POSTAL Study Package 2021

Production and Industrial Engineering

Objective Practice Sets

General Engineering
Volume - V

Basic Thermodynamics

MADE EASY Publications

Basic Thermodynamics

Q.1 The correct sequence of the decreasing order of the value of characteristic gas constants of the given gases is
(a) hydrogen, nitrogen, air, carbon dioxide
(b) carbon dioxide, hydrogen, nitrogen, air
(c) air, nitrogen, carbon dioxide, hydrogen
(d) nitrogen, air, hydrogen, carbon dioxide

Q.2 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 will also not be in thermal equilibrium with each other
(d) when two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other

Q.3 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 the 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.4 Which one of the following is the characteristic equation of a real gas?
(a) $(p + a/v^2)(v - b) = RT$
(b) $(p - a/v^2)(v + b) = RT$
(c) $pv = RT$
(d) $pv = nRT$

Q.5 An ideal gas at 27°C is heated at constant pressure till its volume becomes three times. What would be then the temperature of gas?
(a) 81°C (b) 627°C
(c) 543°C (d) 327°C

Q.6 A closed system is one in which
(a) Mass does not cross boundaries of the system, though energy may do so.
(b) Mass crosses the boundary but not the energy.
(c) Neither mass nor energy cross the boundary of the system.
(d) Both energy and mass cross the boundaries of the system.

Q.7 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I
A. Interchange of matter is not possible in a system
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 thermodynamic is called

List-II
1. Open
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

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

Q.9 The constant volume gas thermometer works on the principle that

(a) at low pressure, the temperature of the gas is independent of its pressure at constant volume.
(b) at high pressure, the temperature of the gas is independent of its pressure at constant volume.
(c) at low pressure, the temperature of the gas is proportional to its pressure at constant volume.
(d) at high pressure, the temperature of the gas is proportional to its pressure at constant volume.

Q.10 Which one of the following substances has constant specific heat at all pressures and temperatures?
(a) Mano-atomic gas (b) Di-atomic gas
(c) Tri-atomic gas (d) Poly-atomic gas

Q.11 Certain quantities cannot be located on the graph by a point but are given by the area under the curve corresponding to the process. These quantities in concepts of thermodynamics are called as
(a) cyclic functions (b) point functions
(c) path functions (d) real functions

Q.12 The internal energy of certain system is a function of temperature alone and is given by the formula $E = 25 + 0.25t$ kJ. If this system executes a process for which the work done by it per degree temperature increase is 0.75 kNm, the heat interaction per degree temperature increase, in kJ, is
(a) – 1.00 (b) – 0.50
(c) 0.50 (d) 1.00

Q.13 The heat transfer Q, the work done W and the change in internal energy U are all zero in the case of
(a) a rigid vessel containing steam at 150°C left in the atmosphere which is at 25°C.
(b) 1 kg of gas contained in an insulated cylinder expanding as the piston moves slowly outwards.
(c) a rigid vessel containing ammonia gas connected through a valve to an evacuated rigid vessel, the vessel, the valve and the connecting pipes being well insulated and the valve being opened and after a time, condition through the two vessel becoming uniform.
(d) 1 kg of air flowing adiabatically from the atmosphere into a previously evacuated bottle.

Q.14 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
A. Work done in a polytropic process
B. Work done in steady flow process
C. Heat transfer in a reversible adiabatic process
D. Work done in an isentropic process

List-II
1. $-\int V dp$
2. Zero
3. $\dfrac{p_1V_1 - p_2V_2}{\gamma - 1}$
4. $\dfrac{p_1V_1 - p_2V_2}{n - 1}$

Codes:

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

Q.15 The work done in compressing a gas isothermally is given by:
(a) $\dfrac{\gamma}{\gamma - 1} p_1V_1\left[\left(\dfrac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]$
(b) $mRT_1 \ln \dfrac{p_2}{p_1}$
(c) $mc_p(T_2 - T_1)$
(d) $mRT_1\left(1 - \dfrac{T_2}{T_1}\right)$

Q.16 A control mass undergoes a process from state 1 to state 2 as shown in the figure below. During this process, the heat transfer to the system is 200 kJ. If the control mass returned adiabatically from state 2 to state 1 by another process, then the work interaction during the return process (in kN-m) would be

