

Two mark questions and answers

UNIT I

BASIC CONCEPT AND FIRST LAW

1. What do you understand by pure substance?

A pure substance is defined as one that is homogeneous and invariable in chemical composition throughout its mass.

2. Define thermodynamic system.

A thermodynamic system is defined as a quantity of matter or a region in space, on which the analysis of the problem is concentrated.

3. Name the different types of system.

1. Closed system (only energy transfer and no mass transfer)
2. Open system (Both energy and mass transfer)
3. Isolated system (No mass and energy transfer)

4. What is meant by closed system? Give an example

When a system has only heat and work transfer, but there is no mass transfer, it is called as closed system.

Example: Piston and cylinder arrangement.

5. Define a open system, Give an example.

When a system has both mass and energy transfer it is called as open system.

Example: Air Compressor.

6. Define an isolated system

Isolated system is not affected by surroundings. There is no heat, work and mass transfer take place. In this system total energy remains constant.

Example: Entire Universe

7. Define: Specific heat capacity at constant pressure.

It is defined as the amount of heat energy required to raise or lower the temperature of unit mass of the substance through one degree when the pressure kept constant. It is denoted by C_p .

8. Define: Specific heat capacity at constant volume.

It is defined as the amount of heat energy required to raise or lower the temperature of unit mass of the substance through one degree when volume kept constant. It is denoted by C_v .

9. What is meant by surroundings?

Any other matter outside the system boundary is called as surroundings.

10. What is boundary?

System and surroundings are separated by an imaginary line is called boundary.

11. What is meant by thermodynamic property?

Thermodynamic property is any characteristic of a substance which is used to identify the state of the system and can be measured, when the system remains in an equilibrium state.

12. Name and explain the two types of properties.

Nov / Dec 2013

The two types of properties are intensive property and extensive property.

Intensive Property: It is independent of the mass of the system.

Example: pressure, temperature, specific volume, specific energy, density.

Extensive Property: It is dependent on the mass of the system.

Example: Volume, energy. If the mass is increased the values of the extensive properties also increase.

13. What is meant by thermodynamic equilibrium?

May / June 2014

When a system is in thermodynamic equilibrium, it should satisfy the following three conditions.

- (a) Mechanical Equilibrium :- Pressure remains constant
- (b) Thermal equilibrium :- Temperature remains constant
- (c) Chemical equilibrium: There is no chemical reaction.

14. Explain Mechanical equilibrium.

If the forces are balanced between the system and surroundings are called Mechanical equilibrium

15. Explain Chemical equilibrium.

If there is no chemical reaction or transfer of matter from one part of the system to another is called Chemical equilibrium

16. Explain Thermal equilibrium.

If the temperature difference between the system and surroundings is zero then it is in Thermal equilibrium.

17. What is Quasi – Static process?

Nov/Dec 2012

The process is said to be quasi – static, it should proceed infinitesimally slow and follows continuous series of equilibrium states at all times. Therefore, the quasi static process may be a reversible process.

18. Define Path function.

May / June 2014, Nov/Dec 2010

The work done by a process does not depend upon the end of the process. It depends on the path of the system follows from state 1 to state 2. Hence work is called a path function.

19. Define point function.

May / June 2014, Nov/Dec 2010

Thermodynamic properties are point functions. The change in a thermodynamic property of a system is a change of state is independent of the path and depends only on the initial and final states of the system.

20. Explain homogeneous and heterogeneous system.

The system consist of single phase is called homogeneous system and the system consist of more than one phase is called heterogeneous system.

21. What is a steady flow process?

Steady flow means that the rates of flow of mass and energy across the control surface are constant.

22. Prove that for an isolated system, there is no change in internal energy. Nov/Dec 2011

In isolated system there is no interaction between the system and the surroundings. There is no mass transfer and energy transfer. According to first law of thermodynamics as

$$dQ = dU + dW; \quad dU = dQ - dW; \quad dQ = 0, \quad dW = 0,$$

Therefore $dU = 0$ by integrating the above equation $U = \text{constant}$, therefore the internal energy is constant for isolated system.

23. Indicate the practical application of steady flow energy equation.

1. Turbine 2.Nozzle 3.Condenser, 4.Compressor.

24. Define state.

Nov/Dec 2011, April /May 2012

The condition of the system at particular time.

25. Define the term process and path

Nov/Dec 2011, April /May 2012

Process

Any change that a system undergoes from one equilibrium state to another is called a *process*.

Path

Series of states through which a system passes during a process is called the *path*.

26. Define the term Cycle

Nov/Dec 2011

It is defined as a series of state changes such that the final state is identical with the initial state.

27. Define Zeroth law of Thermodynamics.

Nov/Dec 2009

When a body A is in thermal equilibrium with body B and also separately with a body C, then B and C will be in thermal equilibrium with each other.

