



POSTAL BOOK PACKAGE 2024

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MECHANICAL ENGINEERING

Objective Practice Sets

Thermodynamics

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Basic Concepts & Zeroth Law of Thermodynamics

MCQ and NAT Questions

- Q.1** A thermodynamic system refers to
(a) any defined region in space with fixed boundary
(b) a specified mass in fluid flow
(c) a specified region of constant volume
(d) a prescribed and identifiable quantity of matter
- Q.2** A system and its environment put together constitute
(a) an adiabatic system
(b) an isolated system
(c) a segregated system
(d) a homogeneous system
- Q.3** A closed system is a
(a) variable mass and variable energy system
(b) fixed mass and variable energy system
(c) fixed mass and fixed energy system
(d) constant entropy system
- Q.4** The study of thermodynamics provides answer to the followings:
1. whether a process is feasible or not
2. to quantify the energy required for a process
3. rate or speed with which a process occurs
4. extent to which a reaction/process takes place
Which of the above statements are correct?
(a) 1, 2 and 3 (b) 1 and 2
(c) 1, 2 and 4 (d) 2, 3 and 4
- Q.5** A system is said to be in thermodynamic equilibrium if
(a) it is in mechanical, chemical and thermal equilibrium.
(b) it is in thermal equilibrium
(c) it is in electrical, chemical and mechanical equilibrium
(d) volume is changing and pressure is constant
- Q.6** Diathermic wall means
(a) it would not allow the flow of heat
(b) it would allow the flow of heat
(c) there is no such thing as diathermic wall
(d) it only allows the flow of mass
- Q.7** An adiabatic boundary is one which
(a) prevents heat transfer
(b) permits heat transfer
(c) prevents work transfer
(d) permits work transfer
- Q.8** In a quasi-equilibrium process, the pressure in a system
(a) remains constant
(b) varies with temperature
(c) is everywhere constant at any instant
(d) increase if volume increases
- Q.9** Which one of the following is not the correct statement about control volume?
(a) Matter flows continuously in and out
(b) Heat and work flows across the control surface
(c) Control volume must be stationary
(d) Focusses a definite volume and volume is enclosed by control surface
- Q.10** Which of the following are intensive properties?
(i) Energy
(ii) Specific Energy
(iii) Pressure
(iv) Density
(a) (i) and (iii) (b) (i), (ii) and (iii)
(c) (ii), (iii) and (iv) (d) (iii) and (iv)
- Q.11** A quasi-static process is
(i) a succession of equilibrium states that can be retraced back to initial condition
(ii) a succession of equilibrium states that cannot be retraced back to initial condition
(iii) infinitely slow
(iv) spontaneous
Which of the above is/are correct?
(a) (i) and (iv) (b) (ii) and (iii)
(c) (iv) only (d) (i) and (iii)

Q.12 In macroscopic approach of thermodynamic analysis,

- (i) a certain quantity of matter is considered, without the events occurring at the molecular level being taken into consideration.
 - (ii) a certain quantity of matter is considered, with events occurring at the molecular level being taken into consideration.
 - (iii) is completely independent of the assumptions regarding the nature of the matter.
 - (iv) nature of the matter has implication on the analysis.
- (a) (i) and (iii) are correct
 - (b) (i) and (iv) are correct
 - (c) (ii) and (iii) are correct
 - (d) only (iii) is correct

Q.13 Consider the following statements:

1. Thermodynamic properties are the macroscopic coordinates significant only for systems existing in states of thermodynamic equilibrium.
2. Engineering thermodynamic studies about rate of storage, transfer and transformation of energy.
3. Engineering thermodynamics studies about storage, transfer and transformation of energy.

Which of the above statements are correct?

- (a) 3 only
- (b) 1 and 3
- (c) 2 only
- (d) 1 and 2

Q.14 For an isolated system executing a process

1. no heat transfer takes place
2. no work is done
3. no mass crosses the boundary
4. no chemical reaction takes place within the system

Which of the above statements are correct?

- (a) 1, 2 and 3
- (b) 1, 3 and 4
- (c) 2, 3 and 4
- (d) all of the above

Q.15 Which of the following aspect is not true regarding microscopic properties of thermodynamic system?

- (a) a knowledge of the structure of matter is essential.
- (b) a limited number of variables/properties are needed to describe the state of matter.
- (c) the values of these variables cannot be measured.
- (d) statistical averaging is adopted to predict the behaviour of individual fluid particles.

