UPPSC-AE 2025

Uttar Pradesh Public Service Commission

Combined State Engineering Services Exam

Assistant Engineer

2000+ MCQs

Fully solved multiple choice questions
with detailed explanations

Practice Book

Mechanical Engineering

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2000+ MCQs for UPPSC-AE (Combined State Engineering Services Examination): Mechanical Engineering

First Edition: 2020
Second Edition: 2021
Reprint: 2023
Reprint: 2024

Reprint: 2025

Published by: MADE EASY Publications Pvt. Ltd, New Delhi-110016

PREFACE

B. Singh (Ex. IES)

With the announcement of vacancies by Uttar Pradesh Public Service Commission (UPPSC) for the post of Assistant Engineer, it has given hope for many engineers between jobs. MADE EASY has always been a success partner for engineers right from the onset of engineering education up to they get a formal tag of engineer.

Owing to needs of students to utilise this opportunity in a fruitful way, it gives me great happiness to introduce Mechanical Engineering Practice book for UPPSC-AE Examination. While preparing this book utmost care has been taken to cover all the chapters and variety of concepts which may be asked in the exam. It contains more than 2000 multiple choice questions with answer key and detailed explanations, segregated in subject wise manner to disseminate all kind of exposure to students in terms of quick learning. Attempt has been made to bring out all kind of probable competitive questions for the aspirants preparing for UPPSC. This book also help every student to perform in an extraordinary way.

Full efforts have been made by MADE EASY team to provide error free solutions and explanations. The book not only covers the syllabus of UPPSC but also useful for other examinations conducted by various Public Service Commissions.

Our team has made their best efforts to make the book error-free. Nonetheless, we would highly appreciate and acknowledge if you find and share any printing/conceptual error. It is impossible to thank all individuals who helped us, but I would like to sincerely acknowledge all the authors, editors and reviewers for putting in their efforts to publish this book.

B. Singh (Ex. IES)
Chairman and Managing Director
MADE EASY Group

Uttar Pradesh Public Service Commission

Combined State Engineering Services Examination

Assistant Engineer

Mechanical Engineering

Paper-I

Engineering Mechanics:
Analysis of force systems, friction, centroid and centre of gravity, trusses and beams, principle of virtual work, kinematics and kinetics of particle, kinematics and kinetics of rigid bodies.

Mechanism and Machines:
Velocity and acceleration of links, cams and followers gears and gear trains clutches, belt drives, brakes and dynamometers, Flywheel and governors, balancing of rotating and reciprocating masses, balancing of multi cylinder engines, Free and forced vibration, damped vibration, whirling of shafts.

Mechanics of Solids:
Stresses and strains, compound stresses strains, Torsion of circular shafts, stresses and deflections in beams unsymmetrical bending, curved beams, Thin and thick cylinders and spheres, Buckling of columns, Energy methods, helical and leaf springs.

Design of Machine Elements:
Design for Static and dynamic loading, Theories of failure, fatigue principles of design of riveted, welded and bolted joints, shafts, springs, bearings, brakes, clutches and flywheels.

Engineering Materials:
Crystal systems and crystallography, crystal imperfections, Alloys and phase diagrams, Heat treatment, ferrous and non ferrous metals and alloys, Mechanical properties and testing.

Manufacturing:
Metal casting, metal forming, metal joining, Mechanics of metal cutting, machining and machine tool operations, unconventional machining methods limits, fits and tolerances, inspection: Surface roughness, comparators, computer integrated manufacturing, Flexible manufacturing systems, jigs and fixtures.

Industrial Engineering:
Production, planning and control, inventory control and operation, research, CPM and PERT.

Mechatronics and Robotics:
Microprocessors and microcontrollers, Architecture, Programming, Computer interfacing Programmable logic controller, sensors and actuators, Piezoelectric accelerometers, Hall effect sensors, optical encoder, resolver, Inductosyn, Pneumatic and Hydraulic Actuators, stepper motor, control system, mathematical modeling, control signals, controllability and observability, Robotics: Robot classification, robot specification. Notation: Direct and inverse kinematics homogeneous co-ordinates and arm equation of four axix SCARA Robot.

Paper-II

Thermodynamics:
Thermodynamic systems and processes, properties of pure substances, concepts and applications of zeroth, first and second law of thermodynamics, entropy, availability and irreversibility, detailed analysis of thermodynamic cycles, ideal and real gases, fuels and combustion.

Fluid Mechanics :
Basic concepts and properties of fluids, manometry, fluid statics, buoyancy, equations of motion, Bernoulli's equation and applications, viscous flow of incompressible fluids, laminar and turbulent flows, flow through pipes and head losses in pipes, dimensional analysis, Forces on immersed bodies and boundary layer over a flat plate, isentropic and adiabatic flows, normal shock waves.

