CBSE

THERMODYNAMICS WS 12

Class 11 - Physics

Section A

1. A Carnot engine has a power output of 150 kW. The engine operates between two reservoirs at 20.0^{o}C and 500^{o}C. How much energy is lost per hour in its exhaust? **[1]**

   a) 330 MJ
   b) 351 MJ
   c) 220 MJ
   d) 320 MJ

2. The efficiency of a Carnot engine is 0.6. It rejects 20 J of heat to sink. The work done by the engine is: **[1]**

   a) 33.3 J
   b) 20 J
   c) 30 J
   d) 50 J

3. A Carnot engine has efficiency 25%. It operates between reservoirs of constant temperatures with temperature difference of 80°C. What is the temperature of the low-temperature reservoir? **[1]**

   a) -25°C
   b) -33°C
   c) 33°C
   d) 25°C

4. A Carnot engine takes 2000 J of heat from a reservoir at 500 K, does some work, and discards some heat to a reservoir at 350 K. what is its efficiency? **[1]**

   a) 27 percent
   b) 32 percent
   c) 30 percent
   d) 28 percent

5. A Carnot engine operates with source at 127°C and sink at 27° C. If the source supplies 40 kJ of heat energy, the work done by the engine is: **[1]**

   a) 30 kJ
   b) 4 kJ
   c) 1 kJ
   d) 10 kJ

6. In a Carnot engine, when T_2 = 0°C and T_1 = 200°C its efficiency is η_1 and when T_1 = 0°C and T_2 = -200°C, its efficiency is η_1, then what is $\frac{\eta_1}{\eta_2}$? **[1]**

   a) 0.577
   b) 0.638
   c) 0.796
   d) 0.733

7. An ideal gas is taken through a Carnot cycle. The isothermal expansion occurs at 250^{o}C, and the isothermal compression takes place at 50.0^{o}C. Assuming that the gas absorbs 1200 J of energy from the hot reservoir during the isothermal expansion, find the energy expelled to the cold reservoir in each cycle. **[1]**

   a) 105J
   b) 110 J
   c) 120 J
   d) 115 J

8. For Carnot engine, which process should be chosen to take the working substance from T_1 to T_2 or vice-versa?

a) Isochoric
b) Isothermal
c) Adiabatic
d) Isobaric

9. An ideal gas is made to go through a cyclic thermodynamical process in four steps. The amounts of heat involved are Q_1 = 600 J, Q_2 = -400 J, Q_3 = -300 J and Q_4 = 200J respectively. **[1]**

The corresponding works involved are W_1 = 300 J, W_2 = - 200 J, W_3 = -150 J and W_4. What is the value of W_4?

a) -50 J
b) 50 J
c) 100 J
d) 150 J

10. A Carnot engine has efficiency $\frac{1}{5}$. Efficiency becomes $\frac{1}{3}$ when temperature of sink is decreased by 50 K. What is the temperature of sink? **[1]**

a) 350 K
b) 300 K
c) 325 K
d) 375 K

11. **Assertion:** The Carnot cycle is useful in understanding the performance of Heat Engines. **[1]**
Reason: The Carnot cycle provides a way of determing the maximum possible efficiency achievable with reservoirs of given temperature.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c) Assertion is correct statement but reason is wrong statement.
d) Assertion is wrong statement but reason is correct statement.

12. **Assertion (A):** A refrigerator transfers heat from lower temperature to higher temperature. **[1]**
Reason (R): Heat cannot be transferred from lower temperature to higher temperature.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

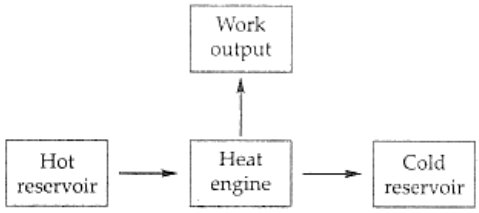
13. **Assertion (A):** Efficiency of a Carnot engine increases on reducing the temperature of sink. **[1]**
Reason (R): The efficiency of a Carnot engine is defined as ratio of net mechanical work done per cycle by the gas to the amount of heat energy absorbed per cycle from the source.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

