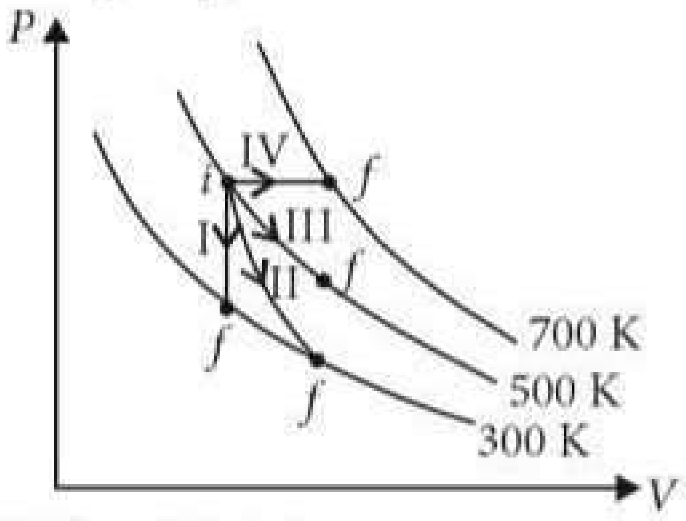
Chapter 9. Thermodynamics and Kinetic Theory

1. Thermodynamic processes are indicated in the following diagram.



Match the following

	Column-1	Column-2
P.	Process I	A. Adiabatic
Q.	Process II	B. Isobaric
R.	Process III	C. Isochoric
S.	Process IV	D. Isothermal

(a) P → C, Q → A, R → D, S → B
(b) P → C, Q → D, R → B, S → A
(c) P → D, Q → B, R → A, S → C
(d) P → A, Q → C, R → D, S → B

(NEET 2017)

2. A carnot engine having an efficiency of $\frac{1}{10}$ 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) 90 J (b) 99 J (c) 100 J (d) 1 J

(NEET 2017)

3. A gas mixture consists of 2 moles of O_2 and 4 moles of Ar at temperature T. Neglecting all vibrational modes, the total internal energy of the system is

(a) 15 RT (b) 9 RT (c) 11 RT (d) 4 RT

(NEET 2017)

4. One mole of an ideal monatomic gas undergoes a process described by the equation PV^3 = constant. The heat capacity of the gas during this process is

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

(NEET-II 2016)

5. The temperature inside a refrigerator is t_2 °C and the room temperature is t_1 °C. The amount of heat delivered to the room for each joule of electrical energy consumed ideally will be

(a) $\frac{t_1}{t_1-t_2}$ (b) $\frac{t_1+273}{t_1-t_2}$

(c) $\frac{t_2+273}{t_1-t_2}$ (d) $\frac{t_1+t_2}{t_1+273}$

(NEET-II 2016)

6. A given sample of an ideal gas occupies a volume V at a pressure P and absolute temperature T. The mass of each molecule of the gas is m. Which of the following gives the density of the gas ?

(a) $P/(kT)$ (b) $Pm/(kT)$
(c) $P/(kTV)$ (d) mkT

(NEET-II 2016)

7. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then

(a) Compressing the gas isothermally or adiabatically will require the same amount of work.
(b) Which of the case (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas.
(c) Compressing the gas isothermally will require more work to be done.
(d) Compressing the gas through adiabatic process will require more work to be done.

(NEET-I 2016)

8. The molecules of a given mass of a gas have r.m.s. velocity of 200 m s^{-1} at 27°C and 1.0×10^5 N m^{-2} pressure. When the temperature and pressure of the gas are respectively, 127°C and 0.05×10^5 N m^{-2}, the r.m.s. velocity of its molecules in m s^{-1} is

(a) $\frac{100\sqrt{2}}{3}$ (b) $\frac{100}{3}$ (c) $100\sqrt{2}$ (d) $\frac{400}{\sqrt{3}}$

(NEET-I 2016)

9. A refrigerator works between 4°C and 30°C. It is required to remove 600 calories of heat every second in order to keep the temperature of the refrigerated space constant. The power required is (Take 1 cal = 4.2 Joules)

(a) 236.5 W (b) 2365 W
(c) 2.365 W (d) 23.65 W

(NEET-I 2016)

10. An ideal gas is compressed to half its initial volume by means of several processes. Which of the process results in the maximum work done on the gas?

(a) Isochoric (b) Isothermal
(c) Adiabatic (d) Isobaric *(2015)*

11. Two vessels separately contain two ideal gases A and B at the same temperature, the pressure of A being twice that of B. Under such conditions, the density of A is found to be 1.5 times the density of B. The ratio of molecular weight of A and B is

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

(2015)

12. The coefficient of performance of a refrigerator is 5. If the temperature inside freezer is −20°C, the temperature of the surroundings to which it rejects heat is

(a) 11°C (b) 21°C (c) 31°C (d) 41°C

(2015)

13. The ratio of the specific heats $\frac{C_p}{C_v} = \gamma$ in terms of degrees of freedom (n) is given by

(a) $\left(1+\frac{2}{n}\right)$ (b) $\left(1+\frac{n}{2}\right)$
(c) $\left(1+\frac{1}{n}\right)$ (d) $\left(1+\frac{n}{3}\right)$

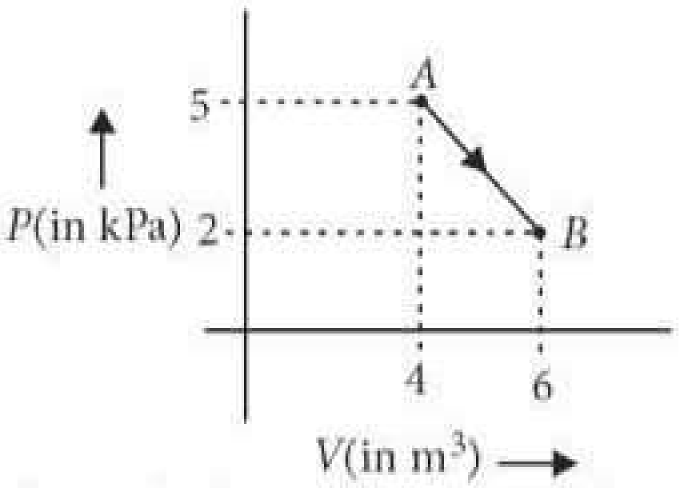
(2015 Cancelled)

14. A Carnot engine, having an efficiency of 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) 90 J (b) 1 J (c) 100 J (d) 99 J

(2015 Cancelled)

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

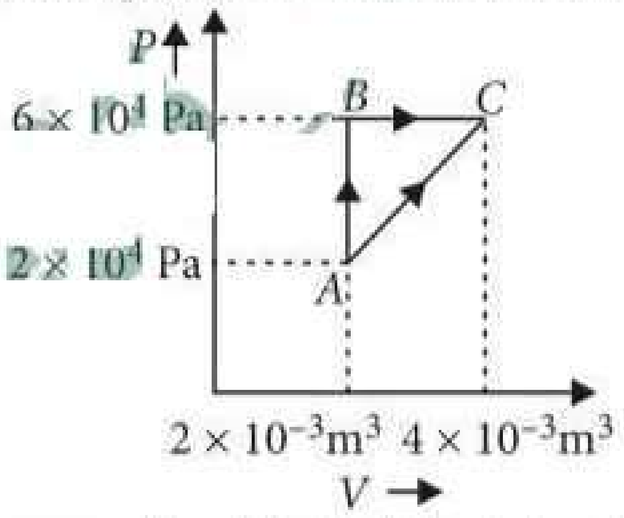


The change in internal energy of the gas during the transition is

(a) 20 J (b) −12 kJ
(c) 20 kJ (d) −20 kJ

(2015 Cancelled)

16. Figure below shows two paths that may be taken by a gas to go from a state A to a state C.



In process AB, 400 J of heat is added to the system and in process BC, 100 J of heat is added to the system. The heat absorbed by the system in the process AC will be

(a) 460 J (b) 300 J
(c) 380 J (d) 500 J

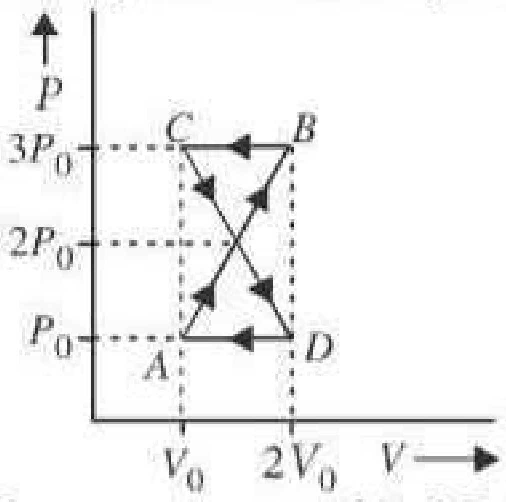
(2015 Cancelled)

17. A monatomic gas at a pressure P, having a volume V expands isothermally to a volume $2V$ and then adiabatically to a volume $16V$. The final pressure of the gas is (Take $\gamma = 5/3$)

(a) $64P$ (b) $32P$ (c) $P/64$ (d) $16P$

(2014)