Answers Basic Thermodynamics

1. (a)	2. (d)	3. (d)	4. (a)	5. (b)	6. (a)	7. (d)
8. (c)	9. (c)	10. (a)	11. (c)	12. (d)	13. (c)	14. (c)
15. (b)	16. (b)	17. (c)	18. (c)	19. (d)	20. (a)	21. (c)
22. (b)	23. (d)	24. (a)	25. (c)	26. (a)	27. (b)	28. (d)
29. (b)	30. (b)	31. (b)	32. (d)	33. (d)	34. (d)	35. (a)
36. (b)	37. (d)	38. (a)	39. (b)	40. (c)	41. (d)	42. (b)
43. (d)	44. (d)	45. (c)	46. (a)	17. (a)	48. (c)	49. (c)
50. (b)	51. (a)	52. (c)	53. (c)	54. (d)	55. (c)	56. (c)
57. (b)	58. (c)	59. (b)	60. (b)	61. (d)	62. (b)	63. (b)
64. (a)	65. (d)	66. (c)	67. (b)	68. (a)	69. (a)	70. (b)
71. (a)	72. (d)	73. (d)	74. (c)	75. (c)	76. (b)	77. (c)
78. (a)	79. (d)	80. (b)	81. (d)	82. (c)	83. (a)	84. (a)
85. (b)	86. (b)	87. (a)	88. (d)	89. (b)	90. (c)	91. (a)
92. (c)	93. (a)	94. (60)	95. (1320.6)	96. (c)	97. (c)	98. (d)
99. (a)	100. (a)	101. (5.7958)	102. (2568.4)	103. (d)	104. (220.93)	105. (a)
106. (c)	107. (a, b, c)	108. (a)	109. (d)	110. (334.36)	111. (c)	112. (b)
113. (a)	114. (6°C)	115. (b)	116. (c)	117. (d)	118. (a)	119. (c)
120. (a)	121. (4.56)	122. (1285.39)	123. (2717)	124. (–55.45)	125. (b)	126. (b)
127. (d)	128. (a)	129. (d)	130. (60%)	131. (a)	132. (c)	133. (d)
134. (a)	135. (b)	136. (d)	137. (c)	138. (a)	139. (a)	140. (1.5)
141. (d)	142. (a)	143. (c)	144. (a)	145. (d)	146. (c)	147. (525)
148. (b)	149. (b)	150. (73.83%)	151. (b)	152. (19.534)	153. (0)	154. (203.96)
155. (a)	156. (b)	157. (a)	158. (b)	159. (a)	160. (0)	161. (50)
162. (2)	163. (380)	164. (c)	165. (b)	166. (b)	167. (a)	168. (2.39)
169. (0.285)	170. (0.030)	171. (15)	172. (c)	173. (d)		

Explanations Basic Thermodynamics

1. (a)

Characteristic gas constant,

$$R = \frac{\text{Universal gas constant}}{\text{Molecular weight}}$$

Hence, $$R \propto \frac{1}{\text{Molecular weight}}$$

Molecular weight of gases are

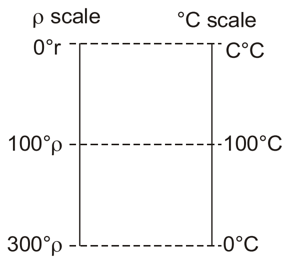
Hydrogen : 2
Nitrogen : 28
Air : 29
Carbon dioxide: 44

Hence $R_{H_2} > R_{N_2} > R_{Air} > R_{CO_2}$

2. (d)

Zeroth law of thermodynamics states that when a body *A* is in thermal equilibrium with a body *B*, and also separately with a body *C*, then *B* and *C* will be in thermal equilibrium with each other. This is the basis of temperature measurement.

3. (d)



$$\frac{300-0}{300-100} = \frac{0-C}{0-100}$$
$$\frac{3}{2} = \frac{C}{100}$$
$$C = 150°C$$

Alternate:

Assume $\rho = a + bC$

$$300 = a + b \times 0$$
$$a = 300$$
$$100 = a + b \times 100$$
$$\frac{100-300}{100} = b$$
$$b = -2$$
$$\rho = 300 - 2C$$

So, If $\rho = 0$

$$300 - 2c = 0$$
$$C = 150°C$$

5. (b)

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$\frac{V_1}{(273+27)} = \frac{3V_1}{T_2}$$

or $T_2 = 300 \times 3 = 900\text{ K} = \mathbf{627°C}$

6. (a)

In a closed system, mass does not cross the boundary but the energy may cross the boundary. For example: Piston cylinder without valves.

7. (d)

Open system – Exchange of heat and mass with surroundings. Example: Compressor

Closed system – Exchange of heat and with surrounding. Example: Green House

Isolated system – Neither exchanger of heat nor exchange of mass with surroundings.

Example: Universe

Interaction of thermodynamic system

Type of system	Mass flow	Work	Heat
Open	*Yes*	*Yes*	*Yes*
Closed	*No*	*Yes*	*Yes*
Isolated	*No*	*No*	*No*

Cyclic Processes: A cyclic process is a process that can be repeated indefinitely often without changing the final state of the system in which the process occurs. The only traces of the effects of a cyclic process are to be found in the surroundings of the system or in other systems.

8. (c)

An isolated system is one in which there is no energy and mass transfer between the system and surrounding.

Examples : Universe, coffee in thermo flask.

