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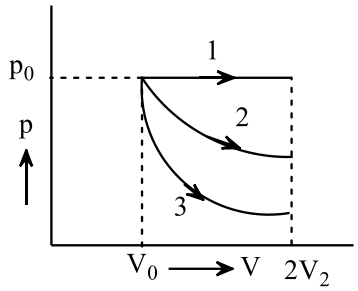
PHYSICS

4.THERMODYNAMICS

Single Correct Answer Type

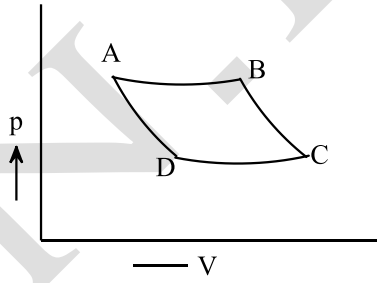
1. A gas is expanded from volume V_0 to $2V_0$ under three different processes shown in figure. Process 1 is isobaric process, process 2 is isothermal and process 3 is adiabatic. Let $\Delta U_1, \Delta U_2$ and ΔU_3 be the change in internal energy of the gas in these three processes. Then,



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) $\Delta U_2 < \Delta U_3 < \Delta U_1$

2. In which thermodynamic process, the change in internal energy 'ΔU', heat supplied 'Q' and the work done in expansion 'W' are all non-zero?
a) Adiabatic b) Isobaric
c) Isothermal d) Isochoric

3. In the indicator diagram, T_a, T_b, T_c, T_d represents temperatures of gas at A, B, C, D respectively. Which of the following is correct relation?



a) $T_a = T_b = T_c = T_d$ b) $T_a \neq T_b \neq T_c \neq T_d$
c) $T_a = T_b$ and $T_c = T_d$ d) None of these

4. The specific heat of hydrogen gas at constant pressure is $C_p = 3.4 \times 10^3$ cal/kg°C and at constant volume is $C_V = 2.4 \times 10^3$ cal/kg°C. If 1 kg hydrogen gas is heated from 10°C to 20°C at constant pressure, the external work done on the gas to maintain it at constant pressure is
a) 10^6 cal b) 10^4 cal
c) 10^3 cal d) 5×10^3 cal

5. The initial pressure and volume of a gas is 'P' and 'V' respectively. First by isothermal process gas is expanded to volume '9V' and then by adiabatic process its volume is compressed to 'V' then its final pressure is (Ratio of specific heat at constant pressure to constant volume= $\frac{3}{2}$)
a) 6P b) 27P
c) 3P d) 9P

6. Six moles of O_2 gas is heated from 20°C to 35°C at constant volume. If specific heat capacity at constant pressure is 8 cal mol^{-1} K^{-1} and R = 8.31Jmol^{-1} K^{-1}, what is change in internal energy of gas?
a) 180 cal b) 300 cal
c) 360 cal d) 540 cal

7. An ideal gas expands adiabatically, $\left(\gamma = \frac{3}{2}\right)$. To reduce the r. m. s. velocity of the molecules 3 times the gas has to be expanded
a) 81 times b) 18 times
c) 9 times d) 27 times

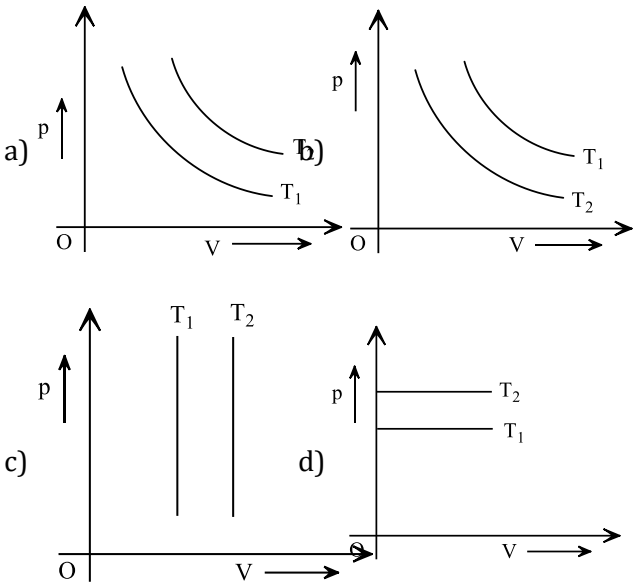
8. A cylinder of fixed capacity (of 44.8 L) contains 2 moles of helium gas at STP. What is the amount of heat needed to raise the temperature of the gas in the cylinder b 20^0 C ? (Take , R = 8.31 J mol^{-1} k^{-1})
a) 996 J b) 831 J
c) 498 J d) 374 J

9. A gas is compressed at a constant pressure of 50 Nm^{-2} from a volume of 10 m^3 to a volume of 4 m^3. Energy of 100 J added to gas by heating. Its internal energy is
a) Increased by 400 J b) Increased by 200 J
c) Increased by 100 J d) Decreased by 200 J

10. A sample of 0.1 g of water at 100^0C and normal pressure (1.013×10^5 Nm^{-2}) requires 54 cal of heat energy to convert to steam at 100^0 C. If the volume of the steam produced is 167.1 cc, the change in internal energy of the sample, is
a) 42.2 J b) 208.8 J

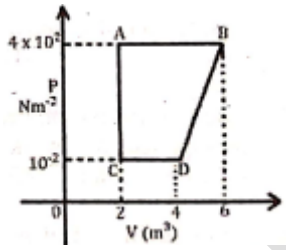
c) 104.3 J d) 84.5 J

11. Identity the graph (s) which correctly represents an isotherm at temperatures T_1 and $T_2 (T_2 > T_1)$.



12. An ideal gas at pressure 'p' is adiabatically compressed so that its density becomes twice that of the initial. If $\gamma = \frac{c_p}{c_v} = \frac{7}{5}$, then final pressure of the gas is
    a) P b) 2p
    c) $\frac{7}{5}$p d) 2.63p

13. For a given cycle as shown in figure the work done during isobaric process is



    a) 400 J b) 1600 J
    c) 200 J d) 800 J

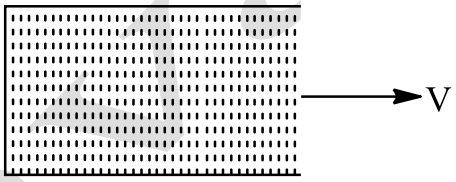
14. A monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ initially at 27°C having volume 'V' is suddenly compressed to one-eighth of its original volume $\left(\frac{V}{8}\right)$. After the compression temperature becomes
    a) 580 K b) 1200 K
    c) 160 K d) 927 K

15. The state of a thermodynamic system is represented by
    a) Pressure only b) Volume only
    c) Pressure, volume and temperature d) Number of moles

16. A polyatomic gas ($\gamma = 4/3$) is compressed to $\left(\frac{1}{8}\right)$ th of its volume adiabatically. If its initial pressure is P_0, its new pressure will be
    a) $2P_0$ b) $8P_0$
    c) $6P_0$ d) $16P_0$

17. In thermodynamics, for an isochoric process, which one of the following statement is INCORRECT?
    a) Energy exchanged is used to do work and also to change internal energy b) No work is done in the process
    c) It is a constant volume process d) Temperature of the system changes during the process

18. The internal energy of a gas contained in a movable box moving with a constant speed v



    a) Depends on v b) Does not depend on v
    c) Depends only on molecular energies d) Both (b) and (c)

19. In a certain process, 400 cal of heat is supplied to a system and at the same 105 J of mechanical work was done on the system. The increase in its internal energy is
    a) 20 cal b) 303 cal
    c) 404 cal d) 425 cal

20. At 27^0 C, a motor car tyre has pressure of 2 atm. The temperature at which the tyre suddenly burst will be (given , $\gamma_{air} = 1.4$)
    a) 246.1 K b) 250 K
    c) 290 K d) 248 K

21. An ideal gas is expanded adiabatically. How many times has the gas to be expanded to reduce the rms speed of molecules 2 times? ($\gamma = 1.5$)
    a) 16 times b) 4 times
    c) 2 times d) 8 times

22. A gas expands adiabatically at constant pressure, such that its temperature $T \propto \frac{1}{\sqrt{V}}$. The value of C_p/C_V of the gas is
    a) 1.30 b) 1.50
    c) 1.67 d) 2.00

23. An ideal gas ($\gamma = 1.5$) is expanded adiabatically. How many times has the gas to

be expanded to reduce r. m. s. velocity of molecules two times?

a) 8 times b) 16 times
c) 12 times d) 20 times

24. 1 mole of an ideal monoatomic gas is heated at a constant pressure of 1 atmosphere from 0°C to 100°C. Work done by the gas is

a) 8.31×10^3 J b) 8.31×10^{-3} J
c) 8.31×10^{-2} J d) 8.31×10^2 J

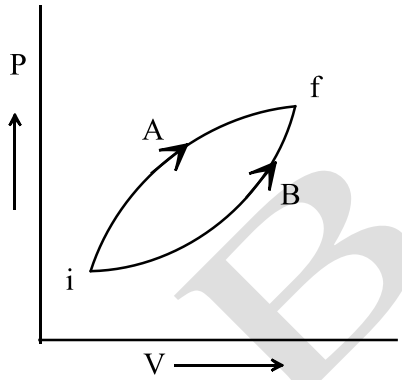
25. An ideal gas which is diatomic $\left(\gamma = \frac{7}{5}\right)$ undergoes an adiabatic change. If the relation between temperature and volume is $TV^x =$ constant, then the value of x is

a) $\frac{1}{3}$ b) $\frac{2}{5}$
c) $\frac{2}{3}$ d) $\frac{1}{4}$

26. Amongst the following variables, state variable is (are)

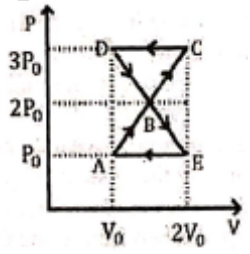
a) Heat b) Work
c) Internal energy d) All of these

27. Following figure shows two processes A and B for a gas. If ΔQ_A and ΔQ_B are the amount of heat absorbed by the system in two cases and ΔU_A and ΔU_B are changes in internal energies respectively, then



a) $\Delta Q_A > \Delta Q_B, \Delta U_A > \Delta U_B$ b) $\Delta Q_A < \Delta Q_B, \Delta U_A < \Delta U_B$
c) $\Delta Q_A > \Delta Q_B, \Delta U_A = \Delta U_B$ d) $\Delta Q_A = \Delta Q_B, \Delta U_A = \Delta U_B$

28. A thermodynamic system undergoes a cyclic process ACDEA as shown in figure. Work done by the system is



a) Zero b) $\frac{3}{2}P_0V_0$
c) P_0V_0 d) $2P_0V_0$

29. The internal energy of a system could be changed

a) By extracting heat from the system b) By doing work done on the system
c) If system do some work on the surroundings d) All of the above

30. In an adiabatic process, pressure is increased by $\frac{2}{3}$%. If $\frac{C_p}{C_v} = \frac{3}{2}$, then the volume decreases by about

a) $\frac{4}{9}$% b) $\frac{2}{3}$%
c) 4% d) $\frac{9}{4}$%

31. The graph of thermodynamic process is a straight line parallel to pressure axis in a pV diagram. The work done in this process is

a) Zero b) $\sqrt{pV}$
c) 2PV d) Infinity

32. If an average person jogs, he produces 14.5×10^4 cal/min. This is removed by the evaporation of sweat. The amount of sweat evaporated per minute (assuming 1 kg requires 580×10^3 cal for evaporation) is

a) 0.25 kg b) 2.25 kg
c) 0.05 kg d) 0.20 kg

33. A monoatomic gas is suddenly compressed to $\left(\frac{1}{8}\right)$ th of its initial volume adiabatically. The ratio of the final pressure to initial pressure of the gas is ($\gamma = 5/3$)

a) 32 b) 8
c) $\frac{40}{3}$ d) $\frac{24}{5}$

34. We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W is the work done by the system, which of the following statements are true?

a) $\Delta U = -W$ is an adiabatic process. b) $\Delta U = W$ in an isothermal process.
c) $\Delta U = -W$ in an isothermal process. d) $\Delta U = W$ in an adiabatic process.

