Fully Solved

4400 MCQs

Useful For

ESE | GATE | PSUs

Mechanical Engineering

MADE EASY
Publications

MADE EASY Publications Pvt. Ltd.

Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016
E-mail: infomep@madeeasy.in
Contact: 011-45124660, 0-8860378007
Visit us at: www.madeeasypublications.org

4400 Multiple Choice Questions for ESE, GATE, PSUs : Mechanical Engineering

First Edition: 2014
Second Edition: 2015
Third Edition: 2017
Reprint: 2018
Reprint: 2019
Reprint: 2020
Reprint: 2021

Reprint: 2022

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

PREFACE

B. Singh (Ex. IES)

It gives me great happiness to introduce the revised edition on Mechanical Engineering containing nearly 4400 MCQs which focuses in-depth understanding of subjects at basic and advanced level which has been segregated topic-wise to disseminate all kind of exposure to students in terms of quick learning and deep apt. The chapter wise segregation has been done to align with contemporary competitive examination pattern. Attempt has been made to bring out all kind of probable competitive questions for the aspirants preparing for ESE, GATE, PSU. The content of this book ensures threshold level of learning and wide range of practice questions which is very much essential to boost the exam time confidence level and ultimately to succeed in all prestigious engineer's examinations. It has been ensured from MADE EASY team to have broad coverage of subjects at chapter level.

Year by year number of competitors are increasing and the variety of questions asked in examination is widening, under such scenario this book will definitely help students to enhance their skills required to succeed in competitive exams like ESE, GATE, PSUs, State Engineering Services etc.

While preparing this book utmost care has been taken to cover all the chapters and variety of concepts which may be asked in the exams. The solutions and answers provided are upto the closest possible accuracy. The full efforts have been made by MADE EASY Team to provide error free solutions and explanations.

I have true desire to serve student community by way of providing good sources of study and quality guidance. I hope this book will be proved an important tool to succeed in competitive examinations. Any suggestions from the readers for the improvement of this book are most welcome.

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

CONTENTS

I. THERMODYNAMICS 1-41

1. Basic Concepts 1
2. Temperature 4
3. Work and Heat Transfer..5
4. First Law of Thermodynamics..7
5. First Law Applied to Flow Process........................ 10
6. Second Law of Thermodynamics 11
7. Entropy 14
8. Availability and Irreversibility 17
9. Properties of Pure Substance........................ 18
10. Properties of Gases........................ 19
11. Thermodynamic Relations........................ 23

II. REFRIGERATION & AIR CONDITIONING .. 42-89

1. Basics of Refrigerating Machine 42
2. Refrigeration Cycles and Systems 44
3. Refrigerants........................ 51
4. Refrigerant Compressors........................ 54
5. Condensers, Evaporators & Expansion Devices 55
6. Properties of Moist Air........................ 57
7. Psychrometric Chart and Its Application to Air-Conditioning........................ 60
8. Comfort Conditions........................ 64
9. Solar Refrigeration........................ 66
10. Air-duct Design........................ 67

III. HEAT AND MASS TRANSFER................90-130

1. Basic Concepts of Heat Transfer........................ 90
2. One-Dimensional Steady-state Conduction 92
3. Heat Dissipation from Extended Surface 98
4. Transient Heat Conduction 100
5. Heat Transfer by Natural Convection 101
6. Heat Transfer by Forced Convection 103
7. Radiation Heat Transfer........................105
8. Condensation and Boiling 110
9. Heat Exchanger........................111
10. Fundamentals of Diffusive & Convective Mass Transfer 113

IV. I.C. ENGINE 131-173

1. Basics 131
2. Air Standard Cycles........................134
3. Conventional and Alternative Fuels 136
4. Fuel Injection, Ignition and Carburation .. 140
5. Combustion and Combustion Chambers 145
6. Supercharging........................ 149
7. Engine Friction, Lubrication and Cooling. 150
8. Engine Emissions and their Control 151
9. Testing and Performance 153

V. FLUID MECHANICS 174-230

1. Properties of Fluids........................ 174
2. Pressure & Its Measurement........................ 177
3. Hydrostatic Forces on Surfaces.................... 179
4. Buoyancy and Floatation 181
5. Kinematics of Flow and Ideal Flow 183
6. Dynamic of Fluid Flow........................ 186
7. Flow Over Notches & Weirs........................ 189
8. Viscous Flow........................ 190
9. Turbulent Flow 193
10. Flow Through Pipes........................ 194
11. Boundary Layer Theory........................ 196
12. Flow in Open Channel........................ 199
13. Dimensional and Model Analysis................ 201
14. Forces on Submerged Bodies...................... 203
15. Flow of Compressible Fluids 204

VI. POWER PLANT ENGINEERING 231-291

1. Fuels and Combustion 231
2. Analysis of Steam Cycles........................ 233
3. Steam Generators 238
4. Steam Turbines 242
5. Nuclear Power Plants........................ 248
6. Hydroelectric Power Plant 251
7. Hydraulic Pump 254
8. Energy Transfer 257
9. Compressors 259
10. Gas Turbine Power Plants........................ 263
11. Jet and Rocket Propulsion System............. 266

VII. STRENGTH OF MATERIALS 292-356

1. Mechanical Properties of Materials 292
2. Stress-Strain Relations & Elastic Constants .. 297
3. Tension, Compression and Shear 299
4. Torsion of Shafts 302
5. Shear Force and Bending Moment............ 305

6. Stresses in Beams 309
7. Analysis of Stress and Strain 312
8. Deflection and Theories of Failure 315
9. Thin & Thick Walled Pressure Vessels 320
10. Struts and Columns 323
11. Helical Springs 326

