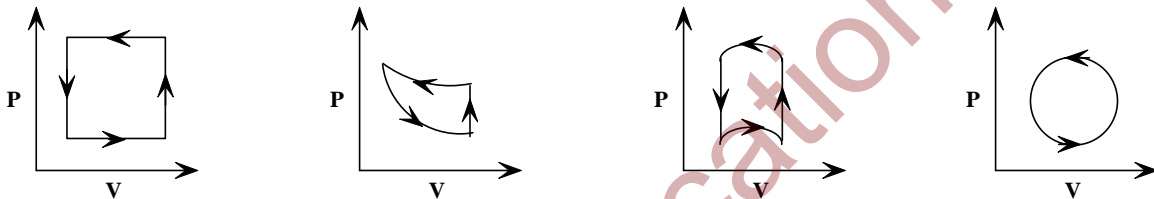


Thermodynamic Processes – Laws

1. Which of the following does not characterize the thermodynamic state of matter?

- 1) Volume 2) Temperature 3) Pressure 4) Work

2. What will be the nature of change in internal energy in case of processes shown below?



- 1) + ve in all cases 2) – ve in all cases
3) – ve in 1 and 3 and + ve in 2 and 4 4) zero in all cases

3. Zeroth law of thermodynamics represents

a) Concept of temperature

b) State of thermal equilibrium of a system c) That heat is a form of energy

- 1) a, b are correct 2) b, c are correct 3) a, c are correct 4) all are correct

4. An ideal gas is heated from 20°C to 40°C under constant pressure. The change in internal energy is

- 1) Zero under constant pressure 2) Double the original value
3) Proportional to change in volume 4) Proportional to change in temperature

5. Which of the following is incorrect regarding the first law of thermodynamics?

- 1) It introduces the concept of internal energy.
- 2) It introduces the concept of entropy.
- 3) It is not applicable to any cyclic process.
- 4) It is a restatement of principle of conservation of energy.

6. In a given process on an ideal gas, $dW = 0$ and $dQ < 0$. Then for the gas

- 1) The temperature will decrease
- 2) The volume will increase
- 3) The pressure will remain constant
- 4) The temperature will increase

7. The specific heat capacity of a gas at constant pressure is greater than that at constant volume because

- 1) At constant volume, all the heat supplied goes to increase the internal energy of the gas.
- 2) At constant volume there is no change in temperature of the gas when heat is supplied.
- 3) At constant pressure, there is no change in internal energy of the gas when heat is supplied.
- 4) The gas expands when its temperature increases at constant pressure.

8. The temperature of the system decreases in the process of

- 1) Free expansion
- 2) Isothermal expansion
- 3) Adiabatic expansion
- 4) Isothermal compression

9. Certain amount of heat supplied to an ideal gas under isothermal conditions will result in

- 1) A rise in temperature
- 2) Doing external work and a change in temperature
- 3) Doing external work
- 4) An increase in the internal energy of the gas

10. Which of the following is true in the case of an adiabatic process, where $\gamma = C_p / C_v$?

- 1) $P^{1-\gamma} T^\gamma = \text{constant}$
- 2) $P^\gamma T^{1-\gamma} = \text{constant}$
- 3) $PT^\gamma = \text{constant}$
- 4) $P^\gamma T = \text{constant}$

11. In the adiabatic compression, the decrease in volume is associated with

- 1) Increase in temperature and increase in pressure
- 2) Decrease in temperature and increase in pressure
- 3) Decrease in temperature and decrease in pressure
- 4) Increase in temperature and decrease in pressure

12. For an adiabatic process, the relation between V and T is given by

- 1) $TV^\gamma = a \text{ constant}$
- 2) $T^\gamma V = a \text{ constant}$
- 3) $TV^{1-\gamma} = a \text{ constant}$
- 4) $TV^{\gamma-1} = a \text{ constant}$

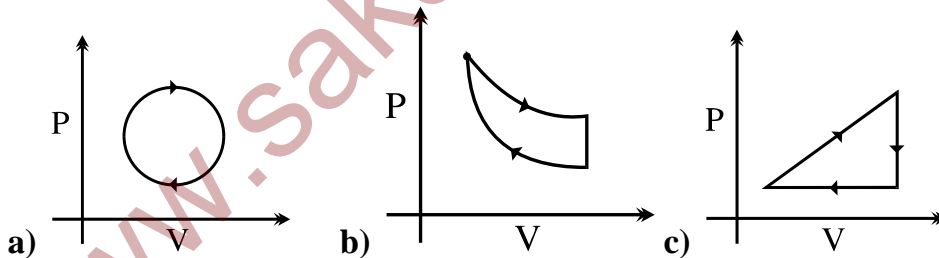
13. Which statement is incorrect?

