PRACTICE QUESTIONS

for SSC-JE : CBT-2

Thermodynamics

Mechanical Engineering

01 Thermodynamics

Q.1 A gas expands from pressure p_1 to pressure $p_2\left(p_2 = \frac{p_1}{10}\right)$. If the process of expansion is isothermal, the volume at the end of expansion is 0.55 m^3. If the process of expansion is adiabatic, then the volume at the end of expansion will be closer to

(a) 0.45 m^3 (b) 0.55 m^3
(c) 0.65 m^3 (d) 0.75 m^3

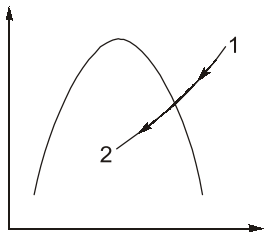
Q.2 When a system undergoes a process such that $\int \frac{dQ}{T} = 0$ and $\Delta S > 0$, the process is

(a) irreversible and adiabatic
(b) reversible and adiabatic
(c) isothermal
(d) isobaric

Q.3 A saturated vapour is compressed to half of its volume without changing its temperature. The result is that

(a) all the vapour condenses to liquid
(b) some of the liquid evaporates and the pressure does not change
(c) the pressure is double its initial value
(d) some of the vapour condenses and the pressure does not change

Q.4 The given diagram shown as isometric cooling process 1-2 of a pure substance. The ordinate and abscissa are respectively



(a) Pressure and volume
(b) Enthalpy and entropy
(c) Temperature and entropy
(d) Pressure and enthalpy

Q.5 In which of the following processes, the heat is fully converted into work?
(a) Reversible adiabatic process (b) Reversible isobaric process
(c) Reversible isometric process (d) Reversible isothermal process

Q.6 Efficiency of a Carnot engine is 75%. If the cycle direction is reversed, then the COP of reversed Carnot cycle is
(a) 1.33 (b) 0.75
(c) 0.33 (d) 1.75

Q.7 Increase in entropy of a system represents
(a) Increase in availability of energy (b) Increase in temperature
(c) Decreases in pressure (d) Degradation of energy

Q.8 Which is true for reversible polytropic process?
(a) Temperature remains constant (b) Entropy remains constant
(c) Enthalpy remains constant (d) Some heat transfer takes place

Q.9 During an adiabatic process, the pressure P of a fixed mass of an ideal gas changes by ΔP and its volume V changes by ΔV. The value of $\Delta V/V$ is given by:
(a) $-\gamma\dfrac{\Delta P}{P}$ (b) $-\dfrac{1}{\gamma}\dfrac{\Delta P}{P}$
(c) $\dfrac{1}{\gamma^3}\dfrac{\Delta P}{P}$ (d) $\dfrac{\Delta P}{P}$

Q.10 Air is compressed to half the volume at constant pressure, then the change in entropy
(a) increase (b) decrease
(c) does not change (d) not predictable

Q.11 Dryness fraction of steam is defined as:
(a) $\dfrac{\text{Mass of dry steam}}{\text{Mass of water vapour in suspension}}$
(b) $\dfrac{\text{Mass of water vapour in suspension}}{\text{Mass of dry steam}}$
(c) $\dfrac{\text{Mass of dry steam}}{\text{Mass of dry steam + Mass of water vapour in suspension}}$
(d) $\dfrac{\text{Mass of water vapour in suspension}}{\text{Mass of water vapour in suspension + Mass of dry steam}}$

Q.12 During a heating process, the temperature of an object rises by 10°C. This temperature rise is equivalent to a temperature rise of
(a) 10°F (b) 18°F
(c) 50°F (d) 68°F

Q.13 A certain amount of fluid at temperature T_1 is mixed with an equal amount of the same fluid at temperature T_2 is an insulated container. With total fluid as the system, consider the following statements:

1. Energy of the system is conserved.
2. Entropy of the system is conserved.
3. Entropy of the system increases.
4. Entropy of the system decreases.

Which of the following options is true?

(a) I and II (b) I and III
(c) I and IV (d) I only

Q.14 Properties of substances like pressure, temperature and density, in thermodynamic coordinates are

(a) path functions (b) point functions
(c) thermodynamic functions (d) real functions

Q.15 Match the following :

List–I (Type of thermometer)	**List–II** (Property proportional to temperature)
A. Mercury-in-glass	**1.** Volume
B. Resistance	**2.** Length
C. Constant volume	**3.** EMF
D. Thermocouple	**4.** Resistance
	5. Pressure

Codes:

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

Q.16 Which of the following is not an pure substance?

