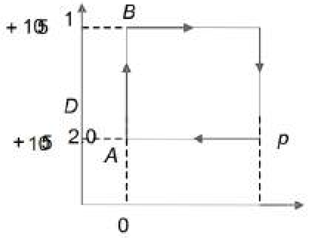
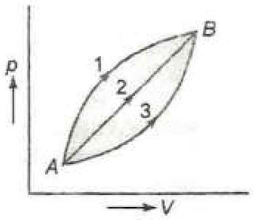
THERMODYNAMICS

---

1. A monoatomic gas is suddenly compressed to $(1/8)^{\text{th}}$ of its innitial volume adiabatically. The ratio of its final pressure to the initial pressure is (Given the ratio of the specific heats of the given gas to be 5/3)
a) 32 b) 40/3 c) 24/5 d) 8
2. The p-V diagram of a gas undergoing a cyclic process ($ABCDA$) is shown in the graph where p is in units of Nm^{-2} and V in cm^3. Identify the incorrect statement.



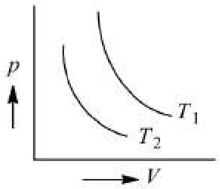
a) 0.4 J work is done by the gas from A to B
b) 0.2 J of work is done on the gas from C and D
c) No work is done by the gas from B to C
d) Work is done by the gas in going from B to C and on the gas from D to A
3. When two bodies A and B are in thermal equilibrium
a) The kinetic energies of all the molecules of A and B will be equal
b) The potential energies of all the molecules of A and B will be equal
c) The internal energies of the two bodies will be equal
d) The average kinetic energy of the molecules of the two bodies will be equal
4. The first law of thermodynamics is concerned with the conservation of
a) Momentum b) Energy c) Mass d) Temperature
5. Which of the following is a slow process
a) Isothermal b) Adiabatic c) Isobaric d) None of these
6. One mole of an ideal gas expands at a constant temperature of 300 K from an initial volume of 10 *litres* to a final volume of 20 *litres*. The work done in expanding the gas is ($R = 8.31\ J/mole\text{-}K$)
a) 750 *joules* b) 1728 *joules* c) 1500 *joules* d) 3456 *joules*
7. An ideal gas heat engine operates in a Carnot's cycle between 227°C and 127°C. It absorbs 6×10^4J at high temperature. The amount of heat converted into work is
a) 1.6×10^4J b) 1.2×10^4J c) 4.8×10^4J d) 3.5×10^4J
8. A mass of dry air at NTP. is compressed to $\frac{1}{20}$ th of its original volume suddenly. If $\gamma = 1.4$, the final pressure would be
a) 20 atm b) 66.28 atm c) 30 atm d) 150 atm
9. If we consider solar system consisting of the earth and sun only as one of the ideal thermodynamic system. The sun works as source of energy having temperature 6000 K and the earth as sink having temperature 300K, the efficiency of solar system would be on the basis of exchange of radiations
a) 30% b) 65% c) 75% d) 95%
10. In figure a certain mass of gas traces three paths 1, 2, 3 from state A to state B. If work done by the gas along three paths are W_1, W_2, W_3 respectively, then



a) $W_1 < W_2 < W_3$ b) $W_1 = W_2 = W_3$ c) $W_1 > W_2 > W_3$ d) Cannot say

11. For free expansion of the gas which of the following is true
a) $Q = W = 0$ and $\Delta E_{\text{int}} = 0$
b) $Q = 0, W > 0$ and $\Delta E_{\text{int}} = -W$
c) $W = 0, Q > 0$ and $\Delta E_{\text{int}} = Q$
d) $W > 0, Q < 0$ and $\Delta E_{\text{int}} = 0$

12. Two isothermally are shown in figure at temperature T_1 and T_2. Which of the following relations is correct?



a) $T_1 > T_2$ b) $T_1 < T_2$ c) $T_1 = T_2$ d) $T_1 = \frac{1}{2} T_2$

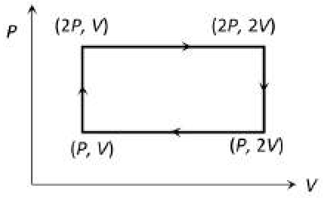
13. A thermos flask made of stainless steel contains several tiny leads shots. If the flask is quickly shaken, up and down several times, the temperature of lead shots
a) Increases by adiabatic process
b) Increases by isothermal process
c) Decreases by adiabatic process
d) Remains same

14. The temperature of the system decreases in the process of
a) Free expansion
b) Adiabatic expansion
c) Isothermal expansion
d) Isothermal compression

15. If the degree of freedom of a gas molecule be f, then the ratio of two specific heat C_p/C_v is given by
a) $\frac{2}{f} + 1$ b) $1 - \frac{2}{f}$ c) $1 + \frac{1}{f}$ d) $1 - \frac{1}{f}$

16. An ideal refrigerator has a freezer at a temperature of $-13°C$. The coefficient of performance of the engine is 5. The temperature of the air (to which heat is rejected) will be
a) 325°C b) 325°K c) 39°C d) 320°C

17. Work done in the given P-V diagram in the cyclic process is

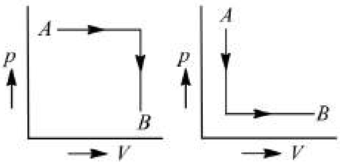


a) PV b) $2PV$ c) $PV/2$ d) $3PV$

18. In an isochoric process if $T_1 = 27°C$ and $T_2 = 127°C$, then P_1/P_2 will be equal to
a) 9/59 b) 2/3 c) 3/4 d) None of these

19. A gas mixture consists of 2 moles of oxygen and 4 moles argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is
a) 4 RT b) 15 RT c) 9 RT d) 11 RT

20. In figure two indicator diagrams are shown. If the amounts of work done in the two cases are W_1 and W_2 respectively, then



a) $W_1 = W_2$ b) $W_1 > W_2$ c) $W_1 < W_2$ d) Cannot say

21. Air is filled in a motor tube at 27°C and at a pressure of 8 atmosphere. The tube suddenly bursts, then temperature of air is [Given γ of air $= 1.5$]

a) $27.5° C$ b) $75° K$ c) $150° K$ d) $150° C$

22. For adiabatic process, wrong statement is

a) $dQ = 0$ b) $dU = -dW$

c) $Q =$ constant d) Entropy is not constant

23. Certain amount of an ideal gas is contained in a closed vessel. The vessel is moving with a constant velocity v. The rise in temperature of the gas when the vessel is suddenly stopped is (M is molecular mass, $\gamma = C_p/C_v$)

a) $\frac{M v^2(\gamma - 1)}{2R}$ b) $\frac{M v^2(\gamma + 1)}{2R}$ c) $\frac{M v^2}{2R_\gamma}$ d) $\frac{M v^2}{2R(\gamma + 1)}$

24. In isochoric process

a) $\Delta U = \Delta Q$ b) $\Delta Q = \Delta W$ c) $\Delta U = \Delta W$ d) None of these

25. Compressed air in the tube of a wheel of a cycle at normal temperature suddenly starts coming out from a puncture. The air inside

a) Starts becoming hotter

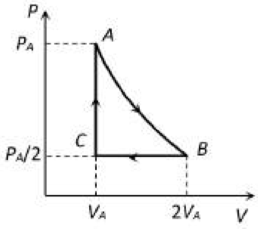
b) Remains at the same temperature

c) Starts becoming cooler

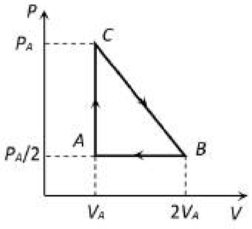
d) May become hotter or cooler depending upon the amount of water vapour present

26. Three moles of an ideal gas $\left(C_P = \frac{7}{2}R\right)$ 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 the gas is compressed at constant volume to its original pressure P_A. The correct P-V and P-T diagrams indicating the process are

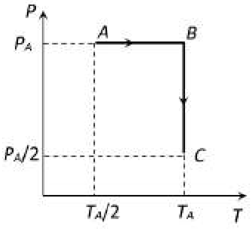
a)



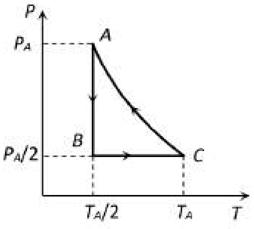
b)



c)



d)



27. 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 restrored and is pressure is then found to be 0.75 of its initial pressure. The ratio of the specific heats of the gas is approximately

a) 1.20 b) 1.41 c) 1.67 d) 1.83

28. A system is given 300 calories of heat and it does 600 *joules* of work. How much does the internal energy of the system change in this process ($J = 4.18 joules/cal$)

a) 654 *joule* b) 156.5 *joule* c) -300 *joule* d) -528.2 *joule*

29. If Q, E and W denote respectively the heat added, change in internal energy and the work done in a closed cycle process, then

a) $E = 0$ b) $Q = 0$ c) $W = 0$ d) $Q = W = 0$

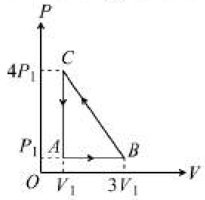
30. During the adiabatic process of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_p/C_v for the gas is

a) 4/3 b) 2 c) 5/3 d) 3/2

31. In Carnot engine efficiency is 40% at hot reservoir temperature T. For efficiency 50% what will be temperature of hot reservoir?

a) $\frac{T}{5}$ b) $\frac{2T}{5}$ c) $6T$ d) $\frac{6T}{5}$

32. An ideal gas is taken via path $ABCA$ as shown in figure. The net work done in the whole cycle is



a) $6P_1V_1$ b) Zero c) $3P_1V_1$ d) $-3P_1V_1$

33. 200 cal of heat is given to a heat engine so that it rejects 150 cal of heat, if source temperature is 400 K, then the sink temperature is

a) 300 K b) 200 K c) 100 K d) 50 K

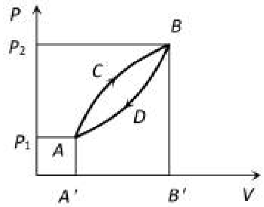
34. In an adiabatic expansion of a gas initial and final temperatures are T_1 and T_2 respectively, then the change in internal energy of the gas is

a) $\frac{R}{\gamma-1}(T_2-T_1)$ b) $\frac{R}{\gamma-1}(T_1-T_2)$ c) $R(T_1-T_2)$ d) Zero

35. An engine has an efficiency of 1/3. the amount of work this engine can perform per kilocalorie of heat input is

a) 1400 cal b) 700 cal c) 700 J d) 1400 J

36. A thermodynamic system is taken from state A to B along ACB and is brought back to A along BDA as shown in the PV diagram. The net work done during the complete cycle is given by the area



a) $P_1ACBP_2P_1$ b) $ACBB'A'A$ c) $ACBDA$ d) $ADBB'A'A$

37. Which one of the following statements is true in respect of usual quantities represented by $\Delta Q, \Delta U$ and ΔW

a) ΔU and ΔW are path dependent
b) ΔQ and ΔU are path dependent
c) ΔU does not dependent on path
d) ΔQ does not depend upon path

38. If an ideal gas is compressed isothermally then

a) No work is done against gas
b) Heat is released by the gas
c) The internal energy of gas will increase
d) Pressure does not change

39. In a mechanical refrigerator, the low temperature coils are at a temperature of −23°C and the compressed gas in the condenser has a temperature of 27°C. The theoretical coefficient of performance is

a) 5 b) 8 c) 6 d) 6.5

40. The work done in an adiabatic change in a gas depends only on

a) Change in pressure
b) Change in volume
c) Change in temperature
d) None of the above

41. An engine is supposed to operate between two reservoirs at temperature 727°C and 227°C. The maximum possible efficiency of such an engine is

a) 1/2 b) 1/4 c) 3/4 d) 1

42. The specific heat of a gas in an isothermal process is

a) Infinite b) Zero c) Negative d) Remains constant

43. If a cylinder containing a gas at high pressure explodes, the gas undergoes

a) Reversible adiabatic change and fall of temperature
b) Reversible adiabatic change and rise of temperature

c) Irreversible adiabatic change and fall of temperature
d) Irreversible adiabatic change and rise of temperature

44. Two soap bubbles of radii x and y coalesce to constitute a bubble of radius z. Then is equal to
a) $\sqrt{x^2+y^2}$ b) $\sqrt{x+y}$ c) $x+y$ d) $\dfrac{x+y}{2}$

45. For which combination of working temperatures the efficiency of Carnot's engine is highest
a) $80\ K, 60\ K$ b) $100\ K, 80\ K$ c) $60\ K, 40\ K$ d) $40\ K, 20\ K$

46. In a cyclic process, work done by the system is
a) Zero
b) Equal to heat given to the system
c) More than the heat given to system
d) Independent of heat given to the system

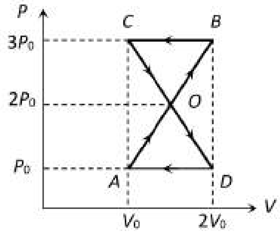
47. In a reversible isochoric change
a) $\Delta W = 0$ b) $\Delta Q = 0$ c) $\Delta T = 0$ d) $\Delta U = 0$

48. Ideal gas undergoes an adiabatic change in its state from $(p_1 V_1 T_1)$ to (p_2, V_2, T_2). The work done (W) in the process is (μ=number of molecules, C_p and C_v are molar specific heats of gas)
a) $W = \mu C_p (T_1 - T_2)$ b) $W = \mu C_v (T_1 - T_2)$ c) $W = \mu C_p (T_1 + T_2)$ d) $W = \mu C_v (T_1 + T_2)$

49. An ideal monoatomic gas at 27°C is compressed adiabatically to 8/27 times of its present volume. The increase in temperature of the gas is
a) 375°C b) 402°C c) 175°C d) 475°C

50. The change in internal energy, when a gas is cooled from 927°C to 27°C
a) 300% b) 400% c) 200% d) 100%

51. A thermodynamic system undergoes cyclic process $ABCDA$ as shown in figure. The work done by the system is

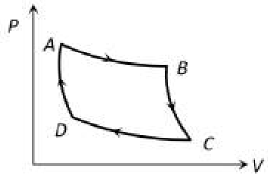


a) $P_0 V_0$ b) $2P_0 V_0$ c) $\dfrac{P_0 V_0}{2}$ d) Zero

52. A refrigerator works between temperature of melting ice and room temperature (17°C). The amount of energy in kWh that must be supplied to freeze 1 kg of water at 0°C is
a) 1.4 b) 1.8 c) 0.058 d) 2.5

53. Value of adiabatic bulk modulus of elasticity of helium at NTP is
a) $1.01 \times 10^5\ \mathrm{Nm^{-2}}$ b) $1.01 \times 10^{-5}\ \mathrm{Nm^{-2}}$ c) $1.69 \times 10^5\ \mathrm{Nm^{-2}}$ d) $1.69 \times 10^{-5}\ \mathrm{Nm^{-2}}$

54. Carnot cycle (reversible) of a gas represented by a Pressure-Volume curve is shown in the diagram
Consider the following statements
I. Area $ABCD$ = Work done on the gas
II. Area $ABCD$ = Net heat absorbed
III. Change in the internal energy in cycle = 0
Which of these are correct

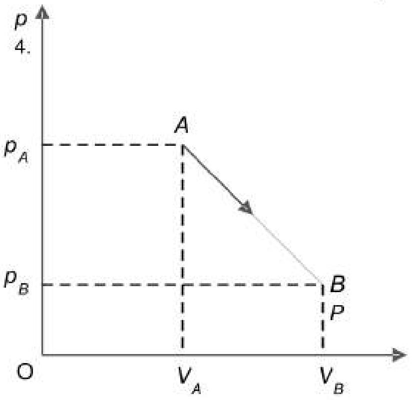


a) I only b) II only c) II and III d) I, II and III

55. In a thermodynamic process, pressure of a fixed mass of a gas is changed in such a manner that the gas molecules gives out $20\,J$ of heat and $10\,J$ of work is done on the gas. If the initial internal energy of the gas was $40\,J$, then the final internal energy will be

a) $30\,J$ b) $20\,J$ c) $60\,J$ d) $40\,J$

56. An ideal gas is taken from point A to the point B, as shown in the p-V diagram, keeping the temperature constant. The work done in the process is



a) $(p_A - p_B)(V_B - V_A)$ b) $\frac{1}{2}(p_B - p_A)(V_B + V_A)$ c) $\frac{1}{2}(p_B - p_A)(V_B - V_A)$ d) $\frac{1}{2}(p_A + p_B)(V_B - V_A)$

57. In isothermal expansion, the pressure is determined by

a) Temperature only b) Compressibility only

c) Both temperature and compressibility d) None of these

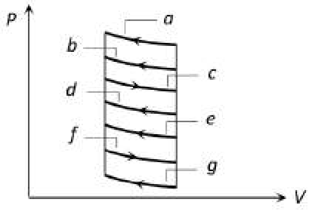
58. The specific heat of an ideal gas varies with temperature T as

a) T^1 b) T^2 c) T^{-2} d) T^0

59. A gas is compressed at a constant pressure of $50 N/m^2$ from a volume of $10m^3$ to a volume of $4m^3$. Energy of $100\,J$ then added to the 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 $200\,J$

60. The P-V diagram shows seven curved paths (connected by vertical paths) that can be followed by a gas. Which two of them should be parts of a closed cycle if the net work done by the gas is to be at its maximum value



a) ac b) cg c) af d) cd

61. Even Carnot engine cannot give 100% efficiency because we cannot

a) Prevent radiation b) Find ideal sources

c) Reach absolute zero temperature d) Eliminate friction

62. How many times a diatomic gas should be expanded adiabatically so as to reduce the root mean square velocity to half

a) 64 b) 32 c) 16 d) 8

63. A Carnot engine operating between temperature T_1 and T_2 has efficiency $\frac{1}{6}$. When T_2 is lowered by 62 K, its efficiency increase to $\frac{1}{3}$. Then T_1 and T_2 are, respectively

a) 372 K and 320 K b) 330 K and 268 K c) 310 K and 248 K d) 372 K and 310 K

64. In an adiabatic change, the pressure and temperature of a monoatomic gas are related as $p \propto T^{-c}$ where c equals

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

65. In an isothermal change of an ideal gas, $\Delta U = 0$. The change in heat energy ΔQ is equal to

a) 0.5 W b) W c) 1.5 W d) 2 W

66. If 150 J of heat is added to a system and the work done by the system is 110 J, then change in internal energy will be

a) 40 J b) 110 J c) 150 J d) 260 J

67. In adiabatic expansion

a) $\Delta U = 0$ b) $\Delta U =$ negative c) $\Delta U =$ positive d) $\Delta W =$ zero

68. The pressure and density of a given mass of a diatomic gas $\left(\gamma = \frac{7}{5}\right)$ change adiabatically from (p, d) to (p', d'). If $\frac{d'}{d} = 32$, then $\frac{p'}{p}$ is ($\gamma =$ ratio of specific heats)

a) 1/128 b) 1/64 c) 64 d) 128

69. During an adiabatic expansion of 2 moles of a gas, the change in internal energy was found $-50J$. The work done during the process is

a) Zero b) $100J$ c) $-50J$ d) $50J$

70. A Carnot engine absorbs an amount Q of heat from a reservoir at an absolute temperature T and rejects heat to a sink at a temperature T and rejects heat to a sink at a temperature of $T/3$. The amount of heat rejected is

a) $Q/4$ b) $Q/3$ c) $Q/2$ d) $2Q/3$

71. The latent heat of vaporization of water is 2240 J/g. If the work done in the process of expansion of 1 g is 168 J, then increase in internal energy is

a) 2408 J b) 2240 J c) 2072 J d) 1904 J

72. The coefficient of performance of a refrigerator work between 10°C and 20°C is

a) 28.3 b) 29.3 c) 2 d) Cannot be calculated

73. A reversible heat engine converts $\frac{1}{6}$th of heat it absorbs from source into work. When temperature of source is 600 K, temperature at which heat exhausts is

a) 500 K b) 100 K c) 0 K d) 600 K

74. Initial pressure and volume of a gas are P and V respectively. First it is expanded isothermally to volume $4V$ and then compressed adiabatically to volume V. The final pressure of gas will be (given $\gamma = 3/2$)

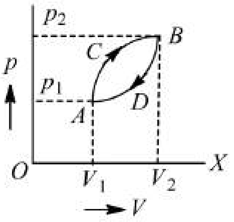
a) $1P$ b) $2P$ c) $4P$ d) $8P$

75. An adiabatic process occurs at constant

a) Temperature and pressure b) Heat

c) Temperature d) Pressure

76. A thermodynamical 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) $ACB\ p_2p_1A$ c) $A\ V_1\ V_2\ BDA$ d) $BD\ Ap_1p_2\ B$

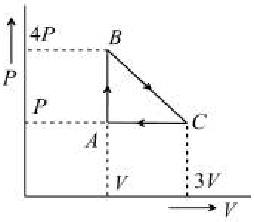
77. A refrigerator with coefficient of performance $\frac{1}{3}$ releases 200 J of heat to a hot reservoir. Then the work done on the working substance is

a) $\frac{100}{3}J$ b) $100J$ c) $\frac{200}{3}J$ d) $150J$

78. A Carnot's engine operates with source at 127°C and sink at 27°C. If the source supplies 40 kJ of heat energy, the work done by the engine is

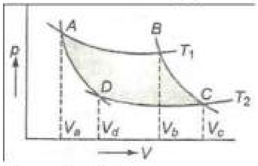
a) 30 kJ b) 10 kJ c) 4 kJ d) 1 kJ

79. An ideal gas is taken around the cycle $ABCA$ as shown in the $P - V$ diagram
The total work done by the gas during the cycles is



a) PV b) $2PV$ c) $4PV$ d) $3PV$

80. In the following $p - V$ diagram figure 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

81. An ideal gas heat engine is operating between 227°C and 127°C. It absorbs 10^4 J of heat at the higher temperature. The amount of heat converted into work is
a) 2000 J b) 4000 J c) 8000 J d) 5600 J

82. 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 ($R = 8.3 \text{ J mol}^{-1}\text{K}^{-1}$)
a) Diatomic b) Triatomic
c) A mixture of monoatomic and diatomic d) Monoatomic

83. Initially two gas samples 1 and 2 are at the same condition. The volume of the two are halved, one isothermally and the other adiabatically. What is the relation between the final pressure p_1 and p_2?
a) $p_1 = p_2$ b) $p_1 > p_2$
c) $p_2 > p_1$ d) Cannot be determined

84. When water is converted into ice, its entropy
a) Increases b) Decreases
c) Remains unchanged d) First decreases and then increases

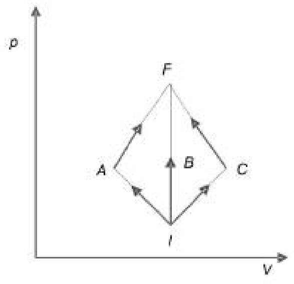
85. When heat is given to a gas in an isothermal change, the result will be
a) External work done b) Rise in temperature
c) Increase in internal energy d) External work done and also rise in temp.

86. An ideal gas expands in such a manner that its pressure and volume can be related by equation $PV^2 =$ constant. During this process, the gas is
a) Heated b) Cooled
c) Neither heated nor cooled d) First heated and then cooled

87. At N.T.P. one mole of diatomic gas is compressed adiabatically to half of its volume, $\gamma = 1.41$. The work done on gas will be
a) 1280 J b) 1610 J c) 1815 J d) 2025 J

88. A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. In the initial temperature of the gas is T_f(in kelvin) and the final temperature is T_f, the value of a is
a) 4 b) 6 c) 5 d) 9

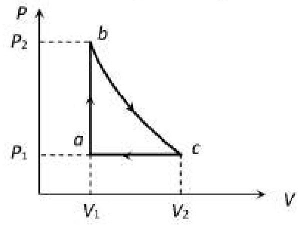
89. In the given p-V diagram, I is the initial state and F is the final state
The gas goes from I to F by
(i) IAF (ii) IBF
(iii) ICF
The heat absorbed by gas is



a) The same in all three processes
b) The same in (i) and (ii)
c) Greater in (i) than in (ii)
d) Greater in (iii) than in (ii)

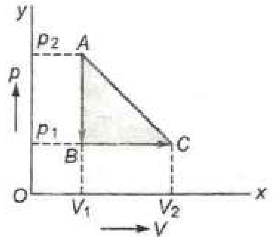
90. When you make ice cubes, the entropy of water
a) Does not change
b) Increases
c) Decreases
d) May either increase or decrease depending on the process used

91. Carbone monoxide is carried around a closed cycle *abc* in which *bc* is an isothermal process as shown in the figure. The gas absorbs $7000\,J$ of heat as its temperature increases from $300\,K$ to $1000\,K$ in going from *a* to *b*. The quantity of heat rejected by the gas during the process *ca* is



a) $4200\,J$
b) $5000\,J$
c) $9000\,J$
d) $9800\,J$

92. Work done by the system in closed path $ABCA$, is

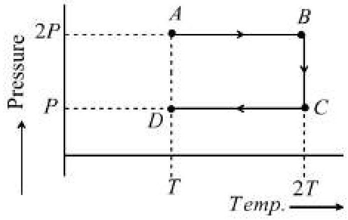


a) Zero
b) $(V_1 - V_2)(p_1 - p_2)$
c) $\dfrac{(p_2 - p_1)(V_2 - V_1)}{2}$
d) $\dfrac{(p_1 + p_1)(V_2 - V_1)}{2}$

93. During an isothermal expansion, a confined ideal gas does $-150J$ of work against its surrounding. This implies that
a) $150\,J$ of heat has been added to the gas
b) $150\,J$ of heat has been removed from the gas
c) $300\,J$ of heat has been added to the gas
d) No heat is transferred because the process is isothermal

94. Value of two principle specific heats of a gas in cal $(\text{mol K})^{-1}$ determined bt different students are given. Which is most reliable?
a) 5, 2
b) 6, 5
c) 7, 5
d) 7, 4

95. An ideal monoatomic gas is taken through the thermodynamic states $A \to B \to C \to D$ via the paths shown in the figure. If U_A, U_B, U_C and U_D represent the internal energy of the gas in states A, B, C and D respectively, then which of the following is not true



a) $U_A = U_D$ b) $U_B < U_A$ c) $U_B = U_C$ d) $U_C > U_D$

96. During an adiabatic expansion, the increase in volume is associated with which of the following possibilities w.r.t. pressure and temperature
Pressure Temperature
a) Increase Increase b) Decrease Decrease c) Increase Decrease d) Decrease Increase

97. Which of the following processes is reversible
a) Transfer of heat by radiation b) Electrical heating of a nichrome wire
c) Transfer of heat by conduction d) Isothermal compression

98. 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 one kilogram 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) $10^5 cal$ b) $10^4 cal$ c) $10^3 cal$ d) $5 \times 10^3 cal$

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

100. Find the change in the entropy in the following process 100 g of ice at 0°C melts when dropped in a bucket of water at 50°C (Assume temperature of water does not change)
a) $-4.5\ cal/K$ b) $+4.5\ cal/K$ c) $+5.4\ cal/K$ d) $-5.4\ cal/K$

101. An ideal expands isothermally from a volume V_1 to 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
a) $p_3 < p_1, W < 0$ b) $p_3 > p_1, W < 0$ c) $p_3 > p_1, W > 0$ d) $p_3 = p_1, W = 0$

102. What is the temperature of source in Carnot cycle of 10% efficiency when heat exhausts at 270 K?
a) 400 K b) 500 K c) 300 K d) 600 K

103. 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

104. The first operation involved in a Carnot cycle is
a) Isothermal expansion b) Adiabatic expansion
c) Isothermal compression d) Adiabatic compression

105. A gas undergoes a process in which its pressure p and volume V are related as Vp^n =constant. The bulk modulus for the gas in this process is
a) np b) $p^{1/n}$ c) $\frac{p}{n}$ d) p^n

106. Four engines are working between the given temperatures ranges given below. For which temperature range the efficiency is maximum
a) 100 K, 80 K b) 40 K, 20 K c) 60 K, 40 K d) 120 K, 100 K

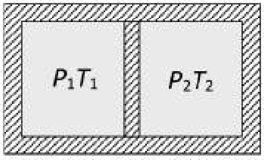
107. A certain mass of gas at 273 K is expanded to 81 times its volume under adiabatic condition. If $\gamma = 1.25$ for the gas, then its final temperature is
a) −235°C b) −182°C c) −91°C d) 0°C

108. In an adiabatic process where 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) $\frac{9}{4}$%

109. $dU + dW = 0$ is valid for
a) Adiabatic process b) Isothermal process c) Isobaric process d) Isochoric process

110. Following figure shows an adiabatic cylindrical container of volume V_0 divided by an adiabatic smooth piston (area of cross-section = A) in two equal parts. An ideal gas ($C_P/C_V = \gamma$) is at pressure P_1 and temperature T_1 in left part and gas of pressure P_2 and temperature T_2 in right part. The piston is slowly displaced and released at a position where it can stay in equilibrium. The final pressure of the two parts will be

(Suppose x = displacement of the piston)



a) P_2 b) P_1 c) $\frac{P_1\left(\frac{V_0}{2}\right)^\gamma}{\left(\frac{V_0}{2}+Ax\right)^\gamma}$ d) $\frac{P_2\left(\frac{V_0}{2}\right)^\gamma}{\left(\frac{V_0}{2}+Ax\right)^\gamma}$

111. The ratio of specific heats of a gas is γ. The change in internal energy of one mole of the gas, when the volume changes from V to $2V$ at constant pressure p is

a) $\frac{\gamma-1}{pV}$ b) pV c) $\frac{pV}{\gamma-1}$ d) $\frac{pV}{\gamma}$

112. 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

113. A Carnot engine is made to work between 200°C and 0°C first and then between 0°C to −200°C. The ratio of efficiencies of the engine in the two cases is

a) 1:2 b) 1:1 c) 1.73:1 d) 1:1.73

114. If heat given to a system is 6 $kcal$ and work done is 6 kJ. Then change in internal energy is

a) 19.1 kJ b) 12.5 kJ c) 25 kJ d) Zero

115. When an ideal gas ($\gamma = 5/3$) is heated under constant pressure, then what percentage of given heat energy will be utilised in doing external work

a) 40% b) 30% c) 60% d) 20%

116. A gaseous mixture contains equal number of hydrogen and nitrogen molecules. Specific heat measurements on this mixture at temperature below 150 K would indicate the value of $\gamma = C_p/C_v$ for the mixture as

a) 3/2 b) 4/3 c) 5/3 d) 7/5

117. Two heat engines A and B have their sources at 1000 K and 1100 K and their sinks are at 500 K and 400 K respectively. What is true about their efficiencies?

a) $\eta_A = \eta_B$ b) $\eta_A > \eta_B$ c) $\eta_A < \eta_B$ d) Cannot say

118. Pressure-temperature relationship for an ideal gas undergoing adiabatic change is ($\gamma = C_p/C_v$)

a) PT^γ = constant b) $PT^{-1+\gamma}$ = constant c) $P^{\gamma-1}T^\gamma$ = constant d) $P^{1-\gamma}T^\gamma$ = constant

119. If the amount of heat given to a system is 35 J and the amount of work done on the system is 15 J, then the change in internal energy of the system is

a) $-50J$ b) $20J$ c) $30J$ d) $50J$

120. Which of the following can not determine the state of a thermodynamic system

a) Pressure and volume b) Volume and temperature

c) Temperature and pressure d) Any one of pressure, volume or temperature

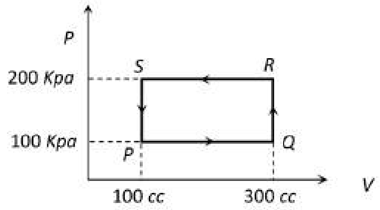
121. A Carnot engine has same efficiency between (i) 100 K and 500 K, (ii) T K and 900 K. The value of T is

a) 180 K b) 90 K c) 270 K d) 360 K

122. An ideal heat engine working between temperature T_1 and T_2 has an efficiency η, the new efficiency if both the source and sink temperature are doubled, will be

a) $\frac{\eta}{2}$ b) η c) 2η d) 3η

123. A thermodynamic system is taken through the cycle $PQRSP$ process. The net work done by the system is



a) $20\ J$ b) $-20\ J$ c) $400\ J$ d) $-374\ J$

124. In which of the processes, does the internal energy of the system remain constant?

a) Adiabatic b) Isochoric c) Isobaric d) Isothermal

125. A system performs work ΔW when an amount of heat is ΔQ added to the system, the corresponding change in the internal energy is ΔU. A unique function of the initial and final states (irrespective of the mode of change) is

a) ΔQ b) ΔW c) ΔU and ΔQ d) ΔU

126. An ideal gas at 27°C is compressed adiabatically to $\frac{8}{27}$ of its original volume. If $\gamma = \frac{5}{3}$, then the rise in temperature is

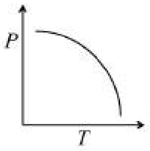
a) $450\ K$ b) $375\ K$ c) $225\ K$ d) $405\ K$

127. If 70 cal of heat is required to raise the temperature of 2 moles of an ideal gas at constant pressure from 30°C to 35°C, then the amount of heat required to raise the temperature of same gas through same range at constant volume is

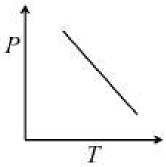
a) 50 cal b) 70 cal c) 60 cal d) 65 cal

128. Graph of isometric process is

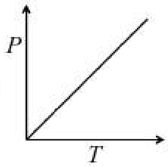
a)



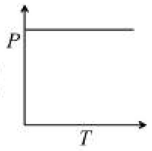
b)



c)



d)



