STUDY MATERIAL

SUBJECT : BASIC MECHANICAL ENGG.(BME)

MODULE-I

SEMESTER :1ST /2ND

(ALL BRANCHES)

CONTENTS :

- OBJECTIVE TYPE QUESTIONS AND ANSWERS
- SHORT TYPE QUESTIONS AND ANSWERS
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DEPARTMENT OF MECHANICAL ENGINEERING

Imp. Notes

- First law of thermodynamics: (a) When a small amount of work (dw) is supplied to a closed system undergoing a cycle, the work supplied will be equal to the heat transfer or heat produced (dQ) in the system. (b) If Q amount of heat is given to a system undergoing a change of state and W is work done by the system and transferred during the process, the net energy ($Q - W$) will be stored in the system named as internal energy or simply energy of the system (ΔU).
- In a steady flow process, thermodynamic properties at any section remain constant with respect to time; it can vary only with respect to space.
- In some flow process mass flow rate is not steady but varies with respect to time. In such a case, the difference in energy flow is stored in system as ΔE_s.
- Second law of thermodynamics: The Kelvin–Planck statement of the second law can be given as: It is impossible for any system to operate in a thermodynamic cycle and deliver a net amount of energy by work to its surroundings while receiving energy by heat transfer from a single thermal reservoir.
- It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower temperature body to higher temperature body.
- A process is said to be reversible if it is possible for its effects to be eradicated in the sense that there is some way by which both the system and its surroundings can be exactly restored to their respective initial states. (It is not physically possible; it is an idealization.)
- A process is irreversible if there is no means by which the system and its surroundings can be exactly restored to their respective initial states.
- The thermal efficiency of an irreversible power cycle is always less than the thermal efficiency of a reversible power cycle when each operates between the same two thermal reservoirs.
- All reversible power cycles operating between the same two thermal reservoirs have the same thermal efficiency.
- Entropy is degree of measurement of disorderness of a system.
- Third law of thermodynamics states that it is impossible to reduce any system to absolute zero in a finite series of operations.
- Boyle's law states that the volume and pressure of a sample of gas are inversely proportional to each other at constant temperature.
- Charles's law states that the volume of a sample of gas is directly proportional to the absolute temperature when pressure remains constant.
- Gay Lussac's law states that the pressure of a sample of gas is directly proportional to the absolute temperature when volume remains constant.
- The sum of all the microscopic forms of energy is called the internal energy of a system and is denoted by U.
- Due to different type of movements of molecules, such as translational, rotational and vibrational, kinetic energy in the system is developed.
- Internal energy may be presented in the form of binding force at atomic level.
- If external energy is supplied to break the bond and to change the phase from solid to liquid or liquid to solid, a certain amount of energy is stored as latent energy. This latent energy represents internal energy of the system.
- In constant volume process, work done is equal to zero.
- In adiabatic process, heat transfer is equal to zero.

MULTIPLE CHOICE QUESTIONS

1. A closed system is one, which
   (a) permits the passage of energy and matter across boundaries
   (b) does not permit the passage of energy and matter across boundaries
   (c) permits the passage of energy but does not permit the passage of matter
   (d) does not permit the passage of energy but permits the matter

2. An isolated system is one, which
   (a) permits the passage of energy and matter across boundaries
   (b) permits passage of energy only

(c) does not permit the passage of energy and matter across boundaries
(d) permits the passage of matter only

3. A system comprising of single phase is known as
(a) open system
(b) closed system
(c) homogeneous system
(d) heterogeneous system

4. Control volume refers to
(a) a specified mass
(b) a fixed region in space
(c) a closed system
(d) none of the above

5. Specific heat is the amount of heat required to raise the temperature
(a) by unit degree of a substance
(b) by unit degree of a unit mass
(c) of a unit mass by 5°C
(d) none of these

6. Internal energy of a perfect gas depends upon
(a) temperature only
(b) temperature and pressure
(c) temperature, pressure and specific heats
(d) none of these