14. **State True or False:** **[1]**
(a) Even Carnot engine cannot have 100 % efficiency. **[1]**

15. **Fill in the blanks:** **[1]**
(a) The efficiency of a Carnot engine is _____ of the nature of the working substance. **[1]**

16. The diamagnetic representation of a heat engine below shows which of the following? **[1]**



a) Positive work
b) An isobaric process
c) An isochoric process
d) An adiabatic process

17. What is the efficiency of Carnot engine Working between ice point and steam point? **[1]**
18. What are two essential features of Carnot's ideal heat engine? **[1]**
19. Under what condition, an ideal Carnot engine has 100% efficiency? **[1]**
20. State Carnot's Theorem? **[1]**
21. What type of process is Carnot's cycle? **[1]**
22. Can we design a reversible Carnot engine in practice? **[1]**
23. Write the equation for the efficiency of Carnot engine. Even Carnot engine cannot have 100 % efficiency. Explain, why? **[1]**
24. Can a Carnot engine be realized in actual practice? **[1]**
25. What is the coefficient of performance (β) of a Carnot refrigerator working between 30°C and O°C? **[1]**
26. Find the efficiency of the Carnot engine working between boiling point and freezing point of water. **[1]**
27. Does the efficiency of a Carnot engine depend on the nature of the working substance? **[1]**
28. On what factors, the efficiency of a Carnot engine depends? **[1]**
29. If the temperature of the sink is increased, what will happen to the efficiency of Carnot engine? **[1]**
30. Draw p-V diagram of a Carnot cycle. **[1]**
31. In a Carnot engine, the temperature of the sink is increased. What will happen to its efficiency? **[1]**

Section B

32. State Carnot's theorem. What is its significance? **[2]**
33. A Carnot engine absorbs 1000 J of heat from a reservoir at $127^\circ C$ and rejects 600 J of heat during each cycle. Calculate **[2]**
    i. efficiency of the engine
    ii. temperature of the sink
    iii. amount of the useful work done during each cycle.
34. A carnot engine takes 3×10^6 cal of heat from a reservoir at $627^\circ C$ and gives it to a sink at $27^\circ C$. Find the work done by the engine. **[2]**
35. The efficiency of a Carnot cycle is $\frac{1}{6}$. If on reducing the temperature of the sink by 65^oC, the efficiency becomes $\frac{1}{3}$, find the initial and final temperatures between which the cycle is working. **[2]**
36. A Carnot cycle is performed by air initially at $327^\circ C$. Each stage represents a compression or expansion in the ratio 1 : 6. Calculate **[2]**
    i. the lowest temperature
    ii. efficiency of the cycle. Given y = 1.4.
37. If you are asked to increase the efficiency of a Carnot engine by increasing the temperature of the source or by decreasing the temperature of the sink by 10 K, which method would you prefer and why? **[2]**
38. A Carnot engine is operating between 600 K and 200 K. Consider that the actual energy produced is 2 kJ per **[2]**

kilocalorie of heat absorbed. Compare the real efficiency with the efficiency of the Carnot engine.

39. In a heat engine, the temperature of the source and sink are 500 K and 375 K. If the engine consumes 25×10^5 J per cycle, find **[2]**

    i. the efficiency of the engine

    ii. work done per cycle

    iii. heat rejected to the sink per cycle.