129. A cylinder fitted with a piston contains 0.2 *moles* of air at temperature 27°C. The piston is pushed so slowly that the air within the cylinder remains in thermal equilibrium with the surroundings. Find the approximate work done by the system if the final volume is twice the initial volume

a) $543\ J$ b) $345\ J$ c) $453\ J$ d) $600\ J$

130. A perfect gas goes from state A to state B by absorbing 8×10^5 J of heat and doing 6.5×10^5 J of external work. It is now transferred between the same two states in another process in which it absorbs 10^5 J of heat. In the second process,

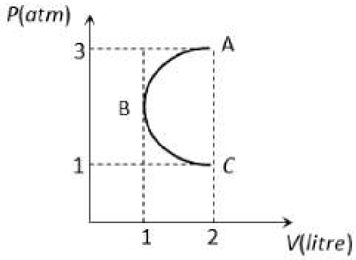
a) Work done on gas is 10^5 J b) Work done on gas is 0.5×10^5 J

c) Work done by gas is 10^5 J d) Work done by gas 0.5×10^5 J

131. Work done by 0.1 mole of a gas at 27°C to double its volume at constant pressure is ($R = 2\ cal\ mol^{-1}{}^\circ C^{-1}$)

a) $54\ cal$ b) $600\ cal$ c) $60\ cal$ d) $546\ cal$

132. In the P-V diagram shown in figure ABC is a semicircle. The work done in the process ABC is



a) Zero

b) $\frac{\pi}{2} atm - lt$

c) $-\frac{\pi}{2} atm - lt$

d) $4\ atm - lt$

133. For an ideal gas, in an isothermal process

a) Heat content remains constant
b) Heat content and temperature remain constant
c) Temperature remains constant
d) None of the above

134. A thermodynamic process in which temperature T of the system remains constant though other variable P and V may change, is called

a) Isochoric process
b) Isothermal process
c) Isobaric process
d) None of these

135. If amount of heat given to a system be 50 J and work done on the system be 15 J, then change in internal energy of the system is

a) 35 J
b) 50 J
c) 65 J
d) 15 J

136. If heat Q is added reversibly to a system at temperature T and heat Q' is taken away from it reversibly at temperature T', then which one of the following is correct

a) $\frac{Q}{T} - \frac{Q'}{T} = 0$
b) $\frac{Q}{T} - \frac{Q'}{T} > 0$
c) $\frac{Q}{T} - \frac{Q'}{T} < 0$
d) $\frac{Q}{T} - \frac{Q'}{T}$ = change in internal energy of the system

137. 500 J of heat energy is removed from 4 moles of a monoatomic ideal gas at constant volume. The temperature drops by

a) 40°C
b) 30°C
c) 10°C
d) 0°C

138. First law of thermodynamics is based on

a) Law of conservation of momentum
b) Law of conservation of energy
c) Law of conservation of charge
d) None of the above

139. A Carnot engine has an efficiency of 1/6. When temperature of sink is reduced by 62°C, its efficiency is doubled. Temperature of source and sink are,

a) 99°C, 37°C
b) 124°C, 62°C
c) 37°C, 99°C
d) 62°C, 124°C

140. Two kg of water is converted into steam by boiling at atmospheric pressure. The volume changes from $2 \times 10^{-3} m^3$ to $3.34 m^3$. The work done by the system is about

a) $-340\ kJ$
b) $-170\ kJ$
c) $170\ kJ$
d) $340\ kJ$

141. One mole of a gas enclosed in a vessel is heated at constant pressure 1 K. Work done by the gas is

a) 1 J
b) $\frac{1}{R}$ J
c) R J
d) None of these

142. Two Carnot engines A and B are operated in succession. The first one, A receives heat from a source at $T_1 = 800K$ and rejects to sink at $T_2 K$. The second engine B receives heat rejected by the first engine and rejects to another sink at $T_3 = 300K$. If the work outputs of two engines are equal, then the value of T_2 is

a) $100\ K$
b) $300\ K$
c) $550\ K$
d) $700\ K$

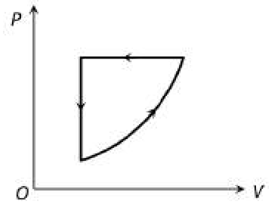
143. A monoatomic gas of n-moles is heated from temperature T_1 to T_2 under two different conditions (i) at constant volume and (ii) at constant pressure. The change in internal energy of the gas is

a) More for (i)
b) More for (ii)
c) Same in both cases
d) Independent of number of moles

144. A gas expands $0.25 m^3$ at constant pressure $10^3 N/m^2$, the work done is

a) $2.5\ ergs$
b) $250\ J$
c) $250\ W$
d) $250\ N$

145. For one complete cycle of a thermodynamic process on a gas as shown in the P-V diagram. Which of following is correct



a) $\Delta E_{\text{int}} = 0, Q < 0$ b) $\Delta E_{\text{int}} = 0, Q > 0$ c) $\Delta E_{\text{int}} > 0, Q < 0$ d) $\Delta E_{\text{int}} < 0, Q > 0$

146. A mono atomic gas is supplied the heat Q very slowly keeping the pressure constant. The work done by the gas will be

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

147. A system is provided with 200 cal of heat and the work done by the system on the surrounding is 40 J. Then its internal energy

a) Increases by 600 J b) Decreases by 800 J c) Increases by 800 J d) Decreases by 50 J

148. 5 mole of an ideal gas with ($\gamma = 7/5$) initially at STP are compressed adiabatically so that its temperature becomes 400°C. The increase in the internal energy of gas in kJ is

a) 21.55 b) 41.55 c) 65.55 d) 50.55

149. In an isothermal process the volume of an ideal gas is halved. One can say that

a) Internal energy of the system decreases b) Work done by the gas is positive

c) Work done by the gas is negative d) Internal energy of the system increases

150. The volume of an ideal gas is 1 litre and its pressure is equal to $72 cm$ of mercury column. The volume of gas is made $900\ cm^3$ by compressing it isothermally. The stress of the gas will be

a) $8\ cm$ (mercury) b) $7\ cm$ (mercury) c) $6\ cm$ (mercury) d) $4\ cm$ (mercury)

151. A scientist says that the efficiency of his heat engine which operates at source temperature 127°C and sink temperature 27°C is 26%, then

a) It is impossible b) It is possible but less probable

c) It is quite probable d) Data is incomplete

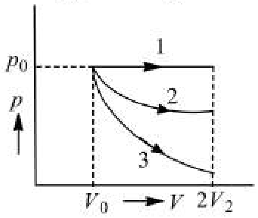
152. A gas under constant pressure of 4.5×10^5 Pa when subjected to 800 kJ of heat changes the volume from 0.5m^3 to 2.0m^3. The change in the internal energy of the gas is

a) 6.75×10^5 J b) 5.25×10^5 J c) 3.25×10^5 J d) 1.25×10^5 J

153. A gas expands with temperature according to the relation $V = kT^{2/3}$. Calculate work done when the temperature changes by 60K?

a) $10\ R$ b) $30\ R$ c) $40\ R$ d) $20\ R$

154. A gas is expanded from volume V_0 to $2V_0$ under three different processes, in figure 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 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) $\Delta U_2 < \Delta U_3 < \Delta U_1$

155. Efficiency of Carnot engine is 100% if

a) $T_2 = 273\ K$ b) $T_2 = 0\ K$ c) $T_1 = 273\ K$ d) $T_1 = 0\ K$

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

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

157. The internal energy of an ideal gas depends upon

a) Specific volume b) Pressure c) Temperature d) Density

158. For an adiabatic expansion of a perfect gas, the value of $\frac{\Delta P}{P}$ is equal to

a) $-\sqrt{\gamma}\frac{\Delta V}{V}$ b) $-\frac{\Delta V}{V}$ c) $-\gamma\frac{\Delta V}{V}$ d) $-\gamma^2\frac{\Delta V}{V}$

159. Unit mass of a liquid volume V_1 is completely charged into a gas of volume V_2 at a constant external pressure p and temperature T. If the latent heat of evaporation for the given mass is L, then the increase in the internal energy of the system is

a) Zero b) $p(V_2 - V_1)$ c) $L - p(V_2 - V_1)$ d) L

160. A Carnot engine working between 450 K and 600 K has a work output of 300 J/cycle. The amount of heat energy supplied to the engine from the source in each cycle is

a) 400 J b) 800 J c) 1600 J d) 1200 J

161. A thermodynamical system is changed from state $(p_1 V_1)$ to (p_2, V_2) by two different processes, the quantity which will remain same will be

a) ΔQ b) ΔW c) $\Delta Q + \Delta W$ d) $\Delta Q - \Delta W$

162. One mole of O_2 gas having a volume equal to 22.4 *litres* at 0°C and 1 atmospheric pressure in compressed isothermally so that its volume reduces to 11.2 *litres*. The work done in this process is

a) $1672.5\,J$ b) $1728\,J$ c) $-1728\,J$ d) $-1572.5\,J$

163. When the amount of work done is 333 *cal* and change in internal energy is 167 *cal*, then the heat supplied is

a) 166 *cal* b) 333 *cal* c) 500 *cal* d) 400 *cal*

164. 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 temperature 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

a) $\frac{T_1 T_2 (p_1 V_1 + p_2 V_2)}{p_1 V_1 T_2 + p_2 V_2 T_1}$ b) $\frac{p_1 V_1 T_1 + p_2 V_2 T_2}{p_1 V_1 + p_2 V_2}$ c) $\frac{p_1 V_1 T_2 + p_2 V_2 T_1}{p_1 V_1 + p_2 V_2}$ d) $\frac{T_1 T_2 (p_1 V_1 + p_2 V_2)}{p_1 V_1 T_1 + p_2 V_2 T_2}$

165. The temperature of reservoir of Carnot's engine operating with an efficiency of 70% is $1000K$. The temperature of its sink is

a) 300 K b) 400 K c) 500 K d) 700 K

166. In thermodynamic processes which of the following statements is not true

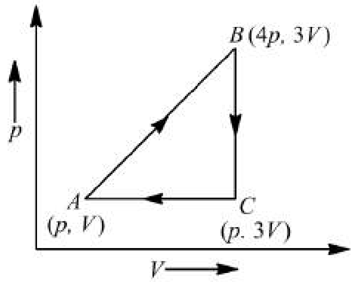
a) In an adiabatic process the system is insulated from the surroundings

b) In an isochoric process pressure remains constant

c) In an isothermal process the temperature remains constant

d) In an adiabatic process PV^γ = constant

167. A sample of ideal monoatomic gas is taken round the cycle $ABCA$ as shown in the figure. The work done during the cycle is



a) $3pV$ b) Zero c) $9pv$ d) $6pv$

168. A Carnot engine works between 600 K and 300 K. In each cycle of operation, the engine draws 1000 J of heat energy from the source. The efficiency of the engine is

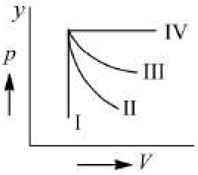
a) 50% b) 70% c) 20% d) 80%

169. Temperature is a measurement of coldness or hotness of an object. This definition is based on

a) Zeroth law of thermodynamics b) First law of thermodynamics

c) Second law of thermodynamics d) Newton's law of cooling

170. Figure shown four thermodynamical process to which a gas sample may be subjected. The isobaric and isothermal curves are

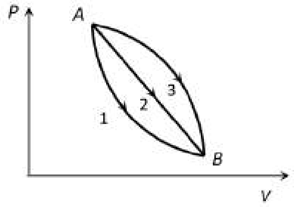


a) IV and III b) II and IV c) I and III d) II and III

171. If a Carnot's engine functions at source temperature 127°C and at sink temperature 87°C, what is its efficiency

a) 10% b) 25% c) 40% d) 50%

172. 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) $Q_1 > Q_2 > Q_3$

173. Choose the incorrect statement from the following

S1 : The efficiency of a heat engine can be 1, but the coefficient of performance of a refrigerator can never be infinity

S2 : The first law of thermodynamics is basically the principle of conservation of energy

S3 : The second law of thermodynamics does not allow several phenomena consistent with the first law

S4 : A process, whose sole result is the transfer of heat from a colder object to a hotter object is impossible

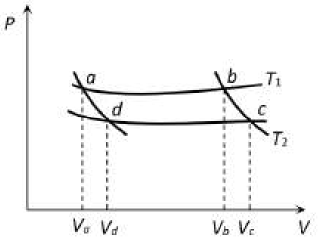
a) S1 b) S3 c) S2 d) S4

174. An engineer claims to have made an engine delivering 10 kW power with fuel consumption of 1 g/s. The calorific value of the fuel is 2 $kcal/g$. Is the claim of the engineer

a) Valid b) Invalid

c) Depends on engine design d) Depends of the load

175. In the following P-V diagram two adiabatics cut two isothermals at temperatures T_1 and T_2 (fig.). The value of $\frac{V_a}{V_d}$ will be



a) $\frac{V_b}{V_c}$ b) $\frac{V_c}{V_b}$ c) $\frac{V_d}{V_a}$ d) V_bV_c

176. A thermally insulated container is divided into two parts by a screen. In one part the pressure and temperature are P and T for an ideal gas filled. In the second part it is vacuum. If now a small hole is created in the screen, then the temperature of the gas will

a) Decrease b) Increase c) Remain same d) None of the above

177. The ratio of specific heat of a gas at constant pressure to that at constant volume is γ. The change in internal energy of one mole of gas when volume change from V to $2V$ at constant pressure p is

a) $R/(\gamma-1)$ b) pV c) $pV/(\gamma-1)$ d) $\frac{\gamma V}{\gamma-1}$

178. 1 cm^3 of water at its boiling point absorbs 540 cal of heat to become steam with a volume $= 1.013 \times 10^5 \mathrm{Nm}^{-2}$ and the mechanical equivalent of heat $= 4.19\ \mathrm{Jcal}^{-1}$, the energy spend in this process in overcoming intermolecular forces is

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

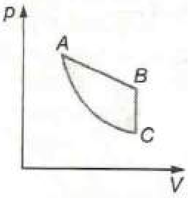
179. Three designs are proposed for an engine operating between 500 K and 300 K. For 1 kcal of heat input, design A claims to produce 3000 J of work, design B claims to produce 2000 J of work and design C claims to produce 1680 J of work. The design which is possible

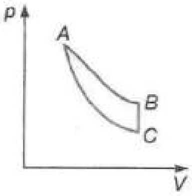
a) A only b) B only c) C only d) All of these

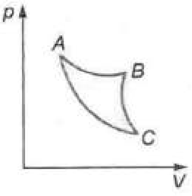
180. Heat is supplied to a diatomic gas at constant pressure. The ratio of $\Delta Q : \Delta U : \Delta W$ is

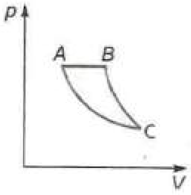
a) 5 : 3 : 2 b) 5 : 2 : 3 c) 7 : 5 : 2 d) 7 : 2 : 5

181. If AB is an isothermal, BC is an isochoric and AC is an adiabatic, which of the graph correctly represents then in figure

a) 

b) 

c) 

d) 

182. Which is incorrect

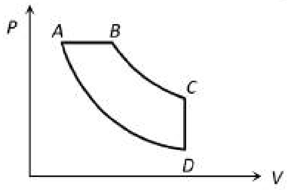
a) In an isobaric process, $\Delta P = 0$ b) In an isochoric process, $\Delta W = 0$

c) In an isothermal process, $\Delta T = 0$ d) In an isothermal process, $\Delta Q = 0$

183. The coefficient of performance of a Carnot refrigerator working between 30°C and 0°C is

a) 10 b) 1 c) 9 d) 0

184. In pressure-volume diagram given below, the isochoric, isothermal, and isobaric parts respectively, are



a) BA, AD, DC b) DC, CB, BA c) AB, BC, CD d) CD, DA, AB

185. In which process the PV indicator diagram is a straight line parallel to volume axis

a) Isothermal b) Isobaric c) Irreversible d) Adiabatic

186. The specific heat capacity of a metal at low temperature (T) is given as $C_p(\mathrm{kJK^{-1}kg^{-1}}) = 32\left(\frac{T}{400}\right)^3$. A 100 g 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

a) Equal to 0.002 KJ b) Greater than 0.148 kJ

c) Between 0.148 kJ and 0.028 kJ d) Less than 0.028 kJ

187. An ideal gas has volume V_0 at 27°C. It is heated at constant pressure so that its volume becomes $2V_0$. The final temperature is

a) 54°C b) 32.6°C c) 327°C d) 150 K

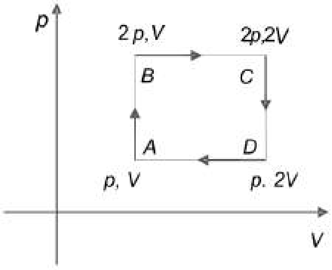
188. When an ideal monoatomic gas is heated at constant pressure, fraction of heat energy supplied which increases the internal energy of gas is

a) 2/5 b) 3/5 c) 3/7 d) 3/4

189. A diatomic gas initially at 18°C is compressed adiabatically to one-eighth of its original volume. The temperature after compression will be

a) 10°C b) 887°C c) 668 K d) 144°C

190. An ideal monoatomic gas is taken around the cycle $ABCD$ as shown in the p-V diagram. The work done during the cycle is given by



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

191. When heat in given to a gas in an isobaric process, then
a) The work is done by the gas
b) Internal energy of the gas increases
c) Both (a) and (b)
d) None from (a) and (b)

192. Work done per mol in an isothermal change is
a) $RT\log_{10}\frac{V_2}{V_1}$ b) $RT\log_{10}\frac{V_1}{V_2}$ c) $RT\log_e\frac{V_2}{V_1}$ d) $RT\log_e\frac{V_1}{V_2}$

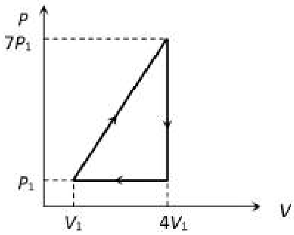
193. Two samples A and B of a gas initially at the same pressure and temperature are compressed from volume V to $V/2$ (A isothermally and adiabatically). The final pressure of A is
a) Greater than the final pressure of B
b) Equal to the final pressure of B
c) Less than the final pressure of B
d) Twice the final pressure of B

194. An ideal gas at a pressure 1 atm and temperature of 27°C is compressed adiabatically until its pressure becomes 8 times the initial pressures. Then the final temperature is $\left(\gamma = \frac{3}{2}\right)$
a) 627°C b) 527°C c) 427°C d) 327°C

195. A Carnot cycle has the reversible processes in the following order
a) Isothermal expansion, adiabatic expansion, isothermal compression and adiabatic compression
b) Isothermal compression, adiabatic expansion, isothermal expansion and adiabatic compression
c) Isothermal expansion, adiabatic compression, isothermal compression and adiabatic expansion
d) Adiabatic expansion, isothermal expansion, adiabatic compression and isothermal compression

196. A diatomic ideal gas is used in a car engine as the working substance. If during the adiabatic expansion part of the cycle, volume of the gas increases from V to $32\ V$. The efficiency of the engine is
a) 0.5 b) 0.75 c) 0.99 d) 0.25

197. In the cyclic process shown in the figure, the work done by the gas in one cycle is



a) $28\ P_1V_1$ b) $14\ P_1V_1$ c) $18\ P_1V_1$ d) $9\ P_1V_1$

198. The pressure inside a tyre is 4 atm at 27°C. If the tyre burts suddenly, new temperature will be $(\gamma = 7/5)$
a) $300\ (4)^{7/2}$ b) $300(4)^{2/7}$ c) $300\ (2)^{7/2}$ d) $300\ (4)^{-2/7}$

199. When an ideal gas in a cylinder was compressed isothermally by a piston, the work done on the gas was found to be 1.5×10^4 *joules*. During this process about
a) 3.6×10^3 *cal* of heat flowed out from the gas
b) 3.6×10^3 *cal* of heat flowed into the gas
c) 1.5×10^4 *cal* of heat flowed into the gas
d) 1.5×10^4 *cal* of heat flowed out from the gas

200. The temperature of a hypothetical gas increases to $\sqrt{2}$ times when compressed adiabatically to half the volume. Its equation can be written as
a) $PV^{3/2} = \text{constant}$ b) $PV^{5/2} = \text{constant}$ c) $PV^{7/3} = \text{constant}$ d) $PV^{4/3} = \text{constant}$

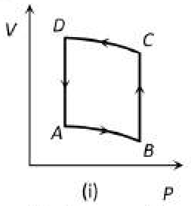
201. In an isothermal change, an ideal gas obeys

a) Boyle's law b) Charle's law c) Gaylussac law d) None of the above

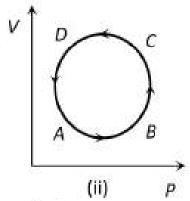
202. In a thermodynamic system working substance is ideal gas, its internal energy is in the form of
a) Kinetic energy only
b) Kinetic and potential energy
c) Potential energy
d) None of these

203. One mole of an ideal gas requires 207 J heat to raise the temperature by 1K, when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by the same range, the heat required will be (Take $R = 8.3 \text{ Jmol}^{-1}\text{ K}^{-1}$)
a) 215.3 J b) 198.7 J c) 207 J d) None of these

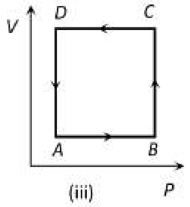
204. In the diagram (i) to (iv) of variation of volume with changing pressure is shown. A gas is taken along the path $ABCD$. The change in internal energy of the gas will be



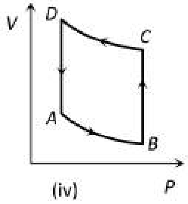
(i)



(ii)



(iii)



(iv)

a) Positive in all cases (i) to (iv)
b) Positive in cases (i), (ii) and (iii) but zero in (iv) case
c) Negative in cases (i), (ii) and (iii) but zero in (iv) case
d) Zero in all four cases

205. Efficiency of a Carnot engine is 50% when temperature of outlet is 500 K. In order to increase efficiency up to 60% keeping temperature of intake the same what is temperature of outlet
a) 200 K b) 400 K c) 600 K d) 800 K

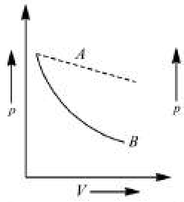
206. The efficiency of Carnot's heat engine is 0.5, when the temperature of the source is $T_1$and that of sink is T_2.The efficiency of anther Carnot's heat engine is also 0.5. The temperature of source and sink of the second engine are respectively
a) $2T_1, 2T_2$ b) $2T_1, \frac{T_2}{2}$ c) $T_1 + 5, T_2 - 5$ d) $T_1 + 10, T_2 - 10$

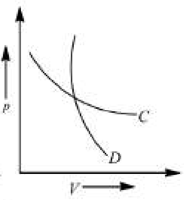
207. A litre of dry air at STP allowed to expand to a volume of 3 L under adiabatic conditions. If $\gamma = 1.40$, the work done is ($3^{1.4} = 4.6555$)
a) 48 J b) 60.7 J c) 90.5 J d) 100.8 J

208. We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W the work done by the system, which 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

209. By opening the door of a refrigerator inside a closed room, the room temperature
a) Remains constant b) Decreases c) Increases d) None of these

210. In the following figure, four curves A, B, $C$and $D$are shown. The curves are





a) Isothermal for $A$and Dwhile adiabatic for $B$and C

b) Adiabatic for A and C while isothermal for B and D
c) Isothermal for A and B while adiabatic for C and D
d) Isothermal for A and C while adiabatic for B and D

211. During adiabatic expansion of 10 moles of a gas, the internal energy decreases by 50 J. Work done during the process is
a) +50 J b) −50 J c) Zero d) Cannot say

212. For which of the following processes is the entropy change zero
a) Isobaric b) Isothermal c) Adiabatic d) None of the above

213. For adiabatic processes $\left(\gamma = \frac{C_p}{C_v}\right)$
a) $P^\gamma V =$ constant b) $T^\gamma V =$ constant c) $TV^{\gamma-1} =$ constant d) $TV^\gamma =$ constant

214. The change in the entropy of a 1 mole of an ideal gas which went through an isothermal process from an initial state (p_1, V_1, T) to the final state (p_2, V_2, T) is equal to
a) Zero b) R In T c) $R \text{ In} \frac{V_1}{V_2}$ d) $R \text{ In} \frac{V_2}{V_1}$

215. In an adiabatic change, the pressure and temperature of monoatomic gas are related with relation $p \propto T^c$, where C is equal to
a) $\frac{5}{4}$ b) $\frac{5}{3}$ c) $\frac{5}{2}$ d) $\frac{3}{5}$

216. The radio of the slopes of $p - V$ graphs of adiabatic and isothermal is
a) $\frac{\gamma - 1}{\gamma}$ b) $\gamma - 1$ c) $\gamma/1$ d) γ

217. If 300 ml of a gas at 27°C is cooled to 7°C at constant pressure, then its final volume will be
a) 540 ml b) 350 ml c) 280 ml d) 135 ml

218. A Carnot engine whose sink is at 300 K has an efficiency of 40%. By how much should the temperature of source be increased so as to increase its efficiency by 50% of original efficiency?
a) 280 K b) 275 K c) 325 K d) 250 K

219. An ideal heat engine exhausting heat at 27°C is to have 25% efficiency. It must take heat at
a) 127°C b) 227°C c) 327°C d) None of these

220. A gas expands under constant pressure P from volume V_1 to V_2. The work done by the gas is
a) $P(V_2 - V_1)$ b) $P(V_1 - V_2)$ c) $P(V_1^\gamma - V_2^\gamma)$ d) $P\frac{V_1V_2}{V_2 - V_1}$

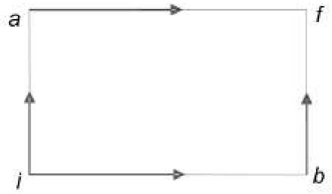
221. For an engine operating between t_1°C and t_2°C, the efficiency will be
a) $\frac{t_1}{t_2}$ b) $1 - \frac{t_2}{t_1}$ c) $\frac{t_1 - t_2}{t_2}$ d) $\frac{t_1 - t_2}{t_1 + 273}$

222. 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 brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by
a) $\frac{(\gamma - 1)}{2(\gamma + 1)R}Mv^2$ b) $\frac{(\gamma - 1)}{2\gamma R}Mv^2$ c) $\frac{\gamma Mv^2}{2R}$ d) $\frac{(\gamma - 1)}{2R}Mv^2$

223. If γ denotes the ratio of two specific heats of a gas, the ratio of slopes of adiabatic and isothermal PV curves at their point of intersection is
a) $1/\gamma$ b) γ c) $\gamma - 1$ d) $\gamma + 1$

224. In the adiabatic compression, the decrease in volume is associated with
a) Increase in temperature and decrease in pressure
b) Decrease in temperature and increase in pressure
c) Decrease in temperature and decrease in pressure
d) Increase in temperature and increase in pressure

225. 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



a) 6 cal b) 16 cal c) 66 cal d) 14 cal

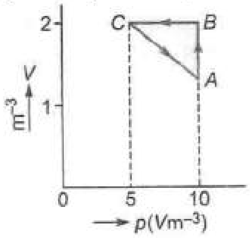
226. For an isothermal expansion of a perfect gas, the value of $\frac{\Delta P}{P}$ is equal

a) $-\gamma^{1/2}\frac{\Delta V}{V}$ b) $-\frac{\Delta V}{V}$ c) $-\gamma\frac{\Delta V}{V}$ d) $-\gamma^2\frac{\Delta V}{V}$

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

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

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



a) -5 J b) -10 J c) -15 J d) -20 J

229. The efficiency of a Carnot engine working between 800 K and 500 K is

a) 0.4 b) 0.625 c) 0.375 d) 0.5

230. When a small amount of heat ΔQ is added to an enclosed gas, then increase in internal energy and external work done are related as

a) $mC_v\Delta T = Q + p\Delta V$ b) $\Delta Q = mC_v\Delta T + p\Delta V$ c) $mC_v = \Delta Q + p\Delta V$ d) $\Delta Q = mC_p\Delta T + p\Delta V$

231. $C_v and\ C_p$ denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then

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) $\frac{C_p}{C_v}$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

d) $C_p . C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

232. The adiabatic elasticity of hydrogen gas ($\gamma = 1.4$) at NTP is

a) $1 \times 10^5 N/m^2$ b) $1 \times 10^{-8} N/m^2$ c) $1.4\ N/m^2$ d) $1.4 \times 10^5\ N/m^2$

233. Which statement is incorrect

a) All reversible cycles have same efficiency

b) Reversible cycle has more efficiency than an irreversible one

c) Carnot cycle is a reversible one

d) Carnot cycle has the maximum efficiency in all cycles

234. If for hydrogen $C_p - C_v = m$ and for the nitrogen $C_p - C_v = n$, where C_p, C_v refer to specific heats per unit mass respectively at constant pressure and constant volume, the relation between m and n is

a) $m = 14\ n$ b) $n = 7\ n$ c) $m = 7\ n$ d) $n = 14\ n$

235. If $\gamma = 2.5$ and volume is equal to $\frac{1}{8}$ times to the initial volume then pressure P is equal to (initial pressure $= P$)

a) $P' = P$ b) $P' = 2P$ c) $P' = P \times (2)^{15/2}$ d) $P' = 7P$

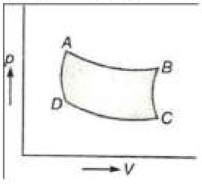
236. What is the value of sink temperature when efficiency of engine is 100%?

a) Zero b) 300 K c) 273 K d) 400 K

237. One mole of an ideal gas expands adiabatically from an initial temperature T_1 to a final temperature T_2.The work done by the gas would be

a) $(C_p - C_v)(T_1 - T_2)$ b) $C_p(T_1 - T_2)$ c) $C_v(T_1 - T_2)$ d) $(C_p - C_v)(T_1 + T_2)$

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



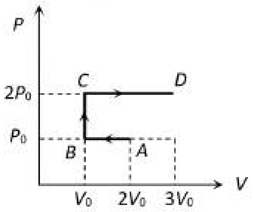
a) $T_a = T_b = T_c = T_d$ b) $T_a \neq T_b \neq T_c \neq T_d$

c) $T_a = T_b$ and $T_c = T_d$ d) None of these

239. A gas for which $\gamma = 1.5$ is suddenly compressed to the $\frac{1}{4}$th of the initial volume. Then the ratio of the final to the initial pressure is

a) 1: 6 b) 1: 8 c) 1: 4 d) 8: 1

240. P-V diagram of an ideal gas is as shown in figure. Work done by the gas in process $ABCD$ is



a) $4P_0V_0$ b) $2P_0V_0$ c) $3P_0V_0$ d) P_0V_0

241. A refrigerator absorbs 2000 cals of heat from ice trays. If the coefficient of performance is 4, then work done by the motor is

a) 2100 J b) 4200 J c) 8400 J d) 500 J

242. In the certain process, 400 cal of heat are supplied to a system and at the same time 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

243. The isothermal Bulk modulus of an ideal gas at pressure P is

a) P b) γP c) $P/2$ d) P/γ

244. A Carnot's engine works between a source at a temperature of 27°C and a sink at −123°C. Its efficiency is

a) 0.5 b) 0.25 c) 0.75 d) 0.4

245. A container of volume $1m^3$ is divided into two equal compartments by a partition. One of these compartments contains an ideal gas at 300 K. The other compartment is vacuum. The whole system is thermally isolated from its surroundings. The partition is removed and the gas expands to occupy the whole volume of the container. Its temperature now would be

a) 300 K b) 239 K c) 200 K d) 100 K

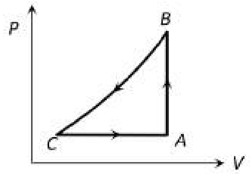
246. A container that suits the occurrence of an isothermal process should be made of

a) Copper b) Glass c) Wood d) Cloth

247. A Carnot engine whose source is at 400 K take 200 cal of heat and rejects 150 cal to the sink. What is the temperature of the sink?

a) 800 K b) 400 K c) 300 K d) Cannot say

248. A sample of an ideal gas is taken through a cycle a shown in figure. It absorbs $50J$ of energy during the process AB, no heat during BC, rejects $70J$ during CA. $40J$ of work is done on the gas during BC. Internal energy of gas at A is $1500J$, the internal energy at C would be



a) 1590 J b) 1620 J c) 1540 J d) 1570 J

249. The change in internal energy of a given mass of gas, when its volume changes from V to $2V$ at constant pressure p is $(\frac{C_p}{C_v} = \gamma$, universal gas constant=R)

a) $\frac{pV}{\gamma}$ b) $\frac{pV}{(2\gamma - 1)}$ c) $\frac{pV}{2(\gamma - 1)}$ d) $\frac{pV}{(\gamma - 1)}$

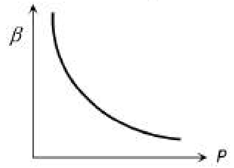
250. A perfect gas contained in a cylinder is kept in vacuum. If the cylinder suddenly bursts, then the temperature of the gas

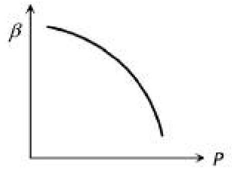
a) Remains constant b) Becomes zero c) Increases d) Decreases

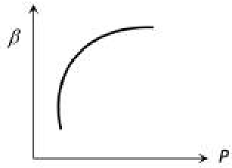
251. If $R =$ universal gas constant, the amount of heat needed to raise the temperature of 2 mole of an ideal monoatomic gas from $273K$ and $373K$ when no work is done