Heat Transfer:
Modes of heat transfer, steady and unsteady heat conduction, thermocouple time constant, critical thickness of insulation, heat transfer from fins, momentum and energy equations for boundary layer flow on a flat plate. Free and forced convection, radiation heat transfer, Stefan-Boltzmann law, shape factor, black and grey body radiation heat exchange, boiling and condensation, heat exchanger analysis, LMTD and NTU – effectiveness methods.

Energy conversion:
SI and CI engines, performance characteristics and testing of IC engines, combustion phenomena in SI and CI engines, carburetion and fuel injection systems, emissions and emission control. Reciprocating and rotary pumps, pelton wheel, Francis and Kaplan turbines, velocity diagrams impulse and reaction principles steam and gas turbines; Rankine and Brayton cycles with regeneration and reheat, high pressure boilers, draft, condensers. Unconventional power systems, including nuclear, MHD, biomass, wind and tidal systems, utilization of solar energy; Reciprocating and rotary compressors; theory and applications, Theory of propulsions, pulse jet and ramjet engines.

Environmental control:
Vapour compression, vapour absorption, steam jet and air refrigeration systems, properties of refrigerant and their nomenclature, psychometrics properties and processes, psychrometic relations, use of pschrometic chart, load estimation, supply air conditions, sensible heat factors, air conditioning system layout, comfort chart, comfort and industrial air conditioning.

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Contents

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UNIT 1

Thermodynamics

Q.1 An adiabatic boundary is one which
(a) prevents heat transfer
(b) permits heat transfer
(c) prevents work transfer
(d) permits work transfer

Q.2 Match **List-I** with **List-II** and select the correct answer using the codes given below.

List-I
A. Centrifugal fan
B. Control volume
C. Intensive property
D. Microscopic property

List-II
1. Open system
2. Internal energy
3. Filling a tire at air station
4. Specific energy

Codes:

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

Q.3 Match the following **List-I** (Thermometer) with **List-II** (Thermometric property) and select the correct answer using the codes given below.

List-I	List-II
A. Mercury-in-glass gas	**1.** Volume
B. Constant pressure gas	**2.** Length
C. Constant volume gas	**3.** EMF
D. Thermocouple	**4.** Pressure

Codes:

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

Q.4 In a quasi-equilibrium process, the pressure in a system
(a) remains constant
(b) varies with temperature
(c) is everywhere constant at an instant
(d) increase if volume increases

Q.5 Ice kept in a well insulated thermo-flask is an example of which system?
(a) closed system
(b) isolated system
(c) open system
(d) non-flow adiabatic system

Q.6 Choose the correct statement among the following:
(a) temperature is an extensive property
(b) mass remains same in an open system
(c) the system boundaries are collapsible and expandable
(d) an isolated system allows exchange of energy in the form of heat only

Q.7 Which one of the following represents open thermodynamic system?
(a) Manual ice cream freezer
(b) Centrifugal pump
(c) Pressure cooker
(d) Bomb calorimeter

Q.8 A thermodynamic system is considered to be an isolated one if
(a) mass transfer and entropy change are zero
(b) entropy change and energy transfer are zero
(c) energy transfer and mass transfer are zero
(d) mass transfer and volume change are zero

Q.9 A control volume is
(a) an isolated system
(b) a closed system but heat and work can cross the boundary
(c) a specific amount of mass in space
(d) a fixed region in space where mass, heat and work can cross the boundary of that region

Q.10 Which of the following is an example of heterogeneous system?
(a) Atmospheric air
(b) Mixture of hydrogen and oxygen
(c) Cooling fluid in a radiator
(d) Mixture of ice, water and steam

Q.11 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.12 The fundamental unit of enthalpy is
(a) MLT^{-2} (b) ML^2T^{-1}
(c) ML^2T^{-2} (d) ML^3T^{-2}

Q.13 A closed thermodynamic system is one in which
(a) there is no energy or mass transfer across the boundary
(b) there is no mass transfer, but energy transfer exists
(c) there is no energy transfer, but mass transfer exists
(d) both energy and mass transfer takes place across the boundary but the mass transfer is controlled by valves

Q.14 Which of the following are intensive properties
1. Kinetic energy 2. Specific enthalpy
3. Pressure 4. Entropy

Codes:
(a) 1 and 3 (b) 2 and 3
(c) 1, 3 and 4 (d) 2 and 4

Q.15 For a system to be in thermal equilibrium the system and its surroundings are to be in
(a) Thermal equilibrium
(b) Chemical equilibrium
(c) Mechanical equilibrium
(d) Thermal, chemical and mechanical equilibrium

Q.16 The energy of an isolated system in a process
(a) can never increase
(b) can never decrease
(c) always remains constant
(d) is always positive

Q.17 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) Focuses an definite volume and volume is enclosed by control surface

Q.18 Zeroth law of thermodynamics states that:
(a) two thermodynamic systems are always in thermal equilibrium with each other.
(b) if two systems are in thermal equilibrium, then the third system will also be in thermal equilibrium.
(c) two systems not in thermal equilibrium with a third system are also not in thermal equilibrium with each other.
(d) when two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other.