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



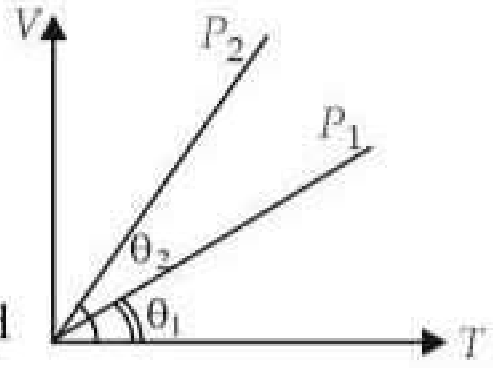
(a) P_0V_0 (b) $2P_0V_0$
(c) $\frac{P_0V_0}{2}$ (d) zero *(2014)*

19. The mean free path of molecules of a gas, (radius r) is inversely proportional to

(a) r^3 (b) r^2

(c) r (d) $\sqrt{r}$ *(2014)*

20. In the given ($V - T$) diagram, what is the relation between pressures P_1 and P_2?



(a) $P_2 < P_1$

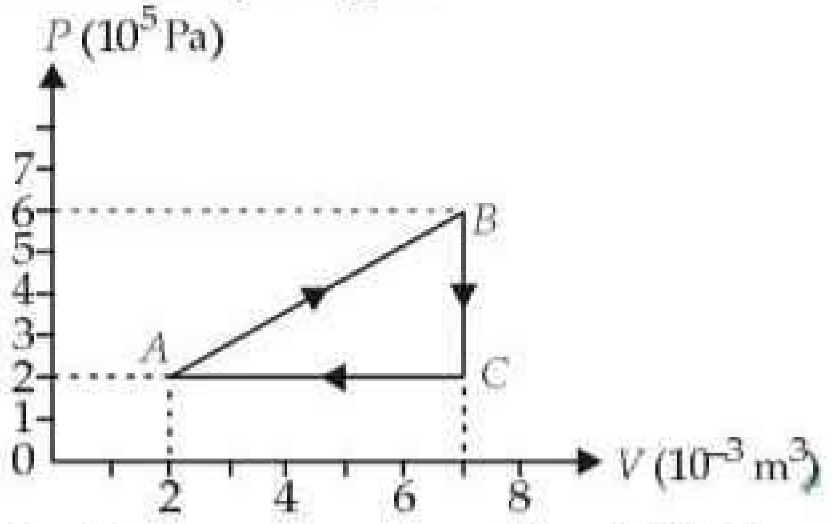
(b) Cannot be predicted

(c) $P_2 = P_1$

(d) $P_2 > P_1$

(NEET 2013)

21. A gas is taken through the cycle $A \rightarrow B \rightarrow C \rightarrow A$, as shown. What is the net work done by the gas?



(a) Zero (b) $-$ 2000 J

(c) 2000 J (d) 1000 J

(NEET 2013)

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

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

(NEET 2013)

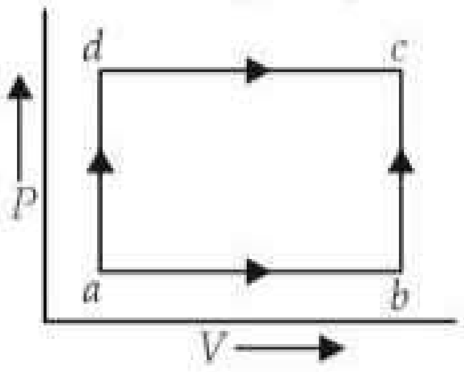
23. The amount of heat energy required to raise the temperature of 1 g of Helium at NTP, from T_1 K to T_2 K is

(a) $\frac{3}{4}N_a k_B(T_2 - T_1)$ (b) $\frac{3}{4}N_a k_B\left(\frac{T_2}{T_1}\right)$

(c) $\frac{3}{8}N_a k_B(T_2 - T_1)$ (d) $\frac{3}{2}N_a k_B(T_2 - T_1)$

(NEET 2013)

24. A system is taken from state a to state c by two paths adc and abc as shown in the figure. The internal energy at a is $U_a = 10$ J. Along the path adc the amount of heat heat absorbed $dQ_1 = 50$ J and the work obtained $dW_1 = 20$ J whereas along the path abc the heat absorbed $dQ_2 = 36$ J. The amount of work along the path abc is



(a) 10 J (b) 12 J (c) 36 J (d) 6 J

(Karnataka NEET 2013)

25. Which of the following relations does not give the equation of an adiabatic process, where terms have their usual meaning?

(a) $P^{1-\gamma}T^{\gamma}$ = constant

(b) PV^{γ} = constant

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

(d) $P^{\gamma}T^{1-\gamma}$ = constant

(Karnataka NEET 2013)

26. Two Carnot engines A and B are operated in series. The engine A receives heat from the source at temperature T_1 and rejects the heat to the sink at temperature T. The second engine B receives the heat at temperature T and rejects to its sink at temperature T_2. For what value of T the efficiencies of the two engines are equal

(a) $\frac{T_1 - T_2}{2}$ (b) $T_1 T_2$

(c) $\sqrt{T_1 T_2}$ (d) $\frac{T_1 + T_2}{2}$

(Karnataka NEET 2013)

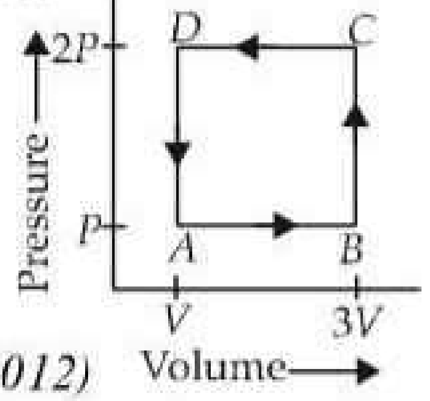
27. In a vessel, the gas is at pressure P. If the mass of all the molecules is halved and their speed is doubled, then the resultant pressure will be

(a) $2P$ (b) P

(c) $P/2$ (d) $4P$

(Karnataka NEET 2013)

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



(a) $2PV$

(b) $4PV$

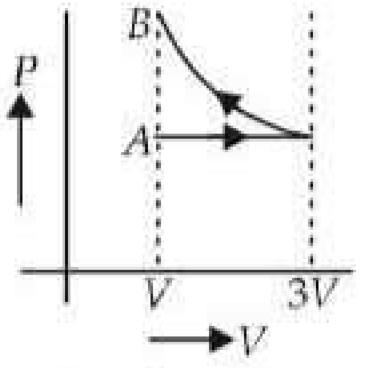
(c) $\frac{1}{2}PV$

(d) PV *(2012)*

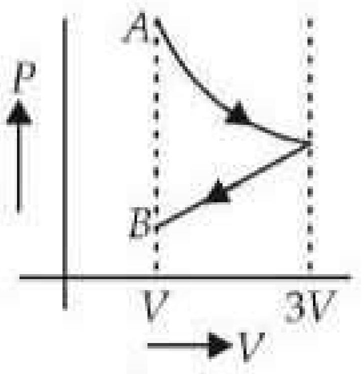
29. One mole of an ideal gas goes from an initial state A to final state B via two processes : It first undergoes isothermal expansion from volume V to $3V$ and then its volume is reduced from $3V$ to

V at constant pressure. The correct P-V diagram representing the two processes is

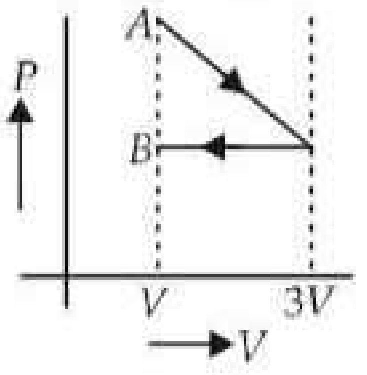
(a)



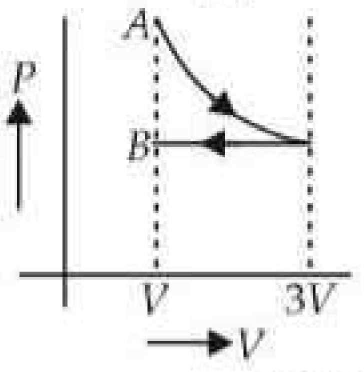
(b)



(c)

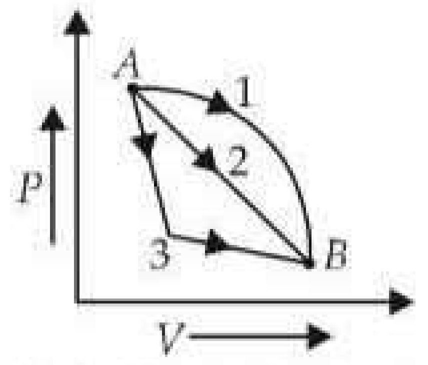


(d)



(2012)

30. An ideal gas goes from state A to state B via three different processes as indicated in the P-V diagram.



If Q_1, Q_2, Q_3 indicate the heat absorbed by the gas along the three processes and ΔU_1, ΔU_2, ΔU_3 indicate the change in internal energy along the three processes respectively, then

(a) $Q_1 > Q_2 > Q_3$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$
(b) $Q_3 > Q_2 > Q_1$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$
(c) $Q_1 = Q_2 = Q_3$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$
(d) $Q_3 > Q_2 > Q_1$ and $\Delta U_1 > \Delta U_2 > \Delta U_3$

(Mains 2012)

31. During an isothermal expansion, a confined ideal gas does –150 J of work against its surroundings. This implies that

(a) 150 J of heat has been removed from the gas
(b) 300 J of heat has been added to the gas
(c) no heat is transferred because the process is isothermal
(d) 150 J of heat has been added to the gas

(2011)

32. 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) 273 cal/K (b) 8×10^4 cal/K
(c) 80 cal/K (d) 293 cal/K *(2011)*

33. A mass of diatomic gas ($\gamma = 1.4$) at a pressure of 2 atmospheres is compressed adiabatically so that its temperature rises from 27°C to 927°C. The pressure of the gas in the final state is

(a) 8 atm (b) 28 atm
(c) 68.7 atm (d) 256 atm

(Mains 2011)

34. If ΔU and ΔW represent the increase in internal energy and work done by the system respectively in a thermodynamical process, which of the following is true?

