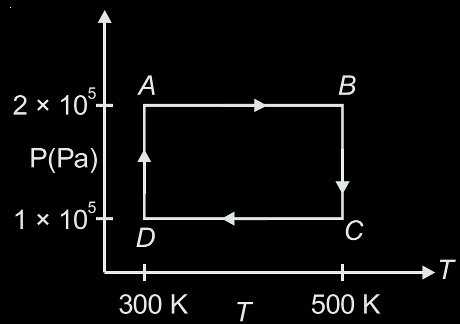
Chapter 13

Thermodynamics

Directions : Question numbers 1, 2 and 3 are based on the following paragraph

Two moles of helium gas are taken over the cycle *ABCDA*, as shown in the *P-T* diagram **[AIEEE-2009]**



1. Assuming the gas to be ideal the work done on the gas in taking it from *A* to *B* is

   (1) 300 R (2) 400 R

   (3) 500 R (4) 200 R

2. The work done on the gas in taking it from *D* to *A* is

   (1) $+414R$ (2) $-690R$

   (3) $+690R$ (4) $-414R$

3. The net work done on the gas in the cycle *ABCDA* is

   (1) $276R$ (2) $1076R$

   (3) $1904R$ (4) Zero

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

   (1) 0.25 (2) 0.5

   (3) 0.75 (4) 0.99

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

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

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

6. The specific heat capacity of a metal at low temperature (T) is given as

$$C_p(\text{kJK}^{-1}\text{kg}^{-1}) = 32\left(\frac{T}{400}\right)^3$$

   A 100 gram vessel of this metal is to be cooled from 20°K to 4°K by a special refrigerator operating at room temperature (27°C). The amount of work required to cool the vessel is **[AIEEE-2011]**

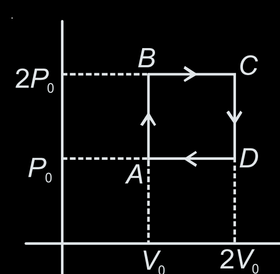
   (1) Less than 0.028 kJ

   (2) Equal to 0.002 kJ

   (3) Greater than 0.148 kJ

   (4) Between 0.148 kJ and 0.028 kJ

7. Helium gas goes through a cycle *ABCDA* (consisting of two isochoric and two isobaric lines) as shown in figure. Efficiency of this cycle is nearly (Assume the gas to be close to ideal gas) **[AIEEE-2012]**



   (1) 9.1% (2) 10.5%

   (3) 12.5% (4) 15.4%

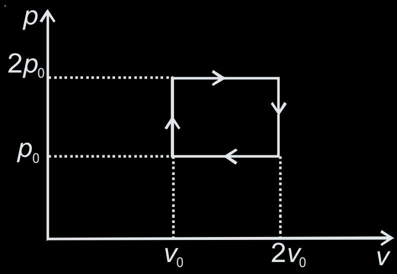
8. A Carnot engine, whose efficiency is 40%, takes in heat from a source maintained at a temperature of 500 K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature most be **[AIEEE-2012]**

   (1) 1200 K

   (2) 750 K

   (3) 600 K

   (4) Efficiency of Carnot engine cannot be made larger than 50%

9. 

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

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

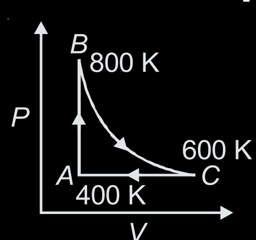
(3) $\left(\frac{11}{2}\right)p_0v_0$ (4) $4p_0v_0$

10. An ideal gas enclosed in a vertical cylindrical container supports a freely moving piston of mass *M*. The piston and the cylinder have equal cross sectional area *A*. When the piston is in equilibrium, the volume of the gas is V_0 and its pressure is P_0. The piston is slightly displaced from the equilibrium position and released. Assuming that the system is completely isolated from its surrounding, the piston executes a simple harmonic motion with frequency **[JEE (Main)-2013]**

(1) $\frac{1}{2\pi}\frac{A\gamma P_0}{V_0 M}$ (2) $\frac{1}{2\pi}\frac{V_0 M P_0}{A^2\gamma}$

(3) $\frac{1}{2\pi}\sqrt{\frac{A^2\gamma P_0}{MV_0}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{MV_0}{A\gamma P_0}}$

11. One mole of diatomic ideal gas undergoes a cyclic process *ABC* as shown in figure. The process *BC* is adiabatic. The temperatures at *A*, *B* and *C* are 400 K, 800 K and 600 K respectively. Choose the correct statement. **[JEE (Main)-2014]**



(1) The change in internal energy in whole cyclic process is 250*R*

(2) The change in internal energy in the process *CA* is 700*R*

(3) The change in internal energy in the process *AB* is –350*R*

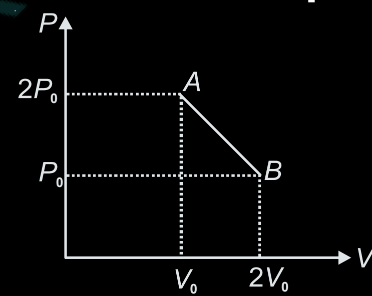
(4) The change in internal energy in the process *BC* is – 500*R*

12. Consider a spherical shell of radius *R* at temperature *T*. The black body radiation inside it can be considered as an ideal gas of photons with internal energy per unit volume $u = \frac{U}{V} \propto T^4$ and pressure $P = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation between *T* and *R* is **[JEE (Main)-2015]**

(1) $T \mu e^{-R}$ (2) $T \mu e^{-3R}$

(3) $T \propto \frac{1}{R}$ (4) $T \propto \frac{1}{R^3}$

13. *n* moles of an ideal gas undergoes a process *A* ® *B* as shown in the figure. The maximum temperature of the gas during the process will be **[JEE (Main)-2016]**



(1) $\frac{3P_0V_0}{2nR}$ (2) $\frac{9P_0V_0}{2nR}$

(3) $\frac{9P_0V_0}{nR}$ (4) $\frac{9P_0V_0}{4nR}$

14. An ideal gas undergoes a quasi-static, reversible process in which its molar heat capacity *C* remains constant. If during this process the relation of pressure *P* and volume *V* is given by PV^n = constant, then *n* is given by (Here C_p and C_v are molar specific heat at constant pressure and constant volume, respectively) **[JEE (Main)-2016]**

(1) $n = \frac{C - C_p}{C - C_v}$ (2) $n = \frac{C_p - C}{C - C_v}$

(3) $n = \frac{C - C_v}{C - C_p}$ (4) $n = \frac{C_p}{C_v}$

15. C_p and C_v are specific heats at constant pressure and constant volume respectively. It is observed that

$C_p - C_v = a$ for hydrogen gas

$C_p - C_v = b$ for nitrogen gas

The correct relation between a and b is **[JEE (Main)-2017]**

(1) $a = \frac{1}{14}b$ (2) $a = b$

(3) $a = 14b$ (4) $a = 28b$

16. Two moles of an ideal monoatomic gas occupies a volume V at 27°C. The gas expands adiabatically to a volume 2 V. Calculate (a) the final temperature of the gas and (b) change in its internal energy. **[JEE (Main)-2018]**

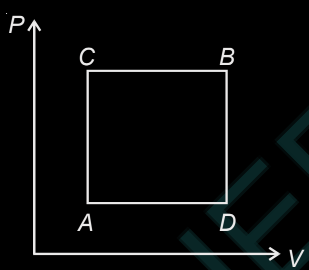
(1) (a) 189 K (b) 2.7 kJ

(2) (a) 195 K (b) –2.7 kJ

(3) (a) 189 K (b) –2.7 kJ

(4) (a) 195 K (b) 2.7 kJ

17. A gas can be taken from A and B via two different processes ACB and ADB.



When path ACB is used 60 J of heat flows into the system and 30 J of work is done by the system. If path ADB is used work done by the system is 10 J. The heat Flow into the system in path ADB is **[JEE (Main)-2019]**

(1) 100 J (2) 80 J

(3) 20 J (4) 40 J

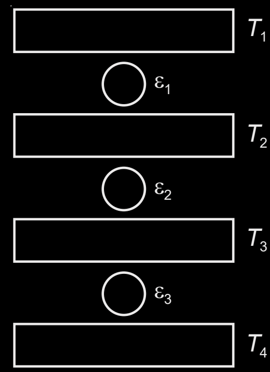
18. Two Carnot engines A and B are operated in series. The first one, A, receives heat at T_1(=600 K) and rejects to a reservoir at temperature T_2. The second engine B receives heat rejected by the first engine and, in turn, rejects to a heat reservoir at T_3 (= 400 K). Calculate the temperature T_2 if the work outputs of the two engines are equal

[JEE (Main)-2019]

(1) 300 K (2) 400 K

(3) 600 K (4) 500 K

19. Three Carnot engines operate in series between a heat source at a temperature T_1 and a heat sink at temperature T_4 (see figure). There are two other reservoirs at temperature T_2 and T_3, as shown, with $T_1 > T_2 > T_3 > T_4$. The three engines are equally efficient if **[JEE (Main)-2019]**



(1) $T_2 = (T_1T_4^2)^{1/3}$; $T_3 = (T_1^2T_4)^{1/3}$

(2) $T_2 = (T_1^3T_4)^{1/4}$; $T_3 = (T_1T_4^3)^{1/4}$

(3) $T_2 = (T_1T_4)^{1/2}$; $T_3 = (T_1^2T_4)^{1/3}$

(4) $T_2 = (T_1^2T_4)^{1/3}$; $T_3 = (T_1T_4^2)^{1/3}$

20. A heat source at $T = 10^3$ K is connected to another heat reservoir at $T = 10^2$ K by a copper slab which is 1 m thick. Given that the thermal conductivity of copper is 0.1 $WK^{-1}m^{-1}$, the energy flux through it in the steady state is

[JEE (Main)-2019]

(1) 200 Wm^{-2} (2) 65 Wm^{-2}

(3) 120 Wm^{-2} (4) 90 Wm^{-2}

21. Half mole of an ideal monoatomic gas is heated at constant pressure of 1 atm from 20°C to 90°C. Work done by gas is close to **[JEE (Main)-2019]**

(Gas constant R = 8.31 J/mol K)

(1) 291 J (2) 581 J

(3) 146 J (4) 73 J

22. A rigid diatomic ideal gas undergoes an adiabatic process at room temperature. The relation between temperature and volume for this process is TV^x = constant, then x is **[JEE (Main)-2019]**

(1) $\frac{2}{5}$ (2) $\frac{2}{3}$

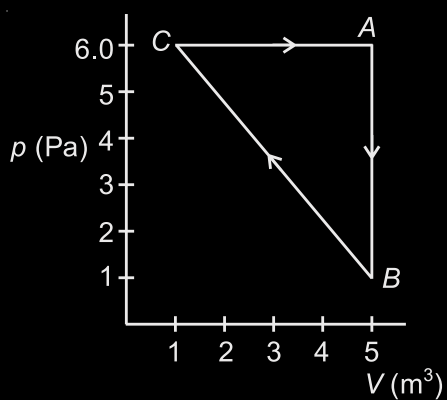
(3) $\frac{5}{3}$ (4) $\frac{3}{5}$

23. In a process, temperature and volume of one mole of an ideal monoatomic gas are varied according to the relation $VT = K$, where K is a constant. In this process, the temperature of the gas is increased by DT. The amount of heat absorbed by gas is (R is gas constant) **[JEE (Main)-2019]**