VIII. THEORY OF MACHINES 357-412

1. Simple Mechanisms 357
2. Velocity and Acceleration Analysis 361
3. Mechanism with Lower Pairs 365
4. Cams 366
5. Toothed Gearing 368
6. Gear Trains 371
7. Static and Dynamic Force Analysis 373
8. Flywheels 376
9. Balancing 378
10. Governors 380
11. Linear Vibration Analysis 382

IX. MACHINE DESIGN 413-462

1. Design Against Static Load 413
2. Design Against Fluctuating Load 416
3. Shafts, Keys and Couplings 418
4. Threaded Joints and Power Screws 422
5. Welded and Riveted Joints 425
6. Friction Clutches 429
7. Belt, Rope and Chain Drives 431
8. Bearings 435
9. Gears 439

X. MATERIAL SCIENCE 463-496

1. Structural of Metals & Alloys 463
2. Equilibrium Diagrams & Phase Changes 466
3. Heat Treatment of Steels 469
4. Plastics, Ceramics and Composite Materials 473
5. Mechanical Properties 477
6. Engineering Alloys & Its Common Applications 481

XI. PRODUCTION ENGINEERING 497-564

1. Casting Processes 497
2. Forming Processes 502
3. Powder Metallurgy 508
4. Metal Cutting and Tool Materials 510
5. Machining Processes 517
6. Joining Processes 523
7. Unconventional Machining Process 527
8. Numerical Control of Machine Tools 530
9. Jigs and Fixtures 532
10. Fits and Tolerance 533
11. Metrology 535

XII. INDUSTRIAL ENGINEERING 565-610

1. Plant Layout 565
2. Loading and Scheduling 567
3. Assembly Line Balancing 570
4. Product Development 572
5. Forecasting 572
6. Break Even Analysis 575
7. Work Study 576
8. Material Requirement Planning 580
9. Quality Analysis and Control 581
10. Inventory Control 584
11. PERT and CPM 587
12. Linear Programming 590
13. Transportation and Assignment Models 592
14. Queuing Theory 593
15. Value Engineering 595

■■■■

UNIT 1

Thermodynamics

1. Basic Concepts

Q.1 The study of thermodynamics provides answer to the followings:
1. whether a process is feasible or not
2. to quantity 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.2 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 transfer and transformation of energy.
3. Engineering thermodynamics studies about storage, transfer and transformation of energy.

Which of the above is/are correct?
(a) 3 only (b) 1 and 3
(c) 2 only (d) 1 and 2

Q.3 An adiabatic boundary is one which
(a) prevents heat transfer
(b) permits heat transfer
(c) prevents work transfer
(d) permits work transfer

Q.4 Match the following **List-I** with **List-II**:

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.5 Match the following **List-I** (Thermometer) with **List-II** (Thermometric property):

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.6 In a quasiequilibrium 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.7 Convert the following readings of pressure to kPa, assuming that the barometer reads 760 mm of Hg and match the **List-I** with **List-II**:

List-I	**List-II**
A. 50 cm Hg vacuum	**1.** 113 kPa
B. 80 cm Hg gauge	**2.** 34.68 kPa
C. 1.2 m of H_2O gauge	**3.** 208 kPa

Codes:

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

Q.8 Match the **List-I** (Terms) with **List-II** (Description) and select the correct answer:

List-I
A. Change of state
B. Path
C. Process

List-II
1. Succession of states
2. One or more properties changes
3. Change of state for specified path

Codes:

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

Q.9 Ice kept in a wall insulated thermo-flask is an example of which system?
(a) closed system
(b) isolated system
(c) open system
(d) non-flow adiabatic system [IES-2009]

Q.10 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 statement are correct?
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) all of the above

Q.11 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.12 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.13 Match **List-I** with **List-II** and select the correct answer:

List-I
A. Interchange of matter is not possible in a
B. Any processes in which the system returns to its original condition or state is called
C. Interchange of matter is possible in a
D. The quantity of matter under consideration in thermodynamics is called

List-II
1. Open system
2. System
3. Closed system
4. Cycle

Codes:

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

[IES-2011]

Q.14 Which one of the following represents open thermodynamic system?
(a) Manual ice cream freezer
(b) Centrifugal pump
(c) Pressure cooker
(d) Bomb calorimeter [IES-2011]

Q.15 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 [IES-2011]

Q.16 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 [IES-2010]

Q.17 A thermodynamic system refers to
(a) any defined region in space
(b) a specified mass in fluid flow
(c) a specified region of constant volume
(d) a prescribed and identifiable quantity of matter

Q.18 In highly rarefied gases, the concept of this loses validity
(a) thermodynamic equilibrium
(b) continuum
(c) stability
(d) macroscopic viewpoint [IES-2012]

Q.19 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.20 Consider the following:
1. Temperature 2. Viscosity
3. Specific entropy 4. Thermal conductivity
Which of the above properties of a system is/are intensive?
(a) 1 only (b) 2 and 3 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4
[ESE-2009]

Q.21 The sequence of processes that eventually returns the working substance to its original state is known as
(a) event
(b) process
(c) thermodynamic property
(d) thermodynamic cycle

Q.22 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.23 Which one of the following is extensive property of a thermodynamics system
(a) Volume (b) Pressure
(c) Temperature (d) Density

Q.24 Which of the following quantities is not the property of the system
(a) Pressure (b) Temperature
(c) Density (d) Heat

Q.25 The fundamental unit of enthalpy is
(a) MLT^{-2} (b) ML^2T^{-1}
(c) ML^2T^{-2} (d) ML^3T^{-2}
[IAS Pre-1994]