Q.19 Match **List-I** with **List-II** and select the correct answer using the codes given below.

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

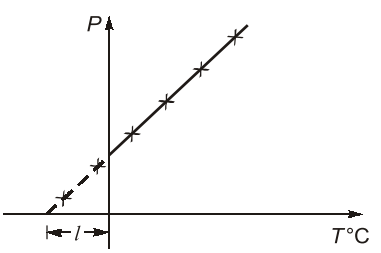
Q.20 Which of the following is used for measuring high temperature beyond 1063°C?
(a) Platinum-platinum/Rhodium thermocouple
(b) Electrical resistance thermometer
(c) Optical method using planck's law of thermal radiation
(d) Constant pressure gas thermometer

Q.21 Zeroth law of thermodynamics form the basis of measurement of
(a) pressure (b) temperature
(c) heat exchanger (d) work

Q.22 The standard fixed point of thermometry is
(a) Ice point
(b) Sulphur point
(c) Triple point of water
(d) Normal boiling point of water

Q.23 Triple point temperature of water is
(a) 273 K (b) 273.14 K
(c) 273.15 K (d) 273.16 K

Q.24 Experimental data obtained from a constant-volume-gas thermometer is shown is the figure below. The value of l in °C is



(a) 273.15 (b) 1.0
(c) –100 (d) –273.15

Q.25 In new temperature scale say °ρ the boiling and freezing points of water at one atmosphere are 100°ρ and 300°ρ respectively, correlate this scale with centigrade scale. The reading of 0°ρ on the centigrade scale is
(a) 0°C (b) 50°C
(c) 100°C (d) 150°C

Q.26 Two blocks which are at different states are brought into contact with each other and allowed to reach a final state of thermal equilibrium. The temperature is specified by the
(a) Zeroth law of thermodynamics
(b) First law of thermodynamics
(c) Second law of thermodynamics
(d) Third law of thermodynamics

Q.27 A closed system receives 60 kJ heat but its internal energy decreases by 30 kJ. Then the work done by the system is
(a) 90 kJ (b) 30 kJ
(c) –30 kJ (d) –90 kJ

Q.28 If the work done on a closed system is 20 kJ/kg, and 40 kJ/kg heat is rejected from the system, its internal energy decreases by
(a) 20 kJ/kg (b) 60 kJ/kg
(c) –20 kJ/kg (d) –60 kJ/kg

Q.29 In a general compression process, 2 kJ of mechanical work is supplied to 4 kg of fluid and 800 J of heat is rejected to the cooling jacket. The change in specific internal energy would be
(a) 100 J/kg (b) 200 J/kg
(c) 300 J/kg (d) 400 J/kg

Q.30 Work done is zero for the following process
(a) constant volume (b) free expansion
(c) throttling (d) all of the above

Q.31 In free expansion process
(a) $W_{1-2} = 0$ (b) $Q_{1-2} = 0$
(c) $dU = 0$ (d) All of the above

Q.32 Which one of the following thermodynamic process approximates the steaming of food in a pressure cooker?
(a) Isenthalpic (b) Isobaric
(c) Isochoric (d) Isothermal

Q.33 The cyclic integral of $(\delta Q - \delta W)$ for a process is
(a) positive (b) negative
(c) zero (d) unpredictable

Q.34 Heat transferred to a closed stationary system at constant volume is equal to
(a) work transfer
(b) increase in internal energy
(c) increase in enthalpy
(d) increase in Gibb's function

Q.35 The maximum amount of mechanical energy that can be converted into heat in any process
(a) depends on source and sink temperature
(b) depends on friction present
(c) depends on nature of mechanical energy
(d) is 100%

Q.36 A paddle wheel used for stirring a liquid contained in a tank supplied 5000 kJ of work and during the stirring operation the tank lost 1500 kJ of heat to the surroundings. If the tank and liquid are considered as a system the change in its internal energy will be

(a) 1500 kJ (b) 3500 kJ
(c) 5000 kJ (d) 6500 kJ

Q.37 The change in enthalpy of a closed system is equal to the heat transferred, if the reversible process takes place at constant

(a) Pressure (b) Temperature
(c) Volume (d) Entropy

Q.38 Match **List-I** with **List-II** and select the correct answer using the codes given below.