(1) $\frac{3}{2}R\Delta T$ (2) $\frac{1}{2}R\Delta T$

(3) $\frac{2K}{3}\Delta T$ (4) $\frac{1}{2}KR\Delta T$

24. For the given cyclic process CAB as shown for a gas, the work done is **[JEE (Main)-2019]**



(1) 30 J (2) 10 J

(3) 5 J (4) 1 J

25. A vertical closed cylinder is separated into two parts by a frictionless piston of mass m and of negligible thickness. The piston is free to move along the length of the cylinder. The length of the cylinder above the piston is l_1, and that below the piston is l_2, such that $l_1 > l_2$. Each part of the cylinder contains n moles of an ideal gas at equal temperature T. If the piston is stationary, its mass, m will be given by **[JEE (Main)-2019]**

(R is universal gas constant and g is the acceleration due to gravity)

(1) $\frac{nRT}{g}\left[\frac{l_1 - l_2}{l_1 l_2}\right]$ (2) $\frac{nRT}{g}\left[\frac{1}{l_2} + \frac{1}{l_1}\right]$

(3) $\frac{RT}{g}\left[\frac{2l_1 + l_2}{l_1 l_2}\right]$ (4) $\frac{RT}{ng}\left[\frac{l_1 - 3l_2}{l_1 l_2}\right]$

26. A thermally insulated vessel contains 150 g of water at 0°C. Then the air from the vessel is pumped out adiabatically. A fraction of water turns into ice and the rest evaporates at 0°C itself. The mass of evaporated water will be closest to

(Latent heat of vaporization of water = 2.10×10^6 J kg^{-1} and Latent heat of Fusion of water = 3.36×10^5 J kg^{-1}) **[JEE (Main)-2019]**

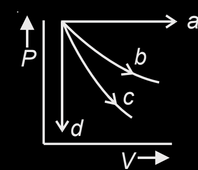
(1) 130 g

(2) 150 g

(3) 20 g

(4) 35 g

27. The given diagram shows four processes i.e., isochoric, isobaric, isothermal and adiabatic. The correct assignment of the processes, in the same order is given by : **[JEE (Main)-2019]**



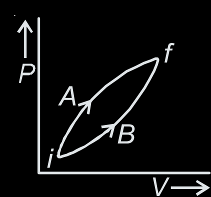
(1) a d c b

(2) a d b c

(3) d a b c

(4) d a c b

28. Following figure shows two processes A and B for a gas. If DQ_A and DQ_B are the amount of heat absorbed by the system in two cases, and DU_A and DU_B are changes in internal energies, respectively, then **[JEE (Main)-2019]**



(1) DQ_A > DQ_B, DU_A = DU_B

(2) DQ_A = DQ_B; DU_A = DU_B

(3) DQ_A > DQ_B, DU_A > DU_B

(4) DQ_A < DQ_B, DU_A < DU_B

29. n moles of an ideal gas with constant volume heat capacity C_V undergo an isobaric expansion by certain volume. The ratio of the work done in the process, to the heat supplied is :

[JEE (Main)-2019]

(1) $\frac{4R}{C_V + R}$ (2) $\frac{R}{C_V + R}$

(3) $\frac{4R}{C_V - R}$ (4) $\frac{R}{C_V - R}$

30. One mole of an ideal gas passes through a process where pressure and volume obey the relation $P = P_0\left[1-\frac{1}{2}\left(\frac{V_0}{V}\right)^2\right]$. Here P_0 and V_0 are constants. Calculate the change in the temperature of the gas if its volume changes from V_0 to $2V_0$.

[JEE (Main)-2019]

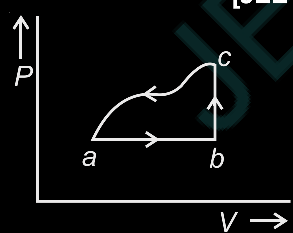
(1) $\frac{1}{4}\frac{P_0V_0}{R}$
(2) $\frac{5}{4}\frac{P_0V_0}{R}$
(3) $\frac{1}{2}\frac{P_0V_0}{R}$
(4) $\frac{3}{4}\frac{P_0V_0}{R}$

31. When heat Q is supplied to a diatomic gas of rigid molecules, at constant volume its temperature increases by DT. The heat required to produce the same change in temperature, at a constant pressure is: **[JEE (Main)-2019]**

(1) $\frac{3}{2}Q$
(2) $\frac{2}{3}Q$
(3) $\frac{7}{5}Q$
(4) $\frac{5}{3}Q$

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

[JEE (Main)-2019]



(1) 130 J
(2) 100 J
(3) 140 J
(4) 120 J

33. A Carnot engine has an efficiency of $\frac{1}{6}$. When the temperature of the sink is reduced by 62°C, its efficiency is doubled. The temperatures of the source and the sink are, respectively,

[JEE (Main)-2019]

(1) 99°C, 37°C
(2) 37°C, 99°C
(3) 124°C, 62°C
(4) 62°C, 124°C

34. A diatomic gas with rigid molecules does 10 J of work when expanded at constant pressure. What would be the heat energy absorbed by the gas, in this process? **[JEE (Main)-2019]**

(1) 30 J
(2) 35 J
(3) 25 J
(4) 40 J

35. A litre of dry air at STP expands adiabatically to a volume of 3 litres. If g = 1.40, the work done by air is ($3^{1.4}$ = 4.6555) [Take air to be an ideal gas]

[JEE (Main)-2020]

(1) 90.5 J
(2) 60.7 J
(3) 48 J
(4) 100.8 J

36. Two ideal Carnot engines operate in cascade (all heat given up by one engine is used by the other engine to produce work) between temperatures, T_1 and T_2. The temperature of the hot reservoir of the first engine is T_1 and the temperature of the cold reservoir of the second engine is T_2. T is temperature of the sink of first engine which is also the source for the second engine. How is T related to T_1 and T_2, if both the engines perform equal amount of work? **[JEE (Main)-2020]**

(1) $T = \frac{T_1+T_2}{2}$

(2) $T = \sqrt{T_1T_2}$

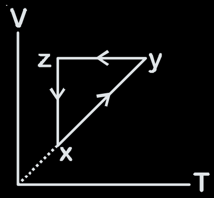
(3) $T = \frac{2T_1T_2}{T_1+T_2}$

(4) T = 0

37. Under an adiabatic process, the volume of an ideal gas gets doubled. Consequently the mean collision time between the gas molecule changes from t_1 to t_2. If $\frac{C_P}{C_V} = \gamma$ for this gas then a good estimate for $\frac{\tau_2}{\tau_1}$ is given by **[JEE (Main)-2020]**

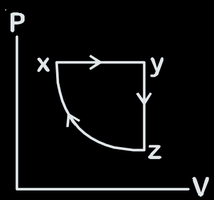
(1) $(2)^{\frac{\gamma+1}{2}}$
(2) $\left(\frac{1}{2}\right)^{\gamma}$
(3) 2
(4) $\frac{1}{2}$

38. A thermodynamic cycle *xyzx* is shown on a *V-T* diagram



The *P-V* diagram that best describes this cycle is (Diagrams are shcematic and not to scale)

[JEE (Main)-2020]

(1)


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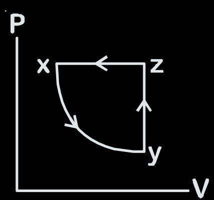

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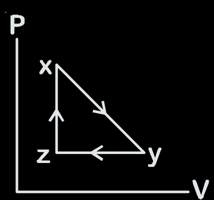

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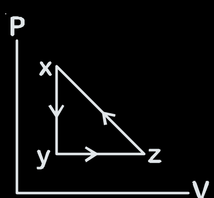


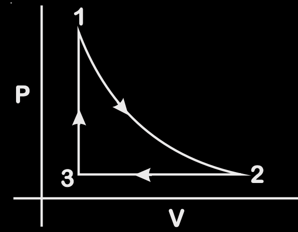
39. A Carnot engine having an efficiency of $\frac{1}{10}$ is being used as a refrigerator. If the work done on the refrigerator is 10 J, the amount of heat absorbed from the reservoir at lower temperature is

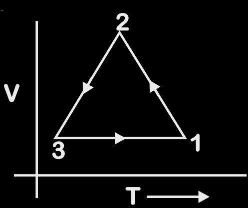
[JEE (Main)-2020]

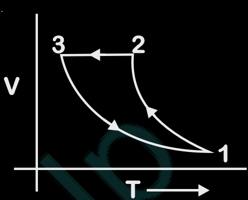
(1) 90 J (2) 1 J

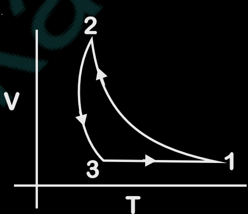
(3) 99 J (4) 100 J

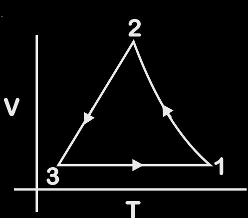
40. Which of the following is an equivalent cyclic process corresponding to the thermodynamic cyclic given in the figure? where, 1 ® 2 is adiabatic. (Graphs are schematic and are not to scale) **[JEE (Main)-2020]**



(1)


(2)


(3)


(4)


41. A heat engine is involved with exchange of heat of 1915 J, – 40J, + 125 J and –Q J, during one cycle achieving an efficiency of 50.0%. The value of *Q* is

[JEE (Main)-2020]

(1) 980 J (2) 40 J

(3) 400 J (4) 640 J

42. A balloon filled with helium (32°C and 1.7 atm.) bursts. Immediately afterwards the expansion of helium can be considered as **[JEE (Main)-2020]**

(1) Irreversible adiabatic

(2) Reversible adiabatic

(3) Irreversible isothermal

(4) Reversible isothermal

43. Match the thermodynamic processes taking place in a system with the correct conditions. In the table : DQ is the heat supplied, DW is the work done and DU is change in internal energy of the system **[JEE (Main)-2020]**

	Process		**Condition**
(I)	Adiabatic	(A)	DW = 0
(II)	Isothermal	(B)	DQ = 0
(III)	Isochoric	(C)	DU ¹ 0, DW ¹ 0, DQ ¹ 0
(IV)	Isobaric	(C)	DU = 0

(1) (I) – (A), (II) – (A), (III) – (B), (IV) – (C)

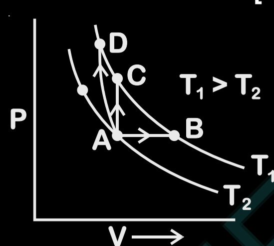
(2) (I) – (B), (II) – (D), (III) – (A), (IV) – (C)

(3) (I) – (A), (II) – (B), (III) – (D), (IV) – (D)

(4) (I) – (B), (II) – (A), (III) – (D), (IV) – (C)

44. Three different processes that can occur in an ideal monoatomic gas are shown in the P vs V diagram. The paths are labelled as A ® B, A ® C and A ® D. The change in internal energies during these process are taken as E_{AB}, E_{AC} and E_{AD} and the work done as W_{AB}, W_{AC} and W_{AD}. The correct relation between these parameters are

[JEE (Main)-2020]



(1) $E_{AB} < E_{AC} < E_{AD}$, $W_{AB} > 0$, $W_{AC} > W_{AD}$

(2) $E_{AB} = E_{AC} = E_{AD}$, $W_{AB} > 0$, $W_{AC} = 0$, $W_{AD} < 0$

(3) $E_{AB} > E_{AC} > E_{AD}$, $W_{AB} < W_{AC} < W_{AD}$

(4) $E_{AB} = E_{AC} < E_{AD}$, $W_{AB} > 0$, $W_{AC} = 0$, $W_{AD} < 0$

45. In an adiabatic process, the density of a diatomic gas becomes 32 times its initial value. The final pressure of the gas is found to be n times the initial pressure. The value of n is **[JEE (Main)-2020]**

(1) 128

(2) 32

(3) $\frac{1}{32}$

(4) 326

46. A Carnot engine operates between two reservoirs of temperatures 900 K and 300 K. The engine performs 1200 J of work per cycle. The heat energy (in J) delivered by the engine to the low temperature reservoir, in a cycle, is ________ .