Q.26 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.27 The value of an extensive property is extensively dependent on
(a) mass or extend 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.28 A diathermic wall is one which
(a) prevents thermal interaction
(b) permits thermal interaction
(c) encourages thermal interaction
(d) discourages thermal interaction

Q.29 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.30 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.31 Which of the following statements regarding the concept of continuum are correct?
1. Large number of molecules enable meaningful statistical averaging and assignment of property values
2. Mean free path of the molecules is order of magnitude higher 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.32 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.33 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
[UPSC JWM-2007]

2. Temperature

Q.34 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.
[IES-1996]

Q.35 The Kelvin temperature of a system can be measured by a
(a) mercury-in-glass thermometer
(b) thermocouple
(c) constant-volume gas thermometer
(d) resistance thermometer

Q.36 As per international practice, the temperature interval from oxygen point to gold point is divided into three main parts. Which of the following temperature interval is not correct?
(a) 0 to 560°C (b) 0 to 660°C
(c) –190 to 0°C (d) 660 to 1093°C

Q.37 Match **List-I** with **List-II** the following:

List-I	List-II
A. Normal boiling point of oxygen	**1.** 100°C
B. Triple point of water	**2.** –183°C
C. Normal boiling point of water	**3.** 1063°C
D. Normal melting point of gold	**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.38 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.39 Match **List-I** (Type of thermometer) **List-II** (Thermometric property) the following:

List-I
A. Mercury-in-glass
B. Thermocouple
C. Thermistor
D. Constant volume gas

List-II
1. Pressure
2. Electrical resistance
3. Volume
4. Induced electric voltage

Codes:

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

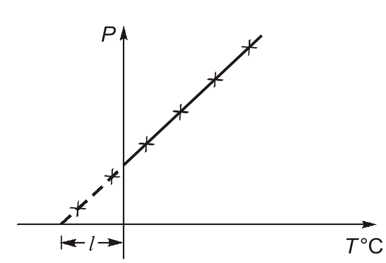
[IES-2007]

Q.40 Zeroth law of thermodynamics form the basis of measurement of
(a) pressure (b) temperature
(c) heat exchanger (d) work

Q.41 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.42 Triple point temperature of water is
(a) 273 K (b) 273.14 K
(c) 273.15 K (d) 273.16 K

Q.43 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.44 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

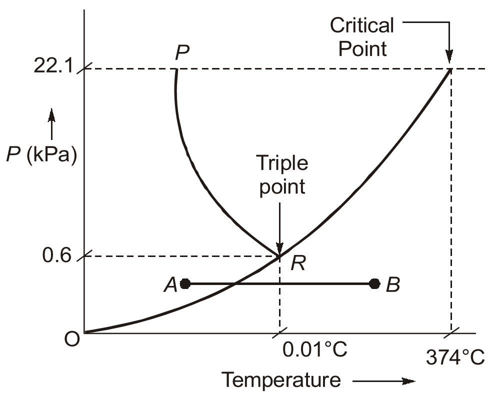
(a) 0°C (b) 50°C
(c) 100°C (d) 150°C

Q.45 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.46 The critical point and triple point data for water are

$T_C = 374°C$, $P_C = 22.1$ MPa
$T_T = 0.01°C$, $P_T = 0.6$ kPa



Indicate the phase change that will occur in following cases:

(i) Ice at 0.5 kPa is heated isobarically
(ii) Water vapour at 400°C is compressed isothermally

(a) (i) along *AB* (ii) along *CD*
(b) (i) along *CD* (ii) along *AB*
(c) (i) along *OD* (ii) along *PR*
(d) (i) along *RD* (ii) along *OR*

3. Work and Heat Transfer

Q.47 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 [IES-2010]

Q.48 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

[IES-2012]

Q.49 The integrating factor of quasi-static displacment work is

(a) $\frac{1}{T}$ (b) $\frac{1}{P}$
(c) $\frac{1}{V}$ (d) $\frac{P}{V}$

Q.50 The integrating factor of reversible heat transfer is

(a) $\frac{1}{T}$ (b) $\frac{1}{P}$
(c) $\frac{1}{V}$ (d) $\frac{P}{T}$

Q.51 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 Gibbs function

Q.52 Which among the following is not a boundary phenomenon?

(a) Work transfer
(b) Heat transfer
(c) Mass transfer
(d) Change of temperature

Q.53 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.54 Which among the following is not true?

(a) Heat and work transfer are the energy interactions.
(b) Both heat and work transfer are path functions and exact differentials.
(c) Heat transfer is the energy interaction due to temperature difference only.
(d) Work and heat transfer are boundary phenomenon.

Q.55 The following data refer to a 6-cylinder, single-acting, two-stroke diesel engine:
Speed – 250 rpm
Cylinder diameter – 0.7 m
Stroke of a piston – 1.2 m
Area of indicator diagram – 5.5×10^{-4} m^2
Length of diagram – 0.06 m
Spring value – 144 MPa per m
What is the net rate of work transfer from the gas to the pistons in kW?
(a) 11434 (b) 20000
(c) 15232 (d) 17323

Q.56 A piston-cylinder device with air at an initial temperature of 28°C undergoes an expansion process for which pressure and volume are related as given below:

P (kPa)	100	50	40	27	15
V (m^3)	0.1	0.15	0.2	0.25	0.4

What is the work done by the system?
(a) 9 kJ (b) 10 kJ
(c) 11 kJ (d) 12 kJ

Q.57 Work done is zero for the following process
(a) constant volume (b) free expansion
(c) throttling (d) all of the above
[RRB Mumbai-2008]

