



**POSTAL
BOOK PACKAGE**

2025

CONTENTS

**MECHANICAL
ENGINEERING**

Objective Practice Sets

Thermodynamics

1. Basic Concepts & Zeroth Law of Thermodynamics 2 - 8
2. Energy and Energy Interactions 9 - 18
3. First Law of Thermodynamics 19 - 29
4. Open System Analysis by First Law 30 - 37
5. Second Law of Thermodynamics 38 - 47
6. Entropy 48 - 67
7. Properties of Pure Substances 68 - 79
8. Thermodynamic Relations 80 - 87

Basic Concepts & Zeroth Law of Thermodynamics

MCQ and NAT Questions

- Q.1** A system and its environment put together constitute
- an adiabatic system
 - an isolated system
 - a segregated system
 - a homogeneous system
- Q.2** A closed system is a
- variable mass and variable energy system
 - fixed mass and variable energy system
 - fixed mass and fixed energy system
 - constant entropy system
- Q.3** A system is said to be in thermodynamic equilibrium if
- it is in mechanical, chemical and thermal equilibrium.
 - it is in thermal equilibrium
 - it is in electrical, chemical and mechanical equilibrium
 - volume is changing and pressure is constant
- Q.4** Diathermic wall means
- it would not allow the flow of heat
 - it would allow the flow of heat
 - there is no such thing as diathermic wall
 - it only allows the flow of mass
- Q.5** An adiabatic boundary is one which
- prevents heat transfer
 - permits heat transfer
 - prevents work transfer
 - permits work transfer
- Q.6** Which one of the following is not the correct statement about control volume?
- Matter flows continuously in and out
 - Heat and work flows across the control surface
 - Control volume must be stationary
 - Focusses a definite volume and volume is enclosed by control surface
- Q.7** Which of the following are intensive properties?
- Energy
 - Specific Energy
 - Pressure
 - Density
- (i) and (iii)
 - (i), (ii) and (iii)
 - (ii), (iii) and (iv)
 - (iii) and (iv)
- Q.8** A quasi-static process is
- a succession of equilibrium states that can be retraced back to initial condition
 - a succession of equilibrium states that cannot be retraced back to initial condition
 - infinitely slow
 - spontaneous
- Which of the above is/are correct?
- (i) and (iv)
 - (ii) and (iii)
 - (iv) only
 - (i) and (iii)
- Q.9** In macroscopic approach of thermodynamic analysis,
- a certain quantity of matter is considered, without the events occurring at the molecular level being taken into consideration.
 - a certain quantity of matter is considered, with events occurring at the molecular level being taken into consideration.
 - is completely independent of the assumptions regarding the nature of the matter.
 - nature of the matter has implication on the analysis.
- (i) and (iii) are correct
 - (i) and (iv) are correct
 - (ii) and (iii) are correct
 - only (iii) is correct
- Q.10** Consider the following statements:
- Thermodynamic properties are the macroscopic coordinates significant only for systems existing in states of thermodynamic equilibrium.
 - Engineering thermodynamic studies about rate of storage, transfer and transformation of energy.

Answers Basic Concepts & Zeroth Law of Thermodynamics

1. (b) 2. (b) 3. (a) 4. (b) 5. (a) 6. (c) 7. (c) 8. (d) 9. (a)
 10. (b) 11. (a) 12. (d) 13. (a) 14. (b) 15. (d) 16. (c) 17. (d) 18. (c)
 19. (d) 20. (d) 21. (d) 22. (c) 23. (b) 24. (d) 25. (d) 26. (c) 27. (c)
 28. (d) 29. (70.41) 30. (a) 31. (a) 32. (b) 33. (b) 34. (d) 35. (a, c)
 36. (b, c)

Explanations Basic Concepts & Zeroth Law of Thermodynamics**1. (b)**

An isolated system is one in which there is no interaction of system with the surrounding.

for isolated system

$$\delta Q = 0$$

$$\delta W = 0$$

The first law gives

$$\delta Q = \delta U + \delta W$$

$$\delta u = 0$$

$$u = \text{constant}$$

The energy of isolated system is constant.

2. (b)

A closed system is a system of fixed mass. There is no mass transfer across the system boundary. There may be energy transfer in or out of the system.

