CLASS – 11

WORKSHEET- THERMODYNAMICS

A. INTRODUCTION TO THERMODYNAMICS

(1 Mark Questions)

1. The zeroth law of thermodynamics for three systems A, B and C in contact demands that
   (a) A and B are in thermal equilibrium (b) B and C are in thermal equilibrium
   (c) A and C are in thermal equilibrium (d) A, B and C are in thermal equilibrium

2. What does the zeroth law of thermodynamics tell us about measuring the temperature of an object?

3. Which one of the following is not a thermodynamic variable?
   (a) pressure (b) temperature (c) volume (d) none of these

4. Define thermodynamic system.

5. What is equation of state?

6. What are extensive state variables?

(3 Marks Questions)

7. What is a system said to be in the state of thermodynamic equilibrium?

8. Define internal energy of a gas. Explain whether it is an extensive or intensive variable? How internal energy of a gas can be changed?

9. What do you mean by extensive and intensive state variables? Explain using suitable example.

B. HEAT, WORK AND INTERNAL ENERGY

(1 Mark Questions)

1. If no external energy is supplied to an expanding gas, will the gas do any work? If yes, then what will be the source of energy?

2. Which of the following is not a path function?

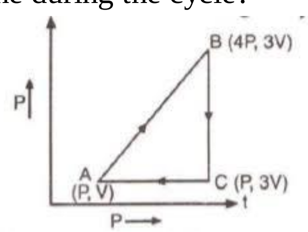
(a) ΔQ (b) ΔQ + ΔW (c) ΔW (d) ΔQ - ΔW

3. During an isothermal expansion, a confined ideal gas does – 150J of work against its surroundings. This implies that
(a) 150 J of heat has been removed from the gas
(b) 150J of heat has been added to the gas
(c) no heat is transferred because the process is isothermal
(d) 150J of heat has been added to the gas

4. One mole of an ideal gas undergoes a cyclic process ABCD, A as shown in the PV diagram. The net work done in the process is (1 atm = 10^6 dyne cm^{-2})
(a) 500J (b) 700J (c) 800J (d) 900J

5. A given system undergoes a change in which the work done by the system equals the decrease in its internal energy. What kind of thermodynamic process does the system undergoes?

6. A sample of an ideal monatomic gas is taken round the cycle ABCA as shown in the figure. What is the work done during the cycle?



7. Can two isothermal curves intersect?

8. Can we convert internal energy into work?

9. If hot air rises up, why is it cooler at the top of mountain than near the sea level? Explain.

10. Why a gas is cooled when expanded?

11. What is isobaric process?

12. What is isochoric process?

(2 Marks Questions)

13. Give difference between heat and work.

14. What do you mean by internal energy of a system?

15. State the sign conventions used in the measurement of heat, work and internal energy.

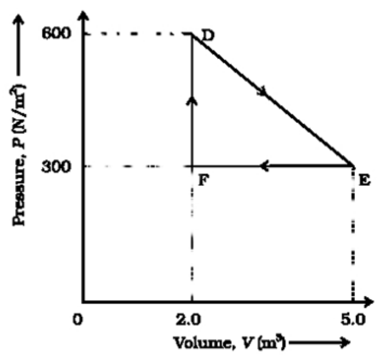
16. A system is given 200 calories of heat and it does 600 joules of work. How much does the internal energy of the system change in this process. (J = 4.18 joule/cal)?

(3 Marks Questions)

17. State first law of thermodynamics and apply it to the boiling process of liquid.

18. When heat energy of 1500J is supplied to a gas at constant pressure, 2.1×10^5 nm^{-2}, there was an increase in its volume equal to 2.5×10^{-3} m^3. What is the increase in its internal energy?

19. A thermodynamic system is taken from an original; state to an intermediate state by the linear process shown in figure.