Q.58 In free expansion process
(a) $W_{1-2} = 0$ (b) $Q_{1-2} = 0$
(c) $dU = 0$ (d) All of the above

Q.59 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.60 The cyclic integral of $(\delta Q - \delta W)$ for a process is
(a) positive (b) negative
(c) zero (d) unpredictable

Q.61 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.62 Thermodynamic work is the product of
(a) two intensive properties
(b) two extensive properties
(c) an intensive property and change in an extensive property
(d) an extensive property and change in an intensive property

Q.63 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.64 The expression for work done during a process $\int p dV$ is applicable for
(a) reversible process only
(b) irreversible process only
(c) polytropic process only
(d) any process

Q.65 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.66 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
[UPSC JWM-2008]

Q.67 Which one of the following statement holds good for the equation

$$\delta Q = dE + \delta W$$

(a) any process undergone by a closed stationary system
(b) any process, reversible and irreversible and for any system
(c) a closed system when only pdV work is present
(d) only reversible process
[UPSC JWM-2008]

Q.68 Change in internal energy in a reversible process occurring in a closed system is equal to the heat transferred, if the process occurs at constant
(a) pressure (b) volume
(c) temperature (d) enthalpy

Q.69 300 kJ/s of heat is supplied at a constant fixed temperature of 290°C to a heat engine. The heat rejection takes place at 8.5°C. Then match the following

Results obtained	Cycle
A. 215 kJ/s are rejected	1. reversible
B. 150 kJ/s are rejected	2. irreversible
C. 75 kJ/s are rejected	3. impossible

Codes:

	A	B	C
(a)	1	2	3
(b)	2	1	3
(c)	3	2	1

Q.70 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.71 A 2 kW electric resistance heater submerged in 5 kg water is turned on and kept on for 10 min. During the process 300 kJ of heat is lost from the water the temperature rise of water is

(a) 57.4°C (b) 71.8°C
(c) 43.1°C (d) 180°C

Q.72 One kg of ice at 0°C is completely melted into water at 0°C at 1 bar pressure. The latent heat of fusion of water is 333 kJ/kg and densities of water and ice at 0°C are 999 kg/m^3 and 916 kg/m^3 respectively. What are the approximate values of work done and energy transferred as heat for the process respectively

(a) –9.4 J & 333 kJ (b) 9.4 J & 333 kJ
(c) 333 kJ & –9.4 J (d) None of these

[IES-2007]

Q.73 It is desired to bring about a certain change in the state of a system by performing work on the system under adiabatic conditions.

(a) The amount of work needed is path dependent
(b) Work alone cannot bring about such a change of state
(c) The amount of work needed is independent of path
(d) More information is needed to conclude anything about the path dependence or otherwise of the work needed

Q.74 Which one of the following statements is true?

(a) Heat can be fully converted into work
(b) Work cannot be fully converted into heat
(c) The efficiency of a heat engine increases as the temperature of the heat source is increased while keeping the temperature of the heat sink fixed
(d) A cyclic process can be devised whose sole effect is to transfer heat from a lower temperature to higher temperature

Q.75 Match the following:

A. Heat	**I.** State function
B. Internal energy	**II.** Path function
C. Work	
D. Entropy	

(a) A-II, B-I, C-I, D-I
(b) A-II, B-I, C-II, D-II
(c) A-II, B-II, C-I, D-I
(d) A-II, B-I, C-II, D-I

Q.76 2 kg of steam in a piston-cylinder device at 400 kPa and 175°C undergoes a mechanically reversible, isothermal compression to a final pressure such that the steam becomes just saturated. What is the work, W, required for the process?

Data:
T = 175°C; P = 400 kPa
v = 0.503 m^3/kg u = 2606 kJ/kg
s = 7.055 kJ/kgK
Saturated vapour, v = 0.216 m^3/kg
u = 2579 kJ/kg, s = 6.622 kJ/kgK

(a) 0 kJ (b) 230 kJ
(c) 334 kJ (d) 388 kJ

4. First Law of Thermodynamics

Q.77 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

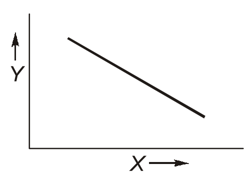
Q.78 A stationary mass of gas is compressed without friction from an initial state of 0.3 m^3 and 1 MPa to a final state of 0.15 m^3 and 1 MPa, the pressure

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.79 An engine is tested by means of a water brake at 1000 rpm. The measured torque of the engine is 10000 Nm and the water consumption of the brake is 0.5 m^3/s, its inlet temperature being 25°C. Assuming that the whole of the engine power is ultimately transferred into heat which is absorbed by the cooling water, what is the water temperature at exit?
(a) 22.5°C (b) 23.5°C
(c) 24.5°C (d) 25.5°C

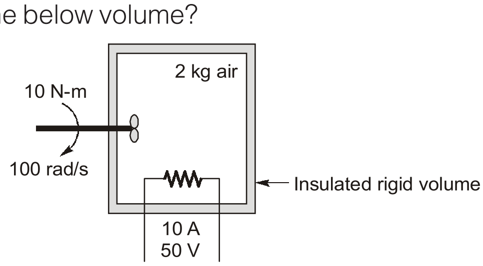
Q.80 The first law of thermodynamics is the law of
(a) conservation of mass
(b) conservation of energy
(c) conservation of momentum
(d) conservation of temperature

Q.81 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.82 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

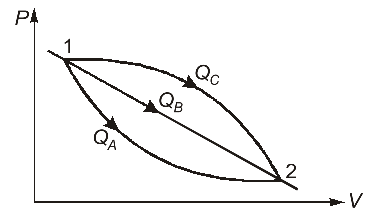
Q.83 What is the temperature rise after 5 minutes in the below volume?