List-I

A. Work done
B. Thermal equilibrium
C. Internal energy
D. No work and heat interaction

List-II

1. Point function
2. Path function
3. Isolated system
4. Equality of temperature

Codes:

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

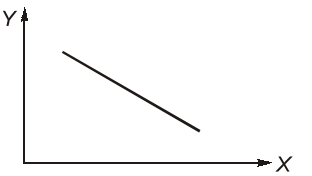
Q.39 In a cyclic process, heat transfer are +15.7 kJ, –26.2 kJ, –4.86 kJ and +31.5 kJ. What is the net work for this cyclic process?

(a) 15.14 kJ (b) 16.41 kJ
(c) 16.14 kJ (d) 15.41 kJ

Q.40 A stationary mass of gas is compressed without friction from an initial state of 0.3 m^3 and 0.1 MPa to a final state of 0.15 m^3 and 0.1 MPa, the pressure remaining constant during the process. There is a transfer of 40 kJ of heat from the gas during the process. What is the change in internal energy of the gas?

(a) –5 kJ (b) +25 kJ
(c) –25 kJ (d) +15 kJ

Q.41 The polytropic process is represented by a straight line in the following figure. What is X and Y respectively?



(a) $\ln V$ and $\ln P$ (b) V and P
(c) $\ln P$ and $\ln V$ (d) P and V

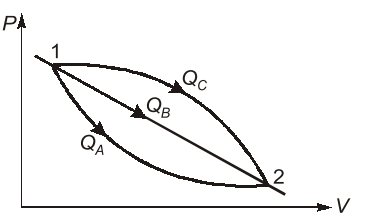
Q.42 A PMM1 is

(a) A thermodynamic machine
(b) A hypothetical machine
(c) A real machine
(d) A hypothetical machine whose operation would violate the first law of thermodynamics

Q.43 Energy is added to 5 kg of air with a paddle wheel until $\Delta T = 100°C$. What is the paddle wheel work if the rigid volume is insulated?

(a) 203 kJ (b) 482 kJ
(c) 412 kJ (d) 359 kJ

Q.44 An ideal gas of mass m at state 1 expands to state 2 via three paths. If Q_A, Q_B and Q_C represent the heat absorbed by the gas along three paths, then



(a) $Q_A < Q_B < Q_C$ (b) $Q_A > Q_B > Q_C$
(c) $Q_A < Q_B > Q_C$ (d) $Q_A > Q_B < Q_C$

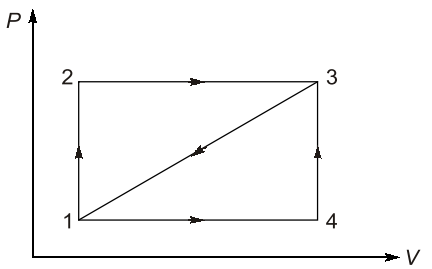
Q.45 Internal energy is defined by

(a) Zeroth law of thermodynamics
(b) First law of thermodynamics
(c) Second law of thermodynamics
(d) Law of entropy

Q.46 Key concept in analyzing the filling of an evacuated tank is

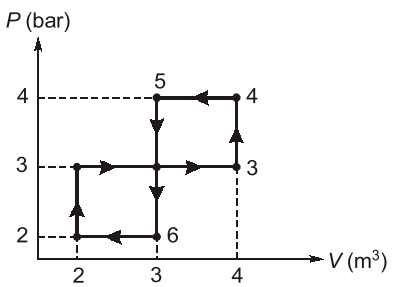
(a) the mass flow rate in the tank remains constant
(b) the enthalpy across the valve remains constant
(c) the internal energy in the tank remains constant
(d) the temperature in the tank remains constant

Q.47 Given that along the path 1-2-3 a system absorbs 100 kJ as heat and does 60 kJ work while along the path 1-4-3 it does 20 kJ work (see figure given). The heat absorbed during the cycle 1-4-3 is



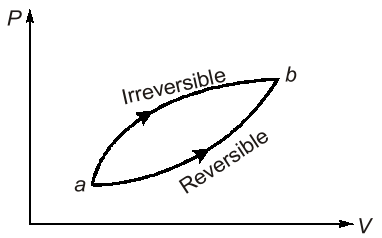
(a) –140 kJ (b) –80 kJ
(c) –40 kJ (d) 60 kJ

Q.48 The net work output for the cycle 1–2–3–4–5–6–1 shown in figure is



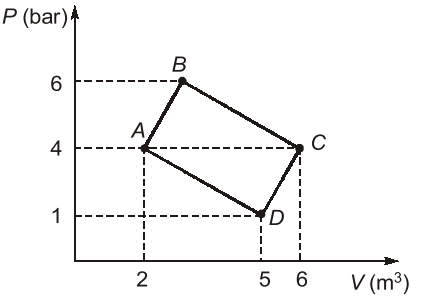
(a) 200 kJ
(b) 1200 kJ
(c) 0 kJ
(d) 1000 kJ

