Previous Years Solved Papers

1560 Objective Solved Questions

Civil Services Preliminary Examination

1998-2010

Useful for Engineering Services Preliminary Examination, GATE and State Engineering Services Examinations

Mechanical Engineering

Detailed Solutions

Topicwise Presentation

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Civil Services Preliminary Examination Previous Years Solved Papers : Mechanical Engineering

First Edition: 2016

Preface

B. Singh (Ex. IES)

Civil Services Examination is considered as a pioneer job in India which is being preferred by engineers. There was a need of good book, which contains error free questions with apt solutions that even a begineer student can understand. I am glad to launch the first edition of this book.

MADE EASY team has made deep study of previous exam papers of Civil Services Preliminary Examination and observed that a good percentage of questions are asked in Engineering Services Exam as well as State Services Exam. Therefore it is advisable to study this book before one takes the exam. This book is also useful for GATE and other competitive examinations for engineering graduates.

The first edition of this book is prepared with due care to provide complete solutions to all questions with accuracy. I would like to give credit of publishing this book to MADE EASY Team for their hard efforts in solving previous years papers in a limited time frame.

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

With Best Wishes

B. Singh

CMD, MADE EASY Group

Previous Years Solved Papers

Civil Services Preliminary Exam.

Mechanical Engineering

CONTENTS

1 Thermodynamics

Basic Concepts & Zeroth Law of Thermodynamics

1. 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 **[CSE-Pre : 1998]**

2. Match **List-I** with **List-II** and select the correct answer:

List-I (*Parameter*)	**List-II** (*Property*)
A. Volume	**1.** Path function
B. Density	**2.** Intensive property
C. Pressure	**3.** Extensive property
D. Work	**4.** Point function

Codes:

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

[CSE-Pre : 1999]

3. Ratio of specific heats for an ideal gas is given by (symbols have the usual meaning)

   (a) $\frac{1}{1-R/C_P}$ (b) $\frac{1}{1-C_P/R}$

   (c) $\frac{1}{1+C_P/R}$ (d) $\frac{1}{1+R/C_p}$

   [CSE-Pre : 1999]

4. In steam and other vapour cycles, the process of removing non-condensable is called
   (a) Scavenging process
   (b) Deaeration process
   (c) Exhaust process
   (d) Condensation process

   [CSE-Pre : 2003]

5. What are the properties of a thermodynamic system, whose value for the entire system is equal to the sum of their values for individual parts of the system ?
   (a) Thermodynamic properties
   (b) Extensive properties
   (c) Intensive properties
   (d) None of the above

   [CSE-Pre : 2006]

6. A new temperature scale in degrees *N* is to be defined. The boiling and freezing point of water on this scale are 400°N and 100°N respectively. What will be the reading on new scale corresponding to 60° C?
   (a) 110° N (b) 180° N
   (c) 210° N (d) 280° N

   [CSE-Pre : 2006]

7. Which thermometer is independent of the substance or material used in its construction?
   (a) Mercury thermometer
   (b) Alcohol thermometer
   (c) Ideal gas thermometer
   (d) Resistance thermometer

   [CSE-Pre : 2006]

8. Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I

A. Constant volume gas thermometer
B. Constant pressure gas thermometer
C. Electrical resistance thermometer
D. Mercury-in-glass thermometer

List-II

1. Length
2. Resistance
3. Pressure
4. Volume

Codes:

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

(c) 1 4 2 3
(d) 3 2 4 1

[CSE-Pre : 2009]

9. On which laws of thermodynamics is the measurement of temperature based ?
(a) Zeroth (b) First
(c) Second (d) Third

[CSE-Pre : 2009]

10. Which one of the following is an intensive thermodynamic property ?
(a) Density (b) Energy
(c) Entropy (d) Volume

[CSE-Pre : 2009]

11. Which of the following is a heterogeneous system?
(a) The cooling of a fluid in a radiator
(b) A mixture of ice, water and steam
(c) A mixture of hydrogen and oxygen
(d) Atmospheric air

[CSE-Pre : 2010]

12. **Assertion (A):** The temperature of a system given by a mercury thermometer and an electric resistance thermometer would not be exactly the same except at their common fixed points.
Reason (R): The empirical temperature scales are dependent on the nature of the thermometric substance used.
(a) Both A and R are true and R is a 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.

[CSE-Pre : 2010]

Energy and Energy Interactions

13. When a can of compressed air is punctured, air blows out to the right and the can will move from right to left. When a vacuum can is punctured such that air enters from the right to left.
(a) The can will move left to right
(b) The can will move right to left
(c) The can will not move
(d) The can will initially move from right to left and then reverse the direction

[CSE-Pre : 2005]

First Law of Thermodynamics

14. A system undergoes a changes of state during which 80 kJ of heat is transferred to it and it does 60 kJ of work. The system is brought back to its original state through a process during which 100 kJ of heat is transferred to it. The work done by the system is
(a) 40 kJ (b) 60 kJ
(c) 120 kJ (d) 180 kJ

[CSE-Pre : 1998]

15. The heat transferred in a thermodynamic cycle of system consisting of our processes are successively 0, 8, 6 and –4 units. The net change in the internal energy of the system will be
(a) –8 (b) zero
(c) 10 (d) –10

[CSE-Pre : 1999]

16. During a process with heat and work interactions, the internal energy of a system increases by 30 kJ. The amounts of heat and work interactions are respectively
(a) –50 kJ and –80 kJ
(b) –50 kJ and 80 kJ
(c) 50 kJ and 80 kJ
(d) 50 kJ and –80 kJ

[CSE-Pre : 1999]

17. In respect of a closed system, when an ideal gas undergoes a reversible isothermal process, the
(a) heat transfer is zero
(b) change in internal energy is equal to work transfer
(c) work transfer is zero
(d) heat transfer is equal to work transfer

[CSE-Pre : 2000]

18. Identify the process of change of a closed system in which the work transfer is maximum
(a) Isothermal (b) Isochoric
(c) Isentropic (d) Polytropic

[CSE-Pre : 2003]

19. A system, executes a cycle during which there are four heat transfers:
Q_{12} = 220 kJ, Q_{23} = –25 kJ, Q_{34} = –180 kJ, Q_{41} = 50 kJ. The work during three of the

processes is W_{12} = 15 kJ, W_{23} = –10 kJ, W_{34} = 60 kJ. The work during the process 4 – 1 is
(a) – 230 kJ (b) 0 kJ
(c) 230 kJ (d) 130 kJ
[CSE-Pre : 2003]

20. In an adiabatic process 6000 J of work performed on a system. In the nonadiabatic process by which the system returns to its original state. 1000 J of heat is added to the system. What is the work done during nonadiabatic process?
(a) +7000 J (b) –7000 J
(c) +5000 J (d) –5000 J
[CSE-Pre : 2004]

21. Match **List-I** (Applications) with **List-II** (Choice of Bearings) and select the correct answer using the codes:

List-I
A. Bottle filling of gas
B. Nernst Simon statement
C. Joule Thomson effect
D. $\int Pdv$

List-II
1. Absolute zero temperature
2. Variable flow
3. Quasistatic path
4. Isenthalpic process
5. Dissipative effect
6. Low grade energy
7. Process and temperature during phase change

Codes:

	A	B	C	D
(a)	6	5	4	3
(b)	2	1	4	3
(c)	2	5	7	4
(d)	6	1	7	4

[CSE-Pre : 2004]

22. A battery is used to light a bulb, run a fan and heat an electric iron in case of a power failure. If each of the above system has 100 W rating and is run for 15 minutes, what are the work done (W) and heat transferred (Q) by the battery?
(a) W = 90 kJ and Q = 90 kJ
(b) W = 180 kJ and Q = 0
(c) W = 270 kJ and Q = 0
(d) W = 90 kJ and Q = 180 kJ
[CSE-Pre : 2005]

23. A system undergoes a change of state during which 100 kJ of heat is transferred to it and it does 50 kJ of work. The system is brought back to its original state through a process during which 120 kJ of heat is transferred to it. What is the work done by the system?
(a) 50 kJ (b) 70 kJ
(c) 120 kJ (d) 170 kJ
[CSE-Pre : 2005]