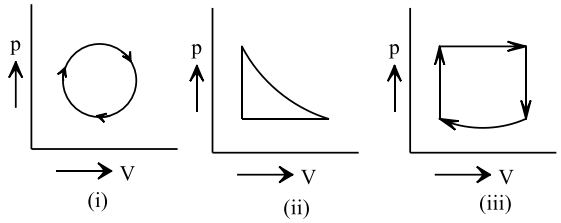
35. If in a thermodynamic system, 'ΔU' represents the increase in its internal energy and 'W' is the amount of work done by the system, then which one of the following statements is true?

a) $\Delta U = W$ in an adiabatic process b) $\Delta U = -W$ in an isothermal process
c) $\Delta U = W$ in an isothermal process d) $\Delta U = -W$ in an adiabatic process

36. In a p- V diagram for an ideal gas (where , p is along Y- axis and V is along X –axis), the value of the ratio "slope of adiabatic curve/slope of the isothermal curve" at any point will be (where symbols have their usual meanings)
a) 1 b) 2
c) C_p/c_v d) C_v/c_p

37. A gas expands with temperature according to the relation $V = kT^{2/3}$. Calculate work done when the temperature changes by 60 K.
a) 10 R b) 30 R
c) 40 R d) 20 R

38. What is the nature of change in internal energy in the following three thermodynamic processes shown in figure?



a) ΔU is positive in all the three cases
b) ΔU is negative in all the three cases
c) ΔU is positive for (i), negative for (ii), zero for (iii)
d) $\Delta U = 0$ in all the cases

39. The thermodynamic process in which no work is done on or by the gas is
a) Isothermal process b) Isobaric process
c) Adiabatic process d) Isochoric process

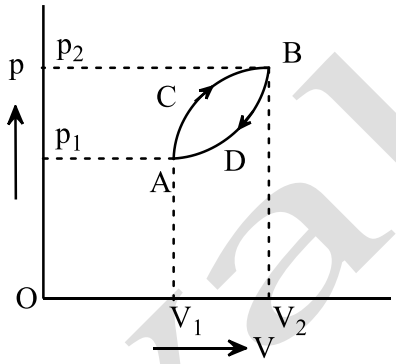
40. Which one of the following equations specific an isobaric process?
[Q = heat supplied ΔP, ΔV and ΔT are change in pressure, volume and temperature respectively]
a) $Q = 0$ b) $\Delta T = 0$
c) $\Delta V = 0$ d) $\Delta P = 0$

41. 10 moles of an ideal gas at constant temperature 500 K is compressed from 50 L to 5 L. Work done in the process is (Take, $R = 8.31 Jmol^{-1} K^{-1}$)
a) -1.2×10^4 J b) -2.4×10^4 J
c) -4.8×10^4 J d) -9.6×10^4 J

42. Out of the following statements, which one is 'NOT' correct in case of thermodynamic process?
a) In an isothermal process, $\Delta T = 0$
b) In an isobaric process, $\Delta P = 0$
c) In an isochoric process, $W = 0$
d) In an isothermal process, $Q \neq 0$

43. A sample of a gas expands from volume 'V_1' to 'V_2'. The amount of work done by the gas is maximum when the expansion is
a) Equal in isothermal and isobaric
b) Isobaric
c) Isothermal
d) Adiabatic

44. A thermodynamic system is taken from state A to state B along ACB and is brought back to A along BDA as shown in figure. Net work done during one complete cycle is given by area



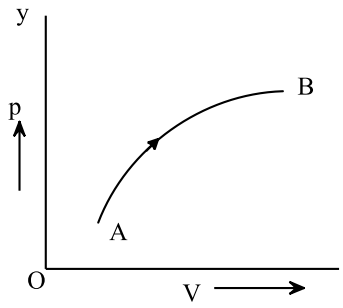
a) ACBDA b) $ACBp_2p_1A$
c) AV_1V_2BDA d) $BDAp_1p_2B$

45. If 'ΔU' is change in internal energy, 'W' is work done and 'Q' is amount of heat exchanged in the thermodynamic system. Match the column I with column II.

	Column I		Column II
(a)	Isothermal process	(i)	(i) $\Delta U = -W$
(b)	Isobaric process	(ii)	$Q = \Delta U$
(c)	Isochoric process	(iii)	$\Delta U = 0$
(d)	Adiabatic process	(iv)	$\Delta U \neq 0$

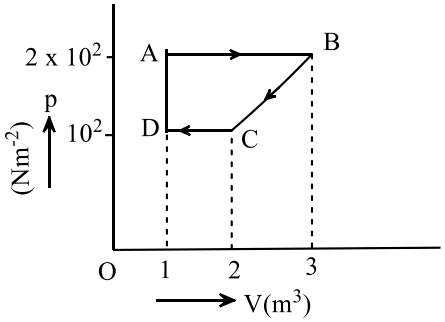
a) (a) → (iii); (b) → (iv); (c) → (ii); (d) → (i)
b) (a) → (i); (b) → (iii); (c) → (iv); (d) → (ii)
c) (a) → (ii); (b) → (iv); (c) → (i); (d) → (iii)
d) (a) → (iii); (b) → (i); (c) → (ii); (d) → (iv)

46. Figure shows a thermodynamic process on one mole of a gas. How does the work done in the process changes with time?



a) Decreases continuously
b) Increases continuously
c) Remains constant
d) First increases and then decreases

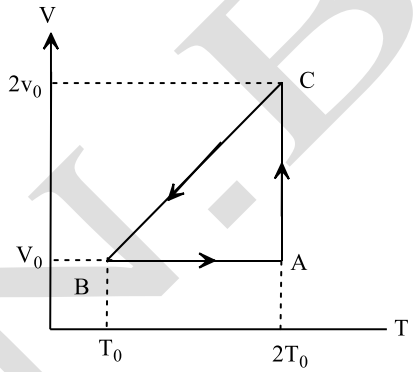
47. A cyclic process is shown in figure. Work done during isobaric expansion is



a) 1600 J
b) 100 J
c) 400 J
d) 600 J

48. If work is done on the system in an adiabatic process,
a) $T_f < T_i$
b) $T_f = T_i$
c) $T_f > T_i$
d) Information is insufficient

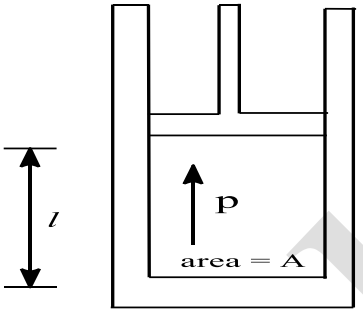
49. The efficiency of an ideal cas with adiabatic exponent γ for the shown cyclic process would be



a) $\frac{(2\ln 2-1)}{\gamma/(\gamma-1)}$
b) $\frac{(1-1\ln 2)}{\gamma/(\gamma-1)}$
c) $\frac{(2\ln 2+1)}{\gamma/(\gamma-1)}$
d) $\frac{(2\ln 2-1)}{\gamma/(\gamma+1)}$

50. In a thermodynamic system, working substance is an ideal gas. Its internal energy is in the form of
a) Both kinetic and potential energy
b) Only kinetic energy
c) Only potential energy
d) Neither kinetic nor potential energy

51. If the system is a gas in a cylinder with a movable piston as shown in the figure below, then



a) $\Delta W = pV$
b) $\Delta W = pV$
c) $\Delta W = p\Delta V$
d) $\Delta W = p\Delta V = V\Delta p$

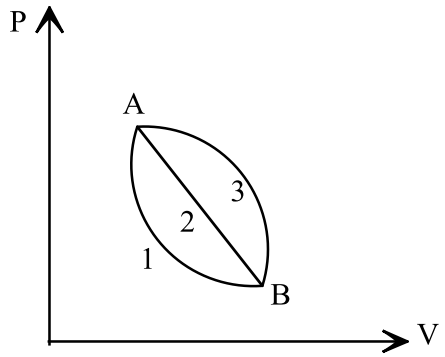
52. For an isothermal expansion or compression, (where ΔW_1 and ΔW_2 are the net work for expansion and compression, respectively)
a) $\Delta W_1 = -ve; \Delta W_2 = +ve$
b) $\Delta W_1 = \Delta W_2: \Delta W_2 = -ve$
c) $\Delta W_1 = +ve\ ; \Delta W_2 = -ve$
d) $\Delta W_1 = \Delta W_2$, at every stage

53. The temperature of an ideal gas increases to 2 times when compressed adiabatically to half the volume. Its equation of state can be written as
a) $pV^{3/2} = \text{constant}$
b) $pV^{4/3} = \text{constant}$
c) $pV^{1/2} = \text{constant}$
d) $pV^2 = \text{constant}$

54. A polyatomic gas ($\gamma = 4/3$) is compressed to $\left(\frac{1}{8}\right)$ th of its volume adiabatically. If its initial pressure is P_0, its new pressure will be
a) $6P_0$
b) $16P_0$
c) $8P_0$
d) $2P_0$

55. 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 be 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) $\left(\frac{L_2}{L_1}\right)^{2/3}$

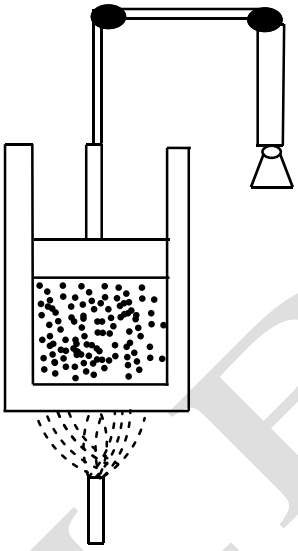
56. An ideal gas of mass m in a state A goes to another state B via three different processes as shown in figure. If Q_1, Q_2 and Q_3 denote the heat absorbed by the gas along the three paths, then



a) $Q_1 < Q_2 < Q_3$ b) $Q_1 < Q_2 = Q_3$
c) $Q_1 = Q_2 > Q_3$ d) $Q_1 > Q_2 > Q_3$

57. One mole of an ideal gas expands adiabatically at constant pressure such that its temperature $T \propto \frac{1}{\sqrt{V}}$. The value of γ for the gas is ($\gamma = \frac{c_p}{c_v}$, V = volume of the gas)
a) 1.8 b) 1.5
c) 1.3 d) 1.4