Q.49 For the two paths as shown in the figure, one reversible and one irreversible, to change the state of the system from a to b,



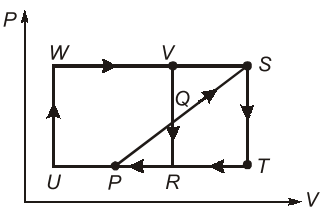
(a) ΔU, Q, W are same
(b) ΔU is same
(c) Q, W are same
(d) ΔU, Q are different

Q.50 The net work done for the closed system shown in the given pressure-volume diagram is



(a) 600 kN-m (b) 700 kN-m
(c) 900 kN-m (d) 1000 kN-m

Q.51 Two ideal heat engine cycles are represented in the given figure. Assume $VQ = QR$; $PQ = QS$ and $UP = PR = RT$. If the work interaction for the rectangular cycle ($WVRU$) is 48 Nm, then the work interaction for the other cycle PST is



(a) 12 Nm (b) 18 Nm
(c) 24 Nm (d) 36 Nm

Q.52 Consider the following statements about steady flow process:

1. The rate of flow of mass energy across the control surface are constant.
2. Thermodynamic properties vary along space as well as time coordinates.
3. Any thermodynamic property will have a fixed value at a particular location and will not alter with time.

Which of the above are correct?

(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.53 Neglecting changes in kinetic and potential energies, the identity $-\int_1^2 v\,dp = h_1 - h_2$ for the shaft work during a steady flow process is valid for

(a) constant volume process
(b) reversible isothermal process
(c) reversible adiabatic process
(d) reversible polytropic process

Q.54 The term Δh in a control volume equation $Q - W = \Delta h$

(a) Accounts for the rate of change in energy of the control volume.
(b) Represents the rate of change of energy between the inlet and outlet.
(c) Is often neglected in control-volume applications?
(d) Includes the work rate due to the pressure forces.

Q.55 Match **List-I** (Devices) with **List-II** (Thermodynamics equations) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Turbine	1. $w = h_2 - h_1$
B. Nozzle	2. $h_1 = h_2$
C. Valve	3. $h_1 = h_2 + \frac{V_2^2}{2}$
D. Compressor	4. $w = h_1 - h_2$

Codes:

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

Q.56 If steam is throttled its

(a) pressure and enthalpy remain unchanged
(b) temperature and entropy remain unchanged
(c) enthalpy remains unchanged but the other property change
(d) enthalpy remains unchanged but pressure may or may not change

Q.57 Compressed air coming out from a punctured football

(a) becomes hotter
(b) becomes cooler
(c) remains at same temperature
(d) attains atmospheric temperature

Q.58 Work output from a system is at the expense of internal energy in a non-flow process carried out

(a) at constant pressure
(b) at constant volume
(c) adiabatically
(d) polytropically

Q.59 Assumptions made in steady-state flow process are

1. Control volume does not move relative to the coordinate frame.
2. Control volume moves relative to the coordinate frame.
3. The state of the mass at each point in the control volume vary with time.
4. The state of the mass at each discrete area of flow on the control surface do not vary with time. The rate at which heat and work cross the control surface remain constant.

(a) 1 and 4 are correct
(b) 1, 3 and 4 are correct
(c) 2, 3 and 4 are correct
(d) 2 and 4 are correct

Q.60 According to first law of thermodynamics, Δ(energy of system) + Δ(energy of surroundings) is equal to

(a) positive
(b) negative
(c) zero
(d) none of these

Q.61 Select the Kelvin-Plank statement of the second law:

(a) an engine cannot produce more heat than the heat it receives.
(b) a refrigerator cannot transfer heat from a low-temperature reservoir to a high temperature reservoir without work.
(c) an engine cannot produce work without discharging heat.
(d) an engine discharges heat if the work is less than the heat it receives.

Q.62 According to the Clausius statement of the second law:

1. heat flows from cold surface to hot surface, unaided.
2. heat flows from hot surface to cold surface, unaided.
3. heat can flow from cold surface to hot surface with the aid of external work.

Which of the above statements is/are correct?

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

Q.157 What is the loss in the available energy in a cycle where 1000 kJ of heat is transferred to 500 K reservoir from 1000 K reservoir? Take atmospheric temperature to be 32°F.

(a) 3200 kJ (b) 1000 kJ
(c) 305 kJ (d) 273 kJ

Q.158 Consider the following statements:

1. Triple point is the point at which three states of matter can be in equilibrium.
2. Critical point is the state at which liquid and vapour phase are in equilibrium.
3. Helium does not have a triple point.

Which of these statements is/are correct?