- 1) All reversible cycles have same efficiency.
- 2) Reversible cycles have more efficiency than irreversible ones
- 3) Carnot cycle is a reversible one.
- 4) Carnot cycle has maximum efficiency.

14. Choose the false statement. 1st Law of thermo dynamics

- 1) Does not tell us about the efficiency with which heat can be converted in to work.
- 2) Does not give any idea about the condition under which a body can use its heat energy to produce the work.
- 3) Tells about the direction of heat flow.
- 4) Defines the internal energy function

15. The following are the P – V diagrams for cyclic process for a gas. Then the heat is absorbed by the gas in the process



- 1) In a and b
- 2) In b and c only
- 3) In a and c only
- 4) In all a,b,c

16. Consider the following statements and choose the correct answer.

a) If heat is added to a system, its temperature must always increase.

b) If positive work is done by a system in thermodynamic process, its volume must increase.

1) Both a and b are true

2) a is correct, but b is wrong

3) a is wrong but b is correct

4) Both a and b are wrong

17. A :Work done by an ideal gas during an expansion is positive.

R :Work done is given by the product of pressure and increase in volume.

1) Both (A) and (R) are true and (R) is the correct explanation of (A).

2) Both (A) and (R) are true and (R) is not the correct explanation of (A).

3) (A) is true but (R) is false.

4) (A) is false but (R) is true.

18. A: During an isothermal process, specific heat of a substance is infinity.

R: Isothermal process is a constant temperature process.

1) Both (A) and (R) are true and (R) is the correct explanation of (A).

2) Both (A) and (R) are true and (R) is not the correct explanation of (A).

3) (A) is true but (R) is false.

4) (A) is false but (R) is true.

19. **A:** At absolute zero, the substance has internal energy.

R: At OK the substance posses the vibrational motion of atoms within the molecules.

- 1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- 2) Both (A) and (R) are true and (R) is not the correct explanation of (A).
- 3) (A) is true but (R) is false.
- 4) (A) is false but (R) is true.

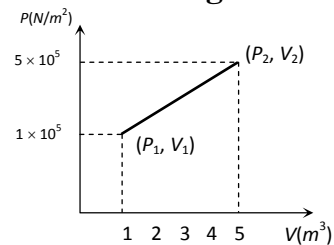
20. **A:** The raise in temperature and internal energy takes place quickly, when the gas heated at constant volume.

R: The gas does not work, when it is heated at constant volume.

- 1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- 2) Both (A) and (R) are true and (R) is not the correct explanation of (A).
- 3) (A) is true but (R) is false.
- 4) (A) is false but (R) is true.

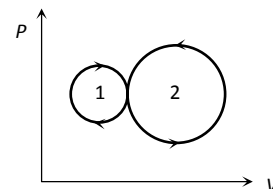
21. A system changes from the state (P_1, V_1) to (P_2, V_2) as shown in the figure. What is the work done by the system?

- | | |
|----------------------------|--------------------------|
| 1) 7.5×10^5 joule | 2) 7.5×10^5 erg |
| 3) 12×10^5 joule | 4) 6×10^5 joule |



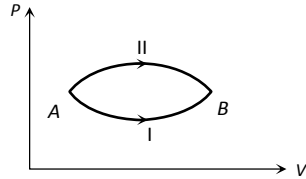
22. In the following indicator diagram, the net amount of work done will be

- | | |
|-------------|-------------|
| 1) Positive | 2) Negative |
| 3) Zero | 4) Infinity |



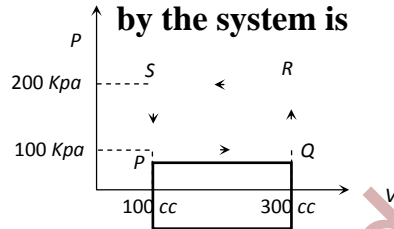
23. A system goes from A to B via two processes I and II as shown in figure. If ΔU_1 and ΔU_2 are the changes in internal energies in the processes I and II respectively, then

- 1) $\Delta U_{II} > \Delta U_I$
- 2) $\Delta U_{II} < \Delta U_I$
- 3) $\Delta U_I = \Delta U_{II}$
- 4) Relation between ΔU_I and ΔU_{II} cannot be determined