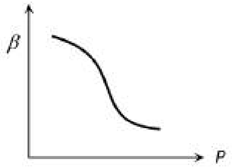
a) 100 R b) 150 R c) 300 R d) 500 R

252. Which of the following graphs correctly represents the variation of $\beta = -(dV/dP)V$ with P for an ideal gas at constant temperature

a)


b)


c)


d)


253. In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state A to B via a process in which the net heat absorbed by the system is 9.35 calories, the net work done by the system in latter case will be

a) 5.9 J b) 16.9 J c) 9.3 J d) 4.6 J

254. An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is p_1 and final pressure is p_3. Total work done is W. Then

a) $p_3 > p_1; W > 0$ b) $p_3 < p_1; W < 0$ c) $p_3 > p_1; W < 0$ d) $p_3 = p_1; W = 0$

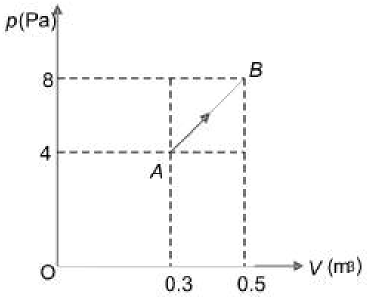
255. N moles of an ideal diatomic gas are in a cylinder at temperature T. Suppose on supplying heat to the gas, its temperature remains constant but n moles get dissociated into atoms. Heat supplied to the gas is

a) Zero b) $\frac{1}{2}nRT$ c) $\frac{3}{2}nRT$ d) $\frac{3}{2}(N - n)RT$

256. In a thermodynamic process pressure of a fixed mass of a gas is changed in such a manner that the gas releases 30 *joules* of heat and 10 joules of work was done on the gas. If the initial internal energy of the gas was 30 *joules*, then the final internal energy will be

a) 2 J b) -18 J c) 10 J d) 58 J

257. An ideal gas expands along the path AB as shown in the p-V diagram. The work done is



a) 4×10^4J b) 1.2×10^5 J c) 2.4×10^5J d) None of the above

258. A refrigerator works between temperature of melting ice and room temperature (17°C). The amount of energy in kWh that must be supplied to freeze 1 kg of water at0°C is

a) 1.4 b) 1.8 c) 0.058 d) 2.5

259. The pressure and density of a diatomic gas ($\gamma = 7/5$) change from (p, ρ) to (p^-, ρ^-) during an adiabatic change. If $\frac{\rho'}{\rho} = 32$, value of $\frac{p'}{p}$ is

a) 32 b) 1/32 c) 128 d) 1/128

260. An ideal gas is subjected to cyclic process involving four thermodynamic states, the amounts of heat (Q) and work (W) involved in each of these states

$Q_1 = 6000\,J, Q_2 = -5500J, Q_3 = -3000J, Q_4 = 3500J$

$W_1 = 2500\,J, W_2 = -1000J, W_3 = -1200J, W_4 = xJ$

The ratio of the net work done by the gas to the total heat absorbed by the gas is η. The values of x and η respectively are

a) 500; 7.5% b) 700; 10.5% c) 1000; 21% d) 1500; 15%

261. If the door of a refrigerator is kept open, then which of the following is true

a) Room is cooled b) Room is heated

c) Room is either cooled or heated d) Room is neither cooled nor heated

262. A Carnot engine whose efficiency is 40%, receives heat at 500 K. If the efficiency is to be 50%, the source temperature for the same exhaust temperature is

a) 900 K b) 600 K c) 700 K d) 800 K

263. An engine takes in compressed steam at 127°C and rejects it at 47°C. Efficiency of the engine is

a) 60% b) 35% c) 20% d) 40%

264. Two cylinders A and B fitted with pistons, contains equal number of moles of an ideal monoatomic gas at 400 K. The piston of A is free to move while that of B is held fixed. Same amount of heat energy is given to the gas in each cylinder. If the rise in temperature of the gas in A is 42 K, the rise in temperature of the gas in B is ($\gamma = 5/3$)

a) 25.2 K b) 35 K c) 42 K d) 70 K

265. In an adiabatic process $90J$ of work is done on the gas. The change in internal energy of the gas is

a) $-90\,J$ b) $+90\,J$

c) $0\,J$ d) Depends on initial temperature

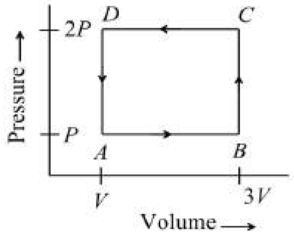
266. If the heat 110 J is added to a gaseous system and it acquires internal energy of 40 J, then the amount of internal work done is

a) 40 J b) 70 J c) 150 J d) 110 J

267. A measure of the degree of disorder of a system is known as

a) Isobaric b) Isotropy c) Enthalpy d) Entropy

268. A thermodynamic system is taken through the cycle $ABCD$ as shown in figure. Heat rejected by the gas during the cycle is



a) $2\,PV$ b) $4\,PV$ c) $\frac{1}{2}\,PV$ d) PV

269. Pressure p, volume V and temperature T of a certain material are related by $p = \alpha T^2/V$, where α is constant. Work done by the material when temperature changes from T_2 to $2T_0$ and pressure remains constant is

a) $3\alpha T_0^2$ b) $5\alpha T_0^2$ c) $\frac{3}{2}\alpha T_0^2$ d) $7\alpha T_0^2$

270. An ideal gas is allowed to expand freely against a vacuum in a rigid insulated container. The gas undergoes

a) An increase in its internal energy
b) A decrease in its internal energy
c) Neither an increase nor a decrease in its temperature or internal energy
d) A decrease in temperature

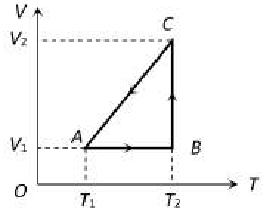
271. When gas in a vessel expands its internal energy decreases. The process involved is

a) Isothermal b) Isobaric c) Adiabatic d) Isochoric

272. Which of the following is unique function of initial and final states?

a) dQ b) dW c) dU d) ΔQ and ΔW

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

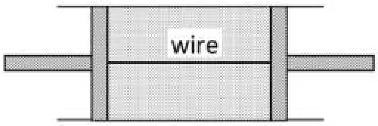


a) $0, RT_2 \ln\left(\frac{V_1}{V_2}\right), R(T_1 - T_2)$
b) $R(T_1 - T_2), 0, RT_1 \ln\frac{V_1}{V_2}$
c) $0, RT_2 \ln\left(\frac{V_2}{V_1}\right), R(T_1 - T_2)$
d) $0, RT_2 \ln\left(\frac{V_2}{V_1}\right), R(T_2 - T_1)$

274. Which relation is correct for isometric process

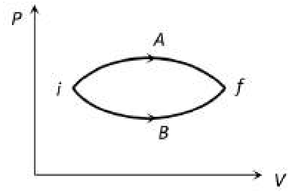
a) $\Delta Q = \Delta U$ b) $\Delta W = \Delta U$ c) $\Delta Q = \Delta W$ d) None of these

275. A cylindrical tube of uniform cross-sectional area A is fitted with two air tight frictionless pistons. The pistons are connected to each other by a metallic wire. Initially the pressure of the gas is P_0 and temperature is T_0, atmospheric pressure is also P_0. Now the temperature of the gas is increased to $2T_0$, the tension in the wire will be



a) $2P_0A$
b) P_0A
c) $\frac{P_0A}{2}$
d) $4P_0A$

276. In the figure given two processes A and B are shown by which a thermo-dynamical system goes from initial to final state F. If ΔQ_A and ΔQ_B are respectively the heats supplied to the systems then



a) $\Delta Q_A = \Delta Q_B$ b) $\Delta Q_A \geq \Delta Q_B$ c) $\Delta Q_A < \Delta Q_B$ d) $\Delta Q_A > \Delta Q_B$

277. An ideal Carnot engine whose efficiency is 40% receives heat at 500 K. If its efficiency were 50%, then in take temperature for same exhaust temperature would be

a) 700 K b) 900 K c) 800 K d) 600 K

278. Two identical samples of a gas are allowed to expand (i) isothermally (ii) adiabatically. Work done is

a) More in the isothermal process b) More in the adiabatic process
c) Neither of them d) Equal in both processes

279. The slopes of isothermal and adiabatic curves are related as

a) Isothermal curve slope = adiabatic curve slope
b) Isothermal curve slope = $\gamma \times$ adiabatic curve slope
c) Adiabatic curve slope = $\gamma \times$ isothermal curve slope
d) Adiabatic curve slope = $1/2 \times$ isothermal curve slope

280. The state of a thermodynamic system is represented by

a) Pressure only b) Volume only
c) Pressure, volume and temperature d) Number of moles

281. In the above question, if $\gamma = 1.5$, the gas may

a) Monoatomic b) Diatomic
c) A mixture of monoatomic and diatomic gases d) A mixture of diatomic and triatomic gases

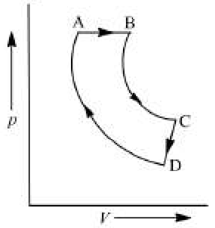
282. An ideal gas A and a real gas B have their volumes increased from V to $2\,V$ under isothermal conditions. The increase in internal energy

a) Of A will be more than B b) Of A will be less than B
c) Will be same in both cases d) Will be zero in both cases

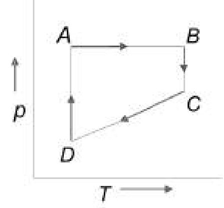
283. An ideal heat engine works between temperatures $T_1 = 500\text{K}$ and $T_2 = 375\text{K}$. If the engine absorbs 600 J of heat from the source, then the amount of heat released to the sink is

a) 450 J b) 600 J c) 45 J d) 500 J

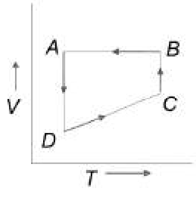
284. A cyclic process $ABCDA$ is shown below in the given p-V diagram. In the following answers the one that represents the same process as in p-V diagram



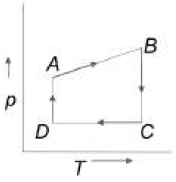
a)



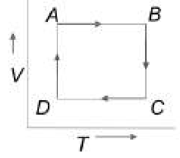
b)



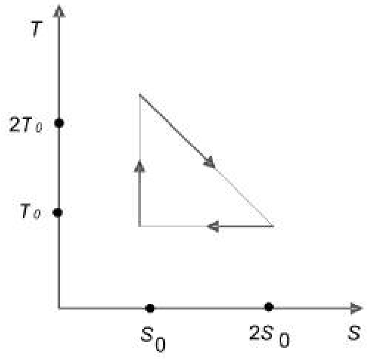
c)



d)



285. The temperature-entropy diagram of a reversible engine cycle is given in the figure. Its efficiency is



a) 1/2 b) 1/4 c) 1/3 d) 2/3

286. A vessel containing 5 *litres* of a gas at 0.8 m pressure is connected to an evacuated vessel of volume 3 *litres*. The resultant pressure inside will be (assuming whole system to be isolated)

a) 4/3 m b) 0.5 m c) 2.0 m d) 3/4 m

287. A Carnot engine whose low-temperature reservoir is at 27°C has efficiency 37.5%. The high-temperature reservoir is at

a) 480°C b) 327°C c) 307°C d) 207°C

288. During an isothermal expansion of an ideal gas

a) Its internal energy decreases
b) Its internal energy does not change
c) The work done by the gas is equal to the quantity of heat absorbed by it
d) Both (b) and (c) are correct

289. During the adiabatic expansion of 2 moles of a gas, change in internal energy was found to be equal to 100 J. Work done in the process will be equal to

a) 100 J b) 50 J c) 200 J d) 400 J

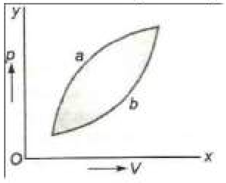
290. Heat is not being exchanged in a body. If its internal energy is increased, then

a) Its temperature will increase b) Its temperature will decrease
c) Its temperature will remain constant d) None of these

291. The temperature of the system decreases in the process of

a) Free expansion b) Adiabatic expansion
c) Isothermal expansion d) Isothermal compression

292. Figure shows two processes a and b for a given sample of a gas, if $\Delta Q_1, \Delta Q_2$ are the amounts of heat absorbed by the system in the two cases, and $\Delta U_1, \Delta U_2$ are changes in internal energies respectively, then



a) $\Delta Q_1 = \Delta Q_2,;\ \Delta U_1 = \Delta U_2$ b) $\Delta Q_1 > \Delta Q_2;\ \Delta U_1 > \Delta U_2$
c) $\Delta Q_1 < \Delta Q_2;\ \Delta U_1 < \Delta U_2$ d) $\Delta Q_1 > \Delta Q_2;\ \Delta U_1 = \Delta U_2$

293. The isothermal bulk modulus of a perfect gas at normal pressure is

a) $1.013 \times 10^5 N/m^2$ b) $1.013 \times 10^6 N/m^2$ c) $1.013 \times 10^{-11} N/m^2$ d) $1.013 \times 10^{11} N/m^2$

294. Which one of the following gases possesses the largest internal energy?

a) 2 moles of helium occupying 1 m^3 at 300 K
b) 56 g of nitrogen at 107 N m^{-2} at 300 K
c) 8 g of nitrogen at 107 Nm^{-2} at 300 K
d) 6×10^{26} molecules of argon occupying 40 m^3 at 900K

295. For the same rise in temperature of one mole of gas at constant volume, heat required for a non linear triatomic gas is K times that required for monatomic gas. The value of K is

a) 1 b) 0.5 c) 2 d) 2.5

296. When heat energy of 1500 *joules*, is supplied to a gas at constant pressure $2.1 \times 10^5 N/m^2$, there was an increase in its volume equal to $2.5 \times 10^{-3} N/m^2$. The increase in internal energy of the gas in joules is

a) 450 b) 525 c) 975 d) 2025

297. When two moles of oxygen is heated from $0°\text{C} - 10°\text{C}$ at constant volume, its internal energy changes by 420 J. What is the molar specific heat of oxygen at constant volume?

a) $5.75\ \text{JK}^{-1}\text{mol}^{-1}$ b) $10.5\ \text{JK}^{-1}\text{mol}^{-1}$ c) $21\ \text{JK}^{-1}\ \text{mol}^{-1}$ d) $42\ \text{JK}^{-1}\text{mol}^{-1}$

298. In the thermodynamical process, pressure of a fixed mass of gas is changed in such a manner that the gas releases 20 J of heat and 8 J of work is done on the gas. if internal energy of the gas was 30 J, then the final internal energy will be

a) 42 J b) 18 J c) 12 J d) 60 J

299. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of the absolute temperature. The ratio $\frac{C_p}{C_v} = \gamma$ for the gas is

a) 2 b) 3/2 c) 5/3 d) 4/3

300. In which thermodynamic process, volume remains same?

a) Isobaric b) Isothermal c) Adiabatic d) Isochoric

301. 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) $2\,p$ b) $\frac{7}{5}p$ c) $2.63\,p$ d) p

302. "Heat Carnot by itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of

a) Second law of thermodynamics b) Conservation of momentum
c) Conservation of mass d) First law of thermodynamics

303. First law of thermodynamics states that

a) System can do work b) System has temperature
c) System has pressure d) Heat is a form of energy

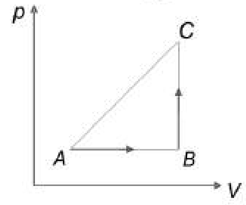
304. Ten moles of an ideal gas at constant temperature 500 K is compressed from 50 L to 5 L. Work done in the process is (Given, $R = 8.31\ \text{J} - \text{mol}^{-1} - \text{K}^{-1}$)

a) -1.2×10^4J b) -2.4×10^4 J c) -4.8×10^4 J d) -9.6×10^4J

305. The work done, W during an isothermal process in which 1 mole of the gas expands from an initial volume V_1 to a final volume V_2 is given by (R=gas constant, T=temperature)

a) $R(V_2 - V_1)\log_e\left(\frac{T_1}{T_2}\right)$ b) $R(T_2 - T_1)\log_e\left(\frac{V_2}{V_1}\right)$ c) $RT\log_e(\frac{V_2}{V_1})$ d) $2RT\log_e\left(\frac{V_1}{V_2}\right)$

306. The p-Vdiagram of a system undergoing thermodynamic transformation is shown in figure. The work done by the system in going from $A \to B \to C$ is 30 J, and 40 J heat is given to the system. The change in internal energy between A and $C$is

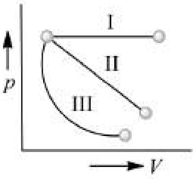


a) 10 J b) 70 J c) 84 J d) 134 J

307. The work done by a gas is maximum when it expands

a) Isothermally b) Adiabatically c) Isentropically d) isobarically

308. As shown in figure three $p - V$ diagrams. In which case, work done is minimum



a) I b) II c) III d) Cannot say

309. At constant temperature, the volume of a gas is to be decreased by 4%. The pressure must be increased by

a) 4% b) 4.16% c) 8% d) 3.86%

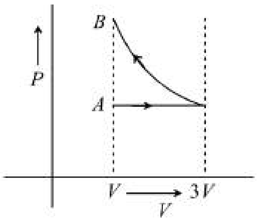
310. Which of the following is not a thermodynamical function

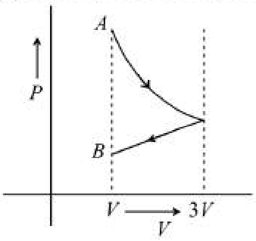
a) Enthalpy b) Work done c) Gibb's energy d) Internal energy

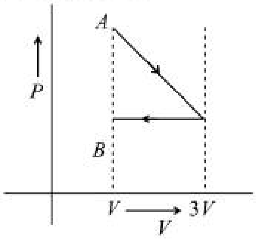
311. A gas is suddenly compressed to ¼ th of its original volume at normal temperature. The increase in its temperature is ($\gamma = 1.5$)

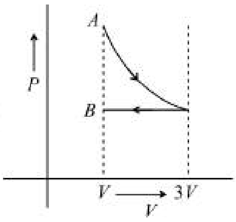
a) 273 K b) 573 K c) 373 K d) 473 K

312. One mole of an ideal gas goes from an initial state A to final state B via two processes : It first undergoes isothermal expansion from volume V to $3V$ and then its volume is reduced from $3V$ to V at constant pressure. The correct P-V diagram representing the two processes is

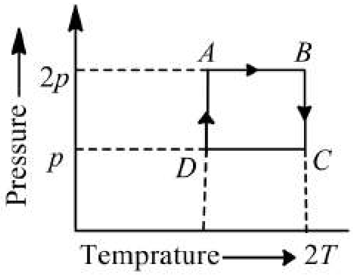
a)


b)


c)


d)


313. One mole of an ideal gas having initial volume V, pressure $2p$ and temperature T undergoes a cyclic process $ABCDA$ as shown below.



The net work done in the complete cycle is

a) Zero b) $\frac{1}{2}RT$ In 2 c) RT In 2 d) $\frac{3}{2}$ RT In 2

314. A Carnot engine used first ideal monoatomic gas and then an ideal diatomic gas, if the source and sink temperatures are 411°C and 69°C, respectively and the engine extract 1000 J of heat from the source in each cycle, then

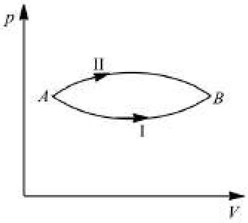
a) Area enclosed by the $p - V$ diagram is 10 J

b) Heat energy rejected by engine is 1st case is 600 J while that in 2nd case in 113 J

c) Area enclosed by the $p - V$ diagram is 500 J

d) Efficiencies of the engine in both the cases are in ratio 21:25

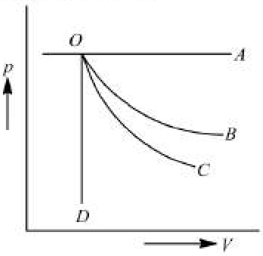
315. A system goes from A to B *via* two processes I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively, then



a) $\Delta U_1 = \Delta U_2$
b) Relation between ΔU_1 and ΔU_2 cannot be determined
c) $\Delta U_2 > \Delta U_1$
d) $\Delta U_2 < \Delta U_1$

316. A Carnot reversible engine converts 1/6 of heat input into work. When the temperature of the sink is reduced by 62 K, the efficiency of Carnot's cycle becomes 1/3. The temperature of the source and sink will be
a) 372 K, 310 K
b) 181 K, 150 K
c) 472 K, 410 K
d) None of these

317. A graph of pressure *versus* volume for an ideal gas for different processes is as shown. In the graph curve OC represents



a) Isochoric process
b) Isothermal process
c) Isobaric process
d) Adiabatic process

318. For adiabatic expansion of a perfect monoatomic gas, when volume increases by 24%, what is the percentage decrease in pressure?
a) 24%
b) 30%
c) 48%
d) 71%

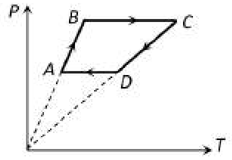
319. The process in which no heat enters or leaves the system is termed as
a) Isochoric
b) Isobaric
c) Isothermal
d) Adiabatic

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

321. In changing the state of thermodynamics from A to B state, the heat required is Q and the work done by the system is W. The change in its internal energy is
a) $Q + W$
b) $Q - W$
c) Q
d) $\frac{Q - W}{2}$

322. For a gas, the difference between the two principle specific heats is 4150 $\text{Jkg}^{-1}\text{K}^{-1}$. What is the specific heat of the gas at constant volume if the ratio of specific heat is 1.4?
a) 5186 $\text{Jkg}^{-1}\text{K}^{-1}$
b) 10375 $\text{Jkg}^{-1}\text{K}^{-1}$
c) 1660 $\text{Jkg}^{-1}\text{K}^{-1}$
d) 8475 $\text{Jkg}^{-1}\text{K}^{-1}$

323. Six moles of an ideal gas performs a cycle shown in figure. If the temperature are $T_A = 600\ K, T_B = 800\ K, T_C = 2200\ K$ and $T_D = 1200\ K$, the work done per cycle is

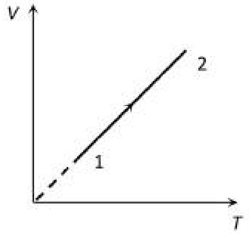


a) 20 kJ
b) 30 kJ
c) 40 kJ
d) 60 kJ

324. The volume of air increases by 5%, in its adiabatic expansion. The percentage decrease in its pressure will be
a) 5%
b) 6%
c) 7%
d) 8%

325. Which of the following parameters does not characterise the thermodynamic state of matter?
a) Temperature
b) Pressure
c) Work
d) Volume

326. Volume versus temperature graph of two moles of helium gas is as shown in figure. The ratio of heat absorbed and the work done by the gas in process 1-2 is



a) 3 b) $\frac{5}{2}$ c) $\frac{5}{3}$ d) $\frac{7}{2}$

327. A gas at pressure 6×10^5 Nm^{-2} and volume 1 m^3 and its pressure falls to 410^5 Nm^{-2}, When its volume is 3m^3. Given that the indicator diagram is a straight line, work done by the system is

a) 6×10^5 J b) 3×10^5 J c) 4×10 J d) 10×10^5 J

328. One mole of a monoatomic gas is heated at a constant pressure of 1 atm from 0 K to 100 K. If the gas constant $R = 8.32$ Jmol^{-1}K^{-1}, the change in internal energy of the gas is approximately

a) 2.3 J b) 46 J c) 8.67×10^3 J d) 1.25×10^3 J

329. Which of the following is true in the case of an adiabatic process, where $\gamma = C_p/C_v$?

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

330. For a monoatomic gas, work done at constant pressure is W. The heat supplied at constant volume for the same rise in temperature of the gas is

a) $W/2$ b) $3W/2$ c) $5W/2$ d) W

331. A container having 1 mole of a gas at a temperature 27°C has a movable piston which maintains at constant pressure in container of 1 atm. The gas is compressed until temperature becomes 127°C. The work done is

($C_p$for gas is 7.03cal/mol − K)

a) 703 J b) 814 J c) 121 J d) 2035 J

332. Which property of the system does not change in an adiabatic process?

a) Volume b) Temperature c) Density d) Total amount of heat

333. The efficiency of Carnot engine when source temperature is T_1 and sink temperature is T_2 will be

a) $\frac{T_1 - T_2}{T_1}$ b) $\frac{T_2 - T_1}{T_2}$ c) $\frac{T_1 - T_2}{T_2}$ d) $\frac{T_1}{T_2}$

334. Calculate change in internal energy of a system which has absorbed 2 kcal of heat and done 500 J of work

a) 7900 J b) 8900 J c) 6400 J d) 5400 J

335. The efficiency of a Carnot engine working between 800 K and 500 K is

a) 0.4 b) 0.625 c) 0.375 d) 0.5

336. The specific heats of an ideal gas at constant pressure and constant volume are 525 J (kg°C)$^{-1}$ and 315 J (kg° C)$^{-1}$ respectively. Its density at NTP is

a) 0.64 kgm^{-3} b) 1.20 kgm^{-3} c) 1.75 kgm^{-3} d) 2.62 kgm^{-3}

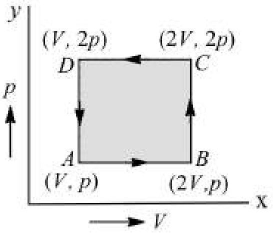
337. Two rigid boxes containing different ideal gases are placed on a table. Box A contains one mole of nitrogen at temperature T_0, while box B contains one mole of helium at temperature$(7/3)T_0$. The boxes are then put into thermal contact with each other, and heat flows between them until the gases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

a) $T_f = \frac{3}{7}T_0$ b) $T_f = \frac{7}{3}T_0$ c) $T_f = \frac{3}{2}T_0$ d) $T_f = \frac{5}{2}T_0$

338. A gas is being compressed adiabatically. The specific heat of the gas during compression is

a) Zero b) Infinite c) Finite but non-zero d) Undefined

339. An ideal monoatomic gas is taken around the cycle $ABCD$ as shown in p versus V diagram. Work done during the cycle is



a) pV　　b) $0.5\ pV$　　c) $2\ pV$　　d) $3\ pV$

340. First law of thermodynamics is given by

a) $dQ = dU + PdV$　　b) $dQ = dU \times PdV$　　c) $dQ = (dU + dV)P$　　d) $dQ = PdU + dV$

341. In a Carnot engine, when $T_2 = 0°\text{C}$ and $T_1 = 200°\text{C}$, its efficiency is η_1 and when $T_1 = 0°\text{C}$ and $T_2 = -200°\text{C}$, its efficiency is η_2, then what in η_1/η_2?

a) 0.577　　b) 0.733　　c) 0.638　　d) Cannot be calculated

342. In adiabatic expansion of a gas

a) Its pressure increases　　b) Its temperature falls

c) Its density increases　　d) Its thermal energy increases

343. 1 mm^3 of gas is compressed at 1 atm pressure and temperature 27°C to 627°C. What is the pressure under adiabatic condition? ($\gamma$for the gas $= 1.5$)

a) $27 \times 10^5\ \text{Nm}^{-2}$　　b) $12 \times 10^5\ \text{Nm}^{-2}$　　c) $15 \times 10^5\ \text{Nm}^{-2}$　　d) $23 \times 10^3\ \text{Nm}^{-2}$

344. A Carnot engine with sink's temperature at 17°C has 50% efficiency. By how much should its source temperature be changed to increase its efficiency to 60%?

a) 225K　　b) 128°C　　c) 580K　　d) 145 K

345. When a gas expands adiabatically

a) No energy is required for expansion

b) Energy is required and it comes from the wall of the container of the gas

c) Internal energy of the gas is used in doing work

d) Law of conservation of energy does not hold

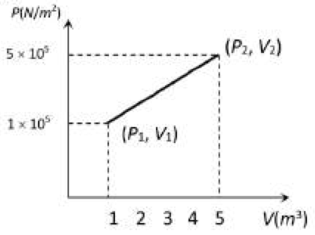
346. A gas is suddenly expanded such that its final volume becomes 3 times its initial volume. If the specific heat at constant volume of the gas is $2R$, then the ratio of initial to final pressure is nearly equal to

a) 5　　b) 6.5　　c) 7　　d) 3.5

347. 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

a) 4.2×10^6 J　　b) 8.4×10^6 J　　c) 16.8×10^6 J　　d) Zero

348. A system changes from the state (P_1, V_1) to $(P_2 V_2)$ as shown in the figure. What is the work done by the system



a) $7.5 \times 10^5\ joule$　　b) $7.5 \times 10^5\ erg$　　c) $12 \times 10^5\ joule$　　d) $6 \times 10^5\ joule$

349. A gas undergoes a change of state during which 100 J of heat is supplied to it and it does 20 J of work. The system is brought back to its original state through a process during which 20 J of heat is released by the gas. The work done by the gas in the second process is

a) 60 J　　b) 40 J　　c) 80 J　　d) 20 J

350. A gas $\left(\gamma = \frac{5}{3}\right)$, expands isobarically. The percentage of heat supplied that increases thermal energy and that is involved in doing work for expansion is

a) 140: 60　　b) 60: 40　　c) 50: 50　　d) 25: 30

351. 800 cc volume of a gas having $\gamma = \frac{5}{3}$ is suddenly compressed adiabatically to 100 cc. If the initial pressure is p, then the final pressure will be

a) $\frac{p}{32}$ b) $\left(\frac{24}{5}\right)p$ c) $8p$ d) $32P$

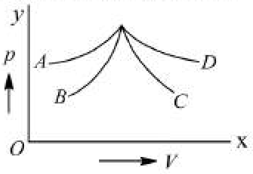
352. In an adiabatic process, the state of a gas is changed from p_1, V_1, T_1 to p_2, V_2, T_2. Which of the following relation is correct?

a) $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$ b) $p_1V_1^{\gamma-1} = p_2V_2^{\gamma-1}$ c) $T_1p_1^{\gamma} = T_2V_2^{\gamma}$ d) $T_1V_1^{\gamma} = T_2V_2^{\gamma}$

353. In a refrigerator, the low temperature coil of evaporator is at −23°C and the compressed gas in the condenser has a temperature of 77°C. How, much electrical energy is spent in freezing 1 kg of water already at 0°C?

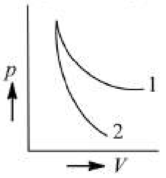
a) 134400 J b) 1344 J c) 80000 J d) 3200 J

354. Figure shows four $p - V$ diagrams. Which of these curves represent isothermal and adiabatic process?



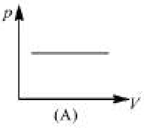
a) D and C b) A and C c) A and B d) B and D

355. $p - V$ plots for two gases during adiabatic processes are shown in figure. Plots 1 and 2 should correspond respectively to

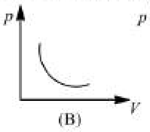


a) He and O_2 b) O_2 and He c) He and Ar d) O_2 and N_2

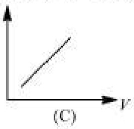
356. Which of the accompanying p-V diagrams best represents an isothermal process?