7. For a closed system, the difference between the heat added to the system and work done by the gas is equal to the change in
(a) enthalpy (b) entropy
(c) internal energy (d) temperature

8. The properties of the system, whose value for the entire system is equal to the sum of their values for individual parts of the system, are known as
(a) thermodynamic properties
(b) extensive properties
(c) intensive properties
(d) none of the above

9. Temperature of a system is
(a) thermodynamic properties
(b) extensive properties
(c) intensive properties
(d) none of the above

10. When two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other
(a) zeroth law of thermodynamics
(b) first law of thermodynamics
(c) second law of thermodynamics
(d) none of the above

11. The measurement of thermodynamic properties known as temperature is based on
(a) zeroth law of thermodynamics
(b) first law of thermodynamics
(c) second law of thermodynamics
(d) none of the above

12. Heat and work are mutually convertible. This statement is
(a) zeroth law of thermodynamics
(b) first law of thermodynamics
(c) second law of thermodynamics
(d) none of the above

13. Second law of thermodynamics defines
(a) enthalpy (b) entropy
(c) heat (d) work

14. Kelvin–Planck's law deals with
(a) conversion of work into heat
(b) conversion of heat into work
(c) conservation of work
(d) conservation of heat

15. According to Kelvin–Planck's statement, a perpetual motion machine
(a) of first kind is possible
(b) of first kind is impossible
(c) of second kind is impossible
(d) of second kind is possible

16. A perpetual motion machine of the first kind, i.e., a machine which produces power without consuming any energy is
(a) possible according to the first law of thermodynamics
(b) impossible according to first law of thermodynamics
(c) impossible according to second law of thermodynamics
(d) possible according to second law of thermodynamics

17. Heat flows from cold substance to hot substance with the aid of external work. This statement is given by
(a) Kelvin (b) Joule
(c) Gay Lussac (d) Clausius

18. Specific heat at constant volume is given by
(a) $\frac{R}{J(\gamma-1)}$ (b) $\frac{\gamma R}{J(\gamma-1)}$
(c) $\frac{R(\gamma-1)}{J}$ (d) $\frac{J(\gamma-1)}{R}$

19. Specific heat at constant pressure is given by
(a) $\frac{R}{J(\gamma-1)}$ (b) $\frac{\gamma R}{J(\gamma-1)}$
(c) $\frac{R(\gamma-1)}{J}$ (d) $\frac{J(\gamma-1)}{R}$

20. The condition for reversibility of a cycle is
(a) $\oint \frac{dQ}{T} < 0$ (b) $\oint \frac{dQ}{T} > 0$
(c) $\oint \frac{dQ}{T} = 0$ (d) none of the above

21. The condition for irreversibility of a cycle is
(a) $\oint \frac{dQ}{T} < 0$ (b) $\oint \frac{dQ}{T} > 0$
(c) $\oint \frac{dQ}{T} = 0$ (d) none of the above

22. If $\oint \frac{dQ}{T} > 0$, the cycle is
(a) reversible (b) irreversible
(c) impossible (d) none of the above

23. Biogas is produced under anaerobic conditions by the fermentation of biological materials. What is the main constituent of biogas?
(a) butane (b) ethane
(c) methane (d) propane

24. A sample of neon gas occupies a volume of 2.8 l at 1.8 atm. What will its volume be at 1.2 atm?
(a) 1.2 l (b) 1.8 l
(c) 2.2 l (d) 4.2 l

25. The pressure required to compress 48 l of oxygen gas at 99.3 kPa in order to reduce its volume to 16 l is
(a) 198 kPa (b) 278 kPa
(c) 298 kPa (d) 320 kPa

26. Volume of sulphur dioxide gas at 0.989 atm is 59 ml. What will be its volume at 0.967 atm?
(a) 60.3 ml (b) 68 ml
(c) 80 ml (d) 108 ml

