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NCERT Solutions for 11th Class Physics:Chapter 12-Thermodynamics

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Exercises

12.1. A geyser heats water flowing at the rate of 3.0 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 4.0×10^4 J/g?

Answer

Water is flowing at a rate of 3.0 litre/min.

The geyser heats the water, raising the temperature from 27°C to 77°C.

Initial temperature, $T_1 = 27°C$

Final temperature, $T_2 = 77°C$

$\therefore$ Rise in temperature, $\Delta T = T_2 - T_1$

= 77 – 27 = 50°C

Heat of combustion = 4×10^4 J/g

Specific heat of water, $c = 4.2\ J\ g^{-1}\ °C^{-1}$

Mass of flowing water, m = 3.0 litre/min = 3000 g/min

Total heat used, $\Delta Q = mc\,\Delta T$

= 3000 × 4.2 × 50

= 6.3×10^5 J/min

$\therefore$ Rate of consumption = $6.3 \times 10^5 / (4 \times 10^4)$ = 15.75 g/min.

12.2. 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}.)

Answer

Mass of nitrogen, $m = 2.0 \times 10^{-2}$ kg = 20 g

Rise in temperature, $\Delta T = 45°C$

Molecular mass of N_2, $M = 28$

Universal gas constant, $R = 8.3$ J mol^{-1} K^{-1}

Number of moles, n = m/M

$= (2 \times 10^{-2} \times 10^3) / 28$

$= 0.714$

Molar specific heat at constant pressure for nitrogen, $C_p = (7/2)R$

$= (7/2) \times 8.3$

$= 29.05$ J mol^{-1} K^{-1}

The total amount of heat to be supplied is given by the relation:

$\Delta Q = nC_P\Delta T$

$= 0.714 \times 29.05 \times 45$

$= 933.38$ J

Therefore, the amount of heat to be supplied is 933.38 J.

12.3. 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.

Answer

(a) In thermal contact, heat flows from the body at higher temperature to the body at lower temperature till temperatures becomes equal. The final temperature can be the mean temperature $(T_1 + T_2)/2$only when thermal capacities of the two bodies are equal.

(b) This is because heat absorbed by a substance is directly proportional to the specific heat of the substance.

(c) During driving, the temperature of air inside the tyre increases due to motion. Accordingto Charle's law, $P \propto T$. Therefore, air pressure inside the tyre increases.

(d) This is because in a harbour town, the relative humidity is more than in a desert town. hence, the climate of a harbour town is without extremes of hot and cold.

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12.4. 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?

Answer

The cylinder is completely insulated from its surroundings. As a result, no heat is exchanged between the system (cylinder) and its surroundings. Thus, the process is adiabatic.

Initial pressure inside the cylinder = P_1

Final pressure inside the cylinder = P_2

Initial volume inside the cylinder = V_1

Final volume inside the cylinder = V_2

Ratio of specific heats, $\gamma = 1.4$

For an adiabatic process, we have:

$P_1V_1^\gamma = P_2V_2^\gamma$

The final volume is compressed to half of its initial volume.

$\therefore\ V_2 = V_1/2$

$P_1V_1^\gamma = P_2(V_1/2)^\gamma$

$P_2/P_1 = V_1^\gamma / (V_1/2)^\gamma$

$= 2^\gamma = 2^{1.4} = 2.639$

Hence, the pressure increases by a factor of 2.639.

12.5. 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)

Answer

The work done (W) on the system while the gas changes from state A to state B is 22.3 J.

This is an adiabatic process. Hence, change in heat is zero.

$\therefore\ \Delta Q = 0$

$\Delta W = -22.3$ J (Since the work is done on the system)

From the first law of thermodynamics, we have:

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

Where,

ΔU = Change in the internal energy of the gas

$\therefore\ \Delta U = \Delta Q - \Delta W = -(-22.3\text{ J})$

$\Delta U = +22.3$ J

When the gas goes from state A to state B via a process, the net heat absorbed by the system is:

$\Delta Q = 9.35\text{ cal} = 9.35 \times 4.19 = 39.1765$ J

Heat absorbed, $\Delta Q = \Delta U + \Delta Q$

$\therefore \Delta W = \Delta Q - \Delta U$

$= 39.1765 - 22.3$

$= 16.8765$ J

Therefore, 16.88 J of work is done by the system.

12.6. 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?