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

Q.159 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.160 Which of the following statements are incorrect?

1. There is no entropy transfer associated with work.
2. There is no entropy transfer associated with heat.
3. There is exergy transfer associated with work.
4. There is no exergy transfer associated with heat.

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

Q.161 Consider the following statements regarding irreversibility

1. Internal irreversibility is due to dissipative effect like internal fluid friction.
2. Internal irreversibility occurs at system boundary.
3. Mechanical irreversibility is due to finite pressure gradient.
4. Chemical irreversibility is due to finite chemical potential (concentration gradient)

Which of these statements are correct?

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

■■■■

Answers Thermodynamics

1.	(a)	2.	(c)	3.	(d)	4.	(c)	5.	(b)	6.	(c)	7.	(b)	8.	(c)
9.	(d)	10.	(d)	11.	(b)	12.	(c)	13.	(b)	14.	(b)	15.	(d)	16.	(a)
17.	(c)	18.	(d)	19.	(b)	20.	(c)	21.	(b)	22.	(c)	23.	(d)	24.	(d)
25.	(d)	26.	(a)	27.	(a)	28.	(a)	29.	(c)	30.	(d)	31.	(d)	32.	(c)
33.	(c)	34.	(b)	35.	(d)	36.	(b)	37.	(a)	38.	(a)	39.	(c)	40.	(c)
41.	(c)	42.	(d)	43.	(d)	44.	(a)	45.	(b)	46.	(b)	47.	(d)	48.	(c)
49.	(b)	50.	(d)	51.	(c)	52.	(b)	53.	(c)	54.	(d)	55.	(a)	56.	(c)
57.	(b)	58.	(c)	59.	(d)	60.	(c)	61.	(c)	60.	(c)	63.	(c)	64.	(c)
65.	(a)	66.	(d)	67.	(c)	68.	(a)	69.	(c)	70.	(a)	71.	(d)	72.	(b)
73.	(b)	74.	(b)	75.	(b)	76.	(d)	77.	(d)	78.	(a)	79.	(b)	80.	(b)
81.	(b)	82.	(a)	83.	(b)	84.	(d)	85.	(b)	86.	(b)	87.	(b)	88.	(a)

89. (c)	90. (d)	91. (d)	92. (b)	93. (b)	94. (a)	95. (d)	96. (d)
97. (b)	98. (a)	99. (d)	100. (c)	101. (b)	102. (a)	103. (c)	104. (d)
105. (a)	106. (d)	107. (b)	108. (c)	109. (d)	110. (b)	111. (b)	112. (b)
113. (a)	114. (b)	115. (c)	116. (c)	117. (d)	118. (d)	119. (b)	120. (d)
121. (c)	122. (a)	123. (b)	124. (c)	125. (b)	126. (b)	127. (b)	128. (d)
129. (a)	130. (d)	131. (d)	132. (a)	133. (b)	134. (d)	135. (b)	136. (a)
137. (c)	138. (b)	139. (c)	140. (b)	141. (d)	142. (c)	143. (d)	144. (b)
145. (a)	146. (b)	147. (b)	148. (a)	149. (b)	150. (d)	151. (d)	152. (c)
153. (a)	154. (c)	155. (a)	156. (a)	157. (d)	158. (d)	159. (c)	160. (c)
161. (c)							

Explanations

3. (d)

Mercury-in-glass : Length
Radiation : Black body radiation
Thermocouple : EMF
Constant volume gas : Pressure
Constant pressure gas : Volume

11. (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

$$\delta Q = dU + \delta W$$
$$dU = 0$$
$$U = \text{constant}$$

The energy of isolated system is constant.

13. (b)

Open system: Both mass and energy transfer takes place

Closed system: No mass transfer, energy transfer may takes place

Isolated system:
Neither energy nor mass transfer takes place.

14. (b)

Specific enthalpy (enthalpy per unit mass) and pressure is intensive property.

19. (b)

Temperature of fixed points	
Point	Temperature (°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

20. (c)

0 – 660°C → Platinum resistance thermocouple
–190 to 0°C → Platinum-platinum/Rhodium Thermocouple > 1063°C → Planck's law of thermal radiation.

21. (b)

- Zeroth law – concept of temperature
- First law – concept of internal energy
- Second law – concept of entropy

26. (a)

Zeroth law gives the concept of temperature.