[JEE (Main)-2020]

47. Starting at temperature 300 K, one mole of an ideal diatomic gas (g = 1.4) is first compressed adiabatically from volume V_1 to $V_2 = \frac{V_1}{16}$. It is then allowed to expand isobarically to volume $2V_2$. If all the processes are the quasi-static then the final temperature of the gas (in °K) is (to the nearest integer) _______. **[JEE (Main)-2020]**

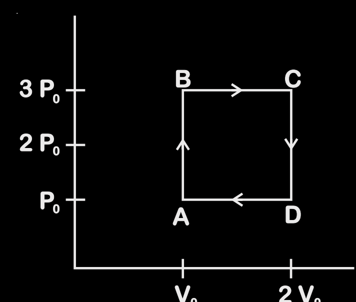
48. An engine takes in 5 moles of air at 20°C and 1 atm, and compresses it adiabatically to 1/10th of the original volume. Assuming air to be a diatomic ideal gas made up of rigid molecules, the change in its internal energy during this process comes out to be X kJ. The value of X to the nearest integer is________. **[JEE (Main)-2020]**

49. If minimum possible work is done by a refrigerator in converting 100 grams of water at 0°C to ice, how much heat (in calories) is released to the surroundings at temperature 27°C (Latent heat of ice = 80 Cal/gram) to the nearest integer ?

[JEE (Main)-2020]

50. The change in the magnitude of the volume of an ideal gas when a small additional pressure DP is applied at a constant temperature, is the same as the change when the temperature is reduced by a small quantity DT at constant pressure. The initial temperature and pressure of the gas were 300 K and 2 atm. respectively. If |DT| = C|DP| then value of C in (K/atm.) is ______. **[JEE (Main)-2020]**

51. An engine operates by taking a monatomic ideal gas through the cycle shown in the figure. The percentage efficiency of the engine is close to ________. **[JEE (Main)-2020]**



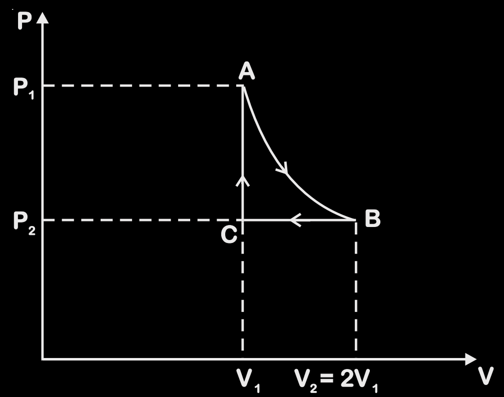
52. n mole of a perfect gas undergoes a cyclic process ABCA (see figure) consisting of the following processes. **[JEE (Main)-2021]**

A → B : Isothermal expansion at temperature T so that the volume is doubled from V_1 to $V_2 = 2V_1$ and pressure changes from P_1 to P_2.

B → C : Isobaric compression at pressure P_2 to initial volume V_1.

$C \rightarrow A$: Isochoric change leading to change of pressure from P_2 to P_1.

Total workdone in the complete cycle ABCA is:



(1) 0

(2) $nRT\left(\ln 2+\frac{1}{2}\right)$

(3) $nRT\left(\ln 2-\frac{1}{2}\right)$

(4) nRTln 2

53. Match List-I with List-II **[JEE (Main)-2021]**

List-I	List-II
(a) Isothermal	(i) Pressure constant
(b) Isochoric	(ii) Temperature constant
(c) Adiabatic	(iii) Volume constant
(d) Isobaric	(iv) Heat content is constant

Choose the correct answer from the options given below :

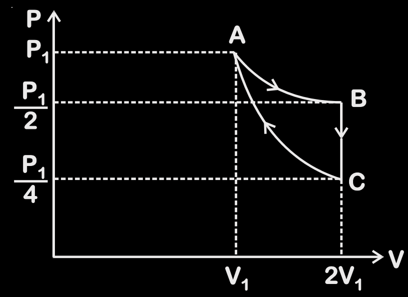
(1) (a) ® (iii), (b) ® (ii), (c) ® (i), (d) ® (iv)

(2) (a) ® (ii), (b) ® (iv), (c) ® (iii), (d) ® (i)

(3) (a) ® (ii), (b) ® (iii), (c) ® (iv), (d) ® (i)

(4) (a) ® (i), (b) ® (iii), (c) ® (ii), (d) ® (iv)

54. If one mole of an ideal gas at (P_1, V_1) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to one-half of the original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of the initial value (B ® C). Then it is restored to its initial state by a reversible adiabatic compression (C to A). The net work done by the gas is equal to: **[JEE (Main)-2021]**



(1) $-\frac{RT}{2(\gamma-1)}$

(2) $RT\left(\ln 2-\frac{1}{2(\gamma-1)}\right)$

(3) 0

(4) RTln2

55. A diatomic gas, having $C_P = \frac{7}{2}R$ and $C_V = \frac{5}{2}R$, is heated at constant pressure. The ratio dU : dQ : dW : **[JEE (Main)-2021]**

(1) 5 : 7 : 2

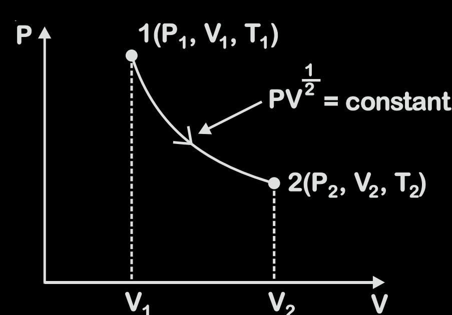
(2) 3 : 5 : 2

(3) 3 : 7 : 2

(4) 5 : 7 : 3

56. In a certain thermodynamical process, the pressure of a gas depends on its volume as kV^3. The work done when the temperature changes from 100°C to 300°C will be ______nR, where n denotes number of moles of a gas. **[JEE (Main)-2021]**

57. Thermodynamic process is shown below on a P-V diagram for one mole of an ideal gas. If $V_2 = 2V_1$ then the ratio of temperature T_2/T_1 is **[JEE (Main)-2021]**



(1) $\sqrt{2}$

(2) 2

(3) $\frac{1}{2}$

(4) $\frac{1}{\sqrt{2}}$

58. A reversible heat engine converts one-fourth of the heat input into work. When the temperature of the sink is reduced by 52 K, its efficiency is doubled. The temperature in Kelvin of the source will be ________. **[JEE (Main)-2021]**

59. The internal energy (U), pressure (P) and volume (V) of an ideal gas are related as U = 3PV + 4. The gas is **[JEE (Main)-2021]**

(1) Diatomic only

(2) Either monoatomic or diatomic

(3) Polyatomic only

(4) Monoatomic only

60. 1 mole of rigid diatomic gas performs a work of $\frac{Q}{5}$ when heat Q is supplied to it. The molar heat capacity of the gas during this transformation is $\frac{xR}{8}$. The value of x is____.

[R = universal gas constant]

[JEE (Main)-2021]

61. The volume V of a given mass of monoatomic gas changes with temperature T according to the relation $V = KT^{\frac{2}{3}}$. The work done when temperature changes by 90 K will be xR. The value of x is ____.

[R = universal gas constant]

[JEE (Main)-2021]

62. In thermodynamics, heat and work are:

[JEE (Main)-2021]

(1) Point functions

(2) Extensive thermodynamic state variables

(3) Path functions

(4) Intensive thermodynamic state variables

63. A Carnot's engine working between 400 K and 800 K has a work output of 1200 J per cycle. The amount of heat energy supplied to the engine from the source in each cycle is: **[JEE (Main)-2021]**

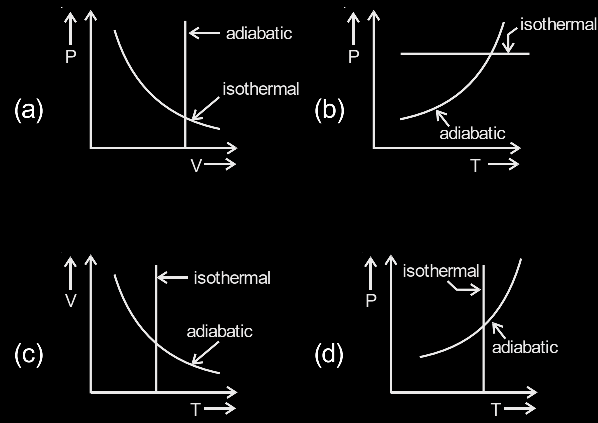
(1) 1800 J

(2) 3200 J

(3) 1600 J

(4) 2400 J

64. Which one is the correct option for the two different thermodynamic processes? **[JEE (Main)-2021]**



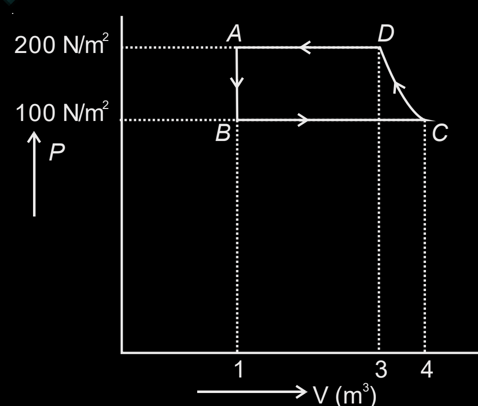
(1) (c) and (d)

(2) (a) only

(3) (c) and (a)

(4) (b) and (c)

65. The P-V diagram of a diatomic ideal gas system going under cyclic process as shown in figure. The work done during an adiabatic process CD is (Use g = 1.4): **[JEE (Main)-2021]**



(1) – 500 J

(2) 200 J

(3) – 400 J

(4) 400 J

66. For an adiabatic expansion of an ideal gas, the fractional change in its pressure is equal to (where g is the ratio of specific heats) :

[JEE (Main)-2021]