3. (a)

A system is said to be in thermodynamic equilibrium if it is in:

1. Thermal equilibrium (equality of temperature)
2. Mechanical equilibrium (equality of force/pressure)
3. Chemical equilibrium (equality of chemical potential)

5. (a)

An adiabatic boundary is one which prevents heat transfer.

6. (c)

Control volume is a volume which is surrounding the device to be analysed. From the boundary of control volume, both mass and energy (in the form of heat and work) can cross.

7. (c)

Intensive properties are independent of size or mass, ex. pressure, temperature, density, thermal conductivity, etc. All specific properties like specific volume, specific internal energy, specific enthalpy, specific entropy are intensive properties.

8. (d)

A quasi-static process is a succession of equilibrium states that can be retraced back to initial condition. It is carried out in infinitely slow manner so that every point passes through equilibrium states.

9. (a)

In macroscopic approach of thermodynamic analysis, individual molecular behaviour is not taken into consideration, but the average behaviour of molecules is taken into consideration. So (i) and (iii) statements are correct.

10. (b)

- Thermodynamic properties are the macroscopic coordinates significant only for systems existing in states of thermodynamic equilibrium.
- Engineering thermodynamics studies about storage transfer and transformation of energy, not the rate of all these.

11. (a)

The isolated system is one in which there is no interaction between the system and surrounding. It is of fixed mass and energy, and there is no mass or energy transfer across the system boundary. However there might be chemical reaction taking place within the system.

Thermodynamic Relations

MCQ and NAT Questions

Q.1 For an ideal gas

(a) $\left(\frac{\partial S}{\partial T}\right)_V > \left(\frac{\partial S}{\partial T}\right)_P$ (b) $\left(\frac{\partial T}{\partial S}\right)_V = \left(\frac{\partial T}{\partial S}\right)_P$

(c) $\left(\frac{\partial T}{\partial S}\right)_V > \left(\frac{\partial T}{\partial S}\right)_P$ (d) None of these

Q.2 Given below are Maxwell's relations which of the following is correct.

(a) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial p}{\partial S}\right)_V$ (b) $\left(\frac{\partial T}{\partial p}\right)_S = -\left(\frac{\partial V}{\partial S}\right)_p$

(c) $\left(\frac{\partial p}{\partial T}\right)_V = -\left(\frac{\partial S}{\partial V}\right)_T$ (d) $\left(\frac{\partial V}{\partial T}\right)_p = -\left(\frac{\partial S}{\partial p}\right)_T$

Q.3 The third Tds equation is given by

(a) $Tds = C_v \left(\frac{\partial T}{\partial V}\right)_p dV + C_p \left(\frac{\partial T}{\partial p}\right)_v dp$

(b) $Tds = C_v \left(\frac{\partial T}{\partial p}\right)_v dp + C_p \left(\frac{\partial T}{\partial V}\right)_p dV$

(c) $Tds = C_v \left(\frac{\partial T}{\partial V}\right)_v - C_p \left(\frac{\partial T}{\partial p}\right)_p dp$

(d) $Tds = C_v \left(\frac{\partial T}{\partial V}\right)_p dV - C_p \left(\frac{\partial T}{\partial p}\right)_v dp$

Q.4 The value of β and μ_J for an ideal gas is

(a) $\beta = \frac{1}{p}$ and $\mu_J = 0$

(b) $\beta = \frac{1}{T}$ and $\mu_J = 0$

(c) $\beta = \frac{1}{T}$ and $\mu_J < 0$

(d) $\beta = \frac{1}{p}$ and $\mu_J < 0$

where, β is volume expansivity and μ_J is Joule - kelvin coefficient

Q.5 Consider the following statements with regard to Joule - Kelvin expansion and choose the correct one.

(a) Inversion curve is the locus of all points at which μ_J is zero.

(b) Inversion curve is the locus of all points having maximum value of μ_J .

(c) Inversion curve is the locus of all points having minimum value of μ_J .