24. During a cycle comprising four processes, the heat transfers during three processes are +45 kJ, –30 kJ, –25 kJ. What should be the heat transfer during the fourth process so that the net work done during the cycle is zero?
(a) Zero (b) + 10 kJ
(c) – 10 kJ (d) – 20 kJ
[CSE-Pre : 2006]

25. A closed system undergoes a process during which 150 kJ of heat is added to it. The system is then restored in its initial state. If the heat transfer and work transfer for the second process are –50 kJ and +75 kJ respectively, what is the work transfer for the first process?
(a) 25 kJ (b) 50 kJ
(c) 75 kJ (d) 100 kJ
[CSE-Pre : 2006]

26. In a reversible isothermal expansion process, the 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) 20 kW (b) 35 kW
(c) 80 kW (d) 100 kW
[CSE-Pre : 2007]

27. Match **List-I** with **List-II** and select the correct answer using the code given below:

List-I
(Process)
A. Constant volume
B. Constant pressure
C. Constant temperature
D. Constant entropy

List-II
(Heat transfer equal to)
1. Zero
2. Change in internal energy

3. Change in enthalpy
4. Work done

Code :

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

[CSE-Pre : 2010]

Open System Analysis by First Law

28. Air is compressed adiabatically in a steady flow process with negligible change in potential and kinetic energy. The work done in the process is given by

(a) $-\int p\,dv$ (b) $+\int p\,dv$

(c) $-\int v\,dp$ (d) $+\int v\,dp$

[CSE-Pre : 2000]

29. In a test of a water-jacketed compressor, the shaft work required is 90 kN-m/kg of air compressed. During compression, increase in enthalpy of air is 30 kJ/kg of air and increase in enthalpy of circulating cooling water is 40 kJ/kg of air. The change in velocity is negligible. The amount of heat lost to the atmosphere from the compressor per kg of air is

(a) 20 kJ (b) 60 kJ
(c) 80 kJ (d) 120 kJ

[CSE-Pre : 2000]

30. For the expression $\int pdv$ to represent the work, which of the following conditions should apply?

(a) The system is closed one and process takes place in non-flow system
(b) The process is non-quasistatic
(c) The boundary of the system should not move in order that work may be transferred
(d) If the system is open one, it should be non-reversible

[CSE-Pre : 2002]

31. Consider the following statements :

1. During a reversible non-flow process, for the same expansion ratio, work done by a gas diminishes as the value of n in $pv^n = C$ increases.
2. Adiabatic mixing process is a reversible process.

Which of the statements given above is/are correct ?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

[CSE-Pre : 2007]

32. Work done between the state 1 and 2 in a flow process is given by which one of the following expressions ?

(a) $-\int_1^2 v\,dp$ (b) $\int_1^2 p\,dv$

(c) $\int_1^2 v\,dp + \int_1^2 p\,dv$ (d) $\int_1^2 v\,dp - \int_1^2 p\,dv$

[CSE-Pre : 2009]

33. An air compressor compresses air with an enthalpy of 100 kJ/ kg to a pressure and temperature that have an enthalpy of 200 kJ/kg. There is 60 kJ/kg of heat lost from the compressor as the air passes through it. Neglecting kinetic and potential energies, what is the power required for an air mass flow of 1 kg/s ?

(a) 60 kW (b) 160 kW
(c) 260 kW (d) 360 kW

[CSE-Pre : 2009]

34. For reversible adiabatic compression in a steady flow process, the work transfer per unit mass is

(a) $\int PdV$ (b) $\int VdP$

(c) $\int TdS$ (d) $\int SdT$

[CSE-Pre : 2010]

35. The expression $\int PdV$ can be used for obtaining work of

(a) Throttling process
(b) Steady flow reversible process
(c) Non-flow reversible process
(d) Adiabatic irreversible process

[CSE-Pre : 2010]

Second Law of Thermodynamics

36. A reversible heat engine operating between hot and cold reservoirs delivers a work output of 54 kJ while it rejects a heat of 66 kJ. The efficiency of this engine is

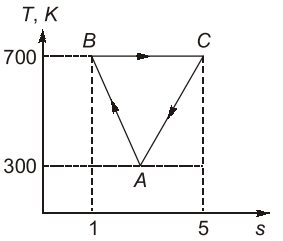
(a) 0.45 (b) 0.66
(c) 0.75 (d) 0.82

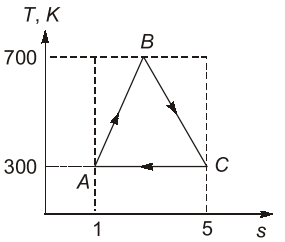
[CSE-Pre : 1998]

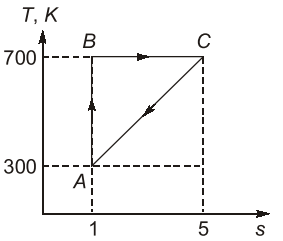
37. **Assertion (A):** The first-law efficiency evaluates the energy quantity utilisation, whereas the second-law efficiency evaluates the energy quality utilisation.
Reason (R): The second-law efficiency for a process is defined as the ratio of change of available energy of the source to the change of available energy of the system.
(a) Both A and R are true and R is a 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.

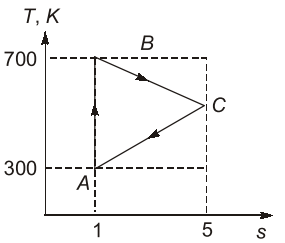
[CSE-Pre : 1998]

38. Which one of the following hypothetical heat engine cycle represents maximum efficiency?

(a)


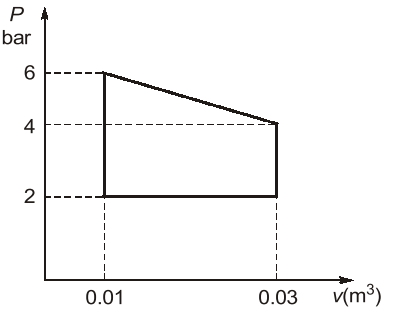
(b)


(c)


(d)


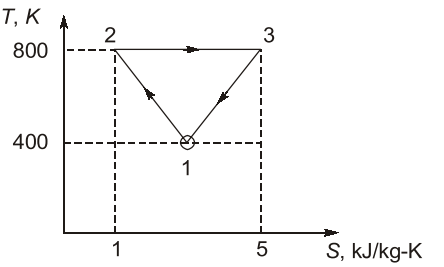
[CSE-Pre : 1999]

39. The mean effective pressure of the thermodynamic cycle shown in the given pressure-volume diagram is



(a) 3.0 bar (b) 3.5 bar
(c) 4.0 bar (d) 4.5 bar

[CSE-Pre : 1999]

40.


The thermal efficiency of the hypothetical heat engine cycle shown in the given figure is
(a) 0.5 (b) 0.45
(c) 0.35 (d) 0.25

[CSE-Pre : 2000]

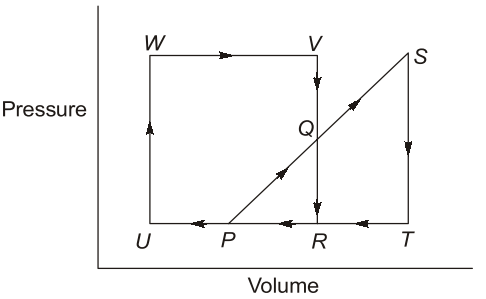
41. A carnot refrigerator works between the temperatures of 200 K and 300 K. If the refrigerator receives 1 kW of heat, the work requirement will be
(a) 0.5 kW (b) 0.67 kW
(c) 1.5 kW (d) 3 kW

[CSE-Pre : 2000]

42. **Assertion (A):** No machine would continuously supply work without expenditure of some other from of energy.
Reason (R): Energy can be neither created nor destroyed, but it can only be transformed from one form into another.
(a) Both A and R are true and R is a 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.

[CSE-Pre : 2001]

43. 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 (WVUR) is 48 Nm, then the work interaction for the other cycle PST is



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

[CSE-Pre : 2001]

44. Which of the following statements are associated with second law of themodynamics?

1. When a system executes a cyclic process, net work transfer is equal to net heat transfer.
2. It is impossible to construct an engine, that operating in a cycle will produce no other effect than the extraction of heat from a reservoir and performance of an equivalent amount of work.
3. It is impossible by any procedure, no matter how idealized, to reduce any system to the absolute zero of temperature in a finite number of operations.
4. It is impossible to construct a device that operating in a cycle will produce no effect other than transfer of heat from a cooler to hotter body.