(a) 423°C (b) 378°C
(c) 224°C (d) 287°C

Q.84 Energy is added to 5 kg of air with a paddle wheel until ΔT = 100°C. What is the paddle wheel work if the rigid volume is insulated?
(a) 203 kJ (b) 482 kJ
(c) 412 kJ (d) 358 kJ

Q.85 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.86 The values of heat and work transfer for the flow processes of a thermodynamic cycle are given below:

Process	Heat transfer (kJ)	Work transfer (kJ)
1	300	300
2	0	250
3	–100	–100
4	0	–250

The thermal efficiency and work ratio for the cycle will be respectively
(a) 33% and 0.66 (b) 66% and 0.36
(c) 36% and 0.66 (d) 33% and 0.36
[IES-1994]

Q.87 According to first law of thermodynamics
(a) total internal energy of a system during a process remains constant
(b) total energy of a system remains constant
(c) work done by a system is equal to the heat transferred by the system
(d) internal energy, enthalpy and entropy during a process remains constant hence it is an Isochoric process.

Q.88 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.89 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.90 First law of thermodynamics is valid for
(a) all processes
(b) only reversible processes

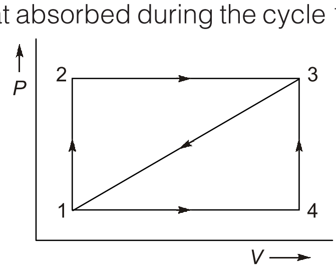
(c) only cyclic processes
(d) only cyclic processes that are carried out reversibly

Q.91 During a thermodynamic process, 84 kJ of heat flows into the system and the work done by the system is 32 kJ. The increase in internal energy of the system is
(a) +52 kJ (b) –52 kJ
(c) +116 kJ (d) –116 kJ
[UP Irrigation-2008]

Q.92 The specific heat at constant pressure for an ideal gas is given by
$c_p = 0.9 + (2.7 \times 10^{-4})T$ (kJ/kgK)
Where T is in kelvin. The change in enthalpy for this ideal gas undergoing a process in which the temperature changes from 27°C to 127°C is most nearly.
(a) 90 kJ/kg (b) 108.9 kJ/kg
(c) 99.5 kJ/kg (d) 105.2 kJ/kg

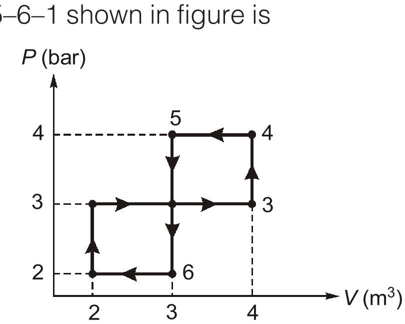
Q.93 A closed system undergoes a process 1-2 for which the values of $Q_{1\text{-}2}$ and $W_{1\text{-}2}$ are +20 kJ and +50 kJ respectively. If the system is returned to state 1 and $Q_{2\text{-}1}$ is –10 kJ what is the value of work $W_{2\text{-}1}$
(a) +20 kJ (b) –40 kJ
(c) –80 kJ (d) +40 kJ

Q.94 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.95 The network output for the cycle 1–2–3–4–5–6–1 shown in figure is

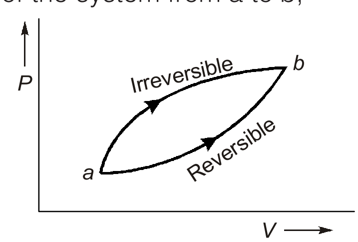


Q.96 In a reversible isothermal expansion process fluid expands from 10 bar and 2 m^3 to 2 bar and 10 m^3. During the process the heat supplied is at the rate of 100 kW. What is the rate of work done during the process
(a) 200 kJ (b) 1200 kJ
(c) 0 kJ (d) 1000 kJ

(a) 20 kW (b) 35 kW
(c) 80 kW (d) 100 kW

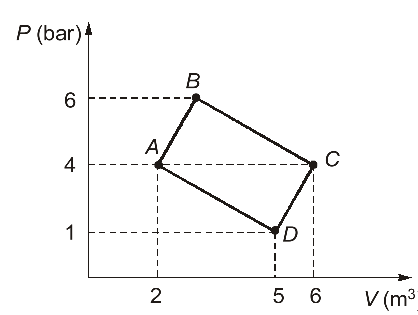
Q.97 The state of an ideal gas is changed from (T_1, P_1) to (T_2, P_2) in a constant volume process. To calculate the change in enthalpy, (Δh) all of the following properties/variables are required.
(a) C_v, P_1, P_2 (b) C_p, T_1, T_2
(c) C_p, T_1, T_2, P_1, P_2 (d) C_v, P_1, P_2, T_1, T_2

Q.98 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
[GATE Chemical Engg.-2007]

Q.99 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.100 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

