DPP – 6 (Thermodynamics)

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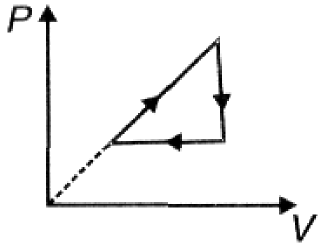
Q 1. An ideal gas with adiabatic exponent $\gamma = 2$ goes through a cycle as shown in figure in which absolute temperature varies 4 times. Find efficiency of cycle ?



(a) 1/9
(b) 1/8
(c) 1/6
(d) 1/5

Q 2. A carnot engine is made to work first between 200 K and 100 K and then between 400 K and 200 K. The ratio of efficiencies in two cases is
(a) 1 : 15
(b) 1 : 1
(c) 1 : 2
(d) 1.73 : 1

Q 3. If in refrigerator, the lower temperature coils of evaporator are -23°C and compressed gas in condenser has a temperature of 77°C. The coefficient of performance is
(a)70
(b) 20
(c) 23
(d) 2.5

Q 4. STATEMENT-1 : Efficiency of engine with sink temperature 0 K is 100%.
because
STATEMENT-2 : Keeping sink at ice point and source at 100° C will bring 100% efficiency.

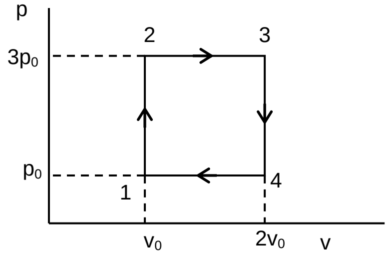
Q 5. STATEMENT-1 : A refrigerator transfers heat from lower temprature to higher temperature.

Because

STATEMENT-2 : Heat cannot be transferred from lower temperature to higher temperature without doing any external work.

Q 6. An ideal heat engine working at source temperature 327°C is attached to a machine which is in turn performs a work of 3.6×10^7 Joule in 1 hr. Assuming the efficiency of heat engine and machine to be 50% each and no loss of heat. Find the sink temperature of heat engine and the power supplied to engine in the form of heat.

Q 7. An ideal monoatomic gas undergoes a cyclic process as shown in the P-V diagram. find efficiency of the cycle?



(a) 10%
(b) 17%
(c) 19%
(d) 21%

Q 8. A carnot engine takes 3000 k-cal of heat from a reservoir at 627°C and gives it to a sink at 27°C. The work done by the engine is
(A) 4.2×10^6 J (B) 8.4×10^6 J
(C) 16.8×10^6 J (D) zero

Q 9. A Carnot engine working between 300 K and 600 K has a work output of 800 J per cycle. The amount of heat energy supplied from the source to the engine in each cycle is -
(A) 800 J (B) 3200 J
(C) 1600 J (D) 6400 J

