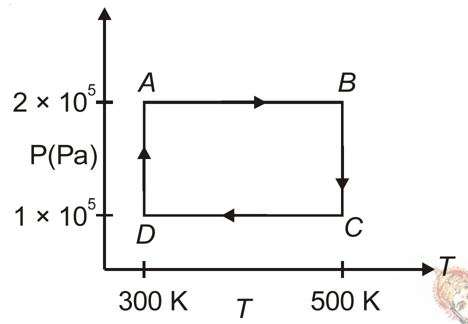
Thermodynamics

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]**

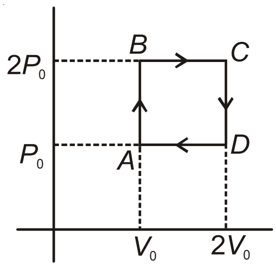
   (1) Less than 0.028 kJ

   (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%

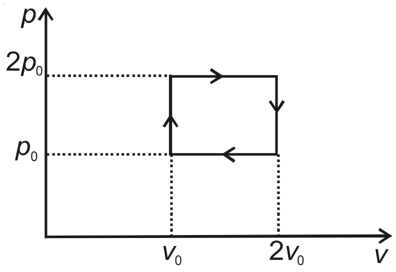
8. A Carnot engine, whose efficiency is 40%, takes in heat from a source maintained at a temperature of 500 K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature most be **[AIEEE-2012]**

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

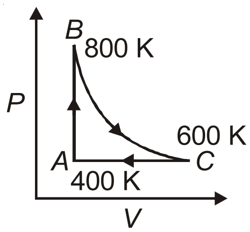
(3) $\left(\frac{11}{2}\right)p_0v_0$ (4) $4p_0v_0$

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) $\frac{1}{2\pi}\frac{A\gamma P_0}{V_0M}$ (2) $\frac{1}{2\pi}\frac{V_0MP_0}{A^2\gamma}$

(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*

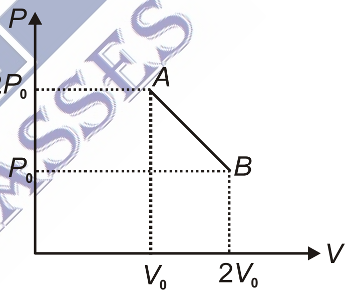
(4) The change in internal energy in the process *BC* is – 500*R*

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

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

13. *n* moles of an ideal gas undergoes a process $A \to B$ 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) $n = \frac{C_p}{C_v}$

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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 $2V$. Calculate (a) the final temperature of the gas and (b) change in its internal energy. **[JEE (Main)-2018]**

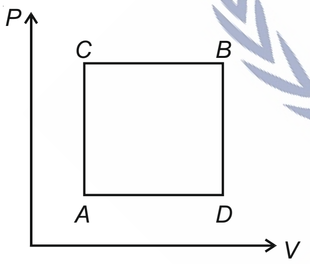
(1) (a) 189 K (b) 2.7 kJ

(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

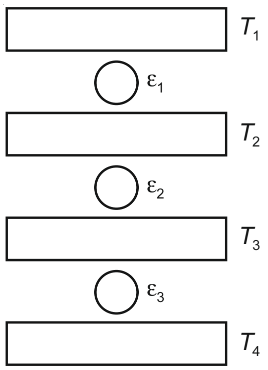
(3) 20 J (4) 40 J

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) $\frac{3}{5}$

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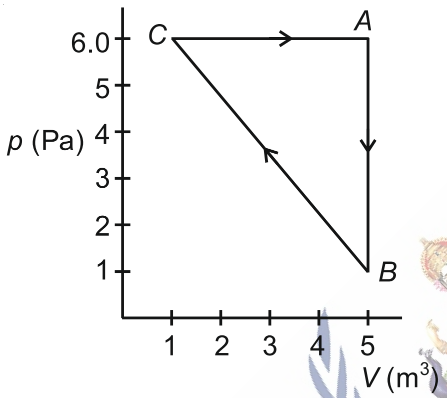
23. In a process, temperature and volume of one mole of an ideal monoatomic gas are varied according to the relation $VT = K$, where K is a constant. In this process, the temperature of the gas is increased by ΔT. The amount of heat absorbed by gas is (R is gas constant) **[JEE (Main)-2019]**

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

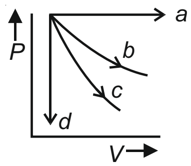
26. A thermally insulated vessel contains 150 g of water at 0°C. Then the air from the vessel is pumped out adiabatically. A fraction of water turns into ice and the rest evaporates at 0°C itself. The mass of evaporated water will be closest to

(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

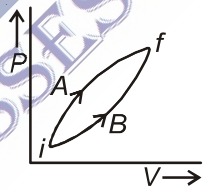
27. The given diagram shows four processes i.e., isochoric, isobaric, isothermal and adiabatic. The correct assignment of the processes, in the same order is given by : **[JEE (Main)-2019]**



(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 ΔQ_A and ΔQ_B are the amount of heat absorbed by the system in two cases, and ΔU_A and ΔU_B are changes in internal energies, respectively, then **[JEE (Main)-2019]**



