ONE CORRECT ANSWER)

1. On an X temperature scale, water freezes at –125.0 X and boils at 375.0 X. On a Y temperature scale, water freezes at –70.0 Y and boils at –30.0 Y. The value of temperature on X–scale equal to the temperature of 50.0 Y on Y–scale is :–
(A) 455.0 X (B) –125.0 X (C) 1375.0 X (D) 1500.0 X

2. A centigrade and a Fahrenheit thermometer are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers 140 F What is the temperature as registered by the centigrade thermometer :–
(A) 30 (B) 40 (C) 60 (D) 80

3. The graph AB shown in figure is a plot of temperature of a body in degree Celsius and degree Fahrenheit. Then :–
(A) Slope of line AB is 9/5
(B) Slope of line AB is 5/9
(C) Slope of line AB is 1/9
(D) slope of line AB is 3/9



4. Two absolute scales X and Y assigned numerical values 200 and 450 to the triple point of water. What is the relation between T_X and T_Y ?
(A) $9T_X = 4T_Y$ (B) $4T_X = 9T_Y$ (C) $T_X = 3T_Y$ (D) None of these

5. A faulty thermometer reads freezing point and boiling point of water as –5 C and 95 C respectively. What is the correct value of temperature as it reads 60 C on faulty thermometer?
(A) 60 C (B) 65 C (C) 64 C (D) 62 C

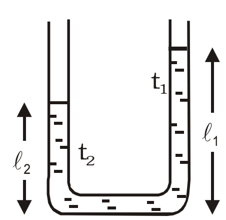
6. A steel scale is to be prepared such that the millimeter intervals are to be accurate within 6 10^{-5} mm. The maximum temperature variation during the ruling of the millimeter marks is (α=12 $10^{-6}C^{-1}$):–
(A) 4.0 C (B) 4.5 C (C) 5.0 C (D) 5.5 C.

7. A meter washer has a hole of diameter d_1 and external diameter d_2 , where $d_2=3d_1$. On heating, d_2 increases by 0.3%. Then d_1 will :–
(A) decrease by 0.1% (B) decrease by 0.3% (C) increase by 0.1% (D) increase by 0.3%.

8. At 4 C, 0.98 of the volume of a body is immersed in water. The temperature at which the entire body gets immersed in water is (neglect the expansion of the body) $(\gamma_w = 3.3\times10^{-4}K^{-1})$:–
(A) 40.8 C (B) 64.6 C (C) 60.6 C (D) 58.8 C

9. Two metal rods of the same length and area of cross–section are fixed ends to end between rigid supports. The materials of the rods have Young moduli Y_1 and Y_2, and coefficients of linear expansion α_1 and α_2. When rods are cooled the junction between the rods does not shift if:–
(A) $Y_1\alpha_1 = Y_2\alpha_2$ (B) $Y_1\alpha_2 = Y_2\alpha_1$ (C) $Y_1\alpha^2_1 = Y_2\alpha^2_2$ (D) $Y^2_1\alpha_1 = Y^2_2\alpha_2$

10. In a vertical U–tube containing a liquid, the two arms are maintained at different temperatures, t_1 and t_2. The liquid columns in the two arms have heights ℓ_1 and ℓ_2 respectively. The coefficient of volume expansion of the liquid is equal to:–

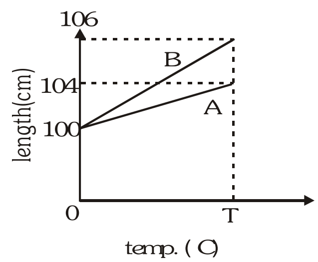


(A) $\dfrac{\ell_1-\ell_2}{\ell_2t_1-\ell_1t_2}$ (B) $\dfrac{\ell_1-\ell_2}{\ell_1t_1-\ell_2t_2}$ (C) $\dfrac{\ell_1+\ell_2}{\ell_2t_1+\ell_1t_2}$ (D) $\dfrac{\ell_1+\ell_2}{\ell_1t_1+\ell_2t_2}$

11. A steel rod of length 1 m is heated from 25 C to 75 C keeping its length constant. The longitudinal strain developed in the rod is:– (Given : Coefficient of linear expansion of steel = 12 x 10^{-6}/ C)
(A) 6 10^{-6} (B) –6 10^{-5} (C) –6 10^{-4} (D) zero

12. A brass disc fits simply in a hole of a steel plate. The disc from the hole can be loosened if the system ($\alpha_{brass} > \alpha_{steel}$)
(A) First heated then cooled (B) First cooled then heated
(C) Is heated (D) Is cooled

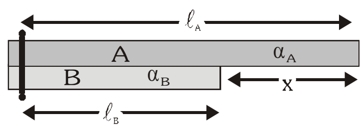
13. The variation of lengths of two metal rods A and B with change in temperature is shown in figure. The ratio of $\frac{\alpha_A}{\alpha_B}$ is:–



(A) $\frac{3}{2}$ (B) $\frac{2}{3}$ (C) $\frac{4}{3}$ (D) $\frac{3}{4}$

14. A steel tape is placed around the earth at the equator when the temperature is 10 C. What will be the clearance between the tape and the ground (assumed to be uniform) if the temperature of the tape rises to 40 C ? Neglect expansion of the earth. Radius of earth at equator is 6400 km & α_{steel} = 1.2 10^{-5} K^{-1}
(A) 2.3 m (B) 2.1 m (C) 2.3 km (D) 230 m

15. Bars of two different metals are bolted together, as shown in figure.The distance x does not change with temperature if:–



(A) $\frac{\ell_A}{\ell_B} = \frac{\alpha_A}{\alpha_B}$ (B) $\frac{\ell_A}{\ell_B} = \frac{\alpha_B}{\alpha_A}$ (C) $\frac{\ell_A^2}{\ell_B^2} = \frac{\alpha_A}{\alpha_B}$ (D) $\frac{\ell_A^2}{\ell_B^2} = \frac{\alpha_B}{\alpha_A}$

16. A metal rod A of length ℓ_0 expands by $\Delta\ell$ when its temperature is raised by 100 C. Another rod B of different metal of length $2\ell_0$ expands by $\Delta\ell/2$ for same rise in temperature. A third rod C of length $3\ell_0$ is made up of pieces of rods A and B placed end to end expands by $2\Delta\ell$ on heating through 100 K. The length of each portion of the composite rod is:–
(A) $\frac{5}{3}\ell_0$, $\frac{4}{3}\ell_0$ (B) ℓ_0, $2\ell_0$ (C) $\frac{3\ell_0}{2}, \frac{3\ell_0}{2}$ (D) $\frac{2}{3}\ell_0, \frac{7}{3}\ell_0$

17. The coefficient of linear expansion 'α' of a rod of length 2m varies with the distance x from the end of the rod as $\alpha = \alpha_0 + \alpha_1 x$ where α_0 = 1.76 10^{-5} C^{-1} and α_1 = 1.2 $10^{-6}m^{-1}$ C^{-1}. The increase in the length of the rod, when heated through 100 C is:–
(A) 2cm (B) 3.76mm (C) 1.2 mm (D) None of these

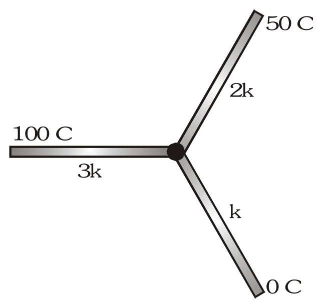
18. The coefficient of linear expansion α of the material of a rod of length ℓ_0 varies with absolute temperature as $\alpha = aT - bT^2$ where a & b are constants. The linear expansion of the rod when heated from T_1 to $T_2 = 2T_1$ is:–
(A) $\left(\frac{3}{2}aT_1^2 - \frac{7b}{3}T_1^3\right)L_0$ (B) $\left(4a - \frac{7b}{3}\right)T_1 L_0$ (C) $\left(2aT_1^2 - \frac{7b}{3}T_1^3\right)L_0$ (D) None of these

19. A clock with a metallic pendulum gains 6 seconds each day when the temperature is 20 C and loses 6 second when the temperature is 40 C. Find the coefficient of linear expansion of the metal.
(A) $1.4 \quad 10^{-5}\ C^{-1}$ (B) $1.4 \quad 10^{-6}\ C^{-1}$ (C) $1.4 \quad 10^{-4}\ C^{-1}$ (D) $0.4 \quad 10^{-6}\ C^{-1}$

20. A steel scale measures the length of a copper rod as ℓ_0 when both are at 20 C, which is the calibration temperature for the scale. The scale reading when both are at 40 C, is:–
(A) $(1+20\alpha_C)\ell_0$ (B) $(1+20\alpha_S)\ell_0$ (C) $\left(\frac{1+20\alpha_S}{1+20\alpha_C}\right)\ell_0$ (D) $\left(\frac{1+20\alpha_C}{1+20\alpha_S}\right)\ell_0$

21. The coefficient of apparent expansion of a liquid when determined using two different vessels A and B are γ_1 and γ_2 respectively. If the coefficient of linear expansion of the vessel A is α_1, the coefficient of linear expansion of the vessel B is:–
(A) $\frac{\alpha_1\gamma_1\gamma_2}{\gamma_1+\gamma_2}$ (B) $\frac{\gamma_1-\gamma_2}{2\alpha_1}$ (C) $\frac{\gamma_1+\gamma_2+\alpha}{3}$ (D) $\frac{\gamma_1-\gamma_2+3\alpha_1}{3}$

22. Three rods of the same dimensions have thermal conductivities 3k, 2k and k. They are arranged as shown, with their ends at 100 C, 50 C and 0 C. The temperature of their junction is:–



(A) 75 C (B) $\frac{200}{3}$°C (C) 40 C (D) $\frac{100}{3}$°C

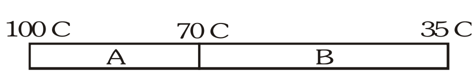
23. A cup of tea cools from 80 C to 60 C in one minute. The ambient temperature is 30 C. In cooling from 60 C to 50 C. It will take :–
(A) 50 s (B) 90 s (C) 60 s (D) 48 s

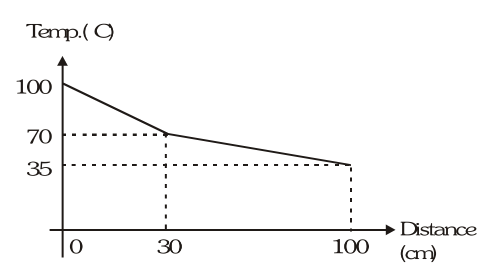
24. Ice starts forming in lake with water at 0 C when the atmospheric temperature is –10 C. If the time taken for 1 cm of ice be 7 hours, then the time taken for the thickness of ice to change from 1 cm to 2 cm is :–
(A) 7 hours (B) 14 hours (C) less than 7 hours (D) more than 7 hours

25. There is a small hole in a container. At what temperature should it be maintained in order that it emits one calorie of energy per second per meter^2 :–
(A) 10K (B) 500K (C) 200K (D) 100K

26. A blackened metallic foil is kept at a distance d from a spherical heater. The power absorbed by the foil is P. If the temperature of heater and distance both are doubled, then the power absorbed by the foil will be:–
(A) 8P (B) 4P (C) 2P (D) P

27. Two different rods A and B are kept as shown in figure. The variation of temperature of different cross sections with distance is plotted in a graph shown in figure. The ratio of thermal conductivities of A and B is-



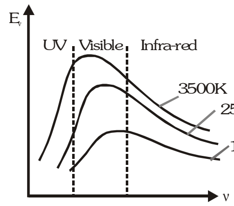


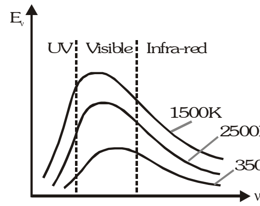
(A) 2 (B) 0.5 (C) 1 (D) 2/3

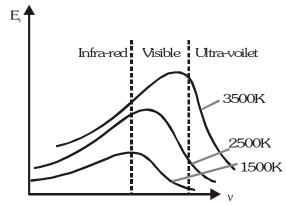
28. The area of cross–section of rod is given by $A = A_0 (1 + \alpha x)$ where A_0 & α are constant and x is the distance from one end. If the thermal conductivity of the material is K, what is the thermal resistance of the rod if its length is ℓ_0?

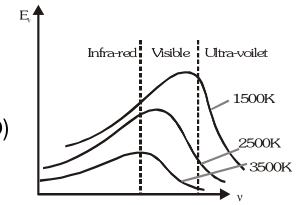
(A) $KA_0\alpha\ \ell n(1 + \alpha\ell_0)$ (B) $\frac{1}{KA_0\alpha}\ell n(1+\alpha\ell_0)$ (C) $\frac{\alpha}{KA_0}\ell n(1+\alpha\ell_0)$ (D) $\frac{KA_0}{\alpha}\ell n(1+\alpha\ell_0)$

29. Which of the following graph shows the correct variation in intensity of heat radiations by black body and frequency at a fixed temperature:–

(A) 

(B) 

(C) 

(D) 

30. A red star and a green star radiate energy at the same rate which star is bigger.
(A) Red (B) Green
(C) Both have same size (D) Can't be say anything

31. 250 g of water and an equal volume of alcohol of mass 200 g are placed successively in the same calorimeter and cools from 60 C to 55 C in 130 sec and 67 sec respectively. If the water equivalent of the calorimeter is 10 g then the specific heat of alcohol in cal/g C is :–
(A) 1.30 (B) 0.67 (C) 0.62 (D) 0.985

32. The weight of a person is 60 kg. If he gets 10 calories of heat through food and the efficiency of his body is 28%, then upto what height he can climb ? Take $g = 10\ m\ s^{-2}$
(A) 100 cm (B) 1.96 cm (C) 400 cm (D) 1000 cm

33. Two identical masses of 5 kg each fall on a wheel from a height of 10m. The wheel disturbs a mass of 2 kg water, the rise in temperature of water will be :–
(A) 2.6 C (B) 1.2 C (C) 0.32 C (D) 0.12 C

34. Hailstone at 0 C falls from a height of 1 km on an insulating surface converting whole of its kinetic energy into heat. What part of it will melt:– [$g = 10\ m/s^2$, $L_{ice} = 330\quad 10^3\ J\ kg^{-1}$]

(A) $\frac{1}{33}$ (B) $\frac{1}{8}$ (C) $\frac{1}{33}\times10^{-4}$ (D) All of it will melt

35. If H_C, H_K and H_F are heat required to raise the temperature of one gram of water by one degree in Celsius, Kelvin and Fahrenheit temperature scales respectively then :–
(A) $H_K > H_C > H_F$ (B) $H_F > H_C > H_K$ (C) $H_K = H_C > H_F$ (D) $H_K = H_C = H_F$

36. Steam at 100 C is passed through 1.1 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15 C till the temperature of the calorimeter and its contents rises to 80 C. The mass of the steam condensed in kg is :–
(A) 0.130 (B) 0.065 (C) 0.260 (D) 0.135

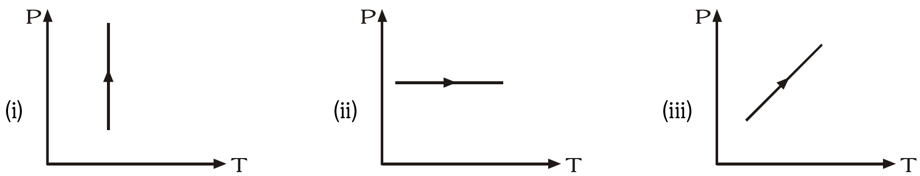
37. Water is used to cool the radiators of engines in cars because :–
(A) of its low boiling point (B) of its high specific heat
(C) of its low density (D) of its easy availability

38. If mass–energy equivalence is taken into account, when water is cooled to form ice, the mass of water should:–
(**Note** : The mass energy of an object is the energy equivalent of its mass, as given by $E = mc^2$, where m = mass of object & c = speed of light)
(A) increase (B) remain unchanged
(C) decrease (D) first increase then decrease

39. If the intermolecular forces vanish away, the volume occupied by the molecules contained in 4.5 kg. water at standard temperature and pressure will be given by :–
(A) 5.6 m^3 (B) 4.5 m^3 (C) 11.2 litre (D) 11.2 m^3

40. A refrigerator converts 100 g of water at 25 C into ice at – 10 C in one hour and 50 minutes. The quantity of heat removed per minute is:– (Specific heat of ice = 0.5 cal/g C, latent heat of fusion = 80 cal/g)
(A) 50 cal (B) 100 cal (C) 200 cal (D) 75 cal

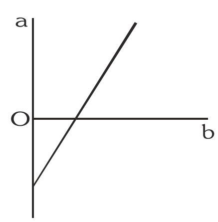
41. Pressure versus temperature graphs of an ideal gas are as shown in figure. Choose the wrong statement:–



(A) Density of gas is increasing in graph (i)
(B) Density of gas decreasing in graph (ii)
(C) Density of gas is constant in graph (iii)
(D) None of the above

42. In a process the density of a gas remains constant. If the temperature is doubled, then the change in the pressure will be:–
(A) 100 % increase (B) 200 % increase (C) 50 % decrease (D) 25 % decrease

43. The expansion of unit mass of a perfect gas at constant pressure is shown in the diagram. Here:–

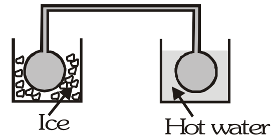


(A) a = volume, b = C temperature
(B) a = volume, b = K temperature
(C) a = C temperature, b = volume
(D) a = K temperature, b = volume

44. Air is filled at 60 C in a vessel of open mouth. The vessel is heated to a temperature T so that $\frac{1}{4}^{th}$ part of air escapes. The value of T is :–
(A) 80 C (B) 444 C (C) 333 C (D) 171 C

45. One mole of an ideal gas undergoes a process $P = \dfrac{P_0}{1+(V_0/V)^2}$ Here P_0 and V_0 are constants. Change in temperature of the gas when volume is changed from $V = V_0$ to $V = 2V_0$ is :–
(A) $-\dfrac{2P_0V_0}{5R}$ (B) $\dfrac{11P_0V_0}{10R}$ (C) $-\dfrac{5P_0V_0}{4R}$ (D) P_0V_0

46. Two identical glass bulbs are interconnected by a thin glass tube at 0°C. A gas is filled at N.T.P. in these bulb is placed in ice and another bulb is placed in hot bath, then the pressure of the gas becomes 1.5 times. The temperature of hot bath will be :–



(A) 100 C (B) 182 C (C) 256 C (D) 546 C

47. A gas has volume V and pressure P. The total translational kinetic energy of all the molecules of the gas is:–

(A) $\frac{3}{2}$PV only if the gas is monoatomic. (B) $\frac{3}{2}$PV only if the gas is diatomic.

(C) $>\frac{3}{2}$PV if the gas is diatomic. (D) $\frac{3}{2}$PV in all cases.

48. A mixture of n_1 moles of monoatomic gas and n_2 moles of diatomic gas has $\frac{C_P}{C_V} = \gamma = 1.5$:–

(A) $n_1 = n_2$ (B) $2n_1 = n_2$ (C) $n_1 = 2n_2$ (D) $2n_1 = 3n_2$

49. Four containers are filled with monoatomic ideal gases. For each container, the number of moles, the mass of an individual atom and the rms speed of the atoms are expressed in terms of n, m and v_{rms} respectively. If T_A, T_B, T_C and T_D are their temperatures respectively then which one of the options correctly represents the order ?

	A	B	C	D
Number of moles	n	3n	2n	n
Mass	4m	m	3m	2m
Rms speed	v_{rms}	$2v_{rms}$	v_{rms}	$2v_{rms}$
Temperature	T_A	T_B	T_C	T_D

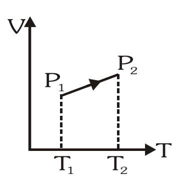
(A) $T_B = T_C > T_A > T_D$ (B) $T_D > T_A > T_C > T_B$ (C) $T_D > T_A = T_B > T_C$ (D) $T_B > T_C > T_A > T_D$

50. 10^{23} molecules of a gas strike a target of area 1 m^2 at angle 45 to normal and rebound elastically with speed 1 kms^{-1}. The impulse normal to wall per molecule is:– [Given : mass of molecule = 3.32 10^{-27}kg]

(A) 4.7 10^{-24} kg ms^{-1} (B) 7.4 10^{-24} kg ms^{-1}

(C) 3.32 10^{-24} kg ms^{-1} (D) 2.33 kg ms^{-1}

51. From the following V–T diagram we can conclude:–

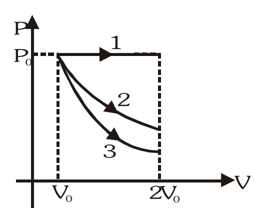


(A) $P_1 = P_2$ (B) $P_1 > P_2$ (C) $P_1 < P_2$ (D) Can't say anything

52. The density in grams per litre of ethylene (C_2H_4) at STP is :–

(A) 1.25 (B) 2.50 (C) 3.75 (D) 5.25

53. A gas is expanded from volume V_0 to $2V_0$ under three different processes. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let ΔU_1, ΔU_2 and ΔU_3, be the change in internal energy of the gas is these processes. Then :–



(A) $\Delta U_1 > \Delta U_2 > \Delta U_3$ (B) $\Delta U_1 < \Delta U_2 < \Delta U_3$

(C) $\Delta U_2 < \Delta U_1 < \Delta U_3$ (D) $\Delta U_2 < \Delta U_3 < \Delta U_1$

54. Some of the thermodynamic parameters are state variables while some are process variables. Some grouping of the parameters are given. Choose the correct one.

(A) State variables : Temperature, No of moles
Process variables : Internal energy, work done by the gas.

(B) State variables : Volume, Temperature
Process variables : Internal energy, work done by the gas.

(C) State variables : Work done by the gas, heat rejected by the gas
Process variables : Temperature, volume.

(D) State variables : Internal energy, volume
Process variables : Work done by the gas, heat absorbed by the gas.

55. For an ideal gas PT^{11} = constant then volume expansion coefficient is equal to :–

(A) $\frac{11}{T}$ (B) $\frac{1}{T}$ (C) $\frac{12}{T}$ (D) $\frac{2}{T}$

56. The internal energy of a gas is given by $U = 5 + 2PV$. It expands from V_0 to $2V_0$ against a constant pressure P_0. The heat absorbed by the gas in the process is :–

(A) $-3P_0V_0$ (B) $3P_0V_0$ (C) $2P_0V_0$ (D) P_0V_0

57. When water is heated from 0 C to 4 C and C_P and C_V are its specific heats at constant pressure and constant volume respectively, then :–

(A) $C_P > C_V$ (B) $C_P < C_V$ (C) $C_P = C_V$ (D) $C_P - C_V = R$

58. The molar specific heat of the process $V \propto T^4$ for CH_4 gas at room temperature is:–

(A) 4R (B) 7R (C) 3R (D) 8R

59. 5n, n and 5n moles of a monoatomic, diatomic and non-linear polyatomic gases (which do not react chemically with each other) are mixed at room temperature. The equivalent degree of freedom for the mixture is :–

(A) $\frac{25}{7}$ (B) $\frac{48}{11}$ (C) $\frac{52}{11}$ (D) $\frac{50}{11}$

60. The internal energy of a gas in an adiabatic process is given by $U = a + bPV$, find γ :–

(A) $\frac{a+1}{a}$ (B) $\frac{b+1}{b}$ (C) $\frac{b+1}{a}$ (D) $\frac{a}{b+1}$

CHECK YOUR GRASP — **ANSWER KEY** — EXERCISE –1

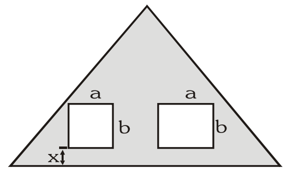
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	C	C	B	A	B	C	D	B	A	A	C	D	B	C	B	A	B	A	A	D
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	D	B	D	D	D	B	B	B	C	A	C	B	D	A	C	D	B	C	A	B
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	D	A	C	D	B	D	D	A	C	A	C	A	A	D	C	B	B	B	D	B

EXERCISE–02

BRAIN TEASURES

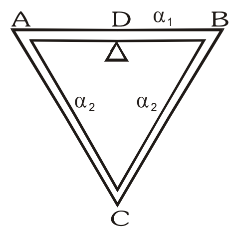
Select the correct alternatives (one or more than one correct answers)

1. A triangular plate has two cavities, one square and one rectangular as shown in figure. The plate is heated.



(A) a increase, b decrease
(B) a and b both increase
(C) a and b increase, x and ℓ decrease
(D) a, b, x and ℓ all increase

2. Three rods of equal length are joined to form an equilateral triangle ABC.D is the midpoint of AB. The coefficient of linear expansion is α_1 for AB, and α_2 for AC and BC. If the distance DC remains constant for small changes in temperature:–



(A) $\alpha_1 = \alpha_2$
(B) $\alpha_1 = 2\alpha_2$
(C) $\alpha_1 = 4\alpha_2$
(D) $\alpha_1 = \frac{1}{2}\alpha_2$

3. If water at 0 C, kept in a container with an open top, is placed in a large evacuated chamber:–
(A) All the water will vaporize.
(B) All the water will freeze.
(C) Part of the water will vaporize and the rest will freeze.
(D) Ice, water and water vapour will be formed and reach equilibrium at the triple point.