Q.16 The value of an extensive property is extensively dependent on

- (a) mass or extent of the system
- (b) interaction of the system with its surroundings
- (c) path followed by the system in going from one state to another
- (d) nature of boundaries, rigid or flexible

Q.17 Which of the following statements regarding the concept of continuum are correct?

1. Small number of molecules enable meaningful statistical averaging and assignment of property values
2. Mean free path of the molecules is order of magnitude much lower than system dimensions
3. Behaviour of individual molecules is disregarded
4. Mean free path of the molecules approaches the order of magnitude of the system dimensions

- (a) 1 and 3
- (b) 2 and 3
- (c) 3 and 4
- (d) 1 and 4

Q.18 State of pure substance can be fixed by specifying

- (a) one property
- (b) two properties
- (c) three properties
- (d) none of these

Q.19 Consider the following statements regarding a pure substance.

1. A pure substance is one that has a homogeneous and invariable chemical composition.
2. It may exist in more than one phase, but the chemical composition is the same in all phases.
3. A mixture of liquid air and gaseous air is a pure substance.
4. A mixture of liquid water and water vapor (steam), and a mixture of ice and liquid water all represent pure substance.

Which of the following statements are correct?

- (a) 3, 2 and 1 only
- (b) 2, 3 and 4 only
- (c) 1 and 4 only
- (d) 4, 2 and 1 only

Q.20 In a mixture there are 5 gases present. The degree of freedom of the mixture is

- (a) 4
- (b) 5
- (c) 6
- (d) 7

- Q.21** A system which is in thermodynamic equilibrium will
- deliver maximum reversible work.
 - have maximum thermal efficiency
 - deliver both maximum reversible work and have maximum thermal efficiency
 - do not deliver anything

- Q.22** Consider the following statements and mark the correct answer.
- Cyclic integral of a property can be zero.
 - Cyclic integral of a property is always greater than zero
 - Cyclic integral of a property is always zero
 - Cyclic integral of a property is less than zero

- Q.23** Consider the following:

- Temperature
- Viscosity
- Internal energy
- Entropy

Which of these are extensive properties?

- 1, 2, 3 and 4
- 2 and 4 only
- 2 and 3 only
- 3 and 4 only

- Q.24** Zeroth law of thermodynamics state that

- Two thermodynamic system are always in thermal equilibrium with each other.
- If two systems are in thermal equilibrium then the third system will also be in thermal equilibrium
- Two systems not in thermal equilibrium with a third system will also not in thermal equilibrium with each other.
- When two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other.

- Q.25** Which one of the following correctly defines 1 K, as per the internationally accepted definition of temperature scale ?

- $1/100^{\text{th}}$ of the difference between normal boiling point and normal freezing point water
- $1/273.15^{\text{th}}$ of the normal freezing point of water
- 100 times the difference between the triple point of water and the normal freezing point of water
- $1/273.15^{\text{th}}$ of the triple point of water

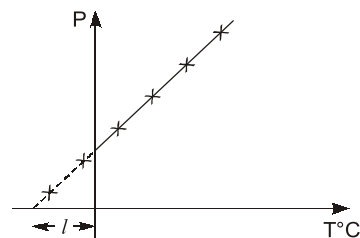
- Q.26** Thermocouple is based on

- Joule's effect
- Peltier effect
- Seebeck effect
- Boyle's Law

- Q.27** An apple loses 4.5 kJ of heat as it cools per $^{\circ}\text{C}$ drop in its temperature. The amount of heat lost from the apple per $^{\circ}\text{F}$ drop in its temperature is

- 1.25 kJ
- 2.5 kJ
- 5.0 kJ
- 8.1 kJ

- Q.28** Experimental data obtained from a constant-volume-gas thermometer is shown in the figure below. The value of I (in $^{\circ}\text{C}$) is



- 273.15
- 1.0
- 100
- 273.15

- Q.29** A new temperature scale in degrees 'N' is to be defined. The boiling and freezing points on these scale are 400°N and 100°N respectively. What will be the reading on new scale corresponding to 60°C ?

- 120°N
- 180°N
- 220°N
- 280°N

- Q.30** The constant volume gas thermometer works on the principle that

- at low pressure, the temperature of the gas is independent of its pressure at constant volume
- at high pressure, the temperature of the gas is independent of its pressure at constant volume
- at low pressure, the temperature of the gas is proportional to its pressure at constant volume
- at high pressure, the temperature of the gas is proportional to its pressure at constant volume

- Q.31** Which of the following is used for measuring high temperature beyond 1063°C ?