28. What are the limitations of first law of thermodynamics?

Nov/Dec 2012

1. According to first law of thermodynamics heat and work are mutually convertible during any cycle of a closed system. But this law does not specify the possible conditions under which the heat is converted into work.
2. According to the first law of thermodynamics it is impossible to transfer heat from lower temperature to higher temperature.
3. It does not give any information regarding change of state or whether the process is possible or not.
4. The law does not specify the direction of heat and work.

29. What is perpetual motion machine of first kind or PMMI?

Nov/Dec 2007, May/June 2010

It is defined as a machine, which would continuously supply mechanical work without some other form of energy disappearing simultaneously. It is impossible to obtain in actual practice, because no machine can produce energy of its own without consuming any other form of energy.

30. Define the term enthalpy?

The Combination of internal energy and flow energy is known as enthalpy of the system. It may also be defined as the total heat of the substance.

Mathematically, enthalpy (**H**) = **U + PV** KJ)

Where, U – internal energy

p – Pressure

v – Volume

In terms of Cp & T $H = mC_p (t_2 - t_1)$ KJ

31. Define the term internal energy

Nov/Dec 2011

Internal energy of a gas is the energy stored in a gas due to its molecular interactions. It is also defined as the energy possessed by a gas at a given temperature.

32. What is meant by thermodynamic work?

It is the work done by the system when the energy transferred across the boundary of the system. It is mainly due to intensive property difference between the system and surroundings.

33. Distinguish between ‘macroscopic energy’ or classical thermodynamics and ‘microscopic energy’ or statistical thermodynamics.

Nov / Dec 2013, Nov/Dec 2012, Nov/Dec 2009

Macroscopic energy or classical thermodynamics

A certain quantity of matter is considered, without the events occurring at the molecular level being taken into account. It is concerned with the effects of the action of many molecules, and these effects can be perceived by human senses.

Pressure is the average rate of change of momentum due to all the molecular collisions made on a unit area.

Microscopic energy or statistical thermodynamics

Each molecule at a given instant has a certain position, velocity and energy and each molecule these change very frequently as a result of collisions. The behavior of the gas is described by the summing up the behavior of each molecule

34. What is meant by ‘hyperbolic processes?’

April/May 2011

Super heated steam acts like gas. The isothermal process in the superheated region is called hyperbolic process. A process in which the gas is heated or expanded in such a way that the product of its pressure and volume remains constant is called hyperbolic process. The curve in such an expansion process is a rectangular hyperbola and hence this is known as hyperbolic expansion.

35. Distinguish between stored energies and interaction energies.

Nov/Dec 2010

36. What do you understand by flow work? Is it different from displacement work?

May/June 2013, April /May 2010, 2009.

Flow work is the energy transferred across the system boundary as a result of energy imparted to the fluid by a pump, blower to make the fluid flow across the control volume.

Flow work is analogous to displacement work.

37. What is the convention for positive and negative work?

38. What are the corollaries to the first law of thermodynamics?

Nov / Dec 2006

Corollary I

There exists a property of a closed system such that a change in its value is equal to the difference between the heat supplied and the work done during any change of state.

Corollary II

The internal energy of a closed system remains unchanged if the system is isolated from its surroundings.

Corollary III

A perpetual motion machine of first kind (PMM-1) is impossible.

39. Is it correct to say 'total heat' or 'heat content' of a closed system? Nov / Dec 2007

Yes. The total heat or heat content of a closed system is also called as enthalpy.

Unit – I Question Bank

1. In an isentropic flow through nozzle, air flows at the rate of 600 kg/hr. At inlet to the nozzle, pressure is 2 MPa and temperature is 127°C. The exit pressure is 0.5 MPa. Initial air velocity is 300 m/s determine (i) Exit velocity of air (ii) Inlet and exit area of nozzle. (16)
(NOV/DEC 2006.)
2. A centrifugal pump delivers 2750 kg of water per minute from initial pressure of 0.8 bar absolute to a final pressure of 2.8 bar absolute. The suction is 2 m below and the delivery is 5 m above the centre of pump. If the suction and delivery pipes are of 15 cm and 1.0 cm diameter respectively, make calculation for power required to run the pump. (16)
(NOV/DEC 2006.)
3. A reciprocating air compressor takes in 2 m³/min air at 0.11 MPa, 293 K which it delivers at 1.5 MPa, 384 K to an after cooler where the air is cooled at constant pressure to 298 K. The power absorbed by the compressor is 4.15 kW. Determine the heat transfer in (i) the compressor (ii) the cooler. State your assumptions. (16)
Nov / Dec 2009
4. In a turbo machine handling an incompressible fluid with a density of 1000 kg/m³ the conditions of the fluid at the rotor entry and exit are as given below:

	Inlet	Exit
Pressure	1.15 MPa	0.05 MPa
Velocity	30 m/sec	15.5 m/sec
Height above datum	10 m	2 m

If the volume flow rate of the fluid is 40 m³/s, estimate the net energy transfer from the fluid as work. (16)
Nov / Dec 2009
5. A rigid tank containing 0.4 m³ of air at 400 kPa and 30°C is connected by a valve to a piston cylinder device with zero clearance. The mass of the piston is such that a pressure of 200 kPa is required to raise the piston. The valve is opened slightly and air is allowed to flow into the cylinder until the pressure of the tank drops to 200 kPa. During this process, heat is exchanged with the surrounding such that the entire air remains at 30°C at all times. Determine the heat transfer for this process. (16)
Nov / Dec 2010
6. The electric heating system used in many houses consists of simple duct with resistance wire. Air is heated as it flows over resistance wires. Consider a 15 kW electric heating system. Air enters the heating section at 100 kPa and 17°C with a volume flow rate of 150 m³/min. If heat is lost from the air in the duct to the surroundings at a rate of 200 W, determine the exit temperature of air. (16)
Nov / Dec 2010
7. A gas contained in a cylinder is compressed from 1 MPa and 0.05 m³ to 2 MPa. Compression is governed by 1.4 VP constant. Internal energy of gas is given by; $U = 7.5 PV - 425$, kJ. where P is pressure in kPa and V is volume in m³. Determine heat, work and change in internal energy assuming compression process to be quasistatic.

Also find out work interaction, if the 180 kJ of heat is transferred to system between same states. Also explain why it is different from above? (16)

April / May 2011

8. In a gas turbine installation air is heated inside heat exchanger up to 750°C from ambient temperature of 27°C . Hot air then enters into gas turbine with the velocity of 50 m/s and leaves at 600°C . Air leaving turbine enters a nozzle at 60 m/s velocity and leaves nozzle at temperature of 500°C . For unit mass flow rate of air determine the following assuming adiabatic expansion in turbine and nozzle,
- Heat transfer to air in heat exchanger
 - Power output from turbine
 - Velocity at exit of nozzle.

Take up for air as 1.005 kJ / kg. K.

(16)

April / May 2011, May / June 2014

9. 25 people attended a farewell party in a small room of size 10 _ 8 m and have a 5 m ceiling. Each person gives up 350 kJ of heat per hour. Assuming that the room is completely sealed off and insulated, calculate the air temperature rise occurring in 10 minutes. Assume C_v of air 0.718 kJ/kg K and $R = 0.287$ kJ/kg K and each person occupies a volume of 0.05 m³. Take $p = 101.325$ kPa and $T = 20^{\circ}\text{C}$. (10)

Nov / Dec 2011

10. Air flows at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s, 100 kPa and 0.95 m³/kg and leaving at 5 m/s, 700 kPa, and 0.19 m³/kg. The internal energy of air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. (1) Compute the rate of shaft work input to the air in kW (2) Find the ratio of the inlet pipe diameter to outer pipe diameter. (8)

Nov / Dec 2011

11. A gas of mass 1.5 kg undergoes a quasi-static expansion which follows a relationship $p = a + bV$, where a and b are constants. The initial and final pressures are 100 kPa and 200 kPa respectively and the corresponding volumes are 0.20 m³ and 1.20 m³. The specific internal energy of the gas is given by the relation $U = 1.5pv - 85$ kJ / kg. Where p is in kPa and v is in m³/kg. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion. (10)

Nov / Dec 2012, May / June 2009

12. A gas flows steadily through compressor. The gas enters the compressor at a temperature of 16°C , a pressure of 100 kPa, and an enthalpy of 391.2 kJ / kg. The gas leaves the compressor at a temperature of 245°C , a pressure of 0.6 MPa, and an enthalpy of 535.5 kJ / kg. There is no heat transfer to (or) from the gas as it flows through the compressor. Evaluate the external work done per unit mass of gas when the velocity at entry 80 m / s and that at exit is 160 m/s.

13. A nozzle is a device for increasing the velocity of a steady flowing steam. At the inlet to a certain nozzle, the enthalpy of the fluid passing is 3000 kJ / kg and the velocity is 60 m / s. At the discharge end, the enthalpy is 2762 kJ / Kg. The nozzle is horizontal and there is negligible heat loss from it. (i) Find the velocity at exit from the nozzle. (ii) If the inlet area is 0.1 m² and the specific volume at inlet is 0.187 m³ / kg. Find the

mass flow rate. (iii) If the specific volume at the nozzle exit is $0.498 \text{ m}^3 / \text{kg}$. Find the exit area of the nozzle. (8)