(a) $\Delta U = -\Delta W$, in an adiabatic process
(b) $\Delta U = \Delta W$, in an isothermal process
(c) $\Delta U = \Delta W$, in an adiabatic process
(d) $\Delta U = -\Delta W$, in an isothermal process *(2010)*

35. If c_p and c_v denote the specific heats (per unit mass of an ideal gas of molecular weight M, then

(a) $c_p - c_v = R/M^2$ (b) $c_p - c_v = R$
(c) $c_p - c_v = R/M$ (d) $c_p - c_v = MR$

where R is the molar gas constant.

(Mains 2010)

36. A monatomic gas at pressure P_1 and volume V_1 is compressed adiabatically to $\frac{1}{8}$th of its original volume. What is the final pressure of the gas?

(a) $64P_1$ (b) P_1 (c) $16P_1$ (d) $32P_1$

(Mains 2010)

37. The internal energy change in a system that has absorbed 2 kcal of heat and done 500 J of work is

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

(2009)

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

(a) In an isochoric process pressure remains constant.
(b) In an isothermal process the temperature remains constant.
(c) In an adiabatic process PV^γ = constant.
(d) In an adiabatic process the system is insulated from the surroundings. *(2009)*

39. At 10°C the value of the density of a fixed mass of an ideal gas divided by it pressure is x. At 110°C this ratio is

(a) $\frac{10}{110}x$ (b) $\frac{283}{383}x$ (c) x (d) $\frac{383}{283}x$

(2008)

40. 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) $Q = W = 0$ *(2008)*

41. An engine has an efficiency of 1/6. When the temperature of sink is reduced by 62°C, its efficiency is doubled. Temperatures of the source is
(a) 37°C (b) 62°C
(c) 99°C (d) 124°C. *(2007)*

42. 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) 380 K (b) 275 K
(c) 325 K (d) 250 K *(2006)*

43. The molar specific heat at constant pressure of an ideal gas is $(7/2)R$. The ratio of specific heat at constant pressure to that at constant volume is
(a) 9/7 (b) 7/5
(c) 8/7 (d) 5/7. *(2006)*

44. 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 to work is
(a) 4.8×10^4 cal (b) 6×10^4 cal
(c) 2.4×10^4 cal (d) 1.2×10^4 cal.
(2005)

45. Which of the following processes is reversible?
(a) Transfer of heat by conduction
(b) Transfer of heat by radiation
(c) Isothermal compression
(d) Electrical heating of a nichrome wire.
(2005)

46. The equation of state for 5 g of oxygen at a pressure P and temperature T, when occupying a volume V, will be
(a) $PV = (5/32)RT$ (b) $PV = 5RT$
(c) $PV = (5/2)RT$ (d) $PV = (5/16)RT$
(where R is the gas constant)
(2004)

47. One mole of an ideal gas at an initial temperature of T K does $6R$ joule 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 *(2004)*

48. An ideal gas heat engine operates in a Carnot cycle between 227°C and 127°C. It absorbs 6 kcal at the higher temperature. The amount of heat (in kcal) converted into work is equal to
(a) 4.8 (b) 3.5
(c) 1.6 (d) 1.2 *(2003)*

49. The efficiency of Carnot engine is 50% and temperature of sink is 500 K. If temperature of source is kept constant and its efficiency raised to 60%, then the required temperature of sink will be
(a) 100 K (b) 600 K
(c) 400 K (d) 500 K *(2002)*

50. A scientist says that the efficiency of his heat engine which work 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 are incomplete. *(2001)*

51. The (W/Q) of a Carnot engine is 1/6, now the temperature of sink is reduced by 62°C, then this ratio becomes twice, therefore the initial temperature of the sink and source are respectively
(a) 33°C, 67°C (b) 37°C, 99°C
(c) 67°C, 33°C (d) 97 K, 37 K.
(2000)

52. To find out degree of freedom, the expression is
(a) $f = \dfrac{2}{\gamma - 1}$ (b) $f = \dfrac{\gamma + 1}{2}$
(c) $f = \dfrac{2}{\gamma + 1}$ (d) $f = \dfrac{1}{\gamma + 1}$. *(2000)*

53. An ideal gas at 27°C is compressed adiabatically to 8/27 of its original volume. The rise in temperature is (Take $\gamma = 5/3$)
(a) 275 K (b) 375 K
(c) 475 K (d) 175 K *(1999)*

54. The degrees of freedom of a triatomic gas is
(a) 6 (b) 4
(c) 2 (d) 8 *(1999)*

55. If the ratio of specific heat of a gas at constant pressure to that at constant volume is γ, the change in internal energy of a mass of gas, when the volume changes from V to $2V$ at constant pressure P, is
(a) $\dfrac{PV}{(\gamma - 1)}$ (b) PV
(c) $\dfrac{R}{(\gamma - 1)}$ (d) $\dfrac{\gamma PV}{(\gamma - 1)}$ *(1998)*

56. 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 isothermal process
(b) $\Delta U = W$ in an isothermal process
(c) $\Delta U = -W$ in an adiabatic process
(d) $\Delta U = W$ in an adiabatic process *(1998)*

57. The efficiency of a Carnot engine operating with reservoir temperature of 100°C and – 23°C will be

(a) $\dfrac{373+250}{373}$ (b) $\dfrac{373-250}{373}$

(c) $\dfrac{100+23}{100}$ (d) $\dfrac{100-23}{100}$ *(1997)*

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

(a) adiabatic (b) equal in all cases

(c) isothermal (d) isobaric. *(1997)*

59. The value of critical temperature in terms of van der Waals' constant a and b is given by

(a) $T_C = \dfrac{8a}{27Rb}$ (b) $T_C = \dfrac{27a}{8Rb}$

(c) $T_C = \dfrac{a}{2Rb}$ (d) $T_C = \dfrac{a}{27Rb}$. *(1996)*

60. An ideal gas, undergoing adiabatic change, has which of the following pressure temperature relationship?

(a) $P^{\gamma}T^{1-\gamma}$ = constant (b) $P^{1-\gamma}T^{\gamma}$ = constant

(c) $P^{\gamma-1}T^{\gamma}$ = constant

(d) $P^{\gamma}T^{\gamma-1}$ = constant. *(1996)*

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

(a) 395.4°C (b) 144°C

(c) 18°C (d) 887.4°C. *(1996)*

62. At 0 K which of the following properties of a gas will be zero?

(a) vibrational energy (b) density

(c) kinetic energy (d) potential energy. *(1996)*

63. An ideal Carnot engine, whose efficiency is 40%, receives heat at 500 K. If its efficiency is 50%, then the intake temperature for the same exhaust temperature is

(a) 800 K (b) 900 K

(c) 600 K (d) 700 K. *(1995)*

64. In an adiabatic change, the pressure and temperature of a monatomic gas are related as $P \propto T^C$, where C equals

(a) $\dfrac{3}{5}$ (b) $\dfrac{5}{3}$ (c) $\dfrac{2}{5}$ (d) $\dfrac{5}{2}$. *(1994)*

65. Which of the following is not thermodynamical function ?

(a) Enthalpy (b) Work done

(c) Gibb's energy (d) Internal energy *(1993)*

66. 110 joule of heat is added to a gaseous system whose internal energy is 40 J, then the amount of external work done is

(a) 150 J (b) 70 J

(c) 110 J (d) 40 J *(1993)*

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

(a) will be same in both A and B

(b) will be zero in both the gases

(c) of B will be more than that of A

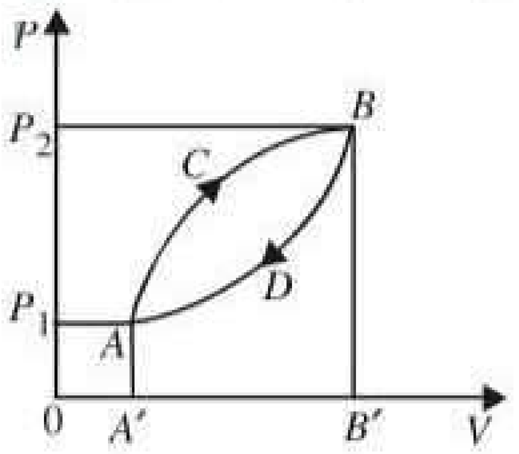
(d) of A will be more than that of B *(1993)*

