Thermodynamics

Question1

0.08kg air is heated at constant volume through 5°C. The specific heat of air at constant volume is 0.17kcal/kg°C and J = 4.18 joule /cal. The change in its internal energy is approximately.

[27-Jan-2024 Shift 1]

Options:

A.

318J

B.

298J

C.

284J

D.

142J

Answer: C

Solution:

$Q = \Delta U$ as work done is zero [constant volume]

$\Delta U = ms \Delta T$

$= 0.08 \times (170 \times 4.18) \times 5$

$\simeq 284\text{J}$

Question2

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

[27-Jan-2024 Shift 2]

Options:

A.

5/3

B.

3/2

C.

7/5

D.

9/7

Answer: B

Solution:

$$P \propto T^3 \Rightarrow PT^{-3} = \text{constant}$$

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

$$P\left(\frac{nRT}{P}\right)^{\gamma} = \text{const}$$

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

$$PT^{\frac{\gamma}{1-\gamma}} = \text{const}$$

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

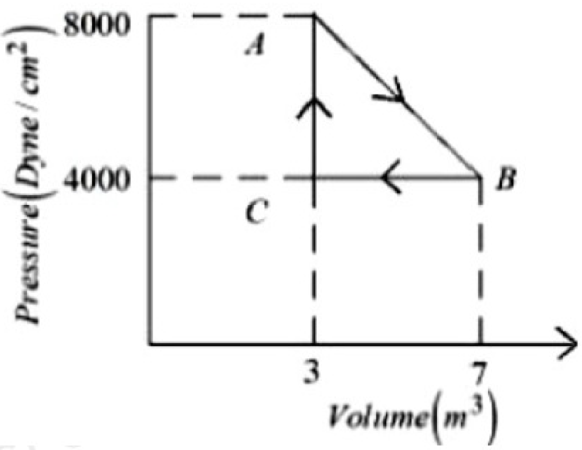
$$\gamma = -3 + 3\gamma$$

$$3 = 2\gamma$$

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

Question3

A thermodynamic system is taken from an original state A to an intermediate state B by a linear process as shown in the figure. It's volume is then reduced to the original value from B to C by an isobaric process. The total work done by the gas from A to B and B to C would be :



[29-Jan-2024 Shift 1]

Options:

A.

33800J

B.

2200J

C.

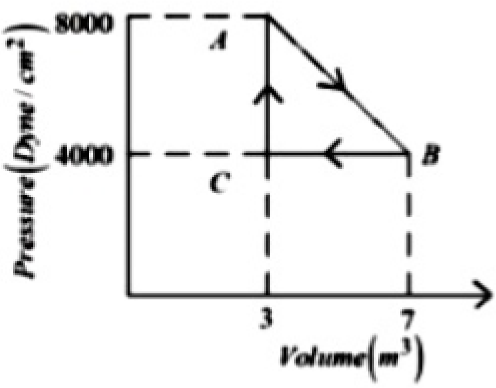
800J

D.

1200J

Answer: C

Solution:



Work done AB $= \frac{1}{2}(8000 + 6000)$ Dyne $/cm^2 \times 4m^3 = (6000\ Dyne/cm^2) \times 4m^3$

Work done $BC = -(4000\ Dyne/cm^2) \times 4m^3$

Total work done $= 2000 \text{ Dyne } / \text{cm}^2 \times 4\text{m}^3$

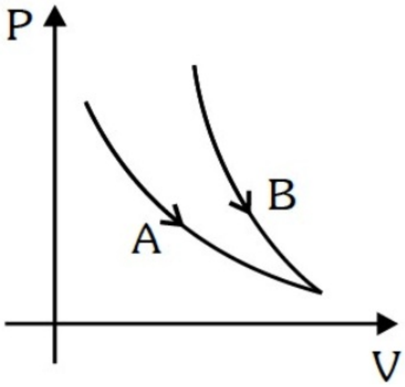
$$= 2 \times 10^3 \times \frac{1}{10^5} \frac{\text{N}}{\text{cm}^2} \times 4\text{m}^3$$

$$= 2 \times 10^{-2} \times \frac{\text{N}}{10^{-4}\text{m}^2} \times 4\text{m}^3$$

$$= 2 \times 10^2 \times 4 \text{ Nm} = 800\text{J}$$

Question4

Choose the correct statement for processes A & B shown in figure.



[30-Jan-2024 Shift 2]

Options:

A.

$PV^{\gamma} = k$ for process B and $PV = k$ for process A.

B.

$PV = k$ for process B and A.

C.

$\frac{P^{\gamma - 1}}{T^{\gamma}} = k$ for process B and $T = k$ for process A.

D.

$\frac{T^{\gamma}}{P^{\gamma - 1}} = k$ for process A and $PV = k$ for process B.

Answer: A and C

Solution:

Steeper curve (B) is adiabatic

Adiabatic $\Rightarrow PV^{v} =$ const.

Or $P\left(\frac{T}{P}\right)^{v} =$ const.

$\frac{T^{v}}{P^{v-1}} =$ const.

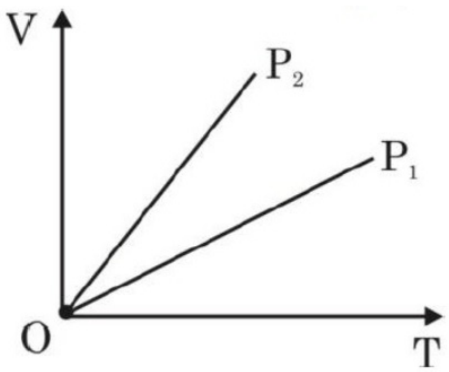
Curve (A) is isothermal

$T =$ const.

$PV =$ const.

Question5

The given figure represents two isobaric processes for the same mass of an ideal gas, then



[31-Jan-2024 Shift 1]

Options:

A.

$P_2 \geq P_1$

B.

$P_2 > P_1$

C.

$P_1 = P_2$

D.

$P_1 > P_2$

Answer: D

Solution:

$PV = nRT$

$V = \left(\frac{nR}{P}\right)T$

$\text{Slope} = \frac{nR}{P}$

$\text{Slope} \propto \frac{1}{P}$

$(\text{Slope})_2 > (\text{Slope})_1$

$P_2 < P_1$

Question6

The pressure and volume of an ideal gas are related as $PV^{3/2} = K$ (Constant). The work done when the gas is taken from state $A(P_1, V_1, T_1)$ to state $B(P_2, V_2, T_2)$ is :

[1-Feb-2024 Shift 1]

Options:

A.

$2(P_1V_1 - P_2V_2)$

B.

$2(P_2V_2 - P_1V_1)$

C.

$2(\sqrt{P_1}V_1 - \sqrt{P_2}V_2)$

D.

$2(P_2\sqrt{V_2} - P_1\sqrt{V_1})$

Answer: B

Solution:

For $PV^x =$ constant

If work done by gas is asked then

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

Here $x = \frac{3}{2}$

$$\therefore W = \frac{P_2V_2 - P_1V_1}{-\frac{1}{2}}$$

$= 2(P_1V_1 - P_2V_2)$..... Option (1) is correct

If work done by external is asked then $W = -2(P_1V_1 - P_2V_2)$..... Option (2) is correct

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Question7

A diatomic gas ($\gamma = 1.4$) does 200J of work when it is expanded isobarically. The heat given to the gas in the process is :

[1-Feb-2024 Shift 2]

Options:

A.

850J

B.

800J

C.

600J

D.

700J

Answer: D

Solution:

$\gamma = 1 + \frac{2}{f} = 1.4 \Rightarrow \frac{2}{f} = 0.4$

$\Rightarrow f = 5$

$W = nR\Delta T = 200J$

$Q = \left(\frac{f+2}{2}\right) nR\Delta T$

$= \frac{7}{2} \times 200 = 700J$

Question8

1g of a liquid is converted to vapour at 3×10^5 Pa pressure. If 10% of the heat supplied is used for increasing the volume by $1600cm^3$ during this phase change, then the increase in internal energy in the process will be :
[24-Jan-2023 Shift 1]

Options:

A. 4320J

B. 432000J

C. 4800J

D. $4.32 \times 10^8 J$

Answer: A

Solution:

Solution:
Work done $= P\Delta V$
$= 3 \times 10^5 \times 1600 \times 10^{-6}$
$= 480J$
Only 10% of heat is used in work done.
Hence $\Delta Q = 4800J$
The rest goes in internal energy, which is 90% of heat.
Change in internal energy $= 0.9 \times 4800 = 4320J$

Question9

Let γ_1 be the ratio of molar specific heat at constant pressure and molar specific heat at constant volume of a monoatomic gas and γ_2 be the similar ratio of diatomic gas. Considering the diatomic gas molecule as a rigid rotator, the ratio, $\frac{\gamma_1}{\gamma_2}$ is
[24-Jan-2023 Shift 2]

Options:

A. $\frac{27}{35}$

B. $\frac{35}{27}$

C. $\frac{25}{21}$

D. $\frac{21}{25}$

Answer: C

Solution:

Solution:

For monoatomic gas $\gamma_1 = \frac{5}{3}$

For diatomic gas at low temperatures

$\gamma_2 = \frac{7}{5}$

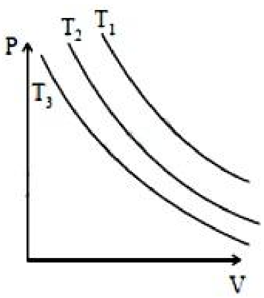
$\therefore \frac{\gamma_1}{\gamma_2} = \frac{\frac{5}{3}}{\frac{7}{5}} = \frac{25}{21}$

Question10

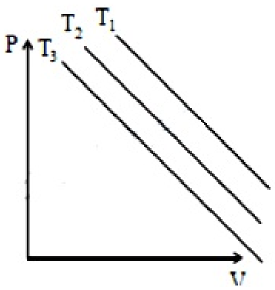
In an Isothermal change, the change in pressure and volume of a gas can be represented for three different temperature; $T_3 > T_2 > T_1$ as : [24-Jan-2023 Shift 2]

Options:

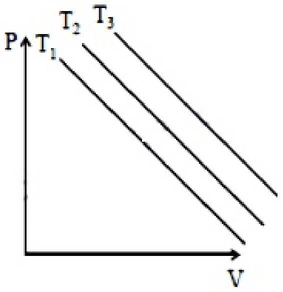
A.



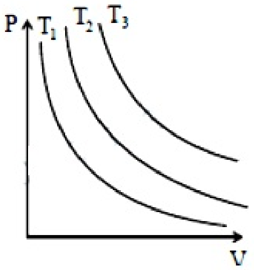
B.



C.



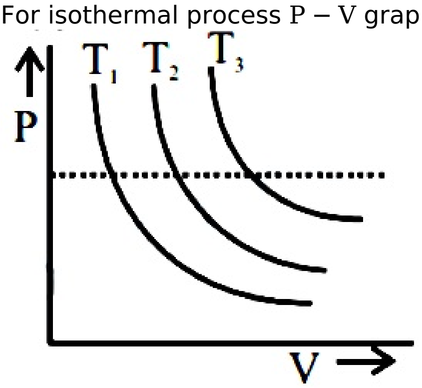
D.



Answer: D

Solution:

Solution:
For isothermal process $P-V$ graph is rectangular hyperbola



As dotted line is isobaric line which implies $T_3 > T_2 > T_1$ as volume is increasing.

Question11

A Carnot engine with efficiency 50% takes heat from a source at 600K. In order to increase the efficiency to 70%, keeping the temperature of sink same, the new temperature of the source will be : [25-Jan-2023 Shift 1]

Options:

A. 360K

B. 1000K

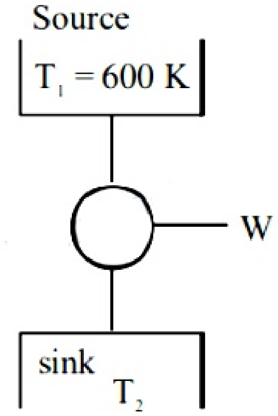
C. 900K

D. 300K

Answer: B

Solution:

Solution:



Initially $\eta = \frac{1}{2}$

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

$\therefore \frac{1}{2} = 1 - \frac{T_2}{600}$

$\Rightarrow \frac{T_2}{600} = \frac{1}{2}$

Now efficiency is increased to 70% and $T_2 = 300$ K, Let temp of source $T_1 = T$

$\Rightarrow \frac{7}{10} = 1 - \frac{300}{T}$

$\Rightarrow \frac{300}{T} = 1 - \frac{7}{10}$

$\Rightarrow \frac{300}{T} = \frac{3}{10} \quad \therefore T_2 = 300K$

Question12

A bowl filled with very hot soup cools from 98°C to 86°C in 2 minutes when the room temperature is 22°C. How long it will take to cool from 75°C to 69°C ?
[25-Jan-2023 Shift 1]

Options:

A. 2 minutes

B. 1.4 minutes

C. 0.5 minute

D. 1 minute

Answer: B

Solution:

Solution:

$\frac{\Delta Q}{\Delta t} = -K(T - T_0)$

$\frac{\Delta Q}{\Delta t} = -K(T_{avg} - T_0)$

(i) $\frac{ms \times 12}{2} = -K\left(\frac{98+86}{2} - 22\right)$

$6 = -\frac{K}{ms}\left[\frac{98+86}{2} - 22\right]$

$6 = -\frac{K}{ms}[70] \ldots\ldots\ldots$ (i)

(ii) $\frac{ms \times 6}{\Delta t} = -K\left(\frac{75+69}{2} - 22\right)$

$\frac{6}{\Delta t} = -\frac{K}{ms}(50)$ .... (II)

(ii) ÷ (i)

$\frac{6}{\Delta t(6)} = \frac{50}{70}$

$\Delta t = \frac{7}{5} = 1.4 \text{ min}$

Question13

Match List I with List II :

List I	List II
A. IsothermalProcess	I. Work done by the gas decreases internal energy
B. Adiabatic Process	II. No change in internal energy
C. Isochoric Process	III. The heat absorbed goes partly to increase internal energy and partly to do work
D. Isobaric Process	IV. No work is done on or by the gas

Choose the correct answer from the options given below : [25-Jan-2023 Shift 2]

Options:

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

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

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

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

Answer: A

Solution:

Solution:
$\Delta U = nC_v \Delta T$
For isothermal process T is constant
So $\Delta U = 0$
$A \longrightarrow II$
Adiabatic process
$\Delta Q = 0$
$\Delta Q = \Delta U + \Delta W$
$\Delta U = -\Delta W$
Work done by gas is positive
So ΔU is negative
$B \longrightarrow I$
For Isochoric process $\Delta W = 0$
$C \longrightarrow IV$

For Isobaric process
$\Delta W = P \Delta V \neq 0$
$\Delta U = nC_V \Delta T \neq 0$
Heat absorbed goes partly to increase internal energy and partly do work.

Question14

According to law of equipartition of energy the molar specific heat of a diatomic gas at constant volume where the molecule has one additional vibrational mode is :-
[25-Jan-2023 Shift 2]

Options:

A. $\frac{9}{2}R$

B. $\frac{5}{2}R$

C. $\frac{3}{2}R$

D. $\frac{7}{2}R$

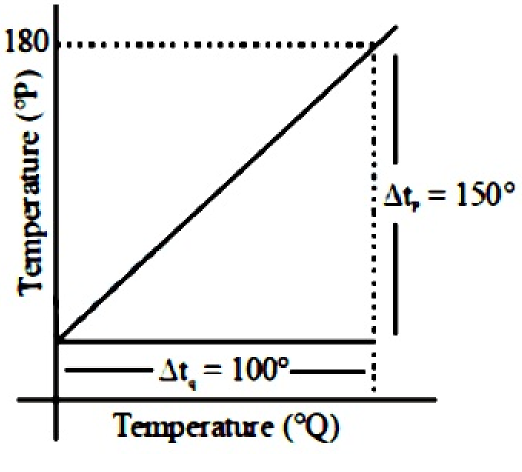
Answer: D

Solution:

Solution:
Diatomic gas molecules have three translational degree of freedom, two rotational degree of freedom & it is given that it has one vibrational mode so there are two additional degree of freedom corresponding to one vibrational mode, so total degree of freedom = 7
$C_v = \frac{fR}{2} = \frac{7R}{2}$

Question15

The graph between two temperature scales P and Q is shown in the figure. Between upper fixed point and lower fixed point there are 150 equal divisions of scale P and 100 divisions on scale Q. The relationship for conversion between the two scales is given by :



[25-Jan-2023 Shift 2]

Options:

A. $\frac{t_Q}{150} = \frac{t_P - 180}{100}$

B. $\frac{t_Q}{100} = \frac{t_P - 30}{150}$

C. $\frac{t_P}{180} = \frac{t_Q - 40}{100}$

D. $\frac{t_P}{100} = \frac{t_Q - 180}{150}$

Answer: B

Solution:

Solution:

$$\frac{\text{reading on scale} - \text{Lower fixed point}}{\text{upper fixed point-lower fixed point}} = \text{constant}$$

$$\frac{t_P - 30}{180 - 30} = \frac{t_Q - 0}{100 - 0}$$

$$\frac{t_P - 30}{150} = \frac{t_Q}{100}$$

Question16

A bicycle tyre is filled with air having pressure of 270 kPa at 27°C. The approximate pressure of the air in the tyre when the temperature increases to 36°C is
[29-Jan-2023 Shift 1]

Options:

A. 270 kPa

B. 262 KPa

C. 278 kPa

D. 360 kPa

Answer: C

Solution:

Solution:

Taking volume constant : $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$$\Rightarrow P_2 = \frac{P_1}{T_1} \times T_2 = \frac{270 \times (309)}{300}$$

$= 278\,\text{kPa}$

Question17

Given below are two statements. One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : If dQ and dW represent the heat supplied to the system and the work done on the system respectively. Then according to the first law of thermodynamics $dQ = dU - dW$.
Reason R : First law of thermodynamics is based on law of conservation of energy.
In the light of the above statements, choose the correct answer from the option given below :
[29-Jan-2023 Shift 1]

Options:

A. A is correct but R is not correct

B. A is not correct but R is correct

C. Both A and R are correct and R is the correct explanation of A

D. Both A and R are correct but R is not the correct explanation of A

Answer: C

Solution:

Solution:
First law of thermodynamics is based on law of conservation of energy and it can be written as $dQ = dU - dW$.
where dW is work done on the system

Question18

A body cools from 60°C to 40°C in 6 minutes. If, temperature of surroundings is 10°C. Then, after the next 6 minutes, its temperature will be °C.
[29-Jan-2023 Shift 1]

Answer: 28

Solution:

Solution:
By average form of Newton's law of cooling

$$\frac{20}{6} = k(50 - 10) \ldots \text{(i)}$$

$$\frac{40 - T}{6} = K\left(\frac{40 + T}{2} - 10\right) \ldots \text{(ii)}$$

From equation (i) and (ii)

$$\frac{20}{40-T} = \frac{40}{10+T/2}$$

$$10 + \frac{T}{2} = 80 - 2T$$

$$\frac{5T}{2} = 70 \Rightarrow T = 28^{\circ}C$$

Question19

Heat energy of 184 kJ is given to ice of mass 600g at $-12^{\circ}C$, Specific heat of ice is $2222.3 Jkg^{-1} {}^{\circ}C^{-1}$ and latent heat of ice in $336\,kJ/kg^{-1}$
(A) Final temperature of system will be $0^{\circ}C$.
(B) Final temperature of the system will be greater than $0^{\circ}C$.
(C) The final system will have a mixture of ice and water in the ratio of 5 : 1.
(D) The final system will have a mixture of ice and water in the ratio of 1 : 5.
(E) The final system will have water only.
Choose the correct answer from the options given below:
[29-Jan-2023 Shift 2]

Options:

A. A and D only

B. B and D only

C. A and E only

D. A and C only

Answer: A

Solution:

Solution:

$\Delta Q = 184 \times 10^{3}$

$m = 0.600\,kg$ at $-12^{\circ}C$

$S = 222.3 J/kg/{}^{\circ}C$

$L = 336 \times 10^{3} J/kg$

$Q_1 = 0.600 \times 2222.3 \times 12 = 16000.56 J$

Remaining heat $\Delta Q_1 = 184000 - 16000.56$

$= 167999.44 J$

For meeting at $0^{\circ}C$

$\Delta Q_2 = 0.600 \times 336000 = 201600 J$ needed

$\therefore 100\%$ ice is not melted

Amount of ice melted

$167999.44 = m \times 336000 = 0.4999\,kg$

$\therefore$ mass of water $= 0.4999\,kg$

Mass of ice $= 0.1001$

$\therefore$ Ratio $= \frac{0.1001}{0.4999} \approx 1 : 5$

Question20

Heat is given to an ideal gas in an isothermal process.
A. Internal energy of the gas will decrease.
B. Internal energy of the gas will increase.
C. Internal energy of the gas will not change.
D. The gas will do positive work.
E. The gas will do negative work.
Choose the correct answer from the options given below:
[30-Jan-2023 Shift 1]

Options:

A. A and E only

B. B and D only

C. C and E only

D. C and D only

Answer: D

Solution:

Solution:
Sol. $dQ = dU + dW \Rightarrow dU = nC_V dT$
$dU = 0$ (for isothermal)
$\therefore U =$ constant
Also $dQ > 0$ (supplied)
Hence $dW > 0$

Question21

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : Efficiency of a reversible heat engine will be highest at $-273^{\circ}C$ temperature of cold reservoir.
Reason R : The efficiency of Carnot's engine depends not only on temperature of cold reservoir but it depends on the temperature of hot reservoir too and is given as $\eta = \left(1 - \frac{T_2}{T_1}\right)$.
In the light of the above statements, choose the correct answer from the options given below :
[30-Jan-2023 Shift 2]