(a) Atmospheric air (b) Combustion products of a fuel
(c) Steam water mixture (d) Mixture of air and liquid air

Q.17 The drinking water needs of an office are met by cooling tab water in a refrigerated water fountain from 23 to 5°C at an average rate of 10 kg/h. If the COP of this refrigerator is 3.1, the approximate power input to this refrigerator is

(a) 68 W (b) 63 W
(c) 56 W (d) 58 W

Q.18 Consider the following :

1. Kinetic energy 2. Potential energy
3. Thermal conductivity 4. Entropy

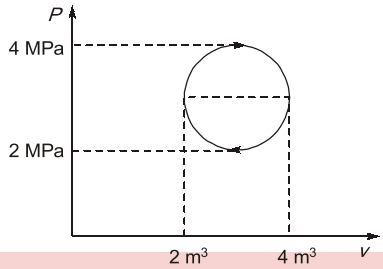
Which of these are extensive properties?

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

Q.19 A closed cycle undergoes a process 1-2 for which the value of $W_{1\text{-}2}$ and $Q_{1\text{-}2}$ is 40 kJ and 20 kJ respectively. If the system is returned to state 1 and the $Q_{2\text{-}1}$ is –10 kJ, what will be the work done $W_{2\text{-}1}$?

(a) –50 kJ (b) –40 kJ
(c) –30 kJ (d) 40 kJ

Q.20 For the cycle shown in the figure, the net heat interaction is

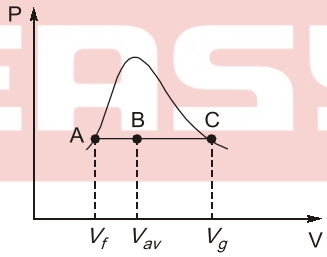


(a) 6282 kJ (b) 3141 kJ
(c) 1510 kJ (d) 4286 kJ

Q.21 Which one of the following phenomena occurs when gas in a piston-in-cylinder assembly expands reversibly at constant pressure?

(a) Heat is added to the gas
(b) Heat is removed from the gas
(c) Gas does work from its own stored energy
(d) Gas undergoes adiabatic expansion

Q.22 Which equation defines the quality of a steam in the given P-V diagram?



(a) $\frac{\overline{AC}}{\overline{AB}}$ (b) $\frac{\overline{AB}}{\overline{AC}}$

(c) $\frac{\overline{BC}}{\overline{AC}}$ (d) $\frac{\overline{AB}}{\overline{BC}}$

Q.23 An inventor claims to have developed an engine that produces 500 kJ of work while receiving 500 kJ of net heat from two reservoirs during a complete cycle of the engine. Such an engine violates

(a) only first law of thermodynamics (b) only second law of thermodynamics
(c) Both (a) and (b) (d) None of these

Q.24 300 kJ of work is done on a system. If the final internal energy of the system is to be 100 kJ less than the initial internal energy of the system then
(a) A heat quantity of 400 kJ is supplied to the system.
(b) A heat quantity of 100 kJ is rejected to the system.
(c) A heat quantity of 400 kJ is rejected from the system.
(d) A heat quantity of 100 kJ is supplied to the system.

Q.25 Under ideal conditions, isothermal, isobaric, isocaloric and adiabatic processes are _____.
(a) static processes (b) dynamic processes
(c) quasi-static processes (d) stable processes

Q.26 A stationary mass of gas is compressed without friction from an initial state of 0.4 m^3 and 0.2 MPa to a final state of 0.2 m^3 and 0.2 MPa. There is a transfer of 37 kJ from the gas during the process. How much does the internal energy of the gas change?
(a) +3 kJ (b) –3 kJ
(c) +3.5 kJ (d) –3.5 kJ

Q.27 A control volume is
(a) a type of volume which entirely depends upon type of working fluid
(b) a fixed region in space where mass, heat and work can cross the boundary
(c) a fixed region in space where heat and work can cross the boundary
(d) a closed system but heat and work can cross the boundary

Q.28 A finite thermal system having heat capacity, C = 0.04 T^2 J/K is initially at 600 K. What is the maximum work obtainable from the thermal system if the surrounding is at 300 K?
(a) 1.78 MJ/kg (b) 1.92 MJ/kg
(c) 2.25 MJ/kg (d) 2.52 MJ/kg

Q.29 Which of the following equation is wrong?