Answers Thermodynamics

1.	(c)	2.	(b)	3.	(a)	4.	(c)	5.	(d)	6.	(c)	7.	(c)	8.	(a)
9.	(b)	10.	(a)	11.	(b)	12.	(c)	13.	(d)	14.	(b)	15.	(c)	16.	(d)
17.	(d)	18.	(b)	19.	(d)	20.	(d)	21.	(d)	22.	(b)	23.	(a)	24.	(d)
25.	(c)	26.	(b)	27.	(a)	28.	(b)	29.	(b)	30.	(d)	31.	(c)	32.	(a)
33.	(c)	34.	(d)	35.	(c)	36.	(a)	37.	(b)	38.	(c)	39.	(d)	40.	(b)
41.	(c)	42.	(d)	43.	(d)	44.	(d)	45.	(a)	46.	(a)	47.	(a)	48.	(a)
49.	(b)	50.	(a)	51.	(a)	52.	(d)	53.	(c)	54.	(b)	55.	(c)	56.	(b)
57.	(d)	58.	(d)	59.	(c)	60.	(c)	61.	(b)	62.	(c)	63.	(d)	64.	(a)
65.	(b)	66.	(a)	67.	(b)	68.	(b)	69.	(b)	70.	(a)	71.	(c)	72.	(a)
73.	(a)	74.	(c)	75.	(d)	76.	(c)	77.	(c)	78.	(c)	79.	(d)	80.	(b)
81.	(c)	82.	(d)	83.	(c)	84.	(a)	85.	(a)	86.	(b)	87.	(b)	88.	(b)
89.	(b)	90.	(a)	91.	(a)	92.	(c)	93.	(b)	94.	(d)	95.	(c)	96.	(d)
97.	(b)	98.	(b)	99.	(b)	100.	(c)	101.	(b)	102.	(d)	103.	(b)	104.	(b)
105.	(b)	106.	(c)	107.	(d)	108.	(b)	109.	(a)	110.	(c)	111.	(b)	112.	(b)
113.	(c)	114.	(d)	115.	(c)	116.	(c)	117.	(c)	118.	(c)	119.	(c)	120.	(a)
121.	(d)	122.	(c)	123.	(a)	124.	(c)	125.	(a)	126.	(d)	127.	(b)	128.	(b)
129.	(b)	130.	(b)	131.	(d)	132.	(d)	133.	(a)	134.	(b)	135.	(b)	136.	(b)
137.	(a)	138.	(b)	139.	(d)	140.	(b)	141.	(b)	142.	(d)	143.	(b)	144.	(c)
145.	(a)	146.	(c)	147.	(b)	148.	(d)	149.	(b)	150.	(c)	151.	(b)	152.	(b)
153.	(a)	154.	(b)	155.	(c)	156.	(c)	157.	(c)	158.	(d)	159.	(d)	160.	(c)
161.	(d)	162.	(d)	163.	(b)	164.	(d)	165.	(d)	166.	(c)	167.	(c)	168.	(a)
169.	(d)	170.	(b)	171.	(b)	172.	(c)	173.	(c)	174.	(b)	175.	(b)	176.	(a)
177.	(b)	178.	(b)	179.	(d)	180.	(a)	181.	(b)	182.	(a)	183.	(d)	184.	(d)
185.	(d)	186.	(a)	187.	(b)	188.	(c)	189.	(d)	190.	(b)	191.	(b)	192.	(d)
193.	(a)	194.	(c)	195.	(b)	196.	(b)	197.	(c)	198.	(c)	199.	(d)	200.	(b)
201.	(d)	202.	(d)	203.	(c)	204.	(d)	205.	(b)	206.	(a)	207.	(b)	208.	(b)
209.	(a)	210.	(b)	211.	(d)	212.	(d)	213.	(c)	214.	(c)	215.	(d)	216.	(b)
217.	(a)	218.	(d)	219.	(d)	220.	(a)	221.	(a)	222.	(d)	223.	(b)	224.	(c)
225.	(c)	226.	(b)	227.	(a)	228.	(a)	229.	(b)	230.	(b)	231.	(a)	232.	(b)
233.	(a)	234.	(d)	235.	(a)	236.	(b)	237.	(a)	238.	(a)	239.	(a)	240.	(b)
241.	(c)	242.	(d)	243.	(c)	244.	(b)	245.	(a)	246.	(a)	247.	(d)	248.	(b)
249.	(b)	250.	(c)	251.	(c)	252.	(a)	253.	(d)	254.	(b)	255.	(a)	256.	(a)
257.	(b)	258.	(c)	259.	(d)	260.	(a)	261.	(b)	262.	(c)	263.	(c)	264.	(b)
265.	(b)	266.	(d)	267.	(c)	268.	(c)	269.	(b)	270.	(b)	271.	(a)	272.	(b)
273.	(a)	274.	(b)	275.	(a)	276.	(d)	277.	(c)	278.	(a)	279.	(d)	280.	(a)
281.	(b)	282.	(c)	283.	(a)	284.	(a)	285.	(c)	286.	(d)	287.	(b)	288.	(c)
289.	(c)	290.	(a)												

Explanations

5. (d)

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

7. (c)

50 cm Hg vacuume:

$$P_{vacuum} = \rho gh$$
$$= 13.6 \times 10^3 \times 9.81 \times 50 \times 10^{-2}$$
$$= 66.70 \text{ kPa}$$
$$P_{abs} = P_{atm} - P_{vac}$$
$$= (760 - 500) \times 9.81 \times 13.6$$
$$= 34.68 \text{ kPa}$$

80 cm Hg gauge:

$$P_{abs} = P_{atm} + P_{guage}$$
$$= (760 + 800) \times 9.81 \times 13.6$$
$$= 208 \text{ kPa}$$

1.2 m of H_2O guage:

$$P_{abs} = P_{atm} + P_{guage}$$
$$= 101.325 + 1.2 \times 9.81 = 113 \text{ kPa}$$

8. (a)

Properties are the coordinates to describe the state of a system. They are state variables of the system. Any operation in which one or more of the properties of a system changes is called a change of state. The succession of states passes through during a change of state is called the path of the change of state is called a process. A thermodynamic cycle is defined as a series of state changes such that the final state is identical with the initial state.

17. (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.