68. The number of translational degrees of freedom for a diatomic gas is

(a) 2 (b) 3

(c) 5 (d) 6 *(1993)*

69. 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) $ADBB'A'A$ *(1992)*

70. If for a gas, $\dfrac{R}{C_V} = 0.67$, this gas is made up of molecules which are

(a) diatomic

(b) mixture of diatomic and polyatomic molecules

(c) monoatomic

(d) polyatomic *(1992)*

71. For hydrogen gas $C_P - C_V = a$ and for oxygen gas $C_P - C_V = b$, so the relation between a and b is given by

(a) $a = 16b$ (b) $16b = a$

(c) $a = 4b$ (d) $a = b$ *(1991)*

72. Three containers of the same volume contain three different gases. The masses of the molecules are m_1, m_2 and m_3 and the number of molecules in their respective containers are N_1, N_2 and N_3. The gas pressure in the containers are P_1, P_2 and P_3 respectively. All the gases are now mixed and put in one of these containers. The pressure P of the mixture will be

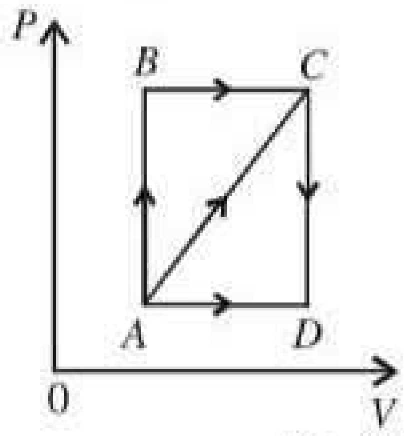
(a) $P < (P_1 + P_2 + P_3)$

(b) $P = \frac{P_1 + P_2 + P_3}{3}$

(c) $P = P_1 + P_2 + P_3$

(d) $P > (P_1 + P_2 + P_3)$ *(1991)*

73. A thermodynamic process is shown in the figure. The pressure and volumes corresponding to some points in the figure are $P_A = 3 \times 10^4$ Pa; $V_A = 2 \times 10^{-3}$ m^3; $P_B = 8 \times 10^4$ Pa; $V_D = 5 \times 10^{-3}$ m^3.
In the process AB, 600 J of heat is added to the system and in process BC, 200 J of heat is added to the system. The change in internal energy of the system is process AC would be



(a) 560 J (b) 800 J

(c) 600 J (d) 640 J *(1991)*

74. Relation between pressure (P) and energy (E) of a gas is

(a) $P = \frac{2}{3}E$ (b) $P = \frac{1}{3}E$

(c) $P = E$ (d) $P = 3E$ *(1991)*

75. One mole of an ideal gas requires 207 J heat to rise the temperature by 10 K when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by the same 10 K, the heat required is
(Given the gas constant $R = 8.3$ J/mole K)

(a) 198.7 J (b) 29 J

(c) 215.3 J (d) 124 J *(1990)*

76. According to kinetic theory of gases, at absolute zero of temperature

(a) water freezes

(b) liquid helium freezes

(c) molecular motion stops

(d) liquid hydrogen freezes *(1990)*

77. For a certain gas the ratio of specific heats is given to be $\gamma = 1.5$. For this gas

(a) $C_V = 3R/J$ (b) $C_P = 3R/J$

(c) $C_P = 5R/J$ (d) $C_V = 5R/J$ *(1990)*

78. A polyatomic gas with n degrees of freedom has a mean energy per molecule given by

(a) $\frac{nkT}{N}$ (b) $\frac{nkT}{2N}$

(c) $\frac{nkT}{2}$ (d) $\frac{3kT}{2}$ *(1989)*

79. At constant volume temperature is increased then

(a) collission on walls will be less

(b) number of collisions per unit time will increase

(c) collisions will be in straight lines

(d) collisions will not change *(1989)*

80. Two containers A and B are partly filled with water and closed. The volume of A is twice that of B and it contains half the amount of water in B. If both are at the same temperature, the water vapour in the containers will have pressure in the ratio of

(a) 1 : 2 (b) 1 : 1

(c) 2 : 1 (d) 4 : 1 *(1988)*

81. First law of thermodynamics is consequence of conservation of

(a) work (b) energy

(c) heat (d) all of these *(1988)*

Answer Key

1.	(a)	**2.**	(a)	**3.**	(c)	**4.**	(d)	**5.**	(b)	**6.**	(b)	**7.**	(d)	**8.**	(d)	**9.**	(a)	**10.**	(c)
11.	(d)	**12.**	(c)	**13.**	(a)	**14.**	(a)	**15.**	(d)	**16.**	(a)	**17.**	(c)	**18.**	(d)	**19.**	(b)	**20.**	(a)
21.	(d)	**22.**	(b)	**23.**	(c)	**24.**	(d)	**25.**	(d)	**26.**	(c)	**27.**	(a)	**28.**	(a)	**29.**	(d)	**30.**	(a)
31.	(d)	**32.**	(d)	**33.**	(d)	**34.**	(a)	**35.**	(c)	**36.**	(d)	**37.**	(c)	**38.**	(a)	**39.**	(b)	**40.**	(a)
41.	(c)	**42.**	(d)	**43.**	(b)	**44.**	(d)	**45.**	(c)	**46.**	(a)	**47.**	(d)	**48.**	(d)	**49.**	(c)	**50.**	(a)
51.	(b)	**52.**	(a)	**53.**	(b)	**54.**	(a)	**55.**	(a)	**56.**	(c)	**57.**	(b)	**58.**	(d)	**59.**	(a)	**60.**	(b)
61.	(a)	**62.**	(c)	**63.**	(c)	**64.**	(d)	**65.**	(b)	**66.**	(b)	**67.**	(b)	**68.**	(b)	**69.**	(c)	**70.**	(c)
71.	(d)	**72.**	(c)	**73.**	(a)	**74.**	(a)	**75.**	(d)	**76.**	(c)	**77.**	(b)	**78.**	(c)	**79.**	(b)	**80.**	(b)
81.	(b)																		

EXPLANATIONS

1. **(a) :** In process I, volume is constant

$\therefore$ Process I → Isochoric; P → C

As slope of curve II is more than the slope of curve III.

Process II → Adiabatic and Process III → Isothermal

$\therefore$ Q → A, R → D

In process IV, pressure is constant

Process IV → Isobaric; S → B

2. **(a) :** The relation between coefficient of performance and efficiency of carnot engine is given as

$$\beta = \frac{1-\eta}{\eta}$$

Given $\eta = \frac{1}{10}, W = 10\text{ J}$

$$\beta = \frac{1-\frac{1}{10}}{\frac{1}{10}} = \frac{9}{10}.10 = 9$$

Since, $\beta = \frac{Q_2}{W}$, where Q_2 is the amount of energy absorbed from the reservoir

$\therefore$ $Q_2 = \beta W = 9 \times 10 = 90\text{ J}$

3. **(c) :** The internal energy of 2 moles of O_2 atom is

$$U_{O_2} = \frac{n_1 f_1}{2} RT = 2 \times \frac{5}{2} \times RT$$

$$U_{O_2} = 5RT$$

The internal energy of 4 moles of Ar atom is

$$U_{Ar} = \frac{n_2 f_2 RT}{2} = 4 \times \frac{3}{2} \times RT = 6RT$$

$\therefore$ The total internal energy of the system is

$$U = U_{O_2} + U_{Ar} = 5RT + 6RT = 11RT$$

4. **(d) :** Process described by the equation, PV^3 = constant

For a polytropic process, PV^{α} = constant

$$C = C_V + \frac{R}{1-\alpha} = \frac{3}{2}R + \frac{R}{1-3} = R$$

5. **(b) :** Temperature inside refrigerator = t_2 °C

Room temperature = t_1 °C

For refrigerator,

$$\frac{\text{Heat given to high temperature } (Q_1)}{\text{Heat taken from lower temperature } (Q_2)} = \frac{T_1}{T_2}$$

$$\frac{Q_1}{Q_2} = \frac{t_1+273}{t_2+273}$$

$$\Rightarrow \frac{Q_1}{Q_1-W} = \frac{t_1+273}{t_2+273} \text{ or } 1-\frac{W}{Q_1} = \frac{t_2+273}{t_1+273}$$

or $$\frac{W}{Q_1} = \frac{t_1-t_2}{t_1+273}$$

The amount of heat delivered to the room for each joule of electrical energy (W = 1 J)

$$Q_1 = \frac{t_1+273}{t_1-t_2}$$

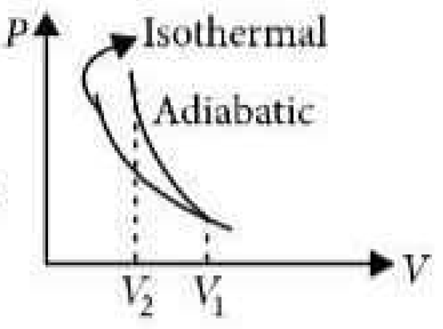
6. **(b) :** As $PV = nRT$ or $n = \frac{PV}{RT} = \frac{\text{mass}}{\text{molar mass}}$ ...(i)

$$\text{Density, } \rho = \frac{\text{mass}}{\text{volume}} = \frac{(\text{molar mass})P}{RT} = \frac{(mN_A)P}{RT}$$

[From eqn. (i)]

$$\rho = \frac{mP}{kT} \qquad (\because R = N_A k)$$

7. **(d) :** $V_1 = V$; $V_2 = V/2$



On P-V diagram,

Area under adiabatic curve > Area under isothermal curve.

