A.K. Yadav

NCERT ANSWERS
CHAPTER 12

1. A geyser heats water flowing at the rate of 3 litres per minute from 27 °C to 77 °C. If the geyser operates on a gas burner, what is the rate of consumption of the fuel if its heat of combustion is 4×10^4 J/g?

Ans. *Given* : $T_1 = 27\ ^0C, \quad T_2 = 77\ ^0C, \qquad Q = 4\times10^4\ J/g$

$m = 3l/\text{min.} = 3000\ g/\text{min}.$

Rise in temperature, $\Delta T = T_2 - T_1 = 77 - 27 = 50\ ^0C$

Total heat used, $\Delta Q = mc\Delta T = 3000\times4.2\times50 = 6.3\times10^5\ J.\text{min}^{-1}$

Rate of consumption $= \dfrac{\Delta Q}{Q} = \dfrac{6.3\times10^5}{4\times10^4} = 15.75 g.\text{min}^{-1}$

2. What amount of heat must be supplied to 2.0×10^{-2} kg of nitrogen (at room temperature) to raise its temperature by 45 °C at constant pressure? (Molecular mass of N_2 = 28; R = 8.3 J mol^{-1} K^{-1}.)

Ans. *Given* : $m = 2\times10^{-2} kg = 20 g, \quad \Delta T = 45\ ^0C, \quad M = 28$

Number of moles, $n = \dfrac{m}{M} = \dfrac{20}{28} = 0.714$

Molar specific heat at constant pressure for nitrogen, $C_P = \dfrac{7}{2}R = \dfrac{7}{2}\times8.3 = 29.05 Jmol^{-1}K^{-1}$

Total heat supplied, $\Delta Q = nC_P\Delta T = 0.714\times29.05\times45 = 933.38J$

3. Explain why

(a) Two bodies at different temperatures T_1 and T_2 if brought in thermal contact do not necessarily settle to the mean temperature $(T_1 + T_2)/2$.

(b) The coolant in a chemical or a nuclear plant (i.e., the liquid used to prevent the different parts of a plant from getting too hot) should have high specific heat.

(c) Air pressure in a car tyre increases during driving.

(d) The climate of a harbour town is more temperate than that of a town in a desert at the same latitude.

Ans. (a) Because the equilibrium temperature is equal to the mean temperature $(T_1 + T_2)/2$ only when the thermal capacities of both the bodies are equal.

(b) Higher the specific heat of the coolant $\longrightarrow$ higher is its heat-absorbing capacity and vice versa. A coolant with high specific heat will prevent different parts of the plant from getting too hot.

(c) Car in motion $\longrightarrow$ Air molecules inside tyre in motion $\longrightarrow$ air temperature inside the tyre increases. According to Charles' law, $P \propto T$

So, the air pressure in it will also increase.

(d) Relative humidity in a harbour town is more than it is in a desert town due to this the climate of a harbour town is more temperate than that of a town in a desert at the same latitude.

4. A cylinder with a movable piston contains 3 moles of hydrogen at standard temperature and pressure. The walls of the cylinder are made of a heat insulator, and the piston is insulated by having a pile of sand on it. By what factor does the pressure of the gas increase if the gas is compressed to half its original volume?

Ans.
- As the cylinder is completely insulated so the process is called adiabatic.
- $P_1V_1^\gamma = P_2V_2^\gamma$

$$P_1V_1^\gamma = P_2\left(\frac{V_1}{2}\right)^\gamma$$

$$\frac{P_2}{P_1} = \frac{V_1^\gamma}{\left(\frac{V_1}{2}\right)^\gamma} = 2^\gamma = 2^{1.4} = 2.639$$

5. In changing the state of a gas adiabatically from an equilibrium state *A* to another equilibrium state *B*, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state *A* to *B* via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in the latter case? (Take 1 cal = 4.19 J)

Ans. Given : $\Delta W = -22.3J$ (work done on the system), $\Delta Q = 0$ (process is adiabatic)