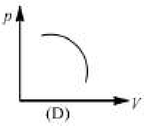
(A)



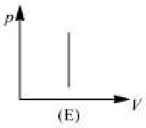
(B)



(C)



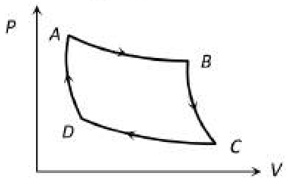
(D)



(E)

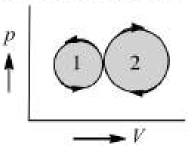
a) A b) B c) C d) D

357. The P-V graph of an ideal gas cycle is shown here as below. The adiabatic process is described by



a) AB and BC b) AB and CD c) BC and DA d) BC and CD

358. In the indicator diagram, net amount of work done will be



a) Positive b) Zero c) Infinity d) Negative

359. If a gas is heated at constant pressure, its isothermal compressibility

a) Remains constant

b) Increases linearly with temperature
c) Decreases linearly with temperature
d) Decreases inversely with temperature

360. 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, L_2 are the lengths of the gas column before and after expansion respectively, then T_1/T_2 is given by
a) $(L_1/L_2)^{2/3}$ b) (L_1/L_2) c) L_1/L_2 d) $(L_2/L_1)^{2/3}$

361. If a system undergoes contraction of volume then the work done by the system will be
a) Zero b) Negligible c) Negative d) Positive

362. The gas law $\frac{PV}{T}$ = constant is true for
a) Isothermal changes only
b) Adiabatic changes only
c) Both isothermal and adiabatic changes
d) Neither isothermal nor adiabatic changes

363. The work done in which of the following process is zero?
a) Isothermal process b) Adiabatic process c) Isochoric process d) None of these

364. A Carnot engine has the same efficiency between 800 K to 500 K and xK to 600 K. The value of x is
a) 100 K b) 960 K c) 846 K d) 754 K

365. Out of the following which quantity does not depend on path
a) Temperature b) Energy c) Work d) None of these

366. If ΔQ and ΔW represent the heat supplied to the system and the work done on the system respectively, then the first law of thermodynamics can be written as
Where ΔU is the internal energy
a) $\Delta Q = \Delta U + \Delta W$ b) $\Delta Q = \Delta U - \Delta W$ c) $\Delta Q = \Delta W - \Delta U$ d) $\Delta Q = -\Delta W - \Delta U$

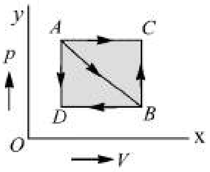
367. If the temperature of 1 mole of ideal gas is changed from 0°C to 100°C at constant pressure, then work done in the process is ($R = 8.3\ J$/Mole-Kelvin)
a) $8.3 \times 10^{-3}\ J$ b) $8.3 \times 10^{-2}\ J$ c) $8.3 \times 10^{2}\ J$ d) $8.3 \times 10^{3}\ J$

368. An ideal gas is expanded adiabatically at an initial temperature of 300 K so that its volume is doubled. The final temperature of the hydrogen gas is ($\gamma = 1.40$)
a) 227.36 K b) 500.30 K c) 454.76 K d) -47°C

369. One mole of an ideal monoatomic gas is heated at a constant pressure of 1 atm 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

370. An ideal gas is compressed isothermally until its pressure is doubled and then allowed to expand adiabatically to regain its original volume
($\gamma = 1.4$ and $2^{-1.4} = 0.38$). The ratio of the final to initial pressure is
a) 0.76:1 b) 1:1 c) 0.66:1 d) 0.86:1

371. An ideal gas is taken from state A to state B following three different paths as shown in $p - V$ diagram, figure Which one of the following is true?



a) Work done is maximum along AB
b) Work done is minimum along AB
c) Work done along ACB = work done along ADB
d) Work done along ADB is minimum

372. 540 *calories* of heat convert 1 cubic centimeter of water of 100°C into 1671 cubic centimeter of steam of 100°C at a pressure of one atmosphere. Then the work done against the atmospheric pressure is nearly
a) 540 *cal* b) 40 *cal* c) Zero *cal* d) 500 *cal*

373. Which of the following is not thermodynamic coordinate?
a) Gas constant (R) b) Pressure (p) c) Volume (V) d) Temperature (T)

374. Compressed by doing work on it A gas is compressed adiabatically till its temperature is doubled. The ratio of its final volume to initial volume will be

a) 1/2 b) More than 1/2 c) Less than 1/2 d) Between 1 and 2

375. Two moles of ideal helium gas are in a rubber balloon at 30°C. The balloon is fully expandable and can be assumed to require no energy in its expansion. The temperature of the gas in the balloon is slowly changed to 35°C. The amount of heat required in raising the temperature is nearly (take $R = 8.31\ J/mol.K$)

a) $62J$ b) $104J$ c) $124J$ d) $208J$

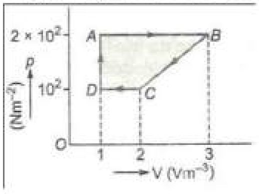
376. A Carnot engine has efficiency 1/5. Efficiency becomes 1/3 when temperature of sink is decreased by 50K. What is the temperature of sink?

a) 325 K b) 375 K c) 300 K d) 350 K

377. The sink temperature of a heat engine 77°C. The efficiency is 30%. The source temperature is

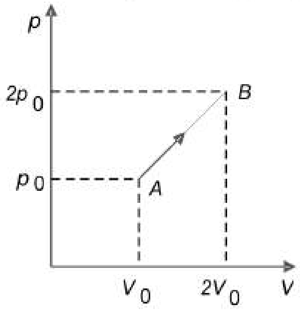
a) 500°C b) 227°C c) 317°C d) 427°C

378. 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

379. The p-Vdiagram of 2 g of helium gas for a certain process $A \rightarrow B$ is shown in the figure. What is the heat given to the gas during the process $A \rightarrow B$?



a) $4p_0V_0$ b) $6p_0V_0$ c) $4.5p_0V_0$ d) $2p_0V_0$

380. The volume of an ideal diatomic gas is doubled isothermally, the internal energy

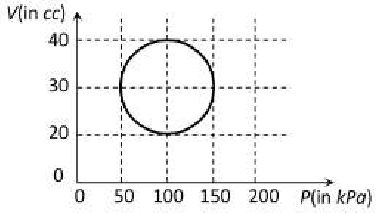
a) Is doubled b) Is halved

c) Is increased four times d) Remains unchanged

381. A cylinder of mass $1kg$ is given heat of $20000\ J$ at atmospheric pressure. If initially temperature of cylinder is 20°C, then work done by the cylinder will be (Given that Specific heat of cylinder $= 400\ J\ kg^{-1}$, Coefficient of volume expansion $= 9 \times 10^{-5}\ °C^{-1}$, Atmospheric pressure $= 10^5 N/m^2$ and density of cylinder $9000\ kg/m^3$)

a) $0.02\ J$ b) $0.05\ J$ c) $0.08\ J$ d) $0.1\ J$

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

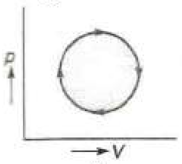


a) $\pi \times 10^3 J$ b) $\frac{\pi}{2}\ J$ c) $4\pi \times 10^2 J$ d) $\pi\ J$

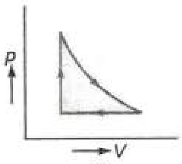
383. An insulator container contains 4 moles of an ideal diatomic gas at temperature T. Heat Q is supplied to this gas, due to which 2 moles of the gas are dissociated into atoms but temperature of the gas remains constant. Then

a) $Q = 2RT$ b) $Q = RT$ c) $Q = 3RT$ d) $Q = 4RT$

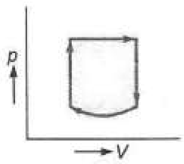
384. What is the nature of change in internal energy in the following three thermodynamical processes shown in figure?



(i)



(ii)



(iii)

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

385. When 1 kg of ice at 0°C melts to water at 0°C, the resulting change in its entropy, taking latent heat of ice to be 80 $cal/°C$ is

a) 293 cal/K b) 273 cal/K c) 8×10^4 cal/K d) 80 cal/K

386. An ideal gas is made to go through a cyclic thermodynamical process in four steps. The amount of heat involved are $Q_1 = 600\,J, Q_2 = -400\,J, Q_3 = -300\,J$ and $Q_4 = 200\,J$ respectively. The corresponding work involved are $W_1 = 300\,J, W_2 = -200\,J, W_3 = -150\,J$ and W_4. What is the value of W_4

a) $-50J$ b) $100J$ c) $150J$ d) $50J$

387. 100 g of water is heated from30°C to 50°C.Ignoring the slight expansion of the water, the change in its internal energy is

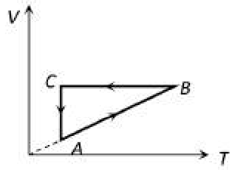
(Specific heat of water is 4184 J/kg/K)

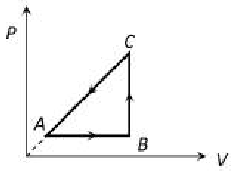
a) 8.4 kJ b) 84 kJ c) 2.1 kJ d) 4.2 kJ

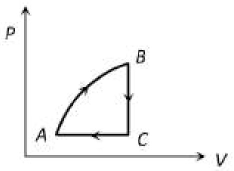
388. In a Carnot engine, the temperature of reservoir is 972°C and that of sink is 27°C. If the work done by the engine when it transfers heat from reservoir to sink is 12.6×10^6J, the quantity of heat absorbed y the engine from the reservoir is

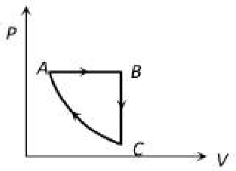
a) 16.8×10^6J b) 4×10^6J c) 7.6×10^6J d) 4.25×10^6J

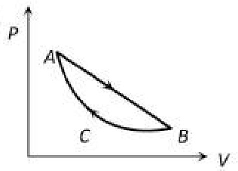
389. A cyclic process $ABCA$ is shown in the V-T diagram. Process on the P-V diagram is



a)


b)


c)


d)


390. An ideal gas is heated at constant pressure and absorbs amount of heat Q. If the adiabatic exponent is γ, then the fraction of heat absorbed in raising the internal energy and performing the work, in

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

391. Calculate change in internal energy when 5 mole of hydrogen is heated to 20°C from 10°C, specific heat of hydrogen at constant pressure is 8 cal $(\text{mol}°\text{C})^{-1}$

a) 200 cal b) 350 cal c) 300 cal d) 475 cal

392. The efficiency of Carnot's engine operating between reservoirs, maintained at temperatures 27°C and −123°C, is

a) 50% b) 24% c) 0.75% d) 0.4%

393. One mole of an ideal gas at an initial temperature of T kelvin does $6R$ 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

394. The internal energy of the gas increases in

a) Adiabatic expansion b) Adiabatic compression

c) Isothermal expansion d) Isothermal compression

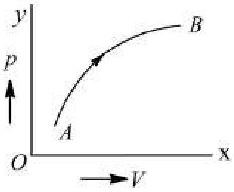
395. The adiabatic Bulk modulus of a perfect gas at pressure is given by

a) P b) $2P$ c) $P/2$ d) γP

396. A sample of gas expands from volume V_1 to V_2. The amount of work done by the gas is maximum when the expansion is

a) Isothermal b) Adiabatic c) Isochoric d) Same in all the cases

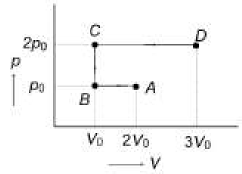
397. Figure shows a thermodynamical process on one moles a gas. How does the work done in the process change with time?



a) Decrease continuously b) Increases continuously

c) Remains constant d) First increase and then decreases

398. $p-V$ diagram of an ideal gas is as shown in figue. Work done by the gas in the process $ABCD$ is

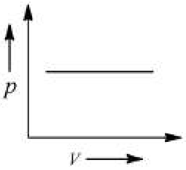


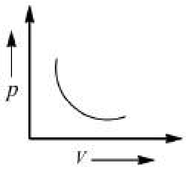
a) $4\, p\, V_0$ b) $2\, p_0\, V_0$ c) $3\, p_0\, V_0$ d) $p_0\, V_0$

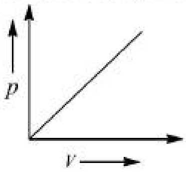
399. A Carnot engine, having an efficiency of $\eta = 1/10$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is

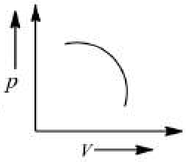
a) 99 J b) 90 J c) 1 J d) 100 J

400. Which of the following p-V diagrams best represents an isothermal process?

a) 

b) 

c) 

d) 

401. When 1 g of water at 0°C and $1 \times 10^5\ N/m^2$ pressure is converted into ice of volume 1.091 cm^3, the external work done will be

a) 0.0091 $joule$ b) 0.0182 $joule$ c) -0.0091 $joule$ d) -0.0182 $joule$

402. The theory of refrigerator is based on

a) Joule –Thomson effect b) Newton's particle theory

c) Joule's effect d) None of the above

403. Temperature of an ideal gas is 300 K. The change in temperature of the gas when its volume changes from V to $2V$ in the process $p = \alpha V$ (here α is a positive constant) is

a) 900 K b) 1200 K c) 600 K d) 300 K

404. Which of the following statement is correct for any thermodynamic system?

a) The internal energy changes in all processes

b) Internal energy and entropy are state functions

c) The change in entropy can never be zero

d) The work done in an adiabatic process is always zero

405. Ten moles of an ideal gas at constant temperature 600 K is compressed from 100 L to 10 L. The work done in the process is

a) 4.11×10^4 J b) -4.11×10^4J c) 11.4×10^4J d) -11.4×10^4J

406. Which is the correct statement

a) For an isothermal change $PV =$ Constant

b) In an isothermal process the change in internal energy must be equal to the work done

c) For an adiabatic change $\frac{P_2}{P_1} = \left(\frac{V_2}{V_1}\right)^\gamma$, where γ is the ratio of specific heats

d) In an adiabatic process work done must be equal to the heat entering the system

407. In an isothermal reversible expansion, if the volume of 96 g of oxygen at 27°C is increased from 70 *litres* to 140 *litres*, then the work done by the gas will be

a) $300\,R\log_{10}2$ b) $81\,R\log_e 2$ c) $900\,R\log_{10}2$ d) $2.3 \times 900\,R\log_{10}2$

408. How much work to be done in decreasing the volume of an ideal gas by an amount of $2.4 \times 10^{-4} m^3$ at normal temperature and constant normal pressure of $1 \times 10^5 N/m^2$

a) $28\,J$ b) $27\,J$ c) $25\,J$ d) $24\,J$

409. The pressure and density of a diatomic gas ($\gamma = \frac{7}{5}$) change adiabatically from $(p_1, \rho_1)$to (p_1, ρ_2). If $\frac{\rho_1}{\rho_2} = 32$, then $\frac{p_1}{p_2}$ should be

a) 16 b) 32 c) 64 d) 128

410. Blowing air with open mouth is an example of

a) Isobaric process b) Isochoric process c) Isothermal process d) Adiabatic process

411. A Carnot engine takes heat from a reservoir at 627°C and rejects heat to a sink at 27°C. Its efficiency will be

a) 3/5 b) 1/3 c) 2/3 d) 200/209

412. Air in a cylinder is suddenly compressed by a piston, which is then maintained at the same position. With the passage of

a) The pressure decreases

b) The pressure increases

c) The pressure remains the same

d) The pressure may increase or decrease depending upon the nature of the gas

413. A given system undergoes a change in which the work done by the system equals the decrease in its internal energy. The system must have undergone an

a) Isothermal change b) Adiabatic change c) Isobaric change d) Isochoric change

414. If $C_V = 4.96 cal/mole\ K$, then increase in internal energy when temperature of 2 moles of this gas is increased from 340 K to 342 K

a) 27.80 cal b) 19.84 cal c) 13.90 cal d) 9.92 cal

415. Adiabatic modulus of elasticity of a gas is $2.1 \times 10^5 \text{Nm}^{-2}$. What will be its isothermal modulus of elasticity? $\left(\frac{C_p}{C_v} = 1.4\right)$

a) 1.2×10^5 Nm^{-2} b) 4×10^5 Nm^{-2} c) 1.5×10^5 Nm^{-2} d) 1.8×10^5 Nm^{-2}

416. Two moles of an ideal monoatomic gas at 27°C occiupies a volume of V. If the gas is expanded adiabatially to the volume $2V$, then the work done by the gas will be ($\gamma = \frac{5}{3}, R = 8.31$ J/mol − K)

a) -2767.23 J b) 2767.23 J c) 2500 J d) -2500 J

417. 5.6 L of helium gas at STP is adiabatically compressed to 0.7 L. Taking the initial temperature to be T_1, the work done in the process is

a) $\frac{9}{8}RT_1$ b) $\frac{3}{2}RT_1$ c) $\frac{15}{8}RT_1$ d) $\frac{9}{2}RT_1$

418. 1 cm^3 of water at its boiling point absorbs 540 cal of heat of become steam with a volume of 1671cm^3. If the atmospheric pressure$=1.013 \times 10^5$ $Nm^{-2}$and the mechanical equivalent of heat =419 J cal^{-1}, the energy spent in this process in overcoming intermolecular forces is

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

419. By what percentage should the pressure of the given mass of gas be increased so to decrease its volume by 10% at a constant temperature?

a) 5% b) 7.2% c) 12.5% d) 11.1%

420. Which of the following is correct in terms of increasing work done for the same initial and final state

a) Adiabatic < Isothermal <Isobaric b) Isobaric < Adiabatic <Isothermal

c) Adiabatic < Isobaric < Isothermal d) None of these

421. The phenomenon of sound propagation in air is

a) Isothermal process b) Isobaric process c) Adiabatic process d) None of these

422. Helium at 27°C has a volume of 8 *litres*. It is suddenly compressed to a volume of 1 *litre*. The temperature of the gas will be [$\gamma = 5/3$]

a) 108°C b) 9327°C c) 1200°C d) 927°C

423. A thermally insulated rigid container contains an ideal gas heated by a filament of resistance 100 Ω through a current of 1*A* for 5 min then change in internal energy is

a) 0 *kJ* b) 10 *kJ* c) 20 *kJ* d) 30 *kJ*

424. A heat engine is a device

a) Which converts mechanical energy into heat energy

b) Which converts heat energy into mechanical energy

c) Absorbs heat from a sink at a lower temperature and rejects to the source at high temperature

d) None of the above

425. In isothermic process, which statement is wrong

a) Temperature is constant b) Internal energy is constant

c) No exchange of energy d) (a) and (b) are correct

426. The internal energy of an ideal gas increases during an isothermal process when the gas is

a) Expanded by adding more molecules to it b) Expanded by adding more heat to it

c) Expanded against zero pressure d) None of these

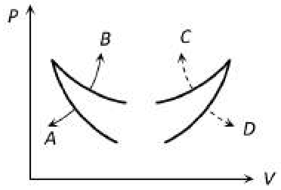
427. During an adiabatic process, the cube of the pressure is found to be inversely proportional to the fourth power of the volume. Then the ratio of specific heats is

a) 1 b) 1.33 c) 1.67 d) 1.4

428. At 27°C a gas suddenly compressed such that its pressure becomes $\frac{1}{8}$th of original pressure. The temperature of the gas will be ($\gamma = 5/3$)

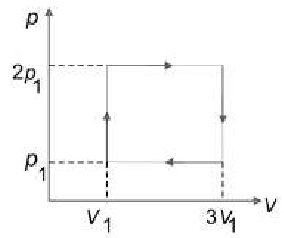
a) −142°C b) 300K c) 327° d) 420 K

429. Four curves *A*, *B*, *C* and *D* are drawn in the adjoining figure for a given amount of gas. The curves which represent adiabatic and isothermal changes are



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

430. Work done in the given cyclic process is



a) p_1V_1 b) $3p_1V_1$ c) $2p_1V_1$ d) zero

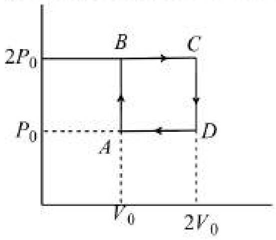
431. Which of the following statements is true?
   a) Internal energy of a gas depends only on the state of the gas
   b) In an isothermal process change in internal energy is maximum
   c) Area under pressure, volume graph equals heat supplied in any process
   d) Work done is state dependent but not path dependent

432. An ideal gas heat engine operates in Carnot cycle between 227°C and 127°C .It absorbs 6×10^4 cal of heat at higher temperature. Amount of heat converted into work is
   a) 1.2×10^4 cal b) 2.4×10^4 cal c) 6×10^4 cal d) 4.8×10^4 cal

433. A thermodynamical system goes from state (i) (p, V) to $(2\,p, V)$ and (ii) (p, V) to $(p, 2V)$. Work done in the two cases is
   a) Zero, zero b) Zero, pV c) pV, zero d) pV, pV

434. If a quantity of heat 1163.4 joule is supplied to one mole of nitrogen gas, at room temperature at constant pressure, then the rise in temperature is
   (Given $R = 8.31 J\ mole^{-1}K^{-1}$)
   a) $54K$ b) $28K$ c) $65K$ d) $40K$

435. Helium gas goes through a cycle $ABCDA$ (consisting of two isochoric and isobaric lines) as shown in figure. Efficiency of this cycle is nearly
   (Assume the gas to be close to ideal gas)



   a) 15.4% b) 9.1% c) 10.5% d) 12.5%

436. 310 J of heat is required to raise the temperature of 2 moles of an ideal gas at constant pressure from 25°C to 35°C. The amount of heat required to raise the temperature of the gas through the same range at constant volume is
   a) 384 J b) 144 J c) 276 J d) 452 J

437. For nitrogen $C_p - C_v = x$ and for argon, $C_p - C_v = y$. The relation between x and y is given by
   a) $x = y$ b) $x = 7y$ c) $y = 7x$ d) $x = \frac{1}{2}y$

438. The perfect gas goes from a state A to another state B by absorbing 8×10^5J of heat and doing 6.5×10^5 J of external work. It is now transferred between the same two states in another process in which it absorbs 10^5J of heat in the second process. Then
   a) Work done on the gas is 0.5×10^5J b) Work done on the gas is 0.5×10^5J
   c) Work done on the gas is 10^5J d) Work done on the gas is 10^5J

439. 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) 840 K b) 280 K c) 560 K d) 380 K

440. The temperature of an ideal gas is kept constant as it expands. The gas does external work. During this process, the internal energy of the gas

a) Decreases
b) Increases
c) Remains constant
d) Depends on the molecular motion

THERMODYNAMICS

: ANSWER KEY :

1)	a	2)	d	3)	c	4)	b	161)	d	162)	d	163)	c	164)	a
5)	a	6)	b	7)	b	8)	b	165)	a	166)	b	167)	a	168)	a
9)	d	10)	c	11)	a	12)	a	169)	a	170)	a	171)	a	172)	a
13)	a	14)	b	15)	a	16)	c	173)	a	174)	b	175)	a	176)	c
17)	a	18)	c	19)	d	20)	b	177)	c	178)	c	179)	c	180)	c
21)	c	22)	d	23)	a	24)	a	181)	b	182)	d	183)	c	184)	d
25)	c	26)	a	27)	b	28)	a	185)	b	186)	c	187)	c	188)	b
29)	a	30)	d	31)	d	32)	d	189)	c	190)	b	191)	c	192)	c
33)	a	34)	a	35)	a	36)	c	193)	c	194)	d	195)	a	196)	b
37)	c	38)	b	39)	a	40)	c	197)	d	198)	d	199)	a	200)	a
41)	a	42)	a	43)	c	44)	a	201)	a	202)	a	203)	b	204)	d
45)	d	46)	b	47)	a	48)	a	205)	b	206)	a	207)	c	208)	a
49)	a	50)	a	51)	d	52)	c	209)	c	210)	d	211)	a	212)	c
53)	c	54)	c	55)	a	56)	d	213)	c	214)	d	215)	c	216)	d
57)	b	58)	d	59)	a	60)	c	217)	c	218)	d	219)	a	220)	a
61)	c	62)	b	63)	d	64)	a	221)	d	222)	d	223)	b	224)	d
65)	b	66)	a	67)	b	68)	d	225)	a	226)	b	227)	c	228)	a
69)	d	70)	b	71)	c	72)	a	229)	c	230)	b	231)	b	232)	d
73)	a	74)	b	75)	b	76)	a	233)	a	234)	a	235)	c	236)	a
77)	d	78)	b	79)	d	80)	a	237)	c	238)	c	239)	d	240)	c
81)	a	82)	a	83)	c	84)	b	241)	a	242)	d	243)	a	244)	a
85)	a	86)	b	87)	c	88)	a	245)	a	246)	a	247)	c	248)	a
89)	d	90)	c	91)	d	92)	c	249)	d	250)	a	251)	c	252)	a
93)	b	94)	c	95)	b	96)	b	253)	b	254)	c	255)	b	256)	c
97)	d	98)	b	99)	d	100)	b	257)	b	258)	c	259)	c	260)	b
101)	b	102)	c	103)	b	104)	a	261)	b	262)	b	263)	c	264)	a
105)	c	106)	b	107)	b	108)	a	265)	b	266)	b	267)	d	268)	a
109)	d	110)	c	111)	c	112)	c	269)	a	270)	c	271)	c	272)	c
113)	d	114)	a	115)	a	116)	a	273)	c	274)	a	275)	b	276)	d
117)	c	118)	d	119)	d	120)	d	277)	d	278)	a	279)	c	280)	c
121)	a	122)	b	123)	b	124)	d	281)	c	282)	d	283)	a	284)	a
125)	d	126)	b	127)	a	128)	c	285)	c	286)	b	287)	d	288)	d
129)	b	130)	b	131)	c	132)	b	289)	a	290)	a	291)	b	292)	d
133)	c	134)	b	135)	c	136)	a	293)	a	294)	d	295)	c	296)	c
137)	c	138)	b	139)	a	140)	d	297)	c	298)	b	299)	b	300)	b
141)	c	142)	c	143)	c	144)	b	301)	c	302)	a	303)	d	304)	d
145)	a	146)	c	147)	c	148)	b	305)	c	306)	a	307)	d	308)	c
149)	c	150)	a	151)	a	152)	d	309)	b	310)	b	311)	a	312)	d
153)	c	154)	a	155)	b	156)	b	313)	c	314)	c	315)	a	316)	a
157)	c	158)	c	159)	c	160)	d	317)	d	318)	b	319)	d	320)	a

321) b
322) b
323) c
324) c
325) c
326) b
327) a
328) d
329) a
330) b
331) b
332) d
333) a
334) a
335) c
336) c
337) c
338) a
339) a
340) a
341) a
342) b
343) a
344) d
345) c
346) a
347) b
348) c
349) a
350) b
351) d
352) a
353) a
354) a
355) b
356) b
357) c
358) a
359) a
360) d
361) c
362) c
363) c
364) b
365) a
366) b
367) c
368) a
369) d
370) a
371) d
372) b
373) a
374) c
375) d
376) c
377) b
378) c
379) b
380) d
381) b
382) b
383) b
384) d
385) a
386) c
387) a
388) a
389) c
390) a
391) c
392) a
393) d
394) b
395) d
396) a
397) b
398) c
399) b
400) c
401) a
402) d
403) b
404) b
405) d
406) a
407) d
408) d
409) d
410) a
411) c
412) a
413) b
414) b
415) c
416) b
417) a
418) c
419) d
420) a
421) b
422) d
423) d
424) b
425) c
426) a
427) b
428) a
429) c
430) c
431) a
432) a
433) b
434) d
435) a
436) b
437) a
438) a
439) d
440) c

THERMODYNAMICS

: HINTS AND SOLUTIONS :

1 **(a)**

In an adiabatic process,

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

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

$$\Rightarrow \frac{p_1}{p_2} = \left(\frac{1}{8}\right)^{5/3}$$

$$\Rightarrow \frac{p_1}{p_2} = \left(\frac{1}{2^3}\right)^{5/3} = \frac{1}{32}$$

$$\therefore \frac{p_2}{p_1} = 32$$

2 **(d)**

The area under p-V diagram =work done

or $W = AD \times DC$

$=(2 \times 10^5 - 1 \times 10^5)\text{Nm}^{-2} \times (4-2) \times 10^{-6}\text{m}^3$

$= 1 \times 10^5 \times 2 \times 10^{-6}\text{J} = 0.2\ \text{J}$

6 **(b)**

$$W_{iso} = \mu RT \log_e \frac{V_2}{V_1}$$

$$= 1 \times 8.31 \times 300 \log_e \frac{20}{10} = 1728J$$

7 **(b)**

Using the relation

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

or $\dfrac{W}{Q_1} = 1 - \dfrac{Q_2}{Q_1}$

or $\dfrac{W}{Q_1} = 1 - \dfrac{T_2}{T_1} \qquad \left(\because \dfrac{Q_1}{Q_2} = \dfrac{T_1}{T_2}\right)$

or $W = Q_1\left(1 - \dfrac{T_2}{T_1}\right)$

$$\therefore W = 6 \times 10^4\left(1 - \frac{(127+273)}{(227+273)}\right)$$

or $W = 6 \times 10^4\left(1 - \dfrac{400}{500}\right)$

$$= 6 \times 10^4 \times \frac{100}{500}$$

$$= 1.2 \times 10^4\ \text{J}$$

8 **(b)**

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

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

$= 66.28$ atm

9 **(d)**

$T_1 = 6000\ K, T_2 = 300\ K$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{6000} = 0.95 \Rightarrow 95\%$$

10 **(c)**

As work done by the gas = area under the $p - V$ curve, therefore $W_1 > W_2 > W_3$

12 **(a)**

As isothermal at T_1 is farther from the origin than the isothermal at T_2, therefore, $T_1 > T_2$

14 **(b)**

In adiabatic expansion of a gas system, gas expands, so temperature of the system decreases.

15 **(a)**

$$\eta = \frac{C_p}{C_v} = 1 + \frac{2}{n} = 1 + \frac{2}{f}$$

16 **(c)**

Given that, the temperature of freezer, $T_2 = -13°\text{C}$

$$\Rightarrow \qquad T_2 = -13 + 273 = 260\ K$$

Coefficient of performance, β=5

The coefficient of performance is defined as,

$$\beta = \frac{T_2}{T_1 - T_2}$$

or $$5 = \frac{260}{T_1 - 260}$$

$$\therefore\ T_1 - 260 = \frac{260}{5}$$

or $T_1 - 260 = 52$

or $T_1 = (52 + 260)\text{K} = 312\text{ K}$

or $T_1 = (312 - 273)°\text{C}$

$\Rightarrow$ $T_1 = 39°\text{C}$

17 **(a)**

Work done = Area of closed PV diagram

$= (2V - V) \times (2P - P) = PV$

18 **(c)**

At constant volume $P \propto T \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{P_1}{P_2} = \frac{300}{400} = \frac{3}{4}$

19 **(d)**

Oxygen is diatomic gas, hence its energy of two moles

$= 2 \times \frac{5}{2}RT = 5RT$

Argon is a monoatomic gas, hence its internal energy of 4 moles $= 4 \times \frac{3}{2}RT = 6RT$

Total Internal energy $= (6 + 5)RT = 11RT$

20 **(b)**

As work done = area under the $p - V$ diagram

$\therefore\ W_1 > W_2$

21 **(c)**

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \Rightarrow \frac{T_2}{T_1} = \left(\frac{1}{8}\right)^{\frac{1.5-1}{1.5}} = \left(\frac{1}{8}\right)^{\frac{1}{3}} = \frac{1}{2}$$

$$\Rightarrow T_2 = \frac{T_1}{2} = \frac{300}{2} = 150K$$

23 **(a)**

KE of the vessel $= \frac{1}{2}Mv^2$

When the vessel is suddenly stopped, the ordered motion of the gas molecules is converted into disordered motion of the molecules increasing thereby the internal energy of the gas. Thus,

$$\Delta U = nC_v\Delta T = \frac{1}{2}mv^2 = \frac{1}{2}(nM)v^2$$

Where n is number of moles of the gas in the vessel and M is molecular weight of the gas.

$$\therefore\ \Delta T = \frac{Mv^2}{2C_v}$$

As $C_v = \frac{R}{\gamma - 1}$

$$\therefore\ \Delta T = \frac{Mv^2(\gamma - 1)}{2R}$$

24 **(a)**

An isochoric process is a constant volume process. In an isochoric process

V=constant or $\Delta V = 0$

So, work done

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

From first law of thermodynamics

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

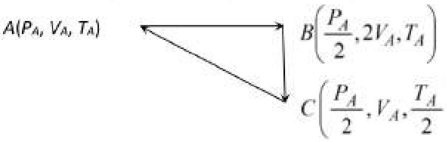
$$\Rightarrow\quad \Delta Q = \Delta U$$

25 **(c)**

Pressure is reduce, so the temperature falls

26 **(a)**

Let the process start from initial pressure P_A, volume V_A and temperature T_A



(i) Isothermal expansion (PV = constant) at temperature T_A to twice the initial volume V_A

(ii) Compression at constant pressure $\frac{P_A}{2}$ to original volume $V_A (i.e.\, V \propto T)$

(iii) Isochoric process (at volume V_A) to initial condition $(i.e.\, P \propto T)$

27 **(b)**

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

$$\Rightarrow\quad \frac{p_2}{p_1} = \frac{V}{V_1}$$

$$\Rightarrow\quad \frac{2p}{p} = \frac{V}{V_1}$$

$$\therefore\quad \frac{V}{V_1} = 2 \qquad \text{...(i)}$$

Now, the gas is expanded adiabatically, so

pV^γ = constant

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

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

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

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

$$\therefore \quad \gamma=1.41$$

28 **(a)**

$J\Delta Q=\Delta U+\Delta W, \Delta U=J\Delta Q-\Delta W$

$\Delta U=4.18\times 300-600=654\,joule$

29 **(a)**

In a closed cyclic process change in internal energy is always zero

$\therefore E=0$

30 **(d)**

Given, $p\propto T^3$ ----(i)

In an adiabatic process

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

$$T\ \alpha\ \frac{1}{p^{(1-\gamma)/\gamma}}$$

$T^{(\gamma/\gamma-1)}\propto p$ ----(ii)

Comparing Eqs. (i) and (ii), we get

$$\therefore \quad \frac{\gamma}{\gamma-1}=3$$

$$3\gamma-3=\gamma$$

$$2\gamma=3$$

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

32 **(d)**

The work done in a PV diagram is the area enclosed.