Select the correct answer using the codes given below:

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

[CSE-Pre : 2001]

45. An electric power generating station produces 400 MW. If the coal releases 36×10^8 kJ/h of energy, the rate of rejection of heat from the power plant is

(a) 200 MW (b) 400 MW
(c) 600 MW (d) 800 MW

[CSE-Pre : 2001]

46. In a certain ideal refrigeration cycle, the COP of heat pump is 5. The cycle under identical conditions running as heat engine will have efficiency as

(a) zero (b) 0.20
(c) 1.00 (d) 6.00

[CSE-Pre : 2001]

47. An inventor claims that heat engine has the following specifications :
Power developed = 50 kW,
Fuel burned per hour = 3 kg,
Heating value of fuel = 75,000 kJ per kg
Temperature limits = 627° C and 27° C,
Cost of fuel = Rs. 30/kg.
Value of power = Rs. 5/k Wh.
The performance of his engine is

(a) possible (b) not possible
(c) economical (d) uneconomical

[CSE-Pre : 2002]

48. **Assertion (A):** The coefficient of performance of a heat pump is greater than that for the refrigerating machine operating , between the same temperature limits.
Reason (R) : The refrigerating machine requires more energy for working where as a heat pump requires less.

(a) Both A and R are true and R is a 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.

[CSE-Pre : 2002]

49. A heat engine using lake water at 12°C as source and the surrounding atmosphere at 2°C as sink executes 1080 cycles per min. If amount of heat supplied per cycle is 57 J, what is the output of the engine ?

(a) 66 W (b) 56 W
(c) 46 W (d) 36 W

[CSE-Pre : 2004]

50. A reversible heat engine runs between high temperature T_1 and low temperature T_2. The work output of this heat engine is used to run a reversible refrigeration cycle absorbing heat at temperature T_3 and rejecting at temperature T_2 What is the COP of the combined system?

(a) $\left(\frac{T_1 - T_2}{T_1}\right)\left(\frac{T_3}{T_2 - T_3}\right)$

(b) $\left(\frac{T_2}{T_1 - T_2}\right)\left(\frac{T_2 - T_3}{T_3}\right)$

(c) $\left(\frac{T_1}{T_1 - T_2}\right)\left(\frac{T_3}{T_2 - T_3}\right)$

(d) $\left(\frac{T_3}{T_1 - T_3}\right)\left(\frac{T_1}{T_2 - T_1}\right)$

[CSE-Pre : 2004]

51. Match **List I** with **List I** and select the correct answer using the codes given below :

List I	List II
A. Reversible cycle	1. Measurement of temperature
B. Mechanical work	2. Clapeyron equation
C. Zeroth Law	3. Clausius Theorem
D. Heat	4. High grade energy
	5. 3rd Law of thermodynamics
	6. Inexact differential

Codes:

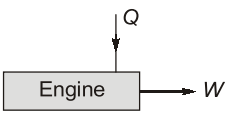
	A	B	C	D
(a)	3	4	1	6
(b)	2	6	1	3
(c)	3	1	5	6
(d)	1	4	5	2

[CSE-Pre : 2004]

52. Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I

A. Heat

B. 

C. Stirring work

D. Mechanical Work

List-II

1. PMM-2
2. High grade energy
3. Variable flow
4. Nernst Simon statement
5. Dissipative work
6. Inexact differential
7. PMM-1

Codes:

	A	B	C	D
(a)	2	5	4	3
(b)	2	1	5	7
(c)	6	3	4	2
(d)	6	1	5	2

[CSE-Pre : 2005]

53. A reversible engine exchanges heat from three thermal reservoirs *A*, *B* and *C* at 1000 K, 800 K and 200 K respectively. If the engine receives 500 kJ from *A* and 400 kJ from *B* then what is the heat exchanged from thermal reservoir *C* ?

(a) 450 kJ rejected to thermal reservoir *C*

(b) 350 kJ rejected to thermal reservoir *C*

(c) 250 kJ rejected to thermal reservoir *C*

(d) 200 kJ rejected to thermal reservoir *C*

[CSE-Pre : 2005]

54. Two reversible engines are working in series between a high temperature reservoir at 1000 K and a low temperature reservoir at 300 K in such a way that the heat rejected by the preceding engine is completely absorbed by the succeeding engine and both the engines develop the same amount of work per cycle. What is the intermediate temperature between first and second engines?

(a) 700 K

(b) 650 K

(c) 350 K

(d) Not possible to be estimated with the given data

[CSE-Pre : 2005]

55. A heat engine working in a thermodynamic cycle draws 500 kJ of heat energy from a source of 1000 K per cycle and rejects certain amount of heat energy at 300 K per cycle. Then, which one of the following is correct?

(a) The amount of heat energy rejected must be 150 kJ

(b) The amount of heat energy rejected must be less than 150 kJ

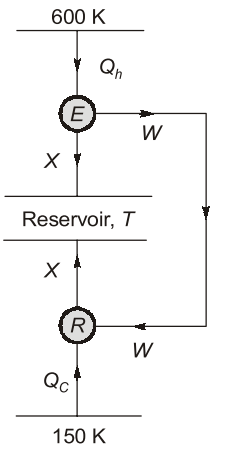
(c) The amount of heat energy rejected must be greater than 150 kJ

(d) It is not possible to make any statements regarding the amount of heat energy rejected per cycle from the data given

[CSE-Pre : 2006]

56. The thermal efficiency of the Carnot engine is 0.5. If the engine is operated as refrigerator, what is the C.O.P. of the refrigerator?
(a) 0.5 (b) 1.0
(c) 2.0 (d) 2.5
[CSE-Pre : 2006]

57. In the system given above, the temperature $T = 300$ K. When is the thermodynamic efficiency η_E of engine E equal to the reciprocal of the COP of R?



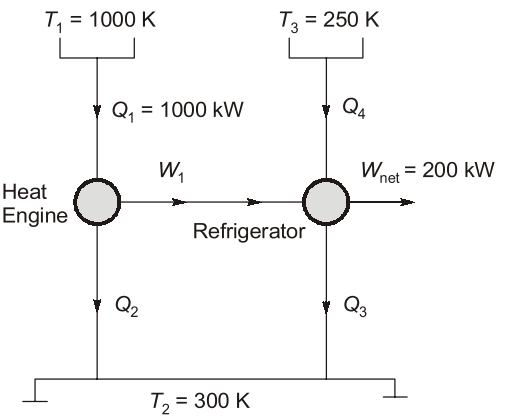
(a) When R acts as a heat pump
(b) When R acts as a refrigerator
(c) When R acts both as a heat pump and a refrigerator
(d) When R acts as neither a heat pump nor a refrigerator
[CSE-Pre : 2007]

58. **Assertion (A):** Two engines A and B work on the Carnot cycle. Engine A uses air as the working substance and B uses steam as the working substance. Both engines are having same efficiency.
Reason (R): Carnot cycle efficiency is independent of working substance.
(a) Both A and R are true and R is a 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.
[CSE-Pre : 2007]

59. While deriving an expression for efficiency of a Carnot cycle, which one of the following is not a correct assumption?
(a) The cylinder head is a perfect insulator
(b) Both piston and cylinder are perfect insulators
(c) The hot body has infinite capacity
(d) The cold body has infinite capacity
[CSE-Pre : 2008]

60. A reversible engine receives heat from a reservoir at 700°C and rejects heat at a temperature T_2. A second reversible engine operating on Carnot cycle receives heat rejected by the first engine and rejects heat to a sink at 37°C. If work output from each of the engines is equal, what is the value of temperature T_2?
(a) 641.5 K (b) 537 K
(c) 516 K (d) 498.5 K
[CSE-Pre : 2008]

61.