(1) $-\gamma \frac{V}{dV}$

(2) $-\gamma \frac{dV}{V}$

(3) $-\frac{1}{\gamma}\frac{dV}{V}$

(4) $\frac{dV}{V}$

67. An ideal gas in a cylinder is separated by a piston in such a way that the entropy of one part is S_1 and that of the other part is S_2. Given that $S_1 > S_2$. If the piston is removed, then the total entropy of the system will be: **[JEE (Main)-2021]**

(1) $S_1 - S_2$

(2) $S_1 \times S_2$

(3) $\frac{S_1}{S_2}$

(4) $S_1 + S_2$

68. The amount of heat needed to raise the temperature of 4 moles of a rigid diatomic gas from 0°C to 50°C when no work is done is _______. (R is the universal gas constant) **[JEE (Main)-2021]**

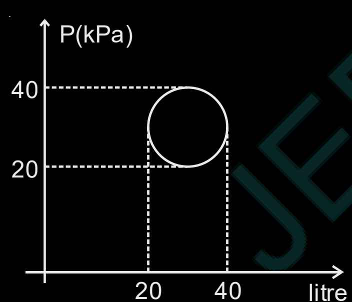
(1) 750 R

(2) 500 R

(3) 250 R

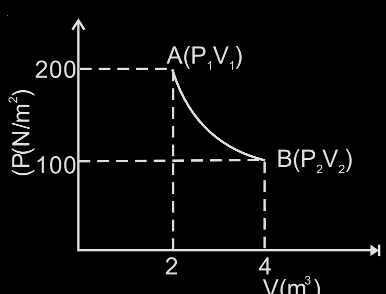
(4) 175 R

69. In the reported figure, heat energy absorbed by a system in going through a cyclic process is _________ pJ. **[JEE (Main)-2021]**



70. One mole of an ideal gas at 27°C is taken from A to B as shown in the given PV indicator diagram. The work done by the system will be ______ $\times 10^{-1}$ J.

[Given : R = 8.3 J / mole K, ln2 = 0.6931] (Round off to the nearest integer) **[JEE (Main)-2021]**



71. A monoatomic ideal gas, initially at temperature T_1 is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If l_1 and l_2 are the lengths of the gas column, before and after the expansion respectively, then the value of $\frac{T_1}{T_2}$ will be

[JEE (Main)-2021]

(1) $\frac{l_2}{l_1}$

(2) $\frac{l_1}{l_2}$

(3) $\left(\frac{l_2}{l_1}\right)^{\frac{2}{3}}$

(4) $\left(\frac{l_1}{l_2}\right)^{\frac{2}{3}}$

72. For a gas $C_P - C_V = R$ in a state P and $C_P - C_V = 1.10\ R$ in a state Q, T_P and T_Q are the temperatures in two different states P and Q respectively, then **[JEE (Main)-2021]**

(1) $T_P < T_Q$

(2) $T_P > T_Q$

(3) $T_P = T_Q$

(4) $T_P = 0.9\ T_Q$

73. A heat engine has an efficiency of $\frac{1}{6}$. When the temperature of sink is reduced by 62°C, its efficiency gets doubled. The temperature of the source is **[JEE (Main)-2021]**

(1) 37°C

(2) 99°C

(3) 124°C

(4) 62°C

74. One mole of an ideal gas is taken through an adiabatic process where the temperature rises from 27°C to 37°C. If the ideal gas is composed of polyatomic molecule that has 4 vibrational modes, which of the following is true?

[R = 8.314 J mol^{-1} K^{-1}] **[JEE (Main)-2021]**

(1) Work done by the gas is close to 332 J

(2) Work done on the gas is close to 332 J

(3) Work done by the gas is close to 582 J

(4) Work done on the gas is close to 582 J

75. Two Carnot engines A and B operate in series such that engine A absorbs heat at T_1 and rejects heat to a sink at temperature T. Engine B absorbs half of the heat rejected by Engine A and rejects heat to the sink at T_3. When work done in both the cases is equal, the value of T is

[JEE (Main)-2021]

(1) $\frac{2}{3}T_1 + \frac{1}{3}T_3$

(2) $\frac{1}{3}T_1 + \frac{2}{3}T_3$

(3) $\frac{3}{2}T_1 + \frac{1}{3}T_3$

(4) $\frac{2}{3}T_1 + \frac{3}{2}T_3$

76. An electric appliance supplies 600 J/min heat to the system. If the system delivers a power of 90 W. How long it would take to increase the internal energy by 2.5×10^3 J? **[JEE (Main)-2021]**

(1) 2.5×10^2 s (2) 2.4×10^3 s

(3) 4.1×10^1 s (4) 2.5×10^1 s

77. A refrigerator consumes an average 35 W power to operate between temperature –10°C to 25°C. If there is no loss of energy then how much average heat per second does it transfer?

[JEE (Main)-2021]

(1) 263 J/s (2) 350 J/s

(3) 298 J/s (4) 35 J/s

78. A heat engine operates between a cold reservoir at temperature T_2 = 400 K and a hot reservoir at temperature T_1. It takes 300 J of heat from the hot reservoir and delivers 240 J of heat to the cold reservoir in a cycle. The minimum temperature of the hot reservoir has to be _______ K.

[JEE (Main)-2021]

79. A reversible engine has an efficiency of $\frac{1}{4}$. If the temperature of the sink is reduced by 58°C, its efficiency becomes double. Calculate the temperature of the sink: **[JEE (Main)-2021]**

(1) 382 K

(2) 280 K

(3) 174 K

(4) 180.4 K

80. A sample of gas with g = 1.5 is taken through an adiabatic process in which the volume is compressed from 1200 cm^3 to 300 cm^3. If the initial pressure is 200 kPa. The absolute value of the workdone by the gas in the process = _____ J.

[JEE (Main)-2021]

81. The temperature of 3.00 mol of an ideal diatomic gas is increased by 40.0°C without changing the pressure of the gas. The molecules in the gas rotate but do not oscillate. If the ratio of change in internal energy of the gas to the amount of workdone by the gas is $\frac{x}{10}$. Then the value of x (round off to the nearest integer) is _____.

(Given R = 8.31 J mol^{-1} K^{-1}) **[JEE (Main)-2021]**

82. A Carnot engine whose heat sinks at 27°C, has an efficiency of 25%. By how many degrees should the temperature of the source be changed to increase the efficiency by 100% of the original efficiency?

[JEE (Main)-2022]

(1) Increases by 18°C

(2) Increases by 200°C

(3) Increases by 120°C

(4) Increases by 73°C

83. A monoatomic gas performs a work of $\frac{Q}{4}$ where Q is the heat supplied to it. The molar heat capacity of the gas will be____ R during this transformation. Where R is the gas constant. **[JEE (Main)-2022]**

84. A steam engine intakes 50 g of steam at 100°C per minute and cools it down to 20°C. If latent heat of vaporization of steam is 540 cal g^{-1}, then the heat rejected by the steam engine per minute is ___ $\times 10^3$ cal.

(Given : specific heat capacity of water : 1 cal g^{-1} °C^{-1}) **[JEE (Main)-2022]**

85. The ratio of specific heats $\left(\frac{C_p}{C_v}\right)$ in terms of degree of freedom (f) is given by:

[JEE (Main)-2022]

(1) $\left(1+\frac{f}{3}\right)$ (2) $\left(1+\frac{2}{f}\right)$

(3) $\left(1+\frac{f}{2}\right)$ (4) $\left(1+\frac{1}{f}\right)$

86. When a gas filled in a closed vessel is heated by raising the temperature by 1°C, its pressure increases by 0.4%. The initial temperature of the gas is _____ K.

[JEE (Main)-2022]

87. The efficiency of a Carnot's engine, working between steam point and ice point, will be

(1) 26.81%

(2) 37.81%

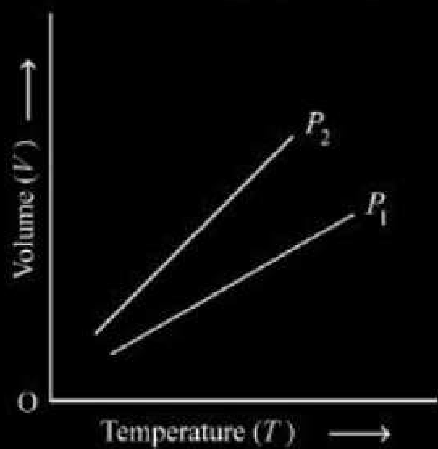
(3) 47.81%

(4) 57.81%

88. In a carnot engine, the temperature of reservoir is 527°C and that of sink is 200 K. If the work done by the engine when it transfers heat from reservoir to sink is 12000 kJ, the quantity of heat absorbed by the engine from reservoir is ___ × 10^6 J.

[JEE (Main)-2022]

89. For a perfect gas, two pressures P_1 and P_2 are shown in figure. The graph shows: **[JEE (Main)-2022]**



(1) $P_1 > P_2$

(2) $P_1 < P_2$

(3) $P_1 = P_2$

(4) Insufficient data to draw any conclusion

90. A diatomic gas (γ = 1.4) does 400 J of work when it is expanded isobarically. The heat given to the gas in the process is ________ J. **[JEE (Main)-2022]**

91. Given below are two statements

Statement-I: When μ amount of an ideal gas undergoes adiabatic change from state (P_1, V_1, T_1) to state (P_2, V_2, T_2), then work done is $W = \frac{\mu R(T_2 - T_1)}{1-\gamma}$, where $\gamma = \frac{C_p}{C_v}$ and R = universal gas constant.

Statement-II: In the above case, when work is done on the gas, the temperature of the gas would rise.

Choose the correct answer from the options given below **[JEE (Main)-2022]**

(1) Both statement-I and statement-II are true

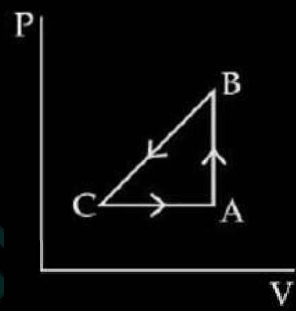
(2) Both statement-I and statement-II are false

(3) Statement-I is true but statement-II is false

(4) Statement-I is false but statement-II is true

92. The total internal energy of two mole monoatomic ideal gas at temperature T = 300 K will be _____ J. (Given R = 8.31 J/mol.K) **[JEE (Main)-2022]**

93. A sample of an ideal gas is taken through the cyclic process $ABCA$ as shown in figure. It absorbs, 40 J of heat during the part AB, no heat during BC and rejects 60 J of heat during CA. A work of 50 J is done on the gas during the part BC. The internal energy of the gas at A is 1560 J. The work done by the gas during the part CA is: **[JEE (Main)-2022]**



(1) 20 J

(2) 30 J

(3) –30 J

(4) –60 J

94. 300 cal. of heat is given to a heat engine and it rejects 225 cal. of heat. If source temperature is 227°C, then the temperature of sink will be _______°C.

[JEE (Main)-2022]

95. 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 the process is purely adiabatic and W_3 if the process is purely isobaric. Then, choose the correct option.