The work done $=\frac{1}{2}(3V_1-V_1).(4P_1-P_1)$

$\Rightarrow W=-3P_1V_1$. If the direction of change is clockwise it is positive. Since here it is anticlockwise, work done is negative

33 **(a)**

Here, $Q_1=200cal, Q_2=150cal, T_1=400K$

As $\frac{Q_1}{Q_2}=\frac{T_1}{T_2}$

$$\therefore T_2=\frac{Q_2}{Q_1}\times T_1=\frac{150}{200}\times 400=300K$$

34 **(a)**

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

35 **(a)**

$$\eta=\frac{W}{Q_1}\Rightarrow W=\eta\,Q_1=\frac{1}{3}\times 1000\text{ cal}=\frac{1000}{3}\times 4.2$$
$$=1400\text{ J}$$

36 **(c)**

The work done in cyclic process is equal to the area enclosed by the PV diagram

37 **(c)**

Internal energy (ΔU) does not depend upon path. It depends only on initial and final states

38 **(b)**

In isothermal process, heat is released by the gas to maintain the constant temperature

39 **(a)**

Coefficient of performance $K=\frac{T_2}{T_1-T_2}$

$$=\frac{(273-23)}{(273+27)-(273-23)}=\frac{250}{300-250}=\frac{250}{50}$$
$$=5$$

40 **(c)**

Work done in adiabatic change $=\frac{\mu R(T_1-T_2)}{\gamma-1}$

41 **(a)**

$$\eta=\frac{T_1-T_2}{T_1}=\frac{(273+727)-(273+227)}{273+727}$$
$$=\frac{1000-500}{1000}=\frac{1}{2}$$

42 **(a)**

In isothermal process temperature remains constant

$i.e.$, $\Delta T=0$. Hence according to $C=\frac{Q}{m\Delta T}\Rightarrow$

$C_{iso}=\infty$

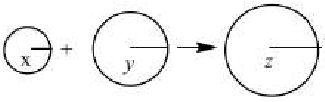
43 **(c)**

Gas cylinder suddenly exploding is an irreversible adiabatic change and work done against expansion reduces the temperature

44 **(a)**

$$n=n_1+n_2$$

$$pV=p_1V_1+p_2V_2$$



$$p_1=p_0+\frac{4T}{x}, p_2=p_0+\frac{4T}{y}, p=p_0+\frac{4T}{z}$$

If the process takes place is vacuum then $p_0=0$

$$p_1 = \frac{4T}{x}, p_2 = \frac{4T}{y}, p = \frac{4T}{z}$$

If process is isothermal

$\therefore \quad p_1V_1 + p_2V_2 = pV$

$\therefore \quad z = \sqrt{x^2 + y^2}$

45 **(d)**

$\eta = 1 - \frac{T_2}{T_1}$; for η to be max. ratio $\frac{T_2}{T_1}$ should be min

46 **(b)**

For cyclic forces $\Delta U = 0$, So, $\Delta Q = \Delta W$

47 **(a)**

$\Delta V = 0 \Rightarrow P\Delta V = 0 \Rightarrow \Delta W = 0$

48 **(a)**

In adiabatic change work done

$$W = \mu C_V \Delta T$$

or $$W = \mu C_V(T_1 - T_2)$$

49 **(a)**

Given $T_1 = 27 + 273 = 300$ K

$$V_1 = V(\text{let})$$

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

Then for adiabatic process

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

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

For monoatomic gas, $\gamma = 5/3$

So, $T_2 = 300\left(\frac{V\times27}{8V}\right)^{\frac{5}{3}-1} = 675$ K

ie, $\quad T_2 = 675 - 273 = 402$°C

Hence, increase in temperature

$= 402 - 27° = 375$°C

50 **(a)**

Here, $T_1 = 927°\text{C} = (927 + 273)K = 1200\text{K}$

$T_2 = 27°\text{C} = (27 + 273)\text{K} = 300\text{K}$

As $U \propto T$

$\therefore \dfrac{\Delta U}{U_2} = \dfrac{U_1 - U_2}{U_2} = \dfrac{1200 - 300}{300} \times 100 = 300\%$

51 **(d)**

$W_{BCOB} = -$ Area of triangle $BCO = -\frac{P_0V_0}{2}$

$W_{AODA} = +$ Area of triangle $AOD = +\frac{P_0V_0}{2}$

52 **(c)**

$T_2 = 0°\text{C} = 273\text{ K}, T_1 = 17°\text{C} = 17 + 273 = 290\text{ K}$

$\text{COP} = \dfrac{Q_2}{W} = \dfrac{T_2}{T_1 - T_2}$

$\dfrac{80 \times 1000 \times 4.2}{W} = \dfrac{273}{290 - 273} = \dfrac{273}{17}$

$W = \dfrac{80 \times 1000 \times 4.2 \times 17}{273}$ J

$W = \dfrac{33.6 \times 17 \times 10^4}{273 \times 3.6 \times 10^5}$ kWh $= 0.058$ kWh

53 **(c)**

$k_a = \gamma p = \left(\frac{5}{3}\right) \times 1.01 \times 10^5\ \text{Nm}^{-2}$

$= 1.69 \times 10^5\ \text{Nm}^{-2}$

54 **(c)**

Work done by the gas (as cyclic process is clockwise) $\therefore \Delta W =$ Area $ABCD$

So from the first law of thermodynamics ΔQ (net heat absorbed) $= \Delta W =$Area $ABCD$

As change in internal energy in cycle $\Delta U = 0$

55 **(a)**

$\Delta Q = -20J;\ \Delta W = -10J$

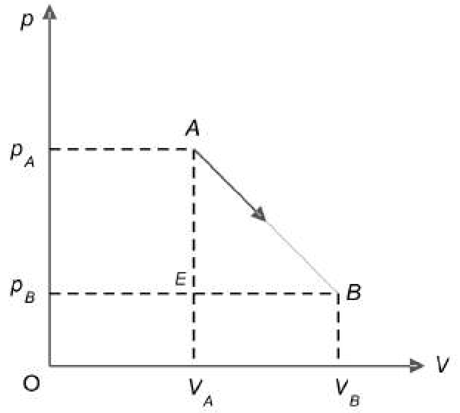
$\Delta Q = (U_f - U_i) + \Delta W$

$\Rightarrow -20 = (U_f - 40) - 10 \Rightarrow U_f = -10 + 40$

$= 30\,J$

56 **(d)**

The p-V diagram is shown below



Work done =area of ABCDEA

= area of ΔABE + area of rectangle $BCDE$

$= \frac{1}{2}(p_A - p_B)(V_B - V_A) + p_B(V_B - V_A)$

$$= \left[\frac{1}{2}(p_A - p_B) + p_B\right](V_B - V_A)$$

$$= \frac{1}{2}(p_A + p_B)(V_B - V_A)$$

57 **(b)**

For such a case, pressure $= \frac{1}{\text{Compressibility}}$

58 **(d)**

Specific heat of an ideal gas does not depend upon temperature

59 **(a)**

From FLOT $\Delta Q = \Delta U + \Delta W = \Delta U + P\Delta V$

$\Rightarrow 100 = \Delta U + 50 \times (4 - 10) \Rightarrow \Delta U = 400\,J$

60 **(c)**

Area enclosed between a and f is maximum. So work done in closed cycles follows a and f is maximum

62 **(b)**

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

$$\Rightarrow \frac{(v_{rms})_1}{(v_{rms})_2} = \sqrt{\frac{T_1}{T_2}}$$

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

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

$$\Rightarrow \frac{(v_{rms})_1}{(v_{rms})_2} = \left(\frac{V_2}{V_1}\right)^{\frac{\gamma-1}{2}}$$

$$\Rightarrow \frac{v}{\frac{v}{2}} = \left(\frac{V_2}{V_1}\right)^{\frac{\frac{7}{5}-1}{2}}$$

$$\Rightarrow 2 = \left(\frac{V_2}{V_1}\right)^{\frac{2}{5}\times\frac{1}{2}} = \left(\frac{V_2}{V_1}\right)^{1/5}$$

$$\Rightarrow \left(\frac{V_2}{V_1}\right) = 2^5 = 32$$

63 **(d)**

$$\eta_1 = 1 - \frac{T_2}{T_1}$$

$$\frac{1}{6} = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = \frac{5}{6}$$

$$\eta_2 = 1 - \frac{T_2 - 62}{T_1}$$

$$\frac{1}{3} = 1 - \frac{T_2 - 62}{T_1}$$

On solving Eqs. (i) and (ii) , we get

$$T_1 = 372\text{ K and } T_2 = 310\text{ K}$$

64 **(a)**

In an adiabatic change,

$p^{1-\gamma}T^{\gamma} =$ constant

Or $pT^{\gamma/1-\gamma} =$ constant

Or $p \propto T^{(1-\gamma)/\gamma}$

Thus, $c = \frac{1-\gamma}{\gamma}$

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

$$\therefore\ -c = \frac{1 - 5/3}{5/3} = -\frac{2}{3} \Rightarrow c = \frac{2}{5}$$

65 **(b)**

According first 1st law of thermodynamics

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

$\Delta Q = 0 + W = W$

66 **(a)**

From the first law of thermodynamics

We have, $Q = \Delta U + W$

$\Delta U = Q - W$

$\Delta U = 150 - 110 = 40\text{J}$

67 **(b)**

In case of adiabatic expansion $\Delta W =$ positive and $\Delta Q = 0$

From FLOT $\Delta Q = \Delta U + \Delta W \Rightarrow \Delta U = -\Delta W$, *i.e.*, ΔU will be negative

69 **(d)**

For adiabatic forces $\Delta W = -\Delta U$ $[\because \Delta Q = 0]$

$\Rightarrow \Delta W = -(-50) = +50J$

70 **(b)**

The efficiency (η) of Carnot engine is

$$\eta = \frac{\Delta W}{\Delta Q_H} = 1 - \frac{Q_{\text{reject}}}{Q_{\text{taken}}} = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

$$\Rightarrow \quad \frac{Q_{\text{reject}}}{Q_{\text{taken}}} = \frac{T_{\text{sink}}}{T_{\text{source}}}$$

$$\Rightarrow \quad Q_{\text{reject}} = \frac{T/3}{T}\ Q = \frac{Q}{3}$$

71 **(c)**

$$\Delta Q = \Delta U + \Delta W \Rightarrow \Delta U = \Delta Q - \Delta W = 2240 - 168 = 2072\,J$$

72 **(a)**

$T_1 = 273 + 20 = 293\text{ K}, T_2 = 273 + 10 = 283\text{ K}$

Coefficient of performance

$$= \frac{T_2}{T_1 - T_2} = \frac{283}{293 - 283} = \frac{283}{10} = 28.3$$

73 **(a)**

$\eta = 1 - \frac{T_2}{T_1}$ or $\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{1}{6} = \frac{5}{6}$

$$T_2 = \frac{5}{6}T_1 = \frac{5}{6} \times 600 = 500\text{ K}$$

74 **(b)**

In isothermal process $P_1V_1 = P_2V_2$

$$\Rightarrow PV = P_2 \times 4V \ \therefore P_2 = \frac{P}{4}$$

In adiabatic process

$$P_2{V_2}^{\gamma} = P_3{V_3}^{\gamma} \Rightarrow \frac{P}{4} \times (4V)^{1.5} = P_3V^{1.5} \Rightarrow P_3 = 2P$$

75 **(b)**

In adiabatic process total amount of heat remains constant.

76 **(a)**

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

77 **(d)**

The coefficient of performance of a refrigerator is given by $\alpha = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$

Where, Q_1 = Amount of heat released to the hot reservoir

Q_2 = Amount of heat extracts from the cold reservoir

W = work done on the working substance

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

Substituting the given values, we get $\frac{1}{3} = \frac{Q_2}{200 - Q_2}$

$$200 - Q_2 = 3Q_2 \Rightarrow 4Q_2 = 200 \Rightarrow Q_2 = \frac{200}{4}J$$

$$= 50J$$

$$\therefore W = Q_1 - Q_2 = 200J - 50J = 150J$$

78 **(b)**

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

$$= 1 - \frac{(273 + 27)}{(273 + 127)}$$

$$= 1 - \frac{300}{400} = \frac{1}{4}$$

$$\eta = \frac{\text{Work done}}{\text{Heat supplied}}$$

$$\frac{1}{4} = \frac{W}{40}$$

$$\Rightarrow \qquad W = 10\text{ kJ}$$

79 **(d)**

$$W = \frac{1}{2}2V.3P = 3PV$$

80 **(a)**

From symmetry considerations and also from theory,

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

81 **(a)**

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{(127 + 273)}{(227 + 273)} = \frac{1}{5}$$

$$W = \eta Q_1 = \frac{1}{5} \times 10^4\text{ J} = 2000\text{ J}$$

82 **(a)**

For adiabatic process,

$$dQ = 0$$

So, $\qquad dU = -\Delta W$

$$\Rightarrow \quad nC_V dT = +146 \times 10^3\text{J}$$

$$\Rightarrow \quad \frac{nfR}{2} \times 7 = 146 \times 10^3$$

[$f \rightarrow$ Degree of freedom]

$$\Rightarrow \quad \frac{10^3 \times f \times 8.3 \times 7}{2} = 146 \times 10^3$$

$$f = 5.02 \approx 5$$

So, it is a diatomic gas.

83 **(c)**

For isothermal process

$p_1V = K$ (constant)

$p_1 = \frac{K}{V}$ ----(i)

$$= \frac{K}{V/2} = 2K$$

For adiabatic process

$P_2V^{\gamma} = K$ (constant)

$\therefore \quad P_2 = \frac{K}{V^{\gamma}}$ ----(ii)

$$= \frac{K}{(V/2)^{\gamma}} = K(2^{\gamma})$$

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

$$P_2 > P_1$$

84 **(b)**

Entropy is a measure of disorder. When water is converted into ice, disorder decreases, hence entropy decreases.

85 **(a)**
In isothermal change, temperature remains constant,
Hence $\Delta U = 0$
Also from $\Delta Q = \Delta U + \Delta W \Rightarrow \Delta Q = \Delta W$

86 **(b)**
$PV^2 =$ constant represents adiabatic equation. So during the expansion of ideal gas internal energy of gas decreases and temperature falls

87 **(c)**
$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 273(2)^{0.41} = 273 \times 1.328$$
$$= 363\ K$$
$$W = \frac{R(T_1 - T_2)}{\gamma - 1} = \frac{8.31(273 - 363)}{1.41 - 1} = -1824$$
$\Rightarrow |W| \approx 1815\ J$

89 **(d)**
Initial and final states are same an all the process

Hence, $\Delta U = 0$ in each case

By $p\Delta V = \Delta Q = \Delta W =$ Area enclosed by curve with volume axis

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

$\Rightarrow \quad Q_1 < Q_2 < Q_3$

90 **(c)**
During formation of ice cubes orderness increases, *ie*, disorderness decreases, hence entropy decreases.

91 **(d)**
For path ab: $(\Delta U)_{ab} = 7000\ J$
By using $\Delta U = \mu C_V \Delta T$
$7000 = \mu \times \frac{5}{2}R \times 700 \Rightarrow \mu = 0.48$
For path ca:
$(\Delta Q)_{ca} = (\Delta U)_{ca} + (\Delta W)_{ca}$ ...(i)
$\because (\Delta U)_{ab} + (\Delta U)_{bc} + (\Delta U)_{ca} = 0$
$\therefore 7000 + 0 + (\Delta U)_{ca} = 0 \Rightarrow (\Delta U)_{ca} = -7000\ J$ ...(ii)
Also $(\Delta W)_{ca} = P_1(V_1 - V_2) = \mu R(T_1 - T_2)$
$= 0.48 \times 8.31 \times (300 - 1000) = -2792.16\ J$ ...(iii)
On solving equations (i), (ii) and (iii)
$(\Delta Q)_{ca} = -7000 - 2792.16 = -9792.16\ J$
$= -9800\ J$

92 **(c)**
Work done = area of ΔABC
$$= \frac{AB \times BC}{2} = \frac{(p_2 - p_1)(V_2 - V_1)}{2}$$

93 **(b)**
$\Delta Q = \Delta U + \Delta W$
$\Delta Q = 0 - 150\ J$
So, heat has been given by the system

94 **(c)**
$C_p - C_v = R = 2$ cal (mol K)$^{-1}$ Difference in the two values must be 2

95 **(b)**
Internal energy of a gas is
$$U = \frac{3}{2}nRT$$
For a given number of moles of the same gas, U depends only T
Therefore U_B at $2T < U_A$ at temperature T is a wrong statement

96 **(b)**
According to first law of thermodynamics
$\Delta Q = \Delta U + \Delta W$
For an adiabatic process, $\Delta Q = 0 \ \therefore\ \Delta U = -\Delta W$
During an adiabatic expansion, ΔW is positive.
Therefore ΔU will be negative, so internal energy decreases and hence temperature of the system decreases
For an adiabatic process $PV^\gamma =$ constant
$$\therefore P'V'^\gamma = PV^\gamma \Rightarrow P' = P\left(\frac{V}{V'}\right)^\gamma$$
As $V' > V, \gamma > 1 \ \therefore P' < P$

97 **(d)**
Slow isothermal expansion or compression of an ideal gas is reversible process, while the other given processes are irreversible in nature

98 **(b)**
From FLOT $\Delta Q = \Delta U + \Delta W$
Work done at constant pressure $(\Delta W)_P = (\Delta Q)_P - \Delta U$
$= (\Delta Q)_P - (\Delta Q)_V$ [As we know $(\Delta Q)_V = \Delta U$]
Also $(\Delta Q)_P = mc_P\Delta T$ and $(\Delta Q)_V = mc_V\Delta T$
$\Rightarrow (\Delta W)_P = m(c_P - c_V)\Delta T$
$\Rightarrow (\Delta W)_P = 1 \times (3.4 \times 10^3 - 2.4 \times 10^3) \times 10$
$= 10^4 cal$

99 **(d)**
In case of no work done W=0 than volume expersion V=0. So, the volume remains zero V=0. This process is called isochoric process.

100 **(b)**
Gain of entropy of ice
$$S_1 = \frac{\Delta Q}{T} = \frac{mL}{T} = \frac{80 \times 100}{(0 + 273)} = \frac{8 \times 10^3}{273} cal/K$$
Loss of entropy of water $= S_2 = -\frac{\Delta Q}{T} = -\frac{mL}{T}$

$$= \frac{80 \times 100}{(273 + 50)} = \frac{8 \times 10^3}{323} cal/K$$

Total change of entropy

$$S_1 + S_2 = \frac{8 \times 10^3}{273} - \frac{8 \times 10^3}{323} = +4.5\ cal/K$$

102 **(c)**

As $\eta = 1 - \frac{T_2}{T_1}$ $\therefore$ $\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{10}{100} = \frac{90}{100}$

or $T_1 = \frac{100 T_2}{90}$

$$= \frac{100}{90} \times 270 = 300 \text{ K}$$

103 **(b)**

For adiabatic expansion, we have the formula

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

Gas equation is ,

$$pV = RT$$

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

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

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

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

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

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

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

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

or $\quad \gamma = \frac{3}{2} = 1.5$

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

105 **(c)**

$Vp^n = \text{constant}$

$$\therefore\ Vp^n = \left(V + \frac{\Delta V}{V}\right)\left(1 + n\frac{\Delta p}{p}\right)$$

$$1 = 1 + \frac{\Delta V}{V} + n\frac{\Delta p}{p} + n\frac{\Delta V}{V}\frac{\Delta P}{p}$$

Or $\frac{\Delta V}{V} = -n\frac{\Delta p}{p}$, (neglecting the product)

As $k = \frac{-\Delta p}{\Delta V / V} = \frac{p}{n}$

106 **(b)**

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

In all the four cases, $T_1 - T_2 = 20$ K. Therefore, η is highest, when T_1 is lowest

107 **(b)**

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

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

$$\Rightarrow T_2 = \left(\frac{1}{81}\right)^{1.25 - 1} \times 273 = \left(\frac{1}{81}\right)^{0.25} \times 273$$

$$= \frac{273}{3} = 91K \rightarrow -182°\text{C}$$

108 **(a)**

In an adiabatic process

$pV^{\gamma} = K \qquad$ (Poisson's equation)

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

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

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

Taking logarithm on both sides, we get

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

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

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

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

$$= -\frac{2}{3} \times \frac{2}{3} = -\frac{4}{9}\%$$

Minus (-) sign implies that volume decreases by $\frac{4}{9}\%$.

109 **(d)**

In adiabatic process

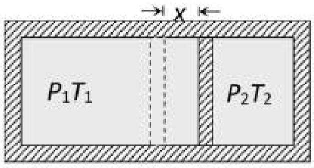
$$\Delta Q = 0$$

Therefore, first law of thermodynamics becomes

$$dU + dW = 0$$

110 **(c)**

As finally the piston is in equilibrium, both the gases must be at same pressure P_f. It is given that displacement of piston be in ideal state x and if A is the area of cross-section of the piston. Hence the final volumes of the left and right part finally can be given by figure as



$V_L = \frac{V_0}{2} + Ax$ and

$V_R = \frac{V_0}{2} - Ax$

As it is given that the container walls and the piston are adiabatic in left side and the gas undergoes adiabatic expansion and on the right side the gas undergoes adiabatic compression. Thus we have for initial and final state of gas on left side

$P_1\left(\frac{V_0}{2}\right)^\gamma = P_f\left(\frac{V_0}{2} + Ax\right)^\gamma$ ...(i)

Similarly for gas in right side, we have

$P_2\left(\frac{V_0}{2}\right)^\gamma = P_f\left(\frac{V_0}{2} - Ax\right)^\gamma$ ...(ii)

From eq. (i) and (ii)

$$\frac{P_1}{P_2} = \frac{\left(\frac{V_0}{2} + Ax\right)^\gamma}{\left(\frac{V_0}{2} - Ax\right)^\gamma} \Rightarrow Ax = \frac{V_0}{2}\left[\frac{P_1^{1/\gamma} - P_2^{1/\gamma}}{P_1^{1/\gamma} + P_2^{1/\gamma}}\right]$$

Now from equation (i) $P_f = \frac{P_1\left(\frac{V_0}{2}\right)^\gamma}{\left[\frac{V_0}{2} + Ax\right]^\gamma}$

111 **(c)**

Change in internal energy

$dU = dQ - dW$

At constant pressure

$dU = C_p dT - p\,dV$

$= C_p dT - R\,dT$

$= \left(C_p - R\right) dT$

$= C_v\,dT$

$= \frac{R}{\gamma - 1} dT$

$= \frac{R}{\gamma - 1} \times \frac{pV}{R}$

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

112 **(c)**

As is known,

$$\frac{\text{slope of adiabatic curve}}{\text{slope of isothermal curve}} = \gamma = \frac{C_p}{C_v}$$

113 **(d)**

$T_1 = 200°\text{C} = 200 + 273 = 473\text{ K}$

$T_2 = 0°\text{C} = 0 + 273 = 273\text{ K}$

$\eta_1 = 1 - \frac{T_2}{T_1} = 1 - \frac{273}{473} = \frac{200}{473}$

Again, $T_1' = 0°\text{C} = (0 + 273)\text{K} = 273\text{ K}$

$T_2' = -200°\text{C} = (-200 + 273)\text{K} = 73\text{ K}$

$\eta_2 = 1 - \frac{T_2}{T_1'} = 1 - \frac{73}{273} = \frac{200}{273}$

$\frac{\eta_1}{\eta_2} = \frac{200}{473} \times \frac{273}{200} = \frac{273}{473} = \frac{1}{1.732}$

114 **(a)**

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

$= 6 \times 4.18 - 6 = 19.08kJ \approx 19.1kJ$

115 **(a)**

$\Delta Q = \Delta U + \Delta W \Rightarrow \frac{\Delta W}{\Delta Q} = 1 - \frac{\Delta U}{\Delta Q} = 1 - \frac{\mu C_V dT}{\mu C_P dT}$

$\Rightarrow \frac{\Delta W}{\Delta Q} = 1 - \frac{C_V}{C_P} = 1 - \frac{3}{5} = \frac{2}{5} = 0.4$

116 **(a)**

Below 150 K, hydrogen behaves as monoatomic gas

$\therefore$ For the mixture, $\gamma = \frac{1}{2}[\gamma_{\text{mono}} + \gamma_{\text{di}}] = \frac{1}{2}\left(\frac{5}{3} + \frac{7}{5}\right) = \frac{3}{2}$

117 **(c)**

$\eta_A = 1 - \frac{T_2}{T_1} = 1 - \frac{500}{1000} = \frac{1}{2}$

$\eta_B = 1 - \frac{T_2}{T_1} = 1 - \frac{400}{1100} = \frac{7}{11}$

Clearly, $\eta_A < \eta_B$

118 **(d)**

$PV^\gamma = \text{constant} \Rightarrow P\left(\frac{RT}{P}\right)^\gamma = \text{constant}$

119 **(d)**

According to first law of thermodynamics

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

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

Here $\Delta Q = 35J, \Delta W = -15J$

$\therefore\ \Delta U = 35J - (-15J) = 50J$

Note : ΔW is negative because work is done on the system

120 **(d)**

State of a thermodynamic system cannot determined by a single variable (P or V or T)

121 **(a)**

$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{100}{500} = 1 - \frac{T}{900}$

$\therefore \ \dfrac{T}{900} = \dfrac{1}{5}$ or T = 180 K

122 **(b)**

In first case $\eta_1 = \frac{T_1 - T_2}{T_1}$

In second case $\eta_2 = \frac{2T_1 - 2T_2}{2T_1} = \frac{T_1 - T_2}{T_1} = \eta$

123 **(b)**

Work done by the system = Area of shaded portion on P-V diagram

$= (300 - 100)10^{-6} \times (100 - 200) \times 10^3$

$= -20\,J$

124 **(d)**

In isothermal process, the internal energy of the system remains constant. Heat supplied in an isothermal change is used to do work against external surrounding or if the work is done on the system then equal amount of heat energy will be liberated by the system.

125 **(d)**

Change in internal energy (ΔU) depends upon initial and final state of the function while ΔQ and ΔW are path dependent

126 **(b)**

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1} \Rightarrow T_2 = 300\left(\frac{27}{8}\right)^{\frac{5}{3}-1} = 300\left(\frac{27}{8}\right)^{\frac{2}{3}}$$

$$= 300\left\{\left(\frac{27}{8}\right)^{1/3}\right\}^2 = 300\left(\frac{3}{2}\right)^2 = 675K$$

$\Rightarrow \Delta T = 675 - 300 = 375K$

127 **(a)**

From $\Delta Q = m\,C_p(\Delta T)$

$70 = 2 \times C_p \times (35 - 30),$

$\therefore\ C_p = 70/10 = 7\ \text{cal}\ (\text{mol}^\circ\text{C})^{-1}$

$C_v = C_p - R = 7 - 2 = \text{cal/mol}^\circ\text{C}$

$\Delta Q' = n\,C_v(\Delta T) = 2 \times 5 \times 5 = 50$ cal

129 **(b)**

$$W = \mu RT \log_e\left(\frac{V_2}{V_1}\right)$$

$= 0.2 \times 8.3 \times \log_e 2 \times (27 + 273)$

$= 0.2 \times 8.3 \times 300 \times 0.693 = 345J$

130 **(b)**

$dU = dQ - dW = 8 \times 10^5 - 6.5 \times 10^5$

$= 1.5 \times 10^5$ J

In the 2nd process, dU remains the same

$\therefore\ dW = dQ - dU = 10^5 - 1.5 \times 10^5$

$= -0.5 \times 10^5$ J

131 **(c)**

$\frac{V_1}{V_2} = \frac{T_1}{T_2} \Rightarrow \frac{V}{2V} = \frac{300}{T_2} \Rightarrow T_2 = 600 \Rightarrow \Delta T = 300$ Now,

$W = P\Delta V = \mu R\Delta T$

$\Rightarrow W = 0.1 \times 2 \times 300 = 60\ cal$

132 **(b)**

W_{AB} is negative (volume is decreasing) and W_{BC} is positive (volume is increasing) and Since, $|W_{BC}| > |W_{AB}|$

$\therefore$ net work done is positive and area between semicircle which is equal to $\frac{\pi}{2}\,atm - lt$

133 **(c)**

In isothermal process temperature remains constant

134 **(b)**

In isothermal process, temperature remains constant

135 **(c)**

Here $dQ = 50$ J, $dW = -15$ J

$dU = dQ - dW = 50 - (-15) = 65$ J

137 **(c)**

For monoatomic gas,

$C_v = \dfrac{3}{2}R = \dfrac{3}{2} \times 8.31\ \text{Jmol}^{-1\circ}\text{C}^{-1}$

$Q = 500$ J, $n = 4 \theta = ?$

$$\theta = \frac{Q}{nC_v} = \frac{500}{4 \times \frac{3}{2} \times 8.31} = 10^\circ\text{C}$$

138 **(b)**

First law of thermodynamics is infact, the law of conservation of energy.

139 **(a)**

$\eta = 1 - \frac{T_2}{T_1} \Rightarrow \frac{T_2}{T_1} = 1 - 2\eta = 1 - \frac{1}{6} = \frac{5}{6}$ ...(i)

in second case $\frac{T_2 - 62}{T_1} = 1 - \eta' = 1 - \frac{2}{6} = \frac{2}{3}$ ...(ii)

from Eqs. (i) and (ii)

now $T_2 - 62 = \frac{2}{3}T_1 = \frac{2}{3} \times \frac{6}{5}\,T_2$

$\Rightarrow\ T_2 = 310\ \text{K} = 310 - 273 = 37^\circ\text{C}$

$T_1 = \dfrac{6}{5}\,T_2 = \dfrac{6}{5} \times 310 = 372\ K = 372 - 273$

$= 99^\circ\text{C}$

140 **(d)**

$W = P\Delta V = 1.01 \times 10^5(3.34 - 2 \times 10^{-3})$

$= 337 \times 10^3 J = 340\ kJ$

141 **(c)**

Work done in expansion $= C_p - C_v = R$ Joule

142 **(c)**

$$\eta_A = \frac{T_1 - T_2}{T_1} = \frac{W_A}{Q_1} \Rightarrow \eta_B = \frac{T_2 - T_3}{T_2} = \frac{W_B}{Q_2}$$

$$\therefore \frac{Q_1}{Q_2} = \frac{T_1}{T_2} \times \frac{T_2 - T_3}{T_1 - T_2} = \frac{T_1}{T_2}\ \therefore W_A = W_B$$

$$\therefore T_2 = \frac{T_1 + T_3}{2} = \frac{800 + 300}{2} = 550K$$

143 **(c)**

Change in internal energy $\Delta U = \mu C_V \Delta T$

It doesn't depend upon type of process. Actually it is a state function

144 **(b)**

$\Delta W = P\Delta V = 10^3 \times 0.25 = 250\,J$

145 **(a)**

$\Delta E_{\text{int}} = 0$, for a complete cycle and for given cycle work done is negative, so from first law of thermodynamics Q will be negative, $i.e., Q < 0$

146 **(c)**

$$\Delta Q = \Delta U + \Delta W \Rightarrow \Delta W = (\Delta Q)_P - \Delta U$$

$$= (\Delta Q)_P \left[1 - \frac{(\Delta Q)_V}{(\Delta Q)_P}\right]$$

$$= (\Delta Q)_P \left[1 - \frac{C_V}{C_P}\right] = Q\left[1 - \frac{3}{5}\right] = \frac{2}{5}Q$$

$\because (\Delta Q)_P = Q$ and $\gamma = \frac{5}{3}$ for monoatomic gas

147 **(c)**

Given, $dQ = +200 \text{ cal} = 200 \times 4.2 = 840\text{ J}$

$dW = +40\text{J}$

From first law of thermodynamics

$dQ = dU + dW$

$dU = dQ - dW$

$=840\text{-}40=800$ J

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

148 **(b)**

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

$$dU = \frac{nRdT}{\frac{7}{5} - 1}$$

$$dU = \frac{5 \times 8.31 \times (400 - 0)}{\frac{7}{5} - 1} = 41550\text{ J}$$

$dU = 41.55$ kJ

149 **(c)**

For isothermal process

$dU = 0$ and work done $= dW = P[(V_2 - V_1)$

$$\because V_2 = \frac{V_1}{2} = \frac{V}{2} \;\therefore dW = -\frac{PV}{2}$$

150 **(a)**

For isothermal process $P_1V_1 = P_2V_2$

$$\Rightarrow P_2 = \frac{P_1V_1}{V_2} = \frac{72 \times 1000}{900} = 80\,cm$$

Stress $\Delta P = P_2 - P_1 = 80 - 72 = 8cm$

151 **(a)**

$$\eta_{\max} = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{400} = \frac{1}{4} = 25\%$$

So 26% efficiency is impossible

152 **(d)**

Here, $p = 4.5 \times 10^5$ Pa,

$dV = (2.0 - 0.5)\text{m}^3 = 1.5\text{ m}^3$

$dU = ?, dQ = 800\text{ kJ} = 8 \times 10^5\text{ J}$

$dW = pdV = 4.5 \times 10^5 \times 1.5 = 6.75 \times 10^5\text{ J}$

$dU = dQ - dW = 8 \times 10^5 - 6.75 \times 10^5$

$= 1.25 \times 10^5$ J

153 **(c)**

As $V = KT^{2/3} \;\therefore\; dV = K\frac{2}{3}T^{-1/3}\,dT$

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

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

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

154 **(a)**

Process 1 is isobaric ($p =$ constant) expansion

Hence, temperature of gas will increase

$\therefore\; \Delta U_1 =$ negative

Process 2 is an adiabatic expansion

$\therefore\; \Delta U_2 = 0$

Process 3 is an adiabatic expansion

Hence, temperature of gas will fall

$\therefore\; \Delta U_3 =$ constant

$\therefore\; \Delta U_1 > \Delta U_2 > \Delta U_3$

155 **(b)**

$\eta = 1 - \frac{T_2}{T_1}$ for 100%, efficiency $\eta = 1$ which gives

$T_2 = 0\,K$

156 **(b)**

Let the initial pressure of the three samples be P_A, P_B and P_C, then $P_A(V)^{3/2} = (2V)^{3/2}P, P_B = P$ and $P_C(V) = P(2V)$

$\Rightarrow P_A : P_B : PC = (2)^{3/2} : 1 : 2 = 2\sqrt{2} : 1 : 2$

158 **(c)**

$PV^\gamma =$ constant : Differentiating both sides

$$P_\gamma V^{\gamma-1}dV + V^\gamma dP = 0 \Rightarrow \frac{dP}{P} = -\gamma\frac{dV}{V}$$

159 **(c)**

From first law of thermodynamics

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

$\Rightarrow \quad mL = \Delta U + p(V_2 - V_1)$

$\Rightarrow \quad \Delta U = L - p(V_2 - V_1) \qquad (\because m = 1)$

160 **(d)**

Given, $T_1 = 600$ K, $T_2 = 450$ K and $W = 300$ J

Efficiency of Carnot engine

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

or $\frac{W}{Q} = 1 - \frac{T_2}{T_1}$

or $\frac{W}{Q} = 1 - \frac{450}{600}$

or $\frac{W}{Q} = \frac{1}{4}$

or $Q = 4W$

or $Q = 4 \times 300 \Rightarrow Q = 1200$ J

161 **(d)**

For all processes, change in internal energy $\Delta U(\Delta Q - \Delta W)$ does not change. It depends only on initial and final states.