So compressing the gas through adiabatic process will require more work to be done.

8. **(d) :** As, $v_{\text{rms}} = \sqrt{\frac{3k_B T}{m}}$

$$\therefore \frac{v_{27}}{v_{127}} = \sqrt{\frac{27+273}{127+273}} = \sqrt{\frac{300}{400}} = \frac{\sqrt{3}}{2}$$

or $$v_{127} = \frac{2}{\sqrt{3}} \times v_{27} = \frac{2}{\sqrt{3}} \times 200 \text{ m s}^{-1} = \frac{400}{\sqrt{3}} \text{ m s}^{-1}$$

9. **(a) :** Given, $T_2 = 4°\text{C} = 277\text{ K}$, $T_1 = 30°\text{C} = 303\text{ K}$

Q_2 = 600 cal per second

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

$$= \frac{277}{303-277} = \frac{277}{26}$$

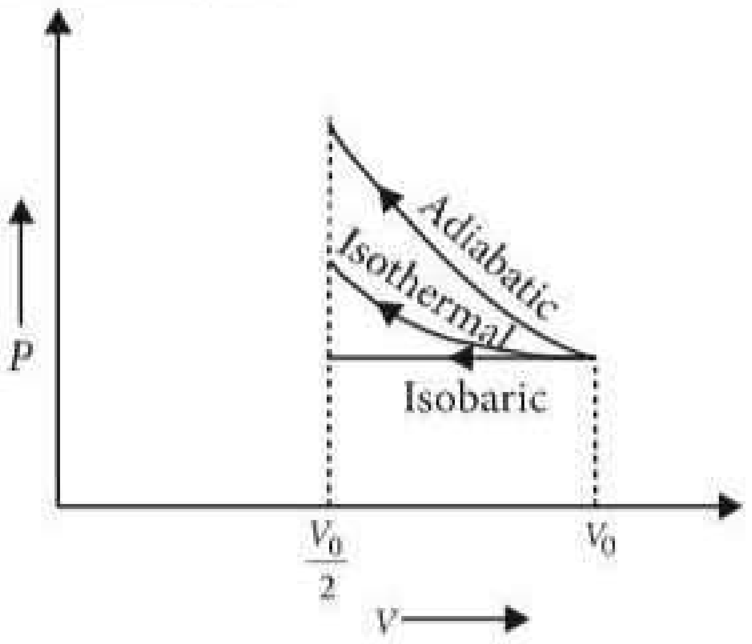
Also, $\alpha = \frac{Q_2}{W}$

$\therefore$ Work to be done per second = power required

$$= W = \frac{Q_2}{\alpha} = \frac{26}{277} \times 600 \text{ cal per second}$$

$$= \frac{26}{277} \times 600 \times 4.2 \text{ J per second} = 236.5\text{ W}$$

10. (c) : The P-V diagram of an ideal gas compressed from its initial volume V_0 to $\frac{V_0}{2}$ by several processes is shown in the figure.



Work done on the gas = Area under P–V curve

As area under the P–V curve is maximum for adiabatic process, so work done on the gas is maximum for adiabatic process.

11. (d) : According to an ideal gas equation, the molecular weight of an ideal gas is

$$M = \frac{\rho RT}{P} \quad \left(\text{as } P = \frac{\rho RT}{M}\right)$$

where P, T and ρ are the pressure, temperature and density of the gas respectively and R is the universal gas constant.

$\therefore$ The molecular weight of A is

$$M_A = \frac{\rho_A RT_A}{P_A} \text{ and that of } B \text{ is } M_B = \frac{\rho_B RT_B}{P_B}$$

Hence, their corresponding ratio is

$$\frac{M_A}{M_B} = \left(\frac{\rho_A}{\rho_B}\right)\left(\frac{T_A}{T_B}\right)\left(\frac{P_B}{P_A}\right)$$

Here, $\frac{\rho_A}{\rho_B} = 1.5 = \frac{3}{2}, \frac{T_A}{T_B} = 1$ and $\frac{P_A}{P_B} = 2$

$$\therefore \quad \frac{M_A}{M_B} = \left(\frac{3}{2}\right)(1)\left(\frac{1}{2}\right) = \frac{3}{4}$$

12. (c) : The coefficient of performance of a refrigerator is

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

where T_1 and T_2 are the temperatures of hot and cold reservoirs (in kelvin) respectively.

Here, $\alpha = 5$, $T_2 = -20°\text{C} = -20 + 273 \text{ K} = 253 \text{ K}$

$T_1 = ?$

$$\therefore \quad 5 = \frac{253 \text{ K}}{T_1 - 253 \text{ K}}$$

$$5T_1 - 5(253 \text{ K}) = 253 \text{ K}$$

$$5T_1 = 253 \text{ K} + 5(253 \text{ K}) = 6(253 \text{ K})$$

$$T_1 = \frac{6}{5}(253 \text{K}) = 303.6 \text{ K} = 303.6 - 273$$

$$= 30.6°\text{C} \approx 31°\text{C}$$

13. (a) For n degrees of freedom, $C_v = \frac{n}{2}R$

Also, $C_p - C_v = R$

$$C_p = C_v + R = \frac{n}{2}R + R = \left(\frac{n}{2}+1\right)R$$

$$\gamma = \frac{C_p}{C_v} = \frac{\left(\frac{n}{2}+1\right)R}{(n/2)R} = \frac{n+2}{n} \quad \therefore \quad \gamma = 1 + \frac{2}{n}$$

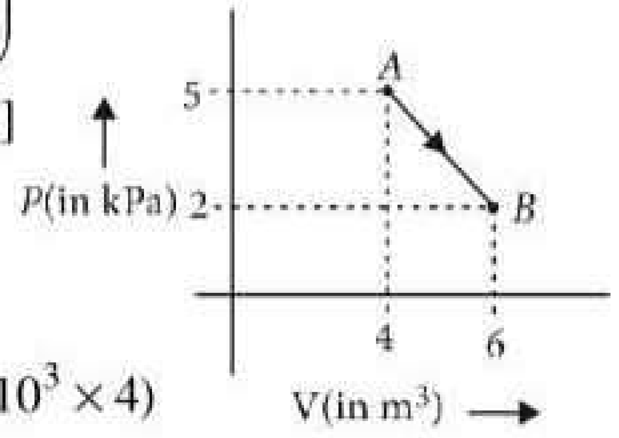
14. (a)

15. (d) : We know, $\Delta U = nC_v \Delta T$

$$= n\left(\frac{5R}{2}\right)(T_B - T_A) \qquad \left[\text{for diatomic gas}, C_v = \frac{5R}{2}\right]$$

$$= \frac{5nR}{2}\left(\frac{P_BV_B}{nR} - \frac{P_AV_A}{nR}\right)$$

$$[\because PV = nRT]$$

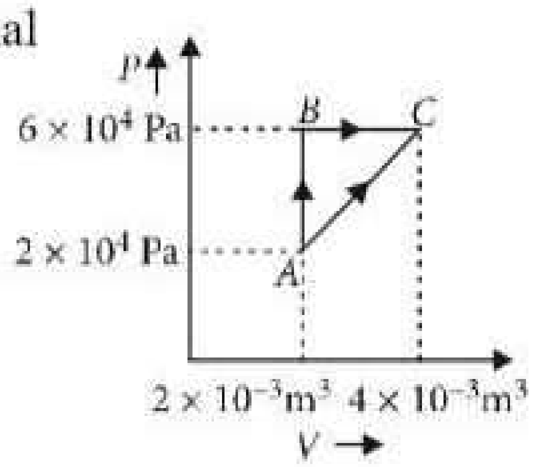


$$= \frac{5}{2}(P_BV_B - P_AV_A)$$

$$= \frac{5}{2}(2 \times 10^3 \times 6 - 5 \times 10^3 \times 4)$$

$$= \frac{5}{2}(-8 \times 10^3) = -20 \text{ kJ}$$

16. (a) : As initial and final points are same so



$\Delta U_{ABC} = \Delta U_{AC}$

AB is isochoric process.

$\Delta W_{AB} = 0$

$\Delta Q_{AB} = \Delta U_{AB} = 400 \text{ J}$

BC is isobaric process.