- Platinum-platinum/Rhodium thermocouple
- Electrical resistance thermometer
- Optical method using Planck's law of thermal radiation
- Constant pressure gas thermometer

Q.32 Match the column and select the correct answer using the codes given below:

Thermometric property	Thermometric property
A. Volume	1. Electric-resistance thermometer
B. Resistance	2. Thermocouple
C. Length	3. Mercury-in-glass thermometer
D. Thermal E.M.F.	4. Constant pressure gas thermometer

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	3	4	1	2
(c)	4	2	3	4
(d)	4	1	3	2

Q.33 Match **List-I** (item) with **List-II** (temperature measuring device) and select the correct answer from the codes given below the lists:

List-I	List-II
A. Condenser	1. Mercury Thermometer
B. Boiler combustion space	2. Radiation Pyrometer
C. Incandescent gas mantels	3. Optical Pyrometer
D. Economiser	4. Base metal Pyrometer

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	2	3	1
(c)	4	3	2	1
(d)	1	3	2	4

Q.34 Match **List-I** with **List-II** the following:

List-I
A. Normal boiling point of oxygen
B. Triple point of water
C. Normal boiling point of water
D. Normal melting point of gold

List-II	
1. 100°C	2. -183°C
3. 1063°C	4. 0.01°C
5. 0.001°C	

Codes:

	A	B	C	D
(a)	2	5	3	1
(b)	2	4	1	3
(c)	2	5	1	3
(d)	3	4	1	2

Direction (Q.35 to Q.37): The following questions consist of two statements, one labelled as '**Assertion (A)**' and the other labelled as '**Reason (R)**'. You are to examine these two statements carefully and select the answers to these items using the codes given below.

Codes:

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not a correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Q.35 Assertion (A): If an alcohol and a mercury thermometer read exactly 0°C at the ice point and 100°C at the steam point and the distance between the two points is divided into 100 equal parts in both thermometers, the two thermometers will give exactly the same reading at 50°C.

Reason (R): Temperature scales are arbitrary.

Q.36 Assertion (A): Air is a pure substance but a mixture of air and liquid air in a cylinder is not a pure substance.

Reason (R): Air is homogenous in composition but a mixture of air and liquid air is heterogeneous.

Q.37 Assertion (A): The three phase (triple state/point) of a single component system possesses a single set of properties.

Reason (R): For a single component system, the Gibbs phase rule, $F = C + 2 - P$ (where F is number of independent, C is number of components in the system and P is number of phases), reduces to $F = 3 - P$.

Direction (Q.38 to Q.41): The following questions consist of two statements, one labelled as '**Statement (I)**' and the other labelled as '**Statement (II)**'. You are to examine these two statements carefully and select the answers to these items using the codes given below.

Codes:

- (a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
- (b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
- (c) Statement (I) is true but Statement (II) is false.
- (d) Statement (I) is false but Statement (II) is true.

Q.38 Statement (I) : Negative temperature are impossible on the Kelvin scale.

Statement (II): The Kelvin scale is thermodynamic temperature scale.

Q.39 Statement (I) : A homogeneous mixture of gases that do not react within themselves can be treated as a pure substance.

Statement (II) : Flue gases can be treated as homogeneous mixture of gases.

Q.40 Statement (I): Thermometers using different thermometric property substance may give different readings except at two fixed points.

Statement (II) : Thermodynamic temperature scale is independent of any particular thermometric substance.

Q.41 Statement (I): Quasi-static process does not always means process must be extremely slow.

Statement (II): Quasi-static process always does not guarantee process to be reversible.

Q.42 The resistance of the windings in a certain motor is found to be 80 ohms at room temperature (25°C). When operating at full load under steady state conditions, the motor is switched off and the resistance of the windings, immediately measured again, is found to be 93 ohms. The windings are made of copper whose resistance at temperature t °C is given by

$$R_t = R_0[1 + 0.00393 t]$$

where R_0 is the resistance at 0 °C. The temperature attained by the coil during full load is _____ °C.

Multiple Select Questions (MSQ)

Q.43 A vessel of 2 m³ volume contains hydrogen at atmospheric pressure (i.e. 76 cm of Hg) and 27°C

temperature. An evacuating pump is connected to vessel and the evacuation process is continued till its pressure becomes 70 cm of Hg vacuum. Which of the following statements is/are correct?