162 **(d)**

$W = -\mu RT \log_e \frac{V_2}{V_1}$

$= -1 \times 8.31 \times (273 + 0) \log_e \left(\frac{22.4}{11.2}\right)$

$= -8.31 \times 273 \times \log_e 2 = -1572.5J$ [$\because \log_e 2 = 0.693$]

163 **(c)**

$\Delta Q = \Delta U + \Delta W = 167 + 333 = 500\ cal$

164 **(a)**

As no work is done and system is thermally insulated from surrounding, it means sum of internal energy of gas in two partitions is constant *ie*, $U = U_1 + U_2$

Assuming both gases have same degree of freedom, then

$$U = \frac{f(n_1 + n_2)RT}{2}$$

and $U_1 = \frac{fn_1RT_1}{2}$, $U_2 = \frac{fn_2RT_2}{2}$

Solving we get,

$$T = \frac{(p_1V_1 + p_2V_2)T_1T_2}{p_1V_1T_2 + p_2V_2T_1}$$

165 **(a)**

$\eta = 1 - \frac{T_2}{T_1} \Rightarrow \frac{70}{100} = 1 - \frac{T_2}{1000} \Rightarrow T_2 = 300\ K$

166 **(b)**

In isochoric process, volume remains constant

167 **(a)**

The work done=area of p-V graph

=area of triangle ABC

$= \frac{1}{2} \times 3p \times 2V = 3pV$

168 **(a)**

$\eta = 1 - \frac{T_2}{T} = 1 - \frac{300}{600} = \frac{1}{2} = 50\%$

170 **(a)**

Curve IV is parallel to volume axis. It represents isobaric curve. Out of II and III, slope of III is smaller. Therefore, III curve represents an isothermal curve

171 **(a)**

$\eta = \frac{T_1 - T_2}{T_1} = \frac{(127 + 273) - (87 + 273)}{(127 + 273)}$

$= \frac{400 - 360}{400} = 0.1 \rightarrow 10\%$

172 **(a)**

Initial and final states are same in all the process

Hence $\Delta U = 0$; in each case

By FLOT; $\Delta Q = \Delta W =$ Area enclosed by curve with volume axis

$\because (\text{Area})_1 < (\text{Area})_2 < (\text{Area})_3 \Rightarrow Q_1 < Q_2 < Q_3$

173 **(a)**

Efficiency of a heat engine, $\eta = 1 - \frac{T_2}{T_1}$

For $\eta = 1 (i.e., 100\%)$ either $T_1 = \infty$ or $T_2 = 0\ K$

As source at infinite temperature or sink at 0 K are not attainable, therefore heat engine cannot have efficiency 1

174 **(b)**

Input energy $= \frac{1g}{s} \times \frac{2kcal}{g} = 2kcal/s$

Output energy $= 10\ kW = 10\ K\ J/S = \frac{10}{4.2} kcal/s$

$\Rightarrow \eta = \frac{\text{output energy}}{\text{input energy}} = \frac{10}{4.2 \times 2} > 1$, it is impossible

175 **(a)**

For adiabatic process $T_1V_b^{\gamma-1} =$ Constant

For bc curve $T_1V_b^{\gamma-1} = T_2V_c^{\gamma-1}$ or $\frac{T_2}{T_1} = \left(\frac{V_b}{V_c}\right)^{\gamma-1}$ ...(i)

For ad curve $T_1V_a^{\gamma-1} = T_2V_d^{\gamma-1}$ or $\frac{T_2}{T_1} = \left(\frac{V_a}{V_d}\right)^{\gamma-1}$ ...(ii)

From equation (i) and (ii) $\frac{V_b}{V_c} = \frac{V_a}{V_d}$

176 **(c)**

This is the case of free expansion of gas. In free expansion $\Delta U = 0 \Rightarrow$ Temp. remains same

177 **(c)**

As $C_p/C_V = \gamma$

$$\therefore \frac{C_p - C_v}{C_v}\gamma - 1$$

or $C_v = \frac{C_p - C_v}{\gamma - 1} = \frac{R}{\gamma - 1}$

$$\Delta U = nC_v dT = n\frac{RdT}{(\gamma - 1)} = \frac{npdV}{\gamma - 1}$$

$$= \frac{np(2V - V)}{\gamma - 1} = \frac{npV}{\gamma - 1}$$

As $n = 1$,

$$\therefore\ \Delta U = \frac{pV}{(\gamma - 1)}$$

178 **(c)**

$$dU = dQ - dW = mL - p(dV)$$

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

$$= 540 - 40 = 500 \text{ cal}$$

179 **(c)**

Maximum value of efficiency

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{500} = \frac{2}{5}$$

As $\eta = \frac{W}{Q_1}$

$$W = \eta Q_1 = \frac{2}{5} \times 1000 \text{ cal}$$

$$= 400 \times 4.2 \text{ J} = 1680 \text{ J}$$

As no engine can produce more than 1680 J, disigns A and B are not possible.

180 **(c)**

$$\Delta Q = \mu C_P \Delta T = \frac{7}{2}\mu R \Delta T \quad \left[C_P = \frac{7}{2}R\right]$$

$$\Delta U = \mu C_V \Delta T = \frac{5}{2}\mu R \Delta T \quad \left[C_V = \frac{5}{2}R\right]$$

and $\Delta W = \Delta Q - \Delta U = \mu R \Delta T$

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

181 **(b)**

As slope of adiabatic AC is more than the slope of isothermal AB, and BC is isochoric (*ie* at constant volume), therefore, figure (b) represents the curves correctly

182 **(d)**

In isothermal process $\Delta Q \neq 0$

183 **(c)**

Coefficient of performance

$$K = \frac{T_2}{T_1 - T_2} = \frac{273}{303 - 273} = \frac{273}{30} = 9.1 \approx 9$$

184 **(d)**

Process CD is isochoric as volume is constant, process DA is isothermal as temperature constant and process AB is isobaric as pressure is constant

186 **(c)**

Heat required to change the temperature of vessel by a small amount dT

$$-dQ = mC_P dT$$

Total heat required

$$-Q = m\int_{20}^{4} 32\left(\frac{T}{400}\right)^3 dT$$

$$= \frac{100 \times 10^{-3} \times 32}{(400)^3}\left[\frac{T^4}{4}\right]_{20}^{4}$$

$\Rightarrow$ $Q = 0.001996$ kJ

Work done required to maintain the temperature of sink to T_2

$$W = Q_1 - Q_2$$

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

$$= \left(\frac{T_1}{T_2} - 1\right) Q_2$$

$$\Rightarrow \quad W = \left(\frac{T_1 - T_2}{T_2}\right) Q_2$$

For $T_2 = 20\ K$

$$W_1 = \frac{300 - 20}{20} \times 0.001996$$

$$= 0.028 \text{ kJ}$$

For $T_2 = 4$ K

$$W_2 = \frac{300 - 4}{4} \times 0.001996$$

$$= 0.148 \text{ kJ}$$

As temperature is changing from 20 K to 4 K, work done required will be more than W_1 but less than W_2.

187 **(c)**

$$\frac{T_2}{T_1} = \frac{V_2}{V_1} = 2 \Rightarrow T_2 = 2 \times T_1 = 2 \times 300 = 600K$$

$$= 327°\text{C}$$

188 **(b)**

$$\frac{dU}{dQ}=\frac{C_v dT}{C_p dT}=\frac{C_v}{C_p}=\frac{(3/2)R}{(5/2)R}=\frac{3}{5}$$

189 **(c)**

For an adiabatic process,

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

$$\Rightarrow \quad T_2=T_1\left[\frac{V_1}{V_2}\right]^{\gamma-1}$$

$$=(273+18)\left[\frac{V}{V/8}\right]^{0.4}=668\text{ K}$$

190 **(b)**

Work done during the cycle

=area enclosed by p-Vgraph

=area of ▭ ABCD

$=AD\times CD$

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

191 **(c)**

When heat is supplied at constant pressure, a part of it goes in the expansion of gas and remaining part is used to increase the temperature of the gas which in turn increases the internal energy

192 **(c)**

For isothermal process $PV=RT\ \Rightarrow P=\frac{RT}{V}$

$\therefore W=PdV=\int_{V_1}^{V_2}\frac{RT}{V}dV=RT\log_e\frac{V_2}{V_1}$

193 **(c)**

A is compressed isothermally, hence

$P_1V=P_2\frac{V}{2}\Rightarrow P_2=2P_1$

and B is compressed adiabatically, hence

$P'_1V^\gamma=P'_2\left(\frac{V}{2}\right)^\gamma\ \Rightarrow P'_2=(2)^\gamma P'_1$

Since $\gamma>1$, hence $P_2'>P_2$ or $P_2<P_2'$

194 **(d)**

Here, $p=1$ atm, $T_1=27$°C

$=27+273=300$ K

$p_2=8$ atm, $T_2=?,\gamma=3/2$

As changes are adiabatic,

$\therefore\ \ p_{1^{\gamma-1}}T_1^{-\gamma}=p_2^{\gamma-1}T_2^{-\gamma}$

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

$T_2-T_1\left(\frac{p_1}{p_2}\right)^{\gamma-1/\gamma}=300(8)^{(1.5-1)/1.5}=300(8)^{1/3}$

$T=600\text{K}=(600-273)°\text{C}=327°\text{C}$

196 **(b)**

The efficiency of cycle is

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

For adiabatic process

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

For diatomic gas $\gamma=\frac{7}{5}$

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

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

$$T_1=T_2(32)^{\frac{7}{5}-1}=T_2(2^5)^{2/5}=T_2\times4$$

$$T_1=4T_2$$

$$\eta=\left(1-\frac{1}{4}\right)=\frac{3}{4}=0.75$$

197 **(d)**

Work done = Area under curve = $\frac{6P_1\times3V_1}{2}=9\,P_1V_1$

198 **(d)**

In adiabatic operation (eg, bursing of tyre)

$p_2^{(1-\gamma)}T_2^\gamma=p_1^{(1-\gamma)}T_1^\gamma$

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

$=300\left(\frac{4}{1}\right)^{\left(\frac{1-7/5}{7/5}\right)}=300(4)^{-2/7}$

199 **(a)**

In isothermal compression, there is always an increase of heat which must flow out of the gas

$\Delta Q=\Delta U+\Delta W\Rightarrow\Delta Q=\Delta W\ [\because\Delta U=0]$

$\Rightarrow\ \Delta Q=-1.5\times10^4J=\frac{1.5\times10^4}{4.18}cal$

$=-3.6\times10^3cal$

200 **(a)**

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

$\therefore\frac{T_1}{T_2}=\left(\frac{V_2}{V_1}\right)^{\gamma-1}$ or $\left(\frac{1}{2}\right)^{\gamma-1}=\sqrt{\frac{1}{2}}$

$\therefore\ \gamma-1=\frac{1}{2}$ or $\gamma=\frac{3}{2}\quad\therefore PV^{3/2}=\text{constant}$

201 **(a)**

In isothermal process, compressibility $E_\theta=P$

202 **(a)**

Ideal gas possess only kinetic energy

203 **(b)**

$C_v-C_p-R=207-8.3=198.7$ J

204 **(d)**

In all given cases, process is cyclic and in cyclic process $\Delta U = 0$

205 **(b)**

$\eta = 1 - \frac{T_2}{T_1} \Rightarrow \frac{1}{2} = 1 - \frac{500}{T_1} \Rightarrow \frac{500}{T_1} = \frac{1}{2}$ ...(i)

$\frac{60}{100} = 1 - \frac{T_2'}{T_1} \Rightarrow \frac{T_2'}{T_1} = \frac{2}{5}$ ...(ii)

Dividing equation (i) by (ii)

$\frac{500}{T_2{}'} = \frac{5}{4} \Rightarrow T_2' = 400K$

206 **(a)**

Efficiency of Carnot's heat engine, $\eta = 1 - \frac{T_2}{T_1}$

Efficiency remains same when both T_1 and T_2 are increased by same factor.

207 **(c)**

Here, $V_1 = 1\text{ L} = 10^{-3}\text{ m}^3, \text{V}_2 = 3\text{L} = 3 \times 10^{-3}\text{m}^3$

$p_1 = 1\text{ atm} = 1.013 \times 10^5 \text{Nm}^{-2}, \gamma = 1.40, W = ?$

As changes are adiabatic,

$p_1 V_1^\gamma = p_2 V_2^\gamma$

$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^\gamma = (3)^{1.4} = 4.6555$

$\therefore \; p_2 = \frac{p_1}{4.6555} = \frac{1.013 \times 10^5}{4.6555}$

$= 0.217 \times 10^5 \text{ Nm}^{-2}$

Work done$= \frac{p_1 V_1 - p_2 V_2}{\gamma - 1}$

$= \frac{1.013 \times 10^5 \times 10^{-3} - 0.217 \times 10^5 \times 3 \times 10^{-3}}{1.4 - 1}$

$= 90.5 \text{ J}$

208 **(a)**

An isothermal process is a constant temperature process. In this process, $T =$ constant or $\Delta T = 0$.

$$\therefore \qquad \Delta U = nC_V \, \Delta T = 0$$

An adiabatic process is defined as one with no heat transfer into or out of a system. Therefore, $\Delta Q = 0$. From the first law of thermodynamics.

$$W = -\Delta U$$

or $$\Delta U = -W$$

209 **(c)**

While working refrigerator reject heat from its inside into the room continuously to keep it cool inside. Now, if the door of the refrigerator is open the heat rejected will be more than that in the previous case. So, the room temperature in this case will be more than the temperature when the door of the refrigerator is closed. Hence, room temperature will increase gradually.

210 **(d)**

The amount of work done in the isothermal cycle is higher than in the adiabatic cycle, because the area under the isothermal curve is larger than the area under the adiabatic curve. Hence, the curves are isothermal for A and C, while adiabatic for B and D.

211 **(a)**

In adiabatic expansion, $dQ = 0$,

$\therefore dW = -dU = -(-50 \text{ J}) = 50 \text{ J}$

213 **(c)**

In adiabatic process $PV^\gamma =$ constant

$\Rightarrow \left(\frac{RT}{V}\right) V^\gamma = \text{constant} \Rightarrow TV^{\gamma-1} = \text{constant}$

214 **(d)**

The change in entropy of an ideal gas

$$\Delta S = \frac{\Delta Q}{T} \qquad \text{...(i)}$$

In isothermal process, there is no change in internal energy of gas *ie*, $\Delta U = 0$

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

$\Rightarrow \quad 0 = \Delta Q - W$

$\Rightarrow \quad \Delta Q = W$

$\therefore$ $\Delta Q =$work done by gas in isothermal process which went through from (p_1, V_1, T) to (p_2, V_2, T)

or $\Delta Q = nRT \log_e \left(\frac{V_2}{V_1}\right)$ ...(ii)

For 1 mole of an ideal gas, n=1

So, from Eqs.(i) and (ii), we get

$\Delta S = R \log_e \left(\frac{V_2}{V_1}\right)$

$= R \text{ In} \left(\frac{V_2}{V_1}\right)$

215 **(c)**

For adiabatic process, Poisson's equation is given by

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

Ideal gas relation is

$pV = RT$

$\Rightarrow \quad V = \frac{RT}{p}$ ---(ii)

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

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

$\Rightarrow \frac{T^{\gamma}}{p^{\gamma-1}} = \text{constant}$ ---(iii)

Where γ is ratio of specific heats of the gas.

Given, $p \propto T^{C}$ ---(iv)

On comparing with Eq. (iii), we have

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

For a monoatomic gas $\gamma = \frac{5}{3}$

We have

$$C = \frac{\frac{5}{3}}{\frac{5}{3} - 1} = \frac{5}{2}$$

216 **(d)**

Slope of $p - V$ graph of adiabatics $= \gamma p/V$

Slope of $p - V$ graph of isothermal $= p/V$

Required ratio $= \gamma$

217 **(c)**

$V \propto T$ at constant pressure

$$\Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2} \Rightarrow V_2 = \frac{V_1 T_2}{T_1} = \frac{300 \times 280}{300} = 280\ ml$$

218 **(d)**

$$\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{40}{100} = \frac{3}{5}$$

$$\therefore\ T_1 = \frac{5}{3} T_2 = \frac{5}{3} \times 300 = 500\text{K}$$

Increase in efficiency = 50% of 40% = 20%

$\therefore$ New efficiency $\eta' = 40 + 20 = 60\%$

$$\therefore\ \frac{T_2}{T'_1} = 1 - \eta' = 1 - \frac{60}{100} = \frac{2}{5}$$

$$T_1' = \frac{5}{2} \times 300 = 750\text{ K}$$

Increase in temperature of source $= T_1' - T_1$

$= 750 - 500 = 250$ K

219 **(a)**

$T_2 = 27°\text{C} = (27 + 273)\text{K} = 300$ K, $\eta = 25\% = \frac{1}{4}$

We know that, $\eta = 1 - \frac{T_2}{T_1}$

$$\Rightarrow \quad \frac{1}{4} = 1 - \frac{300}{T_1}$$

or $\frac{300}{T_1} = 1 - \frac{1}{4}$

$\Rightarrow \frac{300}{T_1} = \frac{3}{4}$

or $T_1 = \frac{300 \times 4}{3}$

$\Rightarrow T_1 = 400\ k$

or $T_1 = (400 - 273)°\text{C} = 127°\text{C}$

220 **(a)**

Work done $= P\Delta V = P(V_2 - V_1)$

221 **(d)**

$$\eta_1 = \frac{T_1 - T_2}{T_1} = \frac{(t_1 + 273) - (t_2 + 273)}{t_1 + 273}$$

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

222 **(d)**

$$\frac{1}{2} M v^2 = C_V . \Delta T$$

$$\frac{1}{2} M v^2 = \frac{R}{\gamma - 1} . \Delta T \Rightarrow \Delta T = \frac{M . v^2 (\gamma - 1)}{2R}$$

$$= \frac{(\gamma - 1) M v^2}{2R}$$

223 **(b)**

Slope of adiabatic curve $= \gamma \times$ (Slope of isothermal curve)

224 **(d)**

In adiabatic compression temperature and hence internal energy of the gas increases. In compression pressure will increase.

225 **(a)**

From first law of thermodynamics,

$$Q = \Delta U + W$$

For path *iaf,*

$50 = \Delta U + 20$

$\therefore \quad \Delta U = U_f - U_i = 30$ cal

For path *ibf,*

$Q = \Delta U + W$

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

=36-30=6cal

226 **(b)**

Differentiate PV = constant $w.r.t.V$

$$\Rightarrow P\Delta V + V\Delta P = 0 \Rightarrow \frac{\Delta P}{P} = -\frac{\Delta V}{V}$$

227 **(c)**

$$K_a = \gamma p = -\frac{\Delta p}{\Delta V/V}$$

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

228 **(a)**

$\Delta W_{AB} = p\Delta V = 10(2-1) = 10\text{J}$

$\Delta W_{BC} = 0$, becuase V is constant,

From first law of thermodynamics,

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

As $ABCA$ is a cyclic process, therefore,

$\Delta U = 0$

$\therefore \ \Delta Q = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$

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

or $\ \Delta W_{CA} = \Delta Q - \Delta W_{AB} = 5 - 10 = -5\text{ J}$

229 **(c)**

Efficiency, $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{500}{800}$

$$= \frac{3}{8} = 0.375$$

230 **(b)**

$\Delta Q = \Delta U + \Delta W = mC_v(\Delta T) + p(\Delta V)$

231 **(b)**

For monoatomic gas,

$$C_P = \frac{5}{2}R$$

And $\quad C_V = \frac{3}{2}R$

For diatomic gas,

$$C_P = \frac{7}{2}R$$

and $\quad C_V = \frac{5}{2}R$

232 **(d)**

$E_\phi = \gamma P = 1.4 \times (1 \times 10^5) = 1.4 \times 10^5 N/m^2$

233 **(a)**

Efficiency of all reversible cycles depends upon temperature of source and sink which will be different.

234 **(a)**

Here, for hydrogen $C_p - C_v = m = \frac{R}{2}$

Or $\ R = 2m$

And for nitrogen, $C_p - C_v = n = \frac{R}{28}$ or $R = 28\,n$

$\therefore \ 2m = 28n$

$m = 14n$

235 **(c)**

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^\gamma \Rightarrow \frac{P'}{P} = (8)^{5/2} \Rightarrow P' = P \times (2)^{15/2}$$

236 **(a)**

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

where, T_2 =sink temperature,

T_1 =source temperature.

For 100% efficiency, $\eta = 1$

$$\therefore \qquad \frac{T_2}{T_1} = 0$$

$\Rightarrow \ $ Either $T_1 = 0\text{ K}\ T_2 = 0\text{ K}$

237 **(c)**

$dW = dU = \mu C_v \Delta T = -C_v(T_2 - T_1) = C_v(T_1 - T_2)$

238 **(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

239 **(d)**

Here, $\gamma = 1.5, V_2 = \frac{1}{4}V_1; \frac{p_2}{p_1} = ?$

As compression is sudden/adiabatic,

$\therefore \ p_2V_2^\gamma = p_1V_1^\gamma$

$$\frac{p_2}{p_1} = \left(\frac{V_1}{V_2}\right)^\gamma = (4)^{1.5} = 8$$

240 **(c)**

$W_{AB} = -P_0V_0, W_{BC} = 0$ and $W_{CD} = 4P_0V_0$

$\Rightarrow W_{ABCD} = -P_0V_0 + 0 + 4P_0V_0 = 3P_0V_0$

241 **(a)**

$Q_2 = 2000$ cal. As COP $= \frac{Q_2}{W}$

$\therefore \ 4 = 2000/W$

$W = 500\text{ cal} = 500 \times 4.2 = 2100\text{ J}$

242 **(d)**

$dQ = 400\text{ cal}, dW = -105\text{ J}$

$= 105/4.2\text{ cal} = -25\text{ cal}\ ; dU = ?$

$dU = dQ - dW$

$dU = 400 - (-25) = 425\text{ cal}$

Note dW is negative because work is done on the system

243 **(a)**

$E_\theta = P$

244 **(a)**

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

$T_2 = -123 + 273 = 150\text{ K}$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{150}{300} = 0.5$$

245 **(a)**

This is the case of free expansion and in the case $\Delta W = 0, \Delta U = 0$ so temperature remains same, $i.e., 300\ K$

246 **(a)**

An isothermal process that takes place at constant temperature, must be carried out in a vessel with conducting wall so that heat generated should go cut at once

247 **(c)**

As $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$ $\therefore T_2 = \frac{Q_2}{Q_1} \times T_1 = \frac{150}{200} \times 400 = 300$ K

248 **(a)**

$\Delta W_{AB} = 0$ as $V =$ constant

$\therefore \Delta Q_{AB} = \Delta U_{AB} = 50J$ [Given]

$U_A = 1500J$

$\therefore U_B = (1500 + 50)J = 1550J$

$\Delta W_{BC} = -\Delta U_{BC} = -40J$ [Given]

$\therefore \Delta U_{BC} = 40J$

$\therefore U_C = (1550 + 40)J = 1590J$

249 **(d)**

In case of gases whatever be the process

$$\Delta U = nC_V \Delta T$$

or $\Delta U = n\Delta\left(\frac{R}{\gamma-1}\right)$ -------(i)

$$pV = nRT_1$$

$$2pV = nRT_2$$

$$\Rightarrow \quad pV = nR(T_2 - T_1)$$

$$\frac{pV}{R} = n\Delta T \qquad (T_2 - T_1 < \Delta T)$$

Substituting in Eq. (i)

$$\Delta U = \frac{pV}{(\gamma - 1)}$$

250 **(a)**

During free expansion of a perfect gas no work is done and also no heat is supplied from outside. Therefore, no change in internal energy. Hence, temperature remains constant

251 **(c)**

$$\Delta C = \Delta U + \Delta W \because \Delta W = 0 \Rightarrow \Delta Q = \Delta U = \frac{f}{2}\mu R \Delta T$$

$$= \frac{3}{2} \times 2R(373 - 273) = 300R$$

252 **(a)**

For an isothermal process $PV =$ constant

$$\Rightarrow PdV + VdP = 0 \Rightarrow -\frac{1}{V}\left(\frac{dV}{dP}\right) = \frac{1}{P}$$

So, $\beta = \frac{1}{P}$ $\therefore$ graph will be rectangular hyperbola

253 **(b)**

According to I$^{\text{st}}$ law of Thermodynamics

$\Delta Q = \Delta U + \Delta W$, in adiabatic process $\Delta Q = 0$

$0 = \Delta U - \Delta W$ (Work done on the system –Ve)

$\Delta U = +\Delta W = +22.3$

[$\therefore$ Work done on the system $\therefore$ internal energy increases]

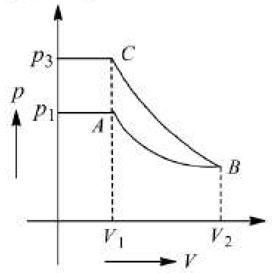
In 2$^{\text{nd}}$ process $\Delta Q = \Delta U + \Delta W$

$9.35 \times 4.18 = 22.3 + \Delta W$

Work done by system $\Delta W = 16.95$

254 **(c)**

As slope of adiabatic process at a given state is more than the slope of isothermal process, therefore, in figure AB is an isotherm and BC is an adiabat



In going from A to B, volume is increasing

$\therefore W_{AB} =$positive

In going from B to C volume is decreasing

$\therefore W_{BC} =$negative

As work done is area under $p - V$ graph, therefore,

$|W_{BC}| > |W_{AB}|$

$\therefore W = W_{AB} + W_{BC} =$ Negative $ie\ W < 0$

From the graph, it is clear that $p_3 > p_1$. Choice (c) is correct

255 **(b)**

Since the gas is enclosed in a vessel, therefore, during heating process, volume of the gas remains constant. Hence, no work is done by the gas. It means heat supplied to the gas is used to increase its internal energy only

Initial internal energy of the gas is $U_1 = N\left(\frac{5}{2}R\right)T$

Since n moles get dissociated into atoms, therefore, after heating, vessel contains $(N - n)$ moles of diatomic gas and $2n$ moles of a monoatomic gas. Hence the internal energy for the gas, after heating, will be equal to

$$U_2 = (N - n)\left(\frac{5}{2}R\right)T + 2n\left(\frac{3}{2}R\right)T$$

$$= \frac{5}{2}NRT + \frac{1}{2}nRT$$

Hence, the heat supplied = increase in internal energy

$= (U_2 - U_1) = \frac{1}{2}nRT$

256 **(c)**

$\Delta Q = \Delta U + \Delta W = \left(U_f - U_i\right) + \Delta W$

$\Rightarrow -30 = \left(U_f - 30\right) - 10 \Rightarrow U_f = 10\,J$

257 **(b)**

Work done =area of trapezium

$= \frac{1}{2} \times (8 \times 10^5 + 4 \times 10^5) \times 0.2 = 1.2 \times 10^5$J

258 **(c)**

$T_2 = 0°\text{C} = 273\text{ K},$

$T_1 = 17°\text{C} = 17 + 273 = 290\text{ K}$

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

$$\frac{80 \times 1000 \times 4.2}{W} = \frac{273}{290 - 273} = \frac{273}{17}$$

$$\therefore \quad W = \frac{80 \times 1000 \times 4.2 \times 17}{273}\text{J}$$

$$\text{or} \quad W = \frac{33.6 \times 17 \times 10^4}{273 \times 3.6 \times 10^5}\text{ kWh}$$

$=0.058$ kWh

259 **(c)**

From $p_1V_1^\gamma = p_1V_2^\gamma$

$\frac{p_2}{p_1} = \left(\frac{V_1}{V_2}\right)^\gamma = \left(\frac{\rho_2}{\rho_1}\right)^\gamma$

$= (32)^{7/5} = (2^5)^{7/5} = 2^7 = 128$

$\therefore \frac{P_2}{P_1} = \frac{P}{P} = 128$

260 **(b)**

From first law of thermodynamics,

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

$\therefore \Delta U_1 = Q_1 - W_1 = 6000 - 2500 = 3500J$

$\Delta U_2 = Q_2 - W_2 = -5500 + 1000 = -4500J$

$\Delta U_3 = Q_3 - W_3 = -3000 + 1200 = -1800J$

$\Delta U_4 = Q_4 - W_4 = 3500 - x$

For cyclic process, $\Delta U = 0$

$\therefore 3500 - 4500 - 1800 + 3500 - x = 0 \Rightarrow x = 700J$

Efficiency, $\eta = \frac{output}{input} \times 100$

$= \frac{W_1 + W_2 + W_3 + W_4}{Q_1 + Q_4} \times 100 = \frac{1000}{9500} \times 100 \Rightarrow \eta = 10.5\%$

261 **(b)**

In a refrigerator, the heat dissipated in the atmosphere is more than that taken from the cooling chamber, therefore the room is heated if the door of a refrigerator is kept open

263 **(c)**

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{(47 + 273)}{(127 + 273)} = 1 - \frac{320}{400} = \frac{1}{5}$$
$$= 20\%$$

265 **(b)**

For adiabatic process $\Delta Q = 0$

From $\Delta Q = \Delta U + \Delta W \Rightarrow 0 = \Delta U - 90 \Rightarrow \Delta U = +90J$

266 **(b)**

Here, $dQ = 110\text{ J}, dU = 40\text{ J}, dW = ?$

From $dQ = dU + dW$

$dW = dQ - dU = 110 - 40 = 70\text{ J}$

268 **(a)**

In cyclic process $\Delta U = 0$

So heat absorbed

$\Delta Q = W =$ Area under the curve

$= -(2V)(P) = -2PV$

So heat rejected $= 2PV$

269 **(a)**

The given relation is $p = \frac{\alpha T^2}{V} \quad \therefore \quad V = \frac{\alpha T^2}{P}$

As pressure is kept constant, $dV = \left(\frac{2\alpha T}{P}\right) dT$

$$W = \int p\, dV = \int_{T_0}^{2T_0} p\left(\frac{2\alpha T}{p}\right) dT$$

$$= 2\alpha \left[\frac{T^2}{2}\right]_{T_0}^{2T_0} = 3\alpha T_0^2$$

270 **(c)**

For vacuum, pressure p=0

Hence, work done $= p\Delta V = 0$

According to first law of thermodynamics

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

$$\therefore \qquad Q = \Delta U$$

Hence the gas undergoes neither an increase nor a decrease in its temperature or internal energy.

271 **(c)**

From, first law of thermodynamics

$dQ = dU + p\, dV$ ------(i)

According to the question when gas expands, its internal energy decreases.

So, from Eq. (i) dQ remains constant

Hence, the process is adiabatic.

272 **(c)**

The internal energy U of a thermodynamic system is a characteristic property of the state of the system, it does not matter, how that state has been obtained U is a unique function because it depends only upon the state of the system.

273 **(c)**

Process AB is isochoric, $\therefore W_{AB} = P\,\Delta V = 0$

Process BC is isothermal $\therefore W_{BC} = RT_2 . \ln\left(\frac{V_2}{V_1}\right)$

Process CA is isobaric

$\therefore W_{CA} = P\Delta V = R\Delta T = R(T_1 - T_2)$

[Negative sign is taken because of compression]

274 **(a)**

For isochoric process $\Delta V = 0 \Rightarrow \Delta W = 0$

From FLOT $\Delta Q = \Delta U + \Delta W \Rightarrow \Delta Q = \Delta U$

275 **(b)**

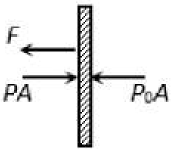
Volume of the gas is constant $V =$ constant $\therefore P \propto T$

i.e., pressure will be doubled if temperature is doubled

$\therefore P = 2P_0$

Now let F be the tension in the wire. Then equilibrium of any one piston gives

$F = (P - P_0)A = (2P_0 - P_0)A = P_0A$



276 **(d)**

$\Delta Q = \Delta U + \Delta W$; ΔU does not depend upon path

$\because \Delta W_A > \Delta W_B \Rightarrow \Delta Q_A > \Delta Q_B$

277 **(d)**

From $\eta = 1 - \frac{T_2}{T_1} \Rightarrow \frac{T_2}{T_1} = 1 - \eta = 1 - \frac{400}{100} = \frac{3}{5}$

$\therefore \;\; T_2 = \frac{3}{5}T_1 = \frac{3}{5} \times 500 = 300 \text{ K}$

Again $\frac{T_2}{T_1'} = 1 - \eta$ or $\frac{300}{T_1'} = 1 - \frac{50}{100} = \frac{1}{2}$

or $T_1 = 600$ K

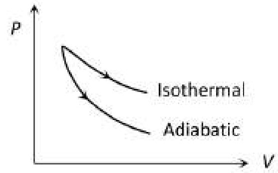
278 **(a)**

In thermodynamic process

Work done = Area covered by PV diagram with V-axis

From graph it is clear that $(\text{Area})_{iso} > (\text{Area})_{adi}$

$\Rightarrow W_{iso} > W_{adi}$



279 **(c)**

For Isothermal process $PV =$ constant

$\Rightarrow \left(\frac{dP}{dV}\right) = \frac{-P}{V} =$ Slope of Isothermal curve

For adiabatic $PV^{\gamma} =$ constant

$\Rightarrow \frac{dP}{dV} = \frac{-\gamma P}{V} =$ Slope of adiabatic curve

Clearly, $\left(\frac{dP}{dV}\right)_{\text{adibatic}} = \gamma\left(\frac{dP}{dV}\right)_{\text{Isothermal}}$

280 **(c)**

For all thermodynamic purposes, the state of a system can be represented by specifying its pressure p, volume V and the temperature T provided the system is in equilibrium.