4. In the previous question, if the specific latent heat of vaporization of water at 0 C is η times the specific latent heat of freezing of water at 0 C, the fraction of water that will ultimately freeze is:–

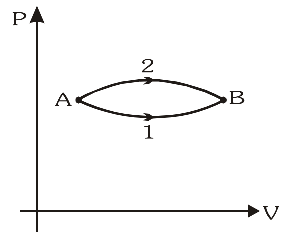
(A) $\frac{1}{\eta}$
(B) $\frac{\eta}{\eta+1}$
(C) $\frac{\eta-1}{\eta}$
(D) $\frac{\eta-1}{\eta+1}$

5. Which of the following statements is/are correct ?
(A) A gas has two specific heats only
(B) A material will have only one specific heat, if and only if its coefficient of thermal expansion is equal to zero.
(C) A gas has infinite number of specific heats.
(D) None of these

6. When two samples at different temperatures are mixed, the temperature of the mixture can be :–
(A) lesser than lower or greater than higher temperature
(B) equal to lower or higher temperature
(C) greater than lower but lesser than higher temperature
(D) average of lower and higher temperatures.

7. Two identical beakers are filled with water to the same level at 4 C. If one say A is heated while the other B is cooled, then:–
(A) water level in A will rise
(B) water level in B will rise
(C) water level in A will fall
(D) water level in B will fall

8. The figure shows two paths for the change of state of a gas from A to B. The ratio of molar heat capacities in path 1 and path 2 is:–



(A) > 1 (B) < 1 (C) 1 (D) Data insufficient

9. During the melting of a slab of ice at 273 K at atmospheric pressure:–

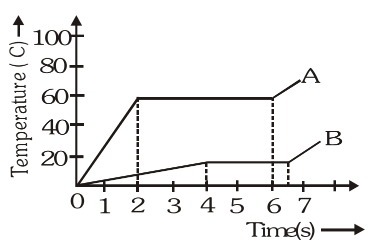
(A) Positive work is done by the ice–water system on the atmosphere.

(B) Positive work is done on the ice–water system by the atmosphere.

(C) The internal energy of ice–water system increases.

(D) The internal energy of the ice–water system decreases.

10. Two substances A and B of equal mass m are heated by uniform rate of 6 cal s^{-1} under similar conditions. A graph between temperature and time is shown in figure. Ratio of heat absorbed H_A / H_B by them for complete fusion is:–

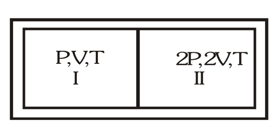


(A) $\frac{9}{4}$ (B) $\frac{4}{9}$ (C) $\frac{8}{5}$ (D) $\frac{5}{8}$

11. Three closed vessels A, B and C at the same temperature T and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only O_2, B only N_2 and C a mixture of equal quantities of 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 is v_2, the average speed of O_2 molecules in vessel C is where M is the mass of an oxygen molecule:–

(A) $(v_1+v_2)/2$ (B) v_1 (C) $(v_1 v_2)^{1/2}$ (D) $\sqrt{3kT/M}$

12. A partition divides a container having insulated walls into two compartments I and II.The same gas fills the two compartments whose initial parameters are given. The partition 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 $\frac{5P}{3}$

13. During experiment, an ideal gas is found to obey a condition P^2/ρ= constant [ρ = 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 the P–T diagram is parabola

(D) The graph of the above process on the P–T diagram is hyperbola

14. An ideal gas can be expanded from an initial state to a certain volume through two different processes (i) PV^2 = constant and (ii) $P = KV^2$ where K is a positive constant. Then:–

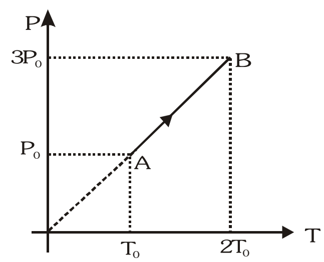
(A) Final temperature in (i) will be greater than in (ii)

(B) Final temperature in (ii) will be greater than in (i)

(C) Total heat given to the gas in (i) case is greater than in (ii)

(D) Total heat given to the gas in (ii) case is greater than in (i)

15. Pressure versus temperature graph of an ideal gas is shown in figure.Density of the gas at point A is ρ_0. Density at B will be:–



(A) $\frac{3}{4}\rho_0$ (B) $\frac{3}{2}\rho_0$ (C) $\frac{4}{3}\rho_0$ (D) $2\rho_0$

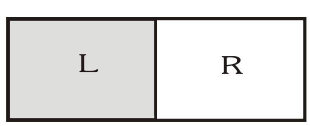
16. When unit mass of water boils to become steam at 100^0C, it absorbs Q amount of heat. The densities of water and steam at 100^0C are ρ_1 and ρ_2 respectively and the atmospheric pressure is P_0. The increase in internal energy of the water is:–

(A) Q (B) $Q+P_0\left(\frac{1}{\rho_1}-\frac{1}{\rho_2}\right)$ (C) $Q+P_0\left(\frac{1}{\rho_2}-\frac{1}{\rho_1}\right)$ (D) $Q-P_0\left(\frac{1}{\rho_1}+\frac{1}{\rho_2}\right)$

17. At temperature T,N molecules of gas A each having mass m and at the same temperature 2 N molecules of gas B each having mass 2 m are filled in a container. The mean square velocity of molecules of gas B is v^2 and x component of mean square velocity of molecules of gas A is w^2. The ratio of w^2 / v^2 is :–

(A) 1 (B) 2 (C) 1/3 (D) 2/3

18. A vessel is partitioned in two equal halves by a fixed diathermic separator. Two different ideal gases are filled in left (L) and right (R) halves. The rms speed of the molecules in L part is equal to the mean speed of molecules in the R part. Then the ratio of the mass of a molecule in L part to that of a molecule in R part is:–



(A) $\sqrt{\frac{3}{2}}$ (B) $\sqrt{\pi/4}$ (C) $\sqrt{2/3}$ (D) $3\pi/8$

19. 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 are true?

(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

20. N(<100) molecules of a gas have velocities 1,2,3.... N, km/s respectively. Then:–

(A) rms speed and average speed of molecules are same

(B) Ratio of rms speed to average speed is $\dfrac{\sqrt{(2N+1)(N+1)}}{6N}$

(C) Ratio of rms speed to average speed is $\dfrac{\sqrt{(2N+1)(N+1)}}{6}$

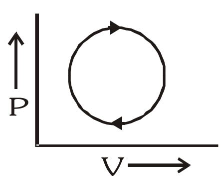
(D) Ratio of rms speed to average speed of a molecule $\dfrac{2}{\sqrt{6}}\sqrt{\dfrac{(2N+1)}{(N+1)}}$

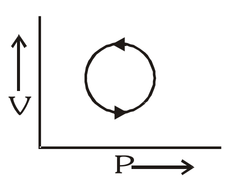
21. Let $\bar{v}$, v_{rms} and v_p respectively denote the mean speed, the root–mean–square speed, and the most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m:–

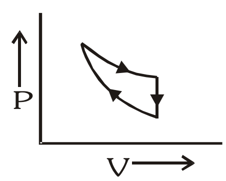
(A) No molecule can have speed greater than v_{rms} (B) No molecule can have speed less than $\dfrac{v_p}{\sqrt{2}}$

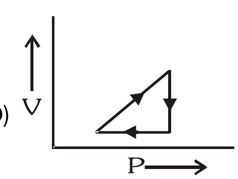
(C) $v_p < \bar{v} < v_{rms}$ (D) The average kinetic energy of a molecule is $\dfrac{3}{4}mv_p^2$

22. The following are the P–V diagrams for cyclic processes for a gas. In which of these processes is heat absorbed by the gas ?

(A) 

(B) 

(C) 

(D) 

23. The internal energy of a system remains constant when it undergoes :–

(A) a cyclic process (B) an isothermal process (C) an adiabatic process

(D) any process in which the heat given out by the system is equal to the work done on the system

24. C_P is always greater than C_V due to the fact that :–

(A) No work is being done on heating the gas at constant volume.

(B) When a gas absorbs heat at constant pressure its volume must change so as to do some external work.

(C) The internal energy is a function of temperature only for an ideal gas.

(D) For the same rise of temperature, the internal energy of a gas changes by a smaller amount at constant volume than at constant pressure.

25. An ideal gas is heated from temperature T_1 to T_2 under various conditions. The correct statement(s) is/are:–

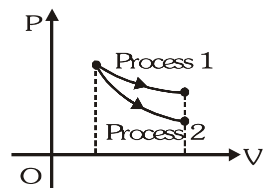
(A) $\Delta U = nC_V (T_2 - T_1)$ for isobaric, isochoric and adiabatic process

(B) Work is done at expense of internal energy in an adiabatic process and both have equal values

(C) $\Delta U = 0$ for an isothermal process

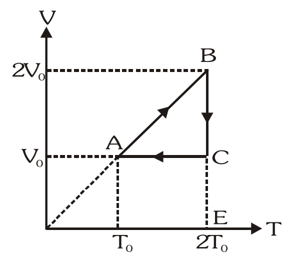
(D) $C = 0$ for an adiabatic process

26. The indicator diagram for two process 1 and 2 carried on an ideal gas is shown in figure.If m_1 and m_2 be the slopes $\left(\frac{dP}{dV}\right)$ for process 1 and process 2 respectively, then:–



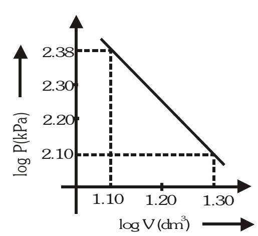
(A) $m_1=m_2$ (B) $m_1>m_2$ (C) $m_1<m_2$ (D) $m_2C_V=m_1C_P$

27. An ideal monoatomic gas undergoes a cycle process ABCA as shown in the fig. The ratio of heat absorbed during AB to the work done on the gas during BC is:–



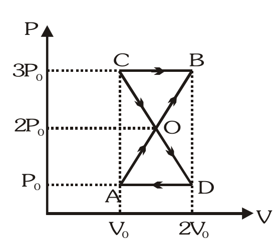
(A) $\frac{5}{2\ell n2}$ (B) $\frac{5}{3}$ (C) $\frac{5}{4\ \ell n2}$ (D) $\frac{5}{6}$

28. Logarithms of readings of pressure and volume for an ideal gas were plotted on a graph as shown in Figure. By measuring the gradient, It can be shown that the gas may be :–



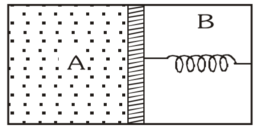
(A) Monoatomic and undergoing an adiabatic change.
(B) Monoatomic and undergoing an isothermal change.
(C) Diatomic and undergoing an adiabatic change.
(D) Triatomic and undergoing an isothermal change.

29. A thermodynamic system undergoes cyclic process ABCDA as shown in figure. The work done by the system is :–



(A) P_0V_0 (B) $2P_0V_0$ (C) $\frac{P_0V_0}{2}$ (D) zero

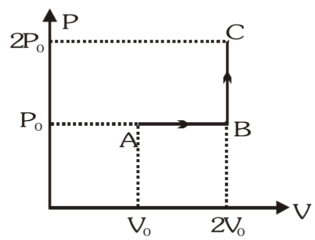
30. A thermally insulated chamber of volume $2V_0$ is divided by a frictionless piston of area S into two equal parts A and B. Part A has an ideal gas at pressure P_0 and temperature T_0 and in part B is vacuum. A massless spring of force constant k is connected with piston and the wall of the container as shown. Initially spring is unstretched. Gas in chamber A is allowed to expand. Let in equilibrium spring is compressed by x_0. Then:–



(A) Final pressure of the gas is $\frac{kx_0 6}{S}$ (B) Work done by the gas is $\frac{1}{2}kx^2{}_0$

(C) Change in internal energy of the gas is $\frac{1}{2}kx^2{}_0$ (D) Temperature of the gas is decreased.

31. One mole of an ideal monatomic gas is taken from A to C along the path ABC. The temperature of the gas at A is T_0. For the process ABC :–



(A) Work done by the gas is RT_0

(B) Change in internal energy of the gas is $\frac{11}{2}RT_0$

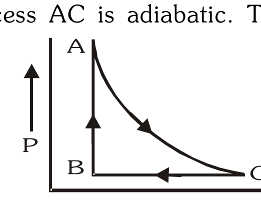
(C) Heat absorbed by the gas is $\frac{11}{2}RT_0$ (D) Heat absorbed by the gas is $\frac{13}{2}RT_0$

32. The specific heats of a gas are C_P=0.2 cal/g C & C_V = 0.15 cal/g C. [Take R=2 cal/mole^0 C]
(A) The molar mass of the gas is 40 g
(B) The molar mass of the gas cannot be determined from the data given
(C) The number of degrees of freedom of the gas molecules is 6
(D) The number of degrees of freedom of the gas molecules is 8

33. Two cylinders A and B fitted with piston contain the equal amount of an ideal diatomic gas at 300K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30K, then the rise in the temperature of the gas in B is:–
(A) 30 K (B) 10 K (C) 50 K (D) 42 K

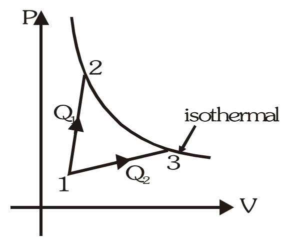
34. One mole of an ideal gas at an initial temperature of T K does 6 R joules of work adiabatically. If the ratio of specific heats of this gas at constant pressure and at constant volume is 5/3, the final temperature of gas will be:–
(A) (T + 2.4) K (B) (T – 2.4) K (C) (T + 4) K (D) (T – 4) K

35. One mole of ideal gas undergoes a cyclic process ACBA as shown in figure. Process AC is adiabatic. The temperatures at A, B and C are 300, 600 and 450K respectively:–
(A) In process CA change in internal energy is 225R.
(B) In process AB change in internal energy is –150R.
(C) In process BC change in internal energy is –225R.
(D) Change in internal energy during the whole cyclic process is +150R.



36. A gas expands such that its initial and final temperatures are equal. Also, the process followed by the gas traces a straight line on the P–V diagram :–
(A) The temperature of the gas remains constant throughout.
(B) The temperature of the gas first increases and then decreases.
(C) The temperature of the gas first decreases and then increases.
(D) The straight line has a negative slope.

37. A gas takes part in two processes in which it is heated from the same initial state 1 to the same final temperature. The processes are shown on the P–V diagram by the straight line 1–2 and 1–3.2 and 3 are the points on the same isothermal curve. Q_1 and Q_2 are the heat transfer along the two processes. Then :–



(A) $Q_1 = Q_2$ (B) $Q_1 < Q_2$ (C) $Q_1 > Q_2$ (D) insufficient data

38. Radiation from a black body at the thermodynamic temperature T_1 is measured by a small detector at distance d_1 from it. When the temperature is increased to T_2 and the distance to d_2, the power received by the detector is unchanged. What is the ratio d_2/d_1?

(A) $\frac{T_2}{T_1}$ (B) $\left(\frac{T_2}{T_1}\right)^2$ (C) $\left(\frac{T_1}{T_2}\right)^2$ (D) $\left(\frac{T_2}{T_1}\right)^4$

39. A point source of heat of power *P* is placed at the center of a spherical shell of mean radius *R*. The material of the shell has thermal conductivity *k*. If the temperature difference between the outer and the inner surface of the shell is not to exceed *T*, then the thickness of the shell should not be less than :–

(A) $\frac{2\pi R^2 kT}{P}$ (B) $\frac{4\pi R^2 kT}{P}$ (C) $\frac{\pi R^2 kT}{P}$ (D) $\frac{\pi R^2 kT}{4P}$

40. A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is λ_0. If at another temperature T' the power radiated is 'P' and wavelength at maximum intensity is $\frac{\lambda_0}{2}$ then:–

(A) P' T' = 32 PT (B) P' T' = 16 PT (C) P' T' = 8 PT (D) P' T' = 4 PT

41. The emissive power of a black body at T=300 K is 100 Watt/m^2. Consider a body B of area A = 10 m^2, coefficient of reflectivity r = 0.3 and coefficient of transmission t=0.5. Its temperature is 300 K. Then which of the following is incorrect:–
(A) The emissive power of B is 20 W/m^2
(B) The emissive power of B is 200 W/m^2
(C) The power emitted by B is 200 Watt
(D) The emissivity of B is = 0.2

42. A metallic sphere having radius 0.08 m and mass m = 10 kg is heated to a temperature of 227 C and suspended inside a box whose walls are at a temperature of 27 C. The maximum rate at which its temperature will fall is:– (Take e = 1, Stefan's constant $\sigma = 5.8 \times 10^{-8}$ Wm^{-2} K^{-4} and specific heat of the metal s = 90 cal/kg/deg, J = 4.2 J/Calorie)
(A) 0.055 C/s (B) 0.066 C/s (C) 0.044 C/s (D) 0.03 C/s

43. A hollow copper sphere & a hollow copper cube of same surface area & negligible thickness , are filled with warm water of same temperature and placed in an enclosure of constant temperature , a few degrees below that of the bodies . Then in the beginning :–

(A) The rate of energy lost by the sphere is greater than that by the cube

(B) The rate of energy lost by the two are equal

(C) The rate of energy lost by the sphere is less than that by the cube

(D) The rate of fall of temperature for sphere is less than that for the cube .

44. Two long, thin, solid cylinders are identical in size, but they are made of different substances with two different thermal conductivities. The two cylinders are connected in series between a reservoir at temperature T_{hot} and a reservoir at temperature T_{cold}. The temperature at the boundary between the two cylinders is T_b. One can conclude that:–

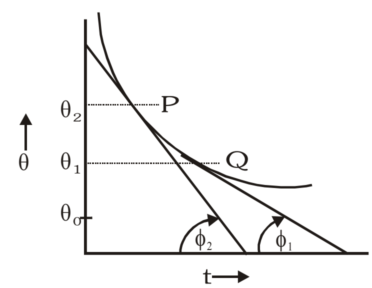
(A) T_b is closer to T_{hot} than it is to T_{cold}.

(B) T_b is closer to T_{cold} than it is to T_{hot}.

(C) T_b is closer to the temp. of the reservoir that is in contact with the cylinder with the lower thermal conductivity.

(D) T_b is closer to the temp. of the reservoir that is in contact with the cylinder with the higher thermal conductivity.

45. A body cools in a surrounding which is at a constant temperature of θ_0. Assume that it obeys Newton's law of cooling. Its temperature θ is plotted against time t. Tangent are drawn to the curve at the points P($\theta = \theta_2$) and Q($\theta = \theta_1$). These tangents meet the time axis at angles of ϕ_2 and ϕ_1 as shown, then:–



(A) $\frac{\tan\phi_2}{\tan\phi_1} = \frac{\theta_1 - \theta_0}{\theta_2 - \theta_0}$ (B) $\frac{\tan\phi_2}{\tan\phi_1} = \frac{\theta_2 - \theta_0}{\theta_1 - \theta_0}$ (C) $\frac{\tan\phi_1}{\tan\phi_2} = \frac{\theta_1}{\theta_2}$ (D) $\frac{\tan\phi_1}{\tan\phi_2} = \frac{\theta_2}{\theta_1}$

46. A spherical body with an initial temperature T_1 is allowed to cool in surroundings at temperature T_0 ($<T_1$). The mass of the body is m, its gram specific heat is c, density ρ, area A. If σ be the Stefan's constant then the temperature T of the body at time t can be best represented by:–

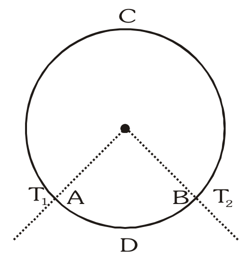
(A) $T = (T_1 - T_0)\, e^{-kt}$ where $k = \frac{12\sigma A T_0^3}{r\rho c}$ (B) $T = (T_1 - T_0)\, \ell n\,(kt)$ where $k = \frac{\sigma A T_0}{mc^3}$

(C) $T = T_0 + (T_1 - T_0)\, e^{-kt}$ where $k = \frac{12\sigma T_0^3}{r\rho c}$ (D) $T = T_1 e^{-kt} - T_0$ where $k = \frac{\sigma A T_0^3}{r\rho c}$

47. A rod of length L with sides fully insulated is of a material whose thermal conductivity varies with temperature as $K = \frac{\alpha}{T}$, where α is a constant. The ends of the rod are kept at temperature T_1 and T_2. The temperature T at x, where x is the distance from the end whose temperature is T_1 is:–

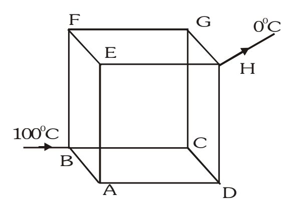
(A) $T_1\left(\frac{T_2}{T_1}\right)^{\frac{x}{L}}$ (B) $\frac{x}{L}\ell n\frac{T_2}{T_1}$ (C) $T_1 e^{\frac{T_2 x}{T_1 L}}$ (D) $T_1 + \frac{T_2 - T_1}{L}x$

48. A ring consisting of two parts ADB and ACB of same conductivity k carries an amount of heat H. The ADB part is now replaced with another metal keeping the temperatures T_1 and T_2 constant. The heat carried increases to 2H. What should be the conductivity of the new ADB part? Given $\frac{ACB}{ADB} = 3$



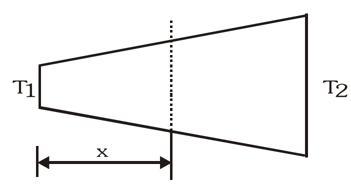
(A) $\frac{7}{3}k$ (B) 2k (C) $\frac{5}{2}k$ (D) 3k

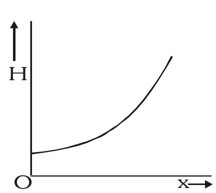
49. Twelve conducting rods form the sides of a uniform cube of side ℓ. If in steady state, B and H ends of the cube are at 100^0C and 0^0C respectively. Find the temperature of the junction 'A' :–

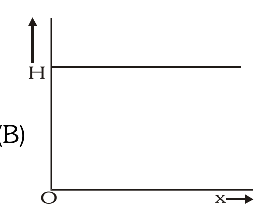


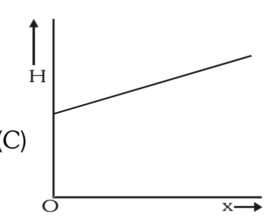
(A) 80^0C (B) 60^0C (C) 40^0C (D) 70^0C

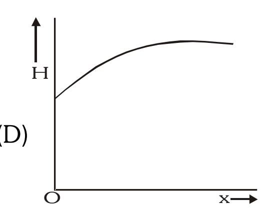
50. Radius of a conductor increases uniformly from left end to right end as shown in Fig. Material of the conductor is isotropic and its curved surface is thermally isolated from surrounding. Its ends are maintained at temperatures T_1 and T_2 ($T_1 > T_2$). If, in steady state, heat flow rate is equal to H, then which of the following graphs is correct ?