9. (c)

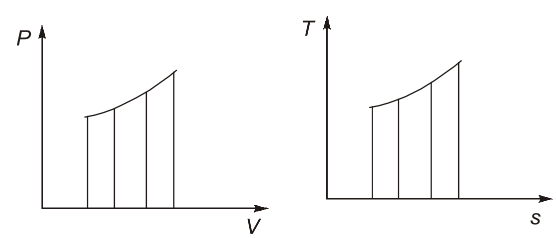
For a constant volume gas thermometer, pressure acts as thermometric property and at low pressure the gas behaves as ideal gas and follows ideal gas equation

$$pV = mRT$$

∴ for V = constant (m, R and also constant)

$$p \propto T$$

11. (c)



Area under curve on P-V represents work when projected on volume axis for closed system

Area under T-s diagram represents heat transfer for a reversible process

12. (d)

$$E = 25 + 0.25t$$
$$\frac{dE}{dt} = 0.25\text{ kJ/°C}$$

and
$$\frac{dW}{dt} = 0.75\text{ kJ/°C}$$

From the first law of thermodynamics

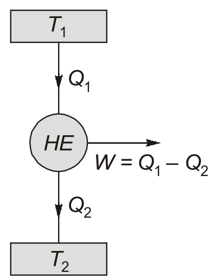
$$\delta Q = dE + \delta W$$
$$\delta Q = 0.25 + 0.75 = 1.00\text{ kJ/°C}$$

19. (d)

S.No.	Q_1 (kJ/min)	Q_2 (kJ/s)	W(kW)	η(%)
1.	1500	16.8	8.2	32.8
2.	1600	17.92	8.75	32.8
3.	1700	19.03	9.30	32.8
4.	1800	20.15	9.05	32.8
5.	2000	–	–	32.8

$$W = Q_1 - Q_2$$

$$\eta = \frac{W}{Q_1}$$



$$0.328 = \frac{W}{\left(\frac{2000}{60}\right)}$$

or $W = 10.93$ kW

21. (c)

From *SFEE* for compressor

$$m\left(h_1 + \frac{V_1^2}{2}\right) + Q = m\left(h_2 + \frac{V_2^2}{2}\right) + W$$

$$m(h_1 - h_2) + m\left(\frac{V_1^2 - V_2^2}{2}\right) + Q = W$$

$$2(-15 + 2) - 3 = W$$

$$-26 - 3 = W$$

$$-29 = W$$

Work required :

$$W = 29 \text{ kW}$$

22. (b)

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

$$\Delta U = -30 \text{ kJ}$$

(decrease in internal energy)

$$\delta W = +50 \text{ kJ}$$

(Work done by the system)

$\therefore$ $Q = -30 + 50 = +20$ kJ

23. (d)

This is the case of *SFEE* neglect internal energy

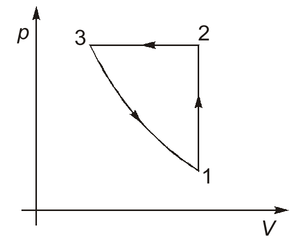
$$m\left(h_1 + \frac{V_1^2}{2}\right) + Q = m\left(h_2 + \frac{V_2^2}{2}\right) + W$$

($Q = 0$ $\because$ adiabatic process)

$\therefore$ $W = 140 + 10$

$= 150$ kJ/kg

24. (a)



Given $U_1 = 100$ kJ

For constant volume process 1-2

From first law of thermodynamic

$$U_1 + Q = U_2 + W$$

$$100 + 170 = U_2 \quad (W = 0)$$

$$U_2 = 270 \text{ kJ}$$

For constant pressure process 2-3

$$U_2 + Q = U_3 + W$$

$$270 - 180 = U_3 - 40$$

$$U_3 = 130 \text{ kJ}$$

$$U_2 > U_3 > U_1$$

Hence at the end of constant volume process, the internal energy is highest.

25. (c)

$$\frac{dQ}{dT} = \frac{dU}{dT} + \frac{dW}{dT}$$

Change in internal energy

$$\frac{dU}{dT} = \frac{dQ}{dT} - \frac{dW}{dT} = 2 - (2 - 0.1T)$$

$$U_2 - U_1 = \int_{T_1}^{T_2} 0.1\,T\,dT = \left|\frac{0.1T^2}{2}\right|_{T_1}^{T_2}$$

$$= \frac{0.1}{2}[150^2 - 100^2] = 625 \text{ kJ}$$

26. (a)

$$\text{Work done} = \int_{V_1}^{V_2} p\,dv$$

$$= p(v_2 - v_1) = p\left(\frac{m}{\rho_2} - \frac{m}{\rho_1}\right)$$

$$= 1 \times 10^5 \times 1\left(\frac{1}{999} - \frac{1}{916}\right)$$

$$\approx -9.4 \text{ J}$$

$$\text{Heat transfer} = mh_{fg}$$

$$= 1 \times 333 = 333 \text{ kJ}$$