- (a) Mass of hydrogen pumped out at constant temperature is 0.15 kg.
- (b) Mass of hydrogen pumped out at constant temperature is 0.372 kg.
- (c) The final pressure in the vessel is 7.546 kPa, if cooling is carried upto 10°C after evacuation process.
- (d) The final pressure in the vessel is 5.14 kPa, if cooling is carried upto 10°C after evacuation process.

Q.44 A temperature scale is being developed using the following relation:

$$t = a \ln(p) + 0.5b$$

where, p is thermometric property and 'a' and 'b' are constants. The ice point and steam point give thermo-metric property value of 3 and 8.

Which of the following statements is/are correct?

- (a) The value of constant 'a' and 'b' is 101.96 and 112 respectively.
- (b) The value of constant 'a' and 'b' is 101.96 and -224 respectively.
- (c) The temperature corresponding to thermometric property of 6.5 is 78.83°C.
- (d) The temperature corresponding to thermometric property of 6.5 is 302.8°C.

Q.45 Which of the following statements is/are correct?

- (a) Ratio of two extrinsic properties is a intrinsic property.
- (b) Extrinsic properties are independent of mass.
- (c) Heat and work are path-functions.
- (d) Free expansion is an irreversible process.

■■■■

Answers

Basic Concepts & Zeroth Law of Thermodynamics

- | | | | | | | | | |
|---------|---------|---------|---------|---------|-------------|------------|------------|---------------|
| 1. (d) | 2. (b) | 3. (b) | 4. (c) | 5. (a) | 6. (b) | 7. (a) | 8. (c) | 9. (c) |
| 10. (c) | 11. (d) | 12. (a) | 13. (b) | 14. (a) | 15. (d) | 16. (a) | 17. (b) | 18. (b) |
| 19. (d) | 20. (c) | 21. (d) | 22. (c) | 23. (d) | 24. (d) | 25. (d) | 26. (c) | 27. (b) |
| 28. (d) | 29. (d) | 30. (c) | 31. (c) | 32. (d) | 33. (d) | 34. (b) | 35. (d) | 36. (a) |
| 37. (a) | 38. (b) | 39. (b) | 40. (b) | 41. (d) | 42. (70.41) | 43. (a, c) | 44. (b, c) | 45. (a, c, d) |

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

A certain quantity of matter or a region in space upon which attention is focused in the analysis of a problem is called a system.

2. (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.

3. (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.

4. (c)

Rate or speed with which a process occurs is provided by heat transfer, not by the study of thermodynamics.

5. (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)

6. (b)

Diathermic wall means it would allow the flow of heat through it.

7. (a)

An adiabatic boundary is one which prevents heat transfer.

8. (c)

In quasi-equilibrium process, the process is carried out infinitely slow so that the pressure in the system is everywhere constant at any instant.

9. (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.

10. (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.

11. (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.

12. (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.

13. (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.

14. (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.

15. (d)

In microscopic approach, individual molecular behaviour is taken into consideration. So, the statement regarding microscopic properties of thermodynamic system that statistical averaging is adopted to predict the behaviour of individual fluid particles, is not true.

16. (a)

Extensive properties depend upon size or mass of the system. Examples Mass, Volume, etc.

17. (b)

In the concept of continuum, even a very small quantity of a system is assumed to contain large number of molecules so that statistical averaging is meaningful and a property value can be assigned to it. Disregarding the behaviour of individual molecules, matter is here treated as continuous. The concept of continuum losses validity when the mean free path of the molecules approaches the order of magnitude of the dimensions of the system.

18. (b)

A pure substance is defined as one that is homogeneous and invariable in chemical composition throughout its mass. The state of a pure substance of given mass can be fixed by specifying two independent intensive properties, provided the system is in equilibrium.

19. (d)

A pure substance is one that has a homogeneous and invariable chemical composition. It may exist in more than one phase, but the chemical composition is the same in all phases. Thus, liquid water, a mixture of liquid water and water vapor (steam), and a mixture of ice and liquid water are all pure substances; every phase has the same chemical composition. In contrast, a mixture of liquid air and gaseous air is not a pure substance because the composition of the liquid phase is different from that of the vapor phase.