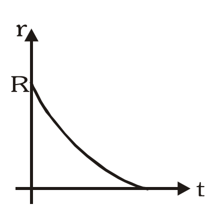
(A)


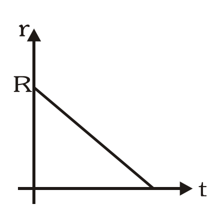
(B)


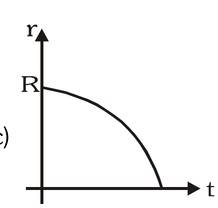
(C)


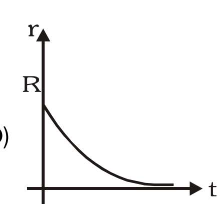
(D)


51. A sphere of ice at 0^0C having initial radius R is placed in an environment having ambient temperature > 0^0C. The ice melts uniformly, such that shape remains spherical. After a time 't' the radius of the sphere has reduced to r. Which graph best depicts r(t)

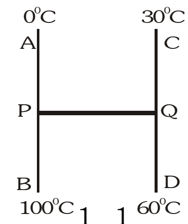
(A)


(B)


c)


(D)


52. Three identical rods AB, CD and PQ are joined as shown. P and Q are mid points of AB and CD respectively. Ends A, B, C and D are maintained at 0^0C, 100^0C, 30^0C and 60^0C respectively. The direction of heat flow in PQ is:–



(A) From P to Q (B) From Q to P

(C) Heat does not flow in PQ (D) Data not sufficient

53. Three bodies A, B and C have equal surface area and thermal emissivities in the ratio $e_A : e_B : e_C = 1 : \frac{1}{2} : \frac{1}{4}$. All the three bodies are radiating at same rate. Their wavelengths corresponding to maximum intensity are λ_A, λ_B and λ_C respectively and their temperatures are T_A, T_B and T_C on kelvin scale, then select the incorrect statement

(A) $\sqrt{T_A T_C} = T_B$ (B) $\sqrt{\lambda_A \lambda_C} = \lambda_B$ (C) $\sqrt{e_A T_A}\sqrt{e_C T_C} = e_B T_B$ (D) $\sqrt{e_A \lambda_A T_A . e_B \lambda_B T_B} = e_C \lambda_C T_C$

54. A and B are two points on a uniform metal ring whose centre is C. The angle ACB = θ. A and B maintained at two different constant temperatures. When θ = 180 , the rate of total heat flow from A to B is 1.2 W. When θ = 90 , this rate will be:–

(A) 0.6 W (B) 0.9 W (C) 1.6 W (D) 1.8 W

55. In a 10–metre–deep lake, the bottom is at a constant temperature of 4 C. The air temperature is constant at –4 C. The thermal conductivity of ice is 3 times that of water. Neglecting the expansion of water on freezing, the maximum thickness of ice will be:–

(A) 7.5 m (B) 6 m (C) 5 m (D) 2.5 m

56. The solar constant for the earth is Σ. The surface temperature of the sun is T K. The sun subtends an angle θ at the earth:–

(A) $\Sigma \propto T^4$ (B) $\Sigma \propto T^2$ (C) $\Sigma \propto \theta^2$ (D) $\Sigma \propto \theta$

57. A system S receives heat continuously from an electrical heater of power 10W. The temperature of S becomes constant at 50 C when the surrounding temperature is 20 C. After the heater is switched off, S cools from 35.1 C to 34.9 C in 1 minute. The heat capacity of S is:–

(A) 100 J/ C (B) 300 J/ C (C) 750 J/ C (D) 1500 J/ C

58. If the absorption coefficient and reflection coefficient of a surface of a body are 0.4 and 0.6 respectively then:–

(A) Emissive power will be 0.2 (B) Transmission power will be 0.2

(C) Body will be totally transparent (D) Body will be totally opaque.

59. Temperature of black body is 3000K when black body cools, then change in wevelength Δ λ = 9 micron corresponding to maximum energy density. Now temperature of black body is :–

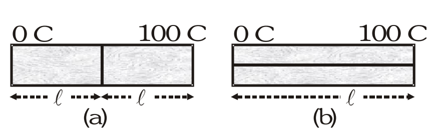
(A) 300 K (B) 2700 K (C) 270 K (D) 1800 K

60. Two Plates of equal areas are placed in contact with each other. Their thickness are 2cm and 3cm respectively. Temperature of external surface of first plate is –25 C and that of external surface of second plate is 25 C What will be temperature of contact surface if the plates :–

(i) Are of same material (ii) Have thermal Conductivity in ratio 2 : 3.

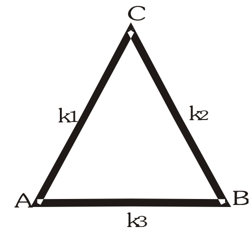
(A) (i) –5 C (ii) 0 C (B) (i) 5 C (ii) 0 C (C) (i) 0 C (ii) –5 C (D) None of these

61. Two identical square rods of metal are welded end to end as shown in figure (a) 20 calories of heat flows through it in 4 minutes. If the rods are welded as shown in figure (b), the same amount of heat will flow through the rods in :–



(A) 1 minute (B) 2 minutes (C) 4 minutes (D) 16 minutes

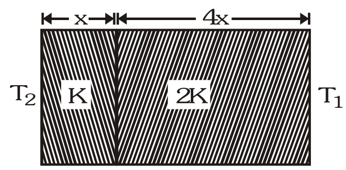
62. Three rods of same dimensions are arranged as shown in the figure. They have thermal conductivities k_1, k_2 & k_3. The points A and B are maintained at different temperatures. For the heat to flow at the same rate along ACB and AB :–



(A) $k_3 = 2(k_1 + k_2)$ (B) $k_3 = \dfrac{k_1k_2}{k_1+k_2}$

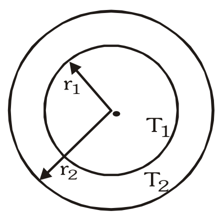
(C) $k_3 = k_1 + k_2$ (D) $k_3 = \dfrac{1}{2}(k_1 + k_2)$

63. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are T_2 and $T_1(T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\dfrac{A(T_2-T_1)K}{x}\right)f$, with f equals to:–



(A) 1 (B) 1/2 (C) 2/3 (D) 1/3

64. The figure shows a system of two concentric spheres of radii r_1 and r_2 and kept at temperatures T_1 and T_2, respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to:–



(A) $\dfrac{(r_2-r_1)}{(r_1r_2)}$ (B) $\ell n\left(\dfrac{r_2}{r_1}\right)$ (C) $\dfrac{r_1r_2}{(r_2-r_1)}$ (D) $(r_2 - r_1)$

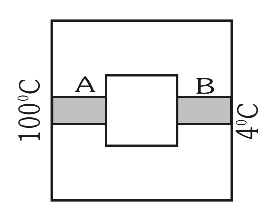
65. The pressure of one mole of an ideal gas varies according to the law $P = P_0 - aV^2$, where P_0 and a are positive constants. The highest temperature that the gas may attain is:–

(A) $\dfrac{2P_0}{3R}\left(\dfrac{P_0}{3a}\right)^{1/2}$ (B) $\dfrac{3P_0}{2R}\left(\dfrac{P_0}{3a}\right)^{1/2}$ (C) $\dfrac{P_0}{R}\left(\dfrac{P_0}{3a}\right)^{1/2}$ (D) $\dfrac{P_0}{R}\left(\dfrac{P_0}{3a}\right)^{1/2}$

66. A thermally insulated vessel contains some water at 0^0C. The vessel is connected to a vacuum pump to pump out water vapour. This results in some water getting frozen. It is given latent heat of vaporization of water at 0 C = 21 10^5 J/kg and latent heat of freezing of water = 3.36 10^5 J/kg. The maximum percentage amount of water that will be solidified in this manner will be:–

(A) 86.2% (B) 33.6% (C) 21% (D) 24.36%

67. A closed cubical box made of perfectly insulating material has walls of thickness 8 cm and the only way for heat to enter or leave the box is through two solid metal plugs A and B, each of cross–sectional area 12 cm^2 and length 8 cm fixed in the opposite walls of the box as shown in the figure. Outer surface A is kept at 100 C while the outer surface B is kept at 4 C. The thermal conductivity of the material of the plugs is 0.5 $cals^{-1}cm^{-1}$ (C^{-1}). A source of energy generating 36 $cals^{-1}$ is enclosed inside the box. The equilibrium temperature of the inner surface of the box (assuming



that it is same at all points on the inner surface) is:–

(A) 38 C (B) 57 C (C) 76 C (D) 85 C

68. Three identical adiabatic containers have helium, neon and oxygen gases at the same pressure. The gases are compressed to half their original volume. Then:–

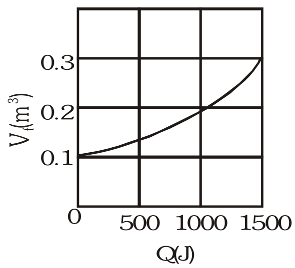
(A) The final temperature of the gas in each container is same

(B) The final pressure of the gas in each container is same

(C) The final temperature of both helium and neon is same

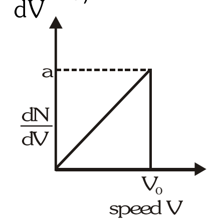
(D) The final pressure of both helium and neon is same

69. Suppose 0.5 mole of an ideal gas undergoes an isothermal expansion as energy is added to it as heat Q. Graph shows the final volume V_f versus Q. The temperature of the gas is :– (use $\ell n\ 9 = 2$ and R= $\frac{25}{3}$ J/mol-K)



(A) 293 K (B) 360 K (C) 386 K (D) 412 K

70. Graph shows a hypothetical speed distribution for a sample of N gas particle :–(for V > V_0; $\frac{dN}{dV}$ =0)



(A) The value of V_0 is 2N.

(B) The ratio V_{avg}/V_0 is equal to 2/3.

(C) The ratio V_{rms}/V_0 is equal to $1/\sqrt{2}$

(D) Three fourth of the total particle has a speed between 0.5 V_0 and V_0.

71. The temperature of an isotropic cubical solid of length ℓ_0, density ρ_0 and coefficient of linear expansion α is increased by 20 C. Then at higher temperature, to a good approximation:–

(A) Length is ℓ_0 $(1+20\alpha)$ (B) Total surface area is ℓ_0^2 $(1+40\alpha)$

(C) Total volume is ℓ_0^3 $(1+60\alpha)$ (D) Density is $\frac{\rho_0}{1+60\alpha}$

72. A glass rod when measured with a zinc scale, both being at 30 C, appears to be of length 100 cm. If the scale shows correct reading at 0 C, then the true length of glass rod at 30 C and 0 C are:–

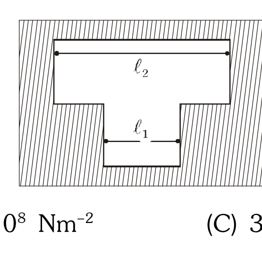
(α_{glass} = 8 10^{-6} C^{-1}, α_{zinc} = 26 10^{-6} K^{-1})

(A) 100.054 cm, 100.054 cm (B) 100.078 cm, 100.078 cm

(C) 100.078 cm, 100.054 cm (D) 100.054 cm, 100.078 cm

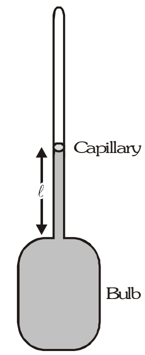
73. Two fine steel wires, fastened between the projections of a heavy brass bar, are just taut when the whole system is at 0 C. What is the tensile stress in the steel wires when the temperature of the system is raised by 200 C?

(α_{brass} = 2 10^{-5} C^{-1}, α_{steel} = 1.2 10^{-5} C^{-1}, Y_{steel} = 200 GNm^{-2})



(A) 3.2 Nm^{-2} (B) 3.2 10^8 Nm^{-2} (C) 32 10^8 Nm^{-2} (D) 0.48 Nm^{-2}

74. In a mercury–glass thermometer the cross–section of the capillary portion is A_0 and the volume of the bulb is V_0 at 273 K. If α and γ are the coefficients of linear and cubical expansion coefficients of glass and mercury respectively then length of mercury in the capillary at temperature t C is (Ignore the increase in cross–sectional area of capillary)



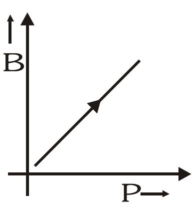
(A) $\frac{V_0}{A_0}(\gamma - 3\alpha)t$ (B) $\frac{V_0}{A_0}(2\gamma - 3\alpha)t$

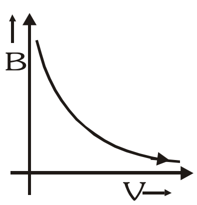
(C) $\frac{V_0}{A_0}(\gamma - 3\alpha)(t+273)$ (D) $\frac{V_0 \gamma t}{A_0}$

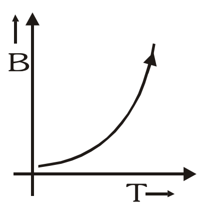
75. 5g of steam at 100 C is mixed with 10 g of ice at 0 C. Choose correct alternative/s) :–(Given s_{water} = 1 cal/g C, L_F = 80 cal/g, L_V = 540 cal/g)
(A) Equilibrium temperature of mixture is 160 C (B) Equilibrium temperature of mixture is 100^0C
(C) At equilibrium, mixture contain $13\frac{1}{3}$ g of water (D) At equilibrium, mixture contain $1\frac{2}{3}$ g of steam

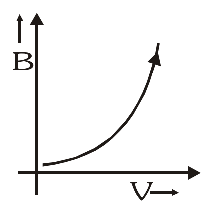
76. n moles of an ideal triatomic linear gas undergoes a process in which the temperature changes with volume as $T = k_1V^2$ where k_1 is a constant. Choose incorrect alternative:–
(A) At normal temperature $C_v = \frac{5}{2}R$ (B) At any temperature $C_p - C_v = R$
(C) At normal temperature molar heat capacity C=3R (D) At any temperature molar heat capacity C=3R

77. A sample of gas follows process represented by PV^2 = constant. Bulk modulus for this process is B, then which of the following graph is correct?

(A)


(B)


(C)


(D)


78. Four moles of hydrogen, two moles of helium and one mole of water vapour form an ideal gas mixture. What is the molar specific heat at constant pressure of mixture ?
(A) $\frac{16}{7}R$ (B) $\frac{23}{7}R$ (C) $\frac{19}{7}R$ (D) $\frac{26}{7}R$

79. A inert gas obeys the law PV^x = constant. For what value of x, it has negative molar specific heat–
(A) $x > 1.67$ (B) $x < 1.67$ (C) $1 < x < 1.4$ (D) $1 < x < 1.67$

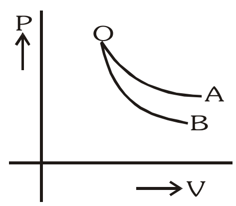
BRAIN TEASERS **ANSWER KEY** EXERCISE -2

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	B,D	C	C	B	BC	BCD	AB	B	BC	C	B	ABCD	BD	AC	B	B	D	D	ABCD	D
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	CD	ABC	ABD	AB	ABCD	CD	C	C	D	ABCD	AC	AC	D	D	A	BD	B	B	B	A
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	B	B	BD	D	B	C	A	A	B	B	B	A	D	C	A	AC	D	D	A	A
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	
Ans.	A	B	D	C	A	A	C	CD	B	ABCD	ACD	C	B	A	BCD	D	ABC	A	D	

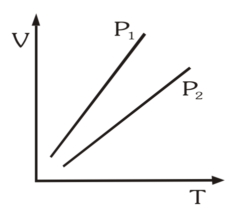
EXERCISE–03 MISCELLANEOUS TYPE QUESTIONS

TRUE / FALSE

1. The root mean square speeds of the molecules of different ideal gases, maintained at the same temperature are the same.
2. The root mean square (rms) speed of oxygen molecules (O_2) at a certain temperature T (degree absolute) is ν. If the temperature is doubled and oxygen gas dissociates into atomic oxygen, the rms speed remains unchanged.
3. At a given temperature, the specific heat of a gas at a constant pressure is always greater than its specific heat at constant volume.
4. Two spheres of the same material have radii 1m and 4m temperature 4000K and 2000K respectively. The energy radiated per second by the first sphere is greater than that by the second.
5. The internal energy of a compressed gas is less than that of a rarefied gas at the same temperature.
6. Given samples of 1 c.c. of hydrogen and 1 c.c. of oxygen, both at N.T.P. Oxygen sample has a larger molecules.
7. A piece of metal is hammered. Its internal energy increase.
8. Tea gets cooled, when sugar is added to it.
9. If a bimetallic strip is heated it will bend towards the metal with higher thermal expansion coefficient.
10. A bottle is filled with water at 30 C and opening at moon than water will be boil.
11. The curve A and B in fig. show P–V graphs for an isothermal and an adiabatic process for an ideal gas. The isothermal process is represented by the curve A.

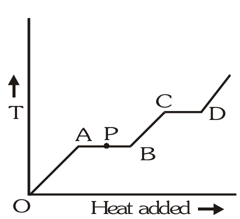


12. Temperature of body can be raised without heating.
13. The volume V versus temperature T graphs for a certain amount of a perfect gas at two pressure P_1 and P_2 are as shown in figure. It follows from the graphs that P_1 is greater than P_2.



FILL IN THE BLANKS

1. One mole of a monoatomic ideal gas is mixed with one mole of a diatomic ideal gas. The molar specific heat of the mixture at constant volume is ....
2. The variation of temperature of a material as heat is given to it a constant rate is shown in the figure. The material is solid state at the point O. The state of the material at the point P is................



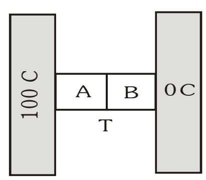
3. The earth receives at its surface radiation from the sun at the rate of 1400 Wm^{-2}. The distance of the centre of the sun from the surface of the earth is 1.5 10^{11} m and the radius of the sun is 7 10^{8} m. Treating the sun as a black body, it follows from the above data that its surface temperature is ......K.

4. A solid copper sphere (density ρ 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. The time required for the temperature of the sphere to drop to 100 K is ....

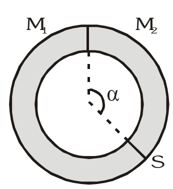
5. A container of volume 1 m^3 is divided into two equal parts by a partition. One part has an ideal gas at 300 K and the other part is vacuum. The whole system is thermally isolated from the surroundings When the partition is removed, the gas expands to occupy the whole volume. Its temperature will now be ....

6. An ideal gas with pressure P, volume V and temperature T is expended isothermally to a volume 2V and a final pressure P_i. If the same gas is expanded adiabatically to a volume 2V, the final pressure is P_a. The ratio of the specific heats of the gas is 1.67. The ratio $\frac{P_a}{P_i}$ is ....

7. Two metal cubes A and B of same size are arranged as shown in figure. The extreme ends of the combination are maintained at the indicated temperatures. The arrangement is thermally insulated. The coefficients of thermal conductivity of A and B are 300 W/m C and 200 W/m C, respectively. After steady state is reached the temperature T of the interface will be ....



8. A ring shaped tube contains two ideal gases with equal masses and relative molar masses M_1 = 32 and M_2 = 28. The gases are separated by one fixed partition and another movable stopper S which can move freely without friction inside the ring. The angle α as shown in the figure is ....degrees.



9. 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 273.16 K, the pressure in the gas thermometer reads 3.0 10^4 N/m^2. When the gas container of the same thermometer is immersed in another system, the gas pressure reads 3.5 10^4 N/m^2. The temperature of this system is therefore......... C.

10. Earth receives 1400 W/m^2 of solar power. If all the solar energy falling on a lens of area 0.2 m^2 is focused onto a block of ice of mass 280 g, the time taken to melt the ice will be .... minutes. (Latent heat of fusion of ice = 3.3 10^5 J/kg)

11. If the degrees of freedom of a gas are f, then $\frac{2C_V}{C_P - C_V}$ will be equal to ....

Match the column

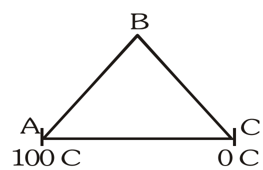
1. Three liquids A, B and C having same specific heat and mass m, 2m and 3m have temperature 20 C, 40 C and 60 C respectively. Temperature of the mixture when :

	Column I		Column II
(A)	A and B are mixed	(p)	35 C
(B)	A and C are mixed	(q)	52 C
(C)	B and C are mixed	(r)	50 C
(D)	A, B and C all three are mixed	(s)	45 C
		(t)	None

2.

	Column–I		Column–II
(A)	Isobaric process	(p)	No heat exchange
(B)	Isothermal process	(q)	Constant pressure
(C)	Isoentropy process	(r)	Constant internal energy
(D)	Isochoric process	(s)	Work done is zero

3. Three rods of equal length of same material are joined to form an equilateral triangle ABC as shown in figure. Area of cross–section of rod AB is S, of rod BC is 2S and that of AC is S, then

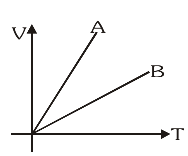


	Column I		Column II
(A)	Temperature of junction B	(p)	Greater than 50 C
(B)	Heat current in AB	(q)	Less than 50 C
(C)	Heat current in BC	(r)	Is equal to heat current in BC
		(s)	Is $\frac{2}{3}$ times heat current in AC
		(t)	None

4.

	Column I		Column II
(A)	In $P = \frac{2}{3}E$, E is	(p)	Change in internal energy is only in isochoric process
(B)	In U=3RT for an monoatomic gas U is	(q)	Translational kinetic energy of unit volume
(C)	In $W = P(V_f - V_i)$, W is	(r)	Internal energy of one mole
(D)	In $\Delta U = nC_v\Delta T$, ΔU is	(s)	Work done in isobaric process
		(t)	None

5. In the V–T graph shown in figure:

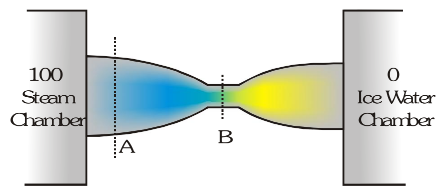


	Column I		Column II
(A)	Gas A is ... and gas B is ...	(p)	monoatomic, diatomic
(B)	P_A / P_B is	(q)	diatomic, monoatomic
(C)	n_A / n_B is	(r)	$>$ 1
		(s)	$<$ 1
		(t)	cannot say any thing

6. For one mole of a monoatomic gas :–

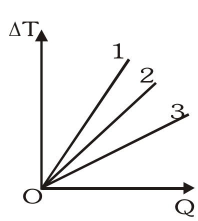
	Column I		Column II
(A)	Isothermal bulk modulus	(p)	$-\frac{RT}{V^2}$
(B)	Adiabatic bulk modulus	(q)	$-\frac{5P}{3V}$
(C)	Slope of P–V graph in isothermal process	(r)	T/V
(D)	Slope of P–V graph in adiabatic process	(s)	4T/3V
		(t)	None

7. A copper rod (initially at room temperature 20 C) of non–uniform cross section is placed between a steam chamber at 100 C and ice–water chamber at 0 C. A and B are cross sections as shown in figure. Then match the statements in column–I with results in column–II using comparing only between cross section A and B. (The mathematical expressions in column–I have usual meaning in heat transfer).



	Column I		Column II
(A)	Initially rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be	(p)	Maximum at section A
(B)	At steady state rate of heat flow $\left(\frac{dQ}{dt}\right)$ will be	(q)	Maximum at section B
(C)	At steady state temperature gradient $\left\lvert\left(\frac{dT}{dx}\right)\right\rvert$ will be	(r)	Minimum at section B
(D)	At steady state rate of change of temperature $\left(\frac{dT}{dt}\right)$ at a certain point will be	(s)	Same for all section

8. The straight lines in the figure depict the variations in temperature ΔT as a function of the amount of heat supplied Q in different process involving the change of state of a monoatomic and a diatomic ideal gas. The initial states (P,V,T) of the two gases are the same. Match the processes as described, with the straight lines in the graph as numbered.



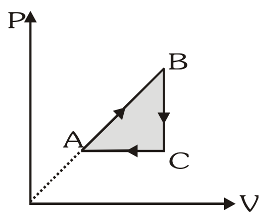
	Column-I		Column-II
(A)	Iosbaric process of monoatomic gas.	(p)	1
(B)	Isobaric process of diatomic gas	(q)	2
(C)	Isochoric process of monoatomic gas	(r)	3
(D)	Isochoric process of diatomic gas	(s)	x-axis (i.e. 'Q' axis)

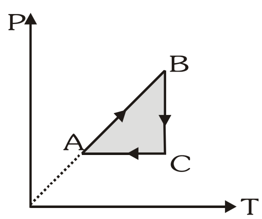
9. An ideal gas whose adiabatic exponent equals to $\gamma = \frac{7}{5}$ is expanded according to the law P=2V. The initial volume of the gas is equal to V_0= 1unit . As a result of expansion the volume increases 4 times. (Take $R = \frac{25}{3}$ units)

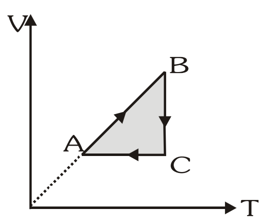
	Column – I		Column – II
(A)	Work done by the gas	(p)	25 units
(B)	Increment in internal energy of the gas	(q)	45 units
(C)	Heat supplied to the gas	(r)	75 units
(D)	Molar heat capacity of the gas in the process	(s)	15 units

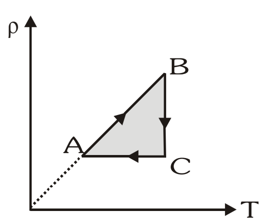
10. For a ideal monoatomic gas match the following graphs for constant mass in different processes (ρ = Density of gas)

Column I

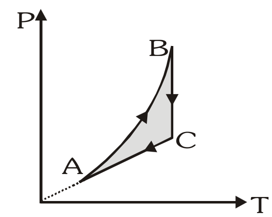
(A) 

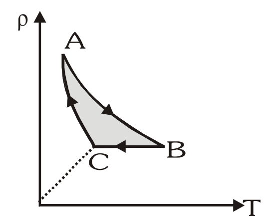
(B) 

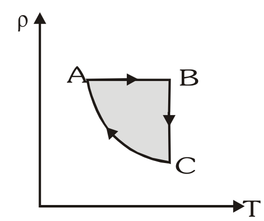
(C) 

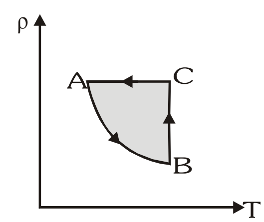
(D) 

Column II

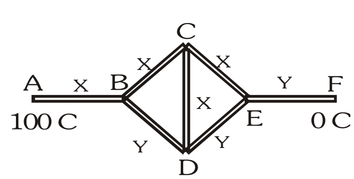
(p) 

(q) 

(r) 

(s) 

11. Four rods of material X and three rods of material Y are connected as shown in figure. All the rods are of identical lengths and cross-sectional area. Given thermal resistance of rod of material X, R_x = R and thermal conductivities of materials are related by relation $K_Y = 2K_X$.