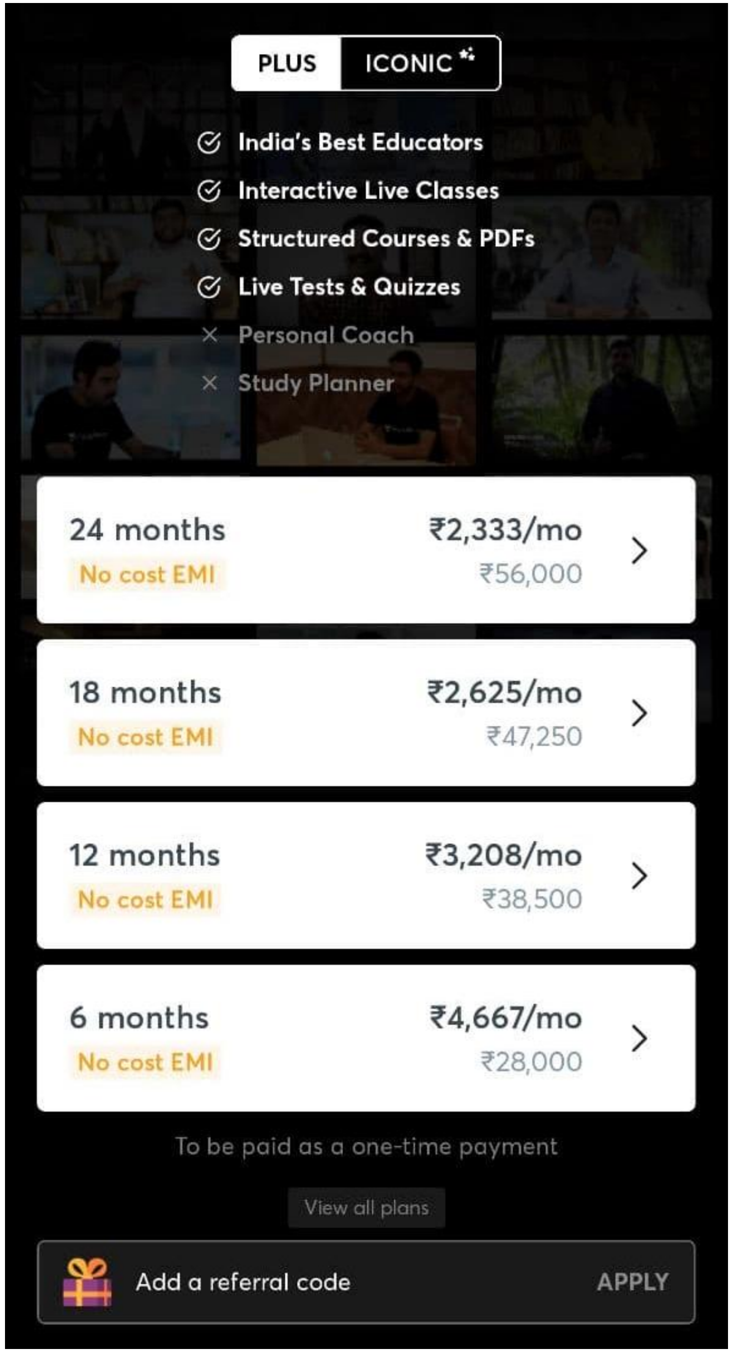
Q 10. An ideal gas heat engine operates Carnot cycle between 227°C and 127°C. It absorbs 6×10^4 calories at the higher temperature. The quantity of heat converted into work is equal to-
(A) 4.8×10^4 cal (B) 3.5×10^4 cal
(C) 1.6×10^4 cal (D) 1.2×10^4 cal

Q 11. A Carnot engine, having an efficiency of h = 1/10 as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is
(A) 99 J (B) 90 J
(C) 1 J (D) 100 J

Q 12. 100 g water at 273K is placed in a carnot refrigerator. Find approximate work done by refrigerator to freeze the water if temperature of surrounding is 300k?
(a) 3323J
(b) 2323J
(c) 1323J
(d) 323J

Answer Key

Q.1 a	Q.2 b	Q.3 d	Q.4 c	Q.5 b
Q.6 300K,40kW	Q.7 c	Q.8 b	Q.9 c	Q.10 d
Q.11 b	Q.12 a			