27. (a)

$$\delta Q = \delta W + \Delta U \quad \text{(As per 1st law)}$$
$$\therefore \quad \delta W = \delta Q - \Delta U$$
$$= 60 + 30 = 90 \text{ kJ}$$

28. (a)

As per first law of thermodynamics:

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

($\because \delta W = -20$ kJ/kg, $\delta Q = -40$ kJ/kg)

$$\Delta U = \delta Q - \delta W$$
$$= -40 + 20 = -20 \text{ kJ/kg}$$

29. (c)

$\delta Q = -800$ J, $\delta W = -2000$ J

30. (d)

For constant volume process

$$W = \int p dV$$

Since, $dV = 0$

$$W = 0$$

For free expansion

$$W = 0$$

Also for throttling process

$$W = 0$$

31. (d)

For free expansion,

$$\delta W = 0$$

No heat interaction takes place,

Hence $\delta Q = 0$

From first law,

$$\delta Q = dU + \delta W$$
$$dU = 0$$

32. (c)

Since volume of pressure cooker is constant hence it is an Isochoric process.

33. (c)

For a process

$$\oint (\delta Q - \delta W) = 0$$

34. (b)

$$\delta Q = dU + \delta W$$

For constant volume, close system work = 0

Hence, $\delta Q = dU$

35. (d)

Since mechanical energy is high grade energy and heat is low grade energy, 100% conversion of high grade energy into low grade energy is possible.

36. (b)

From the first law of thermodynamics

$$\delta Q = dU + \delta W$$
$$-1500 = dU - 5000$$
$$dU = 5000 - 1500$$
$$dU = 3500 \text{ kJ}$$

37. (a)

From T-dS equation

$$TdS = dh - VdP$$
$$TdS = \delta Q \quad \text{(for reversible process)}$$
$$\delta Q = dh \quad \text{when } dP = 0$$

Hence for constant pressure process

$$\delta Q = dh$$

38. (a)

Work done	:	Path function (Given by area under P-v plot)
Internal energy	:	Point function (Not depend on the path followed)
Isolated system	:	No work and Heat Interaction (e.g. Universe)
Thermal equilibrium	:	Equality of temperature

39. (c)

$$\delta Q = \delta W + \Delta U \quad \text{(As per first law)}$$

For the cyclic process,

$$\Delta U = 0$$
$$\therefore \quad \int \delta W = \int \delta Q$$
$$\therefore \quad W = 15.7 - 26.2 - 4.86 + 31.5$$
$$= 16.14 \text{ kJ}$$

40. (c)

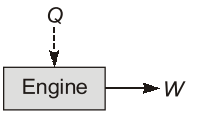
$$Q = \Delta U + W$$
$$Q_{1-2} = U_2 - U_1 + W_{1-2}$$
$$W_{1-2} = \int_1^2 P dV = P(V_2 - V_1)$$
$$= 0.1\,(0.15 - 0.3) = -15 \text{ kJ}$$
$$Q_{1-2} = -40 \text{ kJ}$$
$$\therefore \quad \Delta U = Q_{1-2} - W_{1-2} = -40 + 15 = -25 \text{ kJ}$$

41. (c)

$$PV^n = C \quad \text{(Polytropic process)}$$
$$\ln P + n \ln V = C$$
$$X + nY = C$$
$$\frac{X}{C} + \frac{Y}{(C/n)} = 1 \quad \text{(Equation of straight line)}$$

42. (d)

There can be no machine which would continuously supply mechanical work without some other form of energy disappearing simultaneously. It is fictitious machine.



PMM1

44. (a)

$$Q_A = W_A + \Delta U; \qquad Q_B = W_B + \Delta U$$
$$Q_C = W_C + \Delta U$$

45. (b)

Zeroth law of thermodynamics — concept of temperature

First law of thermodynamics — concept of internal energy

Second law of thermodynamics — concept of entropy.

47. (d)

$$Q_{1-3} = 100 \text{ kJ}; \qquad W_{1-3} = 60 \text{ kJ}$$

From the first law of thermodynamics

$$\delta Q = dU + \delta W \qquad 100 = (U_3 - U_1) + 60$$

$U_3 - U_1 = 40$ kJ

Via point (4)

$$W_{1-3} = 20 \text{ kJ}; \qquad U_{3-1} = 40 \text{ kJ}$$
$$\delta Q = 40 + 20 = 60 \text{ kJ}$$

49. (b)

ΔU is a point function and it is independent of the path followed.

52. (b)

Thermodynamic properties may vary along space coordinates but do not vary with time.

54. (d)

S.F.E.E:

$$Q - W_x = \Delta\left[u + Pv + \frac{V^2}{2} + gz\right]$$

$$Q - W_x = \Delta\left[h + \frac{V^2}{2} + gz\right]$$

Δh accounts for internal energy and pressure forces.

56. (c)

If steam is throttled, its enthalpy remains constant and pressure drop takes place.

59. (d)

Note that control volume does moves relative to the coordinate frame.

60. (c)

System and its surrounding together comprises a universe and universe is considered as isolated system.

Change in energy of isolated system is zero.