	Column I		Column II
(A)	Thermal resistance between B and E	(p)	$\frac{500}{13}$°C
(B)	Thermal resistance between A and F	(q)	$\frac{700}{13}$°C
(C)	Temperature of junction B	(r)	$\frac{2R}{3}$
(D)	Temperature of junction D	(s)	$\frac{13R}{6}$

ASSERTION–REASON

In each of the following questions, a Statement of Assertion (A) is given followed by a corresponding Statement of Reason (R) just below it . Of the Statements mark the correct answer as

1. **Statement–1** : A real gas behaves as an ideal gas at high temperature and low pressure.

and

Statement–2 : Liquid state of an ideal gas is impossible.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

2. **Statement–1** : The ratio $\frac{C_P}{C_V}$ for a monatomic gas is more than for a diatomic gas.

and

Statement–2 : The molecules of a monatomic gas have more degrees of freedom than those of a diatomic gas.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

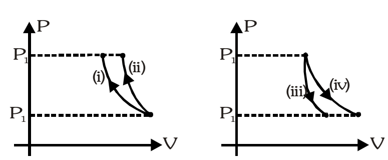
3. **Statement–1** : In adiabatic expansion of monoatomic ideal gas, if volume increases by 24% then pressure decreases by 40%.

and

Statement–2 : For adiabatic process PV^{γ} = constant

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

4. **Statement–1** : In following figure curve (i) and (iv) represent isothermal process while (ii) & (iii) represent adiabatic process.

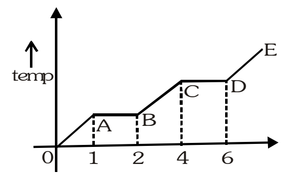


and

Statement–2 : The adiabatic at any point has a steeper slope than the isothermal through the same point.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

5. **Statement–1** : A solid material is supplied heat at a constant rate. The temp. of the material is changing with the heat input as shown in figure. Latent heat of vaporization of substance is double that of fusion (given CD = 2AB).



and

Statement–2 : $L_f \propto AB$ and $L_v \propto CD$

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

6. **Statement–1** : Water kept in an open vessel will quickly evaporate on the surface of the Moon.
and
Statement–2 : The temperature at the surface of the moon is much higher than boiling point of water at Earth.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

7. **Statement–1** : Change in internal energy in the melting process is due to change in internal potential energy.
and
Statement–2 : This is because in melting, distance between molecules increase but temperature remains constant.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

8. **Statement–1** : Air quickly leaking out of a balloon becomes cooler.
and
Statement–2 : The leaking air undergoes adiabatic expansion.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

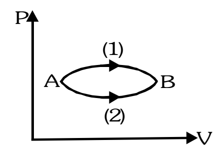
9. **Statement–1** : Absolute zero temperature is not the temperature of zero energy.
and
Statement–2 : Only the internal kinetic energy of the molecules is represented by temperature.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

10. **Statement–1** : An ideal gas has infinitely many molar specific heats.
and
Statement–2 : Specific heat is amount of heat needed to raise the temperature of 1 mole of gas by 1 K.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

11. **Statement–1** : The bulb of one thermometer is spherical while that of the other is cylindrical. Both have equal amount of mercury. The response of the cylindrical bulb thermometer will be quicker.
and
Statement–2 : Heat conduction in a body is directly proportional to cross–sectional area.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

12. **Statement–1** : The steam at 100 C causes more severe burn to human body than the water at 100 C.
and
Statement–2 : The steam has greater internal energy due to latent heat of vaporization.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

13. **Statement–1** : A gas is taken from state A to state B through two different paths. Molar specific heat capacity in path (A) is more as compared to (B).
and



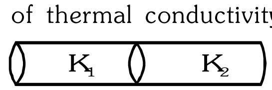
Statement–2 : Specific heat $C = \dfrac{Q}{n\Delta T}$ & Q = ΔU + W and W is equal to area under P–V diagram.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

14. **Statement–1** : On sudden expansion a gas cools.
and
Statement–2 : On sudden expansion, no heat is supplied to system and hence gas does work at the expense of its internal energy.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

15. **Statement–1** : The isothermal curves intersect each other at a certain point.
and
Statement–2 : The isothermal change are done slowly, so the isothermal curves have very little slope.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

16. **Statement–1** : In a process if initial volume is equal to the final volume, work done by the gas is zero.
and
Statement–2 : In an isochoric process work done by the gas is zero.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

17. **Statement–1** : Two solid cylindrical rods of identical size and different thermal conductivity K_1 and K_2 are connected in series. Then the equivalent thermal conductivity of two rod system is less than the value of thermal conductivity of either rod.



and

Statement-2 : For two cylindrical rods of identical size and different thermal conductivity K_1 and K_2 connected in series, the equivalent thermal conductivity K is given by $\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

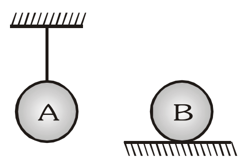
18. **Statement-1** : When a bottle of cold carbonated drink is opened, a slight fog forms around the opening.

and

Statement-2 : Adiabatic expansion of the gas causes lowering of temperature and condensation of water vapours.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

19. **Statement-1** : Equal amount of heat is supplied to two identical spheres A & B (see figure). The increment in temperature for sphere A is more than sphere B.



and

Statement-2 : Work done due to gravity on sphere A is positive while on sphere B is negative.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

20. **Statement-1** : Temperatures near the sea–coast are moderate.

and

Statement-2 : Water has a high thermal conductivity compared to ice.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

21. **Statement-1** : A cloudy night is hotter than a clear sky night.

and

Statement-2 : Clouds are bad absorbers of heat.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

22. **Statement-1** : When hot water is poured in a beaker of thick glass, the beaker cracks.

and

Statement-2 : Glass is a bad conductor of heat and outer surface of the beaker does not expand.

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

23. **Statement–1** : Potential energy of water at 0 C is more than ice at 0 C.
and
Statement–2 : Heat given to melt ice at 0 C is used up in increasing the potential energy of water molecules formed at 0 C.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

24. **Statement–1** : When an electric fan is switched on in a closed room, the air of the room is cooled.
and
Statement–2 : When fan is switched on, the speed of the air molecules will increase.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

25. **Statement–1** : Snow is better insulator than ice.
and
Statement–2 : Snow contain air packet and air is a bad conductor of heat.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

26. **Statement–1** : Animals curl into a ball, when they feel very cold.
and
Statement–2 : Animals by curling their body reduces the surface area.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

27. **Statement–1** : A sphere, a cube and a thin circular plate made of same material and of same mass are initially heated to 200 C, the plate will cool at fastest rate.
and
Statement–2 : Rate of cooling = $\frac{\rho A \sigma}{ms}(T^4 - T_0^4) \propto$ surface area. Surface area is maximum for circular plate.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

28. **Statement–1** : High thermal conductivity of metals is due to presence of free electrons.
and
Statement–2 : Electrons at same temperature have very high average velocity than atoms.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

29. **Statement–1** : Liquids usually expand more than solids.
and
Statement–2 : The intermolecular forces in liquids are weaker than in solids.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

30. **Statement–1** : Water is considered unsuitable for use in thermometers.
and
Statement–2 : Thermal Expansion of water is non uniform.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

31. **Statement–1** : Temperature of a rod is increased and again cooled to same initial temperature then its final length is equal to original length provided there is no deformation take place.
and
Statement–2 : For a small temperature change, length of a rod varies as $\ell=\ell_0(1+\alpha\Delta T)$ provided $\alpha\Delta T<<1$. Here symbol have their usual meaning.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

32. **Statement–1** : Coolant coils are fitted at the top of a refrigerator, for formation of convection current.
and
Statement–2 : Air becomes denser on cooling.
(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

Comprehension Based Questions

Comprehension #1

A certain amount of ice is supplied heat at a constant rate for 7 min. For the first one minute the temperature rises uniformly with time. Then it remains constant for the next 4 min and again the temperature rises at uniform rate for the last 2 min. Given S_{ice} = 0.5 cal/g C, L_f = 80 cal/g :

1. The initial temperature of ice is :–
(A) –10 C (B) –20 C (C) –30 C (D) –40 C

2. Final temperature at the end of 7 min is :
(A) 10 C (B) 20 C (C) 30 C (D) 40 C

Comprehension#2

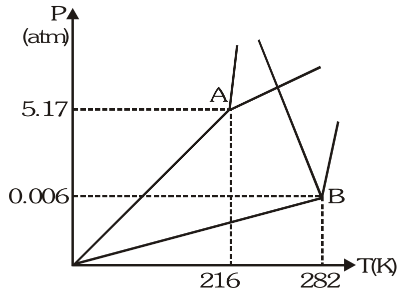
Molar heat capacity of an ideal gas in the process PV^x = constant, is given by : $C=\frac{R}{\gamma-1}+\frac{R}{1-x}$. An ideal diatomic gas with $C_V=\frac{5R}{2}$ occupies a volume V_1 at a pressure P_1. The gas undergoes a process in which the pressure is proportional to the volume. At the end of the process the rms speed of the gas molecules has doubled from its initial value.

1. The molar heat capacity of the gas in the given process is :–
(A) 3 R (B) 3.5 R (C) 4 R (D) 2.5 R

2. Heat supplied to the gas in the given process is :
(A) $7P_1V_1$ (B) $8P_1V_1$ (C) $9P_1V_1$ (D) $10P_1V_1$

Comprehension#3

Each phase of a material can exist only in certain regions of pressure and temperature. P–T phase diagrams, in which pressure is plotted versus temperature, show the regions corresponding to various phases and phase transformations. P–V diagrams, on the other hand, can be used to study pressure volume relationships at a constant temperature.



If the liquid and gaseous phases of a pure substances are heated together in a closed container, both the temperature

and the vapor pressure will increase until a point is reached at which the two phases can no longer be distinguished from one another. The temperature and pressure at which this occurs are called the critical temperature and pressure. Exceeding either of these parameters, by itself, will cause the gas/liquid phase transition to disappear. If the other variable is then changed as well, while the first variable is maintained above its critical point, a gradual transition will occur between the gaseous and liquid phases, with no clear boundary. (The liquid and solid phases, on the other hand, maintain a distinct boundary at all pressures above the triple point.) Shown in figure is a combined P–T phase diagram for materials A and B.

1. If heat is added to solids A and B, each in a container that is open to the atmosphere :–
(A) A will boil and B will melt
(B) A will sublime and B will melt, then boil
(C) A will melt and B will sublime
(D) Both A and B will first melt, then boil

2. Which is true about the substances in figure ?
(A) At 2 atm pressure and 220 K temperature, A is a gas and B is solid
(B) At 6 atm pressure and 280 K temperature, A is a gas and B is a solid
(C) At 5 atm pressure and 100 K temperature, A is a gas and B is a solid
(D) At 4 atm pressure and 300 K temperature, both A and B are liquids

Comprehension#4

Solids and liquids both expand on heating. The density of substance decreases on expanding according to the relation

$\rho_2 = \dfrac{\rho_1}{1+\gamma(T_2-T_1)}$, where, $\rho_1 \rightarrow$ density at T_1, $\rho_2 \rightarrow$ density at T_2, $\gamma \rightarrow$ coefficient of volume expansion of substances.

When a solid is submerged in a liquid, liquid exerts an upward force on solid which is equal to the weight of liquid displaced by submerged part of solid.

Solid will float or sink depends on relative densities of solid and liquid.

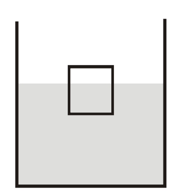
A cubical block of solid floats in a liquid with half of its volume submerged in liquid as shown in figure (at temperature T)

$\alpha_S \rightarrow$ Coefficient of linear expansion of solid

$\gamma_L \rightarrow$ Coefficient of volume expansion of liquid

$\rho_S \rightarrow$ Density of solid at temperature T

$\rho_L \rightarrow$ Density of liquid at temperature T



1. The relation between densities of solid and liquid at temperature T is
(A) $\rho_S = 2\rho_L$
(B) $\rho_S = (1/2)\rho_L$
(C) $\rho_S = \rho_L$
(D) $\rho_S = (1/4)\rho_L$

2. If temperature of system increases, then fraction of solid submerged in liquid
(A) increases (B) decreases (C) remains the same (D) inadequate information

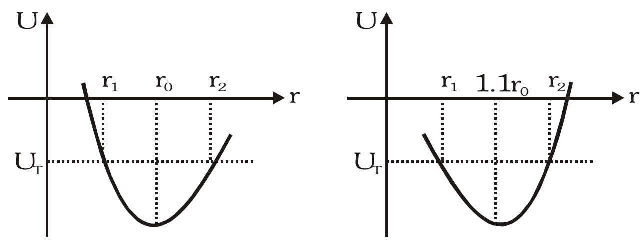
3. Imagine friction submerged does not change on increasing temperature the relation between γ_L and α_S is
(A) $\gamma_L = 3\alpha_S$ (B) $\gamma_L = 2\alpha_S$ (C) $\gamma_L = 4\alpha_S$ (D) $\gamma_L = (3/2)\alpha_S$

4. Imagine the depth of the block submerged in the liquid does not change on increasing temperature then
(A) $\gamma_L = 2\alpha$ (B) $\gamma_L = 3\alpha$ (C) $\gamma_L = (3/2)\alpha$ (D) $\gamma_L = (4/3)\alpha$

5. Assume block does not expand on heating. The temperature at which the block just begins to sink in liquid is
(A) $T + \frac{1}{\gamma_L}$ (B) $T + \frac{1}{(2\gamma_L)}$ (C) $T + \frac{2}{(\gamma_L)}$ (D) $T + \frac{\gamma_L}{2}$

Comprehension#5

Consider a hypothetical situation where we are comparing the properties of two crystals made of atom A and atom B. Potential energy (U) v/s interatomic separation (r) graph for atom A and atom B is shown in figure (i) and (ii) and respectively.



(i) (ii)

1. Choose correct statement
(A) Volume of A and B expand on heating
(B) Volume of A and B contract on heating
(C) A expands on heating and B contracts on heating
(D) A contracts on heating and B expands on heating

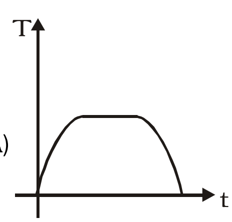
2. When we heat the crystal of either atoms, the atom undergo oscillation. Choose correct statement for atoms of crystal A
(A) Their equilibrium position remains unchanged but average separation decreases
(B) Their equilibrium position remains unchanged but average separation increases
(C) Their separation at equilibrium position as well as average separation increases
(D) Their separation at equilibrium position decreases but average separation increases

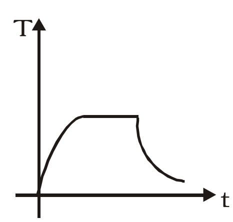
3. It is seen that the potential energy can reach a maximum value of U_T at temperature T=10K. If r_1 and r_2 are 0.9999 r_0 and 1.0003 r_0 for atoms of crystal A, its approximate coefficient of linear expansion can be :–
(A) 4 10^{-5} /K (B) 1 10^{-5} /K (C) 2 10^{-5} /K (D) 3 10^{-5} /K

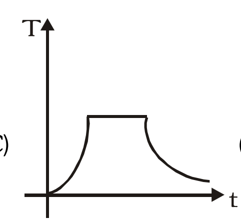
Comprehension#6

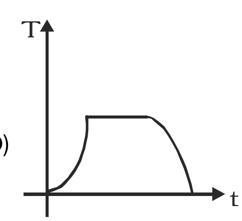
In a home experiment, Ram brings a new electric kettle with unknown power rating. He puts 1 litre water in the kettle and switches on. But to his dismay, the temperature becomes constants at 60^0C after some time. The room temperature is 20^0C. Ram gets bored and switches off the kettle. He sees that during first 20 s water cools down by 2^0C.

1. Which is the best graph for temperature v/s time?

(A) 

(B) 

(C) 

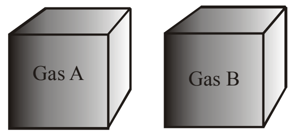
(D) 

2. What is the wattage of the kettle
(A) 840W (B) 1W (C) 100W (D) 420 W

3. What is the time taken for the water to cool to 40^0C. (Approx)
(A) 510 s (B) 270 s (C) 120 s (D) 410 s

Comprehension #7

Two closed identical conducting containers are found in the laboratory of an old scientist. For the verification of the gas some experiments are performed on the two boxes and the results are noted.



Experiment 1. When the two containers are weighed W_A = 225 g, W_B = 160 g and mass of evacuated container W_c=100g.

Experiment 2. When the two containers are given same amount of heat same temperature rise is recorded. The pressure change found are ΔP_A = 2.5 atm. ΔP_B = 1.5 atm

Required data for unknown gas :

Mono (molar mass)	He 4g	Ne 20g	Ar 40g	Kr 84g	Xe 131g	Rd 222g
Dia (molar mass)	H_2 2g	F_2 19g	N_2 28g	O_2 32g	Cl_2 71g	

1. Identify the type of gas filled in container A and B respectively
(A) Mono, Mono (B) Dia, Dia (C) Mono, Dia (D) Dia, Mono

2. Identify the gas filled in the container A and B
(A) N_2, Ne (B) He, H_2 (C) O_2, Ar (D) Ar, O_2

3. Total number of molecules in 'A' (Here N_A = avagadro number)
(A) $\frac{125}{64}N_A$ (B) 3.125 N_A (C) $\frac{125}{28}N_A$ (D) 31.25 N_A

4. The initial internal energy of the gas in container 'A', If the containers were at room temperature 300K initially.
(A) 1406.25 cal (B) 1000 cal (C) 2812.5 cal (D) None of these

5. If the gases have initial temperature 300 K and they are mixed in an adiabatic container having the same volume as the previous containers. Now the temperature of the mixture is T and pressure is P. Then
(A) $P > P_A$, $T > 300$ K (B) $P > P_B$, $T = 300$ K
(C) $P < P_A$, $T = 300$ K (D) $P > P_A$. $T < 300$ K

Comprehension#8

Most substances contract on freezing. However, water does not belong to this category. We know that water expands on freezing. Further, coefficient of volume expansion of water in the temperature range from 0 C to 4 C is negative and above 4 C it is positive. This behaviour of water shapes the freezing of lakes as the atmospheric temperature goes down and it is still above 4 C.

1. As the atmospheric temperature goes down, but it is still above 4 C

(A) Cooled water at the surface flows downward because of its greater density

(B) Cooled water at the surface does not flow downward and remains at the surface because its smaller density

(C) Cooled water at the surface, through it remains on the surface because of its smaller density, will conduct heat from the interior to the atmosphere

(D) Cooled water at the surface flows to the bottom because of its smaller density

2. As the atmospheric temperature goes below 4 C

(A) Cooled water at the surface flows downward because of its greater density

(B) Cooled water at the surface does not flow downward and remains at the surface because of its smaller density

(C) Cooled water at the surface downward because of its smaller density

(D) Temperature of water in the lake reduces with depth

3. If the atmospheric temperature is below 0 C and ice begins to form at t = 0, thickness of ice sheet formed up to a time 't' will be directly proportional to a time 't' will be directly proportional to

(A) t^4 (B) t^2 (C) t (D) $t^{1/2}$

4. If the atmospheric temperature is below 0 C

(A) Ice will form from the bottom upward and the plants and animals in the lake will be displaced to the upper part of the lake.

(B) Ice will form in a random manner throughout the volume of the lake and with the passage of time, different segments of ice will join together to result in a collective ice mass

(C) Ice will form from the surface downward and plant and animal life will survive in the water beneath

(D) Water in the lake does not freeze. In fact, water in the atmosphere freezes and fall into the lake and floats on the surface of lake as ice.

Comprehension#9

Five moles of helium are mixed with two moles of hydrogen to form a mixture. Take molar mass of helium M_1=4g and that of hydrogen M_2=2g

1. The equivalent molar mass of the mixture is

(A) 6g (B) $\frac{13g}{7}$ (C) $\frac{18g}{7}$ (D) None

2. The equivalent degree of freedom f of the mixture is

(A) 3.57 (B) 1.14 (C) 4.4 (D) None

3. The equivalent value of γ is

(A) 1.59 (B) 1.53 (C) 1.56 (D) None

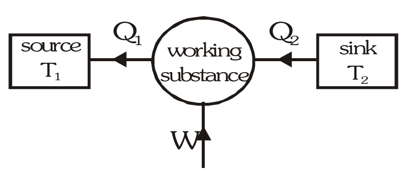
4. If the internal energy of He sample is 100J and that of the hydrogen sample is 200J, then the internal energy of the mixture is

(A) 900 J (B) 128.5 J (C) 171.4J (D) 300J

Comprehension#10

Refrigerator is an apparatus which takes heat from a cold body, work is done on it and the work done together with the heat absorbed is rejected to the source. An ideal refrigerator can be regarded as Carnot's ideal heat engine working in the reverse direction. The coefficient of performance of refrigerator is defined as

$$\beta = \frac{\text{Heat extracted from cold reservoir}}{\text{work done on working substance}} = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$$



A Carnot's refrigerator takes heat from water at 0 C and discards it to a room temperature at 27 C. 1kg of water at 0 C is to be changed into ice at 0 C. (L_{ice} = 80 kcal/kg)

1. How many calories of heat are discarded to the room ?

(A) 72.8 kcal (B) 87.9 kcal (C) 80 kcal (D) 7.9 kcal

2. What is the work done by the refrigerator in this process (1 cal = 4.2 joule)
(A) 7.9 kJ (B) 33.18 kJ (C) 43.18 kJ (D) 23.18 kJ

3. What is the coefficient of performance of the machine ?
(A) 11.1 (B) 10.1 (C) 9.1 (D) 8.1

Comprehension#11

Entropy (S) is a thermodynamic variable like pressure P, volume V and temperature T. Entropy of a thermodynamic system is a measure of disorder of molecular motion. Greater is disorder, greater is entropy. Change in entropy of a thermodynamic system is the ratio of heat supplied to absolute temperature. In an adiabatic reversible process, entropy remains constant while in any irreversible process entropy increases. In nature the processes are irreversible; therefore entropy of universe is continuously increasing.

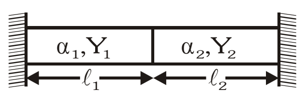
1. The unit of entropy in S–I system is–
(A) cal/K (B) joule/kg (C) joule/K (D) kilocal/ C

2. When milk is heated, its entropy :
(A) increases (B) decreases (C) remains unchanged (D) may decrease or increase

3. After a long–long time, the energy available for work will be :
(A) as much as present value (B) much less than present value
(C) much more than present value (D) can not say

Comprehension#12

Two rods of equal cross sections area are joined end the end as shown in figure. These are supported between two rigid vertical walls. Initially the rods are unstrained.