281 **(c)**

For monatomic gas, $\eta = \frac{5}{3} = 1.67$

And for diatomic gas $\eta = \frac{7}{5} = 1.40$

As actual $\gamma = 1.5$. Therefore, gas must be a mixture of monoatomic and diatomic gases

282 **(d)**

Under isothermal conditions, $T =$constant

$\therefore$ Internal energy =constant *ie*, change in internal energy is zero

283 **(a)**

For heat engine, $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$

$$\Rightarrow \quad Q_2 = \frac{T_2 Q_1}{T_1}$$

$$= \frac{375 \times 600}{500} = 450 \text{ J}$$

284 **(a)**

In p-V diagrams process AB is isobaric process in which pressure remains constant *ie*, p=constant at all temperatures.

Process BC is isothermal process in which, temperature remains constant *ie*, T=constant.

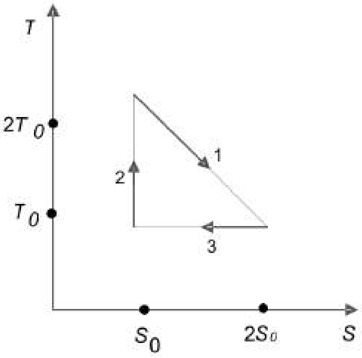
Process CD is isochoric process in which volume remains constant *ie*, p-T diagram CD is a straight line passing through origin.

Process AD is adiabatice process which corresponds to process AD in p-T diagram.

Hence, the correct p-T diagram is shown in option (a).

285 **(c)**

According to the figure



$$Q_1 = T_0S_0 + \frac{1}{2}T_0S_0 = \frac{3}{2}T_0S_0$$

$$Q_2 = T_0(2S_0 - S_0) = T_0S_0$$

$$Q_3 = 0$$

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

$$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{2}{3}$$

$$= \frac{1}{3}$$

286 **(b)**

$0.8 \times 5 = P \times (3 + 5) \Rightarrow P = 0.5\,m$

287 **(d)**

$T_2 = 27 + 273 = 300\text{ K}, \eta = 37.5\%$

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

$\therefore \frac{37.5}{100} = 1 - \frac{300}{T_1}$

Or $\frac{300}{T_1} = \frac{62.5}{100} = \frac{5}{8}$

$T_1 = \frac{2400}{5} = 480\text{ K} = 480 - 273 = 207°\text{C}$

288 **(d)**

In an ideal gas, the internal energy depends only upon the temperature of the gas. When an ideal gas undergoes an isothermal change, there is no change in its internal energy ($\Delta U = 0$)

From first law of thermodynamics

$\Delta U = Q - W$

For isothermal change $\Delta U = 0$

$$\therefore \qquad Q = W$$

Hence, in an isothermal process in an ideal gas the heat absorbed by the gas is entirely used in the work done by the gas.

289 **(a)**

$dU = -100$ J, in adiabatic expansion

$\therefore\ dW = -dU = 100$ J

290 **(a)**

With rise in temperature, internal energy also increases

291 **(b)**

An adiabatic change involves a fall or rise in temperature of the system. If a gas expands under adiabatic conditions, its temperature falls.

292 **(d)**

As initial and final states in the two processes are same. Therefore, $\Delta U_1 = \Delta U_2$. As area under curve $a >$ area under curve b, therefore, $\Delta W_1 > \Delta W_2$

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

$\therefore\ \Delta Q_1 > \Delta Q_2$

293 **(a)**

$E_\theta = P = 1.013 \times 10^5 N/m^2$

294 **(d)**

Internal energy $U =$ number of moles $\times$ number of degrees of freedom $\times \frac{1}{2}RT$

out of four cases, product of number of moles (1000) degrees of freedom (3) and $T(= 900\text{ K})$ is maximum for argon gas

295 **(c)**

For a non-linear triatomic gas, $C_v = 3\,R$

And for a monoatomic gas, $C_v{}' = \frac{3}{2}R$

$$\therefore\ \frac{Q}{Q'} = \frac{C_v}{C_v{}'} = K = \frac{3R}{\frac{3}{2}R} = 2$$

296 **(c)**

According to FLOT

$\Delta Q = \Delta U + P(\Delta V) \Rightarrow \Delta U = \Delta Q - P(\Delta V)$

$= 1500 - (2.1 \times 10^5)(2.5 \times 10^{-3}) = 975\ joule$

297 **(c)**

For isochoric process, internal energy

$\Delta U = nC_V\Delta T = 420\text{J}$

Molar specific heat $C_V = \frac{\Delta U}{n\Delta T}$

$$= \frac{420}{2 \times 10} = 21\text{ JK}^{-1}\text{mol}^{-1}$$

298 **(b)**

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

$\Delta U = (-20) - (-8) = -12$ J

$\Delta U = U_f - U_i = -12$

$\therefore\ U_f = -12 + U_1 = -12 + 30 = 18\text{ J}$

299 **(b)**

In an adiabatic process, $pV^{\gamma} =$ constant

Put $V = \frac{RT}{p}$

$\frac{pR^{\gamma}T^{\gamma}}{p^{\gamma}}$ =constant

$\therefore p^{1-\gamma}T^{\gamma}$ =constant

$p \propto T^{\gamma/\gamma-1}$

$\therefore\ \dfrac{\gamma}{\gamma-1} = 3$

$3\gamma - 3 = \gamma$

$2\gamma = 3$

$\gamma = \dfrac{3}{2}$

300 **(b)**

In isochoric process the volume remains constant.

301 **(c)**

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

$\therefore\ p_2 = p_1\left(\dfrac{V_1}{V_2}\right)^{\gamma} = p_1\left(\dfrac{\rho_2}{\rho_1}\right)^{\gamma}$

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

303 **(d)**

Heat always refers to energy transmitted from one body to another because of temperature difference

304 **(d)**

Work done at constant temperature (*ie*, isothermal process),

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

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

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

305 **(c)**

Work done during isothermal process in expanding volume of gas fromV_1 *to* V_2 is given by

$$W = \int_{V_1}^{V_2} p\,dV$$

$$= \int_{V_1}^{V_2}\left(\frac{nRT}{V}\right)dV \qquad \left(\text{as } p = \frac{nRT}{V}\right)$$

$$= nRT\int_{V_1}^{V_2}\frac{dV}{V} \qquad (\text{as } T = \text{constant})$$

$$= nRT\log_e\left(\frac{V_2}{V_1}\right)$$

For expansion of 1 mole of gas, *ie*, n=1

$W = RT\log_e\left(\dfrac{V_2}{V_1}\right)$

306 **(a)**

Since, work is done by the system, so it is positive. Therefore,

$\Delta W = 30\text{J}$

Heat given to the system,

$\Delta Q = 40\text{J}$

According to first law of thermodynamics, change in internal energy is given by

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

$= 43 - 30 = 10\text{ J}$

308 **(c)**

Area under curve III is minimum. Therefore, work done is minimum

309 **(b)**

At constant temperature,

$p_1V_1 = p_2V_2$

Or $\frac{p_1}{p_2} = \frac{V_2}{V_1}$

Fractional change in volume

$\dfrac{V_1 - V_2}{V_1} = \dfrac{4}{100} = \dfrac{1}{25}$

$1 - \dfrac{V_2}{V_1} = \dfrac{1}{25}$

$\dfrac{V_2}{V_1} = \dfrac{24}{25}$

$\therefore\ \dfrac{p_1}{p_2} = \dfrac{V_2}{V_1} = \dfrac{24}{25}$

or $\frac{p_2}{p_1} = \frac{25}{24}$

$\dfrac{p_2 - p_1}{p_1} = \dfrac{25}{24} - 1 = \dfrac{1}{24}$

% increase in pressure $= \frac{100}{24} = 4.16\%$

310 **(b)**

Work done is not a thermodynamical function

311 **(a)**

For adiabatic process

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

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

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

Given , $V_1 = V, V_2 = \frac{V}{4}, \gamma = 1.5$

$$\therefore \frac{T_1}{T_2} = \left(\frac{V/4}{V}\right)^{1.5-1} = \left(\frac{1}{4}\right)^{0.5} = -\frac{1}{2}$$

$$\Rightarrow \quad T_2 = 2T_1$$

The change in temperature is given by

$$T_2 - T_1 = 2T_1 - T_1 \Rightarrow T_1 = 273 \text{ K}$$

312 **(d)**

1^{st} process is isothermal expansion which is only correct shown in option (d)

2^{nd} process is isobaric compression which is correctly shown in option (d)

313 **(c)**

Work done $\Delta W = p\Delta V$

At constant pressure

$$\Delta W = p(V_f - V_i) = nR(T_f - T_i)$$

At constant temperature

$$\Delta W = nRT \text{ In } \left(\frac{V_f}{V_i}\right) = nRT \text{ In } \left(\frac{P_i}{P_f}\right)$$

$$\therefore \quad \Delta W_{AB} = 1 \times R \times (2T - T) = RT$$

$$\Delta W_{BC} = 1 \times R \times 2T \text{ In} \frac{2p}{P} = 2RT \text{ In } 2$$

$$\Delta W_{CD} = 1 \times R \times (T - 2T) = -RT$$

$$\Delta W_{DA} = 1 \times R \times T \text{ In } \left(\frac{p}{2p}\right) = RT \text{ In } (\frac{1}{2})$$

Net work done in the complete cycle is

$$\Delta W = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CD} + \Delta W_{DA}$$

$$= RT + 2RT \text{ In } 2 - RT + RT \text{ In } \left(\frac{1}{2}\right)$$

$$= 2RT \text{ In } 2 + RT \text{ In } 1 - RT \text{ In } 2$$

$$= 2RT \text{ In } 2 - RT \text{ In } 2$$

$$= RT \text{ In } 2$$

314 **(c)**

Here, $T_1 = 411°\text{C} = (411 + 273)\text{K} = 684 \text{ K}$

$T_2 = 69°\text{C} = (69 + 273)\text{K} = 342 \text{ K}$

$Q_1 = 1000 \text{ J}$

$$\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1} = 1 - \frac{342}{684} = \frac{1}{2}$$

$$W = \frac{Q_1}{Q_2} = \frac{1000}{2} = 500 \text{ J}$$

315 **(a)**

The change in internal energy does not depend upon path followed by the process. It only depends on initial and final states.

Hence, $\quad \Delta U_1 = \Delta U_2$

316 **(a)**

The efficiency of heat engine is given by

$$\eta = \frac{W}{Q} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

where T_1 is temperature of source and T_2 is temperature of sink.

Given, $\eta_1 = \frac{1}{6}, \quad \eta_2 = \frac{1}{3}$

$$\therefore \qquad \frac{1}{6} = \frac{T_1 - T_2}{T_1} \qquad \text{...(i)}$$

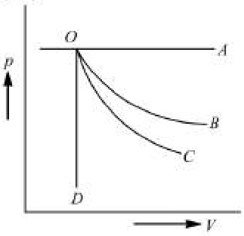
$$\text{and} \quad \frac{1}{3} = \frac{T_1 - (T_2 - 62)}{T_1} \qquad \text{...(ii)}$$

Solving Eqs. (i) and (ii), we get

$$T_1 = 372 \text{ K}$$

and $T_2 = 310$ K

317 **(d)**



(i)Curve *OA* represents isobaric process (since pressure is constant). Since, the slope of adiabatic process is more steeper than isothermal process.

(ii)Curve *OB* represents isothermal process.

(iii)Curve *OC* represents adiabatic process.

(iv)Curve *OD* represents isochoric process.

(since volume is constant).

318 **(b)**

From $p_2V_2^{\gamma} = p_1V_1^{\gamma} \Rightarrow p_2 = p_1\left(\frac{V_1}{V_2}\right)^{\gamma}$

$$p_2 = \left(\frac{100}{124}\right)^{5/3} p_1$$

$$p_2 = 0.6985\, p_1$$

$\therefore$ % decrease in pressure

$= \dfrac{p_1 - p_2}{p_1} \times 100\%$

$= \dfrac{p_1 - 0.6985p_1}{p_1} \times 100$

$= \dfrac{0.3015p_1}{p_1} \times 100\%$

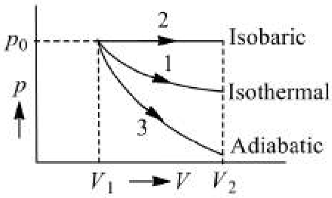
$= 30.15\% = 30\%$

319 **(d)**

In adiabatic process, no transfer of heat takes place between system and surrounding

320 **(a)**

The $p - V$ graphs three given processes are shown in figure



As work done by the gas = area under the $p - V$ graph (between the graph of V axis) and

$(\text{Area})_2 > (\text{Area})_1 > (\text{Area})_3 \quad \therefore W_2 > W_1 > W_3$

321 **(b)**

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

$\Rightarrow \Delta U = \Delta Q - \Delta W = Q - W$ [using proper sign]

322 **(b)**

$C_p - C_v = 4150$

$\dfrac{C_p}{C_v} = 1.4, C_p = 1.4\ C_v$

$\therefore 1.4\ C_v - C_v = 4150$

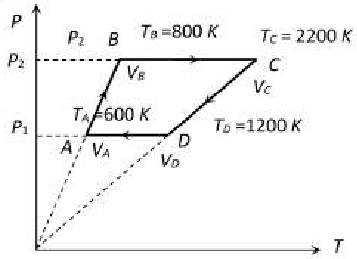
$C_v = 4150/0.4 = 10375 \text{ J kg K}^{-1}$

323 **(c)**

Processes A to B and C to D are parts of straight line graphs of the form $y = mx$

Also $P = \frac{\mu R}{V} T\ (\mu = 6)$

$\Rightarrow P \propto T$. So volume remains constant for the graphs AB and CD



So no work is done during processes for A to B and C to D

i.e., $W_{AB} = W_{CD} = 0$ and $W_{BC} = P_2(V_C - V_B) = \mu R(T_C - T_B)$

$= 6R(2200 - 800) = 6R \times 1400\ J$

Also $W_{DA} = P_1(V_A - V_D) = \mu R(T_A - T_B)$

$= 6R(600 - 1200) = -6R \times 600\ J$

Hence work done in complete cycle

$W = W_{AB} + W_{BC} + W_{CD} + W_{DA}$

$= 0 + 6R \times 1400 + 0 - 6R \times 600$

$= 6R \times 800 = 6 \times 8.3 \times 800 \approx 40\ kJ$

324 **(c)**

$PV^\gamma = K$ or $P\gamma V^{\gamma-1} dV + dP.V^\gamma = 0$

$\Rightarrow \frac{dP}{P} = -\gamma \frac{dV}{V}$ or $\frac{dP}{P} \times 100 = -\gamma \left(\frac{dV}{V} \times 100\right)$

$= -1.4 \times 5 = 7\%$

325 **(c)**

Work does not characterise the thermodynamic state of matter, it is a path function giving only relationship between two quantities.

326 **(b)**

$V.T.$ graph is a straight line passing through origin.

Hence, $V \propto T$ or $P = \text{constant}$

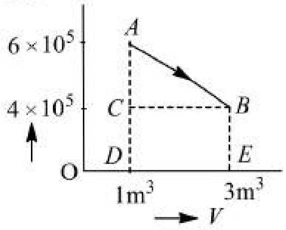
$\therefore\ \Delta Q = nC_P\Delta T$ and $\Delta U = nC_V\Delta T$

Also $\Delta W = \Delta Q - \Delta U = \mu(C_P - C_V)\Delta T$

$\therefore \dfrac{\Delta Q}{\Delta W} = \dfrac{nC_P\Delta T}{n(C_P - C_V)\Delta T} = \dfrac{C_P}{C_P - C_V} = \dfrac{1}{1 - \frac{C_V}{C_P}}$

$\frac{C_V}{C_P} = \frac{3}{5}$ for helium gas. Hence $\frac{\Delta Q}{\Delta W} = \frac{1}{1 - 3/5} = \frac{5}{2}$

327 **(a)**



Work done by the system

= area under $p - V$ diagram

= area of rectangle $BCDE +$ area of ΔABC

$= 4 \times 10^5 \times 2 + \dfrac{2 \times 10^5 \times 2}{2}$

$W = 10 \times 10^5 \text{ J}$

328 **(d)**

$dU = C_v dT = \left(\frac{3}{2}R\right) dT = \frac{3}{2} \times 8.32 \times 100 = 1.25 \times 10^3 \text{ J}$

329 **(a)**

For adiabatic change equation of state is

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

It can also be re-written as

$TV^{\gamma-1} = constant\ \left[as\ p = \frac{nRT}{V}\right]$

and $p^{1-\gamma}T^{\gamma} = \text{constant}\left[as\ V = \frac{nRT}{P}\right]$

330 **(b)**

For the process at constant pressure

$dQ = C_p dT + dw$

$dT = \dfrac{dQ - dW}{C_p}$

For the process at constant volume,

$dQ = C_v dT \quad (\therefore\ dW = 0)$

$= C_v\left(\dfrac{dQ - dW}{C_p}\right) = \dfrac{dQ - dW}{C_p/C_v} = \dfrac{dQ - dW}{\gamma}$

or $(\gamma - 1)dQ = dW$

$\left(\dfrac{5}{3} - 1\right)dQ = W, dQ = \dfrac{3}{2}W$

331 **(b)**

Work done at constant pressure is

$$W = p\,\Delta V = nR\,\Delta T$$

Where p is presure, ΔV the volume change, R the gas constant, ΔT the change in temperature and n the number of moles.

Given, n=1, $T_2 = 127°\text{C} = 400K$,

$T_1 = 27°\text{C} = 300\text{K}, \qquad R = 8.14\ \text{J/mol} - \text{K}$

$\therefore W = 1 \times 8.14 \times (400 - 300)$

W=814 J

332 **(d)**

When a thermodynamic system undergoes a change in such a way that no exchange of heat takes place between system and surrounding, the process is known as adiabatic process. In this process p, V and T changes but $\Delta Q = 0$.

334 **(a)**

$dQ = 2\text{kcal} = 200\text{cal} = 2000 \times 4.2\ \text{J} = 8400\ \text{J}$

$dW = 500\ \text{J},$

$dU = dQ - dW$

$= 8400 - 500 = 7900\ \text{J}$

335 **(c)**

$\eta = 1 - \dfrac{T_2}{T_1} - 1 - \dfrac{500}{800} = \dfrac{3}{8} = 0.375$

336 **(c)**

If M is molecular mass of the gas, then from

$M(C_p - C_v) = R$

$M = \dfrac{8.31}{210} = 0.0392$

If ρ is density of the gas at NTP, then mass of 1 m^3 of gas at NTP= ρ kg

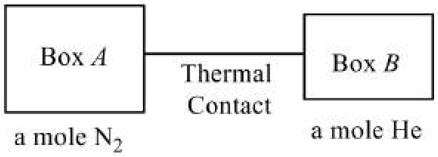
$\therefore$ Mass of 22.4 L ($= 22.4 \times 10^{-3}\text{m}^3$) of gas at NTP $= \rho \times 22.4 \times 10^{-3}$ kg, which is the molecular mass of the gas

$\therefore\ \rho \times 22.4 \times 10^{-3} = 0.0392$

$\rho = \dfrac{0.0392}{22.4 \times 10^{-3}} = 1.75\ \text{kgm}^{-3}$

337 **(c)**

Here, change in internal energy of the system is zero, *ie*, increase in internal energy of one is equal to decrease in internal energy of other.



$$\Delta U_A = 1 \times \frac{5R}{2}(T_f - T_o)$$

$$\Delta U_B = 1 \times \frac{3R}{2}(T_f - \frac{7}{3}T_0)$$

Now, $\Delta U_A + \Delta U_B = 0$

$$\frac{5R}{2}(T_f - T_0) + \frac{3R}{2}\left(T_f - \frac{7T_0}{3}\right) = 0$$

$$5T_f - 5T_0 + 3T_f - 7T_0 = 0$$

$$\Rightarrow \qquad 8T_f = 12T_0$$

$$\Rightarrow \qquad T_f = \frac{12}{8}T_0 = \frac{3}{2}T_0$$

338 **(a)**

$\Delta Q = mc\Delta\theta$. Here $\Delta Q = 0$, hence $c = 0$

339 **(a)**

Work done during the complete cycle= area

$ABCDA = AD \times AB = p \times V$

340 **(a)**

$\Delta Q = \Delta U + \Delta W$ and $\Delta W = P\Delta V$

341 **(a)**

The efficiency η of Carnot engine is defined as the amount of work divided by the heat transferred between the system and the hot reservoir.

$$\eta = \frac{\Delta W}{\Delta Q_H} = 1 - \frac{Tc}{T_H}$$

Where, T_C and T_H are temperatures of cold and hot junctions respectively.

Ist case $T_2 = 0°\text{C} = 0 + 273 = 273\text{K}$

$$T_1 = 200°\text{C} = 200 + 273 = 473\text{ K}$$

$\therefore \quad \eta_1 = 1 - \frac{273}{473} = \frac{200}{473} = 0.4228 \approx 0.423$ ...(i)

IInd case

$T_2 = -200°\text{C} = -200 + 273 = 73\text{K}$

$T_1 = 0°\text{C} = 0 + 273 = 273\text{ K}$

$\eta_2 = 1 - \frac{T_2}{T_1} = 1 - \frac{73}{273} = \frac{200}{273} = 0.732$ ...(ii)

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

$$\frac{\eta_1}{\eta_2} = \frac{0.423}{0.732} \approx 0.577$$

343 **(a)**

For adiabatic change, $\frac{T^\gamma}{p^{\gamma-1}} = \text{constant}$

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

$$\left(\frac{27+273}{627+273}\right)^{1.5} = \left(\frac{1}{p_2}\right)^{0.5}$$

or $\quad \left(\frac{1}{3}\right)^{3/2} = \left(\frac{1}{P_2}\right)^{1/2}$

$\Rightarrow \quad P_2 = 27\text{ atm}$

$$= 27 \times 1.07 \times 10^5$$

$$= 27 \times 10^5\text{ Nm}^{-2}$$

345 **(c)**

$\Delta Q = \Delta U + \Delta W = 0 \Rightarrow \Delta W = -\Delta U$

If ΔW is positive *i.e.*, gas does work then ΔU should be negative meaning internal energy is used in doing work

346 **(a)**

As gas is suddenly expanded so it is an adiabatic process,

ie, $\quad pV^\gamma = constant$

or $\quad p_1V_1^\gamma = p_2V_2^\gamma$

Given, $V_2 = 3V_1, C_V = 2R$

$\therefore \quad C_P = 2R + R = 3R$

$\Rightarrow \quad \gamma = \frac{C_P}{C_V} = \frac{3R}{2R} = 1.5$

$\therefore \quad \frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^\gamma = (3)^{1.5} = 5.1 \approx 5$

347 **(b)**

Given, $T_1 = 627 + 273 = 900K$

$$Q_1 = 3 \times 10^6\text{ cal}$$

$T_2 = 27 + 273 = 300\text{ K}$

$\therefore \quad \frac{Q_1}{T_1} = \frac{Q_2}{T_2}$

$\Rightarrow \quad Q_2 = \frac{T_2}{T_1} \times Q_1$

$$= \frac{300}{900} \times 3 \times 10^6$$

$$= 1 \times 10^6\text{ cal}$$

Work done $= Q_1 - Q_2$

$$= 3 \times 10^6 - 1 \times 10^6 = 2 \times 10^6\text{cal}$$

$$= 2 \times 4.2 \times 10^6\text{ J} = 8.4 \times 10^6\text{ J}$$

348 **(c)**

Work done = Area of PV graph (here trapezium)

$= \frac{1}{2}(1 \times 10^5 + 5 \times 10^5) \times (5 - 1) = 12 \times 10^5 J$

349 **(a)**

In a cyclic process $\Delta U = 0 \Rightarrow \Delta Q = \Delta W$

$\Rightarrow (100 - 20) = 20 + W_2 \Rightarrow W_2 = 60\,J$

350 **(b)**

$\frac{Q_1}{Q_2} = \frac{C_V dT}{p\,dT} = \frac{\frac{3}{2}R}{R} = \frac{3}{2}$ that is 60: 40.

351 **(d)**

For adiabatic process $pV^\gamma = \text{constant}$

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

$\therefore \quad \frac{P_2}{P} = \left(\frac{800}{100}\right)^{5/3}$

$\Rightarrow \quad P_2 = 32\,P$

352 **(a)**

For adiabatic process

$$P_1\,V_1^\gamma = p_2V_2$$

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

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

353 **(a)**

COP$= \frac{T_2}{T_1 - T_2} = \frac{273-23}{(273+77)-(273-23)} = \frac{250}{100} = 2.5$

As COP$=\frac{Q_2}{W}$

$\therefore\ 2.5=\dfrac{1000\times 80\times 4.2}{W}$

or $W=\frac{1000\times80\times4.2}{2.5}=134400$ J

354 **(a)**

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

355 **(b)**

As is clear from figure,

Slope of curve 2 > Slope of curve 1

$(\gamma p)_2=(\gamma p)_1$

$\gamma_2>\gamma_1$

As $\gamma_{\mathrm{He}}>\gamma O_2$

∴ adiabatic curve 2 corresponds to helium and adiabatic curve 1 corresponds to oxygen

356 **(b)**

The isothermal curve on p-V diagram is like a hyperbola.

357 **(c)**

AD and BC represent adiabatic process (more slope)

AB and DC represent isothermal process (less slope)

358 **(a)**

Figure shows that loop 1 is anticlockwise, therefore W_1 is negative, loop 2 is clockwise, therefore W_2 is positive.

Also, loop 2 is bigger

$\therefore\ W_2>W_1$

Hence, $W=-W_1+W_2$ →positive

359 **(a)**

$E_\theta=P$, if $P=$ constant, $E_\theta=$ constant

360 **(d)**

During adiabatic expansion

$TV^{\gamma-1}=$ constant of $T_2V_2^{\gamma-1}=T_1V_1^{\gamma-1}$

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

For monoatomic gas, $\gamma=5/3$

$\dfrac{T_1}{T_2}=\left(\dfrac{AL_2}{AL_1}\right)^{5/3-1}=\left(\dfrac{L_2}{L_1}\right)^{2/3}$

361 **(c)**

$\Delta W=P\Delta V$, here ΔV is negative so ΔW will be negative

363 **(c)**

Isochoric process takes place at constant volume.

Since, there is no change of volume ($\Delta V=0$) therefore

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

364 **(b)**

$\eta=1-\dfrac{T_2}{T_1}=1-\dfrac{500}{800}=1-\dfrac{600}{x}$

$\therefore\ \dfrac{3}{8}=1-\dfrac{600}{x}$

$\dfrac{600}{x}=1-\dfrac{3}{8}=\dfrac{5}{8}$

$5x=4800, x=\dfrac{4800}{5}=960$ K

366 **(b)**

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

∵ Heat supplied to the system so ΔQ → Positive and work is done on the system so ΔW → Negative

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

367 **(c)**

$W=P\Delta V$

$nR(\Delta T)=1\times 8.3\times 100=8.3\times 10^2 J$

368 **(a)**

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

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

$\Rightarrow T_2=300\left(\dfrac{1}{2}\right)^{0.4}=227.36\ K$

369 **(d)**

$dW=dQ-dU$

$=C_2(T_2-T_1)-C_v[\,T_2-T_1\,]$

$=R[T_2-T_1]$

$=8.31\times 100=8.31\times 10^2$ J

370 **(a)**

According to question

$p_fV^\gamma=(2p_i)\left(\dfrac{V}{2}\right)^\gamma$

$\dfrac{P_f}{P_i}=2\left(\dfrac{V}{2V}\right)^\gamma=2(2)^{-\gamma}$

$=2\times 0.38=0.76$

371 **(d)**

$W=\int pdV$ =area under the $p-V$ curve

= minimum along ADB

372 **(b)**

Amount of heat given = 540 *calories*

Change in volume $\Delta V=1670\ c.c$

Atmospheric pressure $P = 1.01 \times 10^6\ dyne/cm^2$

Work done against atmospheric pressure

$$W = P\Delta V = \frac{1.01 \times 10^6 \times 1670}{4.2 \times 10^7} = 40\ cal$$

373 **(a)**

Pressure (p), volume (V) and temperature (T) are the thermodynamic coordinates whereas R is a universal gas constant valued at 8.314 J mol^{-1}K^{-1}.

374 **(c)**

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 2 \Rightarrow \left(\frac{V_2}{V_1}\right)^{\gamma-1} = \frac{1}{2} \Rightarrow \frac{V_2}{V_1} = \left(\frac{1}{2}\right)^{\frac{1}{\gamma-1}} < \frac{1}{2}$$

$$\Rightarrow V_2 < \frac{V_1}{2}$$

375 **(d)**

$$\Delta Q = nC_P\Delta T$$

$$= 2\left(\frac{3}{2}R + R\right)\Delta T$$

$$= 2\left[\frac{3}{2}R + R\right] \times 5$$

$$= 2 \times \frac{5}{2} \times 8.31 \times 5$$

$$= 208\ J$$

376 **(c)**

The efficiency of Carnot engine

$$\eta = \frac{\text{Work output}}{\text{Heat input}} = \frac{W}{Q_H}$$

or $$\eta = \frac{Q_H - Q_L}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

Also we can show that

$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$$

$$\therefore \qquad \eta = 1 - \frac{T_L}{T_H}$$

where T_L is temperature of sink and T_H is temperature of hot reservoir.

According to question

$$\frac{1}{5} = 1 - \frac{T_L}{T_H} \qquad ...(i)$$

and $$\frac{1}{3} = 1 - \frac{T_L - 50}{T_H} \qquad ...(ii)$$

From Eq. (i)

$$\frac{T_L}{T_H} = \frac{4}{5}$$

$$\Rightarrow \qquad T_H = \frac{5}{4}T_L$$

Substituting value of T_H in Eq. (ii), we get

$$\frac{1}{3} = 1 - \frac{T_L - 50}{\frac{5}{4}T_L}$$

or $$\frac{4(T_L - 50)}{5T_L} = \frac{2}{3}$$

or $$T_L - 50 = \frac{2}{3} \times \frac{5}{4}T_L$$

or $$T_L - \frac{5}{6}TL = 50$$

$$\therefore \qquad T_L = 50 \times 6 = 300\text{ K}$$

377 **(b)**

Efficiency of a heat engine

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

or $$\frac{30}{100} = 1 - \frac{77 + 273}{T_1}$$

or $$\frac{350}{T_1} = 1 - \frac{30}{100} = \frac{7}{10}$$

$$\Rightarrow \quad T_1 = 500\text{K} \quad \text{or } 227°\text{C}$$

378 **(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.

379 **(b)**

Change in internal energy from A to B is

$$\Delta U = \frac{f}{2}nR\Delta T = \frac{f}{2}(p_fV_f - p_iV_i)$$

$$= \frac{3}{2}(2p_0 \times 2V_0 - p_0 \times V_0) = \frac{9}{2}p_0V_0$$

Work done in process A to B is equal to the area covered by the graph with volume axis, *ie,*

$$W_{A\to B} = \frac{1}{2}(p_0 + 2p_0) \times (2V_0 - V_0) = \frac{3}{2}p_0V_0$$

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

$$= \frac{9}{2}p_0V_0 + \frac{3}{2}p_0V_0 = 6p_0V_0$$

380 **(d)**

No change in the internal energy of ideal gas, but for real gas internal energy increases because work is done against intermolecular forces.

381 **(b)**

$$\Delta Q = mc\Delta T \Rightarrow \Delta T = \frac{20000J}{1kg \times (400J/kg°\text{C})} = 50°\text{C}$$

$\Rightarrow T_{\text{Final}} = 70°\text{C}$

Hence $W = P_{atm}\Delta V = P_{atm}V_0\gamma\,\Delta T$

$$= (10^5 N/m^2)\left(\frac{1}{9\times 10^3}m^3\right)(9\times 10^{-5}/°\text{C})(50°\text{C})$$
$$= 0.05J$$

382 **(b)**

In cyclic process $\Delta Q =$ Work done $=$ Area inside the closed curve

Treat the circle as an ellipse of area $= \frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$

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

383 **(b)**

$Q = \Delta U = U_f - U_i =$ [internal energy of 4 moles of a monoatomic gas + internal energy of 2 moles of a diatomic gas] – [internal energy of 4 moles of a diatomic gas]

$$= \left(4\times\frac{3}{2}RT + 2\times\frac{5}{2}RT\right) - \left(4\times\frac{5}{2}RT\right) = RT$$

Note: (a) 2 moles of diatomic gas becomes 4 moles of a monoatomic gas when gas dissociated into atoms.