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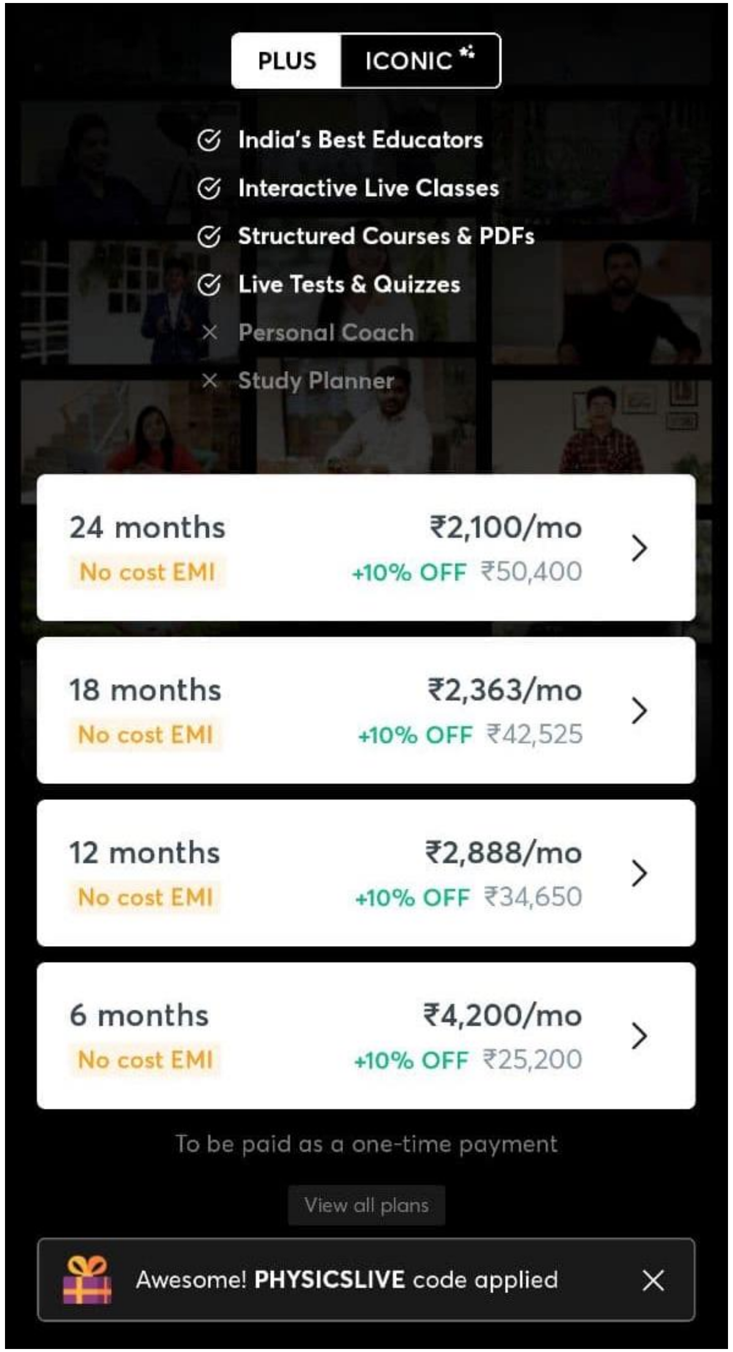

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Written Solution

DPP- 6 Thermodynamics- Heat engine and efficiency

By Physicsaholics Team

1)

Temperature is lowest at A & highest at B (Since PV is lowest at A & highest at B)

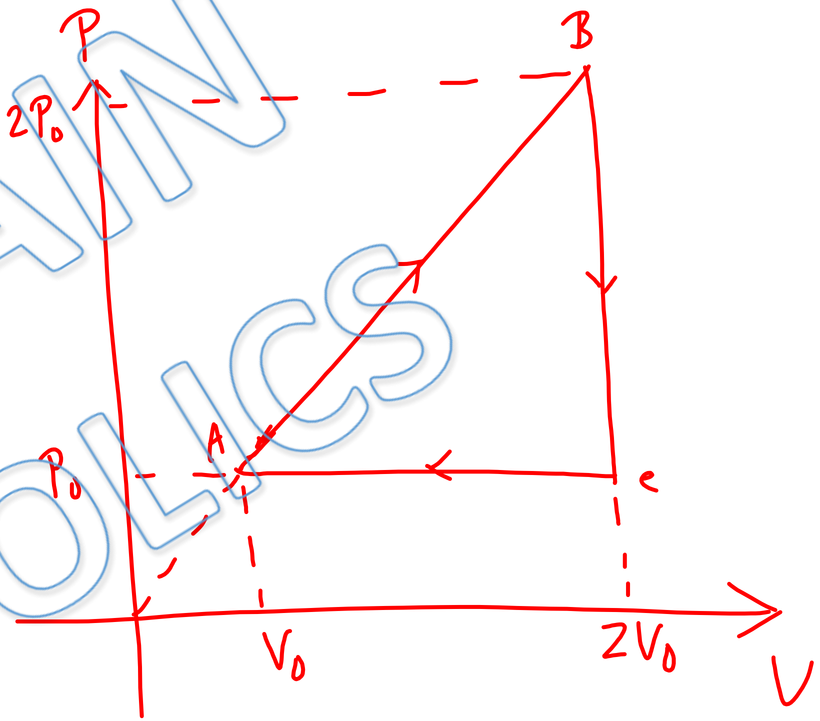
$T_B = 4T_A$ --- (1)