58. Consider a system to be a certain mass of gas contained in a cylinder with movable piston as shown in the figure.
The state of the gas and hence its internal energy can be changed by



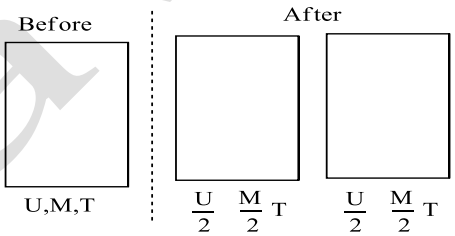
a) Putting the cylinder in contact with the body at a higher temperature than gas
b) Pushing the piston down
c) Either (a)or (b) d) Neither (a)nor (b)

59. Which of the following statements is true?
(ΔU = increase in internal energy, dW = work done by the system)
a) In an adiabatic process $\Delta U = dW$
b) In an adiabatic process $\Delta U = -dW$
c) In an isothermal process $\Delta U = -dW$
d) In an isothermal process $\Delta U = dW$

60. An ideal gas having pressure 'P', volume 'V' and temperature 'T' undergoes a thermodynamic process in which $dW = 0$ and $dQ < 0$. Then for the gas
a) V will increase
b) P may increase or decrease
c) T will increase
d) T will decrease

61. An ideal gas with pressure P, volume V and temperature T is expanded isothermally to a volume 2V and a final pressure P_i. The same gas is expanded adiabatically to a volume 2V, the final pressure is P_a. In terms of the ratio of the two specific heats for the gas 'γ', the ratio $\frac{P_i}{P_a}$ is
a) $2^{\gamma+1}$ b) $2^{\gamma-1}$
c) $2^{1-\gamma}$ d) 2^{γ}

62. A system in equilibrium is divided into two equal parts. The systems before and after the divisions, with respective state variables are as shown below.



Then, from the above, we can say that
a) U is an extensive state variable, whereas M and T are intensive state variables
b) T is an extensive state variable, whereas U and M are intensive state variables
c) U and M are extensive state variables, whereas T is intensive state variable
d) U, M and T all are extensive state variables

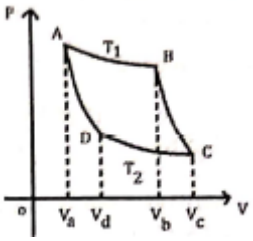
63. A container of volume $1m^3$ is divided into two equal parts by partition. One part has an ideal gas at 300 K and the other part is vacuum. The whole system is thermally insulated from the surrounding. If the partition is removed, the gas expands to occupy the whole volume. The final temperature of the gas is
a) 450 K b) 300 K
c) 600 K d) 150 K

64. In order to compress one kilo mole of a gas adiabatically, the work of 124 kJ is performed and in this process temperature of the gas increase by 6°C, the gas is

[Universal gas constant R = 8.3 J $mol^{-1}K^{-1}$]

a) Mixture of monoatomic and triatomic gas
b) Rigid diatomic
c) Non rigid diatomic
d) Monoatomic

65. In the P – V diagram shown, there are two adiabatic parts of the same gas intersecting two isothermals at T_1 and T_2. The ratio $\left(\frac{V_b}{V_a}\right)$ is equal to



a) $2\left(\frac{V_c}{V_d}\right)$
b) $\left(\frac{V_c}{V_d}\right)^2$
c) $\left(\frac{V_c}{V_d}\right)$
d) $\frac{1}{2}\left(\frac{V_c}{V_d}\right)$

66. Which one of the following parameters does not represent a thermodynamic state of a gas?

a) Volume
b) Work
c) Temperature
d) Pressure

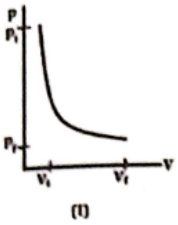
67. A gas at pressure p is adiabatically compressed , so that its density becomes twice that of initial value. Given that $\gamma = C_p / C_v = 7/5$, what will be the final pressure of the gas?

a) 2p
b) $\frac{7}{5}$p
c) 2.63 p
d) P

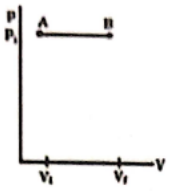
68. 'V' cc volume of a gas having $\gamma = \frac{5}{2}$ s suddenly compressed to $\left(\frac{V}{4}\right)$ c. c. The initial pressure of the gas is P. The final pressure of the gas will be

a) 32P
b) 16P
c) $\frac{P}{32}$
d) $\frac{P}{16}$

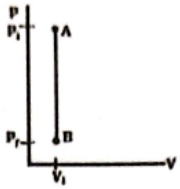
69. Which one of the following p-V diagram is correct for an isobaric process?



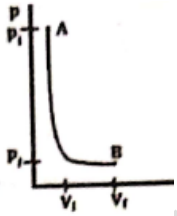
(I)



(II)



(III)



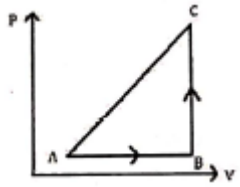
(IV)

a) (III)
b) (II)
c) (IV)
d) (I)

70. In a thermodynamic system, 'W' represents the work done by the system and 'ΔU' is the increase in internal energy. Which of the following statements is TRUE?

a) In an isothermal process, $\Delta U = -W$
b) In an adiabatic process, $\Delta U = W$
c) In an isothermal process, $\Delta U = W$
d) In an adiabatic process, $\Delta U = -W$

71. The p – V diagram of a system undergoing thermodynamic changes is as shown in the figure. The work done by the system in going from A → B → C is 30 J. If 68 J of heat is given to the system, then the change in the internal energy of the system between A and C is



a) 34 J
b) 55 J
c) 50 J
d) 38 J

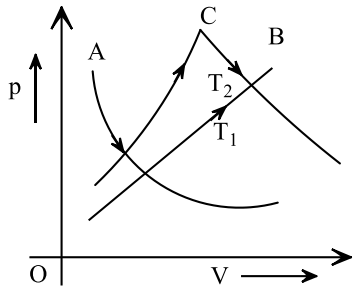
72. A monoatomic ideal gas initially at temperature T_1 is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. L_1 and L_2 are the lengths of the gas columns before and after the expansion respectively. Then $\frac{T_2}{T_1}$ is

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

c) $\left(\frac{L_1}{L_2}\right)^{1/2}$ d) $\left(\frac{L_2}{L_1}\right)^{1/2}$

73. The equation of state for 2g of oxygen at a pressure 'P' and temperature 'T', when occupying a volume 'V' will be
a) $PV = \frac{1}{16}RT$ b) $PV = RT$
c) $PV = 2RT$ d) $PV = 16RT$

74. Among given cures, which one could represent isothermal process?



a) Curve A b) Curve B
c) Curve C d) None of the curves could represent isothermal process

75. 5 moles of an ideal gas with $\gamma = 7/5$, initially at STP is compressed adiabatically, so that its temperature becomes 400^0C. The increase in the internal energy of gas in kJ is
a) 21.55 b) 41.55
c) 65.55 d) 50.55

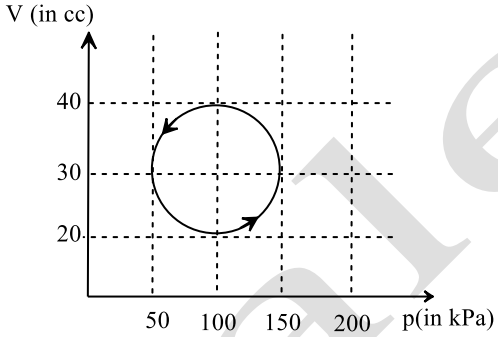
76. The sample of gas expands from volume 'V_1' to 'V_2'. The amount of work done by the gas is greatest when the expansion is
a) Adiabatic b) Isobaric
c) Isothermal d) Free expansion

77. A system is provided with 200 cal of heat and the work done by the system on the surroundings is 40 J. then , its internal energy
a) Increase by 600 J b) Decrease by 800 J
c) Increase by 800 J d) Decrease by 50 J

78. A given mass of a gas is compressed isothermally until its pressure is doubled. It is then allowed to expand adiabatically until its original volume is restored and its pressure is then found to be 0.75 of its initial pressure. The ratio of the specific heat of the gas is approximately
a) 1.20 b) 1.41
c) 1.67 d) 1.83

79. For a heat engine operating between temperatures t_1°C and t_2°C, its efficiency will be
a) $\frac{t_1 - t_2}{t_2}$ b) $\frac{t_1 - t_2}{t_1 + 273}$
c) $\frac{t_1}{t_2}$ d) $1 - \frac{t_2}{t_1}$

80. A system is taken through a cyclic process represented by a circle as shown in the figure. The heat absorbed by the system is



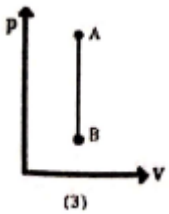
a) $(\pi \times 10^3)$J b) $\left(\frac{\pi}{2}\right)$J
c) $(4\pi \times 10^2)$J d) (π)J

81. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its temperature. The ratio of $\frac{C_p}{C_v}$ for the gas is
a) $\frac{4}{3}$ b) 2
c) $\frac{5}{3}$ d) $\frac{3}{2}$

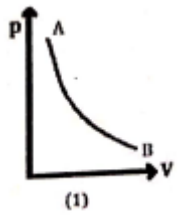
82. An ideal gas at 27°C is compressed adiabatically to $\frac{8}{27}$ of its original volume. [TV^{-1} = constant and $\gamma = 5/3$] Then the rise in temperature is
a) 225K b) 400K
c) 450K d) 375K

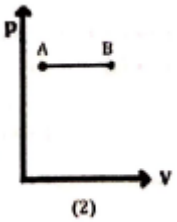
83. A thermodynamic process of uncontrolled change satisfying the equation $Q = W = 0$ (zero) is known as [Q = heat supplied, W = work done]
a) Cyclic process b) Isothermal process
c) Isochoric process d) Free expansion

84. Out of the following graphs, which p-V diagram represents isochoric process?

a) 

b) 

c) 

d) 

85. Which one of the following statement is NOT correct for an isochoric process?
a) The volume remains constant.
b) The energy exchanged is used to change internal energy
c) The temperature of the system changes
d) The work done is positive

86. An ideal gas at 27°C is compressed adiabatically to (8/27) of its original volume. If ratio of specific heats, $\gamma = 5/3$ then the rise in temperature of the gas is
a) 500 K
b) 125 K
c) 250 K
d) 375 K

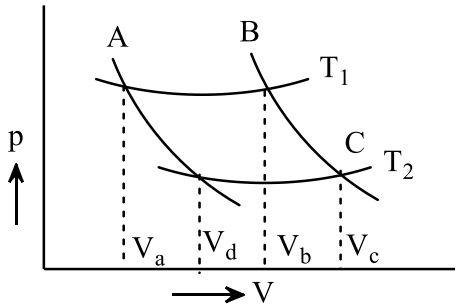
87. A monoatomic gas at pressure 'P' having volume 'V' expands isothermally to a volume 2V and then adiabatically to a volume 16V. The final pressure of the gas is $\left(\gamma = \frac{5}{3}\right)$
a) $\frac{P}{64}$
b) $\frac{P}{128}$
c) $\frac{P}{8}$
d) $\frac{P}{32}$