$\Delta Q_{BC} = \Delta U_{BC} + \Delta W_{BC}$

$100 = \Delta U_{BC} + 6 \times 10^4 (4 \times 10^{-3} - 2 \times 10^{-3})$

$100 = \Delta U_{BC} + 12 \times 10$

$\Delta U_{BC} = 100 - 120 = -20 \text{ J}$

As, $\Delta U_{ABC} = \Delta U_{AC}$

$\Delta U_{AB} + \Delta U_{BC} = \Delta Q_{AC} - \Delta W_{AC}$

$$400 - 20 = \Delta Q_{AC} - \left(2 \times 10^4 \times 2 \times 10^{-3} + \frac{1}{2} \times 2 \times 10^{-3} \times 4 \times 10^4\right)$$

$\Delta Q_{AC} = 460\text{J}$

17. (c) : First, isothermal expansion

$PV = P'(2V); \; P' = \frac{P}{2}$

Then, adiabatic expansion

$P'(2V)^{\gamma} = P_f(16V)^{\gamma}$

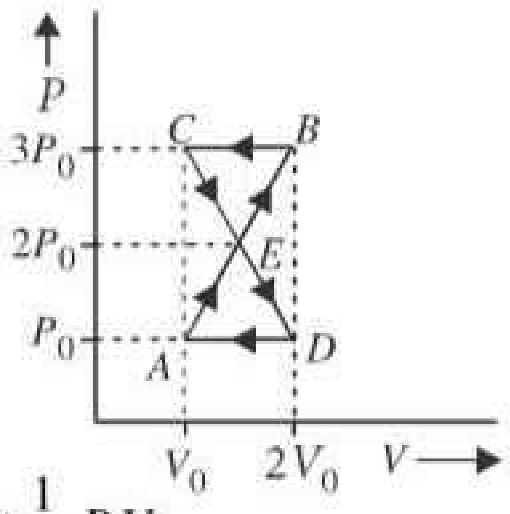
(For adiabatic process, PV^{γ} = constant)

$$\frac{P}{2}(2V)^{5/3} = P_f\,(16V)^{5/3}$$

$$P_f = \frac{P}{2}\left(\frac{2V}{16V}\right)^{5/3} = \frac{P}{2}\left(\frac{1}{8}\right)^{5/3} = \frac{P}{2}\left(\frac{1}{2^3}\right)^{5/3}$$

$$= \frac{P}{2}\left(\frac{1}{2^5}\right) = \frac{P}{64}$$

18. **(d) :** In a cyclic process work done is equal to the area under the cycle and is positive if the cycle is clockwise and negative if anticlockwise.



As is clear from figure,

$$W_{AEDA} = +\text{area of } \Delta AED = +\frac{1}{2}\,P_0V_0$$

$$W_{BCEB} = -\text{Area of } \Delta BCE = -\frac{1}{2}\,P_0V_0$$

The net work done by the system is

$$W_{\text{net}} = W_{AEDA} + W_{BCEB}$$

$$= +\frac{1}{2}P_0V_0 - \frac{1}{2}P_0V_0 = \text{zero}$$

19. **(b) :** Mean free path, $\lambda = \dfrac{1}{\sqrt{2}n\pi d^2}$

where n is the number density and d is the diameter of the molecule.

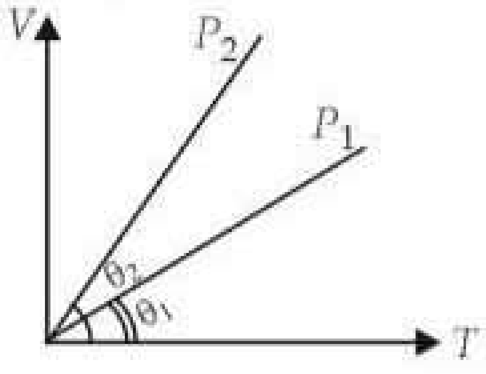
As $d = 2r$

$$\therefore \quad \lambda = \frac{1}{4\sqrt{2}n\pi r^2} \quad \text{or} \quad \lambda \propto \frac{1}{r^2}$$

20. **(a) :** According to ideal gas equation

$PV = nRT$

or $\quad V = \dfrac{nRT}{P}$



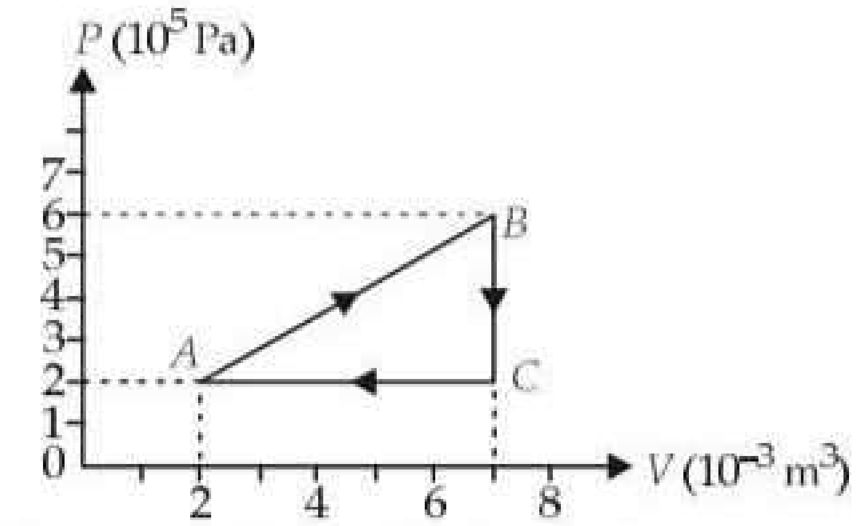
For an isobaric process, P = constant and $V \propto T$

Therefore, $V-T$ graph is a straight line passing through origin. Slope of this line is inversely proportional to P.

In the given figure,

$(\text{Slope})_2 > (\text{Slope})_1 \quad \therefore P_2 < P_1$

21. **(d) :** In a cyclic process, work done is equal to the area under the cycle and is positive if the cycle is clockwise and negative if the cycle is anticlockwise.



$\therefore$ The net work done by the gas is

W = Area of the cycle $ABCA$

$$= \frac{1}{2}\times(7-2)\times10^{-3}\times(6-2)\times10^5$$

$$= \frac{1}{2}\times5\times10^{-3}\times4\times10^5 = 10\times10^2\ \text{J} = 1000\ \text{J}$$

22. **(b) :** $P \propto T^3; \quad PT^{-3}$ = constant ...(i)

For an adiabatic process; $PT^{\gamma/1-\gamma}$ = constant ...(ii)

Comparing (i) and (ii), we get

$$\frac{\gamma}{1-\gamma} = -3;\ \gamma = -3 + 3\gamma$$

$$-2\gamma = -3 \quad \text{or} \quad \gamma = \frac{3}{2}$$

As $\quad \gamma = \dfrac{C_p}{C_v} \quad \therefore \quad \dfrac{C_p}{C_v} = \dfrac{3}{2}$

23. **(c) :** As here volume of the gas remains constant, therefore the amount of heat energy required to raise the temperature of the gas is

$\Delta Q = nC_V\,\Delta T$

Here,

Number of moles, $n = \dfrac{1}{4}$

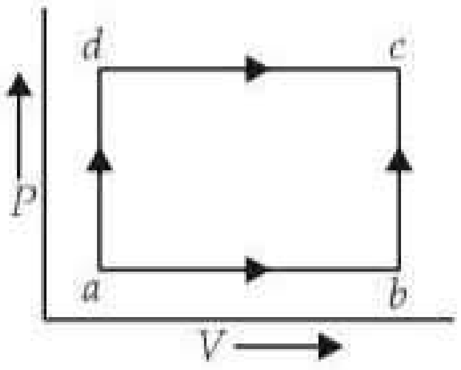
$C_V = \dfrac{3}{2}R$ (∵ He is a monatomic.)

$\Delta T = T_2 - T_1$

$$\therefore \quad \Delta Q = \frac{1}{4}\frac{3}{2}R(T_2 - T_1)$$

$$= \frac{3}{8}N_a k_B(T_2 - T_1) \qquad \left(\because k_B = \frac{R}{N_a}\right)$$

24. **(d) :** According to first law of thermodynamics,



$\delta Q = \delta U + \delta W$

Along the path *adc*

Change in internal energy,

$\delta U_1 = \delta Q_1 - \delta W_1$

$= 50\ \text{J} - 20\ \text{J} = 30\ \text{J}$

Along the path *abc*

Change in internal energy,

$\delta U_2 = \delta Q_2 - \delta W_2;\ \delta U_2 = 36\ \text{J} - \delta W_2$

As change in internal energy is path independent.

$$\therefore \quad \delta U_1 = \delta U_2 \Rightarrow 30 \text{ J} = 36 \text{ J} - \delta W_2$$

$$\delta W_2 = 36 \text{ J} - 30 \text{ J} = 6 \text{ J}$$

25. (d) : For an adiabatic process,

$$PV^\gamma = \text{constant} \qquad \ldots\text{(i)}$$

According to ideal gas equation

$$PV = nRT \Rightarrow P = \frac{nRT}{V}$$

Putting (i), we get

$$\frac{nRT}{V}V^\gamma = \text{constant} \; ; \therefore \; TV^{\gamma-1} = \text{constant}$$

Again from the ideal gas equation

$$V = \frac{nRT}{P}$$

Putting in (i), we get

$$P\left(\frac{nRT}{P}\right)^\gamma = \text{constant} \; ; P^{1-\gamma}T^\gamma = \text{constant}$$

26. (c) : Efficiency of a Carnot engine

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

where T_1 is the temperature of source and T_2 is the temperature of sink respectively.