April / May 2010

14. A room of four persons has two fans, each consuming 0.18 kW power, and three 100 W lamps. Ventilation air at the rate of 80 kg / hr enters with an enthalpy of 84 kJ / kg and leaves with an enthalpy of 59 kJ / kg . If each person puts out heat at the rate of 630 kJ / hr . Determine the rate at which heat is to be removed by a room cooler, so that a steady state is maintained in the room. (7)

(Nov / Dec 2007)

15. Three grams of nitrogen gas at 6 atm and 160°C is expanded adiabatically to double its initial volume, then compressed at constant pressure to its initial volume and then compressed again at constant volume to its initial state. Calculate the net work done on the gas. Draw the $p - V$ diagram for the process. Specific heat ratio of nitrogen is 1.4 . (12)

(May / June 2007)

16. Air expands by isentropic process through a nozzle from 784 kPa and 220°C to an exit pressure of 98 kPa . Determine the exit velocity and the mass flow rate, if the exit area is 0.0006 m^2 . (8)

(May / June 2007)

17. A blower handles 1 kg / sec of air at 293 K and consumes a power of 15 kW . The inlet and outlet velocities of air are 100 m / sec and 150 m / sec respectively. Find the exit air temperature, assuming adiabatic conditions. Take C_p of air as 1.005 kJ / kg.K . (9)

(Nov / Dec 2007)

18. One litre of hydrogen at 273 K is adiabatically compressed to one half of its initial volume. Find the change in temperature of the gas, if the ratio of two specific heats for hydrogen is 1.4 . (4)

(Nov / Dec 2007)

19. The velocity and enthalpy of fluid at the inlet of a certain nozzle are 50 m / sec and 2800 kJ / kg respectively. The enthalpy at the exit of nozzle is 2600 kJ / kg . The nozzle is horizontal and insulated so that no heat transfer takes place from it. Find

(i) Velocity of the fluid at exit of the nozzle

(ii) Mass flow rate, if the area at inlet of nozzle is 0.09 m^2 .

(iii) Exit area of the nozzle, if the specific volume at the exit of the nozzle is $0.495 \text{ m}^3 / \text{kg}$. (12)

(Nov / Dec 2007)

20. A three process cycle operating with nitrogen as the working substance has constant temperature compression at 34°C with initial pressure 100 kPa . Then the gas undergoes a constant volume heating and then polytrophic expansion with 1.35 as index of compression. The isothermal compression requires -67 kJ / kg of work. Determine

(i) P , v and T around the cycle.

(ii) Heat in and out

(iii) Net work.

For nitrogen gas, $C_v = 0.7431 \text{ kJ / kg.K}$. (16)

May / June 2013

21. A fluid is confined in a cylinder by a spring loaded, frictionless piston so that the pressure in the fluid is a linear function of the volume ($p = a + bV$). The internal energy of the fluid is given by $U = (34 + 3.15 pV)$ where U is in kJ , p in kPa and V in

cubic meter. If the fluid changes from an initial state of 170 kPa, 0.03 m³ to final state of 400 kPa, 0.06 m³, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. (12)

Nov / Dec 2012

22. Determine the heat transfer and its direction for a system in which a perfect gas having molecular weight of 6 is compressed from 101.3 kPa, 20°C to a pressure of 600 kPa following the law $pV^{1.3} = \text{constant}$. Take specific heat at constant pressure of gas as 1.7 kJ / kg. K. (16)

May / June 2014

23. Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800°C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650°C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500°C. If the air flow rate is 2 kg /s, Calculate (a) the rate of heat transfer to the air in the heat exchanger (b) the power output from the turbine assuming no heat loss, and (c) the velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as $h = C_p.t$, where C_p is the specific heat equal to 1.005 kJ / kg.K and t is the temperature.

Theory questions

1. Considering a system which changes its state, prove that the internal energy is a point function. (8)
Nov / Dec 2011
2. Define the following terms
(1) Thermodynamics
(2) Macroscopic approach
(3) Continuum. (6)
Nov / Dec 2012, Nov / Dec 2011
3. Deduce the expression for the displacement work in an isothermal process. (4)
(May / June 2007)
4. Describe steady flow energy equation and deduce suitable expression for the expansion of gas in a gas turbine with suitable assumptions. (8)
(May / June 2007)
5. (i) Derive the steady flow energy equation, stating the assumptions made. (6)
(ii) Prove that energy is a property of a system. (5)
(iii) Enumerate and explain the limitations of first law of thermodynamics. (5)
May / June 2013
6. Define enthalpy. How is it related to internal energy? (4)
Nov / Dec 2012
7. Derive steady flow energy equation and reduce it for turbine, pump, nozzle and a heat exchanger. (16)
Nov / Dec 2013
8. Briefly explain the following:
(i) Point function and path function. (4)
(ii) Property, state, process and path (8)
(iii) Quasi- static process. (4)
Nov / Dec 2013