18. (b)

The concept of continuum loses validity when the mean free path of the molecules approaches the order of magnitude of the dimension of the vessel. So, in highly rarefied gases the concept of continuum loses its validity.

21. (d)

Thermodynamic cycle can be defined as a series of state changes such that the final and initial state is identical.

22. (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.

23. (a)

Since volume depends on mass hence it is extensive property.

24. (d)

Since heat transfer is the path function hence it is not the property of the system.

26. (b)

Open system: Both mass and energy transfer takes place

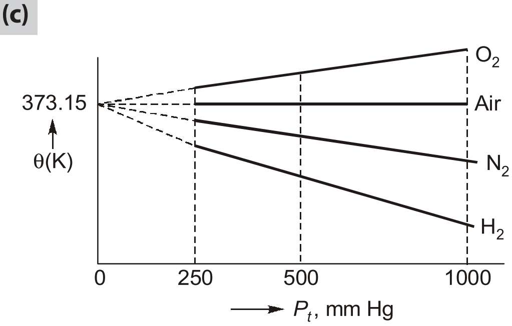
Closed system: No mass transfer, energy transfer may takes place

Isolated system:
Neither energy nor mass transfer takes place.

29. (b)

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

35. (c)



37. (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

38. (c)

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

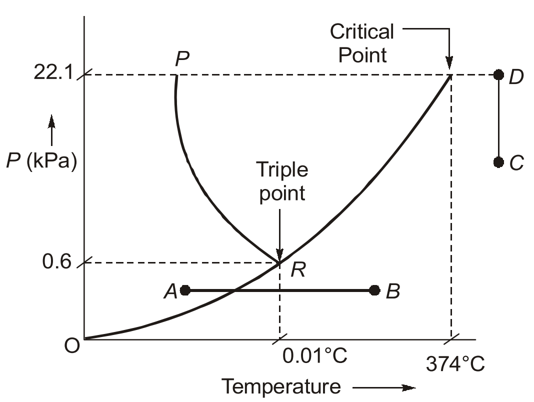
40. (b)

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

45. (a)

Zeroth law gives the concept of temperature.

46. (a)



AB ⇒ Constant pressure heating at around 0.5 kPa.

CD ⇒ Constant temperature compressor at around 400°C.

47. (a)

$$\delta Q = \delta W + \Delta U \quad \text{(As per 1}^{\text{st}}\text{ law)}$$

$$\therefore \quad \delta W = \delta Q - \Delta U$$

$$= 60 + 30 = 90 \text{ kJ}$$

48. (a)

As per first law of thermodynamics:

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

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

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

$$= -40 + 20 = -20 \text{ kJ/kg}$$

49. (b)

Quasistatic work,

$$\delta W = P\, dV$$

$$dV = \frac{1}{P}\delta W$$

An inexact different dW when multiplied by an integrating factor $1/P$ becomes an exact differential dV.

(Point function) = (Integrating factor) × (Path function)

50. (a)

$$\frac{\delta Q}{T} = ds$$

51. (a)

$$\delta W = 0$$

(for constant volume process)

$$\therefore \quad \delta Q = \delta W + \Delta U = 0 + \Delta U$$

$$\therefore \quad \delta Q = \Delta U$$

53. (c)

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

55. (c)

$$P_m = \frac{a_d}{l_d} \times \text{spring constant},$$

$$= \frac{5.5 \times 10^{-4}}{0.06} \times 144 = 5.5 \times 10^{-2} \times 24 \text{ MPa}$$

Net work transfer,

$$= 1.32 \times \frac{\pi}{4} \times 0.7^2 \times 1.2 \times \frac{250}{60} \times 6$$

$$= 15232 \text{ kW}$$

56. (b)

$$W = \int P dV \frac{P_1 V_1 - P_5 V_5}{n - 1}$$

$$= \frac{100 \times 0.1 - 15 \times 0.4}{0.4} = 10 \text{ kJ}$$

(for air, $n = 1.4$)

57. (d)

For constant volume process

$$W = \int p dV$$

Since, $dV = 0$

$W = 0$

For free expansion

$W = 0$

Also for throttling process

$W = 0$

58. (d)

For free expansion,

$\delta W = 0$

No heat interaction takes place,

Hence $\delta Q = 0$

From first law,

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

$dU = 0$

59. (c)

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

60. (c)

For a process

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

61. (b)

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

For constant volume, close system work = 0

Hence, $\delta Q = dU$

62. (c)

$$W = \int_1^2 p dV$$

p → Intensive property

dV → Change in extensive property

63. (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.

65. (b)

From the first law of thermodynamics

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

$$-1500 = dU - 5000$$

$$dU = 5000 - 1500$$

$$dU = 3500 \text{ kJ}$$

66. (a)

From T-dS equation

$TdS = dh - VdP$

$TdS = \delta Q$ (for reversible process)

$\delta Q = dh$ when $dP = 0$

Hence for constant pressure process

$\delta Q = dh$

67. (b)

$$\delta Q = dU + PdV$$

This equation holds good for any process reversible or irreversible.

68. (b)

$$\delta Q = dU + PdV$$

for constant volume process $dV = 0$

$\delta Q = dU$

70. (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

71. (c)

$P = 2$ kW; Mass = 5 kg

Heat lost = 300 kJ

Heat supplied = 2 × 600 = 1200 kJ

Net heat supplied

= 1200 – 300 = 900 kJ

$900 = 5 \times 4.18 (\Delta T)$

$\Delta T = 43.1°C$

72. (a)

$$W = \int_{V_1}^{V_2} PdV = P(V_2 - V_1)$$

$$= 10^5 \left[\frac{1}{999} - \frac{1}{916}\right]$$

$= -9.4$ J

Heat transfer $= mL$

$= 1 \times 333 = 333$ kJ

74. (c)

The efficiency of a heat engine increases as the temperature of the heat source is increased while keeping the temperature of the heat sink fixed.