For engine A, $\eta_A = 1 - \frac{T}{T_1}$

For engine B, $\eta_B = 1 - \frac{T_2}{T}$

As per question, $\eta_A = \eta_B$

$$\therefore \quad 1 - \frac{T}{T_1} = 1 - \frac{T_2}{T} \Rightarrow \frac{T}{T_1} = \frac{T_2}{T} \text{ or } T = \sqrt{T_1T_2}$$

27. (a) : As $P = \frac{1}{3}\frac{mN}{V}v_{\text{rms}}^2$ ...(i)

where m is the mass of each molecule, N is the total number of molecules, V is the volume of the gas.

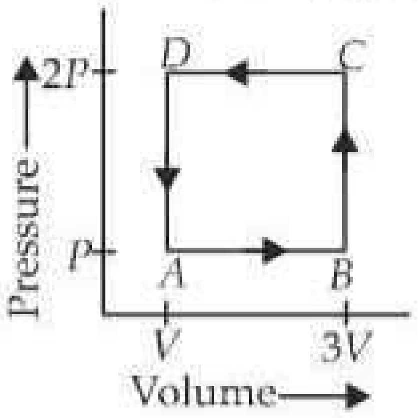
When mass of all the molecules is halved and their speed is doubled, then the pressure will be

$$P' = \frac{1}{3}\left(\frac{m}{2}\right) \times \frac{N}{V} \times (2v_{\text{rms}})^2 = \frac{2}{3}\frac{mN}{V}v_{\text{rms}}^2 = 2P$$

(Using (i))

28. (a) : In a cyclic process, $\Delta U = 0$.

In a cyclic process work done is equal to the area under the cycle and is positive if the cycle is clockwise and negative if anticlockwise.



$$\therefore \quad \Delta W = -\text{Area of rectangle } ABCD = -P(2V)$$

$$= -2PV$$

According to first law of thermodynamics

$\Delta Q = \Delta U + \Delta W$ or $\Delta Q = \Delta W$ (As $\Delta U = 0$)

i.e., heat supplied to the system is equal to the work done

So heat absorbed, $\Delta Q = \Delta W = -2PV$

$\therefore$ Heat rejected by the gas $= 2PV$

29. (d)

30. (a) : Change in internal energy is path independent and depends only on the initial and final states.

As the initial and final states in the three processes are same. Therefore,

$$\Delta U_1 = \Delta U_2 = \Delta U_3$$

Workdone, W = Area under P-V graph

As area under curve 1 > area under curve 2 > area under curve 3

$$\therefore \quad W_1 > W_2 > W_3$$

According to first law of thermodynamics,

$$Q = W + \Delta U$$

As $W_1 > W_2 > W_3$ and $\Delta U_1 = \Delta U_2 = \Delta U_3$

$$\therefore \quad Q_1 > Q_2 > Q_3$$

31. (d)

32. (d) : Heat required to melt 1 kg ice at 0°C to water at 0°C is

$$Q = m_{\text{ice}}L_{\text{ice}} = (1 \text{ kg})\ (80 \text{ cal/g})$$

$$= (1000 \text{ g})\ (80 \text{ cal/g}) = 8 \times 10^4 \text{ cal}$$

Change in entropy, $\Delta S = \frac{Q}{T} = \frac{8 \times 10^4 \text{ cal}}{(273 \text{ K})}$

$$= 293 \text{ cal/K}$$

Note : In the question paper unit of latent heat of ice is given to be cal/°C. It is wrong. The unit of latent heat of ice is cal/g.

33. (d) : For an adiabatic process

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

$$\therefore \quad \left(\frac{T_i}{T_f}\right)^\gamma = \left(\frac{P_i}{P_f}\right)^{\gamma-1} \; ; \; P_f = P_i\left(\frac{T_f}{T_i}\right)^{\frac{\gamma}{\gamma-1}} \qquad \ldots\text{(i)}$$

Here, $T_i = 27°\text{C} = 300 \text{ K}$, $T_f = 927°\text{C} = 1200 \text{ K}$

$P_i = 2 \text{ atm}$, $\gamma = 1.4$

Substituting these values in eqn (i), we get

$$P_f = (2)\left(\frac{1200}{300}\right)^{\frac{1.4}{1.4-1}}$$

$$= (2)(4)^{1.4/0.4} = 2(2^2)^{7/2} = (2)(2)^7 = 2^8 = 256 \text{ atm}$$

34. (a) : According to first law of thermodynamics

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

where,

ΔQ = Heat supplied to the system

ΔU = Increase in internal energy of the system

ΔW = Work done by the system

For an adiabatic process

$\Delta Q = 0 \quad \therefore \ \Delta U = -\Delta W$

For an isothermal process

$\Delta U = 0$

$\therefore \ \Delta Q = \Delta W$

Hence, option (a) is true.

35. **(c) :** Let C_V and C_P be molar specific heats of the ideal gas at constant volume and constant pressure, respectively, then

$$C_P = Mc_p \text{ and } C_V = Mc_v$$
$$C_P - C_V = R \ \therefore \ Mc_p - Mc_v = R \Rightarrow c_p - c_v = R/M$$

36. **(d) :** Ideal gas equation, for an adiabatic process is

PV^{γ} = constant or $P_1V_1^{\gamma} = P_2V_2^{\gamma}$

For monoatomic gas $\gamma = \frac{5}{3}$

$$\therefore \ P_1V_1^{5/3} = P_2\left(\frac{V_1}{8}\right)^{5/3}$$
$$\Rightarrow P_2 = P_1 \times (2)^5 = 32\,P_1.$$

37. **(c) :** Heat energy given $dQ = dU + dW$ where dU is the change in internal energy and dW is the work done.

Given $dQ = 2$ kcal $= 2000 \times 4.2$ J and $dW = 500$ J

$\therefore \ 2000 \times 4.2 = dU + 500 \Rightarrow dU = 7900$ J

38. **(a) :** In isochoric process, it is volume that is kept constant. If pressure is kept constant, it is an isobaric process.

39. **(b) :** Mass of the gas $= m$.

At a fixed temperature and pressure, volume is fixed.

Density of the gas $\rho = \frac{m}{V} \Rightarrow \frac{m}{V.P} = \frac{m}{nRT} = x$

$\therefore \ xT$ = constant.

At 10°C *i.e.*, 283 K, $xT = x$ 283 K

At 110°C, $xT = x'$ 383 K

$$\Rightarrow x' = \frac{283}{383}x$$

40. **(a) :** Internal energy depends only on the initial and final states of temperature and not on the path. In a cyclic process, as initial and final states are the same, change in internal energy is zero. Hence E is ΔU, the change in internal energy.

41. **(c) :** Efficiency of an engine, $\eta = 1 - \frac{T_2}{T_1}$

where T_1 is the temperature of the source and T_2 is the temperature of the sink.

$$\therefore \ \frac{1}{6} = 1 - \frac{T_2}{T_1} \quad \text{or,} \quad \frac{T_2}{T_1} = \frac{5}{6} \qquad \text{...(i)}$$

When the temperature of the sink is decreased by 62°C (or 62 K), efficiency becomes double.

Since, the temperature of the source remains unchanged

$$\therefore \ 2 \times \frac{1}{6} = 1 - \frac{(T_2 - 62)}{T_1} \quad \text{or,} \quad \frac{1}{3} = 1 - \frac{(T_2 - 62)}{T_1}$$

$$\text{or,} \ \frac{2}{3} = \frac{T_2 - 62}{T_1} \quad \text{or,} \ 2T_1 = 3T_2 - 186$$

$$\text{or,} \ 2T_1 = 3\left[\frac{5}{6}\right]T_1 - 186 \quad \text{[using (i)]}$$

$$\therefore \ \left[\frac{5}{2} - 2\right]T_1 = 186 \quad \text{or,} \ \frac{T_1}{2} = 186$$

or, $T_1 = 372$ K = 99°C

42. **(d) :** Efficiency of a Carnot engine, $\eta = 1 - \frac{T_2}{T_1}$

$$\text{or,} \ \frac{T_2}{T_1} = 1 - \eta = 1 - \frac{40}{100} = \frac{3}{5}$$

$$\therefore \ T_1 = \frac{5}{3} \times T_2 = \frac{5}{3} \times 300 = 500 \text{ K.}$$

Increase in efficiency = 50% of 40% = 20%

New efficiency, η' = 40% + 20% = 60%

$$\therefore \ \frac{T_2}{T_1'} = 1 - \frac{60}{100} = \frac{2}{5}$$

$$T_1' = \frac{5}{2} \times T_2 = \frac{5}{2} \times 300 = 750 \text{ K.}$$

Increase in temperature of source $= T_1' - T_1$

$= 750 - 500 = 250$ K.

43. **(b) :** Molar specific heat at constant pressure

$$C_P = \frac{7}{2}R$$

$$\therefore \ C_V = C_P - R = \frac{7}{2}R - R = \frac{5}{2}R.$$

$$\therefore \ \frac{C_P}{C_V} = \frac{(7/2)R}{(5/2)R} = \frac{7}{5}$$

44. **(d) :** $1 - \frac{T_2}{T_1} = 1 - \frac{Q_2}{Q_1} \Rightarrow 1 - \frac{400}{500} = 1 - \frac{Q_2}{6 \times 10^4}$

$$\Rightarrow \frac{4}{5} = \frac{Q_2}{6 \times 10^4} \Rightarrow Q_2 = 4.8 \times 10^4 \text{ cal.}$$

Net heat converted into work

$= 6.0 \times 10^4 - 4.8 \times 10^4 = 1.2 \times 10^4$ cal.