Options:

A. A is true but R is false

B. Both A and R are true but R is NOT the correct explanation of A

C. A is false but R is true

D. Both A and R are true and R is the correct explanation of A

Answer: D

Solution:

Solution:
Both A and R are true and R is the correct explanation of A

Question22

The correct relation between $\gamma = \frac{C_p}{c_v}$ and temperature T is: [31-Jan-2023 Shift 1]

Options:

A. $\gamma \propto \frac{1}{\sqrt{T}}$

B. $\gamma \propto T^{\circ}$

C. $\gamma \propto \frac{1}{T}$

D. $\gamma \propto T$

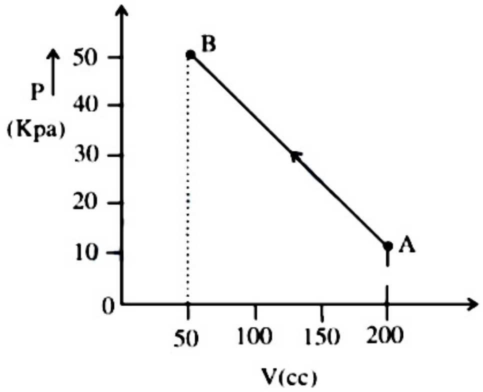
Answer: B

Solution:

Solution:
γ is independent of temperature
Option 2

Question23

The pressure of a gas changes linearly with volume from A to B as shown in figure. If no heat is supplied to or extracted from the gas then change in the internal energy of the gas will be



[31-Jan-2023 Shift 1]

Options:

A. 6J

B. Zero

C. $-4.5\mathrm{J}$

D. 4.5J

Answer: D

Solution:

Solution:

As $\Delta q = 0$
$\Delta u = -W$
$W = \int PdV$
$\Delta u = -W = 30 \times 10^{3} \times 150 \times 10^{-6}$
$= 4500 \times 10^{-3}$
$= 4.5\mathrm{J}$

Question24

A hypothetical gas expands adiabatically such that its volume changes from 08 litres to 27 litres. If the ratio of final pressure of the gas to initial pressure of the gas is $\frac{16}{81}$. Then the ratio of $\frac{Cp}{Cv}$ will be.
[31-Jan-2023 Shift 1]

Options:

A. 3/1

B. 4/3

C. 1/2

D. 3/2

Answer: A

Solution:

Solution:

Let γ be the ratio of $\frac{C_p}{C_v}$
Then for adiabatic process
$PV^{\gamma} =$ Constant
$\Rightarrow \frac{P_i}{P_f} = \left(\frac{V_f}{V_i}\right)^{\gamma}$
$\Rightarrow \frac{81}{16} = \left(\frac{27}{8}\right)^{\gamma}$
$\Rightarrow \gamma = \frac{4}{3}$

Question25

Heat energy of 735J is given to a diatomic gas allowing the gas to expand at constant pressure. Each gas molecule rotates around an internal axis but do not oscillate. The increase in the internal energy of the gas will be:
[31-Jan-2023 Shift 2]

Options:

A. 525J

B. 441J

C. 572J

D. 735J

Answer: A

Solution:

Solution:

$\Delta Q = nC_P \Delta T = 735J$

$\Rightarrow \frac{5nR \Delta T}{2} = 735J$

$\Delta U = nC_V \Delta T = \frac{3}{2}(nR \Delta T) = \frac{3}{2} \times \frac{2}{5} \times 735$

$= 441J$

Question26

A sample of gas at temperature T is adiabatically expanded to double its volume. The work done by the gas in the process is (. given, $\gamma = \frac{3}{2}$) :
[1-Feb-2023 Shift 1]

Options:

A. $W = TR[\sqrt{2} - 2]$

B. $W = \frac{T}{R}[\sqrt{2} - 2]$

C. $W = \frac{R}{T}[2 - \sqrt{2}]$

D. $W = RT[2 - \sqrt{2}]$

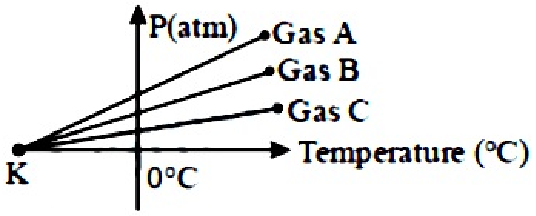
Answer: D

Solution:

$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$
$T V^{1/2} = T_2 (2V)^{1/2}$
$T_2 = \frac{T}{\sqrt{2}}$
$W = \frac{R(T_1 - T_2)}{\gamma - 1} = \frac{R\left(T - \frac{T}{\sqrt{2}}\right)}{\frac{1}{2}} = RT(2 - \sqrt{2})$

Question27

For three low density gases A, B, C pressure versus temperature graphs are plotted while keeping them at constant volume, as shown in the figure.



The temperature corresponding to the point ' K ' is:
[1-Feb-2023 Shift 2]

Options:

A. $-273^{\circ}C$

B. $-100^{\circ}C$

C. $-373^{\circ}C$

D. $-40^{\circ}C$

Answer: A

Solution:

Solution:
For isochoric process
$\frac{P}{T} = n\frac{R}{V} =$ constan t
$P = \frac{nR}{V}(t + 273)$
If $P = 0 \Rightarrow t = -273^{\circ}C$

Question28

A Carnot engine operating between two reservoirs has efficiency $\frac{1}{3}$. When the temperature of cold reservoir raised by x, its efficiency decreases to $\frac{1}{6}$. The value of x, if the temperature of hot reservoir is $99^{\circ}C$, will be:
[1-Feb-2023 Shift 2]

Options:

A. 16.5K

B. 33K

C. 66K

D. 62K

Answer: D

Solution:

Solution:

$T_H = 99^\circ C = 99 + 273$

$= 372K$

$1 - \frac{T_C}{T_H} = \frac{1}{3}$

$l \frac{T_C}{T_H} = \frac{2}{3}$ (1) $\Rightarrow T_C = \frac{2}{3} \times 372$

$= 2 \times 124 = 248K$

$1 - \frac{T_C + X}{T_H} = \frac{1}{6}$

$\frac{5}{6} = \frac{T_C + X}{T_H}$

$\frac{5}{6} = \frac{248 + X}{372}$

$248 + X = 5 \times 62$

$X = 310 - 248 = 62K$

Question29

A source supplies heat to a system at the rate of 1000W. If the system performs work at a rate of 200W. The rate at which internal energy of the system increase is
[6-Apr-2023 shift 1]

Options:

A. 500W

B. 600W

C. 800W

D. 1200W

Answer: C

Solution:

Solution:

From Ist law of thermodynamics,

$dQ = dU + dW$

Also, we can write this as, $\frac{dQ}{dt} = \frac{dU}{dt} + \frac{dW}{dt}$

$\Rightarrow 1000W = \frac{dU}{dt} + 200W$

$\Rightarrow \frac{dU}{dt} = 800W$

Question30

Given below are two statements:
Statement I : If heat is added to a system, its temperature must increase.
Statement II : If positive work is done by a system in a thermodynamic process, its volume must increase. In the light of the above statements, choose the correct answer from the options given below
[8-Apr-2023 shift 1]

Options:

A. Both Statement I and Statement II are true

B. Statement I is true but Statement II is false

C. Both Statement I and Statement II are false

D. Statement I is false but Statement II is true

Answer: D

Solution:

Solution:
St I False
Ex. in isothermal process temp. is constant but heat can be added. ST II True
$w = \int PdV$
If volume increases the w = + ve

Question31

Work done by a Carnot engine operating between temperatures 127°C and 27°C is 2 kJ. The amount of heat transferred to the engine by the reservoir is:
[8-Apr-2023 shift 2]

Options:

A. 2 kJ

B. 4 kJ

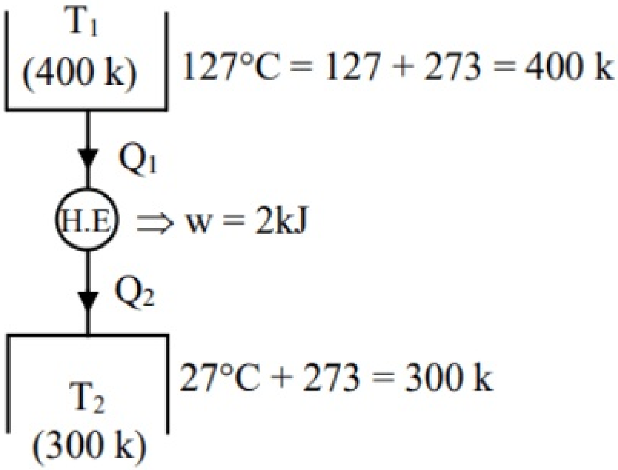
C. 2.67 kJ

D. 8 kJ

Answer: D

Solution:

Solution:



$n = 1 - \frac{300}{400} = \frac{1}{4}$

$n = \frac{w}{Q_1} = \frac{1}{4} \Rightarrow Q_1 = 8\,kJ$

Question32

Consider two containers A and B containing monoatomic gases at the same Pressure (P), Volume (V) and Temperature (T). The gas in A is compressed isothermally to $\frac{1}{8}$ of its original volume while the gas in B is compressed adiabatically to $\frac{1}{8}$ of its original volume. The ratio of final pressure of gas in B to that of gas in A is
[10-Apr-2023 shift 1]

Options:

A. 8

B. 4

C. $\frac{1}{8}$

D. $8^{\frac{3}{2}}$

Answer: B

Solution:

Solution:
By Isothermal Process for (A)

$P_1V_1 = P_2V_2$

$PV = P_2\frac{V}{8}$

$P_2 = 8P$

For B adiabatically $\gamma_{\text{mono}} = \frac{5}{3}$

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

$PV^{5/3} = P_2\left(\frac{V}{8}\right)^{5/3}$

$P_2 = (8)^{5/3}P$

$\frac{P_2}{P_1} = \frac{8^{5/3}}{8P} = (8)^{\frac{2}{3}} = 4$

Question33

A gas is compressed adiabatically, which one of the following statement is NOT true.
[10-Apr-2023 shift 2]

Options:

A. There is no change in the internal energy

B. The temperature of the gas increases.

C. The change in the internal energy is equal to the work done on the gas

D. There is no heat supplied to the system

Answer: A

Solution:

Solution:
In Adiabatic process, $\Delta Q = 0$
If gas is compressed, then w (by gas) $\neq 0$
Therefore by 1st law
$\Delta Q = \Delta u + w$
$0 = \Delta u + w$
$\Delta u = -w \neq 0$
It implies in adiabatic compression, internal energy of gas changes.

Question34

The Thermodynamic process, in which internal energy of the system remains constant is
[11-Apr-2023 shift 2]

Options:

A. Isobaric

B. Isochoric

C. Adiabatic

D. Isothermal

Answer: D

Solution:

Solution:
$\Delta U = nC_V \Delta T$, for all process
For isothermal process, $\Delta T = 0$
So, $\Delta U = 0$
That means internal energy of system remains constant.

Question35

An engine operating between the boiling and freezing points of water will have
A. efficiency more than 27%
B. efficiency less than the efficiency of a Carnot engine operating between the same two temperatures.
C. efficiency equal to 27%
D. efficiency less than 27%
Choose the correct answer from the options given below :
[12-Apr-2023 shift 1]

Options:

A. B and C only

B. B and D only

C. B, C and D only

D. A and b only

Answer: B

Solution:

Solution:
Engine is operating between FP and BP of water.
We asked to find efficiency :
$T_1 = 100^{\circ}C \Rightarrow 100 + 273 = 373K$
$T_2 = 0^{\circ}C \Rightarrow 0 + 273 = 273K$
We know
$\eta = 1 - \frac{T_2}{T_1}$
$\eta = 1 - \frac{273}{373}$
$\eta = \frac{373 - 273}{373} = \frac{100}{373}$
$\eta = 0.268$
and
$\eta\% = 0.268 \times 100$
$\eta\% = 26.8\%$

Question36

The initial pressure and volume of an ideal gas are P_o and V_0. The final pressure of the gas when the gas is suddenly compressed to volume $\frac{V_o}{4}$

will be :
(Given γ = ratio of specific heats at constant pressure and at constant volume)
[13-Apr-2023 shift 2]

Options:

A. $P_0(4)^{\frac{1}{\gamma}}$

B. $4P_0$

C. P_0

D. $P_0(4)^{\gamma}$

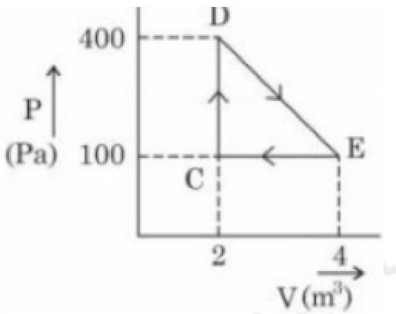
Answer: D

Solution:

Solution:
As, gas in suddenly compressed, the process is adiabatic
So equation of gas for adiabatic process is:
$PV^{\gamma} =$ constant
$P_0V_0^{\gamma} = P_2\left(\frac{V_0}{4}\right)^{\gamma}$
$P_2 = P_0(4)^{\gamma}$

Question37

A thermodynamic system is taken through cyclic process. The total work done in the process is :



[15-Apr-2023 shift 1]

Options:

A. 100J

B. 300J

C. 200J

D. Zero

Answer: B

Solution:

Solution:
Work done = Area of graph

$W = \frac{1}{2}(400 - 100)(4 - 2)$

$W = 300J$

Question38

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?
[24-Jun-2022-Shift-1]

Options:

A. Increases by 18°C

B. Increases by 200°C

C. Increases by 120°C

D. Increases by 73°C

Answer: B

Solution:

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

$\Rightarrow T_H = 400K$

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

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

$\Rightarrow T_H' = 600K$

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

Question39

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
[24-Jun-2022-Shift-2]

Options:

A. $3 \times 10^6 J$

B. Zero

C. $12.6 \times 10^6 J$

D. $8.4 \times 10^6 J$

Answer: C

Solution:

Solution:

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

$= 1 - \frac{400}{1000} = 0.6$

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

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

Question40

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.
[24-Jun-2022-Shift-2]

Answer: 2

Solution:

Solution:

By 1 st law,

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

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

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

Question41

The efficiency of a Carnot's engine, working between steam point and ice point, will be :
[26-Jun-2022-Shift-1]

Options:

A. 26.81%

B. 37.81%

C. 47.81%

D. 57.81%

Answer: A

Solution:

Solution:

$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{273}{373}$

$= 0.26809$

$\approx 26.81\%$

Question42

A thermally insulated vessel contains an ideal gas of molecular mass M and ratio of specific heats 1.4. Vessel is moving with speed v and is suddenly brought to rest. Assuming no heat is lost to the surrounding and vessel temperature of the gas increases by : (R = universal gas constant) [26-Jun-2022-Shift-1]

Options:

A. $\frac{Mv^2}{7R}$

B. $\frac{Mv^2}{5R}$

C. $2\frac{Mv^2}{7R}$

D. $7\frac{Mv^2}{5R}$

Answer: B

Solution:

Solution:

Let there be n moles of gas

$E_{loss} = E_{gain}$

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

$\frac{1}{2}Mv^2 = C_v\Delta T$

here, $\gamma = 1.4 = \frac{7}{5}$ i.e. diatomic gas

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

Now, $\frac{1}{2}Mv^2 = \frac{5R}{2}\Delta T$

$\Delta T = \frac{Mv^2}{5R}$

Question43

A heat engine operates with the cold reservoir at temperature 324K. The minimum temperature of the hot reservoir, if the heat engine takes 300J heat from the hot reservoir and delivers 180J heat to the cold reservoir per cycle, is ______K.
[26-Jun-2022-Shift-2]

Answer: 540

Solution:

Solution:

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

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

$T_H=\frac{324\times5}{3}=540$

Question44

In a carnot engine, the temperature of reservoir is 527°C and that of sink is 200K. 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 ____$\times 10^6$J.
[27-Jun-2022-Shift-1]

Answer: 16

Solution:

Solution:

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

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

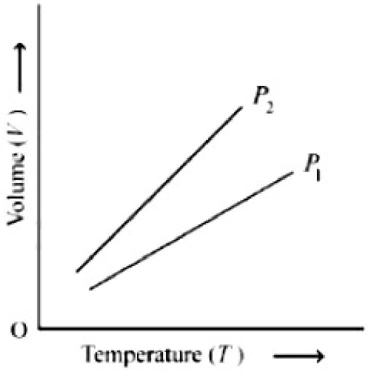
$\therefore\eta=\frac{W}{Q_1}$

$\Rightarrow\frac{3}{4}=\frac{12000\times10^3}{Q_1}$

$\Rightarrow Q_1=16\times10^6$J

Question45

For a perfect gas, two pressures P_1 and P_2 are shown in figure. The graph shows:



[27-Jun-2022-Shift-2]

Options:

A. $P_1 > P_2$

B. $P_1 < P_2$

C. $P_1 = P_2$

D. Insufficient data to draw any conclusion

Answer: A

Solution:

Solution:
As per ideal gas equation, $V = \frac{nR}{P}T$
⇒ Slope of V-T graph is inversely proportional to P.
As $m_2 > m_1 \Rightarrow P_1 > P_2$

Question46

A diatomic gas (γ = 1.4) does 400J of work when it is expanded isobarically. The heat given to the gas in the process is_____ J. [27-Jun-2022-Shift-2]

Answer: 1400

Solution:

Solution:
$W = nR\Delta T = 400J$
$\therefore \Delta Q = nC_P\Delta T$
$= n \times \frac{7}{2}R \times \Delta T = \frac{7}{2} \times (400) = 1400$

Question47

The total internal energy of two mole monoatomic ideal gas at temperature T = 300K will be_____J. (Given R = 8.31 J / mol . K) [28-Jun-2022-Shift-1]

Answer: 7479

Solution:

Solution:

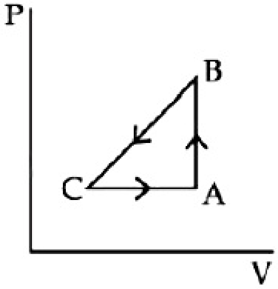
$U = 2\left(\frac{3}{2}R\right)300$

$= 3 \times 8.31 \times 300$

$= 7479J$

Question48

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



[28-Jun-2022-Shift-2]

Options:

A. 20J

B. 30J

C. $-30J$

D. $-60J$

Answer: B

Solution:

$\Delta U_{AB} = 40J$ as process is isochoric.
$\Delta U_{BC} = +50(W_{BC} = -50J)$
$U_C = U_A + \Delta U_{AB} + \Delta U_{BC} = 1650$
For CA process,
$Q_{CA} = -60J$
$\Delta U_{CA} + W_{CA} = -60$
$-90 + W_{CA} = -60$
$\Rightarrow W_{CA} = +30J$
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.