In process AB, $\frac{P}{V} = C \Rightarrow \frac{T}{V^2} = C$

$\Rightarrow T \propto V^2 \Rightarrow$ at B $V = 2V_0$

$W_{gas} = \frac{1}{2} \times V_0 \times P_0 = \frac{P_0 V_0}{2}$

ΔQ is +ve only in AB (In BC & CA, molar heat capacity is +ve & ΔT is −ve)



molar heat capacity in process AB

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

$$\Delta Q_{AB} = nC\,dT = n\,\frac{3R}{2}\left(\frac{4P_0V_0}{nR} - \frac{P_0V_0}{nR}\right) = \frac{9P_0V_0}{2}$$

$$\eta = \frac{W}{\sum +ve\ \Delta Q} = \frac{P_0V_0/2}{9P_0V_0/2} = \frac{1}{9}$$

Ans(a)

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

$\eta_1 = 1 - \frac{100}{200} = 1/2$

$\eta_2 = 1 - \frac{200}{400} = 1/2$

$\frac{\eta_1}{\eta_2} = 1$

Ans (b)

3)

In refrigerator

$$W = Q\left[\frac{T_1}{T_2} - 1\right]$$

Coefficient of performance $= \dfrac{Q}{W} = \dfrac{1}{\frac{T_1}{T_2} - 1} = \dfrac{1}{\frac{273+77}{273-23} - 1}$

$$= \frac{1}{\frac{350}{250} - 1} = \frac{5}{7-5} = \frac{5}{2} = 2.5$$

Ans (d)

4)

$$\eta = \left(1 - \frac{T_1}{T_2}\right) \times 100$$, where T_1 is Sink temperature.
& T_2 is reservoir ,,

If Sink temperature $T_1 = 0 \Rightarrow \eta = 100$

$\Rightarrow$ statement 1 is true

If Sink is at ice point & Source is at 100 c

$$\eta = \left(1 - \frac{273}{373}\right) \times 100 \neq 100$$

Statement 2 is wrong.

Ans. c

5)

function of a refrigerator is to Transfer heat from low temperature body (inside frige) to high temperature surrounding

Refridgerator performs this job by doing some work

⇒ both statements are true but statement 2 is not Explanation of 1

Ans. b

6) work by machine $= 36 \times 10^7$ J

Power output of machine $= \dfrac{36 \times 10^7}{3600} = 10^4$ Watt

Since efficiency is 50%, Power input of machine $= 2 \times 10^4$ Watt

Output power of Heat engine $= 2 \times 10^4$ Watt

Input power (in terms of Heat) of engine $= 2 \times 2 \times 10^4$ (Since η of Heat engine is 50%)

$= 40$ KW

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

$$\Rightarrow \frac{1}{2} = 1 - \frac{T_1}{600}$$

$$\Rightarrow \frac{T_1}{600} = \frac{1}{2} \Rightarrow T_1 = 300\text{K}$$

7)

$W_{gas} = 2P_0V_0$

$\Delta Q_{12} = nC_p\Delta T = n\left[\frac{5}{2}R\right]\left[T_2 - T_1\right]$