Its volume is then reduced to the original value from E to F by an isobaric process. Calculate the total work done by the gas from D to E and E to F. [Ans. 450J]

C. THERMODYNAMIC PROCESS

(1 Mark Questions)

1. State first law of thermodynamics

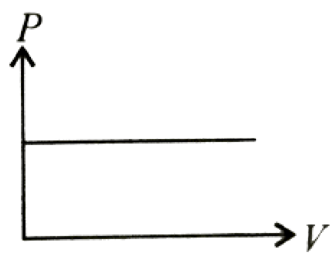
2. First law of thermodynamics does not forbid flow of heat from lower temperature to higher temperature. Comment.

3. When is the heat supplied to a system equal to the increase in its internal energy?

4. In an adiabatic change the specific heat of a gas is
(a) increase with increase in temperature (b) decrease with increase in temperature
(c) not depend upon change in temperature (d) always zero

5. An ideal gas having molar specific heat capacity at constant volume is 3/2R, the molar specific heat capacities at constant pressure is
(a) 1/2R (b) 5/2R (c) 7/2R (d) 9/2R

6. Which of the following process is correct for given P-V diagram?



(a) Adiabatic process (b) isothermal process (c) Isobaric process (d) Isochoric process

(2 Marks Questions)

7. Two bodies at different temperatures T_1 and T_2 if brought in thermal contact do not necessarily settle to the mean temperature $(T_1 + T_2)/2$. Explain.

8. Which is greater C_P or C_V and why?

9. Can a system be heated but its temperature remains constant?

10. If at 50°C and 75cm of mercury pressure, a definite mass of gas is compressed (i) slowly (ii) suddenly, then what will be the final pressure and temperature of the gas in each case if the final volume is one-fourth of the initial volume ($\gamma = 1.5$).

11. The slope of an adiabatic process is greater than an isothermal process. Give reason.

12. Show that the slope of an adiabatic curve at any point is γ times the slope of an isothermal curve at the corresponding point.

13. Under what conditions would an ideal heat engine be cent per cent efficient?

14. A cylinder with a movable piston contains 3 moles of hydrogen at standard temperature and pressure. The walls of the cylinder are made of a heat insulator, and the piston is insulated by having a pile of sane on it. By what factor does the pressure of the gas increase if the gas is compressed to half its original volume? [Ans. 2.64]

(3 Marks Questions)

15. Prove that $C_P - C_V = R$ for ideal gas

16. Establish the relation between two principal specific heats of a gas on the basis of first law of thermodynamics.

17. Two cylinders A and B of equal capacity are connected to each other via a stopcock. The cylinder A contains a gas at standard temperature and pressure, while the cylinder B is complete evacuated. The entire system is thermally insulated. The stopcock is suddenly opened. Answer the following:
(a) What is the final pressure of the gas in A and B?
(b) What is the change in internal energy of the gas?
(c) What is the change in temperature of the gas?
(d) Do the intermediate states of the system (before settling to final equilibrium state) lie on its P-V-T surface?

18. Write two essential conditions for a perfect isothermal change and the two essential conditions for a perfect adiabatic change.

19. Consider one gram mole of an ideal gas of ratio of specific heats γ, enclosed in a cylinder with perfectly non conducting walls fitted with a smooth non conducting piston. Find an expression for work done by the gas when it expands such that its temperature changes from T_1 to T_2.

20. Ten moles of hydrogen at NTP is compressed adiabatically so that its temperature become 400°C. How much work is done on the gas? What is the increase in the internal energy of the gas ($R = 8.4$ J mol^{-1} K^{-1}, $\gamma = 1.4$)

21. Determine the PV relation for a monatomic gas undergoing an adiabatic process.

22. Derive an expression for work done during isothermal process.

23. A refrigerator freezes water at 0°C into 10kg ice at 0°C in time interval of 30 min. Assuming the room temperature to be 20°C, calculate the minimum amount of power needed to make 10kg of ice.