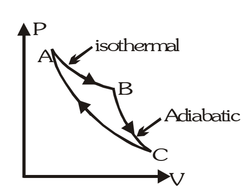
1. If temperature of system is increased by ΔT then junction will not shift if–
(A) $Y_1\alpha_1 = Y_2\alpha_2$ (B) $Y_1\alpha_1\ell_1 = Y_2\alpha_2\ell_2$ (C) $\alpha_1 = \alpha_2$ (D) $Y_2\alpha_1\ell_1 = Y_1\alpha_2\ell_2$

2. If temperature of system is increased by ΔT then thermal stress developed in first rod–
(A) is equal to thermal stress developed in second rod
(B) is greater than thermal stress developed in second rod
(C) is less than thermal stress developed in second rod
(D) None of these

3. If temperature of system is increased by ΔT then shifting in junction if $Y_1\alpha_1 > Y_2\alpha_2$ is given by–
(A) $\frac{\ell_1\ell_2(Y_1\alpha_2 - Y_2\alpha_1)}{Y_1\ell_1 + Y_2\ell_2}$ (B) $\frac{\ell_1\ell_2(Y_1\alpha_1 - Y_2\alpha_2)}{Y_1\ell_2 + Y_2\ell_1}$ (C) $\frac{\ell_1\ell_2(Y_1\alpha_1 - Y_2\alpha_2)}{Y_1\ell_1 + Y_2\ell_2}$ (D) None of these

Comprehension#13

A cyclic process for an ideal gas is shown in figure. Given W_{AB} = +700 J, W_{BC} = +400 J, Q_{CA} =–100J.



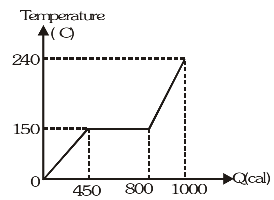
1. Find ΔU_{BC}
(A) –700 J (B) –400 J (C) –100 J (D) 400 J

2. Find W_{CA}
(A) –500 J (B) 500 J (C) 400 J (D) –400 J

3. The efficiency of the cycle is -
(A) 100% (B) 83.44% (C) 85.71% (D) 81.11%

Comprehension#14

A substance is in the solid form at 0 C. The amount of heat added to this substance and its temperature is plotted in the graph. The specific heat capacity of the solid substance is 0.5 cal/g C.



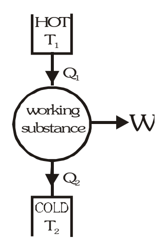
1. The mass of the substance is-
(A) 6g (B) 12g (C) 3g (D) Can't be calculated

2. Latest heat capacity in melting process is-
(A) $\frac{350}{3}$ cal/g (B) $\frac{175}{3}$ cal/g (C) $\frac{400}{3}$ cal/g (D) Can't say

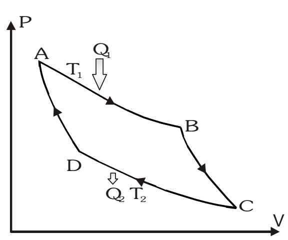
3. Specific heat capacity in the liquid state is-
(A) $\frac{5}{27}$ cal/g C (B) $\frac{5}{27}$ cal/gK (C) $\frac{10}{27}$ cal/g C (D) Can't say

Comprehension#15

The efficiency of a heat engine is defined as the ratio of the mechanical work done by the engine in one cycle to the heat absorbed from the high temperature source. $\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$ Cornot devised an ideal engine which is based on a reversible cycle of four operations in succession : isothermal expansion, adiabatic expansion, isothermal compression and adiabatic compression.



For carnot cycle $\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$. Thus $\eta = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$ According to carnot theorem "No irreversible engine can have efficiency greater than carnot reversible engine working between same hot and cold reservoirs".



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1. A carnot engine whose low temperature reservoir is at 7 C has an efficiency of 50%. It is desired to increase the efficiency to 70%. By how many degrees should the temperature of the high temperature reservoir be increased?

(A) 273 K (B) $\frac{1120}{3}$K (C) 140 K (D) None of these

2. An inventor claims to have developed an engine working between 600K and 300K capable of having an efficiency of 52%, then-

(A) It is impossible (B) It is possible (C) It is nearly possible (D) Data is insufficient

3. Efficiency of a carnot's cycle change from $\frac{1}{6}$ to $\frac{1}{3}$ when source temperature is raised by 100 K. The temperature of the sink is-

(A) $\frac{1000}{3}$K (B) $\frac{500}{3}$K (C) 250 K (D) 100 K

MISCELLANEOUS TYPE QUESTION — **ANSWER KEY** — EXERCISE –3

- **True / False**

1. T 2. F 3. F 4. T 5. F 6. F 7. T 8. T 9. F 10. T 11. T 12. T 13. T

- **Fill in the blanks :**

1. 2r 2. partly solid and partly liquid 3. 5803 4. 1.71 ρrc 5. Temp. remains constant
6. 0.628 7. 60^{0}C 8. 192^{0}C 9. 45.68^{0}C 10. 5.5 11. f

- **Match the Column:**

1. (A) t (B) r, (C) q, (D) t 2. (A) q, (B) r (C) p (D) s 3. (A) p (B) r, (C) t 4.(A) q (B) t (C) s (D) t
5. (A) t (B) t (C) t 6. (A) t (B) t (C) p (D) q 7. (A) p,r (B) s (C) q (D) s 8. (A) q (B) r (C) p (D) q
9. (A) s (B) r (C) q (D) p 10. (A) q (B) r (C) s (D) p 11. (A) r (B) s (C) q (D) p

- **Assertion – Reason**

1. B 2. C 3. D 4. A 5. A 6. C 7. A 8. A 9. D 10. D 11. A
12. A 13. A 14. A 15. E 16. D 17. D 18. A 19. A 20. C 21. A 22. A
23. A 24. D 25. A 26. A 27. A 28. C 29. A 30. A 31. B 32. A

- **Comprehension Based Quesions**

Comp. #1 : 1. D 2. D
Comp. #2 : 1. A 2. C
Comp. #3: 1. D 2. A
Comp. #4 : 1. B 2. D 3. A 4. A 5. A
Comp. #5 : 1. C 2. B 3. C
Comp. #6 : 1. B 2. B 3. B
Comp. #7: 1. C 2. D 3. B 4. C 5. B
Comp. #8 : 1. A 2. B 3. D 4. C
Comp. #9: 1. D 2. A 3. C 4. D
Comp #10 1. B 2. B 3. B
Comp. #11: 1. C 2. A 3. B
Comp. #12: 1. B 2. A 3. B
Comp. #13: 1. B 2. A 3. C
Comp. #14: 1. A 2. B 3. C
Comp. #15: 1. B 2. A 3. A

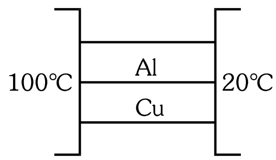
EXERCISE–04 [A]

CONCEPTUAL SUBJECTIVE EXERCISE

1. 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 isosceles 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 isosceles triangle is to remain at a constant height from the knife edge as the temperature changes?

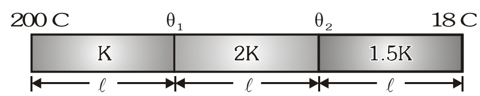
2. A bimetallic strip of thickness d and length L is clamped at one end at temperature t_1. Find the radius of curvature of the strip if it consists of two different metals of expansivity α_1 and α_2 ($\alpha_1>\alpha_2$) when its temperature rises to t_2 C.

3. Two metal cubes with 3 cm–edges of copper and aluminium are arranged as shown in figure. Find



(i) The total thermal current from one reservoir to the other.
(ii) The ratio of the thermal current carried by the copper cube to that carried by the aluminium cube.
Thermal conductivity of copper is 60 W/m–K and that of aluminium is 40 W/m–K.

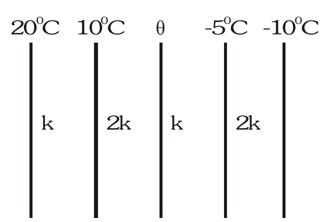
4. Calculate θ_1 and θ_2 in shown situation.



5. A 'thermacole' icebox is a cheap and efficient method for storing small quantities of cooked food in summer in particular. A cubical icebox of side 30 cm has a thickness of 5.0 cm. If 4.0 kg of ice is put in the box, estimate the amount of ice remaining after 6 h. The outside temperature is 45 C, and co–efficient of thermal conductivity of thermacole is 0.01 J s^{-1} m^{1} C^{-1}. [Heat of fusion of water = 335 10^{3} J kg^{-1}]

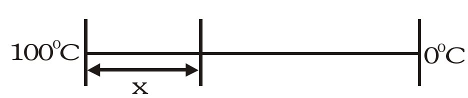
6. An electric heater is used in a room of total wall area 137 m^2 to maintain a temperature of +20 C inside it, when the outside temperature is –10 C. The walls have three different layers materials. The innermost layer is of wood of thickness 2.5 cm, the middle layer is of cement of thickness 1.0 cm and the outermost layer is of brick of thickness 25.0 cm. Find the power of the electric heater. Assume that there is no heat loss through the floor and the ceiling. The thermal conductivities of wood, cement and brick are 0.125, 1.5 and 1.0 W/m/ C respectively.

7. The figure shows the face and interface temperature of a composite slab containing of four layers of two materials having identical thickness. Under steady state condition, find the value of temperature θ.



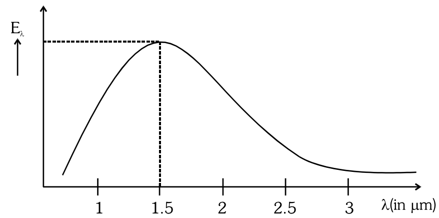
k=thermal conductivity

8. A lagged stick of cross section area 1 cm^2 and length 1m is initially at a temperature of 0^0C. It is then kept between 2 reservoirs of temperature 100^0C and 0^0C. Specific heat capacity is 10 J/kg^{0}C and linear mass density is 2kg/m. Find



(i) Temperature gradient along the rod in steady state
(ii) Total heat absorbed by the rod to reach steady state

9. Calculate the temperature of the black body from given graph.



10. Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are same, the two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiance from B is shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A by 1.0 μm. If the temperature of A is 5802K, Calculate :–
(i) The temperature of (ii) Wavelength λ_B

11. **Answer the following questions in brief :**
(i) A poor emitter has a large reflectivity. Explain why.
(ii) A copper tumbler feels much colder than a wooden block on a cold day. Explain why.
(iii) The earth would become so cold that life is not possible on it in the absence of the atmosphere. Explain why?
(iv) Why clear nights are cooler than cloudy nights ?
(v) Why does a piece of red glass when heated and taken out glow with green light ?
(vi) Why does the earth not become as hot as the sun although it has been receiving heat from the sun for ages ?
(vii) Animals curl into a ball when they are very cool. Why ?
(viii) Heat is generated continuously in an electric heater but its temperature becomes constant after some time. Explain why ?
(ix) A piece of paper wrapped tightly on a wooden rod is observed to get charred quickly when held over a flame as compared to a similar piece of paper when wrapped on a brass rod. Explain why ?
(x) Liquid in a metallic pot boils quickly whose base is made black and rough than in a pot whose base is highly polished. Why ?

12. In an industrial process 10 kg of water per hour is to be heated from 20^0C to 80^0C. To do this, steam at 150^0C is passed from a boiler into a copper coil immersed in water. The steam condenses in the coil and is returned to the boiler as water at 90^0C. How many kg of steam are required per hour? Specific heat of steam = 1 kilocal $kg^{-1}\ {}^0C^{-1}$. Latent heat of steam = 540 kilocal kg^1.

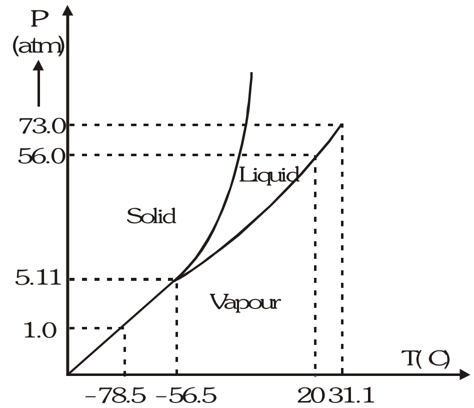
13. Aluminium container of mass 10 g contains 200 g of ice at -20^0C. Heat is added to the system at the rate of 100 calories per second. What is the temperature of the system after four minutes? Draw a rough sketch showing the variation of the temperature of the system as a function of time. Given :
Specific heat of ice = 0.5 cal g^{-1} $(^0C)^{-1}$
Specific heat of aluminium = 0.2 cal g^{-1} $(^0C)^{-1}$
Latent heat of fusion of ice = 80 cal g^{-1}

14. The temperature of equal masses of three different liquids A, B and C are 12^0C, 19^0C and 28^0C respectively. The temperature when A and B are mixed is 16^0C and when B and C are mixed it is 23^0C. What will be the temperature when A and C are mixed?

15. A lead bullet just melts when stopped by an obstacle. Assuming that 25 percent of the heat is absorbed by the obstacle, find the velocity of the bullet if its initial temperature is 27 C.
(Melting point of lead = 327 C, Specific heat of lead = 0.03 cal/g C,
Latent heat of fusion of lead = 6 cal/g, J = 4.2 J/cal.

16. The temperature of 100 g of water is to be raised from 24 C to 90 C by adding steam to it. Calculate the mass of the steam required for this purpose.

17. Answer the following questions based on the P–T phase diagram of carbon dioxide



(i) At what temperature and pressure can the solid, liquid and vapour phases of CO_2 co–exist in equilibrium

(ii) What is the effect of decrease of pressure on the fusion and boiling point of CO_2?

(iii) What are the critical temperature and pressure for CO_2 ? What is their significance?

(iv) Is CO_2 solid, liquid or gas at (a) –70 C under 1 atm, (b) – 60 C under 10 atm, (c) 15 C under 56 atm ?

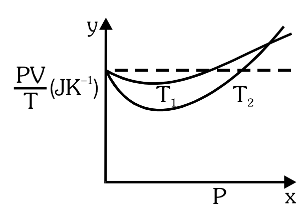
18. Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0 C and a pressure of 76 cm of mercury. One of the bulbs is then placed in melting ice and the other is placed in a water bath maintained at 62 C. What is the new value of the pressure inside the bulbs ? The volume of the connecting tube is negligible.

19. A thin tube of uniform cross–section is sealed at both ends. It lies horizontally, the middle 5 cm containing mercury and the two equal ends containing air at the same pressure P. When the tube is held at an angle of 60 with the vertical direction, the length of the air column above and below the mercury column are 46 cm and 44.5 cm respectively. Calculate the pressure P in centimetres of mercury. (The temperature of the system is kept at 30 C).

20. A closed container of volume 0.2 m^3 contains a mixture of neon and argon gases, at a temperature of 27 C and pressure of 1 10^5 Nm^{-2}. The total mass of the mixture is 28 g. If the molar masses of neon and argon are 20 and 40 g mol^{-1} respectively, find the masses of the individual gases in the container assuming them to be ideal (Universal gas constant R = 8.314 J/mol–K).

21. An oxygen cylinder of volume 30 litres has an initial gauge pressure of 15 atm and a temperature of 27 C. After some oxygen is with drawn from the cylinder, the gauge pressure drops to 11 atm and its temperature drops to 17 C. Estimate the mass of oxygen taken out of the cylinder. (R = 8.31 J $mol^{-1}K^{-1}$, molecular mass of O_2 = 32 u.)

22. Figure shows plot of PV/T versus P for 1.00 10^{-3} kg of oxygen gas at two different temperatures.



(i) What does the dotted plot signify ?

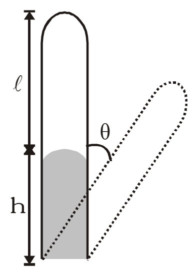
(ii) Which is true. $T_1 > T_2$ or $T_1 < T_2$?

(iii) What is the value of PV/T where the curves meet on the y–axis ?

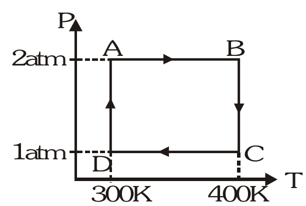
23. For a gas $\frac{R}{C_P} = 0.4$. For this gas calculate the following (i) Atomicity and degree of freedom (ii) Value of C_V and γ (iii) Mean gram – molecular kinetic energy at 300 K temperature

24. One gram mole of oxygen at 27 C and one atmospheric pressure is enclosed in a vessel. (i) 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. (ii) The vessel is next thermally insulated and moved with a constant speed v_0. It is then suddenly stopped. The process results in a rise of the temperature of the gas by 1 C. Calculate the speed v_0.

25. An ideal gas is enclosed in a tube and is held in the vertical position with the closed end upward. The length of the pellet of mercury entrapping the gas is h = 10 cm and the length of the tube occupied by gas is ℓ = 40 cm. Calculate the length occupied by the gas when it is turned through $\theta = 60^0$ and 90^0. Atmospheric pressure, H = 76 cm of mercury.

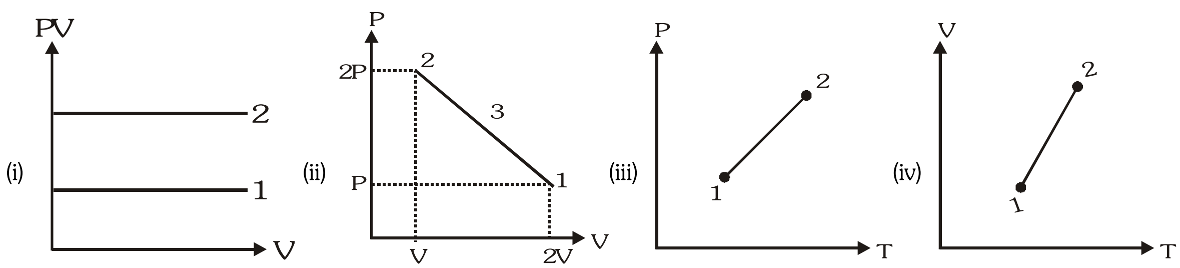


26. Two moles of helium gas undergo a cyclic process as shown in figure. Assuming the gas to be ideal, calculate the following quantities in this process.

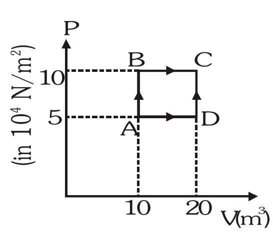


(i) The net change in the heat energy. (ii) The net work done (iii) The net change in internal energy

27. Examine the following plots and predict whether in (i) $P_1 < P_2$ and $T_1 > T_2$, in (ii) $T_1 = T_2 < T_3$, in(iii) $V_1 > V_2$, in(iv) $P_1 > P_2$ or $P_2 > P_1$

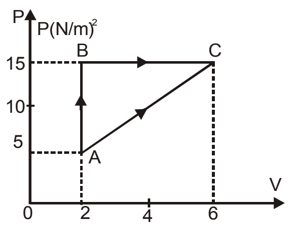


28. A sample of 2 kg monoatomic helium (assumed ideal) is taken from A to C through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC (see fig). Given molecular mass of helium = 4.



(i) What is the temperature of helium in each of the states A, B, C and D ?
(ii) Is there any way of telling afterwards which sample of helium went through the process ABC and which went through the process ADC ? Write Yes and No.
(iii) How much is the heat involved in the process ABC and ADC ?

29. In the given figure an ideal gas changes its state from A to state C by two paths ABC and AC.



(i) Find the path along which work done is the least.

(ii) The internal energy of gas at A is 10J and amount of heat supplied to change its state to C through the path AC is 200J. Calculate the internal energy at C.

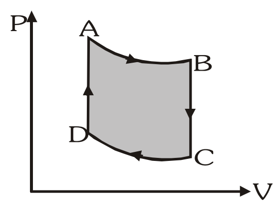
(iii) The internal energy of gas at state B is 20J. Find the amount of heat supplied to the gas from A to B.

30. The pressure in monoatomic gas increases linearly from 4 10^5 N/m^2 to 8 10^5 N/m^2 when its volume increases from 0.2 m^3 to 0.5 m^3 . Calculate the following –

(i) Work done by the gas (ii) Increase in internal energy

(iii) Amount of heat supplied (iv) Molar specific heat of the gas

31. On mole of a monoatomic ideal gas is taken through the cycle shown in figure.



A $\rightarrow$ B : Adiabatic expansion B $\rightarrow$ C : Cooling at constant volume

C $\rightarrow$ D : Adiabatic compression D $\rightarrow$ A : Heating at constant volume

The pressure and temperature at A, B, etc., are denoted by P_A, T_A, P_B, T_B etc.,

respectively. Given that T_A = 1000 K, $P_B = \left(\frac{2}{3}\right)P_A$ and $P_C = \left(\frac{1}{3}\right)P_A$.

Calculate the following quantities : (i) The work done by the gas in the process A $\rightarrow$ B (ii) The heat lost by the gas in the process B $\rightarrow$ C (iii) The temperature T_D. (Given : $\left(\frac{2}{3}\right)^{2/5} = 0.85$)

32. At 27 C two moles of an ideal monoatomic gas occupy a volume V. Then gas is adiabatically expanded until its volume becomes 2V. Calculate : (i) The final temperature of the gas (ii) Change in its internal energy (iii) The work done by the gas during this process

33. Three moles of an ideal gas ($C_P = \frac{7}{2}R$) at pressure, P_A and temperature T_A is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original volume. Finally gas is compressed at constant volume to its original pressure P_A.

(i) Sketch P–V and P–T diagrams for the complete process.

(ii) Calculate the net work done by the gas, and net heat supplied to the gas during the complete process.

34. An ideal gas having initial pressure P, volume V and temperature T is allowed to expand adiabatically until its volume becomes 5.66 V while its temperature falls to $\frac{T}{2}$. (i) How many degrees of freedom do gas molecules have ? (ii) Obtain the work done by the gas during the expansion as a function of the initial pressure P and volume V. [Take $(5.66)^{0.4}=2$]

35. Two moles of helium gas (γ = 5/3) are initially at temperature 27 C and occupy a volume of 20 L. The gas is first expanded at constant pressure until the volume is doubled. Then it undergoes an adiabatic change until the temperature returns to its initial value. (i) Sketch the process on a P–V diagram (ii) What are the final volume and pressure of the gas ? (iii) What is the work done by the gas ?

36. An ideal gas has a specific heat at constant pressure $C_P = \frac{5R}{2}$. The gas is kept in a closed vessel of volume 0.0083 m^3, at a temperature of 300 K and a pressure of 1.6 10^6 N/m^2. An amount of 2.49 10^4 J of heat energy is supplied to the gas. Calculate the final temperature and pressure of the gas.

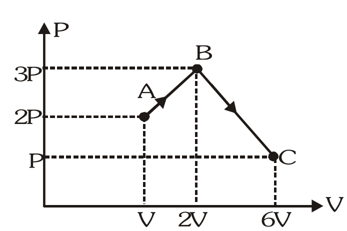
37. Calculate the work done when one mole of a perfect gas is compressed adiabatically. The initial pressure and volume of the gas are 10^5 N/m^2 and 6L respectively. The final volume of the gas is 2L, molar specific heat of the gas at constant volume is $\frac{3R}{2}$.

38. A gaseous mixture enclosed in a vessel of volume V consists of one gram mole of gas A with $\gamma = \frac{C_P}{C_V} = \frac{5}{3}$) an another gas B with $\gamma = \frac{7}{5}$ at a certain temperature T. The gram molecular weights of the gases A and B are 4 and 32 respectively. The gases A and B do not react with each other and are assumed to be ideal. The gaseous mixture follows the equation $PV^{19/13}$ = constant, in adiabatic process. Find the number of gram moles of the gas B in the gaseous mixture.

39. An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are Q_1 = 5960 J, Q_2 = –5585 J, Q_3 = –2980 J and Q_4 = 3645 J respectively. The corresponding quantities of work involved are W_1 = 2200 J, W_2 = –825 J, W_3 = –1100 J and W_4 respectively.
(i) Find the value of W_4. (ii) What is the efficiency of the cycle ?

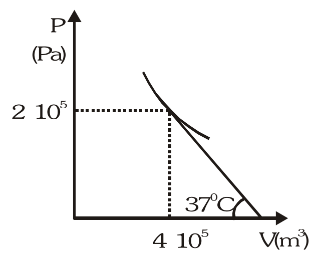
40. A gas has molar heat capacity C = 37.35 J $mole^{-1}K^{-1}$ in the process PT = constant. Find the number of degree of freedom of molecules in the gas.

41. One mole of monoatomic ideal gas undergoes a process ABC as shown in figure. The maximum temperature of the gas during the process ABC is in the form $\frac{xPV}{R}$. Find x.



42. An ideal monoatomic gas occupies volume 10^{-3} m^3 at temperature 3K and pressure 10^3 Pa. The internal energy of the gas is taken to be zero at this point. It undergoes the following cycle : The temperature is raised to 300 K at constant volume, the gas is then expanded adiabatically till the temperature is 3K, followed by isothermal compression to the original volume. Plot the process on a PV diagram. Calculate (i) The work done and the heat transferred in each process and the internal energy at the end of each process, (ii) The thermal efficiency of the cycle.