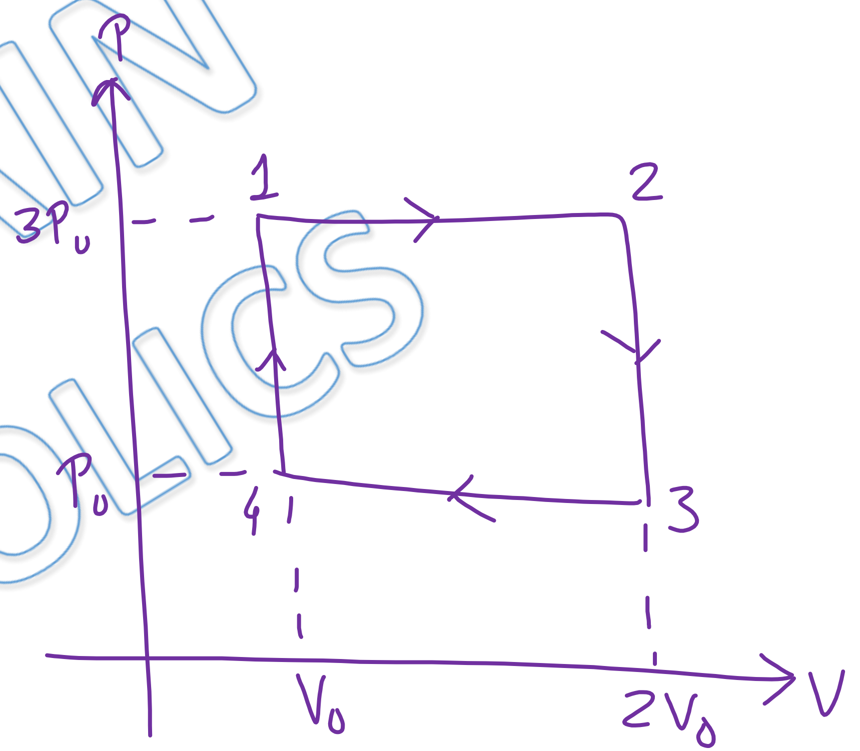
$= \frac{5}{2}\left[6P_0V_0 - 3P_0V_0\right] = \frac{15}{2}P_0V_0$

$\Delta Q_{23} = nC_v\Delta T = -ve$

($C_v \downarrow$ +ve, $\Delta T \downarrow$ −ve)

$\Delta Q_{34} = nC_p\Delta T = -ve.$

($C_p \downarrow$ +ve, $\Delta T \downarrow$ −ve)



$\Delta Q_{41} = nC_v\Delta T = n\left[\frac{3}{2}R\right]\left[T_1 - T_4\right] = \frac{3}{2}\left[3P_0V_0 - P_0V_0\right] = 3P_0V_0$

$\eta = \frac{W_{gas} \times 100}{\sum +ve\ \Delta Q \text{ only}} = \frac{2P_0V_0 \times 100}{\frac{15}{2}P_0V_0 + 3P_0V_0} = 19$

Ans (c)

8)

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

$$\Rightarrow \frac{W}{3000\,KCal} = 1 - \frac{27+273}{627+273}$$

$$\Rightarrow W = 3000\,KCal\left(1 - \frac{300}{900}\right)$$

$$= 2000\,KCal$$

$$= 2000 \times 4.2\,KJ$$

$$= 8.4 \times 10^6\,J$$

Ans (b)

9)

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

$$\Rightarrow \frac{800}{Q} = 1 - \frac{300}{600} = \frac{1}{2}$$

$$\Rightarrow Q = 1600 \text{ J}$$

ANS (c)

10)

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

$$\Rightarrow \frac{W}{6\times10^4} = 1 - \frac{127+273}{227+273}$$

$$\Rightarrow W = 6\times10^4\left[1 - \frac{400}{500}\right]$$

$$= 1.2\times10^4 \text{ Cal}$$

Ans. d

11)

Efficiency of Carnot engine

$$\eta = \frac{1}{10} = 1 - \frac{T_1}{T_2}$$

$T_1 \rightarrow$ low

$T_2 \rightarrow$ high

$$\frac{T_1}{T_2} = 1 - \frac{1}{10} = \frac{9}{10}$$

for Refrigerator

$$W = Q\left(\frac{T_2}{T_1} - 1\right) \Rightarrow 10 = Q\left[\frac{10}{9} - 1\right]$$

$$\Rightarrow Q = 90\,J$$

Ans (b)

12)

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

$$= (100 \times 80 \times 4.2)\left[\frac{300}{273} - 1\right]$$

$$= \frac{33600 \times 27}{273} \text{ J}$$

$$= 3323 \text{ J}$$

Ans. a

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