88. In an adiabatic expansion of a gas initial and final temperatures are T_1 and T_2 respectively then the change in internal energy of the gas is [R = gas constant, γ = adiabatic ratio]
a) $R(T_1 - T_2)$
b) Zero
c) $\frac{R}{\gamma - 1}(T_2 - T_1)$
d) $\frac{R}{\gamma - 1}(T_1 - T_2)$

89. In an isochoric process, if $t_1 = 27°C$ and $t_2 = 127°C$, then $\frac{P_1}{P_2}$ will be equal to [P_1 and P_2 are the pressure at t_1 0°C and t_2 °C respectively]
a) 4/3
b) 9/59
c) 2/3
d) ¾

90. In an adiabatic process the state of a gas is changed from P_1, V_1, T_1 to P_2, V_2, T_2 out of the following relations, the correct one is
a) $P_1V_1^{\gamma} = P_2T_2^{\gamma}$
b) $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$
c) $P_1V_1^{\gamma-1} = P_2V_2^{\gamma-1}$
d) $T_1V_1^{\gamma} = T_2V_2^{\gamma}$

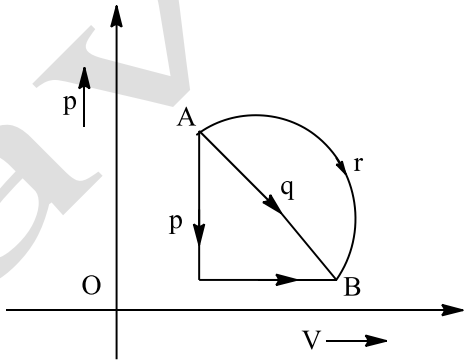
91. In the following p-V diagram, two adiabates cut two isothermals at T_1 and T_2 the value of v_b/v_c is



a) $= V_a/V_d$
b) $< V_a/V_d$
c) $> V_a/V_d$
d) Cannot say

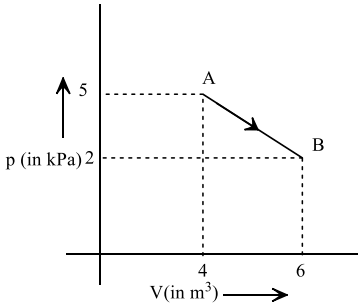
92. In which thermodynamic process, there is no exchange of heat between the system and surroundings?
a) Adiabatic
b) Isobaric
c) Isothermal
d) Isochoric

93. An ideal monoatomic gas is taken from A to B by the following three ways p, q, r as shown in the given p-V curve.



Then, amongst which of these ways, the internal energy would be same?
a) p and r
b) q and r
c) p and q
d) For all the ways, internal energy is same

94. One mole of an ideal diatomic gas undergoes a transition from A to B along a path AB as shown in the figure.



The change in internal energy of the gas during the transition is
a) 20 kJ
b) - 20 kJ
c) 20 J
d) - 12 kJ

95. Which one of the following equations specifies an isochoric process?

[Q = heat supplied, Δp = change in pressure, ΔV = change in volume, ΔT = change in temperature]

a) $\Delta V = 0$ b) $\Delta P = 0$
c) $Q = 0$ d) $\Delta T = 0$

96. Three samples of the same gas A, B and C $\left(\gamma = \frac{3}{2}\right)$ have initially equal volume. Now volume of each sample is doubled. The process is adiabatic for gas A, isobaric for B and isothermal for C. If the final pressures are equal for all the three samples, the ratio of their initial pressure is

a) 2:1:2 b) $\sqrt{2}: 1: \sqrt{2}$
c) $2\sqrt{2}: 1: 2$ d) $2: 1: \sqrt{2}$

97. During an adiabatic process, the pressure p of a fixed mass of an ideal gas changes by Δp and its volume V changes by Δ V. If $\gamma = C_p / C_v$, then Δ V / Vis given by

a) $-\frac{\Delta p}{p}$ b) $-\gamma\frac{\Delta p}{p}\Delta$
c) $-\frac{\Delta p}{\gamma p}$ d) $\frac{\Delta p}{\gamma 2 p}$

98. Ideal gas for which 'γ' = 1.5 is suddenly compressed to $1/4^{th}$ of its initial volume. The ratio of the final pressure to the initial pressure is $\left(\gamma = \frac{C_P}{C_V}\right)$

a) 4:1 b) 8:1
c) 1:16 d) 1:8

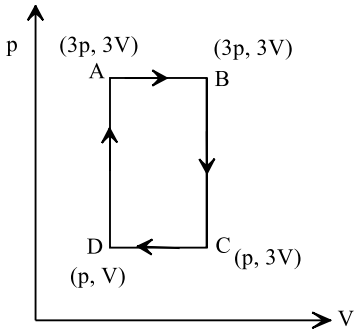
99. 1 cm^3 of water at its boiling point absorbs 540 cal of heat to become steam with a volume = 1671 cm^3 and the mechanical equivalent of heat = 4.19 $Jcal^{-1}$ at normal pressure of 1.013 × 10^5 Nm^{-2}. The energy spend in this process in overcoming intermolecular forces is

a) 540 cal b) 40 cal
c) 500 cal d) zero

100. Which one of the following statements is wrong for an isobaric process?

a) The pressure of the system remains constant
b) There is change in volume, when work is done
c) Temperature of the system remains constant
d) Energy exchanged is used to do work to change internal energy

101. An ideal monoatomic gas is taken around the cycle ABCDA as shown in following p − V diagram. The work done during the cycle is



a) pV b) 2pV
c) 4pV d) zero

102. A thermodynamic process of uncontrolled change satisfying the equation Q = W = 0, is [Q = heat supplied, W = work done]

a) Free expansion b) Cyclic
c) Isochoric d) Isothermal

103. If the heat of 110 J is added to a gaseous system, whose internal energy is 40 J. Then, the amount of external work done is

a) 140 J b) 70 J
c) 110 J d) 150 J

104. 1 g of water of volume 1 cm^3 at 100° c is converted into steam at same temperature under normal atmospheric pressure (= 1×10^5 Pa). The volume of steam formed equals 1671 cm^3. If the specific latent heat of vaporization of water is 2256 J/g . the change in internal energy is

a) 2423 J b) 2089 J
c) 167 J d) 2256 J

105. Amongst the following relations which is true in the case of an adiabatic process, where = C_p/C_V ?

a) $p^{1-\gamma}T^{\gamma} = \text{constant}$ b) $p^{\gamma}T^{1-\gamma} = \text{constant}$
c) $pT^{\gamma} = \text{constant}$ d) $p^{\gamma}T = \text{constant}$

106. The pressure inside a tyre is 4 atm at 27°C. If the tyre bursts suddenly, its final temperature will be (Here, $\gamma = 7/5$)

a) $300(4)^{7/2}$ b) $300(4)^{2/7}$
c) $300(2)^{7/2}$ d) $300(4)^{-2/7}$

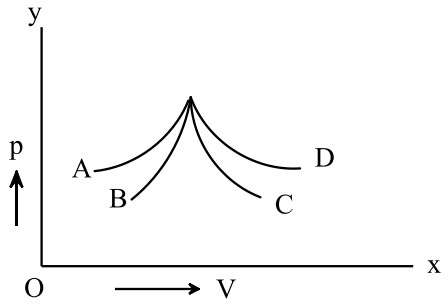
107. In thermodynamic processes which of the following statements is 'NOT CORRECT'?

a) In an isochoric process pressure remains constant
b) In an adiabatic process, PV^t = constant, where symbols have meaning
c) In an isothermal process, the temperature remains constant
d) In an adiabatic process, the system is insulated from surroundings.

108. An ideal gas at 27°C is compressed adiabatically to $\left(\frac{8}{27}\right)$ of its original volume. If the ratio of specific heats (γ) is $\left(\frac{5}{3}\right)$ then the rise in temperature of a gas is
a) 375 K b) 125 K
c) 250 K d) 500 K

109. The relation obeyed by a perfect gas during an adiabatic process is $PV^{3/2}$. The initial temperature of the gas is 'T'. When the gas is compressed to half of its initial volume, the final temperature of the gas is
a) $2\sqrt{2}T$ b) 4T
c) $\sqrt{2}T$ d) 2T

110. Figure shows four p − V diagrams. Which of these curves represent isothermal and adiabatic process?

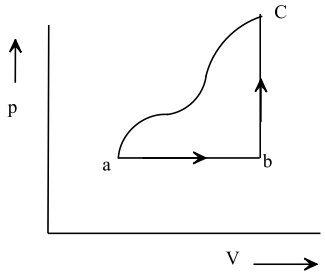


a) D and C b) A and C
c) A and B d) B and D

111. If 'ΔQ' is the amount of heat supplied to 'n' moles of a diatomic gas at constant pressure. 'ΔU' is the change in internal energy and 'ΔW' is the work done, then ΔW: ΔU: ΔQ is
a) 1:2:3 b) 2:5:7
c) 2:3:4 d) 5:7:9

112. Which one of the following is NOT is true statement for an isothermal process?
a) Temperature of process remains constant b) The process is very fast
c) The equation of stated is PV = constant d) There is no change in internal energy of the system

113. A sample of an ideal gas is taken through the cyclic process abca as shown in the figure. The change in the internal energy of the gas along the path ca is −180 J. The gas absorbs 250 J of heat along the path ab and 60 J along the path bc. The work done by the gas along the path abc is



a) 120 J b) 130 J
c) 100 J d) 140 J

114. With same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1, if the process is isothermal, W_2 if isobaric and W_3 if adiabatic, then
a) $W_2 > W_1 > W_3$ b) $W_2 > W_3 > W_1$
c) $W_1 > W_2 > W_3$ d) $W_1 > W_3 > W_2$

115. An ideal gas is taken from the state A (pressure p, volume V) to the state B (pressure p/2, volume 2V), along a straight line path in the p − V diagram. Select the correct statement from the following.
a) The work done by the gas in the process A to B, exceeds the work that would be done by it if system were taken along the isothermal process.
b) In the T − V diagram, the path AB becomes a part of a hyperbola.
c) In the p − T diagram, the path AB becomes a part of a hyperbola.
d) In going from A to B, the temperature T of the gas first decreases to a minimum value and then increases.