(b) Internal energy of μ moles of an ideal gas of degrees of freedom F is given by $U = \frac{f}{2}\mu RT$

$F = 3$ for a monoatomic gas and 5 for diatomic gas

384 **(d)**

As indicator diagram if all the three cases are closed curves, representing cyclic changes, therefore, $U =$ const and $\Delta U = 0$ in all the cases

385 **(a)**

$$\Delta S = \frac{\Delta Q}{T} = \frac{80\times 1000}{273} = 293\ cal/K$$

386 **(c)**

From the first law of thermodynamics,

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

For a cyclic process, $\Delta U = 0$

$\therefore \Delta Q = \Delta W$

$\Delta Q = Q_1 + Q_2 + Q_3 + Q_4$

$= 600J - 400J - 300J + 200J = 100J$

$\Delta W = W_1 + W_2 + W_3 + W_4$

$\Delta W = 300J - 200J - 150J + W_4$

$= -50J + W_4$

Substitute the value of ΔQ and ΔW in eqn. (i), we get

$100J = -50J + W_4$ or $W_4 = 150J$

387 **(a)**

As work done=0

$\Delta U = mc\Delta T$

$= 100\times 10^{-3}\times 4184\times(50-30)$

=84 kJ

388 **(a)**

Efficiency of engine $\eta = \frac{\text{Work done}}{\text{Heat in put}}$

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

$$\frac{W}{Q} = 1 - \frac{T_2}{T_1}$$

$$\Rightarrow \quad \frac{12.6\times 10^6}{Q} = 1 - \frac{27+273}{927+273}$$

$$Q = 16.8\times 10^6\text{J}$$

389 **(c)**

From the given VT diagram

In process $AB, V \propto T \Rightarrow$ Pressure is constant (As quantity of the gas remains same)

In process $BC, V =$ Constant and in process CA, $T =$ constant

$\therefore$ These processes are correctly represented on PV diagram by graph (c)

390 **(a)**

Heat absorbed by the system at constant pressure

$Q = nc_p\Delta T$

Change in internal energy $\Delta U = nc_v\Delta T$

$W = Q - \Delta U$

$$\therefore \frac{W}{Q} = \frac{Q-\Delta U}{Q} = 1 - \frac{\Delta U}{Q}$$

$$= 1 - \frac{nc_v\Delta T}{nc_p\Delta T} = 1 - \frac{c_v}{c_p}$$

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

391 **(c)**

$C_p = 8$ cal $(\text{mol}°\text{C})^{-1}, C_v = C_p - R = 8 - 2 = 6$ cal $(\text{mol }°\text{C})^{-1}$

$dU = mC_v(T_2 - T_1) = 5\times 6(20-10) = 300$ cal

392 **(a)**

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{(273-123)}{(273+27)} = 1 - \frac{150}{300} = \frac{1}{2}$$
$$= 50\%$$

393 **(d)**

In an adiabatic process

$$\Delta Q = 0$$

So, from 1st law of thermodynamics

$$W = -\Delta U$$
$$= -nC_V\,\Delta T$$
$$= -n\left(\frac{R}{\gamma-1}\right)(T_f - T_i)$$
$$= \frac{nR}{\gamma-1}(T_i - T_f) \quad \text{----(i)}$$

Here W=6R J, n=1 mol

R=8.31 J/mol-K, $\gamma = \frac{5}{3}$, $T_i = T$K

Substituting given values in Eq. (i), we get

$$\therefore \quad 6R = \frac{R}{(5/3-1)}(T - T_f)$$

$$\Rightarrow \quad 6R = \frac{3R}{2}(T - T_f)$$

$$\Rightarrow \quad T - T_f = 4$$

$$\therefore \quad T_f = (T-4)\text{K}$$

394 **(b)**

In adiabatic process $\Delta U = -\Delta W$. In compression ΔW is negative, so ΔU is positive $i.e.$ internal energy increases

395 **(d)**

Adiabatic Bulk modulus $E_\phi = \gamma P$

396 **(a)**

W = area under $p - V$ curve = maximum in isothermal expansion

397 **(b)**

As work done in process = area under the curve, which increases continuously

398 **(c)**

$W_{AB} = -p_0V_0$
$W_{BC} = 0$
$W_{CD} = 4\,p_0V_0$
$W_{ABCD} = W_{AB} + W_{BC} + W_{CD}$
$= -p_0V_0 + 0 + 4p_0V_0 = 3p_0V_0$

399 **(b)**

Relation between coefficient of performance and efficiency of refrigerator is

$$\beta = \frac{1-\eta}{\eta}$$

$$\therefore \ \beta = \frac{1-\frac{1}{10}}{\frac{1}{10}} = 9$$

Coefficient of performance, $\beta = \frac{\text{Heat absorbed}(Q_2)}{\text{Work done }(W)}$

$$\Rightarrow \ 9 = \frac{Q_2}{10}$$

or $Q_2 = 90$ J

400 **(c)**

In this process, p and V changes but T=constant *ie*, change in temperature $\Delta T = 0$

Boyle's law is obeyed *ie*, pV=constant

$$\Rightarrow \ p_1V_1 = p_2V_2$$

According to pV=constant, graph between p and V is a part of rectangular hyperbola. Therefore, option(c) is correct.

401 **(a)**

It is an isothermal process. Hence work done
$= P(V_2 - V_1)$
$= 1 \times 10^5 \times (1.091 - 1) \times 10^{-6} = 0.0091\,J$

402 **(d)**

The theory of refrigerator is based on second law or thermodynamics.

403 **(b)**

The given relation is $p \propto V$
Therefore, $p \propto V$
When V chnages from V to $2V$, pressure p is also doubled
For an ideal gas, $\frac{pV}{T}$ =constant
$\therefore\ T \propto pv$. Hence, T becomes $2 \times 2 = 4$ times
ie, 4×300 K = 1200 K

404 **(b)**

Internal energy does not change in isothermal process. ΔS can be zero for adiabatic process. Work done in adiabatic process may be non-zero.

405 **(d)**

$$W = 2.3026\,nRT\log_{10}\left(\frac{V_2}{V_1}\right)$$
$$= 2.3026 \times 10 \times 9.3 \times 600 \log_{10}\left(\frac{10}{100}\right)$$
$$= -11.4 \times 10^4 \text{ J}$$

406 **(a)**

Since $PV = RT$ and $T =$ constant

$\therefore PV =$ constant

407 **(d)**

$$W = \mu RT\log_e\frac{V_2}{V_1}$$

$$= \left(\frac{m}{M}\right) RT\log_e\frac{V_2}{V_1} = 2.3 \times \frac{m}{M} RT\log_{10}\frac{V_2}{V_1}$$

$$= 2.3 \times \frac{96}{32} R(273 + 27)\log_{10}\frac{140}{70}$$

$$= 2.3 \times 900R\log_{10} 2$$

408 **(d)**

$W = P\Delta V = 2.4 \times 10^{-4} \times 1 \times 10^5 = 24J$

409 **(d)**

In an adiabatic process,

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

or $\quad p_1V_1^\gamma = p_2V_2^\gamma$

or $\quad \frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^\gamma \qquad$ ----(i)

Volume of gas $= \frac{\text{Mass}}{\text{Density}}$

ie, $V = \frac{M}{\rho}$ or $V \propto \frac{1}{\rho}$

$$\therefore \frac{V_1}{V_2} = \frac{\rho_2}{\rho_1} = 32$$

Thus, from Eq.(i), we have

$$\frac{P_2}{P_1} = (32)^\gamma = (32)^{7/5} = 2^7 = 128$$

410 **(a)**

We know that blowing air (if sudden) is an adiabatic process. But it is not given as sudden process. Also, as the mouth is open, pressure inside and outside is same. Thus, blowing air with open mouth is isobaric process.

411 **(c)**

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

$$\therefore \quad \eta = 1 - \frac{(27 + 273)}{(273 + 627)}$$

$$= 1 - \frac{300}{900} = \frac{600}{900} = \frac{2}{3}$$

412 **(a)**

Due to compression the temperature of the system increases to a very high value. The causes the flow of heat from system to the surroundings, thus decreasing the temperature. This decrease in temperature results in decrease in pressure

413 **(b)**

According to first law of thermodynamics,

$dQ = dU + dW$

As $dW = -dU$

$dQ = dU - dU = 0$

The change must be adiabatic

414 **(b)**

$$\Delta U = \mu C_V\Delta T = 2 \times 4.96 \times (342 - 340)$$

$$= 19.84\ cal$$

415 **(c)**

$$\frac{E_S}{E_T} = \gamma = \frac{C_P}{C_V} = 1.4$$

$$\frac{2.1 \times 10^5}{E_T} = 1.4$$

or $\quad E_T = \frac{2.1 \times 10^5}{1.4}$

$$= 1.5 \times 10^5\ \text{Nm}^{-2}$$

416 **(b)**

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

$$= \frac{nRT_1}{(\gamma - 1)}\left[1 - \frac{T_2}{T_1}\right]$$

$$= \frac{nRT_1}{(\gamma - 1)}\left[1 - \left[\frac{V_1}{V_2}\right]^{\gamma - 1}\right]$$

$$= \frac{2 \times 8.3 \times 300}{\left[\frac{5}{3} - 1\right]}\left[1 - \left(\frac{1}{2}\right)^{\frac{5}{3} - 1}\right]$$

=+2767.23 J

417 **(a)**

At STP,

22.4 L of any gas is 1 mol,

$$\therefore \quad 5.6\text{ L} = \frac{5.6}{22.4} = \frac{1}{4}\text{mol} = n$$

In adiabatic process,

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

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

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

$\gamma = \frac{C_P}{C_V} = \frac{5}{3}$ for monoatomic He gas

$$\therefore \quad T_2 = T_1 \left(\frac{5.6}{0.7}\right)^{\frac{5}{3}-1} = 4T_1$$

Further in adiabatic process,

Q=0

$\therefore W + \Delta U = 0$

or $W = -\Delta U = -nC_V\Delta T$

$$= -n\left(\frac{R}{\gamma - 1}\right)(T_2 - T_1)$$

$$= -\frac{1}{4}\left(\frac{R}{\frac{5}{3} - 1}\right)(4T_1 - T_1)$$

$$= -\frac{9}{8}RT_1$$

418 **(c)**

According to first law of thermodynamics, $\Delta Q = \Delta U + \Delta W$

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

$$= 540 - \frac{p(V_2 - V_1)}{J}$$

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

$$= 540 - 40 = 500 \text{ cal}$$

419 **(d)**

When T is constant, $pV =$ constant

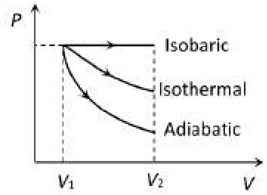
When volume is decreased by 10% *ie*, volume become $\frac{90}{100}$, the pressure must become 100/90

$\therefore$ % increase in pressure$= \frac{(100-90)\times 100}{90} = 11.1\%$

420 **(a)**

In thermodynamic process, work done is equal to the area covered by the PV curve with volume axis

$W_{adiabatic} < W_{isothermal} < W_{isobaric}$



421 **(b)**

Velocity of sound in air increases (v_t) with increase in temperature[$v_t = v_0 + 0.61t$]but is independent of pressure variation.

422 **(d)**

$TV^{\gamma-1} =$ constant $\Rightarrow T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 927°\text{C}$

423 **(d)**

Volume of the ideal gas is constant so $W = P\Delta V = 0$

Using FLOT

$\Delta Q = \Delta U \Rightarrow \Delta U = i^2Rt$

$= 1^2 \times 100 \times 5 \times 60 = 30 \times 10^3 = 30kJ$

424 **(b)**

Heat engine is a device which converts heat into work (mechanical energy) continuously through a cyclic process.

425 **(c)**

In isothermal process, exchange of energy takes place between system and surrounding to maintain the system temperature constant

426 **(a)**

Internal energy of an ideal gas is given by

$U = \frac{f}{2}\mu RT = \frac{f}{2}\left(\frac{N}{N_A}\right)RT \Rightarrow U \propto NT$

In isothermal process $T =$ constant $\Rightarrow U \propto N$

i.e. internal energy increases by increasing number of molecules (N)

427 **(b)**

Equation of an adiabatic process is

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

Given, $P^3 = \frac{k}{V^4}$

$p^3V^4 = k$ (constant)

$\Rightarrow \quad pV^{4/3} = k$ ----(ii)

Comparing Eqs. (i) and (ii), we get

$$\gamma = \frac{4}{3} = 1.33$$

428 **(a)**

In adiabatic process, the relation between temperature (T) and pressure(p) is

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

Where γ is ratio of specific heats.

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

$p_1 = p, p_2 = \frac{p}{8}, \gamma = \frac{5}{3}$

$\therefore \quad \frac{T_1}{T_2} = \left(\frac{p_1}{p_2}\right)^{\frac{\gamma-1}{\gamma}}$

$\Rightarrow \frac{T_1}{T_2} = \left(\frac{8}{1}\right)^{\frac{\frac{5}{3}-1}{5/3}}$

$= (8)^{0.4} = 2.297$

$\Rightarrow T_2 = \frac{T_1}{2.297} = \frac{300}{2.297}$

$= 130.6 \text{ K} \approx 131\text{K}$

$\Rightarrow T_2 = 131 - 273$

$= -142°\text{C}$

429 **(c)**

As we know that slope of isothermal and adiabatic curves are always negative and slope of adiabatic curve is always greater than that of isothermal curve

Hence in the given graph curve A and B represents adiabatic and isothermal changes respectively

430 **(c)**

For cyclic process p-V curve is closed curve and area enclosed by closed path represent the work done.

431 **(a)**

In taking a system from one state to another by different processes, the heat transferred Q and work done W are different, but their difference Q-W is same for all processes. It gives the internal energy of the system.

$\Delta U = Q - W$

Thus, internal energy U of a thermodynamic system is a characteristic property of the state of the system, it does not matter how that state has been obtained.

432 **(a)**

As $\frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \therefore \quad \frac{Q_2}{6\times10^4} = \frac{127+273}{227+273} = \frac{400}{500}$

$Q_2 = \frac{4}{5} \times 6 \times 10^4 = 4.8 \times 10^4$ cal

$\therefore W = Q_1 - Q_2 = 6 \times 10^4 - 4.8 \times 10^4 = 1.2 \times 10^4$ cal

433 **(b)**

As $dW = p\, dV$

$\therefore$ (i) $dW = p \times 0 = 0$

(ii) $dW = p(2V - V) = pV$

434 **(d)**

$\Delta Q = \mu C_P dT$

$\Rightarrow 1163.4 = 1.\frac{7}{2}R.dT$

$\Rightarrow dT = \frac{1163.4 \times 2}{7 \times 8.31} = 40K$

435 **(a)**

$W_{AB} = O; W_{BC} = 2P_0V_0; W_{CD} = 0; W_{DA} = -P_0V_0$

So total work done $= P_0V_0$

From A and B, heat given to the gas

$= nC_v\Delta T = n\frac{3}{2}R\Delta T = \frac{3}{2}V_0\Delta P = \frac{3}{2}P_0V_0$

From B to C, heat given to the system

$= nC_p\Delta T = n\left(\frac{5}{2}R\right)\Delta T = \frac{5}{2}(2P_0)\Delta V = 5P_0V_0$

From C to D and D to A, heat is rejected

Efficiency, $\eta = \frac{\text{work done by gas}}{\text{heat given to the gas}} \times 100$

$\eta = \frac{P_0V_0}{\frac{3}{2}P_0V_0 + 5P_0V_0} = 15.4\%$

436 **(b)**

At constant pressure,

Heat required$= nC_p\Delta T$

$\Rightarrow \quad 310 = 2 \times C_p \times (35 - 25)$

$\Rightarrow \quad C_p = \frac{310}{20} = 15.5\text{J/mol/K}$

Similarly, at constant volume,

Heat required$= nC_V\Delta T$

$= 2(C_p - R) \times (35 - 25) \qquad (\because C_p - C_v = R)$

$= 2 \times (15.5 - 8.3) \times 10$

$= 2 \times 7.2 \times 10 = 144$ J

437 **(a)**

For every gas, $C_p - C_v = R \ \therefore x = y$

438 **(a)**

Given, $\Delta Q_A = +8 \times 10^5$J

$W_A = +6.5 \times 10^5$ J

$\therefore$ Chage in internal energy

$\Delta U_A = Q_A - W_A$

$= 8 \times 10^5 - 6.5 \times 10^5$

$= 1.5 \times 10^5 \text{J}$

In second process

$Q_B = 10^5 \text{J}$

In both the processes, initial and final states are same, so change in internal energy will be same.

$\therefore \quad \Delta U_A = \Delta U_B$

$1.5 \times 10^5 = Q_B - W_B$

$1.5 \times 10^5 = 10^5 - W_B$

$W_B = 10^5 - 1.5 \times 10^5$

$= -0.5 \times 10^5 \text{J}$

Work done is negative, so, work done on the gas is $0.5 \times 10^5 \text{J}$.

440 **(c)**

Internal energy depends only on the temperature of the gas

THERMODYNAMICS

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 1 to 0. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

1

Statement 1: The isothermal curves intersect each other at a certain point

Statement 2: The isothermal changes takes place rapidly, so the isothermal curves have very little slope

2

Statement 1: A Carnot engine working between 100 K and 400 K has an efficiency of 75%

Statement 2: If follows from $\eta = 1 - \frac{T_2}{T_1}$

3

Statement 1: The Carnot cycle is useful in understanding the performance of heat engines

Statement 2: The Carnot cycle provides a way of determining the maximum possible efficiency achievable with reservoirs of given temperatures

4

Statement 1: Efficiency of a Carnot engine decreases with decrease in temperature difference between the source and the sink.

Statement 2: $\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_2}$

5

Statement 1: We can not change the temperature of a body without giving (or taking) heat to (or from) it

Statement 2: According to principle of conservation of energy, total energy of a system should remain conserved

6

Statement 1: Specific heat capacity is the cause of formation of land and sea breeze.

Statement 2: The specific heat of water is more than land.

7

Statement 1: In adiabatic compression, the internal energy and temperature of the system get decreased.

Statement 2: The adiabatic compression is a slow process.

8

Statement 1: First law of thermodynamic does not forbid flow of heat from lower temperature to higher temperature.

Statement 2: Heat supplied to a system is always equal to the increase in its internal energy at constant volume.

9

Statement 1: In an isolated system the entropy increases

Statement 2: The processes in an isolated system are adiabatic

10

Statement 1: The heat supplied to a system is always equal to the increase in its internal energy

Statement 2: When a system changes from one thermal equilibrium to another, some heat is absorbed by it

11

Statement 1: When a glass of hot milk is placed in a room and allowed to cool, its entropy decreases

Statement 2: Allowing hot object to cool does not violate the second law of thermodynamics

12

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

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

13

Statement 1: Work done by a gas in isothermal expansion is more than the work done by the gas in the same expansion, adiabatically

Statement 2: Temperature remains constant in isothermal expansion, and not is adiabatic expansion

14

Statement 1: Air quickly leaking out of a balloon becomes cooler

Statement 2: The leaking air undergoes adiabatic expansion

15

Statement 1: First law of thermodynamics is re-statement of the principle of conservation of energy

Statement 2: Energy is something fundamental

16

Statement 1: If an electric fan be switched on in a closed room, the air of the room will be cooled

Statement 2: Fan air decreases the temperature of the room

17

Statement 1: In an adiabatic process, change in internal energy of a gas is equal to work done on or by the gas in the process

Statement 2: Temperature of gas remains constant in a adiabatic process

18

Statement 1: A reversible engine working between 127°C and 227°C cannot have efficiency more than 20%

Statement 2: Under ideal conditions $\eta = 1 - \frac{T_2}{T_1}$

19

Statement 1: In isothermal process whole of the heat energy supplied to the body is converted into internal energy

Statement 2: According to the first law of thermodynamics $\Delta Q = \Delta U + P\Delta V$

20

Statement 1: An adiabatic process is an isotropic process

Statement 2: $\Delta S = \frac{\Delta Q}{T} = 0 \therefore \ \Delta Q = 0$, Which represents an adiabatic process

21

Statement 1: Zeroth law of thermodynamic explains the concept of energy

Statement 2: Energy is dependent on temperature

22

Statement 1: The entropy of the solids is the highest

Statement 2: Atoms of the solids are arranged in orderly manner

23

Statement 1: It is impossible for a ship to use the internal energy of sea water to operate its engine.

Statement 2: A heat engine is different from a refrigerator.

24

Statement 1: Reversible systems are difficult to find in real world

Statement 2: Most processes are dissipative in nature

25

Statement 1: It is not possible for a system, unaided by an external agency to transfer heat from a body at lower temperature to another body at higher temperature

Statement 2: According to Clausius statement, "No process is possible whose sole result is the transfer of heat from a cooled object to a hotter object

26

Statement 1: The specific heat of a gas in an adiabatic process is zero and in an isothermal process is infinite

Statement 2: Specific heat of a gas is directly proportional to change of heat in system and inversely proportional to change in temperature

27

Statement 1: Internal energy of an ideal gas depends only on temperature and not on volume

Statement 2: Temperature is more important than volume

28

Statement 1: Efficiency of a Carnot engine increased on reducing the temperature of sink

Statement 2: The efficiency of a Carnot engine is defined as ratio of net mechanical work done per cycle by the gas to the amount of heat energy absorbed per cycle from the source

29

Statement 1: The temperature of the surface of the sun is approximately 6000 K. If we take a big lens and focus the sunrays, we can produce a temperature of 8000 K

Statement 2: The highest temperature can be produced according to second law of thermodynamics

30

Statement 1: It is not possible for a system, unaided by an external agency to transfer heat from a body at a lower temperature to another at a higher temperature

Statement 2: It is not possible to violate the second law of thermodynamics

31

Statement 1: Thermodynamic processes in nature are irreversible

Statement 2: Dissipative effects can not be eliminated

32

Statement 1: The isothermal curves intersect each other at a certain point

Statement 2: The isothermal change takes place slowly, so the isothermal curves have very little slope

33

Statement 1: Change of state is an example of isothermal process

Statement 2: Change of state from solid to liquid occurs only at melting point of solid and change of state from liquid to gas occurs only at boiling point of liquid. Thus, there is no change of temperature during change of state

THERMODYNAMICS

: ANSWER KEY :

1)	d	2)	a	3)	a	4)	a	21)	d	22)	d	23)	b	24)	a
5)	d	6)	a	7)	d	8)	b	25)	a	26)	a	27)	c	28)	b
9)	b	10)	d	11)	b	12)	a	29)	d	30)	a	31)	a	32)	d
13)	b	14)	a	15)	c	16)	d	33)	a						
17)	c	18)	a	19)	d	20)	a								

THERMODYNAMICS

: HINTS AND SOLUTIONS :

1 **(d)**
To carry out isothermal process, a perfect gas is compressed or allowed to expand very slowly.

Isothermal curves never intersect each other as they have very little slope

2 **(a)**

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{100}{400} = \frac{3}{4} = 75\%$$

Both, the Assertion and Reason are true and Reason is correct explanation of Assertion

3 **(a)**
Carnot cycle has maximum efficiency

4 **(a)**
As $\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_2}$, therefore, η will decrease if $(T_1 - T_2)$ decreases

Both, the Assertion and Reason are true and latter is correct explanation of the former

5 **(d)**
We can change the temperature of a body without giving (or taking) heat to (or from) it. For example in an adiabatic compression temperature rises and in an adiabatic expansion temperature falls, although no heat is given or taken from the system in the respective changes

6 **(a)**
The temperature of land rises rapidly as compared to sea because of specific heat of land is five times less than that of sea water. Thus, the air above the land become hot and light so rises up because of pressure drops over land. To compensate the drop of pressure, the cooler air starts blowing towards land as well as sea radiate heat energy. The temperature of land falls more rapidly as compared to sea water, as sea water consists of higher specific heat, capacity. The air above sea water being warm and light rises up. To take its place the cold air from land starts blowing towards sea and so set-up breeze.

7 **(d)**
In adiabatic process, there is no exchange of heat bet6ween the system and the surroundings. This can be possible if the gas under adiabatic process is allowed to expand or compressed very quickly. Thus, it is a quick process.

When the gas is compressed adiabatically, the heat produced cannot escape to the surroundings through the insulating walls. As a result, the temperature of the gas and hence, the internal energy increase.

8 **(b)**
First law of thermodynamics tells only about the conversion of mechanical energy into the heat energy and vice-versa. It does not put any condition as to why heat cannot flow from lower temperature to higher temperature.

First law of thermodynamics given

dQ= dU+ dW

If heat is supplied as such its volume does not change ie, dV=0, then whole of the heat energy supplied to the system will increase in its internal energy only.

10 **(d)**
According to first law of thermodynamics, $\Delta Q = \Delta U + \Delta W = \Delta U + P\Delta V$. If heat is supplied in such a manner that volume does not change $\Delta V = 0$, *i.e.*, isochoric process, then whole of the heat energy supplied to the system will increase internal energy only. But, in any other process it is not possible.

Also heat may be absorbed or evolved when state of thermal equilibrium changes

11 **(b)**
When milk cools, its energy content decreases

12 **(a)**
When a bottle of cold carbonated drink is opened a slight fog forms around the opening. This is because adiabatic expansion of gas causes lowering of temperature and condensation of water vapours

13 **(b)**
Adiabatic curve is steeper than isothermal curve. Therefore, area under adiabatic curve is smaller than the area under isothermal; curve *ie*, work done by the gas in adiabatic expansion is smaller than the work done by the gas in isothermal expansion. The reverse is also true. Reason is true. Reason is also true but Reason does not explain Assertion

14 **(a)**
Adiabatic expansion produces cooling

15 **(c)**
First law of thermodynamics is a restatement of the principle of conservation of energy as applied to heat energy. Assertion is true but Reason is false.

16 **(d)**
If an electric fan is switched on in a closed room, the air will be heated because due to motion of the fan, the speed of air molecules will increase. In fact, we feel cold due to evaporation of our sweat

17 **(c)**
In an adiabatic process, no exchange of heat is permissible, $\text{i.}e., \Delta Q = 0$

As, $\Delta Q = \Delta U + \Delta W = 0 \Rightarrow \Delta U = -\Delta W$

Also in adiabatic process, temperature of gas changes

18 **(a)**
Here, $T_1 = 227 + 273 = 500 \text{ K}$

$T_2 = 127 + 273 = 400 \text{ K}$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{400}{500} = \frac{1}{5} = 20\%$$

This is the maximum value of efficiency. Both the Assertion and Reason are true and Reason is correct explanation of Assertion

19 **(d)**
As there is no change in internal energy of the system during an isothermal change. Hence, the energy taken by the gas is utilised by doing work against external pressure. According to FLOT
$\Delta Q = \Delta U + P\Delta V$

Hence $\Delta Q = \Delta U + P\Delta V;\ \Delta U = 0\ \therefore \Delta Q = P\Delta V$

Therefore, reason is true and assertion is false

20 **(a)**
Change in entropy, $\Delta S = \frac{\Delta Q}{T}$. In an adiabatic change, $\Delta Q = 0$

$\therefore\ \Delta S = 0\ \therefore S =$ constant *ie*, entropy remains constant, or it is an isotropic process. Choice (a) is correct

21 **(d)**
Zeroth law of thermodynamics explains the concept of temperature. According to which there exists a scalar quantity called temperature which is property of all thermodynamic system

22 **(d)**
Entropy is a measure of the disorder or randomness of the system. Greater the randomness, greater the entropy

23 **(b)**
For using the internal energy of sea water, to operate the engine of a ship, the internal of the sea water has to be converted into mechanical energy. Since, whole of the internal energy cannot be converted into mechanical energy, a part has to be rejected to a colder body (sink). Since, no such body is available, the internal energy of the sea water cannot be used to operate the engine of the ship A refrigerator is a heat engine working in the reverse direction.

25 **(a)**
Second law of thermodynamics can be explained with the help of example of refrigerator, as we know that in refrigerator, the working substance

extracts heat from colder body and rejects a large amount of heat to a hotter body with the help of an external agency, i. *e*., the electric supply of the refrigerator. No refrigerator can ever work without external supply of electric energy to it

26 **(a)**
$c = \frac{\Delta Q}{m.\Delta\theta}$; a gas may be heated by putting pressure, so it can have values for 0 to ∞

C_P and C_V are it's two principle specific heats, out of infinite possible values

In adiabatic process $C = 0$, and in isothermal process $C = \infty$

27 **(c)**
In an ideal gas, we assume that intermolecular force are zero. No work is done in charging the distance between the molecules. Therefore, internal energy is only kinetic and not potential. Therefore, internal energy of an ideal gas depends only on temperature and not on volume. Assertion is true. Reason is false.

28 **(b)**
Efficiency of carnot cycle $\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$, for Carnot engine when T_2 decreases η increases

29 **(d)**
According to second law of thermodynamics, this is not possible to transfer heat from a body at lower temperature to a body at higher temperature without the aid of an external agent. Since, the given information produces a contradiction in second law of thermodynamics, therefore it is not possible to produce temperature of 8000 K by collecting the sun rays with a lens

31 **(a)**
In reversible process, there always occurs some loss of energy. This is because energy spent in working against the dissipative force is not recovered back. Some irreversible process occurs in nature such as friction where extra work is done to cancel the effect of friction. Salt dissolves in water but a salt does not separate by itself into pure salt and pure water

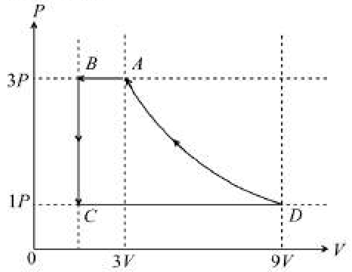
32 **(d)**
As isothermal processes are very slow and so the different isothermal curves have different slopes so they cannot intersect each other

THERMODYNAMICS

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns** I have to be matched with Statements (p, q, r, s) in **columns** II.

1. One mole of a monoatomic ideal gas is taken through a cycle $ABCDA$ as shown in the P-V diagram. Column-II given the characteristics involved in the cycle. Match them with each of the processes given in Column-I

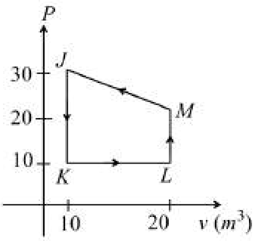


Column-I		**Column- II**	
(A)	Process A → B	(p)	Internal energy decreases
(B)	Process B → C	(q)	Internal energy increases
(C)	Process C → D	(r)	Heat is lost
(D)	Process D → A	(s)	Heat is gained
		(t)	Work is done on the gas

CODES :

	A	**B**	**C**	**D**
a)	P,r	q,s	r,t	p,r,t
b)	r,t	p,r,t	p,r	q,s
c)	p,r,t	p,r	q,s	r,t
d)	q,s	r,t	p,r,t	p,r

2. Match the following for the given process

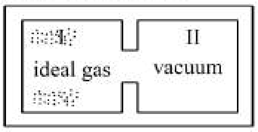
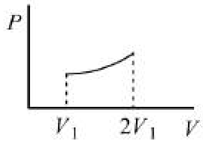


	Column-I		Column- II
(A)	Process $J \rightarrow K$	(p)	$Q > 0$
(B)	Process $K \rightarrow L$	(q)	$W < 0$
(C)	Process $L \rightarrow M$	(r)	$W > 0$
(D)	Process $M \rightarrow J$	(s)	$Q < 0$

CODES :

	A	**B**	**C**	**D**
a)	s	p,r	r	q,s
b)	p,r	q,s	s	r
c)	q,s	s	p,r	r
d)	s	r	q,s	p,r

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

	Column-I		Column- II
(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 	(p)	The temperature of the gas decreases
(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	(q)	The temperature of the gas increases or remains constant
(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	(r)	The gas loses heat
(D)	An ideal monoatomic gas expands such that its pressure P and volume V follows the behavior shown in the graph 	(s)	The gas gains heat

CODES :

	A	**B**	**C**	**D**
a)	P,r	q	q,s	p,s
b)	q	p,r	p,s	q,s
c)	p,s	q,s	q	p,r
d)	q,s	p,s	p,r	q

THERMODYNAMICS

: ANSWER KEY :

1)	c	2)	a	3)	b

THERMODYNAMICS

: HINTS AND SOLUTIONS :

1 **(c)**

$A \rightarrow B \Rightarrow V \downarrow P\ const\ \Rightarrow T \downarrow U \downarrow$ (p), (r), (t)

$B \rightarrow C \Rightarrow d\omega \downarrow 0$

$P \downarrow T \downarrow$

$d\phi = du + d\omega$ (p), (r)

$C \rightarrow D \Rightarrow V \uparrow \Rightarrow T \uparrow$

$du \Rightarrow +ve$

$d\omega = +ve$ (q), (s)

$D \rightarrow A \Rightarrow d\omega \Rightarrow -ve$ (r), (t)

$dq \Rightarrow -ve$

$du = 0$

2 **(a)**

In process J → K : V is constant where as P is decreasing

Therefore, T should also decrease

$\therefore W = O, \Delta U = -ve$ and $Q < 0$

In process K → L : P is constant while V is increasing

Therefore, temperature should also increase

$\therefore W > 0, \Delta U > 0$ and $Q > 0$

In process L → M : This is inverse of process $J \rightarrow K$

$\therefore W = 0, \Delta U > 0$ and $Q > 0$

In process M → J :

V is decreasing. Therefore, $W < 0$

$(PV)_J < (PV)_M$

$\therefore T_J < T_M$

Or $\Delta U < 0$

Therefore, $Q < 0$

3 **(b)**

Column –I : Expansion of ideal gas

Column – II : Thermodynamic change

(A) $\Delta Q = 0$ (as boundary is non conducting) in the case of free expansion $W = 0$

$Q = \Delta U + W$

$0 = \Delta U + 0, \Delta U = 0; U =$ constant, T is constant

(A) → (q) (As temp remains constant)

$(B)\ P \propto \frac{1}{V_2}$

$PV^2 = C$

$\because PV = nRT$

$TV = C$

Since volume increases then temperature decreases.

$Q = n\,C\Delta T$, for polytropic process, $PV^x =$ constant,

$$C = C_v + \frac{R}{1-x}$$

$$C = C_v + \frac{R}{-2+1} = C_v - R \Rightarrow \frac{3}{2}R - R \Rightarrow C = \frac{R}{2}$$

$$\Rightarrow Q = n\frac{R}{2}\Delta T$$

ΔT is negative so Q is negative means heat is lost

(B) → (p,r)

(C) $PV^{4/3} = C, TV^{1/3} = C'$

So when volume increases then temperature decreases

Now $C = C_v + \frac{R}{-\frac{4}{3}+1} = \frac{3}{2}R - 3R \Rightarrow C = -\frac{3}{2}R$

$$Q = nC\Delta T \Rightarrow Q = n\left(-\frac{3}{2}R\right)(\Delta T)$$

As ΔT is negative Q will be positive

Hence (C) → p,s

(D) $T = \frac{PV}{nR}$ as product of P and V increases, so temperature increases $Q = \Delta U + W$

$\Delta U = +ve\ (\Delta T = +ve)$

$W = +ve$ (As volume increases)

So $Q = +ve$

Hence gas gains heat (D) → (q,s)