Chapter 12. Thermodynamics

I. One mark questions (PART – A):

1. What is thermodynamics? (K)
2. Give an example for a thermodynamic variable. (U)
3. What is thermal equilibrium? (K)
4. What is an adiabatic wall? (K)
5. What is diathermal wall?(K)
6. State Zeroth law of thermodynamics. (K)
7. What is the significance of zeroth law of thermodynamics? (U)
8. Define internal energy. (K)
9. What is a state variable?(K)
10. Give an example for a state variable. (U)
11. State first law of thermodynamics. (K)
12. What is the value of change in internal energy for an isothermal process? (U)
13. First law of thermodynamics is a version of which general principle of physics? (U)
14. What is an isothermal process? (K)
15. Give an example for isothermal process. (U)
16. What is an adiabatic process? (K)
17. Give an example for adiabatic process. (U)
18. Define isobaric process. (K)
19. The volume of a gas changes from a volume V_1 to a volume V_2 at a constant pressure P. Write the formula for the work-done in the process. (U)
20. What is isochoric process? (K)
21. What is the value work-done in an isochoric process? (A)
22. Draw a graph showing the variation of specific heat of water with its temperature. (S)
23. What is the value of the difference between specific heat capacity at constant pressure and specific heat at constant volume for a gas? (K)
24. What is an equation of state? (K)
25. Write the equation of state for an ideal gas. (K)
26. What is an isotherm? (K)
27. What is an intensive variable? (K)
28. What is an extensive variable? (K)
29. Give an example for extensive variable. (U)
30. Give an example for intensive variable. (U)
31. Which kind of thermodynamic process obeys Boyle's law? (U)
32. Draw P – V diagram for isothermal process. (S)
33. Draw P – V diagram for adiabatic process. (S)
34. Draw P – V diagram for isobaric process. (S)
35. Draw isothrem for isochoric process. (S)
36. What does the area under P – V diagram for a thermodynamic process indicate? (K)
37. What is a cyclic process? (K)
38. What is the change in internal energy for a cyclic process? (U)
39. What is a heat engine? (K)

40. Define efficiency of a heat engine. (K)
41. Give the expression for the efficiency of a heat engine. (K)
42. Which law forbids an engine from having unit efficiency? (U)
43. What is a refrigerator? (K)
44. Define coefficient of performance of a refrigerator. (K)
45. Write Kelvin – Planck statement of second law of thermodynamics. (K)
46. Write Clausius statement of second law of thermodynamics. (K)
47. Give two examples for irreversible process. (U)
48. What is a Carnot's engine? (K)
49. How does the efficiency of a Carnot's engine depend on the nature of the working substance? (U)
50. What is the efficiency of a heat engine for which temperature of the hot reservoir is equal to the temperature of the cold reservoir? (A)
51. At what temperature of the cold reservoir the efficiency of the Carnot's engine is 100%? (A)

II. Two mark questions (Part – B):

1. State and explain zeroth law of thermodynamics. (K)
2. What is a state variable? Give an example. (U)
3. Mention the factors on which internal energy of a system depends. (K)
4. Mention the ways of changing internal energy of a system? (U)
5. Is the statement "*A gas in a given state has a certain amount of heat*" correct? Justify your answer. (U)
6. State and explain first law of thermodynamics. (K)
7. Write the first law of thermodynamics in mathematical form and explain the terms. (K)
8. An electric heater supplies heat to a system at a rate of 100 W. If system performs work at a rate of 75 J s^{-1}, at what rate is the internal energy increasing? (Ans: 25 W) (S)
9. Explain why air pressure in a car tyre increases during driving. (A)
10. Show that the molar specific heat for a solid equals 3R. (A)
11. What is an isothermal process? Give an example. (K)
12. What is an adiabatic process? Give an example. (K)
13. Differentiate between isothermal and adiabatic process. (U)
14. Calculate the work done by a gas when its volume of a gas increases by 20 cm^3 at 1 atm pressure. (Ans: 2.02 J) (S)
15. In an isobaric process, the temperature of 8 g of helium changes from 27 ^{0}C to 127 ^{0}C. Calculate the work done in the process. (Ans: ΔW = 1.66 kJ) (S)
16. Draw a schematic representation of a heat engine. (S)
17. An ideal heat engine with 40% efficiency has hot reservoir temperature of 600 K. What is the temperature its cold reservoir? (Ans: T_2= 360 K) (S)
18. Find the efficiency of a heat engine which absorbs an energy of 1 kJ and does 650 J work. (Ans: η = 0.65 = 65%) (S)
19. Draw a schematic representation of a heat pump. (S)
20. A refrigerator has a coefficient of performance of 6. If the work done on the refrigerant is 15 J, what is amount of heat that can be extracted from the freezer? (Ans: 90 J)(S)
21. A refrigerator is to maintain eatables kept inside at 9^{o}C. If room temperature is 36 ^{o}C, calculate the coefficient of performance. (Ans: 10.4) (S)

22. Second law of thermodynamics gives a fundamental limitation to the efficiency of a heat engine and the coefficient of performance of a refrigerator. Explain. (A)
23. What limits does the Second law of thermodynamics put on the efficiency of a heat engine and the coefficient of performance of a refrigerator? (A)
24. What is a reversible process? Give an example. (K)
25. What is an irreversible process? Give an example. (K)
26. Differentiate between reversible and irreversible processes. (U)
27. Mention any two causes of irreversibility of a thermodynamic process. (A)