Question49

A cylinder of fixed capacity of 44.8 litres contains helium gas at standard temperature and pressure. The amount of heat needed to raise the temperature of gas in the cylinder by 20.0°C will be : (Given gas constant R = 8.3$JK^{-1}-mol^{-1}$) [29-Jun-2022-Shift-1]

Options:

A. 249J

B. 415J

C. 498J

D. 830J

Answer: C

Solution:

Solution:
No of moles $= \frac{44.8}{22.4} = 2$
Gas is mono atomic so $C_v = \frac{3}{2}R$
$\Delta Q = nC_v \Delta T$
$= 2 \times \frac{3}{2}R(20)$
$= 60R$
$= 60 \times 8.3$
$= 498J$

Question50

300 cal. of heat is given to a heat engine and it rejects 225 cal. If source temperature is 227°C, then the temperature of sink will be ______°C. [29-Jun-2022-Shift-1]

Answer: 102

Solution:

Solution:

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

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

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

$\Rightarrow T_L = 102^{\circ}C$

Question51

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 [29-Jun-2022-Shift-2]

Options:

A. $W_1 < W_2 < W_3$

B. $W_2 < W_3 < W_1$

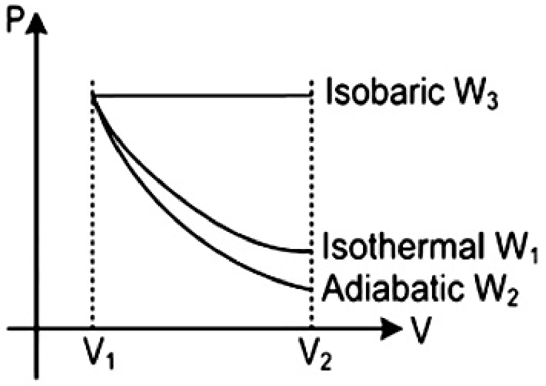
C. $W_3 < W_1 < W_2$

D. $W_2 < W_1 < W_3$

Answer: D

Solution:

Solution:



Comparing the area under the PV graph$A_3 > A_1 > A_2$

$\Rightarrow W_3 > W_1 > W_2$

Question52

A certain amount of gas of volume V at 27°C temperature and pressure $2 \times 10^7 \mathrm{N\,m^{-2}}$ 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 $\gamma = 1.5$) :
[25-Jul-2022-Shift-1]

Options:

A. $3.536 \times 10^5 \mathrm{Pa}$

B. $3.536 \times 10^6 \mathrm{Pa}$

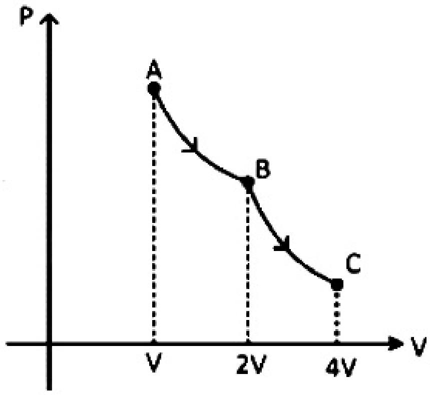
C. $1.25 \times 10^6 \mathrm{Pa}$

D. $1.25 \times 10^5 \mathrm{Pa}$

Answer: B

Solution:

Solution:



Let AB is isothermal process and BC is adiabatic process then for AB process
$P_A V_A = P_B V_B$
$\Rightarrow P_B = 10^7 \mathrm{N\,m^{-2}}$
For process BC
$P_B V_B^{\,r} = P_C V_C^{\,r}$
$P_C = 3.536 \times \times 10^6 \mathrm{Pa}$

Question53

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:
[25-Jul-2022-Shift-2]

Options:

A. 0.41

B. 0.56

C. 0.73

D. 0.70

Answer: B

Solution:

Solution:

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

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

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

$\simeq 0.56$

Question54

7 mol of a certain monoatomic ideal gas undergoes a temperature increase of 40K at constant pressure. The increase in the internal energy of the gas in this process is :
(Given R = 8.3$JK^{-1}mol^{-1}$)
[26-Jul-2022-Shift-1]

Options:

A. 5810J

B. 3486J

C. 11620J

D. 6972J

Answer: B

Solution:

Solution:

$\Delta U = nC_v \Delta T$

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

$= 3486J$

Question55

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 :
[26-Jul-2022-Shift-1]

Options:

A. P

B. 8P

C. 32P

D. 64P

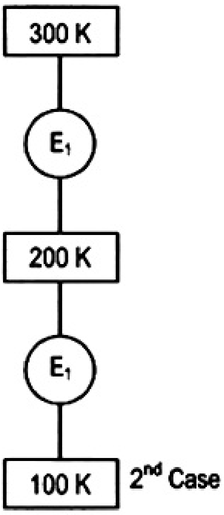
Answer: C

Solution:

Solution:
$PV^{\gamma} =$ constant
$\Rightarrow PV^{\gamma} = (P')\left(\frac{V}{8}\right)^{\gamma}$ where $\gamma = 5/3$
$\Rightarrow P' = 32P$

Question56

In 1^{st} case, Carnot engine operates between temperatures 300K and 100K. In 2^{nd} case, as shown in the figure, a combination of two engines is used. The efficiency of this combination (in 2^{nd} case) will be :



[27-Jul-2022-Shift-2]

Options:

A. same as the 1^{st} case.

B. always greater than the 1^{st} case.

C. always less than the 1^{st} case.

D. may increase or decrease with respect to the 1^{st} case.

Answer: A

Solution:

Solution:
First case : $\eta = 1 - \frac{100}{300} = \frac{2}{3}$
Second case : $\eta_{net} = \eta_1 + \eta_2 - \eta_1\eta_2$
$\eta_1 = 1 - \frac{200}{300} = \frac{1}{3}$

$\eta_2 = 1 - \frac{100}{200} = \frac{1}{2}$
$\eta_{\text{net}} = \frac{1}{3} + \frac{1}{2} - \frac{1}{6} = \frac{2}{3}$
η(first case) = η(second case)

Question57

A Carnot engine has efficiency of 50%. If the temperature of sink is reduced by 400˚C, its efficiency increase by 30%. The temperature of the source will be:
[28-Jul-2022-Shift-1]

Options:

A. 166.7K

B. 255.1K

C. 266.7K

D. 367.7K

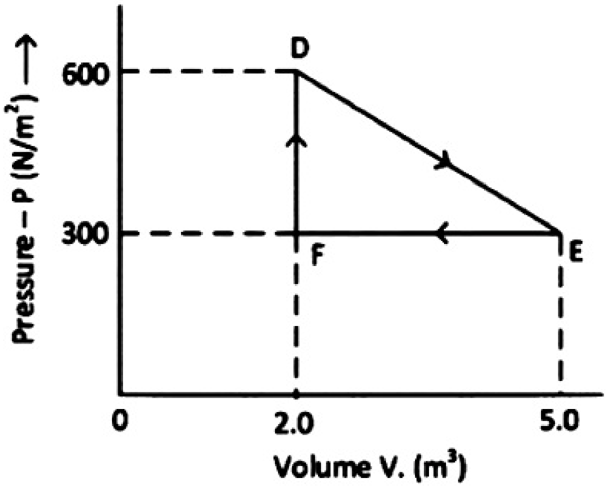
Answer: C

Solution:

Solution:
$\eta = 1 - \frac{T_L}{T_H}$
$\frac{1}{2} = 1 - \frac{T_L}{T_H}$
$\frac{1}{2}(1 \cdot 3) = 1 - \left(\frac{T_L - 40}{T_H} \right)$
$\frac{1}{2}(1 \cdot 3) = \frac{1}{2} + \frac{40}{T_H}$ $T_H = 266.7K$

Question58

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



[29-Jul-2022-Shift-2]

Options:

A. -450J

B. 450J

C. 900J

D. 1350J

Answer: B

Solution:

Solution:

$W_{DE} = \frac{1}{2}(600 + 300)3J$

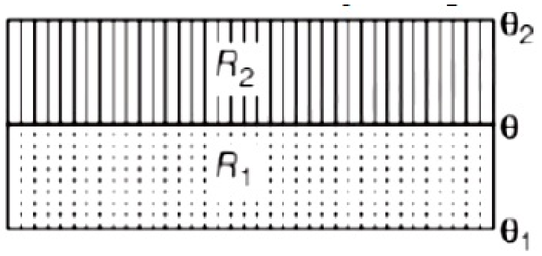
$= 1350J$

$W_{EF} = -300 \times 3 = -900J$

$W_{DEF} = 450J$

Question59

The temperature θ at the junction of two insulating sheets, having thermal resistances R_1 and R_2 as well as top and bottom temperatures θ_1 and θ_2 (as shown in figure) is given by



[26 Feb 2021 Shift 1]

Options:

A. $\frac{\theta_2 R_2 - \theta_1 R_1}{R_2 - R_1}$

B. $\frac{\theta_1 R_2 - \theta_2 R_1}{R_2 - R_1}$

C. $\frac{\theta_1 R_2 + \theta_2 R_1}{R_1 + R_2}$

D. $\frac{\theta_1 R_1 + \theta_2 R_2}{R_1 + R_2}$

Answer: C

Solution:

Solution:
Let, Q = heat current,
k = thermal conductivity,
A = area,
I = length of capacitor
and $\Delta\theta$ = change in temperature .

$\therefore\ Q = \frac{kA\,\Delta\,\theta}{l} = \frac{\Delta\theta}{R}\ \left(\because R = \frac{l}{kA}\right)$

$\Rightarrow\ \frac{\theta_2 - \theta}{R_2} = \frac{\theta - \theta_1}{R_1}$

$\Rightarrow R_1\theta_2 - R_1\theta = R_2\theta - R_2\theta_1$

$\Rightarrow \theta = \frac{R_1\theta_2 + R_2\theta_1}{R_1 + R_2}$

Question60

A reversible heat engine converts one-fourth of the heat input into work. When the temperature of the sink is reduced by 52K, its efficiency is doubled. The temperature in kelvin of the source will be ....
[25 Feb 2021 Shift 2]

Answer: 104

Solution:

Solution:
Given, initial efficiency (η_h) = 1 / 4

$\Rightarrow\ \eta_h = 1 - \frac{T_2}{T_1} = \frac{1}{4} \Rightarrow \frac{T_2}{T_1} = 1 - \frac{1}{4} = \frac{3}{4}$

When temperature of sink is reduced by 50K,

$\eta_2 = 2\eta_1 = 1 - \frac{T_2 - 52}{T_1}$

$\Rightarrow 2 \times \frac{1}{4} = 1 - \frac{T_2}{T_1} + \frac{52}{T_1}$

$\Rightarrow\ \frac{1}{2} = 1 - \frac{3}{4} + \frac{52}{T_1} \Rightarrow \frac{1}{2} - \frac{1}{4} = \frac{52}{T_1}$

$\Rightarrow\ \frac{2}{4} = \frac{52}{T_1}$

$\Rightarrow T_1 = 104K$

Question61

1 mole of rigid diatomic gas performs a work of 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]
[26 Feb 2021 Shift 2]

Answer: 25

Solution:

Solution:
Given, number of mole, $n = 1$
Heat supplied $= Q$
Work done $= Q / 5$
By using first law of thermodynamics,
$\Delta Q = \Delta U + \Delta W$
$Q = \Delta U + Q / 5$
$\Delta U = 4Q / 5 = nC_v \Delta T$ . . . (i)
where, C_V is heat coefficient at constant volume and
ΔT is change in temperature.
Degree of freedom of diatomic gas, $f = 5$
$\therefore\ Q = \frac{5}{4}\frac{f}{2}R\Delta T$ [from Eq. (i)] $\Rightarrow \frac{Q}{\Delta T} = C = \frac{5}{4} \times \frac{5}{2}R = \frac{25}{8}R$
Hence, $x = 25$

Question62

Match List-I with List-II:

List-I	List-II
(A) Isothermal	(i) Pressure constant
(B) Isochoric	(ii) Temperatureconstant
(C) Adiabatic	(iii) Volume constant
(D) Isobaric	(iv) Heat content isconstant

Choose the correct answer from the options given below:
[24feb2021shift1]

Options:

A. (A) rightarrow (i), (B) rightarrow (iii), (C) rightarrow (ii), (D) rightarrow (iv)

B. (A) rightarrow (ii), (B) rightarrow (iii), (C) rightarrow (iv), (D) rightarrow (i)

C. (A) rightarrow (ii), (B) rightarrow (iv), (C) rightarrow (iii), (D) rightarrow (i)

D. (A) rightarrow (iii), (B) rightarrow (ii), (D) rightarrow (i), (D) rightarrow (iv)

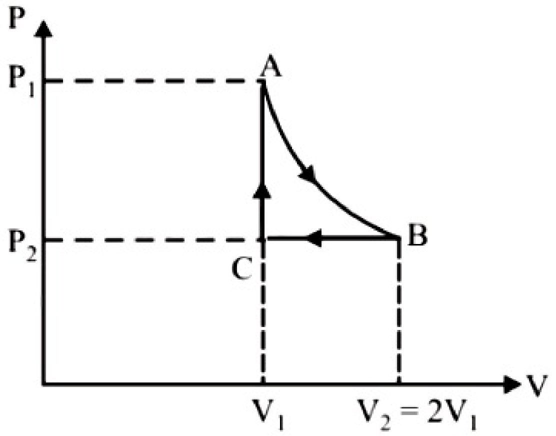
Answer: B

Solution:

Solution:
(A) Isothermal ($\Delta T = 0$) (A) → (ii)
(B) Isochoric ($\Delta V = 0$) (B) → (iii)
(C) Adiabatic ($\Delta Q = 0$) (C) → (iv)
(D) Isobaric ($\Delta P = 0$) (D) → (i)

Question63

n mole a perfect gas undergoes a cyclic process ABCA (see (figure) consisting of the following processes.
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 → A : Isochoric change leading to change of pressure from P_2 to P_1.
Total work done in the complete cycle ABCA is:



[24feb2021shift1]

Options:

A. 0

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

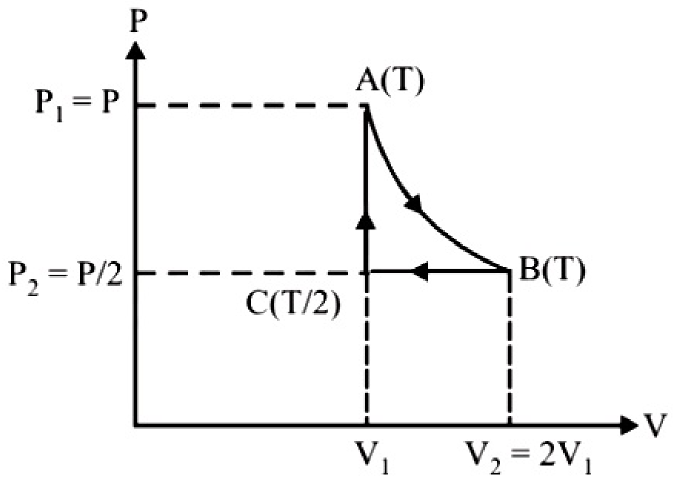
C. $nRT\ \ln 2$

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

Answer: D

Solution:

Work done during isothermal process,



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

$W_{AB} = nRT \ln\left(\frac{2V}{V}\right) = nRT \ln 2$

$W_{BC} = nR(T_C - T_B) = nR\left(\frac{T}{2} - T\right) = -nR\frac{T}{2}$

$W_{CA} = P\Delta V = 0$ ($\because \Delta V = 0$)

$\Rightarrow W_{net} = W_{AB} + W_{BC} + W_{CA}$

$\Rightarrow W_{net} = nRT \ln 2 - \frac{nRT}{2}$

$\Rightarrow W_{net} = nRT\left(\ln 2 - \frac{1}{2}\right)$

Question64

The volume V of a given mass of monoatomic gas changes with temperature T according to the relation $V = kT^{2/3}$. The work done when temperature changes by $90K$ will be xR. The value of x is..........
[R = universal gas constant]
[26 Feb 2021 Shift 2]

Answer: 60

Solution:

Solution:
Given, $V = kT^{2/3}$ ... (i)
where, T is temperature.
Change in temperature, $\Delta T = 90K$
Let p be the pressure, dV be the change in volume and work done be W.
As we know that,
$W = \int p\,dV$ ... (ii)
As, $pV = nRT$
$\therefore p = \frac{nRT}{V}$
Substituting this value in Eq. (ii), we get
$W = \int nRT \frac{dV}{V}$
$W = \int nRT \frac{dV}{kT^{2/3}}$ [using Eq. (i)] ... (iii)
On differentiating Eq. (i) w.r.t. temperature on both sides, we get

$\frac{dV}{dT} = k \cdot \frac{2}{3}T^{1/3}$

$= \frac{2}{3}kT^{-1/3} = \frac{2}{3}\frac{k}{T^{1/3}}$

$\therefore\ dV = 2/3kT^{-1/3}dT$

Substituting this in Eq. (iii), we get

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

$\Rightarrow\ W = \frac{2}{3}nR\int T\,dT = 2/3nR[T]_{T_1}^{T}$

$= 2/3nR[T_2 - T_1] = 2/3nR\,\Delta T$

$= 2/3nR90 = 60nR$

Here, $n = 1$

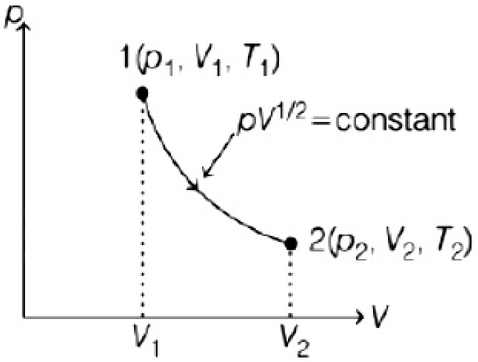
So, work done will be 60R.

Hence, $x = 60$.

Question65

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 $\frac{T_2}{T_1}$ is



[25 Feb 2021 Shift 2]

Options:

A. $\frac{1}{\sqrt{2}}$

B. $\sqrt{2}$

C. $\frac{1}{2}$

D. 2

Answer: B

Solution:

Solution:

Here, p_1 and p_2, T_1 and T_2, V_1 and V_2 are initial and final pressures, temperatures and volumes, respectively.

Given, $V_2 = 2V_1$

$pV^{1/2} =$ constant

From graph, $\gamma =$ adiabatic constant $= 1/2$

$\Rightarrow\ p_1V_1^{1/2} = p_2V_2^{1/2} \Rightarrow \frac{p_1}{p_2} = \left(\frac{2V_1}{V_1}\right)^{1/2} = 2^{1/2}$

Also, $p^{1-\gamma}T^{\gamma} =$ constant (for adiabatic process)

$\Rightarrow \ p_1^{1-\gamma} T_1^{\gamma} = p_2^{1-\gamma} T_2^{\gamma}$

$\Rightarrow \ \left(\frac{p_1}{p_2}\right)^{1-\gamma} = \left(\frac{T_2}{T_1}\right)^{\gamma} \Rightarrow \left(\frac{p_1}{p_2}\right)^{\frac{1-\gamma}{\gamma}} = \frac{T_2}{T_1}$

$\therefore \ T_2 / T_1 = (2^{1/2})^{\frac{1-0.5}{0.5}} = \sqrt{2}$

Question66

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.
[25 Feb 2021 Shift 1]

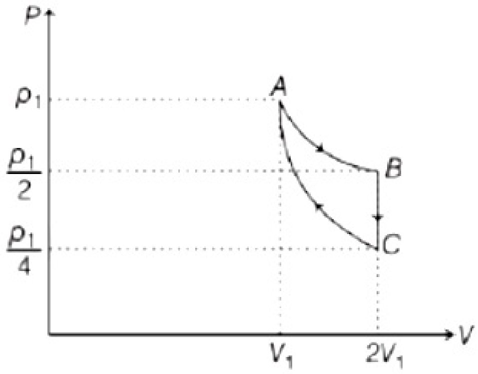
Answer: 50

Solution:

Solution:
Given, pressure (p) $\propto kV^3$
$T_1 = 100^\circ C, T_2 = 300^\circ C$
$\Delta T = T_2 - T_1 = 300 - 100 = 200^\circ C$
⇒ By using ideal gas equation,
$pV = nRT$
$kV^3 \cdot V = nRT \Rightarrow kV^4 = nRT$
On differentiating both sides w.r.t temperature, we get
$4kV^3 \frac{dV}{dT} = nR$
$\Rightarrow \ 4kV^3 dV = nRdT \Rightarrow kV^3 dV = nRdT / 4$
$\Rightarrow \ pdV = nRdT / 4$
As, work done $(W) = pdV = nRdT / 4$
$= \frac{nR}{4} \Delta T = \frac{nR}{4} \times 200 = 50nR$

Question67

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



[24 Feb 2021 Shift 2]

Options:

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

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

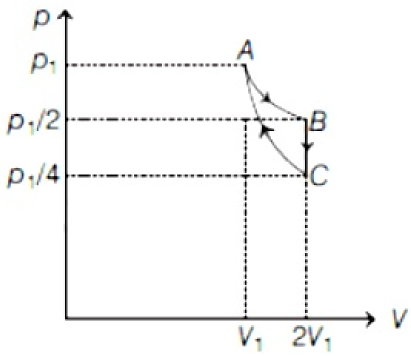
C. 0

D. $\mathrm{RT}\ln 2$

Answer: A

Solution:

Solution:
Let p_i, p_f, V_i and V_f be the initial and final pressure and volume.
Given, AB is isothermal ($\Delta T=0$),
BC is isochoric ($\Delta V=0$)
and CA is adiabatic ($\Delta Q=0$)
Since, isothermal work $(W_{AB})=p_1V_1\ln\frac{V_f}{V_i}$



where, V_i and V_f are volume at A and B, respectively.
$\therefore\ W_{AB}=p_1V_1\ln\frac{2V_1}{V_1}=p_1V_1\ln 2$
Since, at constant volume, work done is zero.
$\therefore\ W_{BC}=0$
Since, W_{CA} is an adiabatic work done,
i.e. $W_{CA}=\frac{1}{1-\gamma}(p_fV_f-p_iV_i)$
$\Rightarrow\ W_{CA}=\frac{1}{1-\gamma}\left(p_1V_1-\frac{p_1}{4}\times 2V_1\right)$
$=\frac{1}{1-\gamma}(p_1V_1-p_1V_1/2)=\frac{1}{1-\gamma}\frac{p_1V_1}{2}$
$\therefore$ Net work done, $W_{net}=W_{AB}+W_{BC}+W_{CA}$
$=p_1V_1\ln 2+0+\frac{1}{1-\gamma}\frac{p_1V_1}{2}$
$=p_1V_1[\ln 2+1/2(1-\gamma)]$

From ideal gas law, $pV = nRT$
$\therefore W_{net} = RT[\ln 2 - 1/2(\gamma - 1)]$
$(\because n = 1)$

Question68

In thermodynamics, heat and work are
[16 Mar 2021 Shift 1]

Options:

A. path functions

B. intensive thermodynamic state variables

C. extensive thermodynamic state variables

D. point functions

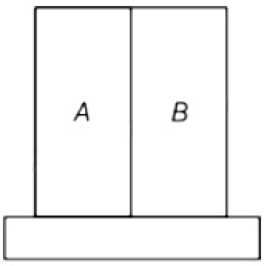
Answer: A

Solution:

Solution:
According to first law of thermodynamics
dQ = dU + dW.......(i)
As we know that, work done by the gas depends on the type of process, i.e. path and dU depends on the initial and final states. So, considering Eq. (i), dQ will also be dependent on path. It means that, in thermodynamics, heat and work are path functions.

Question69

A bimetallic strip consists of metals A and B. It is mounted rigidly as shown. The metal A has higher coefficient of expansion compared to that of metal B. When the bimetallic strip is placed in a cold bath, it will



[16 Mar 2021 Shift 2]

Options:

A. bend towards the right

B. not bend but shrink

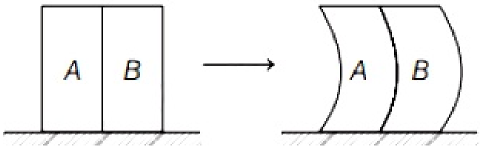
C. Neither bend nor shrink

D. bend towards the left

Answer: D

Solution:

Solution:
As per the question, coefficient of expansion of metal A is higher than that of B.
It means, $\alpha_A > \alpha_B$
If the bimetallic strip is placed in a cold bath, then the length of both strips will decrease.
i.e., $I_A > I_B$
∴ The bimetallic strip will bend towards left.
It can be shown as below.