45. **(c) :** Isothermal compression is reversible, for example, Carnot cycle, heat engine.

46. **(a) :** As $PV = nRT$

$$n = \frac{m}{\text{molecular mass}} = \frac{5}{32} \Rightarrow PV = \left(\frac{5}{32}\right)RT$$

47. **(d) :** Work done in adiabatic process is given as

$$W = \frac{-1}{\gamma-1}\left(P_fV_f - P_iV_i\right)$$

$$6R = \frac{-1}{5/3-1}R\left(T_f - T_i\right) \quad \text{[using } PV = RT]$$

⇒ $T_f - T_i = -4$ ∴ $T_f = (T-4)$ K

48. **(d) :** Efficiency of Carnot engine

$$= \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$\frac{W}{6} = 1 - \frac{400}{500} = \frac{1}{5} \Rightarrow W = \frac{6}{5} = 1.2 \text{ kcal.}$$

49. **(c) :** Efficiency (η) of a carnot engine is given by $\eta = 1 - \frac{T_2}{T_1}$, where T_1 is the temperature of the source and T_2 is the temperature of the sink.

Here, $T_2 = 500$ K

$$\therefore \quad 0.5 = 1 - \frac{500}{T_1} \Rightarrow T_1 = 1000 \text{ K}.$$

Now, $\eta = 0.6 = 1 - \frac{T_2'}{1000}$ (T_2' is the new sink temperature)

⇒ $T_2' = 400$ K.

50. **(a) :** Efficiency is maximum in Carnot engine which is an ideal engine.

$$\because \quad \eta = \frac{400-300}{400} \times 100\% = 25\%$$

∴ efficiency 26% is impossible for his heat engine.

51. **(b) :** $\frac{1}{6} = 1 - \frac{T_2}{T_1}$ or $\frac{5}{6} = \frac{T_2}{T_1}$

and $\frac{1}{3} = 1 - \frac{T_2 - 62}{T_1} = 1 - \frac{5}{6} + \frac{62}{T_1}$

$T_1 = 62 \times 6 = 99°C$ and $T_2 = 37°C$

52. **(a) :** $\gamma = 1 + \frac{2}{f}$

where f is the degree of freedom

$$\therefore \quad \frac{2}{f} = \gamma - 1 \text{ or } f = \frac{2}{\gamma - 1}.$$

53. **(b) :** $TV^{\gamma-1}$ = constant (adiabatic).

∴ $(300)\,(V_0)^{2/3} = (V_f)^{2/3}\,T$

$$T = 300\left(\frac{27}{8}\right)^{2/3} = 300 \times \left(\frac{3}{2}\right)^{3\times\frac{2}{3}} = \frac{300\times 9}{4} = 675 \text{ K}$$

Temperature rise = 675 – 300 = 375 K

54. **(a) :** 3 translational, 3 rotational.

55. **(a) :** Change in internal energy, $\Delta U = nC_V\Delta T$

$$= \frac{nR\Delta T}{(\gamma-1)} = \frac{nP\Delta V}{(\gamma-1)} = \frac{nP(2V-V)}{\gamma-1}.$$

For one mole, $n = 1$. ∴ $\Delta U = PV/(\gamma - 1)$.

56. **(c) :** According to first law of thermodynamics

$\Delta Q = \Delta U + W$

For an adiabatic process, $\Delta Q = 0$.

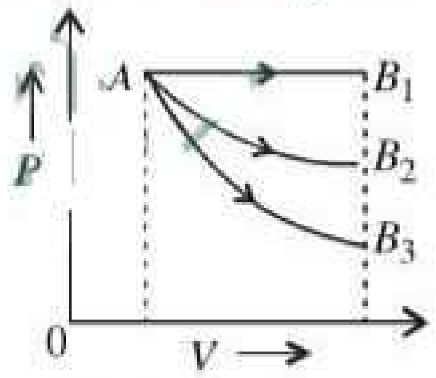
∴ $\Delta U = -W$.

57. **(b) :** Reservoir temperature $(T_1) = 100°C = 373$ K and $T_2 = -23°C = 250$ K.

The efficiency of a Carnot engine

$$\eta = \frac{T_1 - T_2}{T_1} = \frac{373-250}{373}.$$

58. **(d) :** During expansion, work is performed by the gas. The isobaric expansion is represented by the horizontal straight line AB_1, since the adiabatic curve is steeper than the isothermal curve, the adiabatic expansion curve (AB_3) must lie below the isothermal curve (AB_2) as shown in the figure below



Since area under AB_1, is maximum, the work done is maximum in case of isobaric expansion.

59. **(a)**

60. **(b) :** For the adiabatic change, PV^γ = constant.

And for ideal gas, $V = \frac{RT}{P} \propto \frac{T}{P}$.

Therefore $P^{1-\gamma}T^\gamma$ = Constant.

61. **(a) :** Initial temperature $(T_1) = 18°C$

$= (273 + 18) = 291$ K and $V_2 = (1/8)\,V_1$.

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

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

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

$= 291 \times (8)^{1.4-1} = 291 \times (8)^{0.4}$

$= 291 \times 2.297 = 668.4$ K. = 395.4°C.

62. **(c)**

63. **(c) :** Efficiency of Carnot engine $(\eta_1) = 40\% = 0.4$;

Heat intake = 500 K and

New efficiency $(\eta_2) = 50\% = 0.5$.

The efficiency $(\eta) = 1 - \frac{T_2}{T_1}$ or $\frac{T_2}{T_1} = 1 - \eta$.

For first case, $\frac{T_2}{500} = 1 - 0.4$ or $T_2 = 300$ K.

For second case, $\frac{300}{T_1} = 1 - 0.5$ or $T_1 = 600$ K.

64. (d) : For adiabatic change, PV^{γ} = constant

$\Rightarrow \quad P\left(\frac{RT}{\rho}\right)^{\gamma}$ = constant $\Rightarrow P^{1-\gamma}\,T^{\gamma}$ = constant

$\Rightarrow \quad P \propto T^{\frac{-\gamma}{1-\gamma}}$.

Therefore, the value of constant $C = \frac{\gamma}{(\gamma\ -1)}$. For monoatomic gas, $\gamma = \frac{5}{3}$.

Therefore $C = \frac{5/3}{(5/3)-1} = \frac{5/3}{2/3} = \frac{5}{2}$.

65. (b) : Work done is not a thermodynamical function.

66. (b) : $\Delta Q = \Delta U + \Delta W$

$\Rightarrow \quad \Delta W = \Delta Q - \Delta U = 110 - 40 = 70$ J.

67. (b) : Under isothermal conditions, there is no change in internal energy.

68. (b) : Number of translational degrees of freedom are same for all types of gases.

69. (c) : Work done = Area under curve *ACBDA*

70. (c) : Since $\frac{R}{C_V} = 0.67 \Rightarrow \frac{C_P - C_V}{C_V} = 0.67$

$\Rightarrow \quad \gamma = 1.67 = \frac{5}{3}$

Hence gas is monoatomic.

71. (d) : $C_P - C_V = R$ for all gases.

72. (c) : According to Dalton's law of partial pressure, we have $P = P_1 + P_2 + P_3$

73. (a) : Since *AB* is a isochoric process. So no work is done. *BC* is isobaric process.

$W = P_B \times (V_D - V_A) = 240$ J

Therefore $\Delta Q = 600 + 200 = 800$ J

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

$\Rightarrow \quad \Delta U = \Delta Q - \Delta W = 800 - 240 = 560$ J

74. (a) : $\frac{1}{3}Nmc^2 = \frac{2}{3}\left(\frac{1}{2}Nm\right)c^2 = \frac{2}{3}E$

75. (d) : Using $C_P - C_V = R$,

C_P is heat needed for raising by 10 K.

$\therefore \quad C_P = 20.7$ J/mole K

Given $R = 8.3$ J/mole K

$\therefore \quad C_V = 20.7 - 8.3 = 12.4$ J/mole K

$\therefore$ For raising by 10 K = 124 J.

76. (c) : According to classical theory all motion of molecules stop at 0 K.

77. (b) : $\gamma = \frac{C_P}{C_V} = \frac{15}{10} = \frac{3}{2} \Rightarrow C_V = \frac{2}{3}C_P$

$$C_P - C_V = \frac{R}{J} \text{ or } C_P - \frac{2}{3}C_P = \frac{R}{J}$$

or $\quad \frac{C_P}{3} = \frac{R}{J}$ or $C_P = \frac{3R}{J}$

78. (c) : According to law of equipartition of energy, the energy per degree of freedom is $\frac{1}{2}kT$. For a polyatomic gas with *n* degrees of freedom, the mean energy per molcule = $\frac{1}{2}nkT$

79. (b) : As the temperature increases, the average velocity increases. So, the collisions are faster.

80. (b) : Vapour pressure does not depend on the amount of substance. It depends on the temperature alone.

81. (b) : Conservation of energy.