75. (d)

Heat is a path function
Internal energy is a state function
Work is a path function
Entropy is a state function

76. (c)

$$q = T(s_2 - s_1)$$
$$= (175 + 273)(6.622 - 7.055)$$
$$= -193.983 \text{ kJ/kg}$$
$$W = [q - (u_2 - u_1)]\, m$$
$$= \{-193.984 - (2579 - 2606)\} \times 2$$
$$= -333.96 = -334 \text{ kJ}$$

77. (c)

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

For the cyclic process,

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

78. (c)

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

79. (d)

Engine power,

$$P = T \times \frac{2\pi N}{60} = 10{,}000 \times \frac{2 \times \pi \times 1000}{60}$$
$$= 1046.67 \text{ kW}$$
$$Q = 1000 \times 0.5 \times 4.18 \times \Delta T = \text{Power}$$
$$\therefore \quad \Delta T = \frac{1046.67}{1000 \times 0.5 \times 4.18} = 0.5°\text{C}$$

also $\Delta T = T_{w2} - T_{w1}$

$$0.5 = T_{w2} - 25$$

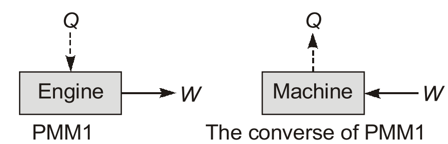
or $T_{w2} = 25.5°\text{C}$

81. (c)

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

82. (d)

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



83. (c)

Energy in = Energy out

Energy in = $10 \times 100 \times 5 \times 60 + 10 \times 50 \times 5 \times 60$

$= 450$ kJ

Energy out = $m\, c_p\, \Delta T$

$$\therefore \quad \Delta T = \frac{Q}{m c_p} = \frac{450}{2 \times 1.005} = 223.88°\text{C}$$

84. (a)

$$Q = m\, C_p\, \Delta T = 5 \times 1.005 \times 100 = 502.5 \text{ kJ}$$

85. (a)

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

$\because$ $W_A < W_B < W_C$ and ΔU same for all

$\therefore$ $Q_A < Q_B < Q_C$

86. (b)

$$\eta = \frac{W_{\text{net}}}{Q_s} = \frac{300 + 250 \quad 100 \quad 250}{300}$$
$$= \frac{200}{300} = \frac{2}{3} \times 100 = 66.67\%$$

$$\text{Work ratio} = \frac{W_{\text{net}}}{\text{Work output by the proess}}$$
$$= \frac{200}{550} = 0.36$$

87. (b)

Since first law of thermodynamics defined as law of conservation of energy hence total energy of a system remains constant.

88. (b)

Zeroth law of thermodynamics — concept of temperature
First law of thermodynamics — concept of internal energy
Second law of thermodynamics — concept of entropy.

91. (a)

From first law of thermodynamics

$\delta Q = dU + \delta W \qquad 84 = dU + 32$

$dU = 52$ kJ

92. (c)

$$dh = c_p dT$$
$$\int dh = \int_{300}^{400} 0.9 + (2.7\times10^{-4})T\,dT$$
$$= 0.9T + (2.7\times10^{-4})\frac{T^2}{2}\Big|_{300}^{400}$$
$$= 99.45 \text{ kJ/kg}$$

93. (b)

For process 1-2

$Q_{1-2} = dU_{1-2} + W_{1-2}; \quad 20 = (U_2 - U_1) + 50$

$U_2 - U_1 = -30$ kJ

For process 2-1

$Q_{2-1} = -10$ kJ $\qquad U_{2-1} = +30$ kJ

$Q_{2-1} = dU_{2-1} + \delta W; \qquad -10 = 30 + \delta W$

$\delta W = -40$ kJ

94. (d)

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

$W_{1-3} = 20$ kJ; $\qquad U_{3-1} = 40$ kJ

$\delta Q = 40 + 20 = 60$ kJ

96. (d)

Note that in case of reversible isothermal expansion change in internal energy is zero hence

$$\delta Q = \delta W = 100 \text{ kW}$$

97. (b)

$$C_p = \frac{dh}{dt}$$

98. (b)

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

101. (b)

$V_1 = 0.03\text{ m}^3 \qquad \delta W = PdV$

$V_2 = 0.06\text{ m}^3$

$P = 1000$ kPa

$W = 1000(0.06 - 0.03)$

$= 1000 \times 0.03$

$\delta Q = 84$ kJ $= 30$ kJ

$\delta Q = dU + \delta W$

$84 = \delta W + 30$

$dU = 54$ kJ

102. (d)

$$Q = m\,c_p\,\Delta T \qquad c_p = \frac{\gamma . R}{(\gamma - 1)}$$

For Oxygen,

$$R = \frac{R_0}{M} = \frac{8314}{32} = 259.8$$
$$C_p = \frac{1.4\times0.2598}{(1.4-1)} = 0.9093 \text{ kJ/kg C}$$
$$Q = m\,c_p\,\Delta T = 2\times0.9093\times100$$
$$= 181.86 \text{ kJ} = 182 \text{ kJ}$$

103. (b)

Work in steady flow process = $\int VdP$
Work in non-flow process = $\int PdV$

104. (b)

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

105. (b)

Bernoulli's equation valid for frictionless incompressible fluids. S.F.E.E. valid for viscous compressible fluids.

107. (d)

S.F.E.E:

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

Δh accounts for internal energy and pressure forces.

110. (c)

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