A reversible heat engine operates as shown above. The engine drives a reversible refrigerator. The net work output of the engine-refrigerator plant is 200 kW. What is the refrigeration effect?
(a) 1500 kW (b) 2000 kW
(c) 2500 kW (d) 3000 kW
[CSE-Pre : 2008]

62. Consider the following statements :
1. The Second Law analysis can be applied to thermodynamic cycles only and not to individual processes.
2. The Second Law analysis clearly gives an idea about the irreversibilities in the heat exchangers whereas no idea is obtained from the First Law analysis.
Which of the following given above is/are correct ?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
[CSE-Pre : 2008]

63. For a Carnot engine $T_1 > T_2$. When T_2 is decreased by ΔT with T_1 remaining same then efficiency is η_1, and when T_1 is increased by ΔT with T_2 remaining same, efficiency is η_2. Which one of the following is the correct expression for $(\eta_1 - \eta_2)$?

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

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

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

(d) $\frac{(T_1 + T_2)\Delta T + (\Delta T)^2}{T_1(T_1 + \Delta T)}$

[CSE-Pre : 2008]

64. **Assertion (A):** A thermo-dynamic cycle that violates the Clausius inequality also violates the second law of thermodynamics.
Reason (R): The Clausius inequality is given by

$$\oint \frac{\delta Q}{T} \geq 0 .$$

(a) Both A and R are true and R is a 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.

[CSE-Pre : 2008]

65. The enthalpy change during reversible closed system, is given by
(a) dH = –SdT – PdV
(b) dH = –SdT + VdP
(c) dH = Tds + PdV
(d) dH = Tds + Vdp

[CSE-Pre : 2010]

Entropy

66. The entropy of a mixture of pure gases is the sum of the entropies of constituents evaluated at
(a) temperature and pressure of the mixture
(b) temperature of the mixture and the partial pressure of the constituents
(c) temperature and volume of the mixture
(d) pressure and volume of the mixture

[CSE-Pre : 1998]

67. An electric motor of 5 kW is subjected to a braking test for 1 hour. The heat generated by the frictional forces in the process is transferred to the surroundings at 20°C. The resulting entropy change will be
(a) 22.1 kJ/K (b) 30.2 kJ/K
(c) 61.4 kJ/K (d) 82.1 kJ/K

[CSE-Pre : 1998]

68. If a system undergoes an irreversible adiabatic process, then (symbols have usual meanings)

(a) $\int \frac{dQ}{T} = 0$ and $\Delta S > 0$

(b) $\int \frac{dQ}{T} = 0$ and $\Delta S = 0$

(c) $\int \frac{dQ}{T} > 0$ and $\Delta S = 0$

(d) $\int \frac{dQ}{T} < 0$ and $\Delta S < 0$

[CSE-Pre : 1999]

69. Match **List-I** with **List-II** and select the correct answer:

List-I
A. The entropy of a pure crystalline substance is zero at absolute zero temperature
B. Spontaneous processes occur in a certain direction
C. If two bodies are in thermal equilibrium with a third body, then they are also in thermal equilibrium with each other
D. The law of conservation of energy

List-II
1. First law of thermodynamics
2. Second law of thermodynamics
3. Third law of thermodynamics
4. Zeroth law of thermodynamics

Codes:

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

[CSE-Pre : 2000]

70. 1600 kJ of energy is transferred from a heat reservoir at 800 K to another heat reservoir at 400 K. The amount of entropy generated during the process would be
(a) 6 kJ/K (b) 4 kJ/K
(c) 2 kJ/K (d) zero

[CSE-Pre : 2000]

71. Clausius inequality is stated as

(a) $\oint \delta Q < 0$ (b) $\oint \delta Q = 0$

(c) $\oint \delta \frac{Q}{T} > 0$ (d) $\oint \delta \frac{Q}{T} \leq 0$

[CSE-Pre : 2001]

72. A heat engine working on Carnot cycle receives heat at the rate of 40 kW from a source at 1200 K and rejects it to a sink at 300 K. The heat rejected is

(a) 30 kW (b) 20 kW
(c) 10 kW (d) 5 kW

[CSE-Pre : 2001]

73. A cyclic heat engine receives 600 kJ of heat from a 1000 K source and rejects 450 kJ to a 300 K sink. The quantity $\oint \delta Q / T$ and efficiency of the engine are respectively

(a) 2.1 kJ/K and 70%
(b) –0.9 kJ/K and 25%
(c) +0.9 kJ/K and 70%
(d) –2.1 kJ/K and 50%

[CSE-Pre : 2001]

74. Entropy of a saturated liquid at 227°C is 2.6 kJ/kg K. Its latent heat of vaporization is 1800 kJ/kg, then the entropy of saturated vapour at 227°C would be

(a) 2.88 kJ/kg K (b) 6.2 kJ/kg K
(c) 7.93 kJ/kg K (d) 10.53 kJ/kg K

[CSE-Pre : 2001]

75. Which one of the following statements is **not** correct?

(a) Change in entropy during a reversible adiabatic process is zero
(b) Entropy increases with the addition of heat
(c) Throttling is a constant entropy expansion process
(d) Change in entropy when a gas is heated under constant pressure is given by $s_2 - s_1 = mC_p \log_e T_2/T_1$

[CSE-Pre : 2003]

76. For a real thermodynamic cycle

(a) $\oint \frac{dQ}{T} > 0$ but $< \infty$

(b) $\oint \frac{dQ}{T} < 0$

(c) $\oint \frac{dQ}{T} = 0$

(d) $\oint \frac{dQ}{T} = \infty$ [CSE-Pre : 2003]

77. Heat flows between two reservoirs having temperature 1000 K and 500 K, respectively. If the entropy change of the cold reservoir is 10 kJ/K, then what is the entropy change for the hot reservoir?

(a) –10 kJ/K (b) –5 kJ/K
(c) 5 kJ/K (d) 10 kJ/K

[CSE-Pre : 2004]

78. M_1 kg of water at T_1 is isobarically and adiabatically mixed with M_2 kg of water at T_2 ($T_1 > T_2$). The entropy change of the universe is

(a) Necessarily positive
(b) Necessarily negative
(c) Always zero
(d) Negative or positive but not zero

[CSE-Pre : 2004]

79. To meet short range changes in demand of a product, which of the following strategies can be considered ?

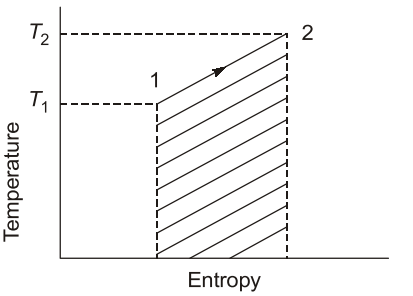
1. Overtime
2. Subcontracting
3. Building up inventory
4. New investments

Select the correct answer from the codes given below :

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

[CSE-Pre : 2004]

80.



In the T-S diagram shown in the figure, which one of the following is represented by the area under the curve ?

(a) Total work done during the process
(b) Total heat absorbed during the process
(c) Total heat rejected during the process
(d) Degree of irreversibility

[CSE-Pre : 2004]

81. A 100 Ω resistor carrying a constant current of 0.5 A is kept at a constant temperature of 300 K by a stream of cooling water. In a time interval of 30 minutes, what are the changes in entropy for the resistor and that of the universe, respectively?
(a) 0 and 150 J/K (b) 150 J/K and 0
(c) 300 J/K and 0 (d) 0 and 300 J/K
[CSE-Pre : 2005]

82. A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.30 kJ/kg K to 0.35 kJ/kg K. At the same time, the entropy of the surroundings decreases from 80 kJ/K to 75 kJ/K. What is the type of this process?
(a) Reversible
(b) Irreversible
(c) Impossible
(d) Not identifiable with the data given
[CSE-Pre : 2005]

83. Consider the following statements :
1. Amount of work from cascaded Carnot engines corresponding to fixed temperature difference falls as one goes to lower absolute level of temperature.
2. On the enthaply-entropy diagram, constant pressure lines diverge as the entropy increases.