40. One of the most efficient engines ever developed operated between 2100 K and 700 k. Its actual efficiency is 40%. What percentage of its maximum possible efficiency is this? **[2]**

41. A Carnot engine whose heat sink is at $27^\circ C$ has an efficiency of 40 %. By how many degrees should the temperature of the source be changed to increase the efficiency by 10% of the original efficiency? **[2]**

42. A reversible engine converts one fifth of heat which it absorbs from source into work. When the temperature of the sink is reduced by 70°, its efficiency is doubled. Calculate the temperature of the source and the sink. **[2]**

43. No real engine can have an efficiency greater than that of a Carnot engine working between the same two temperatures. Give reason. **[2]**

44. A Carnot engine takes 10^6 cal of heat from a source at 827°C and exhausts it to a sink 27°C. How much work does it gives or output? What is engine efficiency? Also, find out the coefficient of performance of the engine, if it is used in reverse direction. **[2]**

45. Consider a Carnot's cycle operating between T_1 = 500 K and T_2 = 300 K producing 1 kJ of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs. **[2]**

46. How does Carnot cycle operates? **[2]**

47. Can a Carnot engine be realised in practice? **[2]**

48. Efficiency of an engine is 0.4, when temperature of its sink (cold body) is 300 K. What is the temperature of the hot body? Find its efficiency, if the temperature of the hot body is kept unchanged, while temperature of the sink (cold body) is lowered by 50 K. (Treat it as reversible engine). **[2]**

49. A reversible heat engine operates with an efficiency of 50%. If during each cycle it rejects 150 cal to a reservoir of heat at $30^\circ C$, then **[2]**

    i. what is the temperature of the other reservoir and

    ii. how much work does it carry out per cycle?

50. A Carnot engine has the same efficiency **[2]**

    i. between 100 K and 500 K

    ii. between T K and 900 K. Calculate the temperature T K of the sink.

51. Assuming that a domestic refrigerator can be regarded as a reversible engine working between the temperature of melting ice and that of the atmosphere ($17^\circ C$), calculate the energy which must be supplied to freeze one kilogram of water already at $0^\circ C$. **[2]**

52. An engine has been designed to work between source and sink temperatures of 177^oC and 27^oC respectively. If the energy input per cycle is 3600 J then find **[2]**

    i. its efficiency

    ii. work done by the engine per cycle.

53. Calculate the difference in efficiencies of a Carnot engine working between **[2]**

    i. 400 K and 350 K

    ii. between 350 K and 300 K.

54. A Carnot engine absorb 6×10^5 cal at 227^0c calculate work done per cycle by the engine if it sinks at 127^0c? **[2]**

55. A reversible engine converts one sixth of heat input into work. When the temperature of the sink is reduced by $62^\circ C$, its efficiency is doubled. Find the temperature of the source and the sink. **[2]**

Section C

56. Temperatures of the hot and cold reservoirs of a Carnot engine is raised by equal amounts. How the efficiency of the Carnot engine affected? **[3]**

57. Two Carnot engines A and B are operated in series. The first one A receives heat at 900 K and rejects it to a reservoir at temperature T. The second engine B operates on this reservoir and rejects heat to a reservoir at 400 K. Calculate temperature T when **[3]**

    i. efficiencies of both A and B are equal.

    ii. the work outputs of both A and B are equal.

58. A Carnot engine having a perfect gas as the working substance is driven backward and is used for freezing water already at $0^\circ C$. If the engine is driven by a 500 W electric motor having an efficiency of 60 %, how long will it take to freeze 15 kg of water. Take $15^\circ C$ and $0^\circ C$ as the working temperatures of the engine and assume there are no heat losses in the refrigerating system. Latent heat of ice = 333×10^3 J kg^{-1}. **[3]**

59. How much energy in watt-hour may be required to convert 2 kg of water into ice at $0^\circ C$, assuming that the refrigerator is ideal? Given the temperature of the freezer is $-13^\circ C$, the room temperature is $25^\circ C$ and the initial temperature of water is $25^\circ C$. **[3]**

60. The temperature T_1 and T_2 of the two heat reservoirs in an ideal carnot engine be 1500°C and 500°C respectively, which of these increasing T_1 by 100°C or decreasing T_2 by 100°C would result in a greater improvement in the efficiency of the engine? **[3]**

61. A perfect Carnot engine utilizes an ideal gas the source temperature is 500 K and sink temperature is 375 K. If the engine takes 600 kcal per cycle from the Source, Calculate **[3]**

    a. The efficiency of engine

    b. Work done per cycle

    c. Heat rejected to sink per cycle

62. Calculate difference in efficiency of a Carnot energy working between:- **[3]**

    i. 400K and 350K

    ii. 350K and 300K

63. An ideal engine operates by taking in steam from a boiler at a temperature of $327^\circ C$ and rejecting heat to the sink at a temperature of $27^\circ C$. The engine runs at 500 rpm and the heat taken is 600 kcal in each revolution. Calculate **[3]**

    i. the Carnot efficiency of the engine

    ii. the work done in each cycle

    iii. the heat rejected in each revolution and

    iv. the power output of this engine.