[JEE (Main)-2022]

(1) $W_1 < W_2 < W_3$

(2) $W_2 < W_3 < W_1$

(3) $W_3 < W_1 < W_2$

(4) $W_2 < W_1 < W_3$

96. A certain amount of gas of volume V at 27°C temperature and pressure 2×10^7 Nm^{-2} expands isothermally until its volume gets doubled. Later it expands adiabatically until its volume gets redoubled. The final pressure of the gas will be (Use, $\gamma = 1.5$)

[JEE (Main)-2022]

(1) 3.536×10^5 Pa

(2) 3.536×10^6 Pa

(3) 1.25×10^6 Pa

(4) 1.25×10^5 Pa

97. Let η_1 is the efficiency of an engine at $T_1 = 447°C$ and $T_2 = 147°C$ while η_2 is the efficiency at $T_1 = 947°C$ and $T_2 = 47°C$. The ratio $\frac{\eta_1}{\eta_2}$ will be

[JEE (Main)-2022]

(1) 0.41 (2) 0.56

(3) 0.73 (4) 0.70

98. 7 mol of a certain monoatomic ideal gas undergoes a temperature increase of 40 K at constant pressure. The increase in the internal energy of the gas in this process is :

(Given $R = 8.3$ JK^{-1} mol^{-1})

[JEE (Main)-2022]

(1) 5810 J (2) 3486 J

(3) 11620 J (4) 6972 J

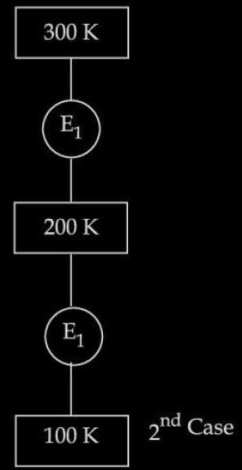
99. A monoatomic gas at pressure P and volume V is suddenly compressed to one eighth of its original volume. The final pressure at constant entropy will be:

[JEE (Main)-2022]

(1) P (2) $8P$

(3) $32P$ (4) $64P$

100. In 1st case, Carnot engine operates between temperatures 300 K and 100 K. In 2nd case, as shown in the figure, a combination of two engines is used. The efficiency of this combination (in 2nd case) will be: **[JEE (Main)-2022]**



(1) Same as the 1st case

(2) Always greater than the 1st case

(3) Always less than the 1st case

(4) May increase or decrease with respect to the 1st case

101. Which statements are correct about degrees of freedom? **[JEE (Main)-2022]**

(A) A molecule with n degrees of freedom has n^2 different ways of storing energy.

(B) Each degree of freedom is associated with $\frac{1}{2}RT$ average energy per mole.

(C) A monatomic gas molecule has 1 rotational degree of freedom whereas diatomic molecule has 2 rotational degrees of freedom.

(D) CH_4 has a total of 6 degrees of freedom.

Choose the correct answer from the option given below:

(1) (B) and (C) only

(2) (B) and (D) only

(3) (A) and (B) only

(4) (C) and (D) only

102. A Carnot engine has efficiency of 50%. If the temperature of sink is reduced by 40°C, its efficiency increases by 30%. The temperature of the source will be: **[JEE (Main)-2022]**

(1) 166.7 K

(2) 255.1 K

(3) 266.7 K

(4) 367.7 K

103. At a certain temperature, the degrees of freedom per molecule for gas is 8. The gas performs 150 J of work when it expands under constant pressure. The amount of heat absorbed by the gas will be _______ J.

[JEE (Main)-2022]

104. The pressure P_1 and density d_1 of diatomic gas $\left(\gamma = \frac{7}{5}\right)$ changes suddenly to P_2 (> P_1) and d_2 respectively during an adiabatic process. The temperature of the gas increases and becomes ______ times of its initial temperature.

(Given $\frac{d_2}{d_1} = 32$) **[JEE (Main)-2022]**

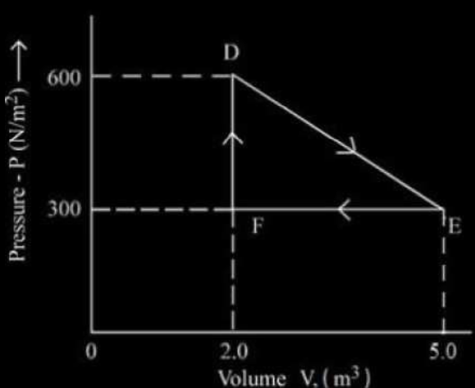
105. Match List I with List II.

	List-I		List-II
A.	Torque	I.	Nms^{-1}
B.	Stress	II.	Jkg^{-1}
C.	Latent Heat	III.	Nm
D.	Power	IV	Nm^{-2}

Choose the correct answer from the options given below: **[JEE (Main)-2022]**

(1) A-III, B-II, C-I, D-IV
(2) A-III, B-IV, C-II, D-I
(3) A-IV, B-I, C-III, D-II
(4) A-II, B-III, C-I, D-IV

106. A thermodynamic system is taken from an original state D to an intermediate state E by the linear process shown in the figure. Its volume is then reduced to the original volume from E to F by an isobaric process. The total work done by the gas from D to E to F will be **[JEE (Main)-2022]**



(1) –450 J
(2) 450 J
(3) 900 J
(4) 1350 J

107. A Carnot engine takes 5000 kcal of heat from a reservoir at 727°C and gives heat to a sink at 127°C. The work done by the engine is

[JEE (Main)-2022]

(1) 3×10^6 J
(2) Zero
(3) 12.6×10^6 J
(4) 8.4×10^6 J

108. Read the following statements:

A. When small temperature difference between a liquid and its surrounding is doubled, the rate of loss of heat of the liquid becomes twice.

B. Two bodies P and Q having equal surface areas are maintained at temperature 10°C and 20°C. The thermal radiation emitted in a given time by P and Q are in the ratio 1 : 1.15.

C. A carnot Engine working between 100 K and 400 K has an efficiency of 75%.

D. When small temperature difference between a liquid and its surrounding is quadrupled, the rate of loss of heat of the liquid becomes twice.

Choose the correct answer from the options given below **[JEE (Main)-2022]**

(1) A, B, C only
(2) A, B only
(3) A, C only
(4) B, C, D only

109. A heat engine operates with the cold reservoir at temperature 324 K. The minimum temperature of the hot reservoir, if the heat engine takes 300 J heat from the hot reservoir and delivers 180 J heat to the cold reservoir per cycle, is _____ K.

[JEE (Main)-2022]

Chapter 13

Thermodynamics

1. Answer (2)

Since process is isobaric

$W_{AB} = 2 \times R \times 200 = 400R$

2. Answer (1)

Since process is isothermal

$\therefore \quad W_{DA} = 2.303 \times 2 \times R \times 300 \log\left(\frac{1}{2}\right)$

$= -415.8R$ J

So, work done on the gas = 415.8R J

Remarks : The exact answer is 415.8R J but the option given in the question is approximate.

3. Answer (1)

$W_{\text{total}} = W_{DA} + W_{BC}$, since $W_{AB} + W_{CD} = 0$

$= 2.303 \times 2 \times R \times 300 \log\left(\frac{1}{2}\right) + 2.303 \times 2 \times R \times 500 \log(2)$

$= 2.303 \times 2R \times 200 \log(2)$

$= 277.2R$

Remarks : The exact answer is 277.2R but the option given in the question is approximate.

4. Answer (3)

For adiabatic expansion

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

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1} = (32)^{\frac{7}{5}-1} = (32)^{2/5} = 4$$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{1}{4} = 0.75$$

5. Answer (2)

This is free expansion T will remain same, while pressure is halved.

6. Answer (4)

Heat energy required $= m \int_{T_1}^{T_2} c\,dT$

$$= \int_{4\text{K}}^{20\text{K}} 0.1 \times 32 \left(\frac{T}{400}\right)^3 dT$$

$\cong 0.002$ kJ

Now, refrigerator is working at 27°C (= 300 K).

Now, if the temperature remains constant at 20°K, then work done by refrigerator

$$= \frac{Q(T_1 - T_2)}{T_2} = \frac{(0.002)(300-20)}{20} = 0.028 \text{ kJ}$$

Work done by refrigerator if temperature remains constant at 4°K

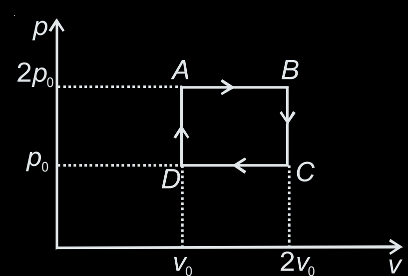
$$= \frac{(0.002)(300-4)}{4} = 0.148 \text{ kJ}$$

As the temperature is varying from 20°K → 4°K, thus the work by refrigerator will be between 0.148 kJ and 0.028 kJ.

7. Answer (4)

8. Answer (2)

9. Answer (2)



Heat is extracted from source in AB & DA

In AB, $Q = nC_P\Delta T$

$$Q = n \times \frac{5R}{2} \times (\Delta T)$$

$$= \frac{5}{2}(4p_0v_0 - 2p_0v_0) = 5p_0v_0$$

In DA, $Q = nC_V\Delta T$

$$= n \times \frac{3R}{2} \times (\Delta T) = \frac{3}{2}(p_0 v_0)$$

Total $= \dfrac{13}{2} p_0 v_0$

10. Answer (3)

PV^{γ} = constant

Differentiating after taking log

$$\frac{dP}{P} + \gamma \frac{dV}{V} = 0$$

$$dP = -\frac{\gamma P\, dV}{V}$$

$$dP = -\frac{\gamma P\, Ax}{V}$$

$F_{\text{restoring}} = -\dfrac{\gamma P\, A^2 x}{V}$ Take $P = P_0$, $V = V_0$

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}} = \frac{1}{2\pi}\sqrt{\frac{\gamma P_0 A^2}{V_0 M}}$$