Which of the statements given above is/are correct ?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
[CSE-Pre : 2007]

84. Which one of the following is the correct statement? Two adiabatics will
(a) intersect at absolute zero temperature
(b) never intersect
(c) become orthogonal at absolute zero temperature
(d) become parallel at absolute zero temperature
[CSE-Pre : 2007]

85. Consider the following statements :
1. Two reversible adiabatics can never intersect each other.
2. For a thermodynamic process, $\frac{dQ}{T} + I \geq 0$, where I is the measure of irreversibility.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
[CSE-Pre : 2008]

86. The statement that the entropy of a pure substance in complete thermodynamic equilibrium becomes zero at the absolute zero of temperature is known as
(a) law of entropy.
(b) first law of thermodynamics.
(c) second law of thermodynamics.
(d) third law of thermodynamics.
[CSE-Pre : 2010]

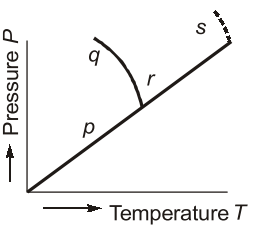
87. In a system which undergoes irreversible process, positive work done is 50 kJ and the heat added 45 kJ. What is the change in entropy?
(a) Zero (b) Positive
(c) Negative (d) Indeterminate
[CSE-Pre : 2010]

Properties of Pure Substances

88. Which one of the following expressions for Tds is true for a simple compressible substance? (Notations have the usual meaning)
(a) $dh - vdp$ (b) $dh + vdp$
(c) $dh - pdv$ (d) $dh + pdv$
[CSE-Pre : 1998]

89. If a pure substance contained in a rigid vessel passed through the critical state on heating, its initial state should be
(a) subcooled water (b) saturated water
(c) wet steam (d) saturated steam
[CSE-Pre : 1998]

90. In the following P – T diagram of water showing phase equilibrium lines, the sublimation line is



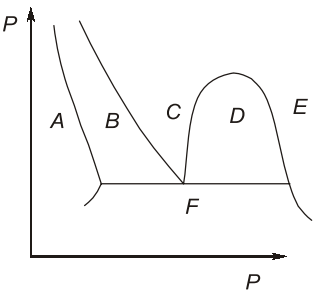
(a) p (b) q
(c) r (d) s
[CSE-Pre : 1998]

91. Which of the following are pure substances?
1. Steam and water mixture in a container.
2. Atmospheric air.
3. Air and liquid air in a container.
4. Gaseous combustion products.

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

[CSE-Pre : 1998]

92. Two-phase regions in the given pressure-volume diagram of a pure substance are represented by



(a) *A*, *E* and *F* (b) *B*, *C* and *D*
(c) *B*, *D* and *F* (d) *A*, *C* and *E*

[CSE-Pre : 1999]

93. **Assertion (A):** Air, a mixture of O_2 and N_2, is a pure substance.
Reason (R): Air is homogeneous in composition and uniform in chemical aggregation.
(a) Both A and R are true and R is a 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.

[CSE-Pre : 2000]

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

[CSE-Pre : 2000]

95. **Assertion (A):** On the enthalpy-entropy diagram of a pure substance the constant dryness fraction lines start from the critical point.
Reason (R): All the three phase co-exist at the critical point.
(a) Both A and R are true and R is a 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.

[CSE-Pre : 2001]

96. Dryness fraction of steam means the mass ratio of
(a) wet steam to dry steam
(b) dry steam to water particles in steam
(c) water particles to total steam
(d) dry steam to total steam

[CSE-Pre : 2001]

97. In a coupled separating and throttling calorimeter, 0.9 is the dryness fraction of steam in the separating unit and 0.95 is the dryness fraction in the throttling unit. What is the approximate value of the dryness fraction of the steam sample?
(a) 0.855 (b) 0.925
(c) 0.947 (d) 0.950

[CSE-Pre : 2005]

98. **Assertion (A):** A mixture of gaseous air in equilibrium with liquid air is a pure substance.
Reason (R): A pure substance has a homogeneous and invariable chemical composition.
(a) Both A and R are true and R is a 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.

[CSE-Pre : 2006]

99. Which one of the following is the correct statement? Steam is said to be superheated when the
(a) actual volume is greater than volume of saturated steam
(b) actual volume is less than volume of saturated steam
(c) actual volume is equal to volume of saturated steam
(d) None of the above

[CSE-Pre : 2007]

100. What is the value of triple point of water?
(a) 273.16 K (b) 373.16 K
(c) 290.45 K (d) 312.45 K

[CSE-Pre : 2008]

Thermodynamic Relations

101. The Gibbs free-energy functions is a property comprising
(a) pressure, volume and temperature
(b) enthalpy, temperature and entropy
(c) temperature, pressure and enthalpy
(d) volume, enthalpy and entropy

[CSE-Pre : 1998]

102. Which one of the following properties remains unchanged for a real gas during Joule—Thomson process?
(a) Temperature (b) Enthalpy
(c) Entropy (d) Pressure

[CSE-Pre : 2000]

103. The specific heat C_p is given by
(a) $T(\partial v/\partial T)_p$ (b) $T(\partial T/\partial S)_p$
(c) $T(\partial S/\partial T)_p$ (d) $T(\partial T/\partial v)_p$

[CSE-Pre : 2000]

104. Match List I with List II and select the correct answer :

List-I
A. Joule Thomson coefficient
B. C_p for monoatomic gas
C. $C_p - C_v$ for diatomic gas
D. $(\partial U/\partial T)_V$

List-II
1. $5/2\ R$
2. C_v
3. R
4. $(\partial T/\partial p)_h$

Codes:

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

[CSE-Pre : 2002]

105. **Assertion (A):** Water will freeze at a higher temperature if the pressure is increased.
Reason (R): Water expands on freezing which by Clapeyron's equation gives negative slope for the melting curve.
(a) Both A and R are true and R is a 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.

[CSE-Pre : 2003]

106. If h, p, T and v refer to enthalpy, pressure, temperature and specific volume respectively; and subscripts g and f refer to saturation conditions of vapour and liquid respectively, then Clausius-Clapeyron equation applied to change of phase from liquid to vapour states is

(a) $\dfrac{dp}{dt} = \dfrac{(h_g - h_f)}{(v_g - v_f)}$ (b) $\dfrac{dp}{dt} = \dfrac{(h_g - h_f)}{T(v_g - v_f)}$

(c) $\dfrac{dp}{dt} = \dfrac{(h_g - h_f)}{T}$ (d) $\dfrac{dp}{dt} = \dfrac{(h_g - h_f)T}{(h_g - h_f)}$

[CSE-Pre : 2003]

107. For an ideal gas, the expression

$$\left[T\left(\frac{\partial s}{\partial T}\right)_p - T\left(\frac{\partial s}{\partial T}\right)_v\right]$$ is equal to

(a) zero (b) C_p / C_v
(c) R (d) RT

[CSE-Pre : 2003]

108. For a gas, pressure p, volume v and temperature T are dependent on each other. Then which one of the following p -v -T relationship will be obeyed?

(a) $\left(\dfrac{\partial p}{\partial T}\right)_v \left(\dfrac{\partial v}{\partial T}\right)_p \left(\dfrac{\partial v}{\partial p}\right)_T = -1$

(b) $\left(\dfrac{\partial p}{\partial T}\right)_v \left(\dfrac{\partial T}{\partial v}\right)_p \left(\dfrac{\partial v}{\partial p}\right)_T = -1$

(c) $\left(\dfrac{\partial p}{\partial T}\right)_v \left(\dfrac{\partial v}{\partial T}\right)_p \left(\dfrac{\partial p}{\partial v}\right)_T = -1$

(d) $\left(\dfrac{\partial p}{\partial T}\right)_v = \left(\dfrac{\partial T}{\partial v}\right)_p \left(\dfrac{\partial p}{\partial v}\right)_T$

[CSE-Pre : 2005]

109. Which of the following thermodynamic properties relate to the Clausius-Clapeyron equation?
1. Pressure
2. Temperature
3. Entropy

4. Specific volume
5. Enthalpy
6. Internal energy

Select the correct answer using the code given below :

(a) 1, 2, 6, 5 (b) 4, 2, 3, 5
(c) 6, 4, 1 (d) 4, 5, 2, 1

[CSE-Pre : 2006]

110. Which one of the following is the correct statement? Clapeyron equation is used for
(a) finding specific volume of vapour
(b) finding specific volume of liquid
(c) finding latent heat of vaporization
(d) finding sensible heat

[CSE-Pre : 2007]

111. Constant pressure lines in the super-heated region of the Mollier diagram have what type of slope?
(a) A positive slope
(b) A negative slope
(c) Zero slope
(d) May have either positive or negative slopes