(d) None of these

Q.6 Choose the correct expression for Joule kelvin coefficient

(a) $\mu_J = \frac{1}{C_v} \left[T \left(\frac{\partial v}{\partial T}\right)_p - v \right]$

(b) $\mu_J = \frac{1}{C_p} \left[T \left(\frac{\partial v}{\partial T}\right)_p - v \right]$

(c) $\mu_J = \frac{1}{C_p} \left[T \left(\frac{\partial v}{\partial T}\right)_v - p \right]$

(d) $\mu_J = \frac{1}{C_v} \left[T \left(\frac{\partial v}{\partial T}\right)_v - p \right]$

Q.7 Consider the Vander Waals equation

$$\left(p + \frac{a}{V^2}\right)(V - b) = RT$$

Choose the correct option

(a) Coefficient a is introduced to account for volume of the molecules

(b) Coefficient b is introduced to account for the volume of the molecules

(c) Coefficient b is introduced to account for the force of cohesion

(d) None of these

Answers **Thermodynamic Relations**

1. (c) 2. (d) 3. (b) 4. (b) 5. (a) 6. (b) 7. (b) 8. (c) 9. (a)
 10. (b) 11. (d) 12. (c) 13. (b) 14. (d) 15. (b) 16. (b) 17. (d) 18. (a)
 19. (d) 20. (d) 21. (b) 22. (a) 23. (a) 24. (3.66) 25. (1000) 26. (a) 27. (d)
 28. (d) 29. (a) 30. (a) 31. (a) 32. (a, b, c, d) 33. (b, c, d) 34. (a, b, c, d)

Explanations **Thermodynamic Relations****1. (c)**

For an ideal gas, $\left(\frac{\partial T}{\partial S}\right)_V > \left(\frac{\partial T}{\partial S}\right)_P$

Slope of constant volume > Slope of constant pressure on T - s diagram.

2. (d)

Four Maxwell's equations are:

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$$

$$\left(\frac{\partial T}{\partial p}\right)_S = \left(\frac{\partial V}{\partial S}\right)_p$$

$$\left(\frac{\partial p}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$$

$$\left(\frac{\partial V}{\partial T}\right)_p = -\left(\frac{\partial S}{\partial p}\right)_T$$

3. (b)

Let entropy S be imagined as a function of p and V , then

$$dS = \left(\frac{\partial S}{\partial p}\right)_V dp + \left(\frac{\partial S}{\partial V}\right)_p dV$$

$$TdS = T\left(\frac{\partial S}{\partial p}\right)_V dp + T\left(\frac{\partial S}{\partial V}\right)_p dV$$

$$= T\left(\frac{\partial S}{\partial p}\right)_V \left(\frac{\partial T}{\partial T}\right)_V dp + T\left(\frac{\partial S}{\partial V}\right)_p \left(\frac{\partial T}{\partial T}\right)_p dV$$

$$= \left\{T\left(\frac{\partial S}{\partial T}\right)_V\right\} \left(\frac{\partial T}{\partial p}\right)_V dp + \left\{T\left(\frac{\partial S}{\partial T}\right)_p\right\} \left(\frac{\partial T}{\partial V}\right)_p dV$$

$$TdS = C_V \left(\frac{\partial T}{\partial p}\right)_V dp + C_p \left(\frac{\partial T}{\partial V}\right)_p dV$$

4. (b)

$$\mu_J = \left(\frac{\partial T}{\partial p}\right)_h = \frac{1}{C_p} \left[T \left(\frac{\partial V}{\partial T}\right)_p - V \right]$$

$$\text{Volume expansivity, } \beta = \frac{1}{V} \left(\frac{\partial V}{\partial T}\right)_p$$

For an ideal gas,

$$\mu_J = \frac{V}{C_p} \left[\frac{T}{V} \left(\frac{\partial V}{\partial T}\right)_p - 1 \right] = \frac{V}{C_p} [\beta T - 1] = 0$$

and
$$\beta = \frac{1}{T}$$

5. (a)

Inversion curve is the locus of all points at which μ_J is zero.

6. (b)

Joule - Kelvin coefficient,

$$\mu_J = \left(\frac{\partial T}{\partial p}\right)_h = \frac{1}{C_p} \left[T \left(\frac{\partial V}{\partial T}\right)_p - V \right]$$

7. (b)

In Van der Waals equation $\left(p + \frac{a}{V^2}\right)(V - b) = RT$, coefficient a is introduced to account for the force of cohesion and coefficient b is introduced to account for the volume of the molecules.

8. (c)

Since $\left(\frac{\partial V}{\partial T}\right)_p^2$ is always positive and $\left(\frac{\partial p}{\partial V}\right)_T$ for

any substance is negative, $(C_p - C_V)$ is always positive. Therefore, C_p is always greater than C_V . Temperature T always have positive value.

9. (a)

Gibbs free energy

$$G = H - TS$$

Helmholtz function

$$A = U - TS$$