III. Three mark questions (Part – C):

1. What is an isobaric process? Derive the expression for work done in an isobaric process in terms of initial and final temperatures of the system. (U)
2. With a schematic diagram, explain the working of a refrigerator. (U)
3. Differentiate between isothermal process and adiabatic process. Give one example for each. (U)
4. Differentiate between reversible process and irreversible process. Give one example for each. (U)

IV. Five mark questions (Part – D):

1. Derive the relation $C_P - C_V = R$ for an ideal gas. (U)
2. What is an isothermal process? Derive an expression for work done in an isothermal process. (U)
3. What is an adiabatic process? Derive an expression for work done in an adiabatic process. (U)
4. With a schematic diagram, explain the working of a heat engine. (U)
5. Explain the working of a Carnot's engine. Write the expression for its efficiency. (U)
6. Derive an expression for the efficiency of a Carnot's heat engine. (U)

V. Five mark problems (All S):

1. 12 g of helium at 127 ^{o}C undergoes isothermal expansion until its volume is four times the initial volume. Calculate the amount of the work done by the gas. Also calculate the amount of heat supplied to the gas. (Given: ln 2 = 0.693)
   (Ans: ΔW = 13.83 kJ; ΔQ = 13.83 kJ)
2. In an adiabatic compressionof a gas, the volume of the gas changes from 3 litres to 1.5 litres. If the initial pressure of the gas is 0.25 MPa, calculate the final pressure of the gas and the work done by the gas in the process. Given: γ for the gas = 1.5
   (Ans: $P_2 = 7.07 \times 10^5$ Pa; ΔW = - 621 J)
3. In a sudden expansion of 96 g of oxygen, the temperature of the gas changes from 125^{o}C to 50^{o}C. Calculate the workdone by the gas in the process. Also calculate the change in internal energy of the gas. (Given: Molecular mass of O_2 = 32 g)
   (Ans: ΔW = 4.68 kJ; ΔU = - 4.68 kJ)
4. Two moles of an ideal gas at 27 ^{o}C and pressure P is adiabatically compressed till its pressure becomes 8P. If the value γ for the gas is 1.5, calculate the final temperature and change ininternal energy of the gas.
   (Ans: T = 600 K, ΔU = 9.98 kJ)

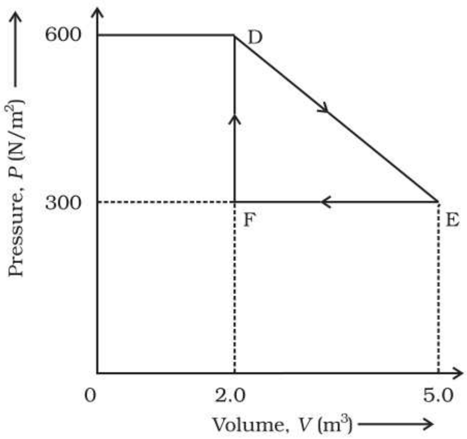
5. A Carnot's engine absorbs 1 kJ of heat from a reservoir at 277 ^{o}C and rejects 500 J of heat in each cycle. Calculate (a) the efficiency of the engine (b) the temperature of the cold reservoir and (c) the amount of useful workdone in each cycle.

   (Ans: η = 0.5 = 50%; T_2 = 275 K; ΔW = 500 J)
6. A 60% efficient reversible engine rejects 600 J of heat to the cold reservoir at a temperature of 50 ^{o}C. Calculate (i) the temperature of the hot reservoir (ii) the work done per cycle?

   (Ans: T_1 = 807.5 K, ΔW = 1500 J)
7. A Carnot's engine converts one – third the heat absorbed by the hot reservoir into work. If the temperature of the hot reservoir is increased by 450 K, the efficiency of the engine is doubled. Calculate the initial temperatures of the hot reservoir and the cold reservoir.

   (Ans: T_1 = 450 K; T_2 = 300 K)
8. A Carnot's engine has an efficiency of 50%. If the temperature of the source is increased by 150 ^{o}C and temperature of the sink is decreased by 50 ^{o}C, the efficiency of the engine increases by 25%. Calculate temperatures of the source and the sink.

   (Ans: T_1 = 350 K; T_2 = 175 K)
9. A thermodynamic system undergoes a cyclic process as shown in the figure. The processes DE, EF and FD are linear. Calculate total work done by the gas per cycle. Also calculate change in internal energy and heat supplied to the system per cycle.



   (Ans: ΔW = 450 J; ΔU = 0; ΔQ = 450 J)
10. What amount of heat must be supplied to 0.02 kg of nitrogen at room temperature to raise its temperature by 45 ^{o}C at constant pressure? What is the work done in the process?(Given: Molecular mass of N_2 = 28 g)

    (Ans: ΔQ = 933.4 J; ΔW = 267.1 J)
11. In changing the state of a gas adiabatically from an equilibrium state *A* to another equilibrium state *B*, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state *A* to *B* via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in the later case?

    (Ans: 16.9 J)
12. A steam engine delivers 5.4 x 10^8 J of work per minute and services 3.6 x 10^9 J of heat per minute from its boiler. What is the efficiency of the engine? How much heat is wasted per second?

    (Ans: η = 0.15 = 15%; 5.1 x 10^7 Js^{-1})