Question70

Two identical metal wires of thermal conductivities K_1 and K_2 respectively are connected in series. The effective thermal conductivity of the combination is
[17 Mar 2021 Shift 1]

Options:

A. $\frac{2K_1K_2}{K_1+K_2}$

B. $\frac{K_1+K_2}{2K_1K_2}$

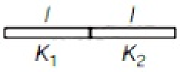
C. $\frac{K_1+K_2}{K_1K_2}$

D. $\frac{K_1K_2}{K_1+K_2}$

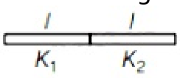
Answer: A

Solution:

Solution:
Two identical metal wires of thermal conductivities K_1 and K_2 respectively connected in series are represented as follows



The above figure can also be represented as



Therefore, the effective thermal conductivity of the combination will be given by

$$R_{eff} = \frac{I}{K_1A} + \frac{I}{K_2A} = \frac{2l}{K_{eq}A}$$

$$\Rightarrow \frac{2I}{K_{eq}A} = \frac{1}{A}\left(\frac{1}{K_1} + \frac{1}{K_2}\right) \Rightarrow \frac{2I}{K_{eq}A} = \frac{I}{A}\left(\frac{K_1+K_2}{K_1K_2}\right)$$

$$\Rightarrow \frac{2}{K_{eq}} = \frac{K_1+K_2}{K_1K_2} \Rightarrow K_{eq} = \frac{2K_1K_2}{K_1+K_2}$$

Question71

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
[18 Mar 2021 Shift 2]

Options:

A. $S_1 \times S_2$

B. $S_1 - S_2$

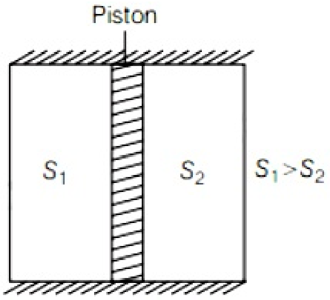
C. $\frac{S_1}{S_2}$

D. $S_1 + S_2$

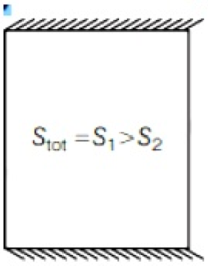
Answer: D

Solution:

Solution:
Entropy present in one part of the system is S_1.
Entropy present in other part of the system is S_2.



After removing piston,

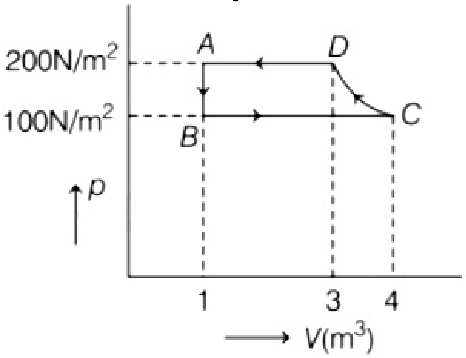


After removing piston,
We know that,
$\Delta S_{unvi} = \Delta S_{sys} + \Delta S_{surr}$
Thus, after removing the piston, the total entropy present in system,
$S_{tot} = S_1 + S_2$

Question72

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, $\gamma = 1.4$)



[18 Mar 2021 Shift 1]

Options:

A. $-500 \mathrm{J}$

B. $-400 \mathrm{J}$

C. $400 \mathrm{J}$

D. $200 \mathrm{J}$

Answer: A

Solution:

Solution:
Given
The final pressure of the adiabatic process, $p_f = 200 \mathrm{N} / \mathrm{m}^2$
The initial pressure of the adiabatic process, $p_i = 100 \mathrm{N} / \mathrm{m}^2$
The initial volume of the adiabatic process, $V_1 = 4 \mathrm{m}^3$
The final volume of the adiabatic process, $V_f = 3 \mathrm{m}^3$
We know that, for an adiabatic process

$$W = \frac{p_f V_f - p_i V_i}{1 - \gamma}$$

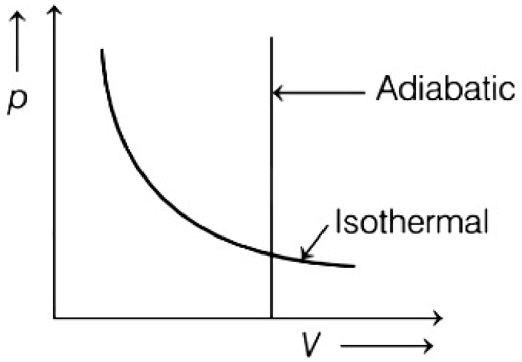
$$\Rightarrow W = \frac{200(3) - (100)(4)}{1 - 1.4}$$

$$\Rightarrow W = -500 \mathrm{J}$$

So, the work done by an adiabatic process is $500 \mathrm{J}$ and negative sign represents the work done on the system.

Question73

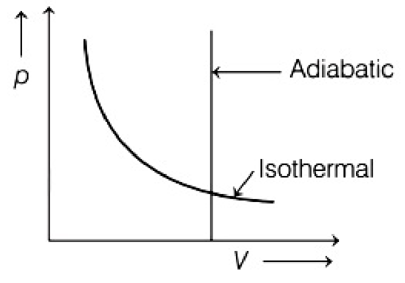
Which one is the correct option for the two different thermodynamic processes?



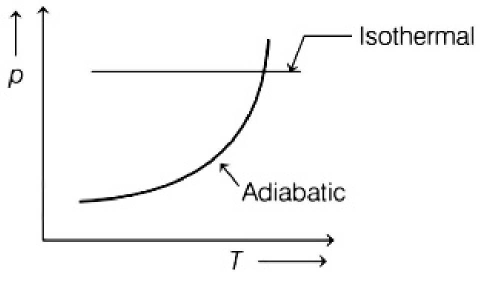
[17 Mar 2021 Shift 2]

Options:

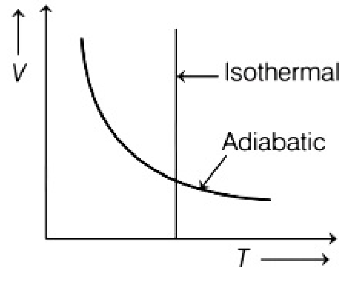
A.



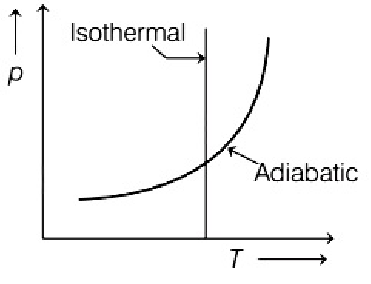
B.



C.



D.



Answer: B

Solution:

Solution:
In graph (A) vertical line is isochoric process, so the graph (A) is incorrect.
In graph (B) horizontal line is isobaric process, so the graph (B) is incorrect.
In graph (C) and (D) vertical line is isothermal process and the curve line is adiabatic process.
So, the correct representation of thermodynamic process graph is (C) and (D).
So, the correct option is (b)

Question74

A Carnot's engine working between 400K and 800K has a work output of 1200J per cycle. The amount of heat energy supplied to the engine from the source in each cycle is
[17 Mar 2021 Shift 1]

Options:

A. 3200J

B. 1800J

C. 1600J

D. 2400J

Answer: D

Solution:

Solution:
Efficiency of Carnot heat engine is given by

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

$= 1 - \frac{Q_2}{Q_1} = \frac{W}{Q_1}$.....(i)

where. $W =$ net work done by the gas
$Q_1 =$ heat absorbed by the gas,
$Q_2 =$ heat released by the gas,
$T_1 =$ temperature of hot reservoir,
and $T_2 =$ temperature of cold reservoir.
Using Eq. (i), we can write

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

$\Rightarrow \frac{400}{800} = 1 - \frac{W}{Q_1} \Rightarrow \frac{W}{Q_1} = 1 - \frac{400}{800}$

$\Rightarrow \frac{W}{Q_1} = 1 - \frac{1}{2} = \frac{1}{2} \Rightarrow \frac{W}{Q_1} = \frac{1}{2}$

$\Rightarrow Q_1 = 2 \times W = 2 \times 1200[\because W_1 = 1200J]$

$= 2400J$

Question75

For an ideal heat engine, the temperature of the source is 127°C. In order to have 60% efficiency the temperature of the sink should be ...... °C.
(Round off to the nearest integer)
[16 Mar 2021 Shift 2]

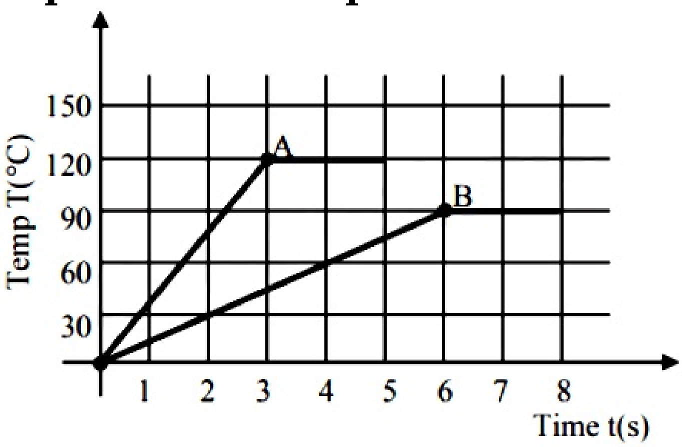
Answer: 113

Solution:

Solution:
Given, temperature of source, $T_H = 127^\circ C$
$= 273 + 127 = 400K$
Efficience, $\eta = 60\% = 0.6$
The efficiency of Carnot (ideal) heat engine is given by
$\eta = \left(1 - \frac{T_L}{T_H}\right)$
where, $T_L =$ temperature of sink,
$0.6 = \left(1 - \frac{T_L}{T_H}\right) \Rightarrow \frac{T_L}{T_H} = 1 - 0.6$
$\frac{T_L}{T_H} = 0.4 \Rightarrow T_L = 0.4 \times T_H$
$= 0.4 \times 400 = 160K$
$= 160 - 273 = -113^\circ C$

Question76

Two different metal bodies A and B of equal mass are heated at a uniform rate under similar conditions. The variation of temperature of the bodies is graphically represented as shown in the figure. The ratio of specific heat capacities is :



[25 Jul 2021 Shift 1]

Options:

A. $\frac{8}{3}$

B. $\frac{3}{8}$

C. $\frac{3}{4}$

D. $\frac{4}{3}$

Answer: B

Solution:

Solution:

$$\left(\frac{\Delta Q}{\Delta t}\right)_A = \left(\frac{\Delta Q}{\Delta t}\right)_B$$

$$mS_A\left(\frac{\Delta T}{\Delta t}\right)_A = mS_B\left(\frac{\Delta T}{\Delta t}\right)_B$$

$$\frac{S_A}{S_B} = \frac{\left(\frac{\Delta T}{\Delta t}\right)_A}{\left(\frac{\Delta T}{\Delta t}\right)_B} = \frac{90/6}{120/3} = \frac{15}{40} = \frac{3}{8}$$

Question77

A body takes 4 min. to cool from 61° C to 59°C. If the temperature of the surroundings is 30°C, the time taken by the body to cool from 51°C to 49° C is :
[27 Jul 2021 Shift 1]

Options:

A. 4 min.

B. 3 min.

C. 8 min.

D. 6 min.

Answer: D

Solution:

Solution:

$$\frac{\Delta T}{\Delta t} = K(T_t - T_s)$$

$T_t =$ average temp

$T_S =$ surrounding temp.

$$\frac{61-59}{4} = K\left(\frac{61+59}{2} - 30\right) \text{.........(1)}$$

$$\frac{51-49}{t} = K\left(\frac{51+49}{2} - 30\right) \text{.........(2)}$$

Divide (1) & (2)

$$\frac{t}{4} = \frac{60-30}{50-30} = \frac{30}{20}$$

so, t = 6 minutes

Question78

In 5 minutes, a body cools from 75°C to 65°C at room temperature of 25°C. The temperature of body at the end of next 5 minutes is _______°C
[22 Jul 2021 Shift 2]

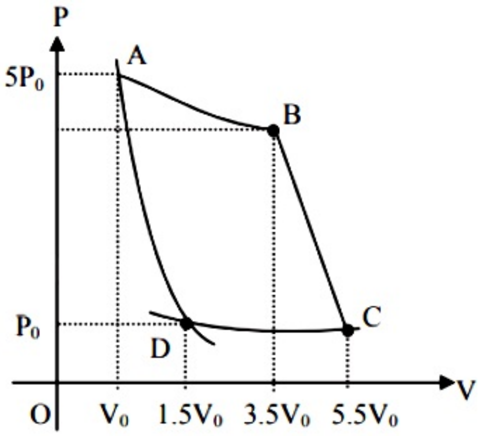
Answer: 57

Solution:

Solution:
By newton's law of cooling (with approximation)
$\frac{\Delta T}{\Delta t} = -C(T_{arg} - T_s)$
$1^{st}\ \frac{-10°C}{5min} = -C(70°C - 25°C)$
$\Rightarrow C = \frac{2}{45}min^{-1}$
$2^{nd}\ \frac{T - 65}{5min} = -C\left(\frac{T + 65}{2} - 25\right) = -\left(\frac{2}{45}\right)\left(\frac{T + 15}{2}\right) \Rightarrow 9(T - 65) = -(T + 15)$
$\Rightarrow 10T = 570$
$\Rightarrow T = 57°C$

Question79

In the reported figure, there is a cyclic process ABCDA on a sample of 1 mol of a diatomic gas. The temperature of the gas during the process $A \rightarrow B$ and $C \rightarrow D$ are T_1 and $T_2 (T_1 > T_2)$respectively.



Choose the correct option out of the following for work done if processes BC and DA are adiabatic.
[27 Jul 2021 Shift 1]

Options:

A. $W_{AB} = W_{DC}$

B. $W_{AD} = W_{BC}$

C. $W_{BC} + W_{DA} > 0$

D. $W_{AB} < W_{CD}$

Answer: B

Solution:

Solution:
Work done in adiabatic process $= \frac{-nR}{\gamma - 1}(T_f - T_i)$

$\therefore W_{AD} = \frac{-nR}{\gamma - 1}(T_2 - T_1)$
and $W_{BC} = \frac{-nR}{\gamma - 1}(T_2 - T_1)$
$\therefore W_{AD} = W_{BC}$

Question80

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 :
[25 Jul 2021 Shift 1]

Options:

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

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

C. $\frac{l_2}{l_1}$

D. $\frac{l_1}{l_2}$

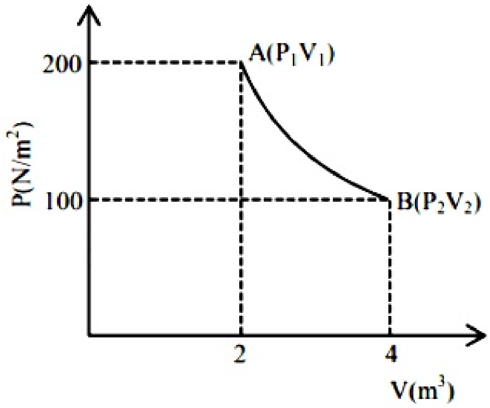
Answer: B

Solution:

Solution:
$PV^r = \text{const}$
$TV^{r-1} = \text{const.}$
$T(l)^{\frac{5}{3}-1} = \text{const}$
$\frac{T_1}{T_2} = \left(\frac{l_2}{l_1}\right)^{2/3}$

Question81

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: $R = 8.3J / mol eK$, $\ln 2 = 0.6931$]
(Round off to the nearest integer)



[20 Jul 2021 Shift 2]

Answer: 17258

Solution:

Solution:
Process of isothermal

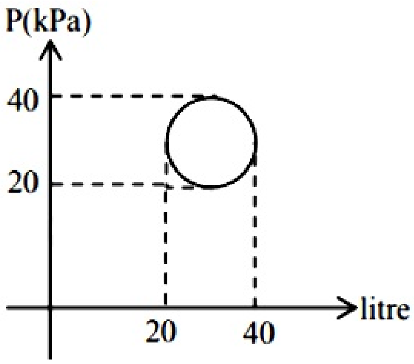
$W = nRT \ln\left(\frac{V_2}{V_1}\right)$

$= 1 \times 8.3 \times 300 \times \ln 2$

$= 17258 \times 10^{-1} J$

Question82

In the reported figure, heat energy absorbed by a system in going through a cyclic process is ______ πJ.

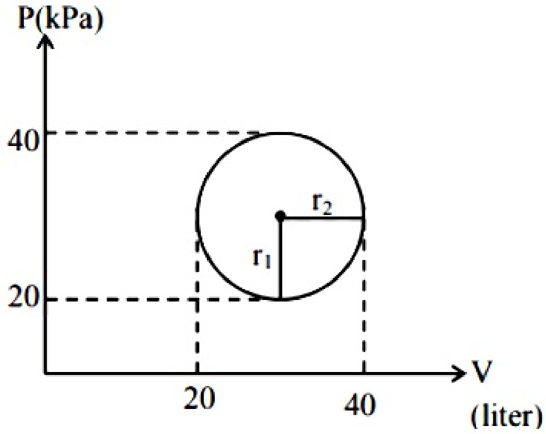


[20 Jul 2021 Shift 1]

Answer: 100

Solution:

Solution:



For complete cyclic process
$\Delta U = 0$
$\therefore$ from $\Delta Q = \Delta U + W$
$= 0 + W$
$\Delta Q = W$
= Area
$= \pi r_1 \cdot r_2$
$= \pi \times (10 \times 10^3) \times (10 \times 10^{-3})$
$\Delta Q = 100\pi$

Question83

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) [20 Jul 2021 Shift 1]

Options:

A. 250 R

B. 750 R

C. 175 R

D. 500 R

Answer: D

Solution:

Solution:
$\Delta Q = \Delta U + \Delta W$
Here $\Delta W = 0$
$\Delta Q = \Delta U = nC_V \Delta T$
$\Delta Q = 4 \times \frac{5R}{2}(50) = 500R$
Hence option (4).

Question84

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, to value of T is :
[27 Jul 2021 Shift 2]

Options:

A. $\frac{2}{3}T_1 + \frac{3}{2}T_3$

B. $\frac{1}{3}T_1 + \frac{2}{3}T_3$

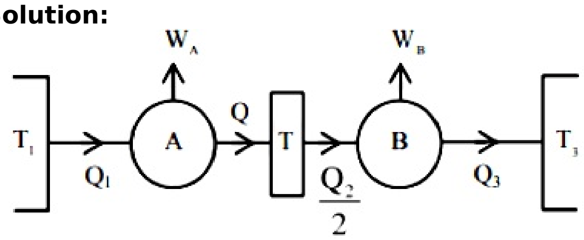
C. $\frac{3}{2}T_1 + \frac{1}{3}T_3$

D. $\frac{2}{3}T_1 + \frac{1}{3}T_3$

Answer: D

Solution:

Solution:



$W_A = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T}{T_1} \Rightarrow \frac{Q_2}{Q_1} = \frac{T}{T_1}$

$W_B = 1 - \frac{Q_3}{(Q_2/2)} = 1 - \frac{T_3}{T} \Rightarrow \frac{2Q_3}{Q_2} = \frac{T_3}{T}$

Now, $W_A = W_B$

$Q_1 - Q_2 = \frac{Q_2}{2} - Q_3$

$\Rightarrow \frac{2Q_1}{Q_2} + \frac{2Q_3}{Q_2} = 3$

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

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

Question85

A heat engine has an efficiency of $\frac{1}{6}$. When the temperature of sink is reduced by 62°C, its efficiency get doubled. The temperature of the source is :
[25 Jul 2021 Shift 2]

Options:

A. 124°C

B. 37°C

C. 62°C

D. 99°C

Answer: D

Solution:

Solution:

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

$2\eta = 1 - \frac{(T_L - 62)}{T_H} = 1 - \frac{T_L}{T_H} + \frac{62}{T_H}$

$\Rightarrow \eta = \frac{62}{T_H} \Rightarrow \frac{1}{6} = \frac{62}{T_H} \Rightarrow T_H = 6 \times 62 = 372K$

In°C $\Rightarrow 372 - 273 = 99°C$

Question86

The height of victoria falls is 63m. What is the difference in temperature of water at the top and at the bottom of fall ? [Given, $1\,cal = 4.2J$ and specific heat of water $= 1\,cal\,g^{-1°}\,C^{-1}$] [27 Aug 2021 Shift 2]

Options:

A. 0.147°C

B. 14.76°C

C. 1.476°C

D. 0.014°C

Answer: A

Solution:

Solution:

Given, height of fall, $H = 63m$

Acceleration due to gravity, $g = 9.8ms^{-2}$

Specific heat of water, $s = 1cal\,g^{-1}C^{-1}$

$= 4.2 \times 10^3 J\,kg^{-1}C^{-1}$

Since, energy, $E = mgH = ms\,\Delta T$

where, $m =$ mass

and $\Delta T =$ change in temperature.