[CSE-Pre : 2007]

112. Which one of the following relationships defines Gibb's free energy *G?*
(a) $G = H + TS$ (b) $G = H - TS$
(c) $G = U + TS$ (d) $G = U - TS$

[CSE-Pre : 2007]

113. According to the Maxwell relation, which of the following is/are correct?

(a) $\left(\frac{\partial v}{\partial T}\right)_P = -\left(\frac{\partial s}{\partial P}\right)_T$

(b) $\left(\frac{\partial s}{\partial v}\right)_T = -\left(\frac{\partial P}{\partial T}\right)_v$

(c) $\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T$

(d) All of the above

[CSE-Pre : 2007]

114. On a *T-S* diagram the slope of constant pressure line (m_p) and the slope of constant volume line (m_v) can be related by which one of the following relations ?
(a) $m_p = m_v$ (b) $m_v > m_p$
(c) $m_p > m_v$ (d) $m_p \cdot m_v = 1$

[CSE-Pre : 2009]

Availability or Exergy

115. Match **List-I** with **List-II** and select the correct answer:

List - I
A. Irreversibility
B. Joule Thomson experiment
C. Joule's experiment
D. Reversible engines

List-II
1. Mechanical equivalent
2. Thermodynamic temperature scale
3. Throttling process
4. Loss of availability

Codes:

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

[CSE-Pre : 1998]

116. If u, T, v, s, h and p refer to internal energy temperature, volume, entropy, enthalpy and pressure respectively; and subscript 0 refers to environmental conditions, availability function for a closed system is given by
(a) $u + p_0v - T_0s$ (b) $u - p_0v + T_0s$
(c) $h + p_0v - T_0s$ (d) $h - p_0v + T_0s$

[CSE-Pre : 2003]

117. For a compression or heating process, what is the expression for effectiveness ε?

(a) $\varepsilon = \frac{\text{Increase of availability of the surroundings}}{\text{Loss of availability of the system}}$

(b) $\varepsilon = \frac{\text{Increase of availability of the system}}{\text{Loss of availability of the surroundings}}$

(c) $\varepsilon = \frac{\text{Loss of availability of the surroundings}}{\text{Increase of availability of the system}}$

(d) $\varepsilon = \frac{\text{Loss of availability of the system}}{\text{Increase of availability of the surroundings}}$

[CSE-Pre : 2008]

118. Which one of the following statements is incorrect?
(a) Availability follows the law of conversion.
(b) Availability is a function of states of matter under consideration and environment.

(c) Availability always depends upon pressure.
(d) Availability increases with temperature drop at low temperature.

[CSE-Pre : 2009]

119. Match **List I** with **List II** and select the correct answer using the code given below the lists:

List-I

A. Keenan function
B. Helmholtz function
C. Availability functions for a closed system
D. Availability functions for a steady flow process

List-II

1. $H - T_0S + mV^2/2 + mgZ$
2. $U + P_0 \cdot v - T_0 \cdot S$
3. $U - T_0 \cdot S$
4. $H - T_0 \cdot S$

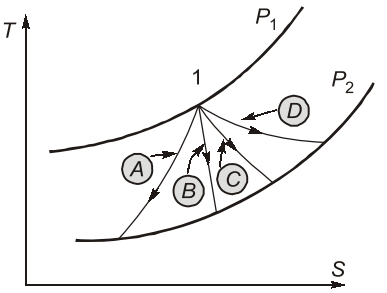
Codes:

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

[CSE-Pre : 2009]

Properties of Gases

120. An ideal gas contained in a rigid tank is cooled, such that $T_2 < T_1$ and $p_2 < p_1$. In the given temperature-entropy diagram, this process path is represented by line labelled



(a) *A* (b) *B*
(c) *C* (d) *D*

[CSE-Pre : 1999]

121. The mathematical conditions at the critical point for a pure substance would be:

(a) $\frac{\partial p}{\partial v} < 0; \frac{\partial^2 p}{\partial v^2} = 0$ and $\frac{\partial^3 p}{\partial v^3} = 0$

(b) $\frac{\partial p}{\partial v} = 0; \frac{\partial^2 p}{\partial v^2} < 0$ and $\frac{\partial^3 p}{\partial v^3} = 0$

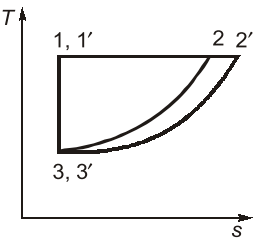
(c) $\frac{\partial p}{\partial v} = 0; \frac{\partial^2 p}{\partial v^2} = 0$ and $\frac{\partial^3 p}{\partial v^3} < 0$

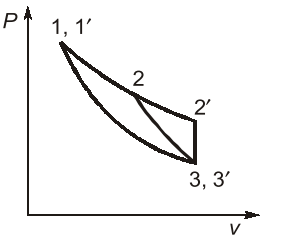
(d) $\frac{\partial p}{\partial v} = 0; \frac{\partial^2 p}{\partial v^2} = 0$ and $\frac{\partial^3 p}{\partial v^3} = 0$

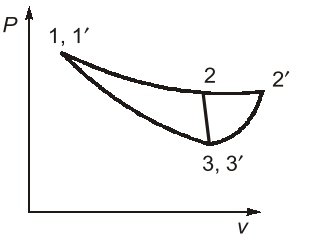
[CSE-Pre : 1999]

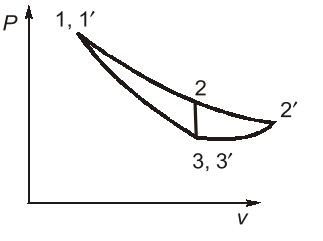
122. Two heat engine cycles (1–2–3–1 and 1′–2′–3′–1′) are shown on T-s co-ordinates in figure.

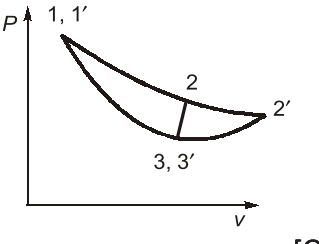
On pressure-volume coordinates, these cycles are best represented as



(a)


(b)


(c)


(d)


[CSE-Pre : 1999]

123. **Assertion (A):** C_p for a gas is always greater than C_v.
Reason (R): C_p includes work of expansion in addition to kinetic energy.
(a) Both A and R are true and R is a 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.
[CSE-Pre : 2000]

124. The volumetric air content of a tyre at 27°C and at 2 bars is 30 litres. If one morning, the temperature dips to –3°C, then the air pressure in the tyre would be
(a) 1.8 bars (b) 1.1 bars
(c) 0.8 bars (d) the same as at 27°C
[CSE-Pre : 2000]

125. One kg of a perfect gas is compressed from pressure p_1 to pressure p_2 by
1. isothermal process
2. adiabatic process
3. the law $pv^{1.1}$ = constant
The correct sequence of these processes in increasing order of their work requirement is
(a) 1, 2, 3 (b) 1, 3, 2
(c) 2, 3, 1 (d) 3, 1, 2
[CSE-Pre : 2000]

126. In free expansion of a gas between two equilibrium states, the work transfer involved
(a) can be calculated by joining the two states on p-v coordinates by any path and estimating the area below
(b) can be calculated by joining the two states by a quasistatic path and then finding the area below
(c) is zero
(d) is equal to heat generated by friction during expansion
[CSE-Pre : 2001]

127. An ideal gas with initial volume, pressure and temperature of 0.1 m^3, 1 bar and 27°C respectively is compressed in a cylinder by a piston such that its final volume and pressure are 0.04 m^3 and 5 bars respectively, then its final temperature will be
(a) –123°C (b) 54°C
(c) 327°C (d) 600°C
[CSE-Pre : 2001]

128. Work done in a free expansion process is
(a) positive (b) negative
(c) zero (d) maximum
[CSE-Pre : 2002]

129. Variation of pressure and volume at constant temperature are correlated through
(a) Charle'slaw (b) Boyle's law
(c) Joule's law (d) Gay Lussac's law
[CSE-Pre : 2002]

130. For a non-flow constant pressure process the heat exchange is equal to
(a) zero
(b) the work done
(c) the change in internal energy
(d) the change in enthalpy
[CSE-Pre : 2003]