63. (c)

Such a heat engine is PMM2 which is impossible. It violates Kelvin-Plank statement.

64. (c)

$$(\text{COP})_{\text{Refrigerator}} = \frac{T_2}{T_1 - T_2};$$

$$(\text{COP})_{\text{H.P}} = \frac{T_1}{T_1 - T_2}$$

$$\therefore (\text{COP})_{\text{H.P}} - (\text{COP})_{\text{Refrigerator}} = 1$$

$$\therefore \qquad (\text{COP})_{\text{H.P}} = 1 + 4 = 5$$

65. (a)

$$\eta = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

66. (d)

$$\eta_1 = 1 - \frac{T_2 - \Delta T}{T_1}$$

(decreasing lower temperature by ΔT)

$$\eta_2 = 1 - \frac{T_2}{T_1 + \Delta T}$$

(increasing higher temperature by ΔT)

$$\eta_1 - \eta_2 = \frac{T_2}{T_1 + \Delta T} - \frac{T_2 - \Delta T}{T_1}$$

$$= \frac{(T_1 - T_2)\,\Delta T + (\Delta T)^2}{T_1(T_1 + \Delta T)}$$

As $(T_1 - T_2) > 0 \quad \therefore \eta_1 - \eta_2 > 0$

So, the more effective way to increase the cycle efficiency is to decrease lower temperature.

67. (c)

$$\eta = 1 - \frac{273+20}{273+200} = 0.38$$

$$\frac{W}{Q_s} = 0.38$$

$$\therefore \quad Q_S = \frac{10}{0.38} = 26.278 \text{ kW}$$

$$Q_S - Q_R = W$$

$$\therefore \quad Q_R = 26.278 - 10 = 16.278 \text{ kJ/s}$$

68. (a)

$$\eta = 1 - \frac{273+10}{273+27} = 0.0567 = 5.67\%$$

$$W_{net} = 10 \text{ kW},$$

$$Q_R = \frac{9900}{60} = 165 \text{ kW}$$

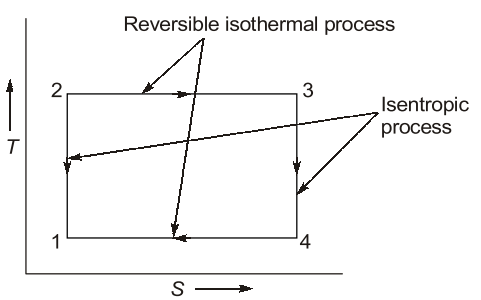
$$Q_S = 10 + 165 = 175 \text{ kW}$$

$$\text{Actual efficiency} = \frac{10}{175} = 5.71\%$$

Actual efficiency is more than the Carnot efficiency which is impossible.

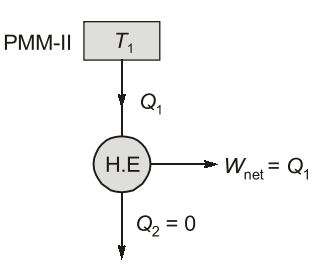
73. (b)

Carnot cycle



Hence Carnot cycle consists of two reversible isothermal and two isentropic process.

74. (b)



If $\quad Q_2 = 0$

i.e. $\quad W_{net} = Q_1$

or $\quad \eta = 100\%$

The heat engine will produce net work in a complete cycle by exchanging heat with only single reservoir thus violating the Kelvin-Plank statement.

77. (d)

Kelvin-Plank gives the concept of heat engine hence, it is conversion of heat into work.

79. (b)

In Carnot engine, source and sink is thermal energy reservoir hence as heat is rejected or extracted, temperature does not change.

82. (a)

For efficiency to be equal

$$T_2 = \sqrt{T_1 T_3} = \sqrt{900 \times 400} = 600\text{K}$$

83. (b)

$$\eta_{actual} = \frac{\text{Output}}{\text{Input}} = \frac{50 \times 100}{\frac{7500 \times 3}{3600}} = 80\%$$

$$\eta_{Carnot} = \frac{600 \times 100}{900} = 66.66\%$$

Since actual efficiency of the engine is greater than Carnot efficiency hence engine is not possible.

84. (d)

Since efficiency of the engine purely depends upon source and sink temperatures and independent of the working substances. All the engines have same efficiency.

85. (b)

$$\eta = \frac{W_{out}}{Q_{in}} = \frac{3}{10} = 0.3 = 30\%$$

86. (b)

Given, $\quad \frac{T_1}{T_2} = \frac{5}{3}$

Efficiency, $\quad \eta = \frac{T_1 - T_2}{T_1} = 1 - \frac{T_2}{T_1}$

$$= 1 - \frac{3}{5} = 0.4$$

Also, $\quad \eta = \frac{\text{Work done}}{\text{Heat supplied}}$