$\therefore \Delta T = \frac{gH}{s} = \frac{9.8 \times 63}{4.2 \times 10^3} = 0.147°C$

Question87

The temperature of equal masses of three different liquids x, y and z are 10°C, 20°C and 30°C, respectively. The temperature of mixture when x is mixed with y is 16°C and that when y is mixed with z is 26°C. The

temperature of mixture when x and z are mixed will be [26 Aug 2021 Shift 2]

Options:

A. 28.32°C

B. 25.62°C

C. 23.84°C

D. 20.28°C

Answer: C

Solution:

Solution:
Given masses of three liquids are equal,
i.e. $m_x = m_y = m_z = m$
Temperature of mixture of liquids x and y, $T_1 = 16°C$
Temperature of mixture of liquids y and z, $T_2 = 26°C$
While mixing the liquids x and y, the heat energy lost by liquid y will be equal to the heat energy absorbed by liquid x.
Consider the specific heat capacity of liquid x is s_x, of liquid y is s_y and of liquid z is s_z.
Now, for liquid x and y, using principle of calorimetry,
Heat gained by liquid x = Heat lost by liquid y
$ms_x(T_1 - 10) = ms_y(20 - T_1)$
$\Rightarrow s_x(16 - 10) = s_y(20 - 16)$
$\Rightarrow \frac{s_x}{s_y} = \frac{2}{3}$ ...(i)
Similarly, for liquid y and z, using principle of calorimetry,
Heat gained by liquid y = Heat lost by liquid z
$ms_y(T_2 - 20) = ms_z(30 - T_2)$
$\Rightarrow s_y(26 - 20) = s_z(30 - 26)$ ...(ii)
$\Rightarrow \frac{s_y}{s_z} = \frac{2}{3}$...(i)
Multiply Eq. (i) by Eq. (ii), we get
$\frac{s_x}{s_z} = \frac{4}{9}$
Consider the mixing of liquids x and z, let the temperature of mixture be T_3.
Using principle of calorimetry for liquids x and z.
Heat gained by liquid x = Heat lost by liquid z
$ms_x(T_3 - 10) = ms_z(30 - T_3)$
$\Rightarrow s_x(T_3 - 10) = s_z(30 - T_3)$
$\Rightarrow \frac{s_x}{s_z} = \frac{30 - T_3}{T_3 - 10}$
$\Rightarrow \frac{4}{9} = \frac{30 - T_3}{T_3 - 10}$
$\Rightarrow 4T_3 - 40 = 270 - 9T_3$
$\Rightarrow T_3 = 23.84°C$

Question88

Two thin metallic spherical shells of radii r_1 and $r_2 (r_1 < r_2)$ are placed with their centres coinciding. A material of thermal conductivity K is filled in the space between the shells. The inner shell is maintained at

temperature θ_1 and the outer shell at temperature $\theta_2(\theta + 1 < \theta_2)$. The rate at which heat flows radially through the material is
[31 Aug 2021 Shift 2]

Options:

A. $\frac{4\pi K r_1 r_2(\theta_2 - \theta_1)}{r_2 - r_1}$

B. $\frac{\pi r_1 r_2(\theta_2 - \theta_1)}{r_2 - r_1}$

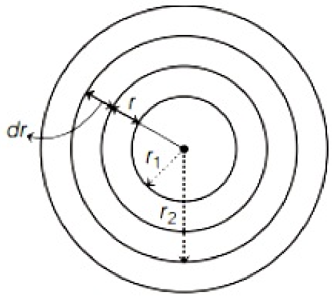
C. $\frac{K(\theta_2 - \theta_1)}{r_2 - r_1}$

D. $\frac{K(\theta_2 - \theta_1)(r_2 - r_1)}{4\pi r_1 r_2}$

Answer: A

Solution:

Solution:
Given that, r_1 and r_2 be the radii of inner and outer shells.



A material of thermal conductivity (K) is filled between region.
Consider an elementary sphere of radius r and thickness dr.
Now, thermal resistance of elementary sphere $dR = \frac{dr}{K4\pi r^2}$ [$\because$ inner surface area,$A = 4\pi r^2$]
So, total thermal resistance,

$$R = \int dR = \int_{r_1}^{r_2} \frac{dr}{4\pi K r^2} = -\frac{1}{4\pi K}\left[\frac{1}{r}\right]_{r_1}^{r_2}$$

$$R = \frac{r_2 - r_1}{4\pi K r_1 r_2}$$

Hence, heat current (or the rate of flow of heat)

$$\frac{dQ}{dt} = \frac{\Delta\theta}{R} = \frac{(\theta_2 - \theta_1)}{\frac{(r_2 - r_1)}{4\pi K r_1 r_2}} = \frac{4\pi K r_1 r_2(\theta_2 - \theta_1)}{r_2 - r_1}$$

Question89

An electric appliance supplies 6000J / min heat to the system. If the system delivers a power of 90W. How long it would take to increase the internal energy by 2.5×10^3J ?
[26 Aug 2021 Shift 1]

Options:

A. 2.5×10^2s

B. 4.1×10^{1}s

C. 24×10^{3}s

D. 2.5×10^{1}s

Answer: A

Solution:

Solution:
Given, heat supplied to the system,
$\frac{\Delta Q}{\Delta t} = 6000 \mathrm{J} / \mathrm{min} = \frac{6000}{60} \mathrm{J} / \mathrm{s} = 100 \mathrm{J} / \mathrm{s}$
Power delivered, $P = \frac{\Delta W}{t} = 90 \mathrm{W}$
Increase in internal energy, $\Delta U = 2.5 \times 10^{3} \mathrm{J}$
From first law of thermodynamics, we have
$\Delta Q = \Delta U + \Delta W$
or $\frac{\Delta Q}{\Delta t} = \frac{\Delta U}{\Delta t} + \frac{\Delta W}{\Delta t}$ ...(i)
Substituting the given values in Eq. (i), we get
$100 = \frac{2.5 \times 10^{3}}{\Delta t} + 90$
$\Rightarrow 10 = \frac{2.5 \times 10^{3}}{\Delta t}$
$\Rightarrow \Delta t = \frac{2.5 \times 10^{3}}{10}$
$\Rightarrow \Delta t = 2.5 \times 10^{2} \mathrm{s}$

Question90

A sample of gas with $\gamma = 1.5$ is taken through an adiabatic process in which the volume is compressed from $1200 \mathrm{cm}^{3}$ to $300 \mathrm{cm}^{3}$. If the initial pressure is 200 kPa. The absolute value of the work done by the gas in the process is .... J.
[31 Aug 2021 Shift 2]

Answer: 480

Solution:

Solution:
Given, sample of an ideal gas with ($\gamma = 1.5$) is taken through
adiabatic process, where
Initial volume, $V_{1} = 1200 \mathrm{cm}^{3} = 12 \times 10^{-4} \mathrm{m}^{3}$
Final volume, $V_{2} = 300 \mathrm{cm}^{3} = 3 \times 10^{-4} \mathrm{m}$
Initial pressure, $p_{1} = 200 \mathrm{kPa} = 2 \times 10^{5} \times \mathrm{Pa}$
Let final pressure $= p_{2}$
Using equation of adiabatic process,
$p_{1} V_{1}{}^{\gamma} = \rho_{2} V_{2}{}^{\gamma}$
$p_{2} = p_{1} \left(\frac{V_{1}}{V_{2}} \right)^{\gamma} = 2 \times 10^{5} \left(\frac{12 \times 10^{-4}}{3 \times 10^{-4}} \right)^{1.5}$

$= 16 \times 10^5 \mathrm{Pa}$

Work done in adiabatic process, $W = \frac{p_1V_1 - p_2V_2}{\gamma - 1}$

Substituting the values, we get

$W = \frac{2 \times 10^5 \times 12 \times 10^{-4} - 16 \times 10^5 \times 3 \times 10^{-4}}{1.5 - 1} = -480\mathrm{J}$

Hence, work done in adiabatic compression is 480 J.

Question91

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. [31 Aug 2021 Shift 1]

Options:

A. 174°C

B. 280°C

C. 180.4°C

D. 382°C

Answer: A

Solution:

Solution:

Given, initial efficiency of engine, $\eta_1 = \frac{1}{4}$

Let, initial temperature of $\sin k = T_2$

Final temperature of $\sin k = T_2 - 58°C$

Final efficiency of engine, $\eta_2 = 2\eta_1 = \frac{2}{4} = \frac{1}{2}$

Temperature of source $= T_1$

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

$\therefore \eta_1 = \frac{1}{4} = 1 - \frac{T_2}{T_1}$

$\Rightarrow \frac{T_2}{T_1} = 1 - \frac{1}{4}$

$\Rightarrow \frac{T_2}{T_1} = \frac{3}{4}$

$\Rightarrow T_1 = \frac{4}{3}T_2$ ...(i)

and $\eta_2 = \frac{1}{2} = 1 - \frac{T_2 - 58}{T_1}$

$\Rightarrow \frac{T_2 - 58}{T_1} = 1 - \frac{1}{2}$

$\Rightarrow \frac{T_2 - 58}{\frac{4}{3}T_2} = \frac{1}{2}$[From Eq. (i)]

$\Rightarrow 2T_2 - 116 = \frac{4}{3}T_2$

$\Rightarrow \frac{2T_2}{3} = 116$

$\Rightarrow T_2 = \frac{116 \times 3}{2} = 58 \times 3 = 174°C$

Question92

A heat engine operates between a cold reservoir at temperature T_2 = 400K and a hot reservoir at temperature T_1. It takes 300 f of heat from the hot reservoir and delivers 240J of heat to the cold reservoir in a cycle. The minimum temperature of the hot reservoir has to be .... K.
[27 Aug 2021 Shift 2]

Answer: 500

Solution:

Solution:
Given, temperature of hot reservoir $= T_1$ Temperature of cold reservoir, $T_2 = 400K$
Heat of hot reservoir, $Q_1 = 300J$
Heat of cold reservoir, $Q_2 = 240J$
Since, efficiency $(\eta) = 1 - \frac{T_2}{T_1} = \frac{Q_1 - Q_2}{Q_1}$

$1 - \frac{T_2}{T_1} = 1 - \frac{Q_2}{Q_1}$

$\Rightarrow 1 - \frac{400}{T_1} = 1 - \frac{240}{300}$

$\Rightarrow \frac{400}{T_1} = \frac{4}{5} \Rightarrow T_1 = 500K$

Question93

A refrigerator consumes an average 35W 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?
[26 Aug 2021 Shift 2]

Options:

A. 263J / s

B. 298J / s

C. 350J / s

D. 35J / s

Answer: A

Solution:

Solution:
Given, power consumed by refrigerator
$P = 35W = 35Js^{-1}$
∴ Energy consumed by refrigerator per second, $W = 35J$
Lower temperature limit, $T_L = -10°C = 263K$
Higher temperature limit, $T_H = 25°C = 298K$
The coefficient of performance of refrigerator is given as
$COP = \frac{T_L}{T_H - T_L} = \frac{Q}{W}$
Here, Q is the heat transferred by the refrigerator.
Substituting the values, we get
$\frac{263}{298 - 263} = \frac{Q}{35}$
$\Rightarrow Q = \frac{263}{35} \times 35 = 263J / s$
Thus, the average heat transfer by refrigerator per second is $263Js^{-1}$.

Question94

Due to cold weather a 1m water pipe of cross-sectional area $1cm^2$ is filled with ice at $-10°C$. Resistive heating is used to melt the ice. Current of 0.5A is passed through 4k Omega resistance. Assuming that, all the heat produced is used for melting, what is the minimum time required?
[Given, latent heat of fusion for water/ice $= 3.33 \times 10^5 Jkg^{-1}$, specific heat of ice $= 2 \times 10^3 Jkg^{-1}$ and density of ice $= 10^3 kg / m^3$]
[1 Sep 2021 Shift 2]

Options:

A. 0.353s

B. 35.3s

C. 3.53s

D. 70.6s

Answer: B

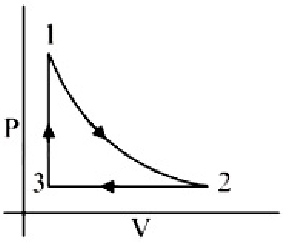
Solution:

Solution:
Given, the length of the water pipe, L = 1 m
The cross-sectional area of the water pipe, $A = 1cm^2 = 10^{-4}m^2$
The temperature of the ice = -10ºC
Current passing in the conductor, I = 0.5 A
Resistance of the conductor, R = 4 kΩ
The latent heat of fusion for ice, ,$L_i = 3.33 \times 10^5 J / kg$
The density of the ice, d $= 1000\, kg / m^3$
The specific heat of the ice, $c_{p,\, ice} = 2 \times 10^3 J / kg$
Heat required to melt the ice at 10°C to 0°C
$Q = mc_p\Delta T + mL_i$
$Q = dVc_p\Delta T + dVL_f$
$= 1000 \times 10^{-4} \times 2 \times 10^3 \times (10) + 1000 \times 10^{-4} \times 3.33 \times 10^5$
$(\because V = A \times L)$
= 35300 J
According to the Joule’s law of heating,
$H = I^2Rt$

$\Rightarrow 35300 = (0.5)^2(4000)(t)$
t = 35.3 s
Thus, the minimum time required to melt the ice is 35.3 s.

Question95

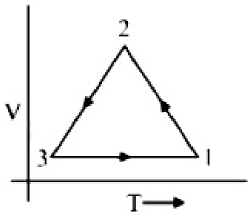
Which of the following is an equivalent cyclic process corresponding to the thermodynamic cyclic given in the figure? where, 1 → 2 is adiabatic. (Graphs are schematic and are not to scale)



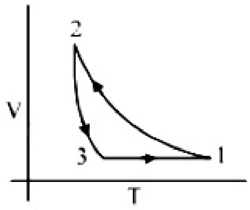
[9 Jan. 2020 I]

Options:

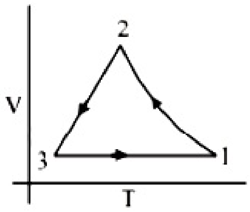
A.



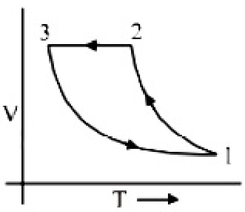
B.



C.



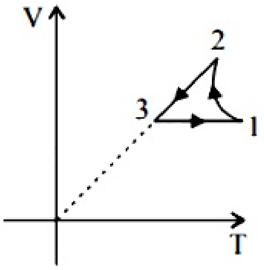
D.



Answer: C

Solution:

Solution:
For process $3 \rightarrow 1$ volume is constant
$\therefore$ Graph given in option (d) is wrong.
And process $1 \rightarrow 2$ is adiabatic $\therefore$ graph in option (1) is wrong
$\because \mathrm{v} =$ constant
$\mathrm{P} \uparrow, \mathrm{T} \uparrow$
For Process $2 \rightarrow 3$ Pressure constant $\mathrm{i.e.}, \mathrm{P} =$ constant
$\therefore \mathrm{V} \downarrow \mathrm{T} \downarrow$
Hence graph (c) is the correct $\mathrm{V} - \mathrm{T}$ graph of given $\mathrm{P} - \mathrm{V}$ graph



Question96

Starting at temperature 300K , 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) ______.
[9 Jan. 2020 II]

Answer: 1818

Solution:

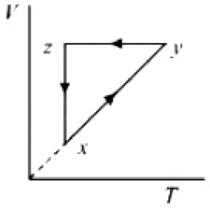
For an adiabatic process,
$\mathrm{T} \mathrm{V}^{\gamma - 1} = \text{constant}$
$\therefore \mathrm{T}_1 \mathrm{V}_1^{\gamma - 1} = \mathrm{T}_2 \mathrm{V}_2^{\gamma - 1}$
$$\Rightarrow \mathrm{T}_2 = (300) \times \left(\frac{\mathrm{V}_1}{\frac{\mathrm{V}_1}{16}} \right)^{1.4 - 1}$$
$\Rightarrow \mathrm{T}_2 = 300 \times (16)^{0.4}$
Ideal gas equation, $\mathrm{PV} = \mathrm{nRT}$
$\therefore \mathrm{V} = \frac{\mathrm{nRT}}{\mathrm{P}}$
$\Rightarrow \mathrm{V} = \mathrm{kT}$ (since pressure is constant for isobaric process)
So, during isobaric process
$\mathrm{V}_2 = \mathrm{kT}_2$ ...(i)
$2\mathrm{V}_2 = \mathrm{kT}_f$ ...(ii)
Dividing (i) by (ii)

$\frac{1}{2} = \frac{T_2}{T_f}$

$T_f = 2T_2 = 300 \times 2 \times (16)^{0.4} = 1818K$

Question97

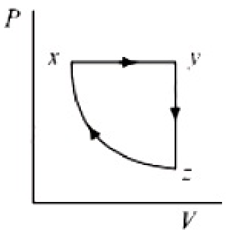
A thermodynamic cycle xyzx is shown on a V-T diagram.



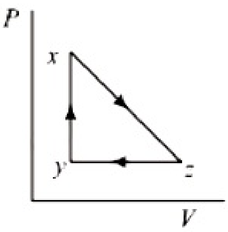
The P-V diagram that best describes this cycle is: (Diagrams are schematic and not to scale)
[8 Jan. 2020 I]

Options:

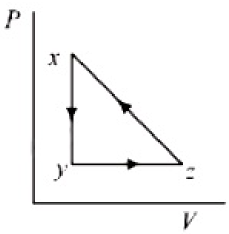
A.



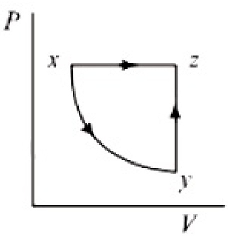
B.



C.



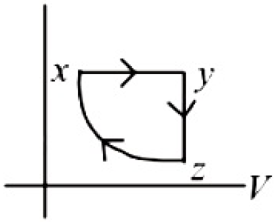
D.



Answer: A

Solution:

Solution:
From the corresponding V-T graph given in question,
Process xy → Isobaric expansion,
Process yz → Isochoric (Pressure decreases)
Process zx → Isothermal compression
Therefore, corresponding PV graph is as shown in figure



Question98

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]
[7 Jan. 2020 I]

Options:

A. 60.7 J

B. 90.5 J

C. 100.8 J

D. 48 J

Answer: B

Solution:

Solution:
$V_1 = 1l \Rightarrow$ initial volume, $V_1 = 1 \times 10^{-3} m^3$
$V_2 = 3l \Rightarrow$ final volume, $V_2 = 3 \times 10^{-3} m^3$
At STP:
$T = 273K$
$P_1 = 101.325 kPa \Rightarrow$ initial pressure $Y = 1.4$
Work done in adiabatic process, $\Delta W = -\left(\frac{P_2 V_2 - P_1 V_1}{Y - 1}\right)$
adiabatic $\Rightarrow PV^{\gamma} =$ constant
$\Rightarrow P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$
$\Rightarrow P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 1.01325 \left(\frac{1 \times 10^{-3}}{3 \times 10^{-3}}\right)^{1.4}$
$\Rightarrow P_2 = 101.325 \times \frac{1}{(3)^{1.4}} = \left(\frac{101.325}{4.6555}\right) kPa$
$P_2 = 21.7646 K Pa$
$\Delta W = -\left(\frac{21.7646 \times 10^3 \times 3 \times 10^{-3} - 101.325 \times 10^3 \times 1 \times 10^{-3}}{1.4 - 1}\right)$

$\Delta W = -\left(\frac{65.2937 - 101.325}{0.4}\right) = 90.5J$

Considering only magnitude, the work done by the air will be 90.5J

Question99

Under an adiabatic process, the volume of an ideal gas gets doubled. Consequently the mean collision time betweenthe gas molecule changes from τ_1 to τ_2. If $\frac{C_p}{C_v} = \gamma$ for thisgas then a good estimate for $\frac{\tau_2}{\tau_1}$ is given by: [7 Jan. 2020 I]

Options:

A. 2

B. $\frac{1}{2}$

C. $\left(\frac{1}{2}\right)^{\gamma}$

D. $\left(\frac{1}{2}\right)^{\frac{\gamma+1}{2}}$

Answer: D

Solution:

Solution:

Mean free path, $\lambda = \left(\frac{RT}{\sqrt{2}\pi d^2 N_A P}\right)$

$V_{rms} = \sqrt{\frac{3RT}{M}}$

$\therefore \tau = \frac{\lambda}{V_{rms}} = \frac{RT}{\sqrt{2}\pi d^2 N_A P} \times \sqrt{\frac{M}{3RT}}$

$\tau \propto \frac{\sqrt{T}}{P}$

$\frac{\tau_1}{\tau_2} = \frac{\sqrt{T_1}}{P_1} \times \frac{P_2}{\sqrt{T_2}} = \left(\frac{P_2}{P_1}\right)\sqrt{\frac{T_1}{T_2}}$

$PV = nRT$

$\frac{P_1}{P_2} \times \frac{V_1}{V_2} = \frac{T_1}{T_2}$

$\Rightarrow 2^{\gamma} \times \frac{V}{2V} = \frac{T_1}{T_2}$

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

$\therefore \frac{\tau_1}{\tau_2} = \left(\frac{P_2}{P_1}\right) \times \sqrt{\frac{T_1}{T_2}} = \frac{1}{2^{\gamma}} \times \sqrt{2^{\gamma-1}} = \frac{2^{\frac{\gamma-1}{2}}}{2^{\gamma}}$

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

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

Question100

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:
[8 Jan. 2020 II]

Options:

A. 99 J

B. 100 J

C. 1 J

D. 90 J

Answer: D

Solution:

Solution:
For carnot refrigerator
Efficiency $= \frac{Q_1 - Q_2}{Q_1}$
Where, $Q_1 =$ heat lost from sorrounding
$Q_2 =$ heat absorbed from reservoir at low
Also, $\frac{Q_1 - Q_2}{Q_1} = \frac{w}{Q_1}$
$\Rightarrow \frac{1}{10} = \frac{w}{Q_1}$
$\Rightarrow Q_1 = w \times 10 = 100J$
So, $Q_1 - Q_2 = w$
$\Rightarrow Q_2 = Q_1 - w$
$\Rightarrow 100 - 10 = Q_2 = 90J$

Question101

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 _______.
[NA 7 Jan. 2020 I]

Answer: 600

Solution:

Solution:
Given; $T_1 = 900K$, $T_2 = 300K$, $W = 1200J$

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

$\Rightarrow 1 - \frac{300}{900} = \frac{1200}{Q_1}$

$\Rightarrow \frac{2}{3} = \frac{1200}{Q_1} \Rightarrow Q_1 = 1800$

Therefore heat energy delivered by the engine to the low temperature reservoir, $Q_2 = Q_1 - W = 1800 - 1200 = 600.00J$

Question102

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? [7 Jan. 2020 II]

Options:

A. $T = \frac{2T_1T_2}{T_1 + T_2}$

B. $T = \frac{T_1 + T_2}{2}$

C. $T = \sqrt{T_1T_2}$

D. $T = 0$

Answer: B

Solution:

Solution:
Let $Q_H =$ Heat taken by first engine
$Q_L =$ Heat rejected by first engine
$Q_2 =$ Heat rejected by second engine
Work done by 1st engine = work done by 2nd engine
$W = Q_H - Q_L = Q_L - Q_2 \Rightarrow 2Q_L = Q_H + Q_2$

$2 = \frac{\theta_H}{\theta_L} + \frac{\theta_2}{\theta_L}$

Let T be the temperature of cold reservoir of first engine. Then in carnot engine.