11. Answer (4)

$$\Delta U = nC_V\Delta T = 1 \times \frac{5R}{2}\Delta T$$

For BC, $\Delta T = -200$ K

$\Rightarrow$ $\Delta U = -500R$

12. Answer (3)

$$P = \frac{1}{3}\left(\frac{U}{V}\right) = \frac{1}{3}kT^4 \qquad \text{...(i)}$$

$$PV = \mu RT \qquad \text{...(ii)}$$

$$\frac{\mu RT}{V} = \frac{1}{3}kT^4$$

$\Rightarrow$ $V \propto T^{-3}$

$$R \propto \frac{1}{T}$$

13. Answer (4)

$$P = \frac{-P_0}{V_0}V + 3P_0$$

$$T = \frac{-P_0 v^2}{V_0 nR} + \frac{3P_0 v}{nR} \qquad \text{...(i)}$$

For $T_{\max}$

$$\frac{dT}{dv} = 0$$

$$\Rightarrow \quad v = \frac{3}{2}v_0 \qquad \text{...(ii)}$$

Using (i) & (ii)

$$T_{\max} = \frac{9}{4}\frac{P_0 V_0}{nR}$$

14. Answer (1)

$$C = C_V + \frac{R}{1-n} \Rightarrow C - C_V = \frac{R}{1-n}$$

or $\quad C = C_P - R - \dfrac{R}{1-n} \Rightarrow C - C_P = \dfrac{nR}{1-n}$

$$\Rightarrow \quad \frac{C - C_P}{C - C_V} = n$$

15. Answer (3)

Let molar heat capacity at constant pressure = X_p

and molar heat capacity at constant volume = X_v

$$X_p - X_v = R$$

$$MC_p - MC_v = R$$

$$C_p - C_v = \frac{R}{M}$$

For hydrogen; $a = \dfrac{R}{2}$

For N_2; $b = \dfrac{R}{28}$

$$\frac{a}{b} = 14$$

$$a = 14b$$

16. Answer (3)

$TV^{\gamma-1}$ = Constant

$$T_f = 300\left(\frac{V}{2V}\right)^{\frac{5}{3}-1} = 189\text{ K}$$

$$\Delta U = nC_v\Delta T = 2\times\frac{3R}{2}\times[189-300]$$

$$= -2.7\text{ kJ}$$

17. Answer (4)

$Q_{ACB} = W_{ACB} + U_{ACB}$

$\Rightarrow$ $60 = 30 + U_{ACB}$

$\Rightarrow$ $30\text{J} = U_{ACB} = U_{ADB}$

And , $Q_{ADB} = W_{ADB} + U_{ADB}$

$= (10 + 30)$ J

$= 40$ J

18. Answer (4)

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2} = \frac{Q_3}{T_3}$$

$W_1 = Q_1 - Q_2$

$W_2 = Q_2 - Q_3$

Given $W_1 = W_2$

$\Rightarrow$ $2T_2 = T_1 + T_3$

$$T_2 = \frac{T_1 + T_3}{2}$$

$T_2 = 500$ K

19. Answer (4)

$$\eta = 1-\frac{T_2}{T_1} = 1-\frac{T_3}{T_2} = 1-\frac{T_4}{T_3}$$

$$T_2 = \sqrt{T_1T_3}$$

$$T_3 = \sqrt{T_2T_4}$$

$$T_3^2 = T_1^{1/2}T_3^{1/2}T_4$$

$$T_3^{3/2} = T_1^{1/2}T_4$$

$$T_3 = \left[T_1T_4^2\right]^{1/3}$$

Similarly $T_2 = \left(T_1^2T_4\right)^{1/3}$

20. Answer (4)

$$\frac{Q}{A} = \frac{K[T_1-T_2]}{L} = \frac{0.1\times 900}{1} = 90\text{ W/m}^2$$

21. Answer (1)

$\Delta W = P\Delta V$

$= nR\Delta T$

$= \frac{1}{2} \times 8.31\ (70)$

$\simeq 291$ J

22. Answer (1)

For adiabatic

PV^{γ} = constant

TV^{x} = constant

$\Rightarrow$ PVV^{x} = constant

$x + 1 = \gamma$

$x = 2/5$

23. Answer (2)

$VT = K$

$PV = RT$

$\Rightarrow$ $V\cdot PV = K'$

$PV^2 = K'$

$$\Rightarrow\ C = \frac{3R}{2} - \frac{R}{2-1} = \frac{R}{2}$$

$$\Delta Q = nC\Delta T = \frac{1}{2}R\Delta T$$

24. Answer (2)

W = Area under PV graph

$= \frac{1}{2} \times 4 \times 5$

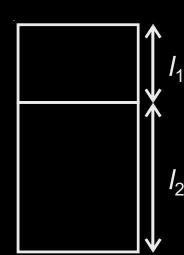
$= 10$ J

25. Answer (1)

$(P_2 - P_1)A = mg$

$$\left[\frac{nRT}{Al_2} - \frac{nRT}{Al_1}\right]A = mg$$

$$\frac{nRT}{g}\left[\frac{l_1 - l_2}{l_1l_2}\right] = m$$



26. Answer (3)

Let amount of water evaporated be m gram.

$\therefore$ $m \times L_v = (150 - m) \times L_s$

$m \times 540 = (150 - m) \times 80$

$\Rightarrow$ $m \simeq 20$ g

27. Answer (3)

Between the isothermal and the adiabatic processes, P-V graph for adiabatic is steeper.

28. Answer (1)

$\Delta W_A > \Delta W_B$

$\Delta U_A > \Delta U_B$

From first law of thermodynamics,

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

$\Delta Q_A > \Delta Q_B$

29. Answer (2)

For Isobaric process

Work done (W) = $nR\Delta T$

and Heat given (Q) = $nC_P\Delta T$

$$\therefore \quad \frac{W}{Q} = \frac{R}{C_P} = \frac{R}{C_V + R}$$

30. Answer (2)

$$\text{If } V_1 = V_0 \Rightarrow P_1 = P_0\left[1 - \frac{1}{2}\right] = \frac{P_0}{2}$$

$$\text{If } V_2 = 2V_0 \Rightarrow P_2 = P_0\left[1 - \frac{1}{2}\left(\frac{1}{4}\right)\right] = \left(\frac{7P_0}{8}\right)$$

$$\left(T = \frac{PV}{nR}\right) \Rightarrow \Delta T = \left|\frac{P_1V_1}{nR} - \frac{P_2V_2}{nR}\right|$$

$$\Delta T = \left|\left(\frac{1}{nR}\right)(P_1V_1 - P_2V_2)\right| = \left(\frac{1}{nR}\right)\left|\left(\frac{P_0V_0}{2} - \frac{7P_0V_0}{4}\right)\right|$$

$$= \frac{5P_0V_0}{4nR}$$

31. Answer (3)

Heat supplied at constant volume

$Q = nC_V\Delta T$

and heat supplied at constant pressure

$Q_1 = nC_p\Delta T$

$$\therefore \quad \frac{Q_1}{Q} = \frac{C_p}{C_v}$$

$$\Rightarrow \quad Q_1 = (Q)\left(\frac{7}{5}\right)$$

32. Answer (1)

For the process $(c - a)$, $\Delta U_{ca} = -180$ J

For process $(b - c) \rightarrow$ Isochoric ($W_{bc} = 0$)

$\therefore \quad \Delta U = 60$ J

Heat absorbs along $(a - b)$, $Q_{ab} = 250$ J

Also $\therefore$ $\Delta U_{\text{cycle}} = 0$

$\therefore \quad \Delta U_{ab} = 120$ J

So $W_{a \rightarrow b} = 130$ J

Total work done from $(a \rightarrow b \rightarrow c)$

$= W_{ab} + W_{bc} = 130$ J

33. Answer (1)

$$\frac{1}{6} = 1 - \frac{T_C}{T_H} \quad \Rightarrow \quad \frac{T_C}{T_H} = \frac{5}{6} \quad \text{...(i)}$$

$$\frac{1}{3} = 1 - \frac{(T_C - 62)}{T_H} \quad \Rightarrow \quad \frac{T_C - 62}{T_H} = \frac{2}{3} \quad \text{...(ii)}$$

$$\frac{T_C - 62}{T_C} = \frac{2 \times 6}{3 \times 5} = \frac{4}{5}$$

$\Rightarrow T_C = 310\ K = 37°$C

$T_H = 372\ K = 99°$C

34. Answer (2)

$W = nR\Delta T = 10$ J

$\Delta Q = (\Delta Q)_P = nC_P\Delta T$

$$\therefore \quad \Delta Q = n \times \frac{7}{2}R \times \Delta T$$

$$= \frac{7}{2} \times (10)$$

$= 35$ J

35. Answer (1)

V_1 = 1 litre, P_1 = 1 atm

V_2 = 3 litre, γ = 1.40,

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

$$\Rightarrow P_2 = P_1 \times \left(\frac{1}{3}\right)^{1.4} = \frac{1}{4.6555} \text{ atm}$$

$$\therefore W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$= \frac{\left(1 \times 1 - \frac{1}{4.6555} \times 3\right) 1.01325 \times 10^5 \times 10^{-3}}{0.4}$$

$= 90.1$ J

Closest value of W = 90.5 J

36. Answer (1)

Let Q_1 : Heat input to first engine

Q_C : Heat rejected by first engine

Q_2 : Heat rejected by second engine

T_C : Lower temperature of first engine

$W = Q_1 - Q_C = Q_C - Q_2$

$\Rightarrow 2Q_C = Q_1 + Q_2$

$\Rightarrow 2T_C = T_1 + T_2 \Rightarrow T_C = \frac{T_1 + T_2}{2}$

37. Answer (1)

$$\tau \propto \frac{1}{n\langle v\rangle}, \langle v\rangle \propto \sqrt{T}$$

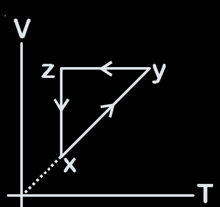
$$\Rightarrow \tau \propto \frac{1}{n\sqrt{T}} \Rightarrow \frac{\tau_2}{\tau_1} = \frac{n_1}{n_2}\sqrt{\frac{T_1}{T_2}}$$

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

$$T_1V_1^{\gamma-1} = T_2(2V_1)^{\gamma-1} \Rightarrow \frac{T_1}{T_2} = 2^{\gamma-1}$$

$$\Rightarrow \frac{\tau_2}{\tau_1} = 2 \times 2^{\frac{(\gamma-1)}{2}} = 2^{\left(\frac{\gamma+1}{2}\right)}$$

38. Answer (1)



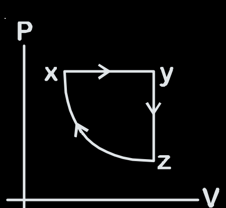
From the corresponding V-T graph

Process xy $\rightarrow$ Isobaric expansion,

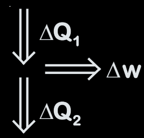
Process yz $\rightarrow$ Isochoric (Pressure decreases)

Process z – x $\rightarrow$ Isothermal compression

Therefore, corresponding PV graph is



39. Answer (1)



$$\frac{\Delta Q_1 - \Delta Q_2}{\Delta Q_1} = \frac{1}{10} = \frac{\Delta w}{\Delta Q_1}$$

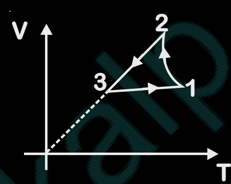
$$\Rightarrow \frac{1}{10} = \frac{\Delta w}{\Delta Q_1}$$

$\therefore \Delta Q_1 = \Delta w \times 10 = 100$ J

So, $\Delta Q_1 - \Delta Q_2 = \Delta w$

$\Rightarrow 100 - 10 = \Delta Q_2 = 90$ J

40. Answer (4)



V = Constant

$P \uparrow \Rightarrow T \uparrow$

$PV^n = C$

$\Rightarrow TV^{n-1} = C$

$V \uparrow \Rightarrow T \downarrow$

P = constant $\Rightarrow V \propto T$

41. Answer (1)

$$\eta = 1 - \frac{Q_R}{Q_g}$$

$$\frac{1}{2} = 1 - \frac{(40 + Q)}{(1915 + 125)}$$

$\Rightarrow Q = 980$ J

42. Answer (1)

Bursting of balloon will result in rapid expansion of gas.