1. $S_{wet} = S_f + \dfrac{xh_{fg}}{T_s}$ $(0 < x < 1)$

2. $S_g = S_f + \dfrac{h_{fg}}{T_s}$ $(x = 1)$

3. $S_{sup} = S_f + \dfrac{h_{fg}}{T_s} + c_p \ln\left(\dfrac{T_{sup}}{T_s}\right)$ (where sup = Superheated steam)

All symbols and notations carry there usual meaning.
(a) 1 only (b) 3 only
(c) 2 only (d) None are wrong

Q.30 Choose the correct statement:
(a) A perfect gas does not obey Pv = RT
(b) A perfect gas obeys the law Pv = RT and has constant specific heat
(c) A perfect gas obeys the law Pv = RT and has variable specific heat
(d) None of these

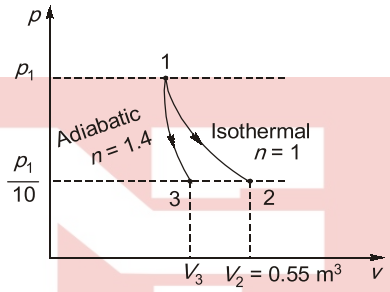
Answer Key

1.	(a)	2.	(a)	3.	(d)	4.	(b)	5.	(d)	6.	(c)	7.	(d)
8.	(d)	9.	(b)	10.	(b)	11.	(c)	12.	(b)	13.	(b)	14.	(b)
15.	(c)	16.	(d)	17.	(a)	18.	(c)	19.	(c)	20.	(b)	21.	(a)
22.	(b)	23.	(d)	24.	(c)	25.	(c)	26.	(c)	27.	(a)	28.	(b)
29.	(d)	30.	(b)										

Detailed Solution

1. (a)

$pV^n = C$



From the above figure

$V_3 < V_2$

hence, $V_3 < 0.55\ m^3$

2. (a)

$(\Delta S)_{system} = S_2 - S_1 = \int_1^2 \frac{\delta Q}{T} + S_{gen}$

(S_{gen} is entropy generation i.e. some entropy is generated during irreversible process)

$\Delta S = \int \frac{\delta Q}{T} = 0$ implies adiabatic and reversible process. But if $\Delta S > 0$, it implies irreversible process.

3. (d)

Between 1 and 2 i.e. in wet region, temperature and pressure does not change independently. Hence for constant temperature process, pressure will be constant.

Note: We can not apply ideal gas equation in wet region.

4. (b)

5. (d)

From 1st law, $\delta Q = \delta W + \Delta U$

For isothermal process, T = constant. So any heat added is spent by the fluid as work.

6. (c)

$\eta_{Carnot} = 75\%$

COP of reversed Carnot cycle is

$$= \frac{1}{\eta_{Carnot}} - 1 = \frac{1}{0.75} - 1 = 0.33$$

7. (d)

Entropy is the measure of degree of disorderness. Increase in entropy of a system represents degradation of energy.

8. (d)

For a reversible polytropic process
(PV^n = Constant),

$$W = \left(\frac{P_1V_1 - P_2V_2}{n-1}\right)$$

Here both heat transfer and work transfer takes place.

9. (b)

For an adiabatic process, PV^{γ} = constant

On differentiating, we get

$$(P \cdot \gamma \cdot V^{\gamma-1})dV + dP \cdot V^{\gamma} = 0$$

$$\frac{dP}{P} = -\gamma \cdot \frac{dV}{V}$$

or,
$$\frac{\Delta V}{V} = -\frac{1}{\gamma} \cdot \frac{\Delta P}{P}$$

10. (b)

Since heat is lost by the air to surroundings while being compressed at constant pressure hence the entropy decreases.

11. (c)

$$\text{Dryness fraction of steam} = \frac{\text{Mass of dry steam}}{\text{Mass of dry steam + Mass of water vapour in suspension}}$$

12. (b)

$$\frac{F-32}{9} = \frac{C}{5}$$

$$\Rightarrow \quad F = \frac{9}{5}C + 32$$

$$DF = \frac{9}{5}\Delta C = \frac{9}{5} \times 10 = 18°F$$

13. (b)

As mixing is irreversible process, so there would be increase in entropy of the system whereas energy will remain constant.

14. (b)

Thermodynamic properties are point functions, since for a given state, there is a definite value of each property. The change in thermodynamic property of a system in a change of state is independent of the path the system follows during the change of state and depends only on the initial and final states of the system.

15. (c)

Type of thermometer	Property proportional to temperature
• Mercury-in glass	Length
• Resistance	Resistance
• Constant volume	Pressure
• Constant pressure	Volume
• Thermocouple	EMF

16. (d)

Mixture of air and liquid air is not a pure substance because the composition of the liquid phase is different from that of the vapour phase.

