Heat Engines

1. **Even Carnot engine cannot give 100% efficiency because we cannot**

   1) Prevent radiation
   2) Find ideal sources
   3) Reach absolute zero temperature
   4) Eliminate friction

2. **Heat cannot by itself flow from a body at lower temperature to a body at higher temperature is a statement or consequence of**

   1) I law of thermodynamics
   2) II law of thermodynamics
   3) Conservation of momentum
   4) Conservation of mass

3. **Consider the statement (A) and (B) and identify the correct answer.**

   A: First law of thermodynamics specifies the condition under which a body can use its heat energy to produce the work.

   B: Second law of thermodynamics states that heat always flows from hot body to cold body by itself.

   1) Both (A) and (B) are true
   2) Both (A) and (B) are false
   3) (A) is true, (B) is false
   4) (A) is false but (B) is true

4. **The second law of thermodynamics is the generalization of the fact that**

   I) Heat always flows from hot body to cold body by itself.

   II) Heat can flow from cold body to hot body itself.

   III) It is impossible for a self acting machine un aided by any external agency to transfer heat from cold body to hotter body.

1) I & II 2) II & III 3) I & III 4) I, II, III & IV

5. Choose the correct statement.

A: It is impossible to derive continuous supply of work by cooling a body to a temperature lower than that of the coldest of its surroundings.

B: Heat engine can convert whole of the heat energy supplied to it into useful work.

1) Only A 2) Only B 3) Both A & B 4) Both A & C

6. The second law of thermodynamics implies-

1) Whole of heat can be converted into mechanical energy.

2) No heat engine can be 100% efficient.

3) Every heat engine has an efficiency of 100%.

4) A refrigerator can reduce the temperature to absolute zero.

7. Two Carnot engines *A* and *B* are operated in succession. The first one, *A* receives heat from a source at $T_1 = 800\,K$ and rejects to sink at $T_2 K$. The second engine *B* receives heat rejected by the first engine and rejects to another sink at $T_3 = 300\,K.$ if the work outputs of two engines are equal, then the value of T_2 is

1) $100K$ 2)$300K$ 3)$550K$ 4)$700K$

8. A Carnot engine absorbs an amount *Q* of heat from a reservoir at an absolute temperature *T* and rejects heat to a sink at a temperature of *T*/3. The amount of heat rejected is

1) Q / 4 2)Q / 3 3) Q / 2 4) 2Q / 3

9. A Carnot engine has the same efficiency between 800 *K* to 500 *K* and *x K* to 600 *K*. The value of *x* is

1) 1000 *K* 2) 960 *K*

3) 846 *K* 4) 754 *K*

10. For a Carnot engine using an ideal gas, the adiabatic expansion ratio is 5 and the value of γ = 1.4. Calculate the efficiency of the engine ($0.2^{0.4} = 0.52$).

1) 21 % 2) 35 % 3) 42 % 4) 48%

Key

1) 3 2) 2 3) 4 4) 3 5) 1 6) 2 7) 3 8) 2 9) 2 10) 4

Hints

7. $\eta_A = \frac{T_1 - T_2}{T_1} = \frac{W_A}{Q_1} \Rightarrow \eta_B = \frac{T_2 - T_3}{T_2} = \frac{W_B}{Q_2}$

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

$\therefore T_2 = \frac{T_1 + T_3}{2} = \frac{800 + 300}{2} = 550\ K$

8. $\eta = 1 - \frac{T_2}{T_1} = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$

Where Q_1 = heat absorbed, Q_2 = heat rejected

$\Rightarrow 1 - \frac{T/3}{T} = \frac{W}{Q_1} \Rightarrow \frac{2}{3} = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$

$\Rightarrow \frac{2}{3} = 1 - \frac{Q_2}{Q_1} \Rightarrow \frac{Q_2}{Q_1} = \frac{1}{3} \Rightarrow Q_2 = \frac{Q_1}{3} = \frac{Q}{3}$

9. In first case, $(\eta_1) = 1 - \frac{500}{800} = \frac{3}{8}$

And in second case, $(\eta_2) = 1 - \frac{600}{x}$

Since $\eta_1 = \eta_2$, therefore $\frac{3}{8} = 1 - \frac{600}{x}$

or $\frac{600}{x} = 1 - \frac{3}{8} = \frac{5}{8}$ or $x = \frac{600 \times 8}{5} = 960\ K$

10. $\eta = 1 - \left(\frac{1}{\rho}\right)^{\gamma - 1} = 1 - \left(\frac{1}{5}\right)^{1.4-1}$

$= 1 - (0.2)^{0.4} = 1 - 0.52 = 0.48 = 48\%$