43. Answer (2)

Theoretical

44. Answer (2)

For all process

$E_{AB} = E_{AC} = E_{AD}$

$W_{AB} > 0$

$W_{AC} = 0$

$W_{AD} < 0$

45. Answer (1)

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

$$V \propto \frac{1}{\rho}$$

$$\frac{P}{\rho^{\gamma}} = \text{constant}$$

46. Answer (600.00)

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

$$\Rightarrow \quad 1-\frac{1}{3}=\frac{1200}{Q_1}$$

$$\Rightarrow \quad \frac{2}{3}=\frac{1200}{Q_1}$$

$$\Rightarrow Q_1 = 1800$$

$$\therefore \; Q_2=\frac{1}{3}\times(1800)=600 \text{ J}$$

47. Answer (1818)

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

$T_2 = 300 \times (16)^{0.4}$

$T_f = 2T_2 = 300 \times 2 \times (16)^{0.4}$

$= 1818$ K

48. Answer (46)

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

$T_1 = 293$ K

$$T_1(V_1)^{\gamma-1} = T_2\left(\frac{V_1}{10}\right)^{\gamma-1} \qquad \text{Here } \gamma = 7/5$$

$$\Rightarrow \quad 293 = T_2\left(\frac{1}{10}\right)^{2/5} \qquad \therefore \quad \gamma - 1 = 2/5$$

$\Rightarrow T_2 = 293(10)^{2/5} = 735.98 \approx 736$ K

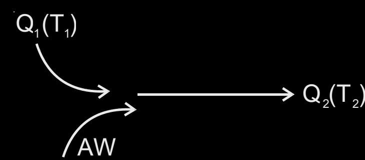
$\therefore\ \Delta T = 443$ K

$$\therefore \ \Delta U = NC_v dT = 5\times\frac{5}{2}\times 8.314\times 443$$

$$\approx 46.038 \times 10^3 \text{ J}$$

$\Rightarrow \Delta U \approx 46$ kJ

49. Answer (8791)



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

$$Q_1 = (100\times 80) = 8000 \text{ cal}$$

$$\therefore \ Q_2 = \frac{8000\times 300}{273} \approx 8791$$

50. Answer (150)

For temperature to be constant

$PV = NRT$

$\Rightarrow \ PdV + VdP = 0$

$$\Rightarrow \ |\Delta V| = \left|\frac{VdP}{P}\right|$$

And at constant pressure

$$PdV = NRdT \qquad \Rightarrow \ |dV| = \left|\frac{NRdT}{P}\right|$$

$$\frac{VdP}{P}=\frac{NRdT}{P} \qquad \Rightarrow \ VdP = NRC\ dP$$

$$\therefore \ V = NRC \qquad \Rightarrow \ C=\frac{V}{NR}=\frac{T}{P}$$

$$\Rightarrow \ C=\frac{300\ K}{2\ atm}=150\left(\frac{K}{atm}\right)$$

51. Answer (19)

$W = 2P_0V_0$

52. Answer (3)

$$W_{AB} = nRT\ln\left(\frac{V_2}{V_1}\right)$$

$$= nRT\ln(2)$$

$$W_{BC} = nR(T_C - T_B) = -\frac{nRT}{2}$$

$$W_{CA} = 0$$

$$\therefore \quad W_{total} = nRT\ln 2 - \frac{nRT}{2} = nRT\left(\ln 2 - \frac{1}{2}\right)$$

53. Answer (3)

Isothermal → T = Constant

Isochoric → V = Constant

Adiabatic → Q = 0

Isobaric → P = Constant

54. Answer (2)

$$W_{A-B} = P_1V_1\ln(2)$$

$$W_{B-C} = 0$$

$$W_{C-A} = \frac{-P_1V_1}{2(\gamma-1)}$$

55. Answer (1)

At constant pressure,

$$dQ = n \times \left(\frac{7R}{2}\right) \cdot \Delta T$$

$$dU = n \times \left(\frac{5R}{2}\right) \cdot \Delta T$$

dW = n × R × ΔT

$$\therefore \quad dU : dQ : dW = \frac{5}{2} : \frac{7}{2} : 1$$

$$= 5 : 7 : 2$$

56. Answer (50)

$P = kV^3$

PV^{-3} = constant

$$W = \frac{nR\Delta T}{1-m}$$

$$= \frac{nR \cdot 200}{1-(-3)}$$

= 50 nR

57. Answer (1)

$PV^{1/2}$ = constant

$\frac{T}{V} \times V^{1/2}$ = constant

$$\Rightarrow \quad T \propto \sqrt{V}$$

$$\therefore \quad \frac{T_2}{T_1} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{2}{1}}$$

$$\Rightarrow \quad \frac{T_2}{T_1} = \sqrt{2}$$

58. Answer (208)

$$\eta = \frac{W}{Q} = 1 - \frac{T_L}{T_H} = \frac{1}{4} \Rightarrow T_L = \frac{3}{4}T_H$$

$$\eta' = 1 - \frac{T_L - 52}{T_H} = \frac{1}{2} \Rightarrow T_L = \frac{1}{2}T_H + 52$$

T_H = 208 K

59. Answer (3)

U = (3)nRT + 4

dU = 3nRdT ⇒ f = 6

60. Answer (25.00)

$$Q = \Delta U + \frac{Q}{5}$$

$$\Rightarrow \Delta U = \frac{4Q}{5} \Rightarrow \frac{5R}{2}\Delta T = \frac{4}{5}Q \quad \text{... (i)}$$

$$\Rightarrow C_{process} = \left(\frac{Q}{\Delta T}\right) \quad \text{... (ii)}$$

From equation (i) and (ii),

$$C_{process} = \frac{25}{8}R$$

61. Answer (60.00)

$$W = \int pdV$$

$$p = \frac{nRT}{V}, V = KT^{2/3} \Rightarrow dV = \frac{2}{3}KT^{-1/3}dT$$

$$\Rightarrow W = \int \frac{nRT}{KT^{2/3}} \frac{2}{3}KT^{-1/3}dT$$

$$= \left(\frac{2}{3}\right)(n)R\,\Delta T$$

$$= \left(\frac{2}{3}\right)(n)R \times 90 = 60\text{ nR} \quad \text{(assuming n = 1)}$$

62. Answer (3)

Heat and work are path functions.

63. Answer (4)

$$\frac{W}{Q}=\left(1-\frac{T_1}{T_2}\right)$$

Q = 2400 J

64. Answer (1)

For adiabatic, TV^{r-1} = constant

$\Rightarrow$ (c) is correct

and, $P\times\left(\frac{T}{P}\right)^{\gamma}$ = constant

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

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

65. Answer (1)

$$\text{Work done } (C\to D)=\frac{P_CV_C-P_DV_D}{\gamma-1}$$

$$=\frac{400-600}{\frac{2}{5}}\text{ J}=-500\text{ J}$$

66. Answer (2)

$$PV^{\gamma}=C$$

$$\Rightarrow (P)(\gamma)V^{\gamma-1}dV+V^{\gamma}dP=0$$

$$\Rightarrow dP=\frac{-\gamma P}{V}dV \quad \Rightarrow \frac{dP}{P}=-\frac{\gamma dV}{V}$$

67. Answer (4)

Entropy will increase.

68. Answer (2)

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

$\Delta W = 0$

$$\Delta U=nR\times\frac{5}{2}\Delta T$$

ΔU = 500 R

69. Answer (100)

W = Area

$$=\pi\left(\frac{40-20}{2}\right)\left(\frac{40-20}{2}\right)\text{J}$$

$= 100\pi$

70. Answer (17258)

Assuming process to be isothermal

$$W=nRT\ln\left(\frac{V_f}{V_i}\right)$$

= 8.3 × 300 × ln (2)

= 1725.819 J

= 17258 × 10^{-1} J

71. Answer (3)

For Adiabatic process

$TV^{\gamma-1} = C$

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

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

$$=\left(\frac{l_2}{l_1}\right)^{\frac{5}{3}-1}$$

$$\frac{T_1}{T_2}=\left(\frac{l_2}{l_1}\right)^{\frac{2}{3}}$$

72. Answer (2)

State P $\Rightarrow$ $C_P - C_V = R$ Ideal gas

State Q $\Rightarrow$ $C_P - C_V = 1.10\,R$ Real gas

As gas behaves like ideal gas at high temperature

So, $T_P > T_Q$

73. Answer (2)

$$\eta=1-\frac{T_L}{T_H}$$

$$\Rightarrow \frac{1}{6}=1-\frac{T_L}{T_H}\Rightarrow\frac{T_L}{T_H}=\frac{5}{6} \qquad \text{...(i)}$$

$$\text{Now, } 2\times\frac{1}{6}=1-\frac{T_L-62}{T_H}\Rightarrow\frac{T_L-62}{T_H}=\frac{2}{3} \qquad \text{...(ii)}$$

From (i) and (ii)

$$\frac{T_L}{T_L-62}=\frac{5}{6}\times\frac{3}{2}=\frac{5}{4}$$

$4T_L = 5T_L - 310$

T_L = 310 K

From (i)

$$T_H=\frac{6}{5}\times T_L=\frac{6}{5}\times 310=372\text{ K}$$

= (372 – 273)°C

= 99°C

74. Answer (4)

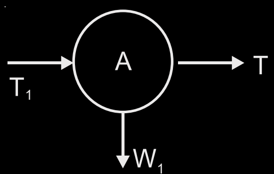
$\Delta T = 37 - 27 = 10°C$

$f = 3 + 3 + 4 \times 2 = 14$

$$\therefore \quad \gamma = 1 + \frac{2}{f} = 1 + \frac{2}{14} = \frac{8}{7}$$

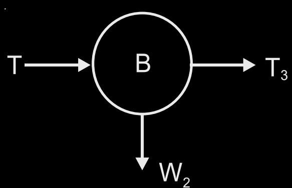
$$\therefore \quad W = \frac{-nR\Delta T}{(\gamma - 1)} = \frac{-1 \times 8.314 \times 10}{\left(\frac{1}{7}\right)} = -582 \text{ J}$$

75. Answer (1)



$$W_1 = Q_1 - Q \quad \Rightarrow \frac{W_1}{Q} = \frac{Q_1}{Q} - 1$$

$$= \frac{T_1}{T} - 1 \qquad \text{... (i)}$$



$$W_2 = \frac{Q}{2} - Q_3 \quad \Rightarrow \frac{W_2}{\frac{Q}{2}} = 1 - \frac{Q_3}{\frac{Q}{2}}$$

$$\Rightarrow \frac{2W_2}{Q} = 1 - \frac{T_3}{T} \qquad \text{...(ii)}$$

From (i) and (ii)

$$2\left(\frac{T_1}{T} - 1\right) = 1 - \frac{T_3}{T}$$

$$\Rightarrow \frac{2T_1}{T} + \frac{T_3}{T} = 3$$

$$\Rightarrow T = \frac{2T_1}{3} + \frac{T_3}{3}$$

76. Answer (1)

Power, P = 6000 J/min

$$= \frac{6000 \text{ J}}{60} \text{ J/s} = 100 \text{ J/s}$$

Power of system = 90 W

Let time taken = t

So $\Delta Q = 100t$, $\Delta W = 90t$

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

$\Rightarrow \quad \Delta U = \Delta Q - \Delta W = 100t - 90t$

$2.5 \times 10^3 = 10t \Rightarrow t = 250$ s

77. Answer (1)

For refrigerator

$$\text{COP} = \frac{W}{Q_2} = \frac{T_H - T_L}{T_L}$$

$$\Rightarrow \frac{35}{Q_2} = \left(\frac{298}{263} - 1\right)$$

$$\Rightarrow Q_2 = \frac{35 \times 263}{35}$$

= 263 J/s

78. Answer (500)

$$\eta = \frac{W}{Q} = \frac{300 - 240}{300} = 1 - \frac{T_2}{T_1}$$

$\Rightarrow T_1 = 500$ K.