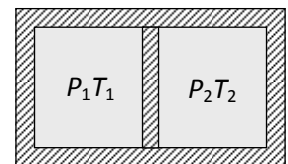
24. A thermodynamic system is taken through the cycle $PQRSP$ process. The net work done by the system is

- 1) $20 J$
- 2) $-20 J$
- 3) $400 J$
- 4) $-374 J$



25. Following figure shows an adiabatic cylindrical container of volume V_0 divided by an adiabatic smooth piston (area of cross-section = A) in two equal parts. An ideal gas ($C_p / C_v = \gamma$) is at pressure P_1 and temperature T_1 in left part and gas at pressure P_2 and temperature T_2 in right part. The piston is slowly displaced and released at a position where it can stay in equilibrium. The final pressure of the two parts will be (Suppose x = displacement of the piston)

- 1) P_2
- 2) P_1
- 3) $\frac{P_1 \left(\frac{V_0}{2}\right)^\gamma}{\left(\frac{V_0}{2} + Ax\right)^\gamma}$
- 4) $\frac{P_2 \left(\frac{V_0}{2}\right)^\gamma}{\left(\frac{V_0}{2} + Ax\right)^\gamma}$



26. 70cal of heat is required in rising the temperature of 2 moles of an ideal gas at constant pressure for 40°C to 45°C ($R = 2\text{cal/mole}^{\circ}\text{C}$). The gas is

- 1) H_2 2) He 3) CO_2 4) NH_3

27.. The temperature of a hypothetical gas increase to $\sqrt{2}$ times when compressed adiabatically to half of the volume. Its equation can be written as

- 1) $PV^{3/2} = \text{cat}$ 2) $PV^{5/2} = \text{at}$ 3) $PV^{7/3} = \text{al}$ 4) $PV^{4/3} = \text{cal}$

28. The temperature of 5 moles of a gas at constant volume is changed from 100°C to 120°C . The change in internal energy is 80J. The total heat capacity of the gas at constant volume will be in joule/Kelvin is

- 1) 8 2) 4 3) 0.8 4) 0.4

29. When an ideal diatomic gas is heated at constant pressure, the fraction of heat energy supplied which is used in doing work to maintain pressure constant is

- 1) $5/7$ 2) $7/2$ 3) $2/7$ 4) $2/5$

30. When a mono-atomic gas expands at constant pressure, the percentage of heat supplied that increases temperature of the gas and in doing external work in expansion at constant pressure is

- 1) 100%, 0 2) 60%, 40% 3) 40%, 60% 4) 75%, 25%

31. H calories of heat is required to increase the temperature of one mole of mono-atomic gas from 20°C to 30°C at const. volume. The quantity of heat required to increase the temperature of 2 moles of a diatomic gas from 20°C to 25°C is at constant volume is

- 1) $\frac{4H}{3}$ 2) $\frac{5H}{3}$ 3) 2 H 4) $\frac{7H}{3}$

32. The pressure and density of a diatomic gas ($\gamma = 7/5$) change adiabatically from

(P, d) to (P^1, d^1). If $\frac{d^1}{d} = 32$, then $\frac{P^1}{P}$ should be

- 1) $1/128$ 2) 32 3) 128 4) none of the above

33. If for hydrogen $C_P - C_V = m$ and for nitrogen $C_P - C_V = n$, Where C_P and C_V refer to specific heats per unit mass respectively at constant pressure and constant volume, the relation between m and n is (molecular weight of hydrogen = 2 and molecular weight of nitrogen = 14)

- 1) $n = 14m$ 2) $n = 7m$ 3) $m = 7n$ 4) $m = 14n$

34. One mole of a mono-atomic gas is mixed with one mole of a diatomic gas. What will be the ' γ ' for the mixture?

- 1) 1.5 2) 1.54 3) 1.4 4) 1.45

35. The ratio of specific heats of a gas is γ . The change in internal energy of one mole of gas when the volume changes from v to $2v$ at constant pressure " p " is

- 1) $\frac{pv}{\gamma-1}$ 2) pv 3) $\gamma-1$ 4) $\frac{pv}{\gamma}$

36. 5 moles of hydrogen ($\gamma = 7/5$) initially at S.T.P. are compressed adiabatically so that its temperature becomes 400°C . The increase in the internal energy of the gas in kilo-J is ($R=8.30\text{Jmole}^{-1}\text{k}^{-1}$)