116. If a gas is compressed isothermally then the r. m. s. velocity of the molecules
a) Increases b) Decreases
c) First decreases and then increases d) Remains the same

117. A mass of dry air at NTP is compressed to $\frac{1}{20}$ th of its original volume suddenly. If $\gamma = 14$, the final pressure would be
a) 20 atm b) 66.28 atm
c) 30 atm d) 150 atm

118. If α is the coefficient of performance of a refrigerator and 'Q_1' is heat released to the hot reservoir, then the heat extracted from the cold reservoir 'Q_2' is

a) $\frac{\alpha Q_1}{\alpha - 1}$ b) $\frac{\alpha Q_1}{1 + \alpha}$

c) $\frac{1 + \alpha}{\alpha} Q_1$ d) $\frac{\alpha - 1}{\alpha} Q_1$

N.B.Navale

Date : 28.03.2025
Time : 01:46:12
Marks : 118

TEST ID: 50
PHYSICS

4.THERMODYNAMICS

: ANSWER KEY :

1)	**a**	**2)**	**b**	**3)**	**c**	**4)**	**b**
5)	**c**	**6)**	**d**	**7)**	**a**	**8)**	**c**
9)	**a**	**10)**	**b**	**11)**	**a**	**12)**	**d**
13)	**b**	**14)**	**b**	**15)**	**c**	**16)**	**d**
17)	**a**	**18)**	**d**	**19)**	**d**	**20)**	**a**
21)	**a**	**22)**	**b**	**23)**	**b**	**24)**	**d**
25)	**b**	**26)**	**c**	**27)**	**c**	**28)**	**a**
29)	**d**	**30)**	**a**	**31)**	**a**	**32)**	**a**
33)	**a**	**34)**	**a**	**35)**	**d**	**36)**	**c**
37)	**c**	**38)**	**d**	**39)**	**d**	**40)**	**d**
41)	**d**	**42)**	**d**	**43)**	**b**	**44)**	**a**
45)	**d**	**46)**	**b**	**47)**	**c**	**48)**	**c**
49)	**a**	**50)**	**b**	**51)**	**c**	**52)**	**c**
53)	**d**	**54)**	**b**	**55)**	**d**	**56)**	**a**
57)	**b**	**58)**	**c**	**59)**	**b**	**60)**	**d**
61)	**b**	**62)**	**c**	**63)**	**b**	**64)**	**b**
65)	**c**	**66)**	**b**	**67)**	**c**	**68)**	**a**
69)	**b**	**70)**	**d**	**71)**	**d**	**72)**	**b**
73)	**a**	**74)**	**a**	**75)**	**b**	**76)**	**b**
77)	**c**	**78)**	**b**	**79)**	**b**	**80)**	**b**
81)	**d**	**82)**	**d**	**83)**	**d**	**84)**	**a**
85)	**d**	**86)**	**d**	**87)**	**a**	**88)**	**c**
89)	**d**	**90)**	**b**	**91)**	**a**	**92)**	**a**
93)	**d**	**94)**	**b**	**95)**	**a**	**96)**	**c**
97)	**c**	**98)**	**b**	**99)**	**c**	**100)**	**c**
101)	**c**	**102)**	**a**	**103)**	**b**	**104)**	**b**
105)	**a**	**106)**	**d**	**107)**	**a**	**108)**	**a**
109)	**c**	**110)**	**a**	**111)**	**b**	**112)**	**b**
113)	**b**	**114)**	**a**	**115)**	**a**	**116)**	**d**
117)	**b**	**118)**	**b**				

N.B.Navale

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PHYSICS

4.THERMODYNAMICS

: HINTS AND SOLUTIONS :

Single Correct Answer Type

1 **(a)**

Process 1 is isobaric (= constant) expansion.
Hence, temperature of gas will increase.
$\therefore \quad \Delta U_1 =$ positive
Process 2 is an isothermal process
$\therefore \quad \Delta U_2 = 0$
Process 3 is adiabatic expansion.
Hence, temperature of gas will fall.
$\therefore\ \Delta U_3 =$ negative
$\therefore \Delta U_1 > \Delta U_2 > \Delta U_3$

2 **(b)**

In adiabatic process $\Delta Q = 0$, in isothermal process $\Delta U = 0$ and in isochoric process $W = 0$

3 **(c)**

AB and CD are isothermal curves, therefore $T_a = T_b$ and $T_c = T_d$ but all the four temperatures are not equal.

4 **(b)**

We know that, from first law of thermodynamics,

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

Work done at constant pressure,

$(\Delta W)_p = (\Delta Q)_p - \Delta U$

As we know, $(\Delta Q)_V = \Delta U$

Also, $(\Delta Q)_p = nC_p\Delta T$

and $(\Delta Q)_V = nC_V\Delta T \Rightarrow (\Delta W)_p = n(C_p - C_V)\Delta T$

$\Rightarrow (\Delta W)_p = 1 \times (3.4 \times 10^3 - 2.4 \times 10^3) \times 10$

$(\Delta W)_p = 10^4$ cal

5 **(c)**

$\frac{C_p}{C_v} = \frac{3}{2}$

Case I: Isothermal process

$P_1V_1 = P_2V_2$

$PV = P_2 \times 9V$

$\therefore P_2 = \frac{P}{9}$

Case II: Adiabatic process

$P_2V_2^{\gamma} = P_3V_3^{\gamma}$

$\frac{P}{9}(9V)^{\gamma} = P_3(V)^{\gamma}$

$P_3 = \frac{P}{9}9^{\gamma}\frac{V^{\gamma}}{V^{\gamma}} = \frac{P}{9}9^{\frac{3}{2}}$

$= \frac{P}{9} \times 27 = 3P$

6 **(d)**

Consider n moles of a gas which undergo isochoric process, i.e. V = constant. From first law of thermodynamics,

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

Here, $\Delta W = 0 \Rightarrow \Delta Q = \Delta V$ ...(i)
As, we konw, $\Delta Q = nC_v\Delta T$
Substituting in Eq. (i), we get
$\Delta U = nC_V\Delta T$ ...(ii)
Mayer's relation can be written as
$\Rightarrow\ C_p = C_v - R$

$\Rightarrow\ C_v - C_p = R$ ...(iii)

From Eqs. (ii) and (iii), we have

$\Delta U = n(C_p - R)\Delta T$
Given, $n = 6, C_p = 8$ cal mol^{-1} K^{-1},
$R = 8.31$ J mol^{-1} K^{-1} $= 2$ cal mol^{-1} K^{-1}
Hence, $\Delta U = 6(8-2)(35-20) = 6 \times 6 \times 15 = 540$ cal

7 **(a)**

R. M. S. velocity $C \propto \sqrt{T}$

$\therefore \frac{C_2}{C_1} = \sqrt{\frac{T_2}{T_1}} = \frac{1}{3}$

$$\therefore \frac{T_2}{T_1} = \frac{1}{9}$$

For an adiabatic process

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$\therefore \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{T_1}{T_2} = 9$$

$$\therefore \left(\frac{V_2}{V_1}\right)^{\frac{3}{2}-1} = 9$$

$$\therefore \left(\frac{V_2}{V_1}\right)^{\frac{1}{2}} = 9$$

$$\therefore \frac{V_2}{V_1} = 81$$

8 **(c)**

Since, the volume of cylinder is fixed and helium is a monoatomic gas.

The internal energy $= nC_v \Delta T$

$$U = \frac{1}{2} f n R \Delta T$$

$\left(\therefore cv = \frac{1}{2} f R\right)$

$$U = \frac{1}{2} \times 3 \times 2 \times 8.31 \times 20 =$$

498 J

9 **(a)**

From first law of thermodynamics,

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

$$\Rightarrow \quad 100 = \Delta U + 50 - (4 - 10) \Rightarrow \Delta U = 400 \text{ J}$$

10 **(b)**

According to the question,

Heat spent during the conversion of sample of water at 100^0C to steam is

$$\Delta Q = 54 \text{ cal} = 54 \times 4.18 \text{ J}$$

$$= 225.72 \text{ J}$$

Normal pressure ,$p = 1.1013 \times 10^5 \text{ Nm}^{-2}$

Net work done during the conversion would be given as

$$\Delta W = p \Delta V$$

$$= p[V_{steam} - V_{water}]$$

Here, $V_{steam} = 167.1 \text{ cc} = 167.1 \times 10^{-6} \text{ m}^3$

$V_{water} = 0.1 \text{ g} = 0.1 \text{cc} = 0.1 \times 10^{-6} \text{ m}^3$

$$\therefore \quad \Delta W = 1.013 \times 10^5 [(167.1 - 0.1) \times 10^{-6}]$$

$$= 1.013 \times 167 \times 10^{-1} = 16.917 \text{ J}$$

Now, from first law of thermodynamics,

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

where, ΔU is the change in internal energy of the sample.

$$\Rightarrow \quad \Delta U = \Delta Q - \Delta W$$

Substituting the values in the above equation, we get

$$\Delta U = 225.72 - 16.917 = 208.8 \text{ J}$$

11 **(a)**

For isothermal process, $pV =$ constant.

Therefore, $p - V$ graph is a rectangular hyperbola.

Since, $T_2 > T_1$

$\Rightarrow \quad (pV)_{at\, T_2} > (pV)_{at\, T_1}$

$\Rightarrow$ Thus, the graph given in option (a) correctly represents the given situation.

12 **(d)**

Since density becomes twice, its volume will become half.

$$\therefore \frac{V_1}{V_2} = 2$$

$\therefore$ For adiabatic process we have

$$\therefore P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$\therefore \frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = (2)^{7/5} = (2)^{1.4} = 2.63$$

13 **(b)**

For isothermal expansion we have

$$P_1 V_1 = P_2 V_2$$

$$\therefore P_2 = P_1 \frac{V_1}{V_2} = P_1 \times \frac{1}{2} = \frac{P}{2}$$

$$\therefore P_1 = \frac{P}{2}$$

For adiabatic process:

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$\therefore P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = P_1 \left(\frac{1}{2}\right)^{\gamma} = \frac{P}{2^{\gamma}}$$

$$\therefore P_a = \frac{P}{2^{\gamma}}$$

$$\therefore \frac{P_i}{P_a} = \frac{2^{\gamma}}{2} = 2^{\gamma-1}$$

14 **(b)**

$$T_1 = 27°\text{C} = 27 + 273 = 300 \text{ K}$$

$$V_1 = V, V_2 = \frac{V}{8}, \gamma = \frac{5}{3}$$

For an adiabatic process $TV^{\gamma-1} = \text{constant}$

$\therefore T_1V^{\gamma-1} = T_2V_2^{\gamma-1}$

$\therefore \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (8)^{\frac{5}{3}-1} = (8)^{\frac{2}{3}} = 4$

$\therefore T_2 = 4T_1 = 4 \times 300 = 1200\ K$

16 **(d)**

For adiabatic expression, we have

$P_2V_2^{\gamma} = P_1V_1^{\gamma}$

$\therefore \frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = (8)^{\frac{4}{3}} = 16$

$\therefore P_2 = 16P_1 = 16P_0$

17 **(a)**

In isochoric process, volume remains constant and hence no work is done. Hence statements (A) is incorrect.

18 **(d)**

The internal energy of a gas contained in a movable box depends only on the molecular energies.i.e.it is the sum of the kinetic energies and potential energies of the molecules of gas. The kinetic energy of the moving box is not included in the internal energy, thus internal energy does not depend on the speed v of the box

19 **(d)**

Here , dQ = 400 cal, dW = - 105 J

= -(105/4.2) cal = - 25 cal, dU = ?

Now, dU = dQ - dW = 400 – (-25) = 425 cal

Note dW is negative because work is done on the system.

20 **(a)**

When a system undergoes a change under condition that no exchange of heat takes place between the system and surroundings, then such a process is called adiabatic.

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

Where , is ratio of specific heats, p is pressure and T is temperature.