17. (a)

$$\text{Refrigerating effect, } q_A = m\, c_P\, DT = \frac{10}{3600} \times 4.2 \times 1000 \times 18$$

$$= \frac{10 \times 42 \times 18}{36} = 210\,\text{W}$$

$$\text{COP} = \frac{q_A}{W_{input}}$$

$$\therefore \quad W_{input} = \frac{q_A}{COP} = 67.74\ \text{W}$$

18. (c)

$$\text{Kinetic energy} = \frac{1}{2}mV^2$$

$$\text{P.E.} = mgh$$

19. (c)

According to 1st law of thermodynamics

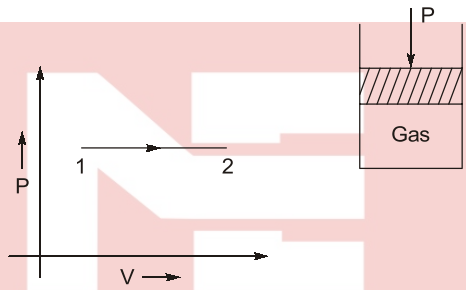
$$\oint Q = \oint W$$

$$\Rightarrow \quad Q_{1-2} + Q_{2-1} = W_{1-2} + W_{2-1}$$
$$20 - 10 = 40 + W_{2-1}$$
$$10 = 40 + W_{2-1}$$
$$\Rightarrow \quad W_{2-1} = -30 \text{ kJ}$$

20. (b)

$$\oint Q = \oint W = \text{Area under } p\text{-}v \text{ diagram}$$
$$= pR^2 = p\,(1)\,m^3\,(1)\,MPa$$
$$= p \times 1\,m^3 \times 1000\,kPa = 3141\,kJ$$

21. (a)



The ambient pressure P is acting on the piston. If the cylinder is placed in contact with a hot body (having temperature infinitesimally more than temperature of gas), energy flows into the system and the gas expands. That is the system which undergoes reversible isobaric process.
So, here heat is added to the gas.

22. (b)
From the given diagram, we can write

$$V_{av} = v_f + x(v_g - v_f)$$
$$\frac{v_{av} - v_f}{v_g - v_f} = x$$
$$x = \frac{v_{av} - v_f}{v_{fg}} = \frac{\overline{AB}}{\overline{AC}}$$

23. (d)
In a cycle, Net work = Net heat
So first law is not violated.
Then, there are two reservoirs and engine produces work by exchanging heat with two reservoirs. Hence, second law is also not violated.

24. (c)

$$dQ = DU + dW$$
$$DU = -100 \text{ kJ}$$
$$dW = -300 \text{ kJ}$$
$$\Rightarrow \quad dQ = -400 \text{ kJ}$$

25. (c)

A quasi-static process is a thermodynamic process that happens infinitely slowly. No real process is quasi-static but such process can be approximated by performing them very slowly. Any reversible process is necessarily a quasi-static one.

26. (a)

$$W_{1-2} = \int_1^2 PdV = P(V_2 - V_1)$$
$$= -0.2 \times 10^6 (0.4 - 0.2)$$
$$= -0.2 \times 0.2 \times 10^6 = -40 \text{ kJ}$$
$$Q_{1-2} = -37 \text{ kJ}$$
$$Q_{1-2} = DU + W_{1-2}$$
$$\therefore \quad DU = Q_{1-2} - W_{1-2}$$
$$= -37 + 40 = 3 \text{ kJ}$$

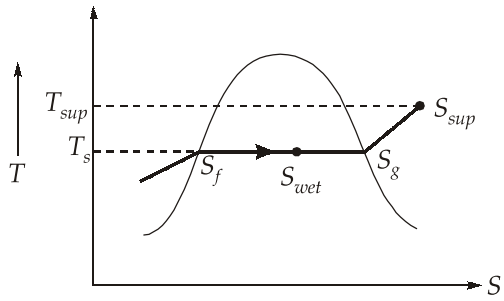
27. (b)

Open system volume or a control volume.

28. (d)

$$C = 0.04T^2, \quad T_1 = 300 \text{ K}, \quad T_2 = 600 \text{ K}$$
$$W_{max} = \int_{T_1}^{T_2} CdT = \int_{300}^{600} 0.04T^2 dT = \frac{0.04}{3}\left(600^3 - 300^3\right) = 2.52\, MJ/\text{kg}$$

29. (d)



- $$S_{wet} = x \times \frac{h_{fg}}{T_s}$$

- $$S_g = S_f \times \frac{h_{fg}}{T_s}$$

- $$S_{sup} = S_f + \frac{h_{fg}}{T_s} + C_p \ln\left(\frac{T_{sup}}{T_s}\right)$$

30. (b)

For perfect gas specific heat = constant

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