43. P–V graph for an ideal gas undergoing polytropic process PV^m = constant is shown here. Find the value of m.

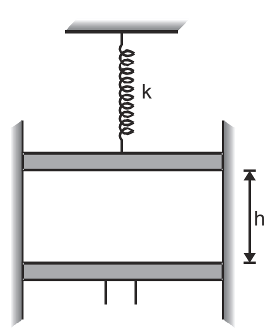


44. One mole of an ideal gas is heated isobarically from the freezing point to the boiling point of water each under normal pressure. Find out the work done by the gas and the change in its internal energy. The amount of heat involved is 1kJ.

45. A vertical cylinder of cross–sectional area 0.1 m^2 closed at both ends is fitted with a frictionless piston of mass M dividing the cylinder into two parts. Each part contains one mole of an ideal gas in equilibrium at 300K. The volume of the upper part is 0.1 m^3 and that of the lower part is 0.05 m^3. What force must be applied to the piston so that the volumes of the two parts remain unchanged when the temperature is increased to 500K?

46. There is a soap bubble of radius 2.4 10^{-4} m in air cylinder which is originally at the pressure of 10^5 Nm^{-2}. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure of air in the cylinder. The surface tension of the soap film is 0.08 N/m.

47. An ideal gas at NTP is enclosed in a adiabatic vertical cylinder having area of cross section A = 27 cm^2, between two light movable pistons as shown in the figure. Spring with force constant k = 3700 N/m is in a relaxed state initially. Now the lower piston is moved upwards a height $\frac{h}{2}$, being the initial length of gas column. It is observed that the upper piston moves up by a distance $\frac{h}{16}$. Find h taking γ for the gas to be 1.5. Also find the final temperature of the gas.



CONCEPTUAL SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE–4(A)

1. $4L_2^2\alpha_2 = L_1^2\alpha_1$

2. $\dfrac{d}{(\alpha_1-\alpha_2)(t_2-t_1)}$

3. (i) 240W (ii) 1.5

4. $\theta_1 = 116^0C$, $\theta_2 = 74^0C$

5. 3.739 kg

6. 9000 W

7. 5^0C

8. (i) $-100\ ^0C/m$, (ii) 1000J

9. 1927 K

10. (i) 1934 K (ii) 1.5 μm

11. (i) According to Kirchoff's law, a good absorber is a good emitter. Since a body with large reflectivity is a poor absorber, so it will also be a poor emitter.

(ii) Copper is a good conductor of heat, whereas a wood is a bad conductor of heat. When copper tumbler is touched, the heat will flow from our body which is at higher temperature than the copper tumbler and hence we feel cold. In case of wooden tray, no heat is transferred from our body to the tray and hence we do not feel cold.

(iii) The atmosphere of earth behaves as an insulating envelop to infra red radiations, which do not allow the whole heat received by earth during day time to escape from it during night. But if there is no atmosphere, then the whole heat radiated by earth will leave its surface and it becomes too cold.

(iv) On a clear night, the earth radiates energy into space at a rate proportional to the fourth power of its temperature (about 300 K). The incoming radiation from space is very small because its average temperature is near absolute zero. On the other hand with cloud over, the earth radiates at 300 K, but the radiation is absorbed in the clouds, which radiate energy back to earth again the radiation is trapped, like the green house effect.

(v) A red glass absorbs green light strongly at room temperature. When it is heated, it emits green light, thus satisfying Kirchoff's law.

(vi) Because during day time it receives the heat but it radiates the heat during nights.

(vii) The energy radiates per unit time is directly proportional to the surface area of the body. By curling into a ball, the surface area of the body of the animals decreases and hence loss of heat is reduced.

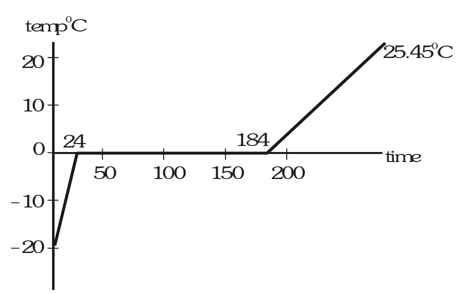
(viii) This is because the rate at which heat is generated becomes equal to the rate at which heat is lost by radiation (i.e., steady state) after some time when the heater is switched on.

(ix) Wood is a bad conductor of heat and is unable to conduct away the heat. So the paper quickly reaches its ignition temp. and is charred. On the other hand, brass is a good conductor of heat and conducts away the heat quickly. So the paper does not reach its ignition point easily.

(x) Black and rough surface is a good absorber of heat than the polished surface. That is why liquid in metallic pot boils quickly whose base is made black and rough.

12. 1 kg

13.



14. $20.3\ ^0C$

15. 12. 96 ms^{-1}

16. 12 g

17. (i) -56.6^0C, 5.11 atm (ii) both decrease (iii) 31.1^0C, 73 atm (iv) (a) vapour (b) solid (c) liquid

18. 83.83 cm of Hg

19. 75.4 cm of Hg

20. M_{neon} = 4.074 g M_{orgon} = 23.926 g

21. 0.139 kg

22. (i) ideal gas behaviour (ii) $T_1 > T_2$ (iii) $0.26\ JK^{-1}$

23. (i) mono atomic, 3 (ii) $\frac{3}{2}R,\ \frac{5}{3}$ (iii) 450 R

24. (i) 1.96 10^{27} (ii) 36 m/s

25. 37.2 cm, 34.7 cm

26. (i) 1152 J (ii) 1152 J (iii) zero

27. (i) $P_1<P_2$, $T_1<T_2$ (ii) $T_1=T_2<T_3$ (iii) $V_1<V_2$ (iv) $P_1>P_2$

28. (i) T_A = 120.34 K, T_B = 240.68 K, T_C = 481.36 K, T_D = 240.68 K
(ii) No (iii) Q_{ABC}=3.25 10^6 J, Q_{ADC} = 2.75 10^6 J

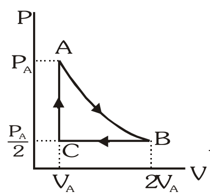
29. AC, 170 J, 10 J

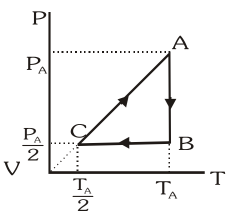
30. (i) 1.8 10^5 J (ii) 4.8 10^5 J (iii) 6.6 10^5 J (iv) 17.1 J/mole–K

31. (i) 1869.75 J (ii) – 52.97.6 J (iii) 500 K

32. (i) 189 K (ii) –2767 J (iii) 2767 J

33. (i)

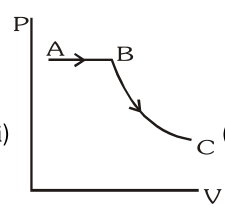




(ii) $0.58\ RT_A$

34. (i) f=5 (ii) W=12.3 PV

35. (i)



(ii) 113 L, 0.44 10^5 N/m^2, (iii) 12459 J

36. 675 K, 3.6 10^6 N/m^2

37. –972 J

38. 2 mole

39. (i) 765 J (ii) 10.82 %

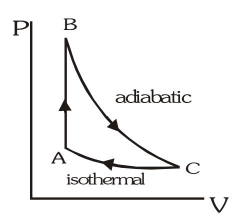
40. 5

41. x=8

42. (i) For process A$\rightarrow$ W=0, Q = 148.5 J, U=148.5 J

For process B$\rightarrow$ W = 148.5 J, Q=0, U=148.5 J

For process C$\rightarrow$ W=6.9 J, Q=–6.9 J, U=0



(ii) η =0.954

43. 1.5

44. 830 J, 170 J

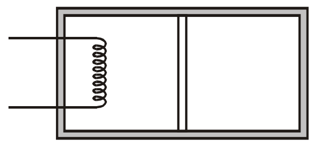
45. 1660 N

46. 8.08 10^5 Pa

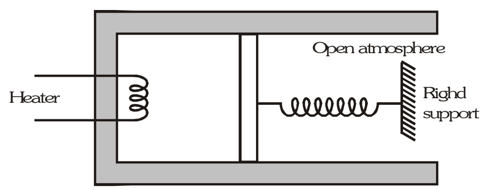
47. 1.6 m, 365 K

EXERCISE–04 [B] BRAIN STORMING SUBJECTIVE EXERCISE

1. The rectangular box shows in figure has a partition which can slide without friction along the length of the box. Initially each of the two chambers of the box has one mole of a monoatomic ideal gas (γ = 5/3) at a pressure P_0, volume V_0 and temperature T_0. The chamber on the left is slowly heated by an electric heater. The walls of the box and the partition are thermally insulated. Heat loss through the lead wires of the heater is negligible. The gas in the left chamber expands pushing the partition until the final pressure in both chambers becomes $\frac{243P_0}{32}$. Determine (i) the final temperature of the gas in each chamber and (ii) the work done by the gas in the right chamber.



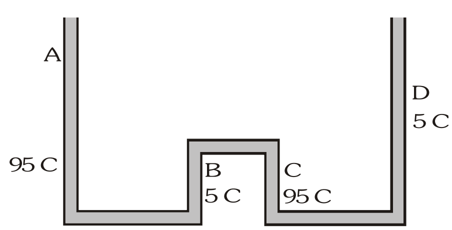
2. An ideal monoatomic gas is confined in a cylinder by a spring–located position of cross–section $8.0 \quad 10^{-3}$ m^2. Initially the gas is at 300 K and occupies a volume of $2.4 \quad 10^{-3}$ m^3 and the spring is in its relaxed (unstretched, uncompressed) state. The gas is heated by a small electric heater until the piston moves out slowly by 0.1 m. Calculate the final temperature of the gas and the heat supplied (in joules) by the heater. The force constant of the spring is 8000 N/m, and the atmospheric pressure $1.0 \quad 10^5$ Nm^{-2}. The cylinder and the piston are thermally insulated. The piston is massless and there is no friction between the piston and the cylinder. Neglect heat loss through the lead wires of the heater. The heat capacity of the heater coil is negligible. Assume the spring to the massless.



3. A cylindrical block of length 0.4 m and area of cross–section 0.04 m^2 is placed coaxially on a thin metal disc of mass 0.4 kg and of the same cross–section. The upper face of the cylinder is maintained at a constant temperature of 400 K and the initial temperature of the disc is 300 K. If the thermal conductivity of the material of the cylinder is 10 V/mK and the specific heat capacity of the material of the disc is 600 J/kg–K, how long will it take for the temperature of the disc of increase to 350 K? Assume, for purposes of calculation, the thermal conductivity of the disc to be very high and the system to be thermally insulated except for the upper face of the cylinder.

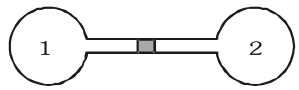
4. One mole of a diatomic ideal gas (γ = 1.4) is taken through a cyclic process starting from point A. The process A $\rightarrow$ B is an adiabatic compression. B $\rightarrow$ C is isobaric expansion, C $\rightarrow$ D an adiabatic expansion and D $\rightarrow$ A is isochoric. The volume ratio are $\frac{V_A}{V_B}$ =16 and $\frac{V_C}{V_D}$ = 2 and the temperature at A is T_A = 300 K. Calculate the temperature of the gas at the points B and D and find the efficiency of the cycle.

5. The apparatus shown in figure consists of four glass columns connected by horizontal sections. The height of two central columns B and C are 49 cm each. The two outer columns A and D are open to the atmosphere. A and C are maintained at a temperature of 95 C while the columns B and D are maintained at 5 C. The height of the liquid in A and D measured from the base line are 52.8 cm and 51 cm respectively. Determine the coefficient of thermal expansion of the liquid.

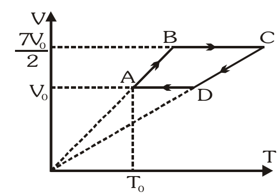


6. A double–pane window used for insulating a room thermally from outside consists of two glass sheets each of area 1 m^2 and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state, the room glass interface and the glass–outdoor interface are at constant temperatures of 27 C and 0 C respectively. Calculate the rate of heat flow through the window pane. Also find the temperatures of other interfaces. Given thermal conductivities of glass and air as 0.8 and 0.08 W m^{-1}K^{-1} respectively.

7. Two spherical flasks having total volume V_0 = 1.0 L containing air are connected by a tube diameter d = 6 mm and length λ = 1m. A small droplet of mercury contained in the tube is at its middle at 0 C. By what distance do the mercury droplets move if the flask 1 is heated by 2 C while flask 2 is cooled by 2 C. Ignore any expansion of flask wall.



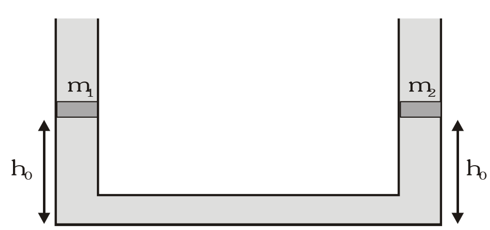
8. A sample of an ideal non linear triatomic gas has a pressure P_0 and temperature T_0 taken through the cycle as shown starting from A. Pressure for process C $\rightarrow$ D is 3 times P_0. Calculate heat absorbed in the cycle and work done.



9. Two moles of an ideal monoatomic gas are confined within a cylinder by a massless and frictionless spring loaded piston of cross–sectional area 4 10^{-3} m^2. The spring is, initially in its relaxed state. Now the gas is heated by an electric heater, placed inside the cylinder, for some time. During this time, the gas expands and does 50 J of work in moving the piston through a distance 0.10 m. The temperature of the gas increases by 50 K. Calculate the spring constant and the heat supplied by the heater.

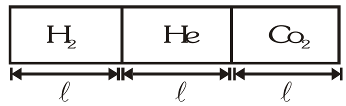
10. A weightless piston divides a thermally insulated cylinder into two parts of volumes V and 3V.2 moles of an ideal gas at pressure P=2 atmosphere are confined to the part with volume V=1 litre. The remainder of the cylinder is evacuated. The piston is now released and the gas expands to fill the entire space of the cylinder. The piston is then pressed back to the initial position. Find the increase in internal energy in the process and final temperature of the gas. The ratio of the specific heat of the gas γ = 1.5.

11. Two vertical cylinders are connected by a small tube at the bottom. It contains a gas at constant temperature. Initially the pistons are located at the same height. The diameters of the two cylinders are different. Outside the cylinder the space is vacuum. Gravitational acceleration is g. h_0 = 20 cm, m_1 = 2 kg and m_2 = 1 kg. The pistons are initially in equilibrium. If the masses of the piston are interchanged find the separation between the two pistons when they are again in equilibrium. Assume constant temperature.

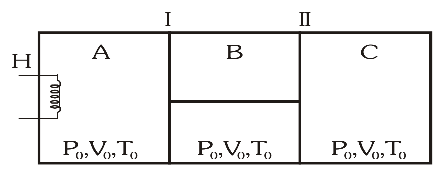


12. A barometer is faulty. When the true barometer reading are 73 cm and 75 cm of Hg, the faulty barometer reads 69 cm and 70 cm respectively (i) What is the total length of the barometer tube? (ii) What is the true reading when the faulty barometer reads 69.5 cm? (iii) What is the faulty barometer reading when the true barometer reads 74 cm?

13. A non–conducting cylindrical vessel of length 3ℓ is placed horizontally & is divided into three parts by two easily moving piston having low thermal conductivity as shown in figure. These parts contains H_2, He and CO_2 gas at initial temp. $\theta_1 = 372^0C$, $\theta_2 = -15^0C$ and $\theta_3 = 157^0C$ respectively. If initial length and pressure of each part are ℓ and P_0 respectively, calculate final pressure and length of each part. Use : γ_{CO_2} = 7/5.



14. The figure shows an insulated cylinder divided into three parts, A, B & C. Pistons I and II are connected by a rigid rod and can move without friction inside the cylinder. Piston I is perfectly conducting while piston II is perfectly insulating. The initial state of the gas $(\gamma = 1.5)$ present in each compartment A, B and C is as shown. Now, compartment A is slowly given heat through a heater H such that the final volume of C becomes $\frac{4V_0}{9}$. Assume the gas to be ideal and find. (i) final pressure in each compartment A,B and C (ii) final temperatures in each compartment A,B and C (iii) heat supplied by the heater (iv) work done by gas in A and B (v) heat flowing across piston I



15. An ideal diatomic gas undergoes a process in which its internal energy relates to the volume as $U = a\sqrt{V}$, where a is a constant. (i) find the work performed by the gas and the amount of heat to be transferred to this gas to increase its internal energy by 100J. (ii) find the molar specific heat of the gas for this process.

BRAIN STORMING SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE-4(B)

1. (i) T_1 = 12.94 T_0 T_2 = 2.25 T_0
   (ii) –1.875 RT_0
2. 800 K, 720 K
3. 166. 32 S
4. T_B = 909K, T_D = 791.4 K, 61.4%
5. 6.7 10^5 /^{0}C
6. 41.6 W, 26.48^{0}C, 0.52^{0}C
7. 0.259
8. $31P_0V_0$, $-5P_0V_0$
9. 2000 N/m, 1295 J
10. 400 J, $2T_0$
11. 30 cm
12. 74 cm, 73.94 cm, 69.52 cm
13. $\frac{13}{12}P$, ℓ_1 = 0.6 ℓ, ℓ_2 = 1.5 ℓ, ℓ_3 = 0.9 ℓ
14. (i) $P_A = P_C = \frac{27}{8}P_0$, $P_B = \frac{21}{4}P_0$ (ii) $T_A = T_B = \frac{21}{4}T_0$, $T_C = \frac{3}{2}T_0$ (iii) 18 P_0V_0 (iv) $W_A = P_0V_0$, W_B=0(v) $\frac{17}{2}P_0V_0$
15. (i) 80J, 180 J (ii) 4.5 R

EXERCISE–05(A)

PREVIOUS YEAR QUESTIONS

K.T.G., CALORIMETRY :

1. Cooking gas containers are kept in a lorry moving with uniform speed. The temperature of the gas molecules inside will- [AIEEE - 2002]
(1) increase (2) decrease
(3) remains same (4) decrease for some, while increase for others

2. At what temperature is the rms velocity of a hydrogen molecule equal to that of an oxygen molecules at 47 C? [AIEEE-2002]
(1) 80 K (2) –73 K (3) 3 K (4) 20 K

3. 1 mole of a gas with $\gamma = 7/5$ is mixed with 1 mole of a gas with $\gamma = 5/3$, then the value of γ for the resulting mixture is [AIEEE-2002]
(1) 7/5 (2) 2/5 (3) 24/16 (4) 12/7

4. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_P/C_V for the gas is- [AIEEE -2003]
(1) 4/3 (2) 2 (3) 5/3 (4) 3/2

5. One mole of ideal monoatomic gas ($\gamma = 5/3$) is mixed with one mole of diatomic gas ($\gamma = 7/5$). What is γ for the mixture ? γ denotes the ratio of specific heat at constant pressure, to that at constant volume- [AIEEE - 2004]
(1) 3/2 (2) 23/15 (3) 35/23 (4) 4/3

6. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio $\frac{C_p}{C_v}$ of the mixture is-
(1) 1.59 (2) 1.62 (3) 1.4 (4) 1.54 [AIEEE - 2005]

7. If C_P and C_V denote the specific heats of nitrogen per unit mass at constant pressure and constant volume respectively, then- [AIEEE - 2007]
(1) $C_P - C_V = R/28$ (2) $C_P - C_V = R/14$ (3) $C_P - C_V = R$ (4) $C_P - C_V = 28\ R$

8. An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume V_1 and contains ideal gas at pressure P_1 and temperature T_1. The other chamber has volume V_2 and contains ideal gas at pressure P_2 and tempeature T_2. If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be- [AIEEE - 2008]
(1) $\frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}$ (2) $\frac{P_1V_1T_1 + P_2V_2T_2}{P_1V_1 + P_2V_2}$ (3) $\frac{P_1V_1T_2 + P_2V_2T_1}{P_1V_1 + P_2V_2}$ (4) $\frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_1 + P_2V_2T_2}$

9. The speed of sound in oxygen (O_2) at a certain tempeature is 460 ms^{-1}. The speed of sound in helium (He) at the same temperature will be (assume both gases to be ideal) [AIEEE - 2008]
(1) $460\sqrt{\frac{200}{21}}\ ms^{-1}$ (2) $500\sqrt{\frac{200}{21}}\ ms^{-1}$ (3) $650\sqrt{2}\ ms^{-1}$ (4) $330\sqrt{2}\ ms^{-1}$

10. One kg of a diatomic gas is at a pressure of8 10^4 N/m^2. The density of the gas is 4 kg/m^3. What is the energy of the gas due to its thermal motion ? [AIEEE - 2009]
(1) 6 10^4 J (2) 7 10^4 J (3) 3 10^4 J (4) 5 10^4 J

11. 100 g of water is heated from 30 C to 50 C Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J/kg/K) :- [AIEEE - 2011]
(1) 84 kJ (2) 2.1 kJ (3) 4.2 kJ (4) 8.4 kJ

12. Three perfect gases at absolute temperatures T_1, T_2 and T_3 are mixed. The masses of molecules are m_1, m_2, and m_3 and the number of molecules are n_1, n_2 and n_3 respectively. Assuming no loss of energy, then final temperature of the mixture is :- [AIEEE - 2011]

(1) $\frac{n_1T_1^2+n_2T_2^2+n_3T_3^2}{n_1T_1+n_2T_2+n_3T_3}$ (2) $\frac{n_1^2T_1^2+n_2^2T_2^2+n_3^2T_3^2}{n_1T_1+n_2T_2+n_3T_3}$ (3) $\frac{T_1+T_2+T_3}{3}$ (4) $\frac{n_1T_1+n_2T_2+n_3T_3}{n_1+n_2+n_3}$

13. The specific heat capacity of a metal at low temperautre (T) is given as $C_p(kJk^{-1}kg^{-1}) = 32\left(\frac{T}{400}\right)^3$ .A 100 gram vessel of this metal is to be cooled from 20 K to 4 K by a special refrigerator operating at room temperature (27 C). The amount of work required to cool the vessel is:- [AIEEE - 2011]

(1) equal to 0.002 kJ (2) greater than 0.148 kJ
(3) between 0.148 kJ and 0.028 kJ (4) less than 0.028 kJ

14. A container with insulating walls is divided into two equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure P and temperature T, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be :- [AIEEE - 2011]

(1) $\frac{P}{2}, T$ (2) $\frac{P}{2}, \frac{T}{2}$ (3) P, T (4) $P, \frac{T}{2}$

THERMODYNAMICS:

15. Which statement is incorrect ? [AIEEE - 2002]
(1) All reversible cycles have same efficiency
(2) Reversible cycle has more efficiency than an irreversible one
(3) Carnot cycle is a reversible one
(4) Carnot cycle has the maximum efficiency in all cycles

16. If mass-energy equivalence is taken into account, when water is cooled to form ice, the mass of water should- [AIEEE - 2002]
(1) increase (2) remain unchanged (3) decrease (4) first increase then decrease

17. Even carnot engine cannot give 100% efficiency because we cannot- [AIEEE - 2002]
(1) prevent radiation (2) find ideal sources
(3) reach absolute zero temperature (4) eliminate friction

18. "Heat cannot be itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of- [AIEEE - 2003]
(1) second law of thermodynamics (2) conservation of momentum
(3) conservation of mass (4) first law of thermodynamics

19. Which of the following parameters does not characterise the thermodynamic state of matter ?[AIEEE - 2003]
(1) Temperature (2) Pressure (3) Work (4) Volume

20. A carnot engine takes 3 10^6 cal of heat from a reservoir at 627 C and gives it to a sink at 27 C. The work done by the engine is- [AIEEE - 2003]
(1) 4.2 10^6 J (2) 8.4 10^6 J (3) 16.8 10^6 J (4) zero

21. Which of the following statements is correct for any thermodynamic system ? [AIEEE - 2004]
(1) The internal energy changes in all processes
(2) Internal energy and entropy are state functions
(3) The change in entropy can never be zero
(4) The work done in an adiabatic process is always zero

22. Two thermally insulated vessels 1 and 2 are filled with air at temperatures (T_1, T_2), volume (V_1, V_2) and pressure (P_1, P_2) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be- **[AIEEE-2004]**

(1) $T_1 + T_2$ (2) $\frac{(T_1+T_2)}{2}$ (3) $\frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_2+P_2V_2T_1}$ (4) $\frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_1+P_2V_2T_2}$

23. Which of the following is incorrect regarding the first law of thermodynamics ? **[AIEEE - 2005]**

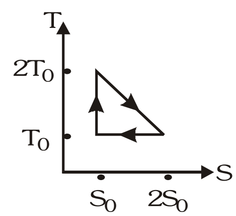
(1) It is applicable to any cyclic process

(2) It is a restatement of the principle of conservation of energy

(3) It introduces the concept of the internal energy

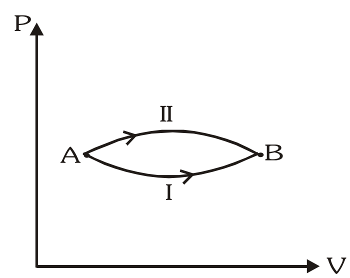
(4) It introduced the concept of the entropy

24. The temperature-entropy diagram of a reversible engine cycle is given in thefigure. Its efficiency is-



(1) 1/2 (2) 1/4 (3) 1/3 (4) 2/3 **[AIEEE - 2005]**

25. A system goes from A to B via two processes I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively then- **[AIEEE - 2005]**



(1) $\Delta U_1 = \Delta U_2$ (2) relation between ΔU_1 and ΔU_2 cannot be determined

(3) $\Delta U_2 > \Delta U_1$ (4) $\Delta U_2 < \Delta U_1$

26. Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while box B contains one mole of helium at temperature (7/3) T_0. The boxes are then put into thermal contact with each other, and heat flows between them until the gases reach a common final temperature (Ignore the heat capacity of boxes). Then, the final temperature of gases, T_f, in terms of T_0 is- **[AIEEE - 2006]**

(1) $T_f = \frac{3}{7}T_0$ (2) $T_f = \frac{7}{3}T_0$ (3) $T_f = \frac{3}{2}T_0$ (4) $T_f = \frac{5}{2}T_0$

27. The work of 146 kJ is performed in order to compress one kilo mole of a gas adiabatically and in this process the temperature of the gas increases by 7 C. The gas is- ($R = 8.3\ J\ mol^{-1}\ K^{-1}$) **[AIEEE - 2006]**

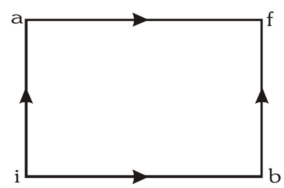
(1) diatomic (2) triatomic

(3) a mixture of monoatomic and diatomic (4) monoatomic

28. A carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigetator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is- **[AIEEE - 2007]**

(1) 99 J (2) 90 J (3) 1 J (4) 100 J

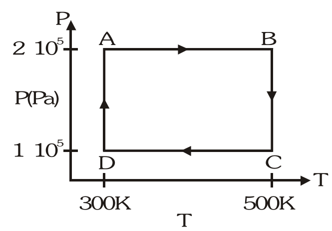
29. When a system is taken from state i to state f along the path iaf, it is found that Q = 50 cal and W = 20 cal. Along the path ibf Q = 36 cal. W along the path ibf is- **[AIEEE - 2007]**



(1) 6 cal (2) 16 cal (3) 66 cal (4) 14 cal

Directions : Question number 30, 31 and 32 are based on the following paragraph.