$\therefore \left(\frac{p2}{p1)}\right)^{\gamma-1} = \left(\frac{T_2}{T_1}\right)^{\gamma}$

$\Rightarrow \left(\frac{1}{2}\right)^{0.4} = \left(\frac{T_2}{300}\right)^{1.4}$

$\therefore \left(\frac{1}{2}\right)^{\frac{2}{7}} = \left(\frac{T_2}{300}\right) \Rightarrow T_2 = 246.1\ K$

21 **(a)**

R. M. S. velocity

$C \propto \sqrt{T}$

$\therefore \frac{C_2}{C_1} = \sqrt{\frac{T_2}{T_1}}$

$\therefore \frac{1}{2} = \sqrt{\frac{T_2}{T_1}}$

$\therefore \frac{T_2}{T_1} = \frac{1}{4}$

For adiabatic process

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

$\therefore \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{T_1}{T_2} = 4$

$\left(\frac{V_2}{V_1}\right)^{1.5-1} = 4$

$\left(\frac{V_2}{V_1}\right)^{\frac{1}{2}} = 4$

$\therefore \frac{V_2}{V_1} = 16$

22 **(b)**

For adiabatic expansion, we have the formula

$pV^{\gamma} = \text{constant}$ ...(i)

Gas equation,

$pV = RT \Rightarrow p = \frac{RT}{V}$ .... (ii)

From Eqs. (i) and (ii), we obtain

$\left(\frac{RT}{V}\right)V^{\gamma} = \text{constant}$

$\Rightarrow TV^{\gamma-1} = \text{constant}$ .... (iii)

But $T \propto \frac{1}{\sqrt{V}}$ (given)

$\Rightarrow TV^{1/2} = \text{constant}$ .... (iv)

Thus, using Eqs. (iii) and (iv), we get

$\gamma - 1 = \frac{1}{2}$

Or $\gamma = \frac{3}{2} = 1.5$

$\Rightarrow \frac{C_p}{C_v} = 1.5$

23 **(b)**

R. M. S. velocity

$C \propto \sqrt{T}$

$$\therefore \frac{C_2}{C_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\therefore \frac{1}{2} = \sqrt{\frac{T_2}{T_1}}$$

$$\therefore \frac{T_2}{T_1} = \frac{1}{4}$$

For adiabatic expansion,

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$\therefore \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{T_1}{T_2} = 4$$

$$\therefore \left(\frac{V_2}{V_1}\right)^{1.5-1} = 4$$

$$\therefore \left(\frac{V_2}{V_1}\right)^{0.5} = 4$$

$$\therefore \frac{V_2}{V_1} = 16$$

24 **(d)**

$dW = dQ - dU = C_p (T_2 - T_1) - C_v (T_2 - T_1)$

$= R (T_2 - T_1)$

$= 8.31 \times 100$

$= 8.31 \times 10^{-2}$ J

25 **(b)**

For an adiabatic process $TV^{\gamma-1} = \text{constant}$

$$\gamma = \frac{7}{5}$$

$$\therefore \gamma - 1 = \frac{7}{5} - 1 = \frac{2}{5}$$

$$\therefore TV^{\frac{2}{5}} = TV^x$$

$$\therefore x = \frac{2}{5}$$

26 **(c)**

In thermodynamics, heat and work are not state variables. They are modes of energy transfer to a system resulting in change in its internal energy, which is a state variable.

27 **(c)**

According to the first law of thermodynamics,
Heat supplied (ΔQ) = Work done (W) + Change in internal energy of the system (ΔU)

$\Delta Q_A = \Delta U_A + W_A$.

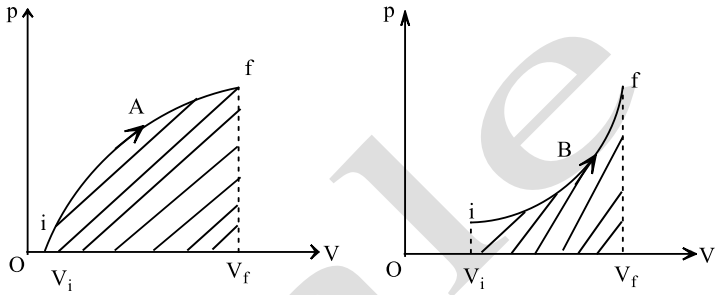
Similarly, for process B,

$\Delta Q_B = \Delta U_B + W_B$

Now, we know that,

work done for a process = area under its $p - V$ curve

Here,



Thus, it is clear from the above graphs,

$W_A > W_B$ ...(i)

Also, since the initial and final state are same in both process, so

$\Delta U_A = \Delta U_B$ ...(ii)

So, from Eqs. (i) and (ii), we can conclude that

$\Delta Q_A > \Delta Q_B$

29 **(d)**

Heat and work are two distinct modes of energy transfer to a system that results in change in its internal energy. Thus either by extracting heat or doing work

On the system or if work is done by system on surrounding, the internal energy of the system can be changed.

30 **(a)**

In an adiabatic process,

$pV^\gamma = \text{constant} = k$ (say)

where, p is pressure, V is volume and γ is ratio of the specific heats.

Given, $\frac{C_p}{C_V} = \gamma = \frac{3}{2}$

$\therefore \quad pV^{3/2} = k$

Taking logarithm of both sides, we get

$$\log p + \frac{3}{2}\log V = \log k$$

$$\therefore \frac{\Delta p}{p} + \frac{3}{2}\frac{\Delta V}{V} = 0$$

$$\Rightarrow \frac{\Delta V}{V} = -\frac{2}{3}\frac{\Delta p}{p}$$

$$\Rightarrow \frac{\Delta V}{V} \times 100 = -\frac{2}{3}\left(\frac{\Delta p}{p} \times 100\right) = -\frac{2}{3} \times \frac{2}{3} = -\frac{4}{9}\%$$

Negative sign implies that volume decreases by $\frac{4}{9}\%$.

31 **(a)**

If the graph is parallel to pressure axis, the volume is constant.

$W = P\Delta V$

Since, $\Delta V = 0, W = 0$

32 **(a)**

Amount of sweat evaporated/minute

$$= \frac{\text{Sweat produced / minute}}{\text{Number of cals required for evaporation / kg}}$$

$$= \frac{14.5 \times 10^4}{580 \times 10^3}$$

$$= \frac{145}{580} = 0.25 \text{ kg}$$

33 **(a)**

$\frac{V_2}{V_1} = \frac{1}{8}, \gamma = \frac{5}{3}$

For adiabatic process,

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$$\therefore \frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} = (8)^{5/3} = (2)^5 = 32$$

34 **(a)**

An isothermal process is a constant temperature process. In this process

$T = \text{constant or } \Delta T = 0$

$\therefore \quad \Delta U = nC_V\Delta T = 0$

An adiabatic process is defined as one with no heat transfer into or out of a system.

Therefore, $Q = 0$. From the first law of thermodynamics,

$W = -\Delta U \quad \text{or} \quad \Delta U = -W$

35 **(d)**

By first law of thermodynamics

$\Delta Q = \Delta U + W$

For an adiabatic process $\Delta Q = 0$

$\therefore \Delta U = -W$

36 **(c)**

As, it is known,

$$\frac{\text{slope of adiabatic curve}}{\text{slope of isothernmal curve}} = \frac{\gamma p/V}{p/V} = \gamma = \frac{Cp}{Cv}$$

37 **(c)**

According to the question $V = kT^{2/3}$

$$\therefore \quad dV = k\frac{2}{3}T^{-1/3}dT \quad \text{(after differentiating)}$$

$$\therefore \quad \frac{dV}{V} = \frac{\frac{2}{3}kT^{-1/3}dT}{kT^{2/3}} = \frac{2}{3}\frac{dT}{T}$$

$$\text{W ork done, } W = \int_{T_1}^{T_2} RT\frac{dV}{V} = \int_{T_1}^{T_2} RT\frac{2}{3}\frac{dT}{T}$$

$$W = \frac{2}{3}R(T_2 - T_1) = \frac{2}{3}R \times 60 = 40R$$

38 **(d)**

As indicator diagrams in all the three cases are closed curves, representing cyclic changes, therefore $U =$ constant and $\Delta U = 0$ in all the cases.

39 **(d)**

In isochoric process, the volume remains constant and hence work done $dw = P.\, dv$ in zero.

40 **(d)**

In isobaric process pressure remains constant

41 **(d)**

Given, $n = 10$ mol, $T = 500$ K,

$V_1 = 50$ L and $V_2 = 5$ L

Work done at constant temperature (i.e. isothermal process),

$$W = 2.3nRT \log_{10}\left(\frac{V_2}{V_1}\right)$$

$$= 2.3 \times 10 \times 8.31 \times 500 \times \log_{10}\left(\frac{5}{50}\right)$$

$$= -9.5565 \times 10^4 \text{ J}$$

$$\approx -9.6 \times 10^4 \text{ J}$$

42 **(d)**

For isothermal process $Q \neq 0$

43 **(b)**

Area under the curve is maximum in isobaric process.

44 **(a)**

In a cyclic process, work done is equal to area of the loop ACBDA representing the cycle of changes.

45 **(d)**

In isothermal process, temperature remains constant.

$\therefore \Delta U = 0$

In isochoric process, volume remains constant, work done is zero, hence $Q = \Delta U$

In adiabatic process, $Q = 0$ hence $\Delta U = -w$

In isobaric process $\Delta w \neq 0$, hence $\Delta U \neq 0$

46 **(b)**

As work done in a process = area under the curve. As the area under the curve is increasing with time; so, the work done is also increases continuously.

47 **(c)**

Isobaric expansion is represented by curve AB.

Work done = Area under AB

$= 2 \times 10^2 \times (3-1)$

$= 4 \times 10^2 = 400$ J

48 **(c)**

In adiabatic process, heat remains constant. So, from first law of thermodynamics,

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

$\Rightarrow \quad \Delta U + \Delta W = 0$

When work is done on system, $\Delta W = -$ ve

$\Rightarrow \quad \Delta U = -\Delta W = +$ve

As, $\Delta U = nC_V \Delta T = +$ve $\Rightarrow \Delta T = +$ve

$\Rightarrow$ T increases or $T_f > T_i$.

49 **(a)**

As, $W_{CB} = p\Delta V = nR\Delta T = -nR(2T_0 - T_0) = -nRT_0$

$W_{BA} = p\Delta V = 0 \qquad (\because \Delta V = 0)$

and $W_{AC} = nRT\ln\left(\frac{V_2}{V_1}\right) = 2nRT_0\ln\left(\frac{2V_0}{V_0}\right)$

$= +2nRT_0\ln 2$

Total work done $= W_{AC} + W_{CB} + W_{BA}$

$= 2\,nRT_0\ln 2 - nRT_0 + 0$

$= nRT_0(2\ln 2 - 1)$

Also, input heat, $\Delta Q_{BC} = nC_p\Delta T = \frac{nR\gamma T_0}{\gamma - 1}$

$\therefore$ Efficiency $= \frac{\text{W ork done}}{\text{ln put heat}} = \frac{(2\ln 2 - 1)}{\gamma/(\gamma - 1)}$

50 **(b)**

Work done during the process AB is given by area under the line AB

$W = P(v_2 - v_1)$

$= 4 \times 10^2 \times (6-2)$

$= 16 \times 10^2$ J

$= 1600$ J

51 **(c)**

For the given system,

Volume (V) = (l) (A)

Let piston moves a distance dl.