- 1) 21.55 2) 41.50 3) 65.55 4) 80.55

37. During an adiabatic process, the pressure of a gas is proportional to the cube of its absolute temperature. The value of γ for that gas is

- 1) $3/5$ 2) $4/3$ 3) $5/3$ 4) $3/2$

38. A mono-atomic ideal gas, initially at temperature T_1 , is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly IF L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then T_1/T_2 is given by

- 1) $\left(\frac{L_1}{L_2}\right)^{\frac{2}{3}}$ 2) $\frac{L_1}{L_2}$ 3) $\frac{L_2}{L_1}$ 4) $\left(\frac{L_2}{L_1}\right)^{\frac{2}{3}}$

39. Two cylinders A and B fitted with pistons contain equal number of moles of an ideal mono-atomic gas at 400K. The piston A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 42K, then the rise in temperature of the gas in B is ($\gamma = 5/3$)

- 1) 21 K 2) 35 K 3) 42 K 4) 70 K

40. Heat is supplied to a diatomic gas at constant pressure. The ratio of $\Delta Q : \Delta U : \Delta W$ is

- 1) 5 : 3 : 2 2) 5 : 2 : 3 3) 7 : 5 : 2 4) 7 : 2 : 5

Key

- 1) 4 2) 4 3) 1 4) 4 5) 2 6) 1 7) 1 8) 3 9) 3 10) 1
 11) 1 12) 4 13) 1 14) 3 15) 4 16) 3 17) 1 18) 1 19) 1 20) 1
 21) 3 22) 2 23) 3 24) 2 25) 3 26) 1 27) 1 28) 2 29) 1 30) 3
 31) 2 32) 3 33) 3 34) 1 35) 1 36) 2 37) 4 38) 4 39) 4 40) 3

Hints

21. Work done = Area of PV graph (here trapezium)

$$= \frac{1}{2}(1 \times 10^5 + 5 \times 10^5) \times (5 - 1) = 12 \times 10^5 J$$

22. The cyclic process 1 is clockwise whereas process 2 is anticlockwise. Clockwise area represents positive work and anticlockwise area represents negative work. Since negative area (2) > positive area (1), hence net work done is negative.

23. As internal energy is a point function therefore change in internal energy does not depend upon the path followed i.e. $\Delta U_I = \Delta U_{II}$

24. Work done by the system = Area of shaded portion on $P-V$ diagram

$$= (300 - 100)10^{-6} \times (200 - 10) \times 10^3 = 20 J$$

25. As finally the piston is in equilibrium, both the gases must be at same pressure P_f . It is given that displacement of piston be in final state x and if A is the area of cross-section of the piston. Hence the final volumes of the left and right part finally can be given by figure as

$$V_L = \frac{V_0}{2} + Ax \quad \text{and} \quad V_R = \frac{V_0}{2} - Ax$$

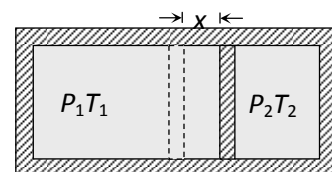
As it is given that the container walls and the piston are adiabatic in left side and the gas undergoes adiabatic expansion and on the right side the gas undergoes adiabatic compressive. Thus we have for initial and final state of gas on left side

$$P_1 \left(\frac{V_0}{2} \right)^\gamma = P_f \left(\frac{V_0}{2} + Ax \right)^\gamma \quad \dots (i)$$

Similarly for gas in right side, we have

$$P_2 \left(\frac{V_0}{2} \right)^\gamma = P_f \left(\frac{V_0}{2} - Ax \right)^\gamma \quad \dots (ii)$$

From eq. (i) and (ii)



$$\frac{P_1}{P_2} = \frac{\left(\frac{V_0}{2} + Ax\right)^\gamma}{\left(\frac{V_0}{2} - Ax\right)^\gamma} \Rightarrow Ax = \frac{V_0}{2} \left[\frac{P_1^{1/\gamma} - P_2^{1/\gamma}}{P_1^{1/\gamma} + P_2^{1/\gamma}} \right]$$

Now from equation (i) $P_f = \frac{P_1 \left(\frac{V_0}{2}\right)^\gamma}{\left[\frac{V_0}{2} + Ax\right]^\gamma}$

26. $Q = nC_p dT \Rightarrow C_p = \frac{Q}{ndT} = \frac{70}{2 \times 5} = \frac{7}{2} R$

The gas is diatomic.