20. (c)

According to Gibbs phase rule.

$$P + F = C + 2$$

if $P = \text{No. of phases} = 1 \text{ (gas)}$

$C = \text{No. of components} = n$

$$1 + F = n + 2$$

$$F = n + 1$$

Here $n = \text{No. of components} = 5$

$$F = 5 + 1 = 6$$

21. (d)

A system in thermodynamic equilibrium will have same properties as its surroundings so it won't deliver anything by interacting with its surroundings.

22. (c)

For a cyclic process, the initial and final states of the system are the same and hence, the change in any property is zero, i.e.

$$\oint dV = 0, \quad \oint dp = 0,$$

$$\oint dT = 0$$

where the symbol \oint denotes the cyclic integral for the closed path. Therefore, the cyclic integral of a property is always zero.

24. (d)

Zeroth law of thermodynamics state that when a body A is in thermal equilibrium with body B and body B is in thermal equilibrium with body C separately, then A and C are in thermal equilibrium.

25. (d)

1 K = 1/273.15th of the triple point of water

26. (c)

Thermocouple is based on principle of Seebeck effect. If two different metals are joined at two different junctions which are kept at different temperature then an emf is generated between the two junctions which is directly proportional to the temperature difference between them. According to Seebeck effect,

$$\text{EMF} \propto T_2 - T_1$$

27. (b)

$$Q \text{ per } ^\circ\text{C} = 4.5 \text{ kJ}$$

$$Q \text{ per } ^\circ\text{F} = \frac{Q \text{ per } ^\circ\text{C}}{1.8} = \frac{4.5}{1.8} = 2.5 \text{ kJ}$$

28. (d)

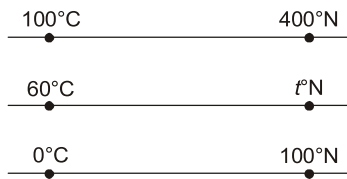
$$\text{We know, } K = ^\circ\text{C} + 273.15$$

But Kelvin scale has minimum value zero,

$$^\circ\text{C} = -273.15$$

So, the value of l is -273.15°C

29. (d)



From figure it can be written as,

$$\frac{100 - 0}{60 - 0} = \frac{400 - 100}{t - 100}$$

$$\frac{100}{60} = \frac{300}{t - 100}$$

$$t = 280^\circ\text{N}$$

30. (c)

For a constant volume gas thermometer, pressure acts as thermometric property and at low pressure the gas behaves as ideal gas and follows ideal gas equation

$$pV = mRT$$

\therefore for $V = \text{constant}$ (m, R are also constant)

$$p \propto T$$

31. (c)

$0 - 660^\circ\text{C} \rightarrow$ Platinum resistance thermocouple
 -190 to $0^\circ\text{C} \rightarrow$ Platinum-platinum/Rhodium thermocouple
 $> 1063^\circ\text{C} \rightarrow$ Planck's law of thermal radiation.

32. (d)

Constant pressure gas thermometer has volume as thermodynamic property.

- Electric resistance thermometer - Resistance
- Mercury in glass thermometer - Length
- Thermocouple - Thermal EMF

33. (d)

- Condenser - Mercury thermometer
- Boiler combustion space - Optical Pyrometer
- Incandescent gas mantels - Radiation Pyrometer
- Economizer - Base Metal Pyrometer

34. (b)

Temperature of fixed points	
Point	Temperature ($^\circ\text{C}$)
Normal boiling point of oxygen	-182.97
Standard triple point of water	0.01
Normal boiling point of water	100.00
Normal boiling point of sulphur	444.6
Normal melting point of antimony	630.5
Normal melting point of silver	960.8
Normal melting point of gold	1063

35. (d)

The expansion of different fluid does not vary linearly with temperature.

36. (a)

Air is a pure substance but a mixture of air and liquid air in a cylinder is not a pure substance, since the relative proportions of oxygen and nitrogen differ in the gas and liquid phases in equilibrium, thus mixture of air and liquid air is heterogeneous.

41. (d)

A quasi-equilibrium process can be viewed as a sufficiently slow process that allows the system to adjust itself internally so that properties in one part of the system do not change any faster than those at other parts. Quasi means 'almost'. As the name indicates that a process takes place in a system almost in equilibrium at every time is called a quasi-equilibrium process. In general, most of the engineering processes can be treated as being quasi-equilibrium.

42. (70.41)

$$80 = R_0[1 + 0.00393 \times 25]$$

$$\therefore R_0 = 72.843^\circ\text{C}$$

Now,

$$93 = 72.843[1 + 0.00393 \times t]$$

$$\therefore t = 70.41^\circ\text{C}$$