Answer

(a) When the stopcock is suddenly opened, the volume available to the gas at 1 atmospheric pressure will become two times. Therefore, pressure will decrease to one-half, i.e., 0.5 atmosphere.

(b) There will be no change in the internal energy of the gas as no work is done on/by the gas.

(c) Since no work is being done by the gas during the expansion of the gas, the temperature of the gas will not change at all.

(d) No, because the process called free expansion is rapid and cannot be controlled. the intermediate states are non-equilibrium states and do not satisfy the gas equation. In due course, the gas does return to an equilibrium state.

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

Answer

Work done by the steam engine per minute, $W = 5.4 \times 10^8$ J

Heat supplied from the boiler, $H = 3.6 \times 10^9$ J

Efficiency of the engine = Output energy / Input energy

$\therefore \eta = W / H = 5.4 \times 10^8 / (3.6 \times 10^9) = 0.15$

Hence, the percentage efficiency of the engine is 15 %.

Amount of heat wasted = $3.6 \times 10^9 - 5.4 \times 10^8$

$= 30.6 \times 10^8 = 3.06 \times 10^9$ J

Therefore, the amount of heat wasted per minute is 3.06×10^9 J.

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12.8.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?

Answer

Heat is supplied to the system at a rate of 100 W.

$\therefore$ Heat supplied, $Q = 100$ J/s

The system performs at a rate of 75 J/s.

$\therefore$ Work done, $W = 75$ J/s

From the first law of thermodynamics, we have:

$Q = U + W$

Where,

U = Internal energy

$\therefore U = Q - W$

= 100 – 75

= 25 J/s

= 25 W

Therefore, the internal energy of the given electric heater increases at a rate of 25 W.

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12.9. A thermodynamic system is taken from an original state to an intermediate state by the linear process shown in Fig. (12.13).

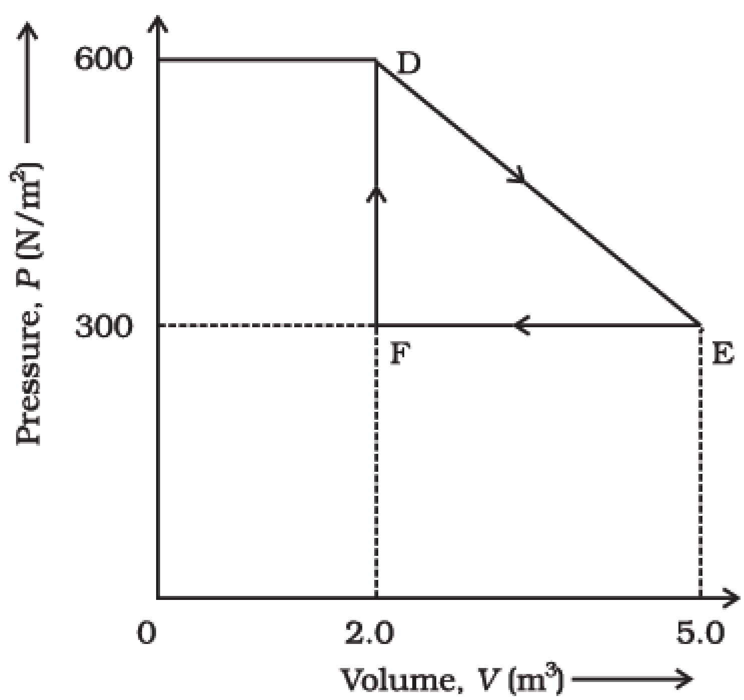

Fig. 12.13

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.

Answer

Total work done by the gas from D to E to F = Area of ΔDEF

Area of ΔDEF = (1/2) DE × EF

Where,

DF = Change in pressure

= 600 N/m^2 – 300 N/m^2

= 300 N/m^2

FE = Change in volume

= 5.0 m^3 – 2.0 m^3

= 3.0 m^3

Area of ΔDEF = (1/2) × 300 × 3 = 450 J

Therefore, the total work done by the gas from D to E to F is 450 J.

12.10. A refrigerator is to maintain eatables kept inside at 9°C. If room temperature is 36° C, calculate the coefficient of performance.

Answer

Temperature inside the refrigerator, T_1 = 9°C = 282 K

Room temperature, T_2 = 36°C = 309 K

Coefficient of performance = $T_1 / (T_2 - T_1)$

= 282 / (309 - 282)

= 10.44

Therefore, the coefficient of performance of the given refrigerator is 10.44.

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Chapterwise NCERT Solutions for Class 11 Physics:

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