CHAPTER NO. 11 (HEAT AND THERMODYNAMICS)

Question 11.1:- Why is the average velocity of the molecules in a gas zero but the average of the square of velocities is not zero?

Answer:- The number of molecules in a small sample of gas is very large and they perform random translational motion. At any instant, the number of molecules moving in any direction with certain velocity is equal to number of molecules moving with same velocity in opposite direction. The average velocity of molecules is zero. Suppose one molecule is moving along x-axis with velocity v_x, after the collision with the wall, its velocity will be $-v_x$ and $\langle v_x \rangle = \frac{v_x+(-v_x)}{2} = 0$.

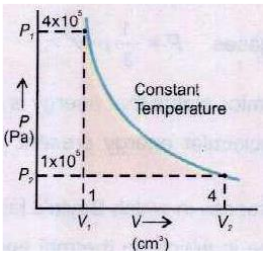
In such cases, motion is recognized by average of square velocities which is always non-zero as given:-

$\langle v_x^2 \rangle = \frac{v_x^2+(-v_x)^2}{2} = \langle v_x^2 \rangle \neq 0$

Question 11.2:- Why does the pressure of a gas in a car tyre increase when it is driven through some distance?

Answer:- When a car covers some distance on the road, its tyres have to overcome the frictional effects of the road. The work done against the friction appears as heat energy which increases the translational kinetic energy of the gas molecules in the tyres. The rate of collision of molecules with the walls of the tyre increases and hence pressure increases.

Question 11.3:- A system undergoes from state P_1V_1 to state P_2V_2 as shown in figure. What will the change in internal energy?

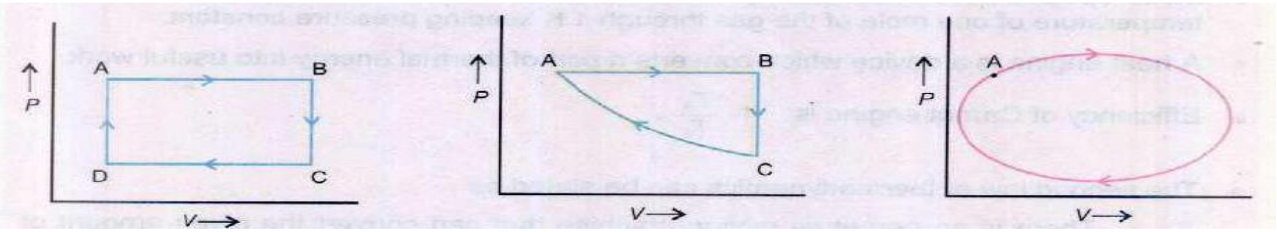


Answer:- In the system represented by given diagram, we can verify that Boyle's law is applicable as $P_1V_1 = P_2V_2$.

Boyle's law is valid when temperature is constant i.e. isothermal process so no change in internal energy will take place.

Change in internal energy = $\Delta U = 0$.

Question 11.4:- Variation of volume by pressure is given in figure. A gas is taken along the paths ABCDA, ABCA and A to A. What will be the change in internal energy?



Answer:- In all the given systems, the system returns to its initial state which is called a cycle. The change in internal energy will be zero in all the cases.

Question 11.5:- Specific heat of a gas at constant pressure is greater than specific heat at constant volume. Why?

Answer:- When a gas is heated at constant volume, no work is done on the gas by heat energy as $W = P \Delta V = 0$. All the heat supplied to gas is utilized in increasing the internal energy of the gas.

When a gas is heated at constant pressure, heat is utilized in increasing the internal energy of the gas and doing work on the system.

This indicates that for same rise in temperature, more heat is required at constant pressure than at constant volume so molar specific heat at constant pressure is always greater than molar specific heat at constant volume.

Question 11.6:- Give an example of a process in which no heat is transferred to or from a system but the temperature of the system changes.

Answer:- An adiabatic process is the one in which no heat is transferred to or from the system but temperature of the system changes. In an adiabatic process, $Q = 0$.

First law of thermodynamics states that $Q = W + \Delta U$

$0 = W + \Delta U$

$W = -\Delta U$.

In an adiabatic expansion, temperature of gas decreases because gas has to do work on the basis of its internal energy.

In an adiabatic compression, temperature of gas increases because work done on the system increases the internal energy and the temperature of the gas.

Question 11.7:- Is it possible to convert internal energy into mechanical energy? Explain with an example.

Answer:- Yes, it is possible.

In an adiabatic expansion, volume is increased by decreasing the pressure and work is done by the system by using its internal energy. Hence, we can say that internal energy of the system is being converted into mechanical energy.

Question 11.8:- Is it possible to construct a heat engine that will not expel heat into atmosphere?

Answer:- No, it is not possible as it is against the Kelvin statement of second law of thermodynamics.

Heat engines absorb heat from heat reservoir, convert some of it into work and reject the remaining heat into atmosphere i.e. cold reservoir. It is impossible to devise a process which may convert all heat extracted from a reservoir entirely into work without making any change in working system.

Question 11.9:- A thermos flask containing milk as a system is shaken rapidly. Does the temperature of milk rise?

Answer:- A thermos flask is an insulated system. When milk in a thermos flask is shaken rapidly, work is done on the system which is converted into mechanical energy of the system (milk). This increases the temperature of the milk inside the thermos flask.

Question 11.10:- What happens to the temperature of the room, when an airconditioner is left running on a table in the middle of the room?

Answer:- The temperature of the room will not decrease rather it will increase. The heat absorbed from the room is expelled in the same room plus the work done by the compressor is also converted and expelled in the same room.

Question 11.11:- Can the mechanical energy be converted completely into heat energy? If so give an example.

Answer:- Yes, mechanical energy can be completely converted into heat energy.

1) During an adiabatic compression, the work done (mechanical energy) on the system increases the internal energy of the gas. Hence work done is converted into heat energy.
2) During an isothermal compression, work done on the system (mechanical energy) appears in the form of heat energy out of the system as W = Q in isothermal process.

Question 11.12:- Does entropy of a system increase or decrease due to friction?

Answer:- The entropy of the system always increases due to friction. Useful energy is always dissipated in doing work against friction. When work is done against friction, the change in entropy $\Delta S = \Delta Q / T$ is positive and entropy increases.

Question 11.13:- Give an example of a natural process that involves an increase in entropy.

Answer:- Melting of ice into water is a natural process that involves increase in entropy. When ice melts at melting temperature T, some amount of heat is

transferred from surroundings to ice which is positive and change in entropy ΔS = ΔQ / T is positive. Thus, entropy increases when ice melts.

Question 11.14:- An adiabatic process is the one in which

Answer:- a. No heat is added to or taken out of a system (Correct)

b. No change of temperature takes place

c. Boyle's law is applicable

d. Pressure and volume remain constant

Question 11.15:- Which one of the following process is irreversible?

Answer:- a. Slow compression of an elastic spring

b. Slow evaporation of a substance in an isolated vessel

c. Slow compression of a gas

d. A chemical explosion (Correct)

Question 11.16:- An ideal reversible heat engine has

Answer:- a. 100% efficiency

b. Highest efficiency (Correct)

c. An efficiency that depends on the nature of working substance

d. None of these