27. $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

$$TV^{\gamma-1} = \sqrt{2} T \left(\frac{V}{2}\right)^{\gamma-1}$$

$$V^{\gamma-1} = \sqrt{2} \left(\frac{V}{2}\right)^{\gamma-1}$$

$$2^{\gamma-1} = 2^{1/2}$$

$$\gamma - 1 = 1/2$$

$$\gamma = \frac{3}{2}$$

$$\therefore PV^\gamma = \text{Cons tan } t \Rightarrow PV^{3/2} = \text{Cons tan } t$$

28. Heat capacity = $\frac{dQ}{dT} = \frac{80}{20} = 4 \text{ J/}^\circ\text{C}$

29. $\frac{dW}{dQ} = 1 - \frac{1}{\gamma} = 1 - \frac{5}{7} \Rightarrow \frac{dW}{dQ} = \frac{2}{7}$

$$30. \frac{dU}{dQ} = \frac{1}{\gamma} \times 100 = \frac{3}{5} \times 100 = 60\%$$

$$\frac{dW}{dQ} = \left(1 - \frac{1}{\gamma}\right) \times 100 = \left(1 - \frac{3}{5}\right) \times 100 = 40\%$$

$$31. (dQ)_v = n.c_v.dT$$

$$\frac{H^1}{H} = \frac{2.(5R/2)5}{1.(3R/2).10}$$

$$\frac{H^1}{H} = \frac{5}{3} \Rightarrow H^1 = \frac{5H}{3}$$

$$32. \gamma = 7/5 \quad P \propto d^\gamma$$

$$\frac{P^1}{P} = \left(\frac{d^1}{d}\right)^\gamma = (32)^{7/5} = 128$$

$$33. C_p - C_v = r = \frac{R}{M}$$

$$m = \frac{R}{M_1} n = \frac{R}{M_2}$$

$$\frac{m}{n} = \frac{M_2}{M_1} = \frac{14}{2}$$

$$m = 7n$$

$$34. \gamma_{mix} = \frac{n_1 c_{p1} + n_2 c_{p2}}{n_1 c_{v1} + n_2 c_{v2}}$$

$$= \frac{(1)\left(\frac{5R}{2}\right) + (1)\left(\frac{7R}{2}\right)}{(1)\left(\frac{3R}{2}\right) + (1)\left(\frac{5R}{2}\right)} = \frac{12}{8} = \frac{3}{2}$$

$$35. \frac{dU}{dW} = \frac{1}{\gamma - 1}$$

$$\frac{dU}{P(V_f - V_i)} = \frac{1}{\gamma - 1}$$

$$\frac{dU}{P(2V - V)} = \frac{1}{\gamma - 1}$$

$$36. du = -n \left(\frac{R}{r-1} \right) (T_1 - T_2)$$

$$du = +5 \frac{8.31}{\left(\frac{7}{5} - 1 \right)} \cdot (400)$$

$$= \frac{5 \times 5 \times 8.31}{2} \times 400 = 41.550 \text{ kJ}$$

$$37. P \propto T^{\frac{r}{r-1}}$$

$$P \propto T^3$$

$$\frac{r}{r-1} = 3 \Rightarrow r = \frac{3}{2}$$

$$\frac{C_p}{C_v} = \frac{3}{2}$$

$$38. T_{1r-1} \cdot V_1^{r-1} = T_2 \cdot V_2$$

$$V = A \cdot L$$

$$T_1 (AL_1)^{\frac{5}{3}-1} = T_2 (AL_2)^{\left(\frac{5}{3}-1\right)}$$

$$\frac{T_1}{T_2} = \left(\frac{L_2}{L_1} \right)^{2/3}$$

$$39. n.C_p(42) = n.C_v(dT)_2$$

$$\frac{5R}{2} \times 42 = \frac{3R}{2} (dT)_2$$

$$(dT)_2 = \frac{5}{3} \times 42 = 70k$$

$$40. \frac{du}{dQ} = \frac{1}{r} = \frac{5}{7}$$

$$du = \frac{5}{7} dQ$$

$$\frac{dw}{dQ} = \left(1 - \frac{1}{r}\right) = \frac{2}{7}$$

$$dw = \frac{2}{7} dQ$$

$$\Delta Q : \Delta U : \Delta W = 1 : \frac{5}{7} : \frac{2}{7} = 7 : 5 : 2$$

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