(1) $\Delta Q_A > \Delta Q_B$, $\Delta U_A = \Delta U_B$

(2) $\Delta Q_A = \Delta Q_B$; $\Delta U_A = \Delta U_B$

(3) $\Delta Q_A > \Delta Q_B$, $\Delta U_A > \Delta U_B$

(4) $\Delta Q_A < \Delta Q_B$, $\Delta U_A < \Delta U_B$

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

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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) $\frac{3}{4}\frac{P_0V_0}{R}$

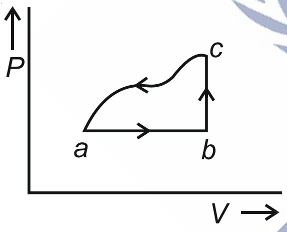
31. When heat Q is supplied to a diatomic gas of rigid molecules, at constant volume its temperature increases by ΔT. The heat required to produce the same change in temperature, at a constant pressure is: **[JEE (Main)-2019]**

(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 $\gamma = 1.40$, 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) $T = \frac{2T_1T_2}{T_1+T_2}$

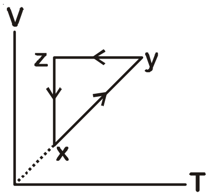
(4) T = 0

37. Under an adiabatic process, the volume of an ideal gas gets doubled. Consequently the mean collision time between the gas molecule changes from τ_1 to τ_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) $\left(\frac{1}{2}\right)^{\frac{\gamma+1}{2}}$ (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]

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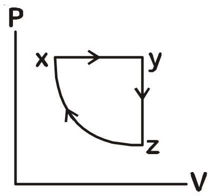
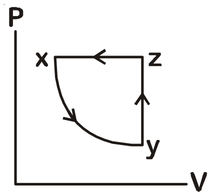
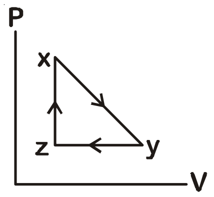
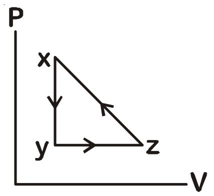
(1) 

(2) 

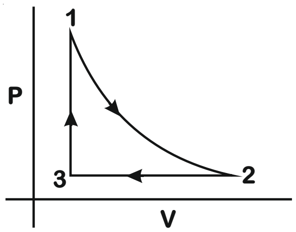
(3) 

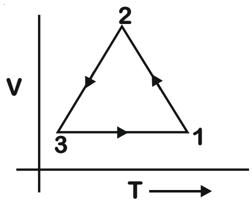
(4) 

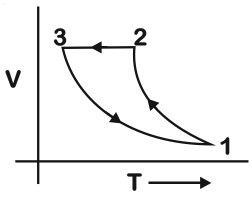
39. A Carnot engine having an efficiency of $\frac{1}{10}$ is being used as a refrigerator. If the work done on the refrigerator is 10 J, the amount of heat absorbed from the reservoir at lower temperature is **[JEE (Main)-2020]**

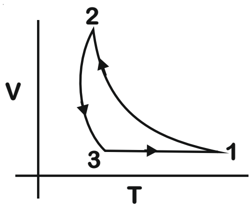
(1) 90 J (2) 1 J
(3) 99 J (4) 100 J

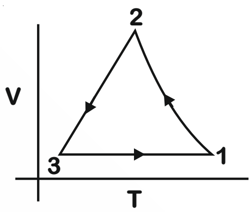
40. Which of the following is an equivalent cyclic process corresponding to the thermodynamic cyclic given in the figure? where, 1 → 2 is adiabatic. (Graphs are schematic and are not to scale) **[JEE (Main)-2020]**



(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

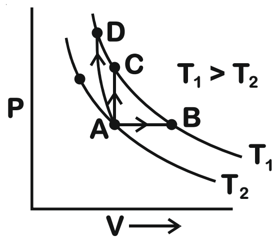
43. Match the thermodynamic processes taking place in a system with the correct conditions. In the table : ΔQ is the heat supplied, ΔW is the work done and ΔU is change in internal energy of the system **[JEE (Main)-2020]**

	Process		**Condition**
(I)	Adiabatic	(A)	$\Delta W = 0$
(II)	Isothermal	(B)	$\Delta Q = 0$
(III)	Isochoric	(C)	$\Delta U \neq 0$, $\Delta W \neq 0$, $\Delta Q \neq 0$
(IV)	Isobaric	(C)	$\Delta U = 0$

(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 $A \to B$, $A \to C$ and $A \to D$. 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 ($\gamma = 1.4$) 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]**

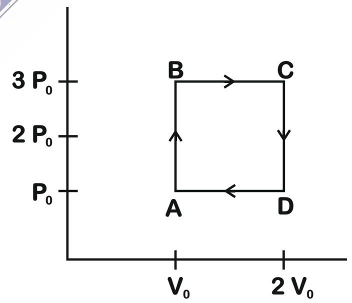
48. An engine takes in 5 moles of air at 20°C and 1 atm, and compresses it adiabatically to $1/10^{th}$ of the original volume. Assuming air to be a diatomic ideal gas made up of rigid molecules, the change in its internal energy during this process comes out to be X kJ. The value of X to the nearest 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 ΔP is applied at a constant temperature, is the same as the change when the temperature is reduced by a small quantity ΔT at constant pressure. The initial temperature and pressure of the gas were 300 K and 2 atm. respectively. If $|\Delta T| = C|\Delta P|$ 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]**



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