131. A higher value of Van der Waals' constant for a gas indicates that the
(a) molecules of the gas have smaller diameter
(b) gas can be easily liquefied
(c) gas has higher molecular weight
(d) gas has lower molecular weight
[CSE-Pre : 2003]

132. If a gas obeys van der Waals' equation at the critical point, then what does $RT_c / P_c V_c$ equal to?
(a) zero (b) unity
(c) 1.50 (d) 2.67
[CSE-Pre : 2004]

133. The equation of state :
$$pv = RT\left(1+\frac{B}{v}+\frac{C}{v^2}+\frac{D}{v^3}+\ldots\right),$$
is known as
(a) Van der Waals equation
(b) Benedict-Webb-Rubin equation
(c) Gibbs equation
(d) Virial equation
[CSE-Pre : 2005]

134. Which one of the following is heat absorbed or rejected during a polytropic process?
(a) $\left(\frac{\gamma - n}{\gamma - 1}\right) \times$ work done

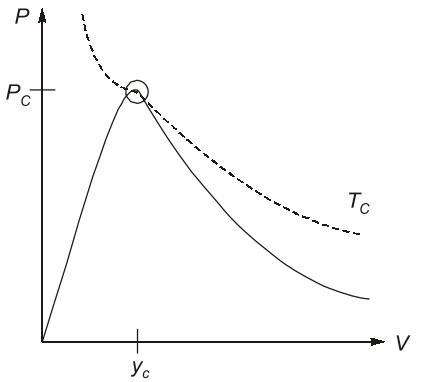
(b) $\left(\frac{\gamma - n}{\gamma - 1}\right)^2 \times$ work done

(c) $\left(\frac{\gamma - n}{\gamma - 1}\right)^3 \times$ work done

(d) $\left(\frac{\gamma - n}{1 - \gamma}\right) \times$ work done

[CSE-Pre : 2006]

135.



In the above figure, y_c corresponds to the critical point of a pure substance under study. Which of the following mathematical conditions applies/ apply at the critical point?

(a) $\left(\frac{\partial P}{\partial v}\right)_{T_c} = 0$ (b) $\left(\frac{\partial^2 P}{\partial v^2}\right)_{T_c} = 0$

(c) $\left(\frac{\partial^3 P}{\partial v^3}\right)_{T_c} < 0$ (d) All of these

[CSE-Pre : 2007]

136. If M_1, M_2, M_3 be molecular weight of constituent gases and m_1, m_2, m_3.... their corresponding mass fractions, then what is the molecular weight M of the mixture equal to ?

(a) $m_1M_1 + m_2M_2 + m_3M_3 + \ldots$

(b) $\frac{1}{m_1M_1 + m_2M_2 + m_3M_3 + \ldots}$

(c) $\frac{1}{m_1M_1} + \frac{1}{m_2M_2} + \frac{1}{m_3M_3} + \ldots$

(d) $\frac{1}{\left(\frac{m_1}{M_1}\right) + \left(\frac{m_2}{M_2}\right) + \left(\frac{m_3}{M_3}\right) + \ldots}$

[CSE-Pre : 2007]

137. If a gas obeys van der Waals equation at the critical point, then $\frac{RT_c}{p_c v_c}$ is equal to which one of the following?

(a) 0 (b) 1

(c) 1.5 (d) 2.67

[CSE-Pre : 2007]

138. Which one of the following is the correct expression for change in the internal energy for a small temperature change ΔT for an ideal gas?

(a) $\Delta U = C_v \times \Delta T$ (b) $\Delta U = C_p \times \Delta T$

(c) $\Delta U = \frac{C_p}{C_v} \times \Delta T$ (d) $\Delta U = (C_p - C_v)\Delta T$

[CSE-Pre : 2007]

139. **Assertion (A):** For a perfect gas, hyperbolic expansion is an isothermal expansion.

Reason (R): For a perfect gas, Pv/T = constant.

(a) Both A and R are true and R is a 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.

[CSE-Pre : 2007]

140. What is the rate of heat interchange per unit change of volume for a polytropic process, $pV^n = C ? \left(\gamma = \frac{C_P}{C_v}\right)$

(a) $\frac{n-1}{\gamma - 1} \times p$ (b) $\frac{\gamma - n}{\gamma - 1} \times p$

(c) $\frac{\gamma - n}{n - 1} \times p$ (d) $\frac{n-1}{\gamma - n} \times p$

[CSE-Pre : 2008]

141. What is the value of n in an adiabatic expansion pV^n = constant ? (no heat is supplied or rejected to the surroundings) $\left(\gamma = \frac{C_p}{C_v}\right)$

(a) γ (b) $\frac{\gamma}{2}$

(c) $\frac{\gamma}{6}$ (d) $\frac{\gamma}{3}$

[CSE-Pre : 2008]

142. For an ideal gas, R = 0.264 kJ/kg K, γ = 1.18 and heat transfer is 160 kJ. What is the value of C_p?
(a) 1.53
(b) 1.62
(c) 1.73
(d) Cannot be determined with the given data
[CSE-Pre : 2008]

143. What is the ratio of the slopes of p-v curves for an adiabatic process and an isothermal process ?
(a) $\frac{1}{\gamma}$ (b) $\gamma + 1$
(c) γ (d) $\frac{1}{\gamma} + 1$
[CSE-Pre : 2008]

144. What is the molecular weight (approximate) for the gas whose specific heats are as follows ?
C_p = 1.967 kJ/kg K
C_v = 1.507 kJ / kg K
(a) 17 (b) 18
(c) 19 (d) 20
[CSE-Pre : 2008]

145. What is the value of slope for an isothermal process on p - v diagram for an ideal gas ?
(a) $-\frac{p}{v}$ (b) $-\frac{v}{p}$
(c) $-\frac{1}{(pv)}$ (d) $-pv$
[CSE-Pre : 2008]

146. **Assertion (A):** The deviation of a gas from ideal gas behaviour is least in the vicinity of the critical point.
Reason (R): The compressibility factor for all gases is approximately the same at the same reduced pressure and temperature.
(a) Both A and R are true and R is a 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.
[CSE-Pre : 2008]

147. Which one of the following equations of state takes into account volume of gas molecules alone ?
(a) Clausius equation
(b) Van der Waals equation
(c) Redlich-Kwong equation
(d) Virial equation
[CSE-Pre : 2009]

148. For a gas that is allowed to expand reversibly and adiabatically, there is no change in
(a) internal energy (b) temperature
(c) entropy (d) enthalpy
[CSE-Pre : 2010]

■■■■

Answers Thermodynamics

1.	(c)	2.	(c)	3.	(a)	4.	(b)	5.	(b)	6.	(d)	7.	(c)	8.	(b)
9.	(a)	10.	(a)	11.	(b)	12.	(c)	13.	(b)	14.	(c)	15.	(b)	16.	(a)
17.	(d)	18.	(c)	19.	(b)	20.	(a)	21.	(b)	22.	(c)	23.	(d)	24.	(b)
25.	(a)	26.	(d)	27.	(b)	28.	(c)	29.	(a)	30.	(a)	31.	(a)	32.	(a)
33.	(b)	34.	(b)	35.	(c)	36.	(a)	37.	(c)	38.	(b)	39.	(a)	40.	(d)
41.	(a)	42.	(b)	43.	(c)	44.	(b)	45.	(c)	46.	(b)	47.	(b)	48.	(c)
49.	(d)	50.	(a)	51.	(a)	52.	(d)	53.	(d)	54.	(b)	55.	(a)	56.	(b)
57.	(a)	58.	(a)	59.	(a)	60.	(a)	61.	(c)	62.	(b)	63.	(c)	64.	(c)
65.	(d)	66.	(c)	67.	(c)	68.	(a)	69.	(c)	70.	(c)	71.	(d)	72.	(c)
73.	(b)	74.	(b)	75.	(c)	76.	(b)	77.	(b)	78.	(a)	79.	(a)	80.	(b)
81.	(a)	82.	(a)	83.	(b)	84.	(b)	85.	(a)	86.	(d)	87.	(b)	88.	(a)
89.	(c)	90.	(a)	91.	(d)	92.	(c)	93.	(a)	94.	(d)	95.	(c)	96.	(d)
97.	(a)	98.	(d)	99.	(a)	100.	(a)	101.	(b)	102.	(b)	103.	(c)	104.	(b)
105.	(a)	106.	(b)	107.	(c)	108.	(b)	109.	(d)	110.	(c)	111.	(a)	112.	(b)
113.	(c)	114.	(b)	115.	(d)	116.	(a)	117.	(b)	118.	(d)	119.	(d)	120.	(a)
121.	(c)	122.	(c)	123.	(a)	124.	(a)	125.	(b)	126.	(c)	127.	(c)	128.	(c)
129.	(b)	130.	(d)	131.	(b)	132.	(d)	133.	(d)	134.	(a)	135.	(d)	136.	(d)
137.	(d)	138.	(a)	139.	(a)	140.	(c)	141.	(a)	142.	(c)	143.	(c)	144.	(b)
145.	(a)	146.	(d)	147.	(b)	148.	(c)								

Explanations

1. (c)

$$\text{Work} = P\Delta V \text{ or } \int P dV$$

Where pressure is intensive property and volume is extensive property.