27. A sample of hydrogen gas at 6.5 atm pressure occupies a volume of 2.2 l. What will be its volume at 1.15 atm?
(a) 10 l (b) 12 l
(c) 14 l (d) 16 l

28. A balloon full of air has a volume of 2.75 l at a temperature of 291 K. What will be volume of the balloon at 318 K?
(a) 2.10 l (b) 3.01 l
(c) 3.5 l (d) 4.12 l

29. A sample of argon gas has a volume of 0.43 ml at 297 K. At what temperature will it have a volume of 0.57 ml?
(a) 394 K (b) 294 K
(c) 494 K (d) 194 K

30. When the atmospheric pressure is increased on a balloon, the volume of the balloon will
(a) increase (b) decrease
(c) stay the same (d) none of these

31. When the temperature of a gas is increased in a balloon, the volume of the balloon will
(a) increase (b) decrease
(c) stay the same (d) none of these

32. When the volume of a gas is decreased, the pressure of the gas will
(a) increase (b) decrease
(c) stay the same (d) none of these

33. A balloon is filled with helium gas to a pressure of 107 kPa when the temperature is 295 K. If the temperature changes to 318 K, what will be the pressure of the helium in the balloon?
(a) 115 kPa (b) 125 kPa
(c) 135 kPa (d) 145 kPa

34. An isothermal process is governed by
(a) Boyle's law (b) Charle's law
(c) Joule's law (d) Gay Lussac's law

35. When the expansion follows the law $PV^n = C$, the process is
(a) isothermal process
(b) adiabatic process
(c) polytropic process
(d) hyperbolic process

36. Real gas follows the relation
(a) $PV = RT$ (b) $PV^n = RT$
(c) $PV = nRT$ (d) $(PV)^n = C$

37. For real gas, $C_p = C_v$, at
(a) absolute zero
(b) critical temperature
(c) triple point
(d) all temperature

Answers

1. (c), 2. (c), 3. (c), 4. (b), 5. (b), 6. (a), 7. (c), 8. (b), 9. (c), 10. (a), 11. (a), 12. (b), 13. (b) 14. (b), 15. (c), 16. (b), 17. (d), 18. (a), 19. (b), 20. (c), 21. (a), 22. (c), 23. (c), 24. (d), 25. (c), 26. (a), 27. (b), 28. (b), 29. (a), 30. (b), 31. (a), 32. (a), 33. (a), 34. (a), 35. (c), 36. (c), 37. (a)

FILL IN THE BLANKS

1. The system and surrounding together constitute _____ system.
2. In an adiabatic process, energy can be exchanged in the form of _____.
3. For an ideal gas (dh/dT) is a measure of _____ at constant pressure.
4. Second law of thermodynamics establishes the law of _____.
5. The slope of constant volume line on T–S diagram is _____ than that of constant pressure line.
6. The unit of entropy is _____.
7. In case of free expansion enthalpy _____.
8. The entropy of universe tends to be _____.

Answers

1. Isolated, 2. Heat, 3. Specific heat, 4. Entropy, 5. More, 6. kJ/kg K, 7. Remains constant, 8. Maximum.

REVIEW QUESTIONS (Imp. Questions for Semester Exam)

1. What is prime mover? Discuss its importance in energy conversion.
2. Explain the various sources of energy mentioning renewable and non-renewable sources.
3. What do you mean by non-conventional energy sources? How does it differ from conventional sources?
4. Explain the scope of solar energy and its future applications.
5. Define: (i) property, (ii) state, (iii) system, (iv) control volume, and (v) process.
6. Discuss the concept of thermal equilibrium and state zeroth law of thermodynamics.
7. What do you understand by quasi-static process? How it is achieved?
8. Differentiate among temperature, heat, and internal energy.
9. Derive an expression for first law of thermodynamics applied to a closed system. Define the internal energy of a system.
10. Define work. Show that work done $W = PdV$.
11. Discuss the thermodynamics system, surrounding, and universe. Also discuss the various types of system with suitable example.
12. Prove that work and heat are the path function.
13. Derive the expression for work done in steady flow process.
14. Distinguish between the term 'change of state', 'path', and 'process'.
15. State the zeroth law of thermodynamics and first law of thermodynamics.
16. Explain and derive steady flow energy equation (SFEE).
17. State the Kelvin–Planck and Clausius statements of second law of thermodynamics. Explain the equivalence of Kelvin–Planck and Clausius statements.
18. State and explain Carnot theorem.
19. Write the statement of Boyle's law.
20. Write the statement of Charle's law.
21. Write the statement of Gay–Lussac's law.