24. A geyser heats water flowing at the rate of 3.0 litres per minute from 27°C to 77°C. If the geyser operates on a gas burner, what is the rate of consumption of the fuel if its heat of combustion is 4.0×10^4 J/g? [Ans. 15.75 g min^{-1}]

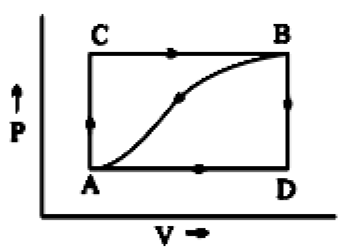
25. What amount of heat must be supplied to 2.0×10^{-2} kg of nitrogen at room temperature to raise its temperature by 45°C at constant pressure? Given molecular weight of N_2 is 28 and R = 8.3 J mol^{-1} K^{-1} and C_V (diatomic gases) = 7/2 R. [Ans. 933.75J]

26. In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3J is done on the system. If the gas is taken from state A to B via 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 latter case? (take 1 cal = 4.19J) [Ans. +16.9J]

27. Two cylinders A and B of equal capacity are connected to each other via a stopcock. The cylinder A contains a gas at standard temperature and pressure, while the cylinder B is completely evacuated. The entire system is thermally insulated. The stopcock is suddenly opened.
Answer the following:
(i) What is the final pressure of the gas in A and B?
(ii) What is the change in internal energy of the gas?
(iii) What is the change in temperature of the gas?
(iv) Do the intermediate states of the system (before settling to final equilibrium state) lie on its P-V-T surface?

(5 Marks Questions)

28. When a system is taken from state A to state B along the path ACB, 80 kcal of heat flows into the system and 30 kcal of work is done



(a) How much does heat flows into the system along path ADB if the work done is 10kcal?

(b) When the system is returned from B to A along the curved path the work done is 20kcal. Does the system absorb or liberate heat?

(c) If $U_A = 0$ and $U_D = 40$kcal, find the heat absorbed in the process AD.

29. Describe melting and boiling process on the basis of first law of thermodynamics

30. Consider a PV diagram in which the path followed by one mole of perfect gas in a cylindrical container is shown in figure.

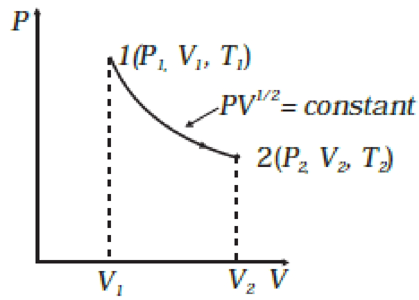


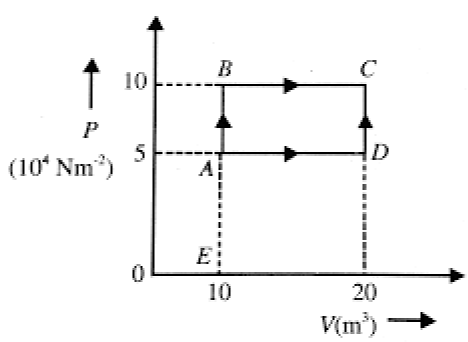
Fig. 12.9

(a) Find the work done when the gas is taken from state 1 to state 2.

(b) What is the ratio of temperature T_1/T_2 if $V_2 = 2V_1$?

(c) Given the internal energy for one mole of gas at temperature T is (3/2)RT, find the heat supplied to the gas when it is taken from state 1 to state2 with $V_2 = 2V_1$.

31. A sample of 2kg of monatomic helium (assumed ideal) is taken through the process ABC and another sample of 2kg of the same gas is taken through the process ADC (figure). Given molecular mass of Helium = 4, R = 8.3 j mol^{-1} K^{-1}.



(a) What is the temperature of Helium in each of the states of A, B, C and D?

(b) How much is the heat involved in each of the process ABC and ADC?

32. A mixture of 1.78kg of water and 262g of ice at 0°C is in a reversible process, brought to a final equilibrium state where the water/ice ratio by mass is 1:1 at 0°C.
(i) Calculate the entropy change of the system during this process
(ii) The system is the returned to the first equilibrium state, but in an irreversible way (by using a Bunsen burner for instance). Calculate the entropy change of the system during this process.