2. (c)

Path function - their magnitude depend on the path followed during a process, eg, work and heat.

Intensive property - independent of mass of the substance

Extensive property - Dependent on the mass of the substance.

Point function - all properties are point function as they depend on the state only and not how that state is reached.

3. (a)

$$C_P - C_V = R$$

$$\gamma = \frac{C_P}{C_V} = \frac{C_P}{C_P - R} = \frac{1}{1 - \frac{R}{C_P}}$$

4. (b)

The process of removing non-condensable gases from the steam cycle is known as deaeration.

5. (b)

Extensive properties are those whose value for the entire system is equal to the sum of their values for individual parts of the system because extensive properties depend on the amount of substance.

6. (d)

We know that

$$t = AL + B$$

At freezing and boiling points of water,

$$100 = A L_I + B \text{ (for freezing)} \quad ...(i)$$

$$400 = A L_S + B \text{ (for boiling)} \quad ...(ii)$$

$$300 = A(L_S - L_I)$$

$$\Rightarrow \quad A = \frac{300}{L_S - L_I}$$

$$100 = \frac{300 L_I}{L_S - L_I} + B$$

$$B = 100 - \frac{300 L_I}{L_S - L_I}$$

$$t = \frac{300}{L_S - L_I} L + 100 - \frac{300 L_I}{L_S - L_I}$$

$$t°\text{N} = 100 + \left(\frac{L - L_I}{L_S - L_I}\right) 300$$

For centrigrade scale,

$$t°\text{C} = \left(\frac{L - L_I}{L_S - L_I}\right) 100 + 0$$

$$t°\text{N} = 100 + \frac{t°C}{100} \times 300 = 3 \times t°\text{C} + 100$$

$$t°\text{N} = 3 \times 60 + 100 = 280°\text{N}$$

7. (c)

Ideal gas thermometer is independent of material used in its construction.

9. (a)

Zeroth law of thermodynamics is based on measurement of temperature, while first law is based on conservation of energy; Second law defines spontaneity of the process. Third law states that entropy of a pure substance becomes zero at absolute zero temperature.

10. (a)

Intensive property are independent of mass of the substance. Density is an intensive property.

11. (b)

In case of mixture of ice, water and steam, more than one phase exists, so it is a heterogeneous system.

12. (c)

Temperature scales are arbitrary.

14. (c)

$$Q_{1-2} = \Delta E_{1-2} + W_{1-2}$$

or $\quad 80 = \Delta E_{1-2} + 60$

or $\quad \Delta E_{1-2} = 20 \text{ kJ}$

$$Q_{2-1} = \Delta E_{2-1} + W_{2-1}$$

or $\quad 100 = -20 + W_{2-1}$

or $\quad W_{2-1} = 100 + 20 = 120 \text{ kJ}$

15. (b)

Net change in internal energy is zero in a cyclic process.

16. (a)

(i) $\Delta Q - \Delta W = \Delta U$, $\Delta U = -50 + 80 = 30$ kJ

(ii) $\Delta U = -50 - 80 = -130$ kJ

(iii) $\Delta U = 50 - 80 = -30$ kJ

(iv) $\Delta U = 50 + 80 = 130$ kJ

As the internal energy increases by 30 kJ, correction option is (a)

17. (d)

$$Q = \Delta U + W \quad \leftarrow \text{As per 1st law of thermodynamics}$$

For an ideal gas, $\Delta U = 0$

$$Q = W$$

So, Heat transfer = Work transfer

18. (c)

In case of isentropic process, work transfer is maximum.

19. (b)

$\Sigma Q_{net} = \Sigma W_{net}$ ($\Delta U = 0$ for cyclic process)

$Q_{12} + Q_{23} + Q_{34} + Q_{41} = W_{12} + W_{23} + W_{34} + W_{41}$

$W_{41} = 220 - 25 - 180 + 50 - 15 + 10 - 60 = 0$ kJ

20. (a)

$$\Sigma Q_{net} = \Sigma W_{net}$$

$$1000 + 0 = -6000 + W$$

[$Q = 0$ for adiabatic process]

$$W = 7000 \text{ J}$$

22. (c)

Work done for one appliance

$$= 100\left(\frac{J}{s}\right)\times 15\times 60(s)$$

$$= 90 \text{ kJ}$$

Work done by battery for three appliances

$$= 3 \times 90 = 270 \text{ kJ}$$

As the electrical energy stored in a battery (as internal energy) is high grade energy, so it can be completely converted to the work.

$$Q = -270 + 270 = 0 \text{ kJ}$$

23. (d)

$$\Sigma Q_{net} = \Sigma W_{net}$$
$$100 + 120 = 50 + W$$
$$W = 220 - 50 = 170 \text{ kJ}$$

24. (b)

For cyclic process,

$$\Sigma Q_{net} = \Sigma W_{net}$$

But $\Sigma W_{net} = 0$

$$\therefore +45 - 30 - 25 + Q = 0$$
$$Q = 55 - 45 = 10 \text{ kJ}$$

25. (a)

For cyclic process,

$$\Sigma W_{net} = \Sigma Q_{net}$$
$$W + 75 = 150 - 50$$
$$W = 25 \text{ kJ}$$

26. (d)

For isothermal process, temperature remains constant so there is no change in internal energy.

$$dQ = dU + dW$$
$$dQ = dW = 100 \text{ W}$$

28. (c)

For closed system, $w = \int pdv$

For steady flow, $w = -\int vdp$

29. (a)

$$W = (\Delta h)_{air} + (\Delta h)_{water} + Q$$
$$Q = 90 - 30 - 40 = 20 \text{ kJ/kg}$$

30. (a)

$\int pdv$ is the expression for closed system and process takes place in non-flow system.

31. (a)

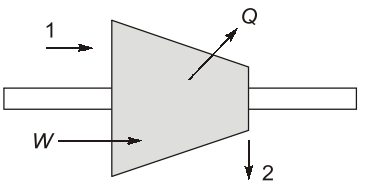
In adiabatic mixing, there is always increase in entropy accompanied by increase in amount of irreversibility. So adiabatically mixing is an irreversible process.

32. (a)

For steady flow process,

$$W = -\int_1^2 v\, dp$$

33. (b)



$$W + h_1 = Q + h_2$$
$$W = (h_2 - h_1) + Q$$
$$= 100 + 60 = 160 \text{ kJ/kg}$$
$$W = 160 \times 1 = 160 \text{ kW}$$

34. (b)

For steady flow process,

$$W = \int VdP$$

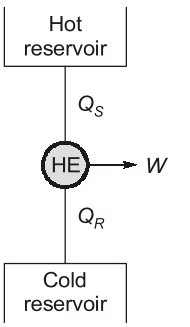
35. (c)

For non-flow reversible process,

$$W = \int PdV$$

36. (a)

$$W = 54 \text{ kJ}$$
$$Q_R = 66 \text{ kJ}$$
$$W = Q_S - Q_R$$
$$Q_S = 54 + 66$$
$$Q_S = 120 \text{ kJ}$$
$$\eta_{HE} = \frac{W}{Q_S} = \frac{54}{120} = 0.45$$



Efficiency = 45%