$\Rightarrow$ dV = A dl, for constant A ...(i)

Force on piston = (pressure) (area) =pA

So, work = force $\times$ distance

= (p A) (dl) = p (A dl)

dW = p dV [using E q.(i)]

$\Rightarrow \Delta W = p\,\Delta V$

52 **(c)**

In isothermal expansion, $V_2 > V_1$

As, work done in an isothermal process is given by

$\Delta W = nRT\ln\frac{V_2}{V_1}$

$\Rightarrow$ In this case, $\Delta W_1 > 0$

or $\Delta W_1 = +$ ve

Similarly, in isothermal compression, $V_1 > V_2$

$\Rightarrow \Delta W_2 < 0$

$\Rightarrow \Delta W_2 = -$ ve

53 **(d)**

For adiabatic process, $pV^\gamma = TV^{\gamma-1} =$ constant

$\Rightarrow \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$

Here, $T_2 = 2T_1$ and $V_2 = \frac{V_1}{2}$

$\left(\frac{1}{2}\right)^{\gamma-1} = \left(\frac{1}{2}\right)$

$\Rightarrow \gamma - 1 = 1$ or $\gamma = 2$

$\Rightarrow pV^\gamma = pV^2 =$ constant

54 **(b)**

For an adiabatic process $PV^\gamma =$ constant.

$\therefore P_1V_1^\gamma = P_2V^\gamma$

$\therefore \frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^\gamma = (8)^{4/3} = 16$

$\therefore P_2 = 16P_1 = 16P_0$

55 **(d)**

For an adiabatic process,

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

or $T_1L_1^{\gamma-1} = T_2L_2^{\gamma-1} \qquad (\therefore A = \text{Constant})$

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

$\because \gamma = \frac{5}{3}$ for a monoatomic gas,

$\because \gamma - 1 = \frac{2}{3}$

Thus, $\frac{T_1}{T_2} = \left(\frac{L_2}{L_1}\right)^{2/3}$

56 **(a)**

Initial and final states are same in all the process.

Hence, $\Delta U = 0$ is same for each case.

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

= Area enclosed by curve with volume axis.

$\because$ (Area)$_1$ < (Area)$_2$ < (Area)$_3$

$\Rightarrow Q_1 < Q_2 < Q_3$

57 **(b)**

For an adiabatic process at constant pressure we have

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

Given

$T \propto \frac{1}{\sqrt{V}}$

$\therefore TV^{\frac{1}{2}} = \text{constant}$

By (1) and (2)

$\gamma - 1 = \frac{1}{2}$

$\therefore \gamma = 1.5$

58 **(c)**

When the cylinder is put in contact with a body at a higher temperature than that of gas, then the temperature difference will cause a flow of energy (heat) from hotter body to gas. This increase the internal energy of the gas.

Similarly, if we push the piston down, i.e. do some work on the system, it also results in increasing the internal energy of the gas.

Thus internal energy or state of the gas can be changed by either of the ways mentioned in options (a) and (b).

59 **(b)**

We have

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

In an adiabatic process, $\Delta O = 0$

$\therefore \Delta U = -\Delta W$

60 **(d)**

According to the first law of thermodynamics

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

If $\Delta W = 0$, then $\Delta Q = \Delta U$

If $\Delta Q < Q$, then $\Delta U < 0$

If internal energy decreases, then temperature will decrease.

61 **(b)**

In a thermodynamic system, working substance is an ideal gas. Its internal energy is in the form of only kinetic energy.

62 **(c)**

Extensive state variables indicate the size of the system, whereas intensive do not.

So, if the system in equilibrium is divided into two equal parts, the variables that remain unchanged for each part are intensive. On contrary, the variables whose value get halved in each part are extensive.

So, from the given values, we can say that U (internal energy) and M (mass) are extensive state variables and T (temperature) is an intensive state variable.

63 **(b)**

Since the system is isolated from the surroundings, it is an adiabatic process. Since the gas expands into vacuum the external pressure is zero and hence work done is zero. There will be no change in internal energy and hence no change in temperature.

64 **(b)**

For adiabatic process

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

$W = -125$ kJ, $n = 1$ kmole,

$T_2 - T_1 = 6°C$

$\therefore 1 - \gamma = \frac{nR(T_2 - T_1)}{W} = \frac{1 \times 8.3 \times 6}{-125} = -0.4$

$\therefore \gamma = 1.4$

$\therefore$ Gas is rigid diatomic.

65 **(c)**

For adiabatic process $PV^{\gamma} = \text{constant}$ and $PV = nRT$

$\therefore PT^{\gamma-1} = \text{constant}$

BC is adiabatic, $T_1V_b^{\gamma-1} = T_2V_c^{\gamma-1}$ ... (i)

AD is adiabatic, $T_1V_a^{\gamma-1} = T_2V_d^{\gamma-1}$ ... (ii)

So, $\left(\frac{V_b}{V_a}\right)^{\gamma-1} = \left(\frac{V_c}{V_d}\right)^{\gamma-1}$

$\therefore \frac{V_b}{V_a} = \frac{V_c}{V_d}$

67 **(c)**

For adiabatic process, $p_2V_2^{\gamma} = p_1v_1^{\gamma}$

$\therefore$ Final pressure, $p_2 = p_1\left(\frac{V_1}{V_2}\right)^{\gamma} = p_1\left(\frac{p_2}{p_1}\right)^{\gamma}$

$$= p\left(\frac{2}{1}\right)^{7/5} = 2.63\ p$$

68 **(a)**

For an adiabatic process

$$P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma}$$

$$\frac{V_1}{V_2} = 4$$

$$= (4)^{\frac{5}{2}} = 2^5 = 32$$

$$\therefore P_2 = 32P_1 = 32P$$

69 **(b)**

In isobaric process, pressure remains constant

70 **(d)**

According to the first law of thermodynamics

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

For adiabatic process

$$\Delta Q = 0$$

$$\therefore \Delta U = -W$$

71 **(d)**

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

$$68 = \Delta U + 30$$

$$\therefore \Delta U = 68 - 30 = 38\ K$$

72 **(b)**

For adiabatic expansion we have

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

$$\therefore \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \left(\frac{L_1}{L_2}\right)^{\gamma-1} \quad [\because v \propto L]$$

$$= \left(\frac{L_1}{L_2}\right)^{\frac{5}{3}-1} = \left(\frac{L_1}{L_2}\right)^{\frac{2}{3}}$$

$$\left[\text{For monoatomic gas } \gamma = \frac{5}{3}\right]$$

73 **(a)**

$$PV = nRT$$

$$n = \frac{m}{M} = \frac{2}{32} = \frac{1}{16}$$

74 **(a)**

In isothermal process, temperature is constant.

From ideal gas equation, $pV = nRT$

At constant temperature, $pV = constant$.

So, with decreasing pressure p, V must increase to keep product pV constant. This inverse relation between p and V is depicted correctly by curve A, where p decreases with increasing V.

75 **(b)**

Here , $n = 5$, $\gamma = \frac{7}{5}$, $T_1 = 0^0C$, $T_2 = 400^0\ C$

$\therefore$ The internal energy of gas , $dU = n\frac{nRdt}{(\gamma-1)}$

$$= \frac{5 \times 8.31 \times (400-0)}{\left(\frac{7}{5}-1\right)}$$

$$= 41550\ J = 41.55\ kJ$$

76 **(b)**

Area under the curve in P-V graph is maximum for isobaric process. Hence work done in maximum is isobaric process.

77 **(c)**

Given, $dQ = +200$ cal

$= 200 \times 4.2 = 840$ J

And $dW = +40$ J

From first law of thermodynamics,

$dQ = dU + dW$

$dU = dQ - dW$

$= 840-40$

$= 800$ J

So, the internal energy of the system increases by 800 J.

78 **(b)**

In isothermal process, temperature of the gas remains constant, so the gas obeys Boyle's law. i.e.

$$p \propto \frac{1}{V} \Rightarrow \frac{p_2}{p_1} = \frac{V_1}{V_2}$$

$$\frac{2p}{p} = \frac{V_1}{V_2} \Rightarrow \frac{V_1}{V_2} = 2 \quad ...(i)$$

Now, the gas is expanded adiabatically, so

$pV^{\gamma} = constant$

$$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^{\gamma}$$

$$\Rightarrow \frac{2p}{0.75p} = \left(\frac{2}{1}\right)^{\gamma} \quad \text{(since, volume is restored)}$$

$$\Rightarrow \log\left(\frac{8}{3}\right) = \gamma \log 2$$

$$\log 8 - \log 3 = \gamma \log 2$$

$$\Rightarrow \gamma = 1.41$$

79 **(b)**

Efficiency $\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$

$= \frac{t_1 - t_2}{t_1 + 273}$

80 **(b)**

In cyclic process, ΔQ = work done = area inside the closed curve (treat the circle as an ellipse)

$= \pi \frac{(p_2 - p_1)}{2} \frac{(V_2 - V_1)}{2}$

$\Rightarrow \Delta Q = \frac{\pi}{4}\{(150 - 50) \times 10^3 \times (40 - 20) \times 10^{-6}\} = \left(\frac{\pi}{2}\right) J$

81 **(d)**

According to question,

$p \propto T^3$

As, $pV = nRT \Rightarrow T \propto pV$

$\Rightarrow p \propto (pV)^3 \Rightarrow p^2V^3 = \text{constant}$

$pV^{3/2} = \text{constant}$

$\therefore \frac{C_p}{C_v} = \gamma = \frac{3}{2}$ $(\because pV^\gamma = \text{constant})$

82 **(d)**

$T_1 = 27°C = 27 + 273 = 300\ K$

$\frac{V_2}{V_1} = \frac{8}{27}$

$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$\therefore T_2 = T_1 \left(\frac{V_2}{V_1}\right)^{\gamma-1}$

$= 300 \times \left(\frac{27}{8}\right)^{\frac{5}{3}-1}$

$= 300 \times \left(\frac{27}{8}\right)^{\frac{2}{3}}$

$= 300 \times \left(\frac{3}{2}\right)^2$

$= 675\ K$

Rise in temperature

$= 675 - 300 = 375\ K$

83 **(d)**

A thermodynamic process of uncontrolled change satisfying the equation $Q = W = 0$ (zero) is known as free expansion.

84 **(a)**

In isochoric process volume remains constant.

Hence graph A represents isochoric process.

85 **(d)**

For isochoric process, the work done is zero.

86 **(d)**

For an adiabatic process $TV^{\gamma-1} = \text{constant}$

$\therefore \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

$= \left(\frac{27}{8}\right)^{\frac{5}{3}-1} = \left(\frac{27}{8}\right)^{\frac{2}{3}} = \frac{9}{4}$

$\therefore T_2 = \frac{4}{9}.T_1$

$= \frac{4}{9} \times 300 = 675\ K$

$\therefore T_2 - T_1 = 675 - 300 = 375\ K$

87 **(a)**

For isothermal process:

$P_1V_1 = P_2V_2$

$\therefore P_2 = \frac{P_1V_1}{V_2} = \frac{P_1}{2}$

$\left(\because \frac{v_1}{v_2} = \frac{1}{2}\right)$

For adiabatic process:

$P_2V_2^\gamma = P_3V_3^\gamma$

$P_3 = P_2 \left(\frac{V_2}{V_3}\right)^\gamma$

$= P_2 \left(\frac{2V_1}{V_3}\right)^\gamma$

$= \frac{P_1}{2}\left(\frac{1}{8}\right)^{\frac{5}{3}}$

$\left[\therefore \frac{V_1}{V_3} = \frac{1}{16}\right]$

$= \frac{P_1}{2}.\frac{1}{32} = \frac{P_1}{64}$

88 **(c)**

In adiabatic process work done is equal to the change in internal energy.