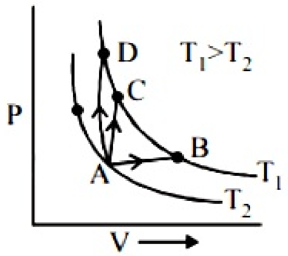
$\frac{Q_H}{Q_L} = \frac{T_1}{T}$ and $\frac{Q_L}{Q_2} = \frac{T}{T_2}$

$\Rightarrow 2 = \frac{T_1}{T} + \frac{T_2}{T}$ using (i)

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

Question103

Three different processes that can occur in an ideal monoatomic gas are shown in the P vs V diagram. The paths are lebelled 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:



[5 Sep. 2020 (I)]

Options:

A. $E_{AB} = E_{AC} < E_{AD}$, $W_{AB} > 0$, $W_{AC} = 0$, $W_{AD} < 0$

B. $E_{AB} = E_{AC} = E_{AD}$, $W_{AB} > 0$, $W_{AC} = 0$, $W_{AD} > 0$

C. $E_{AB} < E_{AC} < E_{AD}$, $W_{AB} > 0$, $W_{AC} > W_{AD}$

D. $E_{AB} > E_{AC} > E_{AD}$, $W_{AB} < W_{AC} < W_{AD}$

Answer: B

Solution:

Solution:
Temperature change ΔT is same for all three processes
A → B; A → C and A → D
$\Delta U = nC_v\Delta T =$ same
$E_{AB} = E_{AC} = E_{AD}$
Work done, $W = P \times \Delta V$
AB→ volume is increasing ⇒$W_{AB} > 0$
AD→ volume is decreasing ⇒$W_{AD} < 0$
AC→ volume is constant ⇒$W_{AC} = 0$

Question104

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 :
[5 Sep. 2020 (II)]

Options:

A. 32

B. 326

C. 128

D. $\frac{1}{32}$

Answer: C

Solution:

Solution:
In adiabatic process
$PV^{\gamma} =$ constant
$\therefore P\left(\frac{m}{\rho}\right)^{\gamma} =$ constant $\left(\because V = \frac{m}{\rho}\right)$
As mass is constant
$\therefore P \propto \rho^{\gamma}$
If P_i and P_f be the initial and final pressure of the gas and ρ_i and ρ_f be the initial and final density of the gas. Then
$\frac{P_f}{P_i} = \left(\frac{\rho_f}{\rho_i}\right)^{\gamma} = (32)^{7/5}$
$\Rightarrow \frac{nP_i}{P_i} = (2^5)^{7/5} = 2^7$
$\Rightarrow n = 2^7 = 128$

Question105

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.

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	(D) $\Delta U = 0$

[4 Sep. 2020 (II)]

Options:

A. (I)-(A), (II)-(B), (III)-(D), (IV)-(D)

B. (I)-(B), (II)-(A), (III)-(D), (IV)-(C)

C. (I)-(A), (II)-(A), (III)-(B), (IV)-(C)

D. (I)-(B), (II)-(D), (III)-(A), (IV)-(C)

Answer: D

Solution:

Solution:
(I) **Adiabatic process :** No exchange of heat takes place with surroundings.
$\Rightarrow \Delta Q = 0$

(II) **Isothermal process :** Temperature remains constant

$\therefore \Delta T = 0 \Rightarrow \Delta U = \frac{f}{2} nR\Delta T \Rightarrow \Delta U = 0$

No change in internal energy [$\Delta U = 0$]

(III) Isochoric process volume remains constant

$\Delta V = 0 \Rightarrow W = \int P \, . \, dV = 0$

Hence work done is zero.

(IV) In isobaric process pressure remains constant.

$W = P \, . \, \Delta V \neq 0$

$\Delta U = \frac{f}{2} nR\Delta T = \frac{f}{2}[P\Delta V] \neq 0$

$\therefore \Delta Q = nC_p \Delta T \neq 0$

Question106

A balloon filled with helium (32°C and 1.7 atm.) bursts. Immediately afterwards the expansion of helium can be considered as : [3 Sep. 2020 (I)]

Options:

A. irreversible isothermal

B. irreversible adiabatic

C. reversible adiabatic

D. reversible isotherm7al

Answer: B

Solution:

Solution:

Bursting of helium balloon is irreversible and in this process $\Delta Q = 0$, so adiabatic.

Question107

An engine takes in 5 mole of air at 20°C and 1 atm, and compresses it adiabaticaly 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 ________. [NA 2 Sep. 2020 (I)]

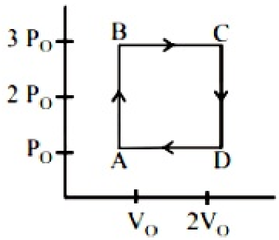
Answer: 46

Solution:

For adiabatic process, $TV^{\gamma-1}$ = constant
or ,$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$
$T_1 = 20°nd\ \ \gamma = \frac{7}{5}$
$T_1(V_1)^{\gamma-1} = T_2\left(\frac{V_1}{10}\right)^{\gamma-1}$
$\Rightarrow 293 = T_2\left(\frac{1}{10}\right)^{2/5} \Rightarrow T_2 = 293(10)^{2/5} \simeq 736K$
$\Delta T = 736 - 293 = 443K$
During the process, change in internal energy
$\Delta U = NC_V\Delta T = 5 \times \frac{5}{2} \times 8.3 \times 443 \simeq 46 \times 10^3 J = X\,kJ$
$\therefore X = 46$

Question108

An engine operates by taking a monatomic ideal gas through the cycle shown in the figure. The percentage efficiency of the engine is close is ______.

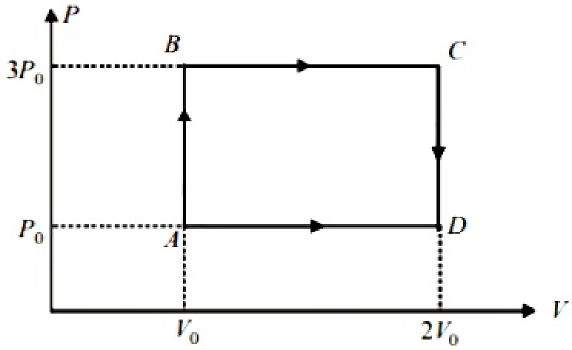


[NA 6 Sep. 2020 (II)]

Answer: 19

Solution:

Solution:



From the figure,
Work, $W = 2P_0V_0$
Heat given, $Q_{in} = W_{AB} + W_{BC} = n\,.\,C_V\Delta T_{AB} + nC_P\Delta T_{BC}$
$= n\frac{3R}{2}(T_B - T_A) + \frac{n5R}{2}(T_C - T_B)\ \left(\because C_v = \frac{3R}{2}\text{ and }C_P = \frac{5R}{2}\right)$
$= \frac{3}{2}(P_BV_B - P_AV_A) + \frac{5}{2}(P_CV_C - P_BV_B)$
$= \frac{3}{2} \times [3P_0V_0 - P_0V_0] + \frac{5}{2}[6P_0V_0 - 3P_0V_0]$
$= 3P_0V_0 + \frac{15}{2}P_0V_0 = \frac{21}{2}P_0V_0$

Efficiency, $\eta = \frac{W}{Q_{in}} = \frac{2P_0V_0}{\frac{21}{2}P_0V_0} = \frac{4}{21}$

$\eta\% = \frac{400}{21} \approx 19$

Question109

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?
[NA 3 Sep. 2020 (II)]

Answer: 8791

Solution:

Solution:
Given,
Heat absorbed, $Q_2 = mL = 80 \times 100 = 8000$ Cal
Temperature of ice, $T_2 = 273K$
Temperature of surrounding,
$T_1 = 273 + 27 = 300K$
Efficiency $= \frac{w}{Q_2} = \frac{Q_1 - Q_2}{Q_2} = \frac{T_1 - T_2}{T_2} = \frac{300 - 273}{273}$
$\Rightarrow \frac{Q_1 - 8000}{8000} = \frac{27}{273} \Rightarrow Q_1 = 8791\,\text{Cal}$

Question110

A heat engine is involved with exchange of heat of 1915 J, – 40 J, +125 J and – Q J, during one cycle achieving an efficiency of 50.0%. The value of Q is :
[2 Sep. 2020 (II)]

Options:

A. 640 J

B. 40 J

C. 980 J

D. 400 J

Answer: C

Solution:

Efficiency, η = $\frac{\text{Work done}}{\text{Heat absorbed}} = \frac{W}{\sum Q}$

$= \frac{Q_1 + Q_2 + Q_3 + Q_4}{Q_1 + Q_3} = 0.5$

Here, $Q_1 = 1915J$, $Q_2 = -40J$ and $Q_3 = 125J$

$\therefore \frac{1915 - 40 + 125 + Q_4}{1915 + 125} = 0.5$

$\Rightarrow 1915 - 40 + 125 + Q_4 = 1020$

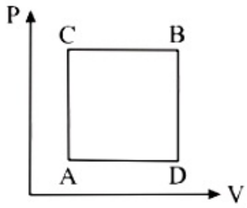
$\Rightarrow Q_4 = 1020 - 2000$

$\Rightarrow Q_4 = -Q = -980J$

$\Rightarrow Q = 980J$

Question111

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



When path ACB is used 60 J of heat flows into the system and 30J 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 :
[9 Jan. 2019 I]

Options:

A. 40 J

B. 80 J

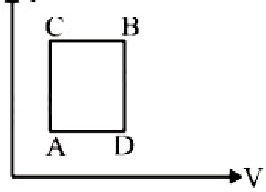
C. 100 J

D. 20 J

Answer: A

Solution:

Solution:



Δ U remains same for both paths ACB and ADB

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

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

$\Rightarrow U_{ACB} = 30J$

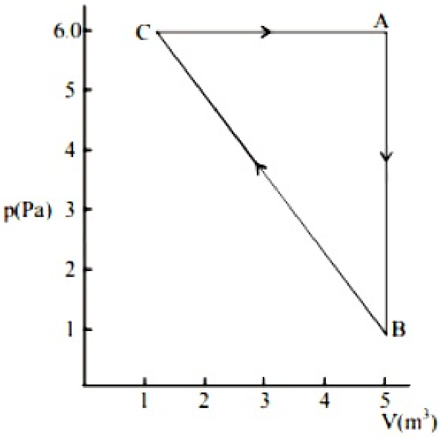
$\therefore \Delta U_{ADB} = \Delta U_{ACB} = 30J$

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

$= 10J + 30J = 40J$

Question112

For the given cyclic process CAB as shown for gas, the work done is:



[12 Jan. 2019 I]

Options:

A. 30 J

B. 10 J

C. 1 J

D. 5 J

Answer: B

Solution:

Solution:
Total work done by the gas during the cycle is equal to area of triangle ABC.
$\therefore \Delta W = \frac{1}{2} \times 4 \times 5 = 10J$

Question113

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:
[11 Jan. 2019 I]

Options:

A. $\frac{3}{5}$

B. $\frac{2}{5}$

C. $\frac{2}{3}$

D. $\frac{5}{3}$

Answer: B

Solution:

Solution:
Equation of adiabatic change is
$T V^{\gamma - 1}$ = constant
Put $\gamma = \frac{7}{5}$, we get: $\gamma - 1 = \frac{7}{5} - 1$
$\therefore x = \frac{2}{5}$

Question114

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: (Gas constant R = 8.31 J/mol-K) [10 Jan. 2019 II]

Options:

A. 581 J

B. 291 J

C. 146 J

D. 73 J

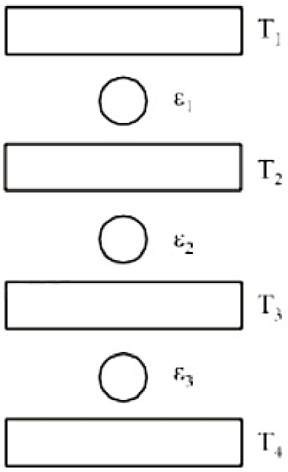
Answer: B

Solution:

Solution:
Work done,
$W = P\Delta V = nR\Delta T = \frac{1}{2} \times 8.31 \times 70 \simeq 291 J$

Question115

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 $T_2{}^4$ and T_3, as shown, with $T_1 > T_2 > T_3 > T$ (4) The three engines are equally efficient if:



[10 Jan. 2019 I]

Options:

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

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

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

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

Answer: B

Solution:

Solution:
According to question, $\eta_1 = \eta_2 = \eta_3$
$\therefore 1 - \frac{T_2}{T_1} = 1 - \frac{T_3}{T_2} = 1 - \frac{T_4}{T_3}$
[$\because$ Three engines are equally efficient]
$\Rightarrow \frac{T_2}{T_1} = \frac{T_3}{T_2} = \frac{T_4}{T_3}$
$\Rightarrow T_2 = \sqrt{T_1 T_3}$
$T_3 = \sqrt{T_2 T_4}$
From (i) and (ii)
$T_2 = (T_1^2 T_4)^{1/3}$
$T_3 = (T_1 T_4^2)^{1/3}$

Question116

Two Carnot engines A and B are operated in series. The first one, A receives heat at $T_1 (= 600K)$ 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 $T_3 (= 400K)$. Calculate the temperature T_2 if the work outputs of the two engines are equal:

[9 Jan. 2019 II]

Options:

A. 600 K

B. 400 K

C. 300 K

D. 500 K

Answer: D

Solution:

Solution:

$\eta_A = \frac{T_1 - T_2}{T_1} = \frac{W_A}{Q_1}$

and, $\eta_B = \frac{T_2 - T_3}{T_2} = \frac{W_B}{Q_2}$

According to question,

$W_A = W_B$

$\therefore \frac{Q_1}{Q_2} = \frac{T_1}{T_2} \times \frac{T_2 - T_3}{T_1 - T_2} = \frac{T_1}{T_2}$

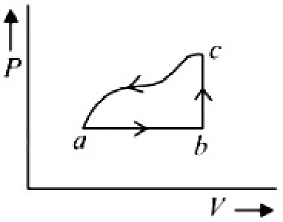
$\therefore T_2 = \frac{T_1 + T_3}{2}$

$= \frac{600 + 400}{2}$

$= 500K$

Question117

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 down by the gas along the path abc is:



[12 Apr. 2019 I]

Options:

A. 120 J

B. 130 J

C. 100 J

D. 140 J

Answer: B

Solution:

Solution:
$\Delta U_{ac} = -(\Delta U_{ca}) = -(-180) = 180J$
$Q = 250 + 60 = 310J$
Now $Q = \Delta U + W$
or $310 = 180 + W$
or $W = 130J$

Question118

A cylinder with fixed capacity of 67.2 lit contains helium gas at STP. The amount of heat needed to raise the temperature of the gas by 20oC is : [Given that R = 8.31 $Jmol^{-1}$ K^{-1}] [10 Apr. 2019 I]

Options:

A. 350 J

B. 374 J

C. 748 J

D. 700 J

Answer: C

Solution:

Solution:
As the process is isochoric so,
$Q = nc_v\Delta T = \frac{67.2}{22.4} \times \frac{3R}{2} \times 20 = 90R = 90 \times 8.31 \simeq 748J$

Question119

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: [10 Apr. 2019 I]

Options:

A. $\frac{nR}{C_V + nR}$

B. $\frac{nR}{C_V - nR}$

C. $\frac{4nR}{C_V - nR}$

D. $\frac{4nR}{C_V + nR}$

Answer: A

Solution:

Solution:
At constant volume
Work done
$(W) = nR\Delta T$
Heat given $Q = C_v\Delta T + nR\Delta T$
So, $\therefore \frac{W}{Q} = \frac{nR\Delta T}{C_v\Delta T + nR\Delta T} = \frac{nR}{C_V + nR}$

Question120

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 and V_0 are constants. Calculate the charge in the temperature of the gas if its volume changes from V_o to $2V_o$.
[10 Apr. 2019 II]

Options:

A. $\frac{1}{2}\frac{P_oV_o}{R}$

B. $\frac{5}{4}\frac{P_oV_o}{R}$

C. $\frac{3}{4}\frac{P_oV_o}{R}$

D. $\frac{1}{4}\frac{P_oV_o}{R}$

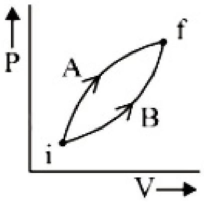
Answer: B

Solution:

Solution:
We have given,
$P = P_0\left[1 - \frac{1}{2}\left(\frac{V_0}{V}\right)^2\right]$
When $V_1 = V_0$
$\Rightarrow P_1 = P_0\left[1 - \frac{1}{2}\right] = \frac{P_0}{2}$
When $V_2 = 2V_0$
$\Rightarrow P_2 = P_0\left[1 - \frac{1}{2}\left(\frac{1}{4}\right)\right] = \left(\frac{7P_0}{8}\right)$
$\Delta T = T_2 - T_1 = \left|\frac{P_1V_1}{nR} - \frac{P_2V_2}{nR}\right| \left[\because T = \frac{PV}{nR}\right]$
$\Delta T = \left|\left(\frac{1}{nR}\right)(P_1V_1 - P_2V_2)\right| = \left(\frac{1}{nR}\right)\left|\left(\frac{P_0V_0}{2} - \frac{7P_0V_0}{4}\right)\right|$
$= \frac{5P_0V_0}{4nR} = \frac{5P_0V_0}{4R}(\because n = 1)$

Question121

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:



[9 April 2019 I]

Options:

A. $\Delta Q_A < \Delta Q_B$, $\Delta U_A < \Delta U_B$

B. $\Delta Q_A > \Delta Q_B$, $\Delta U_A > \Delta U_B$

C. $\Delta Q_A > \Delta Q_B$, $\Delta U_A = \Delta U_B$

D. $\Delta Q_A = \Delta Q_B$; $\Delta U_A = \Delta U_B$

Answer: C

Solution:

Solution:
Internal energy depends only on initial and final state
So, $\Delta U_A = \Delta U_B$
Also $\Delta Q = \Delta U + W$
AS $W_A > W_B \Rightarrow \Delta Q_A > \Delta Q_B$

Question122

A thermally insulted vessel contains 150g 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 closed to:(Latent heat of vaporization of water $= 2.10 \times 10^6 \text{J kg}^{-1}$ and Latent heat of Fusion of water $= 3.36 \times 10^5 \text{J kg}^{-1}$) [8 April 2019 I]

Options:

A. 150 g

B. 20 g

C. 130 g

D. 35 g

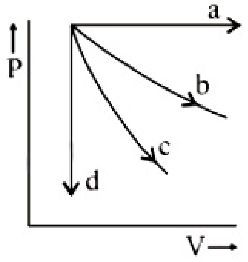
Answer: B

Solution:

Solution:
Suppose amount of water evaporated be M gram.
Then $(150-M)$ gram water converted into ice.
so, heat consumed in evoporation = Heat released in fusion
$M \times L_v = (150-M) \times L$
$M \times 2.1 \times 10^6 = (150-M) \times 3.36 \times 10^5$
$\Rightarrow M = 20g$

Question123

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 :



[8 April 2019 II]

Options:

A. a d b c

B. d a c b

C. a d c b

D. d a b c

Answer: D

Solution:

Solution:
a → Isobasic, b → Isothermal, c → Adiabatic, d → Isochoric

Question124

A Carnot engine has an efficiency of 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.
[12 Apr. 2019 II]

Options:

A. 62°C, 124°C

B. 99°C, 37°C

C. 124°C, 62°C

D. 37°C, 99°C

Answer: B

Solution:

Solution:

Using, $n = 1 - \frac{T_2}{T_1}$

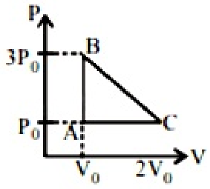
$n = \frac{1}{6} = 1 - \frac{T_2}{T_1}$

and $\frac{T}{3} = 1 - \frac{T_2 - 62}{T_1}$

On solving, we get $T_1 = 99°C$ and $T_2 = 37°C$

Question125

One mole of an ideal monoatomic gas is taken along the path ABCA as shown in the PV diagram. The maximum temperature attained by the gas along the path BC is given by



[Online April 16, 2018]

Options:

A. $\frac{25}{8}\frac{P_0 V_0}{R}$

B. $\frac{25}{4}\frac{P_0 V_0}{R}$

C. $\frac{25}{16}\frac{P_0 V_0}{R}$

D. $\frac{5}{8}\frac{P_0 V_0}{R}$

Answer: A

Solution:

Solution:

Equation of the BC

$P = P_0 - \frac{2P_0}{V_0}(V - 2V_0)$

using $PV = nRT$

Temperature, $T = \dfrac{P_0V - \dfrac{2P_0V^2}{V_0} + 4P_0\sim V}{1 \times R}$

($\because$n = 1 mole given)