Two moles of helium gas are taken over the cycle ABCDA, as shown in the P–T diagram.



30. Assuming the gas to be ideal the work done on the gas in taking it from A to B is :- **[AIEEE - 2009]**

(1) 400 R (2) 500 R (3) 200 R (4) 300 R

31. The work done on the gas in taking it from D to A is :- **[AIEEE - 2009]**

(1) –690 R (2) +690 R (3) –414 R (4) +414 R

32. The net work done on the gas in the cycle ABCDA is :- **[AIEEE - 2009]**

(1) 1076 R (2) 1904 R (3) Zero (4) 276 R

33. A diatomic ideal gas is used in a carnot engine as the working substance. If during the adiabatic expansion part of the cycle the volume of the gas increases from V to 32 V, the efficiency of the engine is :-**[AIEEE - 2010]**

(1) 0.25 (2) 0.5 (3) 0.75 (4) 0.99

34. A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats γ. It is moving with speed v and is suddenly broght to rest. Assuming no heat is lost to the surroundings, its temperature increases by :- **[AIEEE - 2011]**

(1) $\frac{\gamma M v^2}{2R}K$ (2) $\frac{(\gamma-1)}{2R}Mv^2K$ (3) $\frac{(\gamma-1)}{2(\gamma+1)R}Mv^2K$ (4) $\frac{(\gamma-1)}{2\gamma R}Mv^2K$

35. A Carnot engine operating between temperatures T_1 and T_2 has efficientcy $\frac{1}{6}$. When T_2 is lowered by 62 K, its efficiency increases to $\frac{1}{3}$. Then T_1 and T_2 are, respectively:- **[AIEEE - 2011]**

(1) 330 K and 268 K (2) 310 K and 248 K (3) 372 K and 310 K (4) 372 K and 330 K

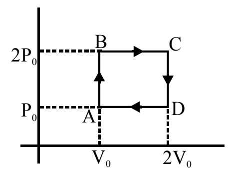
36. An aluminium sphere of 20 cm diameter is heated from 0 C to 100 C. Its volume changes by (given that coefficient of linear expansion for aluminium α_{Al} = 23 10^{-6}/ C :- **[AIEEE - 2011]**

(1) 28.9 cc (2) 2.89 cc (3) 9.28 cc (4) 49.8 cc

37. A metal rod of Young's modulus Y and coefficient of thermal expansion α is held at its two ends such that its length remains invariant. If its temperature is raised by t C, the linear stress developed in it is:- **[AIEEE - 2011]**

(1) $\frac{\alpha t}{Y}$ (2) $\frac{Y}{\alpha t}$ (3) $Y\alpha t$ (4) $\frac{1}{(Y\alpha t)}$

38. 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 (Assume the gas to be close to ideal gas) :- **[AIEEE - 2012]**

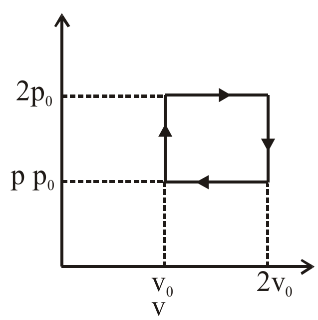


(1) 12.5% (2) 15.4% (3) 9.1% (4) 10.5%

39. A Carnot engine, whose efficiency is 40% takes in heat from a source maintained at a temperature of 500 K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature must be :- **[AIEEE - 2012]**

(1) 600 K (2) efficiency of Carnot engine cannot be made larger than 50%
(3) 1200 K (4) 750 K

40. The above p-v diagram represents the thermodynamic cycle of an engine, operating with an ideal monoatomic gas. The amount of heat, extracted from the source in a single cycle is : **[AIEEE - 2013]**



(1) p_0v_0 (2) $\left(\frac{13}{2}\right)p_0v_0$ (3) $\left(\frac{11}{2}\right)p_0v_0$ (4) $4p_0v_0$

MODE OF HEAT TRANSFER :

41. Heat given to a body which raises its temperature by 1 C is- **[AIEEE - 2002]**

(1) water equivalent (2) thermal capacity (3) specific heat (4) temperature gradient

42. Which of the following is more close to a black body- **[AIEEE - 2002]**

(1) Black board paint (2) Green leaves (3) Black holes (4) Red roses

43. Infrared radiations are detected by- **[AIEEE - 2002]**

(1) spectrometer (2) pyrometer (3) nanometer (4) photometer

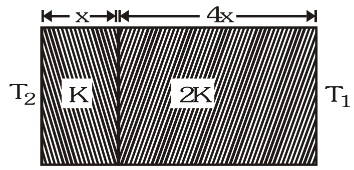
44. Two spheres of the same material have radii 1 m and 4 m and temperatures 4000 K and 2000 K respectively. The ratio of the energy radiated per second by the first sphere to that by the second is- **[AIEEE - 2002]**

(1) 1 : 1 (2) 16 : 1 (3) 4 : 1 (4) 1 : 9

45. If the temperature of the sun were to increase from T to 2T and its radius from R to 2R, then the ratio of the radiant energy received on earth to what it was previously, will be- [AIEEE - 2004]

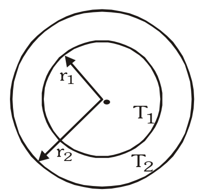
(1) 4 (2) 16 (3) 32 (4) 64

46. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are T_2 and $T_1 (T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right)f$, with f equals to- [AIEEE - 2004]



(1) 1 (2) 1/2 (3) 2/3 (4) 1/3

47. The figure shows a system of two concentric spheres of radii r_1 and r_2 and kept at temperatures T_1 and T_2, respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to- [AIEEE - 2005]

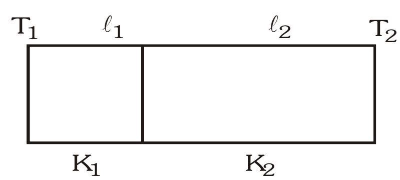


(1) $\frac{(r_2 - r_1)}{(r_1 r_2)}$ (2) $\ell n\left(\frac{r_2}{r_1}\right)$ (3) $\frac{r_1 r_2}{(r_2 - r_1)}$ (4) $(r_2 - r_1)$

48. Assuming the sun to be a spherical body of radius R at a temperature of T K, evaluate the total radiant power, incident on earth, at a distance r from the sun- (when radius of earth is r_0) [AIEEE - 2006]

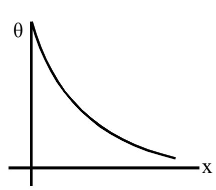
(1) $4\pi r_0^2 R^2 \sigma T^4/r^2$ (2) $\pi r_0^2 R^2 \sigma T^4/r^2$ (3) $r_0^2 R^2 \sigma T^4 / 4\pi R^2$ (4) $R^2 \sigma T^4/r^2$

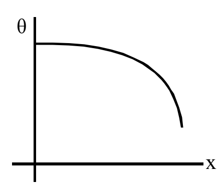
49. One end of a thermally insulated rod is kept at a temperature T_1 and the other at T_2. The rod is composed of two sections of lengths ℓ_1 and ℓ_2 and thermal conductivities K_1 and K_2 respectively. The temperature at the interface of the two sections is- [AIEEE - 2007]

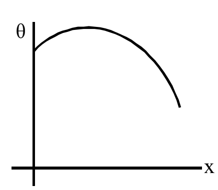


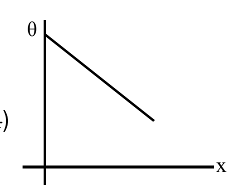
(1) $(K_2\ell_2T_1 + K_1\ell_1T_2)/(K_1\ell_1 + K_2\ell_2)$ (2) $(K_2\ell_1T_1 + K_1\ell_2T_2)/(K_2\ell_1 + K_1\ell_2)$
(3) $(K_1\ell_2T_1 + K_2\ell_1T_2)/(K_1\ell_2 + K_2\ell_1)$ (4) $(K_1\ell_1T_1 + K_2\ell_2T_2)/(K_1\ell_1 + K_2\ell_2)$

50. A long metallic bar is carrying heat from one of its ends to the other end under steady-state. The variation of temperature θ along the length x of the bar from its hot end is best described by which of the following figures? [AIEEE - 2009]

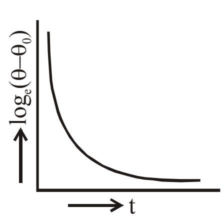
(1) 

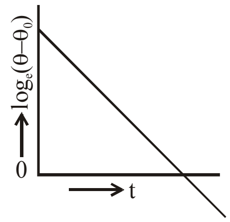
(2) 

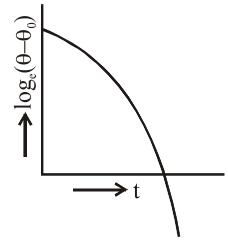
(3) 

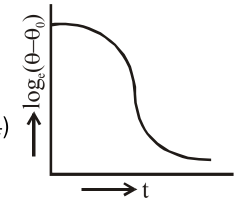
(4) 

51. A liquid in a beaker has temperature $\theta(t)$ at time t and θ_0 is temperature of surroundings, then according to Newton's law of cooling the correct graph between $\log_e(\theta - \theta_0)$ and t is :- [AIEEE - 2012]

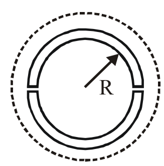
(1) 

(2) 

(3) 

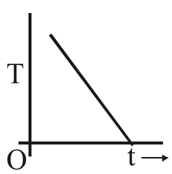
(4) 

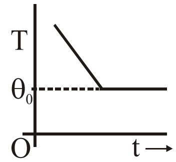
52. A wooden wheel of radius R is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross sectional area S and Length L. L is slightly less than $2\pi R$. To fit the ring on the wheel, it is heated so that its temperature rises by ΔT and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semicircular parts together. If the coefficient of linear expansion of the metal is α, and its Young's modulus is Y, the force that one part of the wheel applies on the other part is : [AIEEE - 2012]

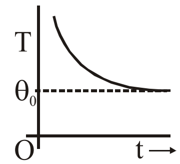


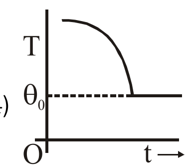
(1) $2SY\alpha\Delta T$ (2) $2\pi SY\alpha\Delta T$ (3) $SY\alpha\Delta T$ (4) $\pi SY\alpha\Delta T$

53. If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature θ_0 the graph between the temperature T of the metal and time t will be closed to : [AIEEE - 2013]

(1) 

(2) 

(3) 

(4) 

ANSWER-KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	4	3	4	1	2	1	1	1	3	4	4	3	1	1	1	3	1	3	2
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	3	4	3	1	3	1	2	1	1	4	4	3	2	3	1	3	2	4	2
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53							
Ans.	2	1	2	1	4	4	3	2	3	4	2	1	3							

EXERCISE–05(B) PREVIOUS YEAR QUESTIONS

MCQ'S WITH ONE CORRECT ANSWER

1. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to per N_2 molecule is :– [IIT-JEE 1998]
(A) 1 : 1 (B) 1 : 2
(C) 2 : 1 (D) depends on the moment of inertia of the two molecules

2. Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of the gas in A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to the same final volume 2V. The changes in the pressure in A and B are found to be ΔP and $1.5\ \Delta P$ respectively. Then :– [IIT-JEE 1998]
(A) $4m_A = 9m_B$ (B) $2m_A = 3m_B$ (C) $3m_A = 2m_B$ (D) $9m_A = 4m_B$

3. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300 K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temp. of the gas in B is:– [IIT-JEE 1998]
(A) 30 K (B) 18 K (C) 50 K (D) 42 K

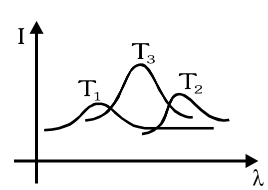
4. A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. The Wien constant, b = 2.88 10^6 nm–K. Then :– [IIT-JEE 1998]
(A) $U_1 = 0$ (B) $U_3 = 0$ (C) $U_1 > U_2$ (D) $U_2 > U_1$

5. The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 K is :– [IIT-JEE 1999]
(A) $\sqrt{\left(\frac{2}{7}\right)}$ (B) $\sqrt{\left(\frac{1}{7}\right)}$ (D) $\frac{\sqrt{3}}{5}$ (D) $\frac{\sqrt{6}}{5}$

6. 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 :– [IIT-JEE 1999]
(A) 4RT (B) 15RT (C) 9RT (D) 11RT

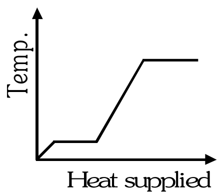
7. A monoatomic ideal gas, initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then $\frac{T_1}{T_2}$ is given by
(A) $\left(\frac{L_1}{L_2}\right)^{2/3}$ (B) $\left(\frac{L_1}{L_2}\right)$ (C) $\left(\frac{L_2}{L_1}\right)$ (D) $\left(\frac{L_2}{L_1}\right)^{2/3}$ [IIT-JEE 2000]

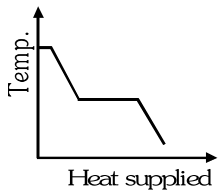
8. The plots of intensity versus wavelength for three black bodies at temperature T_1, T_2 and T_3 respectively are as shown. Their temperatures are such that:– [IIT-JEE 2000]

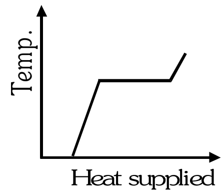


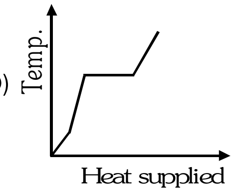
(A) $T_1 > T_2 > T_3$ (B) $T_1 > T_3 > T_2$ (C) $T_2 > T_3 > T_1$ (D) $T_3 > T_2 > T_1$

9. A block of ice at –10 C is slowly heated and converted to steam at 100 C. Which of the following curves represents the phenomena qualitatively:– **[IIT-JEE 2000]**

(A) 

(B) 

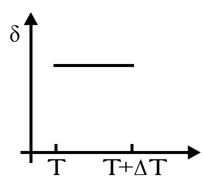
(C) 

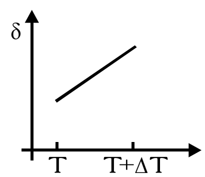
(D) 

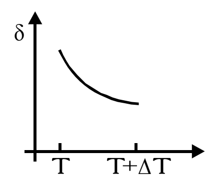
10. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways, the work done by the gas W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic, then :– **[IIT-JEE 2000]**

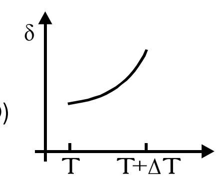
(A) $W_2 > W_1 > W_3$ (B) $W_2 > W_3 > W_1$ (C) $W_1 > W_2 > W_3$ (D) $W_1 > W_3 > W_2$

11. An ideal gas is initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quantity $\delta = \dfrac{\Delta V}{V\Delta T}$ varies with temperature as:–**[IIT-JEE 2000]**

(A) 

(B) 

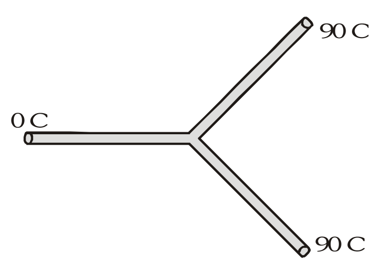
(C) 

(D) 

12. Two monoatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to the gas 2 is given by :– **[IIT-JEE 2000]**

(A) $\sqrt{\dfrac{m_1}{m_2}}$ (B) $\sqrt{\dfrac{m_2}{m_1}}$ (C) $\dfrac{m_1}{m_2}$ (D) $\dfrac{m_2}{m_1}$

13. Three rods made of the same material and having the same cross–section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0 C and 90 C respectively. The temperature of junction of the three rods will be : **[IIT-JEE 2001]**



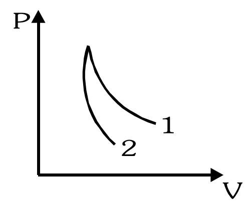
(A) 45 C (B) 60 C (C) 30 C (D) 20 C

14. In a given process of an ideal gas, dW = 0 and dQ < 0. Then for the gas :– **[IIT-JEE 2001]**

(A) the temperature will decrease (B) the volume will increase

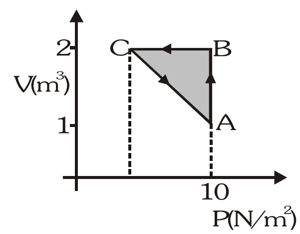
(C) the pressure will remain constant (D) the temperature will increase

15. P–V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to : [IIT-JEE 2001]



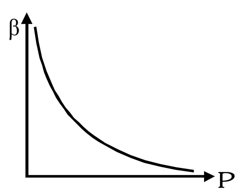
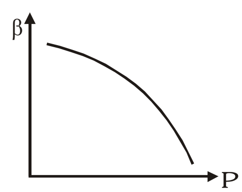
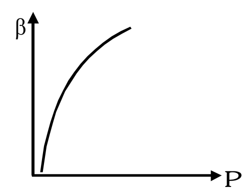
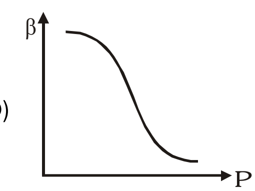
(A) He and O_2 (B) O_2 and He (C) He and Ar (D) O_2 and N_2

16. An ideal gas is taken through the cycle A → B → C → A, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process C → A is :– [IIT-JEE 2002]



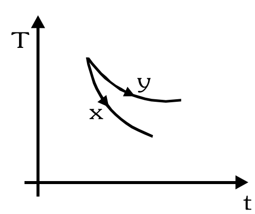
(A) –5J (B) –10J (C) –15J (D) –20J

17. Which of the following graphs correctly represent the variation of $\beta = -\dfrac{dV/dP}{V}$ with P for an ideal gas at constant temperature ? [IIT-JEE 2002]

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

18. An ideal black–body at room temperature is thrown into a furnance. It is observed that [IIT-JEE 2003]
(A) initially it is the darkest body and at later times the brightest
(B) it is the darkest body at all times
(C) it cannot be distinguished at all times
(D) initially it is the darkest body and at later times it cannot be distinguished

19. The graph, shown in the diagram, represents the variation of temperature (T) of the bodies, x and y having same surface area, with time (t) due to the emission of radiation. Find the correct relation between the emissivity and absorptivity power of the two bodies :– [IIT-JEE 2003]

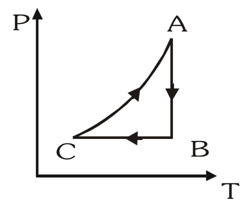


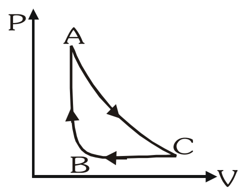
(A) $e_x > e_y$ and $a_x < a_y$ (B) $e_x < e_y$ and $a_x > a_y$ (C) $e_x > e_y$ and $a_x > a_y$ (D) $e_x < e_y$ and $a_x < a_y$

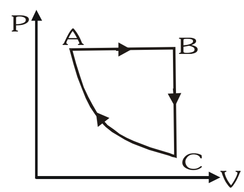
20. Two rods, one of aluminium and the other made of steel, having initial length ℓ_1 and ℓ_2 are connected together to form a single rod of length $\ell_1 + \ell_2$. The coefficient of linear expansion for aluminium and steel area α_a and α_s respectively. If the length of each rod increases by the same amount when their temperature are raised by t C, then find the ratio $\dfrac{\ell_1}{\ell_1 + \ell_2}$:- **[IIT-JEE 2003]**

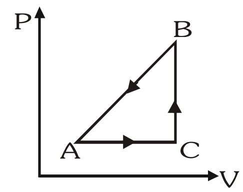
(A) $\dfrac{\alpha_s}{\alpha_a}$ (B) $\dfrac{\alpha_a}{\alpha_s}$ (C) $\dfrac{\alpha_s}{(\alpha_a + \alpha_s)}$ (D) $\dfrac{\alpha_a}{(\alpha_a + \alpha_s)}$

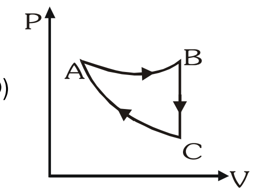
21. The P–T diagram for an ideal gas is shown in the figure, where AC is anadiabatic process, find the corresponding P–V diagram :- **[IIT-JEE 2003]**



(A) 

(B) 

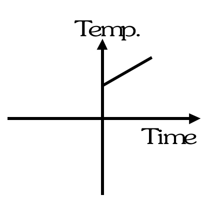
(C) 

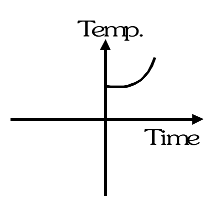
(D) 

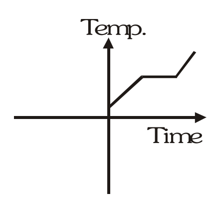
22. 2 kg of ice at –20 C is mixed with 5 kg of water at 20 C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/kg/ C while the latent heat of fusion of ice is 80 kcal/kg :– **[IIT-JEE 2003]**

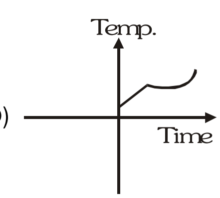
(A) 7 kg (B) 6 kg (C) 4 kg (D) 2 kg

23. Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represent the variation of temperature with time :– **[IIT-JEE 2004]**

(A) 

(B) 

(C) 

(D) 

24. An ideal gas expands isothermally from a volume V_1 and V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is P_1 and final pressure is P_3. The total work done is W. Then :– **[IIT-JEE 2004]**

(A) $P_3 > P_1$, $W > 0$ (B) $P_3 < P_1$, $W < 0$ (C) $P_3 > P_1$, $W < 0$ (D) $P_3 = P_1$, $W = 0$

25. Two identical conducting rods are first connected independently to two vessels, one containing water at 100 C and the other containing ice at 0 C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 g/s be the rate of melting of ice in the two cases respectively. The ratio $\dfrac{q_1}{q_2}$ is :–