79. Answer (3)

$$\frac{1}{4} = \left(1 - \frac{T_2}{T_1}\right) \qquad \text{...(1)}$$

$$\frac{1}{2} = 1 - \frac{(T_2 - 58)}{T_1} \qquad \text{...(2)}$$

From (1) and (2)

$T_{sink} = 174$ K

80. Answer (480)

$P_{initial} = 200$ kPa $= P_1$(say)

$P_{final} = P_2$(Say) $= 1600$ kPa

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{240 - 480}{1.5 - 1} = -480 \text{ J}$$

81. Answer (25)

d.o.f = 5

For isobaric process polytric coefficient = n = 0

$$\frac{\Delta U}{W} = \frac{1-n}{\gamma - 1}$$

$$= \frac{1}{\frac{2}{f}} = \frac{5}{2} = \frac{25}{10}$$

82. Answer (2)

Initially : $\frac{1}{4}=1-\frac{300}{T_H}$

$\Rightarrow\ T_H = 400$ K

Finally : Efficiency becomes $\frac{1}{2}$

$\Rightarrow\ \frac{1}{2}=1-\frac{300}{T_H^{'}}$

$\Rightarrow\ T_H^{'}=600$ K

$\Rightarrow$ Temperature of the source increases by 200°C.

83. Answer (2)

By 1st law,

$\Delta U=\Delta Q-\frac{\Delta Q}{4}=\frac{3}{4}\Delta Q$

$\Rightarrow nC_v\Delta T=\frac{3}{4}nC\Delta T$

$\Rightarrow C=\frac{4C_v}{3}=2R$

84. Answer (31)

ΔQ_{rej} = 50 × 540 + 50 × 1 × (100 – 20)

= 50 × [540 + 80]

= 50 × 620

= 31000 cal

= 31 × 10^3 cal

85. Answer (2)

$\frac{C_P}{C_V}=\gamma$

$C_V=\left(\frac{f}{2}\right)R$ and $C_P-C_V=R$

$\Rightarrow \frac{C_P}{C}=\frac{1+f/2}{f/2}=1+\frac{2}{f}$

86. Answer (250)

$PV = nRT$

So, $\frac{dP}{P}\times 100=\frac{dT}{T}\times 100$

$0.4=\frac{1}{T}\times 100$

$\Rightarrow T = 250$ K

87. Answer (1)

$\eta=1-\frac{T_C}{T_H}=\frac{T_H-T_C}{T_H}$

$=\frac{100}{373}\times 100\%$

= 26.81%

$\Rightarrow$ option (1)

88. Answer (16)

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

$=1-\frac{200}{800}=\frac{3}{4}$

$\therefore\ \eta=\frac{W}{Q_1}$

$\Rightarrow\ \frac{3}{4}=\frac{12000\times 10^3}{Q_1}$

$\Rightarrow\ Q_1 = 16\times 10^6$ J

89. Answer (1)

As per ideal gas equation, $V=\frac{nR}{P}T$

$\Rightarrow$ Slope of V-T graph is inversely proportional to P.

As $m_2 > m_1 \Rightarrow P_1 > P_2$

90. Answer (1400)

$W = nR\Delta T = 400$ J

$\therefore\ \Delta Q = nC_P\Delta T$

$=n\times\frac{7}{2}R\times\Delta T=\frac{7}{2}\times(400)=1400$

91. Answer (1)

$W = \dfrac{\mu R(T_2 - T_1)}{1-r}$ for a polytropic process for adiabatic process $r = \gamma$

$\Rightarrow$ Statement I is true

In an adiabatic process

$\Delta U = -\Delta W$

$\Rightarrow$ If work is done on the gas

$\Rightarrow$ ΔW is negative

$\Rightarrow$ ΔU is positive or temperature increases

$\Rightarrow$ Statement II is true

92. Answer (7479)

$U = 2\left(\dfrac{3}{2}R\right)300$

$= 3 \times 8.31 \times 300$

$= 7479$ J

93. Answer (2)

$\Delta U_{AB} = 40$ J as process is isochoric.

$\Delta U_{BC} + W_{BC} = 0$

$\Delta U_{BC} = +50$ $\qquad$ ($W_{BC} = -50$ J)

$U_{C} = U_A + \Delta U_{AB} + \Delta U_{BC} = 1650$

For CA process,

$Q_{CA} = -60$ J

$\Delta U_{CA} + W_{CA} = -60$

$-90 + W_{CA} = -60$

$\Rightarrow$ $W_{CA} = +30$ J

The graph given is inconsistent with the statement BC may be adiabatic and CA cannot be like isobaric as shown, as increasing volume while rejecting heat at same time.

94. Answer (102)

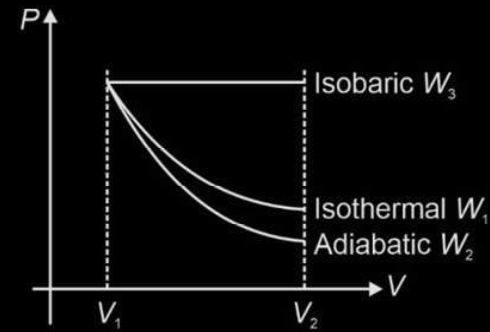
$\eta = \dfrac{W}{Q} = \dfrac{300 - 225}{300}$

$\Rightarrow \dfrac{75}{300} = 1 - \dfrac{T_L}{T_H}$

$\Rightarrow T_L = \dfrac{3}{4}T_H = \dfrac{3}{4}(500) = 375$ K

$\Rightarrow T_L = 102°$C

95. Answer (4)

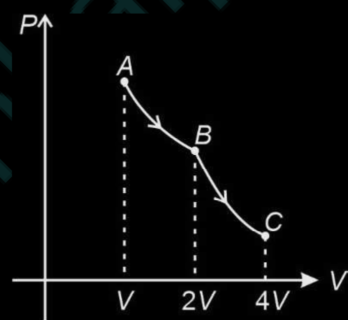


Comparing the area under the PV graph

$A_3 > A_1 > A_2$

$\Rightarrow$ $W_3 > W_1 > W_2$

96. Answer (B)



Let AB is isothermal process and BC is adiabatic process then for AB process

$P_AV_A = P_BV_B$

$\Rightarrow$ $P_B = 10^7$ Nm^{-2}

For process BC

$P_BV_B^r = P_CV_C^r$

$P_C = 3.536 \times 10^6$ Pa

97. Answer (2)

$\eta_1 = 1 - \dfrac{420}{720} = \dfrac{300}{720}$

And $\eta_2 = 1 - \dfrac{320}{1220} = \dfrac{900}{1220}$

$\Rightarrow \dfrac{\eta_1}{\eta_2} = \dfrac{300}{720} \times \dfrac{1220}{900}$

$\simeq 0.56$

98. Answer (2)

$\Delta U = nC_v\Delta T$

$= 7 \times \frac{3R}{2} \times 40$

$= 3486$ J

99. Answer (3)

PV^{γ} = constant

$\Rightarrow \; PV^{\gamma} = (P')\left(\frac{v}{8}\right)^{\gamma}$ where $\gamma = 5/3$

$\Rightarrow \; P' = 32P$

100. Answer (3)

$\eta_{net} = \frac{W_1 + W_2}{Q_1}$

$\eta_{net} = \frac{W_1}{Q_1} + \frac{W_2}{Q_1}$

$\eta_{net} = \eta_1 + \frac{W_2}{Q_2} \times \frac{Q_2}{Q_1}$

$\eta_{net} = \eta_1 + (\eta_2)(1 - \eta_1)$

$1 - \eta_1 < 1$

$\Rightarrow \eta_{net} < \eta_1 + \eta_2$

101. Answer (2)

Statement A is incorrect, statement B is correct by equipartition of energy. Statement C is incorrect as monoatomic does not have any rotational degree of freedom and CH_4 is a polyatomic gas so it has 6 degree of freedom. So only B and D are correct.

102. Answer (3)

$1 - \frac{T_L}{T_H} = 0.5$ ....(1)

$1 - \frac{T_L - 40}{T_H} = 0.65$ ....(2)

$\Rightarrow T_H = \frac{800}{3}\text{ K} \simeq 266.7\text{K}$

103. Answer (750)

$f = 8$

$W = P\,dV = 150$

$Q = W + \Delta U$

$= P\,dV + \frac{f}{2}PdV$

$Q = 5 \times 150 = 750$ J

104. Answer (4)

$P_1V_1^{\gamma} = P_2V_2^{2}$

$\frac{P_1}{d_1^{\gamma}} = \frac{P_2}{d_2^{\gamma}}$

$\frac{d_1T_1}{d_1^{\gamma}} = \frac{d_2T_2}{d_2^{\gamma}}$

$T_2 = \left(\frac{d_2}{d_1}\right)^{\gamma-1} T_1$

$= (32)^{\frac{2}{5}}\, T_1$

$T_2 = 4T_1$

105. Answer (2)

Torque $\rightarrow$ Nm

Stress $\rightarrow$ N/m^2

Latent heat $\rightarrow$ J/kg

Power $\rightarrow$ N m/s

A-III, B-IV, C-II, D-I

106. Answer (2)

$W = \frac{1}{2} \times (5-2) \times (600-300)$ J

$= \frac{1}{2} \times 3 \times 300$

$= 450$ J

107. Answer (3)

Efficiency $\eta = 1 - \frac{T_L}{T_H}$

$= 1 - \frac{400}{1000}$

= 0.6

$\Rightarrow \quad 0.6 = \frac{W}{Q}$

$\Rightarrow \quad W = 0.6Q = 3000 \text{ kcal} = 12.6 \times 10^6 \text{ J}$

108. Answer (1)

From Newton's cooling law $\frac{dQ}{dt} = -k(T - T_s)$ the statement *A* is correct

For *B*

$U = \sigma e A T^4$

So, $\frac{U_1}{U_2} = \left(\frac{283}{293}\right)^4 \simeq \frac{1}{1.15}$

Statement *B* is correct

For *C*

$\eta = 1 - \frac{T_1}{T_2} = 1 - \frac{100}{400} = \frac{3}{4}$

So, efficiency is 75% *C* is correct

For *D*

From Newton's law of cooling $\frac{dQ}{dt} = -k(T - T_s)$

The statement is wrong

109. Answer (540)

$\left(1 - \frac{324}{T_H}\right) = \frac{300 - 180}{300}$

$1 - \frac{2}{5} = \frac{324}{T_H}$

$T_H = \frac{324 \times 5}{3} = 540$

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