$T = \frac{P_0}{F}\left[5V - \frac{2V^2}{V_0}\right]$

$\frac{dT}{dV} = 0 \Rightarrow 5 - \frac{4V}{V_0} = 0 \Rightarrow V = \frac{5}{4}V_0$

$T = \frac{P_0}{R}\left[5 \times \frac{5V_0}{4} - \frac{2}{V_0} \times \frac{25}{16}V_0^2\right] = \frac{25}{8}\frac{P_0V_0}{R}$

Question126

One mole of an ideal monoatomic gas is compressed isothermally in a rigid vessel to double its pressure at room temperature, 27°C. The work done on the gas will be:
[Online April 15, 2018]

Options:

A. 300R ln 6

B. 300R

C. 300R ln 7

D. 300R ln 2

Answer: D

Solution:

Solution:

Work done on gas $= nRT\ln\left(\frac{p_f}{p_1}\right) = R(300)\ln(2)$

$= 300R\ln 2\left(\because \frac{P_f}{p_i} = 2\,\text{given}\right)$

Question127

A Carnot's engine works as a refrigerator between 250 K and 300 K. It receives 500 cal heat from the reservoir at the lower temperature. The amount of work done in each cycle to operate the refrigerator is:
[Online April 15, 2018]

Options:

A. 420 J

B. 2100 J

C. 772 J

D. 2520 J

Answer: A

Solution:

Solution:
Given: Temperature of cold body, $T_2 = 250\mathrm{K}$ temperature of hot body; $T_1 = 300\mathrm{K}$
Heat received, $Q_2 = 500$ cal work done, $W = ?$

Efficiency $= 1 - \frac{T_2}{T_1} = \frac{W}{Q_2 + W} \Rightarrow 1 - \frac{250}{300} = \frac{W}{Q_2 + W}$

$W = \frac{Q_2}{5} = \frac{500 \times 4.2}{5}\mathrm{J} = 420\mathrm{J}$

Question128

Two Carnot engines A and B are operated in series. Engine A receives heat from a reservoir at 600K and rejects heat to a reservoir at temperature T. Engine B receives heat rejected by engine A and in turn rejects it to a reservoir at 100K. If the efficiencies of the two engines A and B are represented by η_A and η_B respectively, then what is the value of $\frac{\eta_A}{\eta_B}$

[Online April 15, 2018]

Options:

A. $\frac{12}{7}$

B. $\frac{12}{5}$

C. $\frac{5}{12}$

D. $\frac{7}{12}$

Answer: D

Solution:

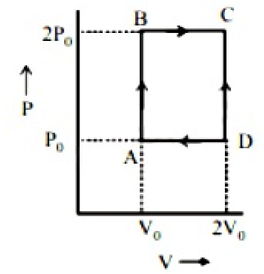
Solution:
(d) Efficiency of engine A, $n_A = \frac{T_1 - T_2}{T_1}$

and $n_B = \frac{T_2 - T_3}{T_2}$; $T_2 = \frac{T_1 + T_3}{2} = 350\mathrm{K}$

or $\frac{n_A}{n_B} = \frac{\frac{600 - 350}{600}}{\frac{350 - 100}{350}} = \frac{7}{12}$

Question129

An engine operates by taking n moles of an ideal gas through the cycle ABCDA shown in figure. The thermal efficiency of the engine is : (Take C_v = 1.5 R, where R is gas constant)



[Online April 8, 2017]

Options:

A. 0.24

B. 0.15

C. 0.32

D. 0.08

Answer: B

Solution:

Solution:
Work-done (W) = P_0V_0
According to principle of calorimetry
Heat given $= Q_{AB} = Q_{BC}$
$= nC_v dT_{AB} + nC_P dT_{BC}$
$= \frac{3}{2}(nRT_B - nRT_A) + \frac{5}{2}(nRT_C - nRT_B)$
$= \frac{3}{2}(2P_0V_0 - P_0V_0) + \frac{5}{2}(4P_0V_0 - 2P_0V)$
$= \frac{13}{2}P_0V_0$
Thermal efficiency of engine $(\eta) = \frac{W}{Q_{given}} = \frac{2}{13} = 0.15$

Question130

200g water is heated from 40°C to 60°C. Ignoring the slight expansion of water, the change in its internal energy is close to (Given specific heat of water = 4184 J/kgK):
[Online April 9, 2016]

Options:

A. 167.4 kJ

B. 8.4 kJ

C. 4.2 kJ

D. 16.7 kJ

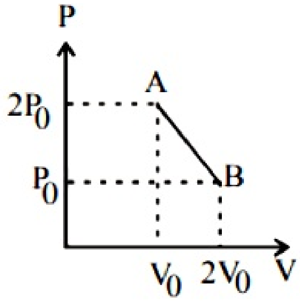
Answer: D

Solution:

Solution:
Volume of water does not change, no work is done on or by the system ($W = 0$)
According to first law of thermodynamics
$Q = \Delta U + W$
For Isochoric process $Q = \Delta U$
$\Delta U = \mu c d T = 2 \times 4184 \times 20 = 16.7 kJ$

Question131

'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 :



[2016]

Options:

A. $\frac{9P_0V_0}{2nR}$

B. $\frac{9P_0V_0}{nR}$

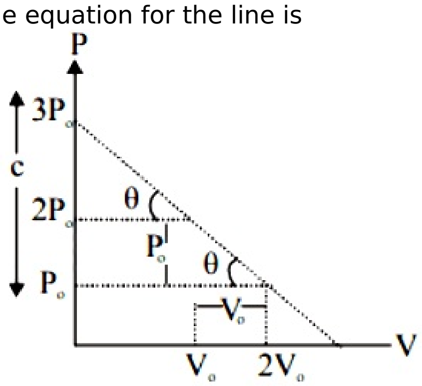
C. $\frac{9P_0V_0}{4nR}$

D. $\frac{3P_0V_0}{2nR}$

Answer: C

Solution:

Solution:
The equation for the line is



$P = \frac{-P_0}{V_0}V + 3P \left[\text{slope} = \frac{-P_0}{V_0}, c = 3P_0\right]$
$PV_0 + P_0V = 3P_0V_0$ ...(i)
But $pV = nRT$
$\therefore P = \frac{nRT}{V}$ ...(ii)
From (i) & (ii)
$\frac{nRT}{V}V_0 + P_0V = 3P_0V_0$
From(i) & (ii)
$\frac{nRT}{V}V_0 + P_0V = 3P_0V_0$
$\therefore nRTV_0 + P_0V^2 = 3P_0V_0V$
For temperature to be maximum $\frac{dT}{dV} = 0$
Differentiating e.q. (iii) by ' V ' we get
$nRV_0\frac{dT}{dV} + P_0(2V) = 3P_0V_0$
$\therefore nRV_0\frac{dT}{dV} = 3P_0V_0 - 2P_0V$
$\frac{dT}{dV} = \frac{3P_0V_0 - 2P_0V}{nRV_0} = 0$
$V = \frac{3V_0}{2} \quad \therefore P = \frac{3P_0}{2}$[From (i)]
$\therefore T_{max} = \frac{9P_0V_0}{4nR}$ [From (iii)]

Question132

The ratio of work done by an ideal monoatomic gas to the heat supplied to it in an isobaric process is : [Online April 9, 2016]

Options:

A. $\frac{2}{5}$

B. $\frac{3}{2}$

C. $\frac{3}{5}$

D. $\frac{2}{3}$

Answer: A

Solution:

Solution:
Efficiency of heat engine is given by
$\eta = \frac{w}{Q} = 1 - \frac{C_V}{C_P} = \frac{R}{C_p} = \frac{R}{\frac{5R}{2}} = \frac{2}{5}$
$(\because C_p - C_v = R)$
For monoatomic gas $C_P = \frac{5}{2}R$.

Question133

A Carnot freezer takes heat from water at 0°C inside it and rejects it to the room at a temperature of 27°C. The latent heat of ice is $336 \times 10^3 \text{J kg}^{-1}$. If 5kg of water at 0°C is converted into ice at 0°C by the freezer, then the energy consumed by the freezer is close to :
[Online April 10, 2016]

Options:

A. $1.51 \times 10^5 \text{J}$

B. $1.68 \times 10^6 \text{J}$

C. $1.71 \times 10^7 \text{J}$

D. $1.67 \times 10^5 \text{J}$

Answer: D

Solution:

Solution:

$\Delta H = mL = 5 \times 336 \times 10^3 = Q_{sink}$

$\frac{Q_{sink}}{Q_{source}} = \frac{T_{sink}}{T_{source}}$

$\therefore Q_{source} = \frac{T_{source}}{T_{sink}} \times Q_{sink}$

Energy consumed by freezer

$\therefore w_{output} = Q_{source} - Q_{sink} = Q_{sink}\left(\frac{T_{source}}{T_{sink}} - 1\right)$

Given: $T_{source} = 27°C + 273 = 300K$

$T_{sink} = 0°C + 273 = 273k$

$W_{output} = 5 \times 336 \times 10^3\left(\frac{300}{273} - 1\right) = 1.67 \times 10^5 \text{J}$

Question134

Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increases as V^q where V is the volume of the gas. The value of q is: $\left(\gamma = \frac{C_p}{C_v}\right)$

[2015]

Options:

A. $\frac{\gamma + 1}{2}$

B. $\frac{\gamma - 1}{2}$

C. $\frac{3\gamma + 5}{6}$

D. $\frac{3\gamma - 5}{6}$

Answer: A

Solution:

Solution:

$\tau = \frac{1}{\sqrt{2}\pi d^{2}\left(\frac{N}{V}\right)\sqrt{\frac{3RT}{M}}}$

$\mu \frac{V}{\sqrt{T}}$

As, $T V^{\gamma - 1} = K$

So, $\tau \propto V^{\gamma + 1/2}$

Therefore, $q = \frac{\gamma + 1}{2}$

Question135

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:
[2015]

Options:

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

B. $T \propto \frac{1}{R^{3}}$

C. $T \propto e^{-R}$

D. $T \propto e^{-3R}$

Answer: A

Solution:

Solution:

As, $P = \frac{1}{3}\left(\frac{U}{V}\right)$

But $\frac{U}{V} = K T^{4}$

So, $P = \frac{1}{3} K T^{4}$

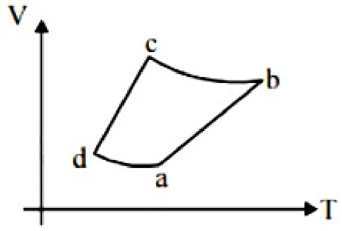
or $\frac{uRT}{V} = \frac{1}{3} K T^{4}$ $\left[\text{ As } PV = uRT\ \right]$

$\frac{4}{3} pR^{3} T^{3} = \text{ constant}$

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

Question136

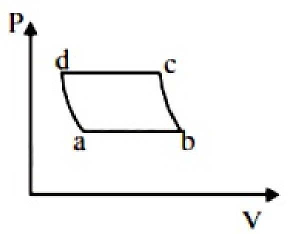
An ideal gas goes through a reversible cycle a→b→c→d has the V - T diagram shown below. Process d®a and b→c are adiabatic.



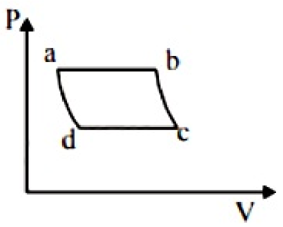
The corresponding P - V diagram for the process is (all figures are schematic and not drawn to scale) :
[Online April 10, 2015]

Options:

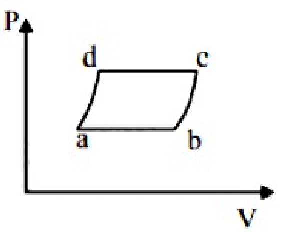
A.



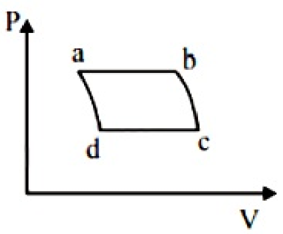
B.



C.



D.



Answer: B

Solution:

Solution:
In VT graph
ab-process : Isobaric, temperature increases.
bc process : Adiabatic, pressure decreases.
cd process : Isobaric, volume decreases.
da process : Adiabatic, pressure increases.
The above processes correctly represented in P-V diagram (b).

Question137

A solid body of constant heat capacity 1 J/°C is being heated by keeping it in contact with reservoirs in two ways :
(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat.
(ii) Sequentially keeping in contact with 8 reservoirs such that each reservoir supplies same amount of heat.
In both the cases body is brought from initial temperature 100°C to final temperature 200°C. Entropy change of the body in the two cases respectively is :
[2015]

Options:

A. ln2, 2ln2

B. 2ln2, 8ln2

C. ln2, 4ln2

D. ln2, ln2

Answer: D

Solution:

Solution:
The entropy change of the body

Question138

A gas is compressed from a volume of $2m^3$ to a volume of$1m^3$ at a constant pressure of 100 N/m^2 . Then it is heated at constant volume by supplying 150 J of energy. As a result, the internal energy of the gas:
[Online April 19, 2014]

Options:

A. increases by 250 J

B. decreases by 250 J

C. increases by 50 J

D. decreases by 50 J

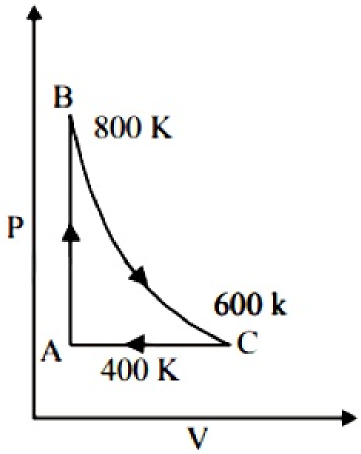
Answer: A

Solution:

Solution:
As we know,
$\Delta Q = \Delta u + \Delta w$ (Ist law of thermodynamics)
$\Rightarrow \Delta Q = \Delta u + P\Delta v$
or $150 = \Delta u + 100(1 - 2)$
$= \Delta u - 100$
$\therefore \Delta u = 150 + 100 = 250J$
Thus the internal energy of the gas increases by 250J

Question139

One mole of a 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:



[2014]

Options:

A. The change in internal energy in whole cyclic process is 250 R.

B. The change in internal energy in the process CA is 700 R.

C. The change in internal energy in the process AB is - 350 R.

D. The change in internal energy in the process BC is – 500 R.

Answer: D

Solution:

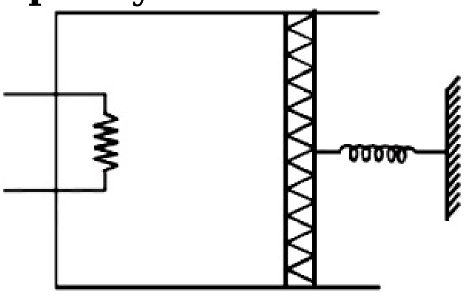
Solution:
In cyclic process, change in total internal energy is zero.
$\Delta U_{cyclic} = 0$

$\Delta U_{BC} = nC_v\Delta T = 1 \times \frac{5R}{2}\Delta T$
Where, $C_v =$ molar specific heat at constant volume.
For BC, $\Delta T = -200K$
$\therefore \Delta U_{BC} = -500R$

Question140

An ideal monoatomic gas is confined in a cylinder by a spring loaded piston of cross section $8.0 \times 10^{-3} m^2$. Initially the gas is at $300K$ and occupies a volume of $2.4 \times 10^{-3} m^3$ and the spring is in its relaxed state as shown in figure. The gas is heated by a small heater until the piston moves out slowly by 0.1m. The force constant of the spring is $8000N / m$ and the atmospheric pressure is $1.0 \times 10^5 N / m^2$. The cylinder and the piston are thermally insulated. The piston and the spring are massless and there is no friction between the piston and the cylinder. The final temperature of the gas will be:

(Neglect the heat loss through the lead wires of the heater. The heat capacity of the heater coil is also negligible).



[Online April 11, 2014]

Options:

A. 300 K

B. 800 K

C. 500 K

D. 1000 K

Answer: C

Solution:

Solution:

Question141

During an adiabatic compression, $830J$ of work is done on 2 moles of a diatomic ideal gas to reduce its volume by 50%. The change in its temperature is nearly:

$(R = 8.3 J K^{-1} mol^{-1})$
[Online April 11, 2014]

Options:

A. 40 K

B. 33 K

C. 20 K

D. 14 K

Answer: C

Solution:

Solution:
Given : work done, $W = 830J$
No. of moles of gas, $\mu = 2$
For diatomic gas $\gamma = 1.4$
Work done during an adiabatic change
$W = \frac{\mu R(T_1 - T_2)}{\gamma - 1}$
$\Rightarrow 830 = \frac{2 \times 8.3(\Delta T)}{1.4 - 1} = \frac{2 \times 8.3(\Delta T)}{0.4}$
$\Rightarrow \Delta T = \frac{830 \times 0.4}{2 \times 8.3} = 20K$

Question142

The equation of state for a gas is given by $PV = nRT + \alpha V$, where n is the number of moles and alpha is a positive constant. The initial temperature and pressure of one mole of the gas contained in a cylinder are T_0 and P_0 respectively. The work done by the gas when its temperature doubles isobarically will be:
[Online April 9, 2014]

Options:

A. $\frac{P_0 T_0 R}{P_0 - \alpha}$

B. $\frac{P_0 T_0 R}{P_0 + \alpha}$

C. $P_0 T_0 R \ln 2$

D. $P_0 T_0 R$

Answer: A

Solution:

Question143

A Carnot engine absorbs 1000 J of heat energy from a reservoir at 127°C and rejects 600 J of heat energy during each cycle. The efficiency of engine and temperature of sink will be:
[Online April 12, 2014]

Options:

A. 20% and – 43°C

B. 40% and – 33°C

C. 50% and – 20°C

D. 70% and – 10°C

Answer: B

Solution:

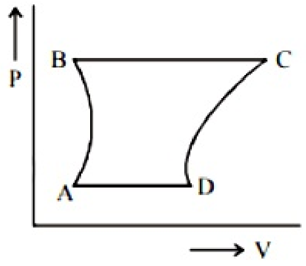
Solution:
Given :
$Q_1 = 1000J$
$Q_2 = 600J$
$T_1 = 127°C = 400K$
$T_2 = ?$
$\eta = ?$
Efficiency of carnot engine,
$\eta = \frac{W}{Q_1} \times 100\%$
or, $\eta = \frac{Q_2 - Q_1}{Q_1} \times 100\%$
or, $\eta = \frac{1000 - 600}{1000} \times 100\%$
$\eta = 40\%$
Now, for carnot cycle $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$
$\frac{600}{1000} = \frac{T_2}{400}$
$T_2 = 600 \times 4001000$
$= 240K$
$= 240 - 273$
$\therefore T_2 = -33°C$

Question144

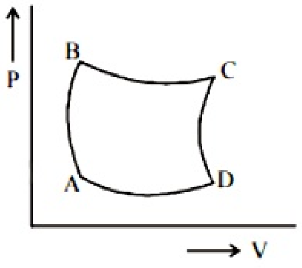
A certain amount of gas is taken through a cyclic process (A B C D A) that has two isobars, one isochore and one isothermal. The cycle can be represented on a P-V indicator
diagram as :
[Online April 22, 2013]

Options:

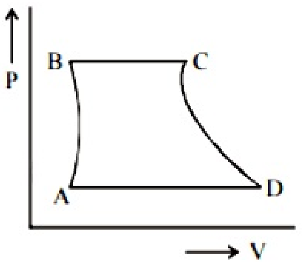
A.



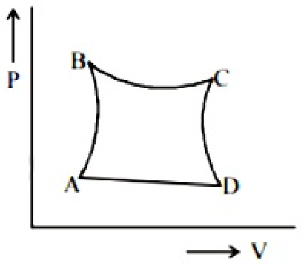
B.



C.



D.

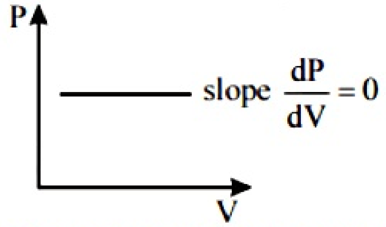


Answer: C

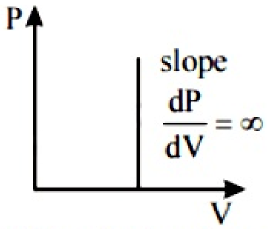
Solution:

Solution:

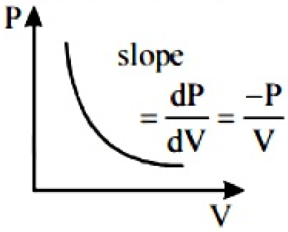
P-V indicator diagram for isobaric



P-V indicator diagram for isochoric process



P-V indicator diagram for isothermal process



Question145

An ideal gas at atmospheric pressure is adiabatically compressed so that its density becomes 32 times of its initial value. If the final pressure of gas is 128 atmospheres, the value of 'γ' of the gas is :
[Online April 22, 2013]

Options:

A. 1.5

B. 1.4

C. 1.3

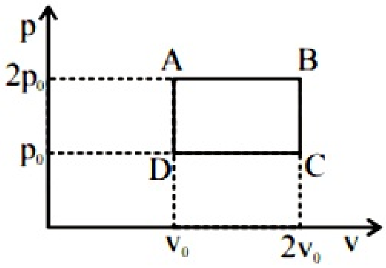
D. 1.6

Answer: B

Solution:

Solution:
Volume of the gas1v = $\frac{m}{d}$ and
Using PV^{γ} = constant
$\frac{P'}{P} = \frac{V}{V'} = \left(\frac{d'}{d}\right)^{\gamma}$
or $128 = (32)^{\gamma}$
$\therefore \gamma = \frac{7}{5} = 1.4$

Question146



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

Options:

A. $p_0 v_0$

B. $\left(\frac{13}{2}\right) p_0 v_0$

C. $\left(\frac{11}{2}\right) p_0 v_0$

D. $4p_0 v_0$

Answer: B

Solution:

Solution:
Heat is extracted from the source in path DA and AB is

$$\Delta Q = \frac{3}{2}R\left(\frac{P_0 V_0}{R}\right) + \frac{5}{2}R\left(\frac{2P_0 V_0}{R}\right)$$

$$\Rightarrow \frac{3}{2}P_0 V_0 + \frac{5}{2}2P_0 V_0 = \left(\frac{13}{2}\right)P_0 V_0$$

Question147

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement 1: An inventor claims to have constructed an engine that has an efficiency of 30% when operated between the boiling and freezing points of water. This is not possible.