Short Questions and Answers

MODULE 1

Thermodynamics

1.1. Define thermodynamic system.

A specified space or region containing matter or group of matter, where the transformation of mass and energy from one form to another is studied, is called thermodynamic system.

1.2 Define thermodynamic system Classify the following system as open/closed/isolated

(a) Mixture of ice and water in a metal container (b) A wind mill.

Thermodynamic system is defined as a space or constrained area upon which our attention is concentrated on. It is the region to be studied.

(a) Mixture of ice and water in a metal container - closed system

(b) A wind mill - open system

1.3 What is meant by thermodynamic system? How do you classify it?

Thermodynamic system is defined as any space or matter or group of matter where the energy transfer or energy conversions are studied.

It may be classified into three types.

(a) open system

(b) closed system

(c) isolated system.

1.4 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 with valves closed.

1.5 Define open system. Give an example.

When a system has heat, work and mass transfer, it is called as open system. Example: Air compressor.

1.6. What is surroundings?

The space or matter external to a thermodynamic system is called surroundings.

1.7 Differentiate closed and open system:

Closed System		Open System	
1.	There is no mass transfer. Only heat and work will transfer.	1.	Mass transfer will take place, in addition with heat and work transfer.
2.	System boundaries are real.	2.	System boundaries are often imaginary.
	Example: Piston & cylinder arrangement, Thermal power plant.		Air compressor, boiler.

1.8 Define an isolated system:

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

Example: Entire Universe.

1.9 What is meant by surroundings?

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

1.10 What is boundary?

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

1.11. Define property of a system.

Any characteristic used to identify the system and it can be measured directly or indirectly when the system is in equilibrium is known as property., (e.g) pressure, volume, temperature.

1.12 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 it can be measured, when the system remains in an equilibrium state.

1.13. How do you classify the property?

Thermodynamic property can be classified into two types.

1. Intensive or Intrinsic property
2. Extensive or Extrinsic property.

1.14. Define intensive and extensive properties.

The property of a thermodynamic system which is independent of its mass is called intensive property. (e.g) pressure, temperature. The property of a thermodynamic system which is dependent or proportional to its mass is called extensive property. (e.g) volume

1.15. Differentiate Intensive and Extensive properties.

Intensive Properties		**Extensive Properties**	
1.	Independent on the mass of the system.	1.	Dependent on the mass of the system.
2.	If we consider part of the system, these properties remain same.	2.	If we consider part of the system it will have a lesser value.
	e.g. pressure, Temperature, specific volume etc.		e.g. Total energy, Total volume, weight etc.,

1.16. Define the term process.

It is defined as the change of states undergone by a fluid due to energy flow.

1.17. Define the term Cycle.

When a system undergoes a series of processes and return to its original state, it is known as cycle.

1.18. What is meant by open and closed cycle?

In a closed cycle, the same working substance will recirculate again and again.

In an open cycle, the working substance will be exhausted to the surroundings after expansion.

1.19 What is meant by reversible and irreversible process?

If a process traces the same path in the reverse direction when the process is reversed, then it is called reversible process. It is possible only when the system passes through a continuous series of equilibrium state.

If a system does not passes through continuous equilibrium state, then the process is said to be irreversible. All the processes in the world are irreversible processes.