$W = \frac{R}{\gamma - 1}(T_2 - T_1)$

89 **(d)**

$t_1 = 27°C = 27 + 273 = 300\ K$

$t_2 = 127°C = 127 + 273 = 400\ K$

In an isochoric process, volume remains constant.

$\therefore \frac{P_1}{P_2} = \frac{t_1}{t_2} = \frac{300}{400} = \frac{3}{4}$

90 **(b)**

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$\frac{RT_1}{v_1}V_1^{\gamma} = \frac{RT_2}{V_2}V_2^{\gamma}$

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

91 **(a)**

From symmetry considerations and also from theory,

$\frac{V_a}{V_d} = \frac{V_b}{V_c}$

92 **(a)**

In adiabatic thermodynamic process, there is no exchange of heat between the system and surroundings.

93 **(d)**

Internal energy is a state variable which depends only on the state of the system, not on how that state was achieved. Thus, in the given case, internal energy of the ideal monoatomic gas would be same in all three ways taken by it to go from A to B.

94 **(b)**

For a diatomic gas, $C_v = \frac{5}{2}R$

The change in internal energy of gas in the transition from A to B.

$\Delta U = nC_v dT$

$= \frac{5}{2}R\left(\frac{P_BV_B}{R} - \frac{P_AV_A}{R}\right) \qquad \left(\because T = \frac{pV}{R}\right)$

$= \frac{5}{2} \times (12 - 20) = -20 kJ$

95 **(a)**

In an isochoric process, the volume remains constant.

$\therefore \Delta V = 0$

96 **(c)**

Given: $V_2 = 2V_1, \gamma = \frac{3}{2}$

For adiabatic process (gas A) :

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$\therefore \frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^{\gamma} = (2)^{\frac{3}{2}} = 2\sqrt{2}$

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$\therefore P_1 = 2\sqrt{2}P_2$

For isobaric process (gas B) : In isobaric process pressure remains constant

$\therefore P_1 = P_2$ or $\frac{P_1}{P_2} = 1$

For isothermal process (gas C) : In isothermal process, temperature remains constant.

$\therefore P_1v_1 = P_2v_2$

or $\frac{P_1}{P_2} = \frac{v_2}{v_1} = 2$ or $P_1 = 2P_2$

$\therefore$ Ratio of initial pressure is $2\sqrt{2}: 1: 2$

97 **(c)**

As , B $\gamma p = -\frac{\Delta p}{\Delta V/V}$

$\therefore \frac{\Delta V}{V} = -\frac{\Delta p}{\gamma p}$

98 **(b)**

For adiabatic process

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

$\therefore \frac{P_2}{P_1} = (V_1/V_2)^{\gamma} = (4)^{3/2} = 8$

99 **(c)**

As , from the first law of thermodynamics,

$dU = dQ - dW = m\ L - p\ (dV)$

$= 1 \times 540 - \frac{1.013 \times 10^5 (1671-1)10^{-6}}{4.2}$

$= 540 - 40 = 500$ cal

101 **(c)**

Work done = Area of curve enclosed

$= (3V - V) \times (3p - p) = 2V \times 2p = 4pV$

102 **(a)**

A thermodynamic process of uncontrolled change satisfying the equation $Q = W = 0$, is free expansion.

103 **(b)**

Quantity of heat supplied to system is equal to increase in internal energy and external work. According to first law of thermodynamics, when some quantity of heat (dQ) is supplied to a system capable of doing external work, then the quantity

of heat absorbed by the system (dQ) is equal to sum of the increase in the internal energy of the system (dU) due to rise in temperature and the external work done by the system (dW) in expansion, i.e.

$dQ = dU + dW$

When a gas expands, work done by the gas dW is taken as positive and when a gas is compressed, work is done on the gas dW is taken as negative. The external work done is

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

$= 110 - 40 = 70$ J

104 **(b)**

Given, mass of water $m = 1g$

Volume of 1g of water $= 1cm^3 = 10^{-6}\ m^3$

Volume of 1 g of steam $= 1671cm^3 = 1671 \times 10^{-6}\ m^3$

Pressure, $P = 1\times 10^5$ pa

Latent heat of vaporization of water, $L = 2256$ J/g

Change in volume,

$\Delta V = (1671\text{-}1) \times 10^{m3}$

$= 1670 \times 10^{-6}\ M^3$

...(i)

Heat supplied , $\Delta Q = mL = 1 \times 2256 = 2256$ J

...(ii)

As the steam expands, so the work done in expansion is

$\Delta W = p\Delta V$

$= 1 \times 10^5 \times 1670 \times 10^{-6}$

[from Eq. (i)]

$=167$ J

...(iii)

According to first law of thermodynamics,

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

$\Rightarrow \Delta U = \Delta Q - \Delta W$

$= 2256\text{-}167$ [from Eqs. (ii) and (iii)]

$= 2089$ J

105 **(a)**

For adiabatic change, the equation of state is

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

Also, for ideal gas,

$pV = nRT$

$\Rightarrow V = \frac{nRT}{p}$

So, $p\left(\frac{nRT}{p}\right)^\gamma = \text{constant}$

$\Rightarrow \frac{p}{p^\gamma}T^\gamma = \frac{\text{constant}}{(nR)^\gamma} = \text{constant}$

$\Rightarrow p_*^{1-\gamma}T^\gamma = \text{constant}$

106 **(d)**

In an adiabatic process, $p_2^{(1-\gamma)}T_2^\gamma = p_1^{(1-\gamma)}T_1^\gamma$

Final temperature, $T_2 = T_1\left(\frac{p_1}{p_2}\right)^{(1-\gamma)/\gamma}$

$= 300\left(\frac{4}{1}\right)^{\frac{(1-7/5)}{7/5}}$

$= 300(4)^{-2/7}$

108 **(a)**

For adiabatic process,

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

$\therefore \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \left(\frac{27}{8}\right)^{\frac{5}{3}-1}$

$= \left(\frac{27}{8}\right)^{\frac{2}{3}} = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$

$\therefore T_2 = \frac{9}{4}T_1 = \frac{9}{4} \times 300 = 675$ K

$\therefore T_2 - T_1 = 675 - 300 = 375$ K

109 **(c)**

Relation between P and V is given as

$PV^{\frac{3}{2}} = \text{constant}$

$\therefore \gamma = \frac{3}{2}$

The relation between T and V is given by

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

$\therefore T_1V_1^{\gamma-1} = T_0V_0^{\gamma-1}$

$\therefore T_1V_1^{1/2} = T_0V_0^{1/2}$

$\therefore \frac{T_2}{T_1} = (V_1/V_2)^{1/2} = 2^{1/2} = \sqrt{2}$

$\therefore T_2 = \sqrt{2}T_1 = \sqrt{2}T$

110 **(a)**

In curves A and B, pressure and volume both increase. Therefore, temperature must rise and heat must be supplied to do work. So, A and B cannot be required curves. Out of C and D, slope of D smaller. Therefore, D is isothermal curve and C

is adiabatic curve.

111 **(b)**

We know,

$\Delta Q = nC_p\Delta T$

$\Delta U = nC_v\Delta T$

$W = P\Delta V = nR\Delta T$

$\Delta W : \Delta U : \Delta Q = R : C_v : C_p$

For a diatomic gas

$f = 5$

$\therefore C_v = \frac{f}{2}R = \frac{5}{2}R$

$C_p - C_v + R = \frac{7}{2}R$

$\therefore R : C_v : C_p = 1 : \frac{5}{2} : \frac{7}{2} = 2 : 5 : 7$

112 **(b)**

In isothermal process, the temperature remains constant due to exchange of heat with the surroundings, which takes some time. Hence process is not very fast.

113 **(b)**

In Process a → b

Given, $\Delta Q_{ab} = 250$ J

$\therefore \quad 250 = \Delta U_{ab} + \Delta W_{ab}$ .... (i)

In Process b → c

Given, $\Delta Q_{bc} = 60$ J

Also, V is constant, so $\Delta V = 0$

$\Rightarrow \quad \Delta W_{bc} = p(\Delta V)_{bc} = 0$

$\therefore \quad 60 = \Delta U_{bc} + 0$

$\Rightarrow \quad \Delta U_{bc} = 60$ J .... (ii)

In Process c → a

Given, $\Delta U_{ca} = -180$ J .... (iii)

Now, for complete cycle,

$\Delta U_{abca} = \Delta U_{ab} + \Delta U_{bc} + \Delta U_{ca} = 0$ .... (iv)

From Eqs. (ii), (iii) and (iv), we get

$\Delta U_{ab} = -\Delta U_{bc} - \Delta U_{ca}$

$\Delta U_{ab} = -60 + 180 = 120$ J .....(v)

From Eq. (i), we get

$250 = 120 + \Delta W_{ab}$

$\Rightarrow \Delta W_{ab} = 130$ J

Work done by the gas along the path abc,

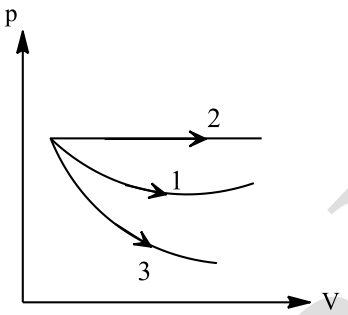
$\Delta W_{abc} = \Delta W_{ab} + \Delta W_{bc} = 130 + 0$

$\Rightarrow \Delta W_{abc} = 130$ J

114 **(a)**

As, work done = Area under the curve

Area $_2$ > Area $_1$ > Area $_3$



So, for isobaric process, work done is largest, next for isothermal and then for adiabatic process,

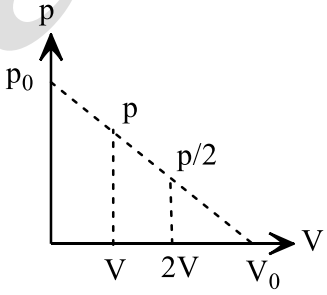
$\therefore \quad W_2 > W_1 > W_3$

115 **(a)**

Work done, $W_1 = \frac{1}{2}\left(p + \frac{p}{2}\right)V = \frac{3}{4}pV = 0.75pV$

If the system were taken along the isothermal process,

$W_2 = RT \times 2.3026\log_{10}\left(\frac{2V}{V}\right) = 0.693pV$



As $W_1 > W_2$

Thus, statement (a) is correct.

116 **(d)**

In an isothermal process there is no change of internal energy. Hence RMS velocity remains unchanged.

117 **(b)**

From $p_2V_2^{\gamma} = p_1V_1^{\gamma}$

$\Rightarrow \quad p_2 = p_1\left(\frac{V_1}{V_2}\right)^{\gamma} = 1\left(\frac{V_1}{V_1/20}\right)^{1.4}$

$= 66.28$ atm

118 **(b)**

$\alpha = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$

$\frac{1}{\alpha} = \frac{Q_1 - Q_2}{Q_2} = \frac{Q_1}{Q_2} - 1$

$\frac{Q_1}{Q_2} = \frac{1}{\alpha} + 1 = \frac{1 + \alpha}{\alpha}$

$$Q_2 = \frac{\alpha Q_1}{1+\alpha}$$