From 1st law of thermodynamics, $\Delta U = \Delta Q - \Delta W = 0 - (-22.3) = 22.3J$

Net heat absorbed by the system, $\Delta Q = 9.35cal = 9.35 \times 4.19 = 19.1765J$

Work done, $\Delta W = \Delta Q - \Delta U = 39.1765 - 22.3 = 16.8765J$

6. Two cylinders *A* and *B* of equal capacity are connected to each other via a stopcock. *A* contains a gas at standard temperature and pressure. *B* is completely evacuated. The entire system is thermally insulated. The stopcock is suddenly opened. Answer the following :

(a) What is the final pressure of the gas in *A* and *B?*

(b) What is the change in internal energy of the gas?

(c) What is the change in the temperature of the gas?

(d) Do the intermediate states of the system (before settling to the final equilibrium state) lie on its *P-V-T* surface?

Ans. (a) Stop-cock opened $\longrightarrow$ Volume of gas gets doubled.

Pressure will decrease to half i.e. 0.5 atm. as volume is inversely proportional to pressure.

(b) As no work is done by or on the gas, the internal energy of the gas will not change.

(c) No change in temperature of gas as no work is being done by the gas during the expansion.

(d) Sudden/ free expansion is a rapid and non- controllable process. As the intermediate states are non-equilibrium states, they do not lie on the *P-V-T* surface of the system.

7. A steam engine delivers 5.4×10^8 J of work per minute and services 3.6×10^9J of heat per minute from its boiler. What is the efficiency of the engine? How much heat is wasted per minute?

Ans. Work done by steam engine per minute, W = 5.4 x 10^8 J

Heat supplied by boiler, Q = 3.6 x 10^9 J

- Efficiency of engine, on one column, $\eta = \frac{W}{Q} = \frac{5.4\times10^8}{3.6\times10^9} = 0.15 \quad or \quad 15\%$
- Amount of heat wasted, $Q' = Q - W = 3.6\times10^9 - 5.4\times10^8 = 30.6\times10^8\ J$

8. An electric heater supplies heat to a system at a rate of 100W. If system performs work at a rate of 75 joules per second. At what rate is the internal energy increasing?

Ans. *Given* : $Q = 100W = 100Js^{-1}, \quad W = 75Js^{-1}$

To find : $U = ?$

Sol^n : $U = Q - W = 100 - 75 = 25Js^{-1} = 25W$

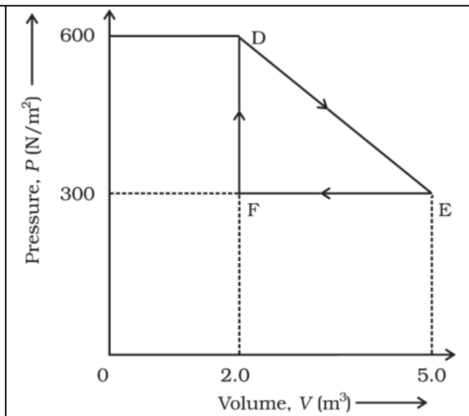
From 1st law of thermodynamics

$Q = U + W$

So, $U = Q - W$

9. A thermodynamic system is taken from an original state D to an intermediate state by the linear process shown in Fig. (12.13) Its volume is then reduced to the original value from E to F by an isobaric process.

Calculate the total work done by the gas from D to E to F



Ans. Work done by gas from D to E to F, $W = Area\,of\ \Delta DEF = \frac{1}{2}\times DE\times EF = \frac{1}{2}\times300\times3 = 450J$

10. A refrigerator is to maintain eatables kept inside at 9 ^{0}C. If room temperature is 36 ^{0}C, calculate the coefficient of performance.

Ans. *Given* : $T_1 = 9\,^0C = 282K, \quad T_2 = 36\,^0C = 309K$

To find : $\beta = ?$

Sol^n : $\beta = \frac{T_1}{T_2 - T_1} = \frac{282}{309-282} = \frac{282}{27} = 10.44$