33. Explain why:
(a) Two bodies at different temperature T_1 and T_2 (if brought in thermal contact do not necessarily settle to mean temperature $(T_1 + T_2)/2$.
(b) The coolant in a chemical or a nuclear plant (i.e. the liquid used to prevent the different parts of a plant from getting too hot) should have high specific heat.
(c) At pressure in a car tyre increases during driving.
(d) The climate of a harbour town in more temperate than that of a town in a desert at the same latitude.

D. IIND LAW OF THERMODYNAMICS HEAT ENGINE AND REFRIGERATOR

(1 Mark Questions)

1. A heat engine has an efficiency η. Temperatures of source and sink are each decreased by 100K. The efficiency of the engine
(a) increases (b) decreases (c) remains constant (d) becomes 1

2. When the door of a refrigerator is kept open then the room temperature starts
(a) cool down (b) hot up
(c) first cool down and then hot up (d) neither cool down nor hot up

3. Give two examples of heat pump.

4. State second law of thermodynamics.

5. The conclusion of second law of thermodynamics is that
(a) no heat engine can have efficiency η equal to zero.
(b) no heat engine can have efficiency η equal to one.
(c) no heat engine can have efficiency η greater than one.
(d) no heat engine can have efficiency η less than one.

6. When the door of refrigerator is kept open we cannot cool the room. It may be against

(a) conservation of energy (b) first law of thermodynamics
(c) conservation of momentum (d) second law of thermodynamics

7. Which of the following processes described below is irreversible?

(a) the increase in temperature of an iron rod by hammering it.
(b) a gas in a small container at a temperature T_1 is brought in contact with a big reservoir at a higher temperature T_2 which increase the temperature of the gas.
(c) an ideal gas is enclosed in a piston cylinder arrangement with adiabatic walls. A weight W is added to the piston resulting in compression of gas.
(d) all of the above

8. Consider a Carnot cycle operating between source temperature 750K and sink temperature 350K producing 1.25kJ of mechanical work per cycle, the heat transferred to the engine by the reservoirs

(a) 1.34 kJ (b) 2.34kJ (c) 3.34kJ (d) 4.34kJ

9. A Carnot engine absorbs 750J of heat energy from a reservoir at 137°C and rejects 500J of heat during each cycle, then the temperature of sink is

(a) 0.25°C (b) 0.34°C (c) 0.44°C (d) 0.54°C

10. What are two essential features of Carnot ideal heat engine?

(2 Marks Questions)

11. A refrigerator maintains eatables, kept inside at 9°C. If the room temperature is 37.2°C, calculate the coefficient of performance of the refrigerator.

12. State the limitations of second law of thermodynamics.

13. No real engine can have an efficiency greater than that of a Carnot engine working between the same two temperatures. Give reason.

14. Can a Carnot engine be realized in practice?

(3 Marks Questions)

15. What is Carnot engine? What is its efficiency?

16. A steam engine works with reservoirs at temperatures of 207°C and 37°C while a gasoline combustion engine has temperatures of 1550°C and 475°C. Which of the two engines is more efficient?

17. 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?

18. Derive the work done in an Adiabatic process.

19. A steam engine delivers 5.4×10^{8} J of work per minute and services 3.6×10^{9} J of heat per minute from its boiler. What is the efficiency of the engine? How much heat us wasted per minute? [Ans. 3.1×10^{9} J]

20. A refrigerator is to maintain eatables kept inside at 9°C. If room temperature is 36°C, calculate the coefficient of performance. [Ans. 10.4]

(5 Marks Questions)

21. (a) Explain the basic principle of a heat engine.
(b) Can the efficiency of a heat engine be 100%? Give reason for your answer.

22. A refrigerator whose coefficient of performance β is 5 extracts heat from the cooling component at the rate of 250J per cycle.
(a) How much work per cycle is required to operate the refrigerator cycle?
(b) How much heat per cycle is discharged to the room which acts as high temperature reservoir?

23. State Carnot theorem. Prove that the efficiency of a reversible heat engine is maximum.