(A) $\dfrac{1}{2}$ (B) $\dfrac{2}{1}$ (C) $\dfrac{4}{1}$ (D) $\dfrac{1}{4}$ **[IIT-JEE 2004]**

26. Three discs, A, B and C having radii 2m, 4m and 6m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are Q_A, Q_B and Q_C respectively :– **[IIT-JEE 2004]**

(A) Q_A is maximum (B) Q_B is maximum (C) Q_C is maximum (D) $Q_A = Q_B = Q_C$

27. Water of volume 2L in a container is heated with a coil of 1 kW at 27 C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27 C to 77 C ? (Give specific heat of water is 4.2 kJ/kg) :– [IIT-JEE 2005]

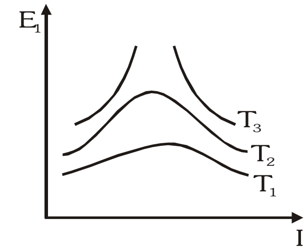
(A) 8 min 20 s (B) 6 min 2 s (C) 7 min (D) 14 min

28. In which of the following process, convection does not take place primarily :– [IIT-JEE 2005]

(A) Sea and land breeze (B) Boiling of water

(C) Warming of glass of bulb due to filament (D) Heating air around a furnace

29. Variation of radiant energy emitted by sun, filament of tungsten lamp and welding arc as a function of its wavelength is shown in figure. Which of the following option is the correct match :– [IIT-JEE 2005]



(A) Sun–T_1, tungsten filament–T_2, welding arc–T_3

(B) Sun–T_2, tungsten filament–T_1, welding arc–T_3

(C) Sun–T_3, tungsten filament–T_2, welding arc–T_1

(D) Sun–T_3, tungsten filament–T_1, welding arc–T_2

30. Calorie is defined as the amount of heat required to raise temperature of 1 g of water by 1 C and it is defined under which of the following conditions :– [IIT-JEE 2005]

(A) From 14.5 C to 15.5 C at 760 mm of Hg (B) From 98.5 C to 99.5 C at 760 mm of Hg

(C) From 13.5 C to 14.5 C at 76 mm of Hg (D) From 3.5 C to 4.5 C at 76 mm of Hg

31. A body with area A and temperature T and emissivity e = 0.6 is kept inside a spherical black body. What will be the maximum energy radiated :– [IIT-JEE 2005]

(A) 0.60 eAT^4 (B) 0.80 eAT^4 (C) 1.00 eAT^4 (D) 0.40 eAT^4

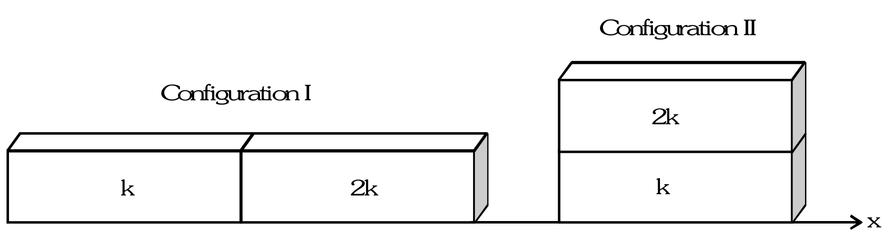
32. An ideal gas is expanding such that PT^2 = constant. The coefficient of volume expansion of the gas is:–

(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ (C) $\frac{3}{T}$ (D) $\frac{4}{T}$ [IIT-JEE 2008]

33. Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is 4 : 3. The ratio of their densities is :- [IIT-JEE 2013]

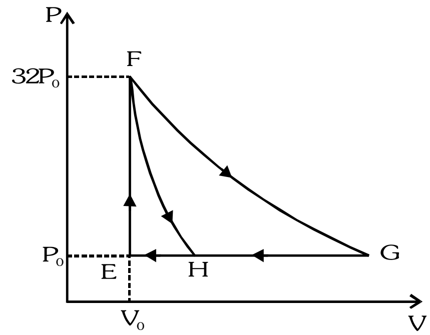
(A) 1 : 4 (B) 1 : 2 (C) 6 : 9 (D) 8 : 9

34. Two rectangular blocks, having identical dimensions, can be arranged either in configuration I or in configuration II as shown in the figure. One of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is :- [IIT-JEE 2013]



(A) 2.0 s (B) 3.0 s (C) 4.5 s (D) 6.0 s

35. One mole of a monatomic ideal gas is taken along two cyclic processes E→F→G→E and E→F→H→E as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.



Match the paths in List I with the magnitudes of the work done in the List II and select the correct answer using the codes given blow the lists. [IIT-JEE 2013]

	List I		List II
P.	G → E	1.	$160\ P_0V_0\ \ln 2$
Q.	G → H	2.	$36\ P_0V_0$
R.	F → H	3.	$24\ P_0V_0$
S.	F → G	4.	$31\ P_0V_0$

Codes :

	P	Q	R	S
(A)	4	3	2	1
(B)	4	3	1	2
(C)	3	1	2	4
(D)	1	3	2	4

MCQs with one or more than one correct answer

1. Let $\bar{v}$, v_{rms} and v_p respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then:–

(A) No molecule can have energy greater than $\sqrt{2}\ v_{rms}$ [IIT-JEE 1998]

(B) No molecule can have speed less than $\frac{v_p}{\sqrt{2}}$

(C) $v_p < \bar{v} < v_{rms}$

(D) The average kinetic energy of a molecule is $\frac{3}{4}mv_p^2$

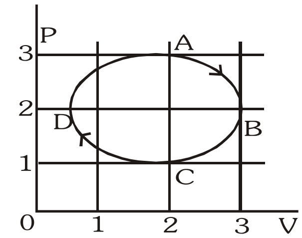
2. During the melting of a slab of ice at 273 K at atmospheric pressure :– [IIT-JEE 1998]
(A) Positive work is done by the ice–water system on the atmosphere
(B) Positive work is done on the ice–water system by the atmosphere
(C) the internal energy of the ice–water increases
(D) The internal energy of the ice–water system decreases

3. A bimetallic strip is formed out of two identical strips one of copper and the other of brass. The coefficients of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then R is :– [IIT-JEE 1999]
(A) Proportional to ΔT
(B) Inversely proportional to ΔT
(C) Proportional to $|\alpha_B - \alpha_C|$
(D) Inversely proportional to $|\alpha_B - \alpha_C|$

4. C_V and C_P denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then [IIT-JEE 2009]

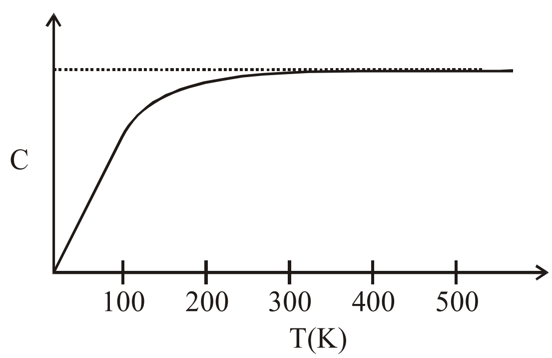
(A) $C_P - C_V$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
(B) $C_P + C_V$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
(C) C_P/C_V is larger for a diatomic ideal gas than for a monatomic ideal gas
(D) $C_P \cdot C_V$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

5. The figure shows the P-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then, [IIT-JEE 2009]



(A) the process during the path A → B is isothermal
(B) heat flows out of the gas during the path B → C → D
(C) work done during the path A → B → C is zero
(D) positive work is done by the gas in the cycle ABCDA

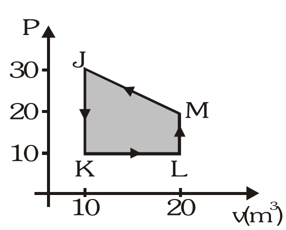
6. The figure below shows the variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500 K at a constant rate. Ignoring any volume change, the following statement(s) is (are) correct to a reasonable approximation :- [IIT-JEE 2013]



(A) The rate at which heat is absorbed in the range 0–100 K varies linearly with temperature T.
(B) Heat absorbed in increasing the temperature from 0–100 K is less than the heat required for increasing the temperature from 400–500 K.
(C) There is no change in the rate of heat absorption in the range 400–500 K
(D) The rate of heat absorption increases in the range 200–300 K

MATCH THE COLUMN

1. For the given process :– [IIT-JEE 2006]



	Column I		Column II
(A)	Process J → K	(p)	W > 0
(B)	Process K → L	(q)	W < 0
(C)	Process L → M	(r)	Q > 0
(D)	Process M → J	(s)	Q < 0

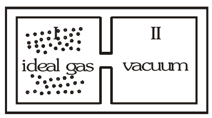
2. Column–I gives some devices and Column–II gives some processes on which the functioning of these devices depend. Match the devices in Column–I with the process in Column–II. [IIT-JEE 2007]

	Column I		Column II
(A)	Bimetallic strip	(p)	Radiation from a hot body
(B)	Stem engine	(q)	Energy conversion
(C)	Incandescent lamp	(r)	Melting
(D)	Electric fuse	(s)	Thermal expansion of solids

3. **Column I** contains a list of processes involving expansion of an ideal gas. Match this with **Column II** describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4 4 matrix given in the ORS. [IIT-JEE 2008]

Column I

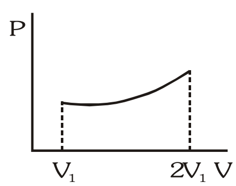
(A) An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the Chamber II has vacuum. The valve is opened.



(B) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^2}$, where V is the volume of the gas.

(C) An ideal monoatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$, where V is its volume

(D) An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph



Column II

(p) The temperature of the gas decreases

(q) The temperature of the gas increases or remains constant

(r) The gas loses heat

(s) The gas gains heat

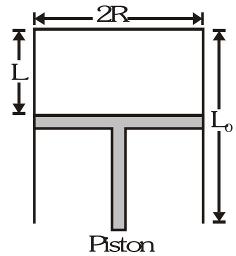
ASSERTION & REASON

1. **Statement–I** : The total translation kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume. [IIT-JEE 2007]
Because :
Statement–II : The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.
(A) statement–I is true, statement–II is true; statement–II is a correct explanation for statement–I
(B) statement–I is true, statement–II is true, statement–II is NOT a correct explanation for statement–I
(C) statement–I is true, statement–II is false
(D) statement–I is false, statement–II is true

COMPREHENSION TYPE QUESTIONS

Comprehension# 1 [IIT-JEE 2007]

A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.



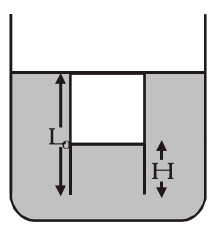
1. The piston is now pulled out slowly and held at a distance 2L from the top. The pressure in the cylinder between its top and the piston will then be :–

(A) P_0 (B) $\frac{P_0}{2}$ (C) $\frac{P_0}{2}+\frac{Mg}{\pi R^2}$ (D) $\frac{P_0}{2}-\frac{Mg}{\pi R^2}$

2. While the piston is at a distance 2L from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is :–

(A) $\left(\frac{2P_0\pi R^2}{\pi R^2P_0+Mg}\right)(2L)$ (B) $\left(\frac{2P_0\pi R^2-Mg}{\pi R^2P_0}\right)(2L)$ (C) $\left(\frac{P_0\pi R^2+Mg}{\pi R^2P_0}\right)(2L)$ (D) $\left(\frac{P_0\pi R^2}{\pi R^2P_0-Mg}\right)(2L)$

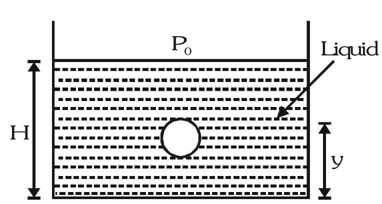
3. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies :–



(A) $\rho g(L_0 - H)^2 + P_0(L_0 - H) + L_0P_0 = 0$ (B) $\rho g(L_0 - H)^2 - P_0(L_0 - H) - L_0P_0 = 0$
(C) $\rho g(L_0 - H)^2 + P_0(L_0 - H) - L_0P_0 = 0$ (D) $\rho g(L_0 - H)^2 - P_0(L_0 - H) + L_0P_0 = 0$

Comprehension# 2 [IIT-JEE 2008]

A small spherical monoatomic ideal gas bubble $\left(\gamma=\frac{5}{3}\right)$ is trapped inside a liquid of density ρ_ℓ (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure is P_0 (Neglect surface tension).



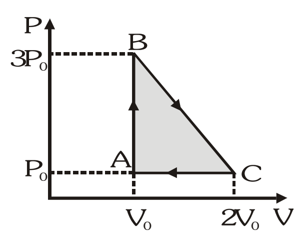
1. As the bubble moves upwards, besides the buoyancy force the following forces are acting on it.
(A) Only the force of gravity
(B) The force due to gravity and the force due to the pressure of the liquid
(C) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid
(D) The force due to gravity and the force due to viscosity of the liquid.

2. When the gas bubble is at a height y from the bottom, its temperature is :–
(A) $T_0\left(\frac{P_0+\rho_\ell gH}{P_0+\rho_\ell gy}\right)^{2/5}$ (B) $T_0\left(\frac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{2/5}$ (C) $T_0\left(\frac{P_0+\rho_\ell gH}{P_0+\rho_\ell gy}\right)^{3/5}$ (D) $T_0\left(\frac{P_0+\rho_\ell g(H-y)}{P_0+\rho_\ell gH}\right)^{3/5}$

3. The buoyancy force acting on the gas bubble is (Assume R is the universal gas constant)
(A) $p_\ell nRgT_0\,\frac{(P_0+\rho_\ell gH)^{2/5}}{(P_0+\rho_\ell gy)^{7/5}}$ (B) $\frac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{2/5}[P_0+\rho_\ell g(H-y)]^{3/5}}$
(C) $p_\ell nRgT_0\,\frac{(P_0+\rho_\ell gH)^{3/5}}{(P_0+\rho_\ell gy)^{8/5}}$ (D) $\frac{\rho_\ell nRgT_0}{(P_0+\rho_\ell gH)^{3/5}[P_0+\rho_\ell g(H-y)]^{2/5}}$

SUBJECTIVE QUESTIONS

1. One mole of an ideal monoatomic gas is taken round the cyclic process ABCA as shown in figure. Calculate:

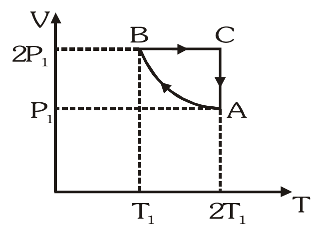


(i) The work done by the gas. [IIT-JEE 1998]
(ii) The heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB.
(iii) The net heat absorbed by the gas in the path BC.
(iv) The maximum temperature attained by the gas during the cycle.

2. A solid body X of heat capacity C is kept in an atmosphere whose temperature is T_A = 300 K. At time t = 0, the temperature of X is T_0 = 400 K. It cools according to Newton's law of cooling. At time t_1 its temperature is found to be 350 K. At this time (t_1) the body X is connected to a large body Y at atmospheric temperature T_A through a conducting rod of length L, cross–section area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross–section area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time t = $3t_1$. [IIT-JEE 1998]

3. Two moles of an ideal monoatomic gas initially at pressure P_1 and volume V_1 undergo an adiabatic compression until its volume is V_2. Then the gas is given heat Q at constant volume V_2. [IIT-JEE 1999]
(i) Sketch the complete process on a P–V diagram.
(ii) Find the total work done by the gas, the total change in internal energy and the final temperature of the gas. (Give your answer in terms of P_1, V_1, V_2, Q and R)

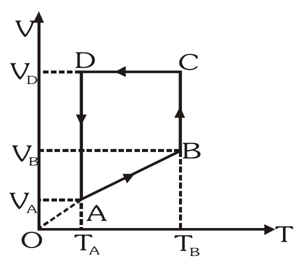
4. Two moles of an ideal monoatomic gas is taken through a cycle ABCA as shown in the P–V diagram. During the process AB, pressure and temperature of the gas very such that PT = constant. If T_1 = 300K, calculate



(i) The work done on the gas in the process AB and [IIT-JEE 2000]
(ii) The heat absorbed or released by the gas in each of the processes.
Give answers in terms of the gas constant P.

5. An ice cube of mass 0.1 kg at 0 C is placed in an isolated container which is at 227 C. The specific heat S of the container varies with temperature T according to the empirical relation S = A + BT, where A = 100 cal/kg–K and B = 2 10^{-2} cal/kg–K^2. If the final temperature of the container is 27 C, determine the mass of the container (Latent heat of fusion for water = 8 10^4 cal/kg, specific heat of water = 10^3 cal/kg–K). [IIT-JEE 2001]

6. A monoatomic ideal gas of two moles is taken through a cyclic process starting from A as shown in the figure. The volume ratio are $\frac{V_B}{V_A}$ =2 and $\frac{V_D}{V_A}$ =4. If the temperature T_A at A is 27 C. Calculate :



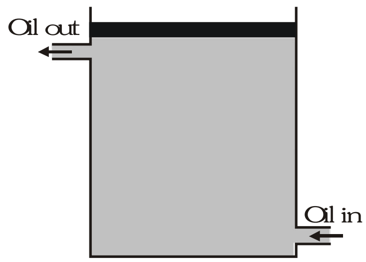
(i) The temperature of the gas at point B. [IIT-JEE 2001]
(ii) Heat absorbed or released by the gas in each process.
(iii) The total work done by the gas during the complete cycle.
Express your answer in terms of the gas constant R.

7. A 5m long cylindrical steel wire with radius 2 10^{-3} m is suspended vertically from a rigid support and carries a bob of mass 100 kg at the other end. If the bob gets snapped, calculate the change in temperature of the wire ignoring losses. (For the steel wire : Young's modulus = 2.1 10^{11} Pa; Density = 7860 Kg/m^3 ; Specific heat = 420 J/kg–K). [IIT-JEE 2001]

8. A cubical box of side 1m contains helium gas (atomic weight 4) at a pressure of 100 N/m^2. During an observation time of 1s, an atom travelling with the root mean square speed parallel to one of the edges of the cube, was found to make 5000 hits with a particular wall, without any collision with other atoms.
Take : R = 25/3 J/mol–K and k = 1.38 10^{-23} J/K. [IIT-JEE 2002]
(i) Evaluate the temperature of the gas.
(ii) Evaluate the average kinetic energy per atom.
(iii) Evaluate the total mass of helium gas in the box.

9. An insulated box containing a monoatomic gas of molar mass M moving with a speed v_0 is suddenly stopped. Find the increment in gas temperature as a result of stopping the box. [IIT-JEE 2003]

10. The top of an insulated cylindrical container is covered by a disc having emissivity 0.6 and conductivity 0.167 W/km and thickness 1 cm. The temperature is maintained by circulating oil as shown : **[IIT-JEE 2003]**

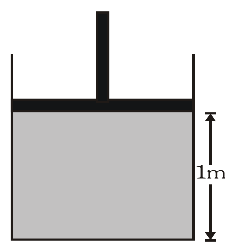


(i) Find the radiation loss to the surroundings in J/m^2 s if temperature of the upper surface of disc is 127 C and temperature of surroundings is 27 C.

(ii) Also find the temperature of the circulating oil. Neglect the heat loss due to convection.

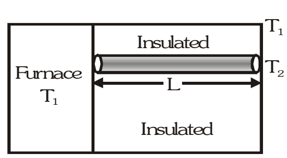
(Give : $\sigma = \frac{17}{3} \quad 10^{-8}$ W^{-2}K^{-4}]

11. The piston cylinder arrangement shown contains a diatomic gas at temperature 300 K. The cross–sectional area of the cylinder is 1m^2. Initially the height of the piston above the base of the cylinder is 1m. The temperature is now raised to 400 K at constant pressure. Find the new height of the piston above the base of the cylinder. If the piston is now brought back to its original height without any heat loss, find the new equilibrium temperature of the gas. You can leave the answer in fraction. **[IIT-JEE 2004]**



12. A cube of coefficient of linear expansions α_s is floating in a bath containing a liquid of coefficient of volume expansion γ_1. When the temperature is raised by ΔT, the depth upto which the cube is submerged in the liquid remains the same. Find the relation between α_s and γ_1 showing all the steps. **[IIT-JEE 2004]**

13. One end of a rod of length L and cross–sectional area A is kept in a furnace of temperature T_1. The other end of the rod is kept at a temperature T_2. The thermal conductivity of the material of the rod is K and emissivity of the rod is e. it is given that $T_2 = T_s + \Delta T$, where $\Delta T << T_S$, Ts being the temperature of the surroundings. If $\Delta T \propto (T_1 - T_s)$, find the proportionality constant that heat is lost only by radiation at the end where the temp, of the rod is T_2. **[IIT-JEE 2004]**



14. A metal of mass 1 kg at constant atmospheric pressure and at initial temperature 20 C is given a heat of 200000 J. Find the following : **[IIT-JEE 2005]**

(i) change in temperature (ii) work done and (iii) change in internal energy.

(Given : Specific heat 400 J/kg/ C, coefficient of cubical expansion, $\gamma = 8 \quad 10^{-5}$ / C, density ρ = 9000 kg/m^3, atmospheric pressure = 10^5 N/m^2.

15. In an insulated vessel, 0.05 kg steam at 373 K and 0.45 kg of ice at 253 K are mixed find the final temperature of the mixture (in kelvin). Given : L_{fusion} = 80 cal/g = 336 J/g; $L_{vaporization}$ = 540 cal/g = 2268 J/g; S_{ice} = 2100 J/kg, K = 0.5 cal/gK; and S_{water} = 4200 J/kg, K = 1 cal/gK **[IIT-JEE 2006]**

16. A metal rod AB of length 10x has its one end A in ice at 0 C and the other end B in water at 100 C. It a point P on the rod is maintained at 400 C, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at λx distance from the ice end then find out the value of λ. [Neglect any heat loss to the surrounding.] **[IIT-JEE 2009]**

PREVIOUS YEARS QUESTIONS **ANSWER KEY** EXERCISE –5

- **MCQ's (Single Correct answers)**

1.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	C	D	D	C	D	D	B	A	A	C	B	B	A	B	A	A
18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
D	D	C	A	B	C	C	D	B	A	C	D	A	A	C	D	A
35																
A																

- **MCQ's (one or more than one correct)**

1	2	3	4	5	6
C,D	B,C	B,D	B,D	B,D	ABCD

- **Match the column**

1. (A) s, (B) p,r (C) r (D) q,s 2. (A) q,s (B) q, (C) p,q(D) q,r 3. (A) q, (B) p,r (C) p,s (D) q,s

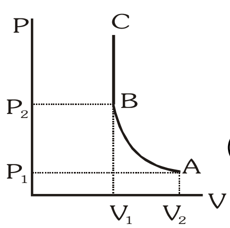
- **Comprehension Based Questions**

Comprehension#1 1. A 2. D 3. C
Comprehension#2 1. D 2. B. 3.B

- **Assertion–Reason** 1. B

- **Subjective Questions**

1. (i) P_0V_0 (ii) $\frac{5}{2}P_0V_0$, $3P_0V_0$ (iii) $\frac{1}{2}P_0V_0$ (iv) $\frac{25}{8}\frac{P_0V_0}{R}$ 2. $\left[300+12.5e^{-\frac{2KAt_1}{CL}}\right]K$

3. (i) 

(ii) W= $\frac{3}{2}P_1V_1\left[1-\left(\frac{V_1}{V_2}\right)^{2/3}\right]$, $\Delta U = \frac{3}{2}P_1V_1\left[\left(\frac{V_1}{V_2}\right)^{2/3}-1\right]$, T= $\frac{Q}{3R}+\frac{P_1V_2}{2R}\left(\frac{V_1}{V_2}\right)^{5/3}$

4. (i) 1200 R (ii) Q_{AB} = –2100 R, Q_{BC} = 1500 R, Q_{CA} = 1200R ℓn2
5. 0.5 kg
6. (i) 600 K (ii) 1500R, 831.6K, –900R, –831.6R (iii) 600R
7. 4.568 10^{-3} ^{0}C
8. (i) 160K (ii) 3.3 10^{-21} J (iii) 0.3 g
9. $\frac{Mv_0^2}{3R}$
10. (i) 595 W/m^2 (ii) 162.6^{0}C
11. $400\left(\frac{4}{3}\right)^{0.4}$ K
12. $\gamma_\ell = 2\alpha_S$
13. $\frac{K}{4e\sigma LT_S^3+K}$
14. (i) 70^{0}C (ii) 0.05 J (iii) 19999.95 J
15. 273 K
16. 9