Statement 2: The efficiency of a real engine is always less than the efficiency of a Carnot engine operating between the same two temperatures.
[Online May 19, 2012]

Options:

A. Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.

B. Statement 1 is true, Statement 2 is false.

C. Statement 1 is false, Statement 2 is true.

D. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

Answer: D

Solution:

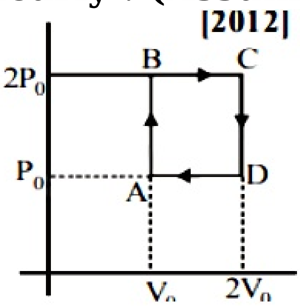
Solution:
According to Carnot's theorem - no heat engine working between two given temperatures of source and sink can be more efficient than a perfectly reversible engine i.e. Carnot engine working between the same two temperatures.

Efficiency of Carnot's engine, $n = 1 - \frac{T_2}{T_1}$

where, $T_1 =$ temperature of source
$T_2 =$ temperature of sink

Question148

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



[2012]

Options:

A. 15.4 %

B. 9.1 %

C. 10.5%

D. 12.5 %

Answer: A

Solution:

Solution:
The efficiency $\eta = \frac{\text{output work}}{\text{heat given to the system}}$

$= n\frac{3}{2}R\Delta T = \frac{3}{2}V_0\Delta P = \frac{3}{2}P_0V_0$

$W_i = \frac{n}{2}(P_0V_0) + \frac{n}{2}(2P_0V_0) + 2P_0V_0$

Heat given in going B to C = $nCp\Delta T$

$= n\left(\frac{5}{2}R\right)\Delta T = \frac{5}{2}(2P_0)\Delta V$

$= 5P_0V_0$

and $W_0 =$ area under PV diagram P_0V_0

$\eta = \frac{W}{Q} = \frac{P_0V_0}{\frac{13}{2}P_0V_0} = \frac{2}{13}$

Efficiency in %

$\eta = \frac{2}{13} \times 100 = \frac{200}{13} \simeq 15.4\%$

Question149

An ideal monatomic gas with pressure P, volume V and temperature T is expanded isothermally to a volume 2V and a final pressure P_i. If the same gas is expanded adiabatically to a volume 2V, the final pressure is P_a. The ratio $\frac{P_a}{P_i}$ is

[Online May 26, 2012]

Options:

A. $2^{-1/3}$

B. $2^{1/3}$

C. $2^{2/3}$

D. $2^{-2/3}$

Answer: D

Solution:

Solution:

For isothermal process :

$PV = P_i 2V$

$P = 2P_i$ ......(i)

For adiabatic process

$PV^{\gamma} = P_a(2V)^{\gamma}$

(∵ for monatomic gas $\gamma = 5/3$)

or, $2P_1V^{\frac{5}{3}} = P_a(2V)^{\frac{5}{3}}$ [From (i)]

$\Rightarrow \frac{P_a}{P_i} = \frac{2}{2^{\frac{5}{3}}}$

$\Rightarrow \frac{P_a}{P_i} = 2^{\frac{-2}{3}}$

Question150

The pressure of an ideal gas varies with volume as $P = \alpha V$, where α is a constant. One mole of the gas is allowed to undergo expansion such that its volume becomes ' m ' times its initial volume. The work done by the gas in the process is
[Online May 19, 2012]

Options:

A. $\frac{\alpha V}{2}(m^2 - 1)$

B. $\frac{\alpha^2 V^2}{2}(m^2 - 1)$

C. $\frac{\alpha}{2}(m^2 - 1)$

D. $\frac{\alpha V^2}{2}(m^2 - 1)$

Answer: D

Solution:

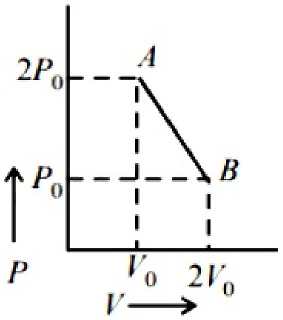
Solution:
Given $P = \alpha V$

Work done, $w = \int_V^{mV} P\,dV$

$= \int_V^{mV} \alpha V\,dV = \frac{\alpha V^2}{2}(m^2 - 1)$.

Question151

n moles of an ideal gas undergo a process A → B as shown in the figure. Maximum temperature of the gas during the process is



[Online May 12, 2012]

Options:

A. $\frac{9P_0V_0}{nR}$

B. $\frac{3P_0V_0}{2nR}$

C. $\frac{9P_0V_0}{2nR}$

D. $\frac{9P_0V_0}{4nR}$

Answer: B

Solution:

Solution:
Work done during the process A → B
= Area of trapezium (= area bounded by indicator diagram with V-axis)
$= \frac{1}{2}(2P_0 + P_0)(2V_0 - V_0) = \frac{3}{2}P_0V_0$
Ideal gas eqn : $PV = nRT$
$\Rightarrow T = \frac{PV}{nR} = \frac{3P_0V_0}{2nR}$

Question152

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement 1: In an adiabatic process, change in internal energy of a gas is equal to work done on/by the gas in the process.

Statement 2: The temperature of a gas remains constant in an adiabatic process.
[Online May 7, 2012]

Options:

A. Statement 1 is true, Statement 2 is true, Statement 2 is a correct explanation of Statement 1.

B. Statement 1 is true, Statement 2 is false

C. Statement 1 is false, Statement 2 is true.

D. Statement 1 is false, Statement 2 is true, Statement 2 is not a correct explanation of Statement 1.

Answer: B

Solution:

Solution:
In an adiabatic process, $\delta H = 0$
And according to first law of thermodynamics
$\delta H = \delta U + W$
$\therefore W = -\delta U$

Question153

A Carnot engine, whose efficiency is 40%, takes in heat from a source

maintained at a temperature of 500K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature must be :
[2012]

Options:

A. efficiency of Carnot engine cannot be made larger than 50%

B. 1200 K

C. 750 K

D. 600 K

Answer: C

Solution:

Solution:
The efficiency of the carnot's heat engine is given as

$\eta = \left(1 - \frac{T_2}{T_1}\right) \times 100$

When efficiency is 40%,

$T_1 = 500K ; \eta = 40$

$40 = \left(1 - \frac{T_2}{500}\right) \times 100$

$\Rightarrow \frac{40}{100} = 1 - \frac{T_2}{500}$

$\Rightarrow \frac{T_2}{500} = \frac{60}{100} \Rightarrow T_2 = 300K$

When efficiency is 60%, then

$\frac{60}{100} = \left(1 - \frac{300}{T_2}\right) \Rightarrow \frac{300}{T_2} = \frac{40}{100}$

$\Rightarrow T_2 = \frac{100 \times 300}{40} \Rightarrow T_2 = 750K$

Question154

The door of a working refrigerator is left open in a well insulated room. The temperature of air in the room will
[Online May 26, 2012]

Options:

A. decrease

B. increase in winters and decrease in summers

C. remain the same

D. increase

Answer: D

Solution:

In a refrigerator, the heat dissipated in the atmosphere is more than that taken from the cooling chamber, therefore the room is heated. If the door of a refrigerator is kept open.

Question155

A container with insulating walls is divided into 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 completly evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be :
[2011 RS]

Options:

A. $\frac{P}{2}, \frac{T}{2}$

B. P, T

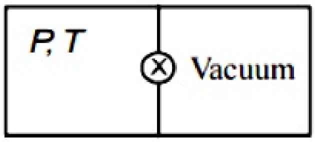
C. P, $\frac{T}{2}$

D. $\frac{P}{2}$, T

Answer: D

Solution:

Solution:



It is the free expansion
∴ So, T remains constant
$\Rightarrow P_1 V_1 = P_2 V_2$
$\Rightarrow P \frac{V}{2} = P_2 (V)$
$P_2 = \left(\frac{P}{2}\right)$

Question156

A Carnot engine operating between temperatures T_1 and T_2 has efficiency $\frac{1}{6}$. When T_2 is lowered by 62K its efficiency increases to $\frac{1}{3}$. Then T_1 and T_2 are, respectively:
[2011]

Options:

A. 372 K and 310 K

B. 330 K and 268 K

C. 310 K and 248 K

D. 372 K and 310 K

Answer: D

Solution:

Solution:
Efficiency of engine

$\eta_1 = 1 - \frac{T_2}{T_1} = \frac{1}{6}$

$\Rightarrow \frac{T_2}{T_1} = \frac{5}{6}$ ....(i)

When T_2 is lowered by 62K, then

Again, $\eta_2 = 1 - \frac{T_2 - 62}{T_1}$

$= 1 - \frac{T_2}{T_1} + \frac{62}{T_1} = \frac{1}{3}$ ....(ii)

Solving (i) and (ii), we get,

$T_1 = 372K$ and $T_2 = \frac{5}{6} \times 372 = 310K$

Question157

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 [2010]

Options:

A. 0.5

B. 0.75

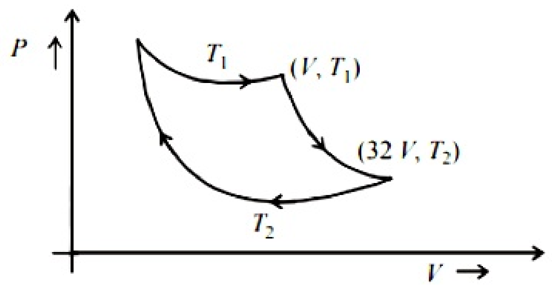
C. 0.99

D. 0.25

Answer: B

Solution:

Solution:



For adiabatic expansion $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$
$\Rightarrow T_1 V^{g-1} = T_2 (32V)^{g-1}$
$\Rightarrow \frac{T_1}{T_2} = (32)^{\gamma-1}$
For diatomic gas, $\gamma = \frac{7}{5}$
$\therefore \gamma - 1 = \frac{2}{5}$
$\therefore \frac{T_1}{T_2} = (32)^{\frac{2}{5}} \Rightarrow T_1 = 4T_2$
Now, efficiency $= 1 - \frac{T_2}{T_1}$
$= 1 - \frac{T_2}{4T_2} = 1 - \frac{1}{4} = \frac{3}{4} = 0.75.$

Question158

Assuming the gas to be ideal the work done on the gas intaking it from A to B is
[2009]

Options:

A. 300 R

B. 400 R

C. 500 R

D. 200 R

Answer: B

Solution:

Solution:
The process $A \rightarrow B$ is isobaric.
$\therefore$ work done $W_{AB} = nR(T_2 - T_1)$
$= 2R(500 - 300) = 400R$

Question159

The work done on the gas in taking it from D to A is
[2009]

Options:

A. + 414 R

B. – 690 R

C. + 690 R

D. – 414 R

Answer: A

Solution:

Solution:
The process D to A is isothermal as temperature is constant.
Work done, $W_{DA} = 2.303 nRT \log_{10} \frac{P_D}{P_A}$
$= 2.303 \times 2R \times 300$
$\log_{10} \frac{1 \times 10^5}{2 \times 10^5} - 414R$
Therefore, work done on the gas is $+414R$.

Question160

The net work done on the gas in the cycle ABCDA is [2009]

Options:

A. 279 R

B. 1076 R

C. 1904 R

D. zero

Answer: A

Solution:

Solution:
The net work in the cycle ABCDA is
$W = W_{AB} + W_{BC} + W_{CD} + W_{DA}$
$= 400R + 2.303 nRT \log \frac{P_B}{P_C} + (-400R) - 414R$
$= 2.303 \times 2R \times 500 \log \frac{2 \times 10^5}{1 \times 10^5} - 414R$
$= 693.2R - 414R = 279.2R$

Question161

An insulated container of gas has two chambers separated by an insulating partition. One of the chambers has volume V_1 and contains ideal gas at pressure P_1 and temperature T_1. The other chamber has volume V_2 and contains ideal gas at pressure P_2 and temperature T_2. If the partition is removed without doing any work on the gas, the final equilibrium temperature of the gas in the container will be [2008]

Options:

A. $\frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_2+P_2V_2T_1}$

B. $\frac{P_1V_1T_1+P_2V_2T_2}{P_1V_1+P_2V_2}$

C. $\frac{P_1V_1T_2+P_2V_2T_1}{P_1V_1+P_2V_2}$

D. $\frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_1+P_2V_2T_2}$

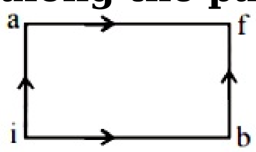
Answer: A

Solution:

Solution:
Here Q = 0 and W = 0. Therefore from first law of thermodynamics $\Delta U = Q + W = 0$
Internal energy of first vessle + Internal energy of second vessel = Internal energy of combined vessel
$n_1C_vT_1 + n_2C_vT_2 = (n_1+n_2)C_vT$
$\therefore T = \frac{n_1T_1+n_2T_2}{n_1+n_2}$
For first vessel $n_1 = \frac{P_1V_1}{RT_1}$ and for second vessle $n_2 = \frac{P_2V_2}{RT_2}$
$\therefore T = \frac{\frac{P_1V_1}{RT_1}\times T_1 + \frac{P_2V_2}{RT_2}\times T_2}{P_1V_1RT_1 + \frac{P_2V_2}{RT_2}}$
$= \frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_2+P_2V_2T_1}$

Question162

When a system is taken from state i to state f along the path iaf, it is found that Q = 50 cal and W = 20 cal. Along the path ibf Q = 36 cal. W along the path ibf is



[2007]

Options:

A. 14 cal

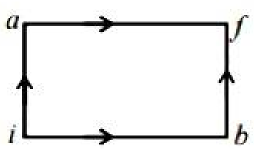
B. 6 cal

C. 16 cal

D. 66 cal

Answer: B

Solution:



(b) For path iaf,

$Q_1 = 50\text{cal}$, $W_1 = 20\text{cal}$

By first law of thermodynamics,

$\Delta U = Q_1 - W_1 = 50 - 20 = 30\text{cal}$

For path ibf

$Q_2 = 36\text{cal}$

$W_2 = ?$

$\Delta U_{ibf} = Q_2 - W_2$

Since, the change in internal energy does not depend on the path, therefore $\Delta U_{iaf} = \Delta U_{ibf}$

$\Delta U_{iaf} = \Delta U_{ibf}$

$\Rightarrow 30 = Q_2 - W_2$

$\Rightarrow W_2 = 36 - 30 = 6$ cal.

Question163

A Carnot engine, having an efficiency of η = 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 [2007]

Options:

A. 100 J

B. 99 J

C. 90 J

D. 1 J

Answer: C

Solution:

Solution:

The efficiency (η) of a Carnot engine and the coefficient of performance (β) of a refrigerator are related as

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

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

$\therefore \beta = \frac{1 - n}{n} = \frac{Q_2}{W}$

$\therefore \beta = \frac{1 - \frac{1}{10}}{\left(\frac{1}{10}\right)} = \frac{Q_2}{W}$

is independent of path taken by the process.

$\Rightarrow 9 = \frac{Q_2}{10}$

$\Rightarrow Q_2 = 90\text{J}$.

Question164

The work of 146 kJ is performed in order to compress one kilo mole of gas adiabatically and in this process the temperature of the gas increases by 7°C. The gas is
($R = 8.3 J\ mol^{-1} K^{-1}$)
[2006]

Options:

A. diatomic

B. triatomic

C. a mixture of monoatomic and diatomic

D. monoatomic

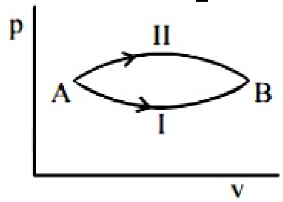
Answer: A

Solution:

Solution:
Work done in adiabatic compression is given by
$W = \frac{nR\Delta T}{1-\gamma}$
$\Rightarrow -146000 = \frac{1000 \times 8.3 \times 7}{1-\gamma}$
or $1-\gamma = -\frac{58.1}{146} \Rightarrow \gamma = 1 + \frac{58.1}{146} = 1.4$
Hence the gas is diatomic.

Question165

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



[2005]

Options:

A. relation between ΔU_1 and ΔU_2 can not be determined

B. $\Delta U_1 = \Delta U_2$

C. $\Delta U_2 < \Delta U_1$

D. $\Delta U_2 > \Delta U_1$

Answer: B

Solution:

Solution:
Change in internal energy is independent of path taken by the process. It only depends on initial and final states i.e., $\Delta U_1 = \Delta U_2$

Question166

Which of the following is incorrect regarding the first law of thermodynamics?
[2005]

Options:

A. It is a restatement of the principle of conservation of energy

B. It is not applicable to any cyclic process

C. It does not introduces the concept of the entropy

D. It introduces the concept of the internal energy

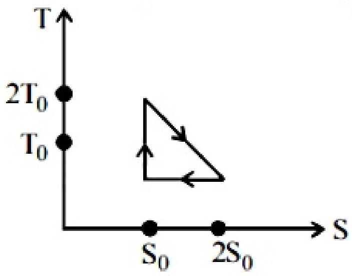
Answer: 0

Solution:

Solution:
First law is applicable to a cyclic process. Concept of entropy is introduced by the second law of thermodynamics.

Question167

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



[2005]

Options:

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. $\frac{2}{3}$

D. $\frac{1}{3}$

Answer: D

Solution:

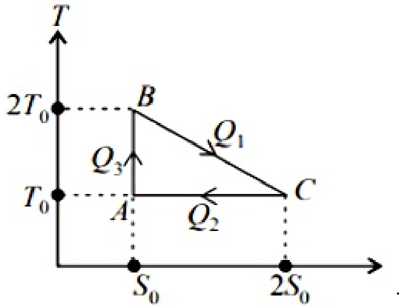
Solution:

$Q_1 =$ area under BC $= T_0S_0 + \frac{1}{2}T_0S_0$

$Q_2 =$ area under AC $= T_0(2S_0 - S_0) = T_0S_0$

and $Q_3 = 0$

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



$= 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_0S_0}{\frac{3}{2}T_0S_0} = \frac{1}{3}$

Question168

Which of the following statements is correct for any thermodynamic system ? [2004]

Options:

A. The change in entropy can never be zero

B. Internal energy and entropy are state functions

C. The internal energy changes in all processes

D. The work done in an adiabatic process is always zero.

Answer: B

Solution:

Solution:

Internal energy and entropy are state function, they are independent of path taken.

Question169

Which of the following parameters does not characterize the thermodynamic state of matter?

[2003]

Options:

A. Temperature

B. Pressure

C. Work

D. Volume

Answer: C

Solution:

Solution:
Work is not a state function. The remaining three parameters are state function.

Question170

“Heat cannot by itself flow from a body at lower temperature to a body at higher temperature” is a statement or consequence of [2003]

Options:

A. second law of thermodynamics

B. conservation of momentum

C. conservation of mass

D. first law of thermodynamics

Answer: A

Solution:

Solution:
This is a consequence of second law of thermodynamics

Question171

A Carnot engine takes 3×10^6 cal of heat from a reservoir at 627°C, and gives it to a sink at 27°C. The work done by the engine is [2003]

Options:

A. $4.2 \times 10^6 J$

B. $8.4 \times 10^6 J$

C. 16.8×10^6J

D. zero

Answer: B

Solution:

Solution:
Here, $T_1 = 627 + 273 = 900K$
$T_2 = 27 + 273 = 300K$
Efficiency, $\eta = 1 - \frac{T_2}{T_1}$
$= 1 - \frac{300}{900} = 1 - \frac{1}{3} = \frac{2}{3}$
But $\eta = \frac{W}{Q}$
$\therefore \frac{W}{Q} = \frac{2}{3} \Rightarrow W = \frac{2}{3} \times Q = \frac{2}{3} \times 3 \times 10^6$
$= 2 \times 10^6$ cal
$= 2 \times 10^6 \times 4.2J = 8.4 \times 10^6 J$

Question172

Which statement is incorrect?
[2002]

Options:

A. All reversible cycles have same efficiency

B. Reversible cycle has more efficiency than an irreversible one

C. Carnot cycle is a reversible one

D. Carnot cycle has the maximum efficiency in all cycles

Answer: A

Solution:

Solution:
All reversible engines have same efficiencies if they are working for the same temperature of source and sink.
If the temperatures are different, the efficiency is different.

Question173

Even Carnot engine cannot give 100% efficiency because we cannot
[2002]

Options:

A. prevent radiation

B. find ideal sources

C. reach absolute zero temperature

D. eliminate friction

Answer: C

Solution:

In Carnot's cycle we assume frictionless piston, absolute insulation and ideal source and sink (reservoirs).
The efficiency of carnot's cycle $\eta = 1 - \frac{T_2}{T_1}$
The efficiency of carnot engine will be 100% when its $\mathrm{sink}(T_2)$ is at $0\mathrm{K}$.
The temperature of $0\mathrm{K}$ (absolute zero) cannot be realised in practice so, efficiency is never 100%.