64. A Carnot engine is working between ice point and steam point. It is desired to increase its efficiency by 20% (a) by changing temperature of hot reservoir alone, (b) by changing temperature of colder reservoir only. Calculate the change in temperature in each case. **[3]**

65. A Carnot engine with ideal gas is used for freezing water which is at 0°C. The engine is operated by a 600 W electric motor having an efficiency of 50%. Find time to freeze 25 kg of water. Take 25°C and 0°C as the source **[3]**

and sink. Latent heat of ice = $333 \times 10^3 J\ kg^{-1}$.

66. In a Carnot's engine, the temperature of the heat source and heat sink are 500 K and 375 K, respectively. If the engine consumes 6×10^6 J per cycle, find **[3]**

i. the efficiency of engine,

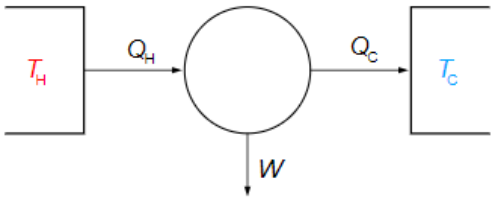
ii. work done per cycle by the engine, and

iii. heat rejected by the engine in each cycle of operation.

Section D

Question No. 67 to 71 are based on the given text. Read the text carefully and answer the questions: **[5]**

Carnot principles are only for cyclical devices like heat engines, which state that the efficiency of an irreversible heat engine is always less than the efficiency of a reversible one operating between the same two reservoirs. The efficiencies of all reversible heat engines operating between the same two reservoirs are the same.



67. In a Carnot cycle, the working medium rejects heat at a _____ temperature.

a) constant
b) Increase
c) lower
d) higher

68. Which of the following is NOT a state variable?

a) Entropy
b) Internal energy
c) All of these
d) Work

69. The efficiency of a reversible heat engine is

a) $(T_1/T_2) + 1$
b) $1 + (T_2/T_1)$
c) $(T_1/T_2) - 1$
d) $1 - (T_2/T_1)$

70. Other factors remaining constant, if the temperature of the source is increased, the efficiency of the Carnot engine will:

a) constant
b) increase
c) decrease
d) increase or decrease depending upon temperature ratio

71. Over the complete Carnot cycle, entropy:

a) constant
b) increase
c) first increase and then decrease
d) decrease

72. Five moles of an ideal gas is taken in a Carnot engine working between 100°C and 30°C. The useful work done in 1 cycle is 420J. Calculate the ratio of the volume of the gas at the end and beginning of the isothermal expansion? **[5]**

73. Two Carnot engines A and B are operated in series. The first one A receives heat at 800 K and rejects to a reservoir at temperature T K. The second engine B receives the heat rejected by the first engine and in turn rejects to a heat reservoir at 300 K. Calculate the temperature T K for the following cases. **[5]**

i. When the outputs of the two engines are equal.

ii. When the efficiencies of the two engines are equal.

74. What is meant by a thermodynamic reversible process? Write two characteristics of a reversible process. State in brief the meaning of Carnot cycle. Write an expression for the efficiency of a Carnot engine. What is the advantage of Carnot engine in terms of efficiency? **[5]**

75. i. State second law of thermodynamics. How is a heat engine different from a refrigerator? **[5]**

ii. Show that for a Carnot engine, efficiency $\eta = 1 - \frac{T_2}{T_1}$ ($T_2 < T_1$) where T_1 is the temperature of the source and

T_2 is the temperature of the sink.