Exemplar Solutions for Class 11 Physics Chapter 11 - Thermodynamics

Very Short Answers

12. Can a system be heated and its temperature remains constant?

Answer: Yes, this is possible during isothermal processes. For temperature to remain constant, the work done by the system against the surroundings should equal the heat supplied.

According to the first law of thermodynamics: $\Delta Q = \Delta U + \Delta W$

For isothermal process: $\Delta T = 0 \Longrightarrow \Delta U = 0$

Therefore: $\Delta Q = \Delta W$

The heat supplied is completely converted to work done by the system.

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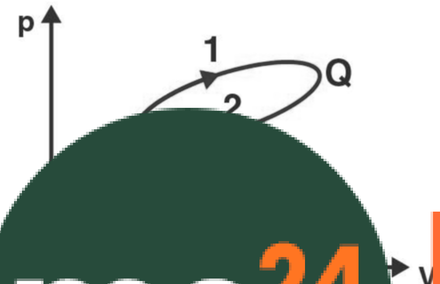
13. A system goes from P to Q by two different paths in the P-V diagram as shown in the figure. Heat given to the system in path 1 is 1000 J. The work done by the system along path 1 is more than path 2 by 100 J. What is the heat exchanged by the system in path 2?



Fro[illegible]odynamics: $Q = \Delta U + W$

Since internal energy change depends only on initial and final states: $\Delta U_1 = \Delta U_2 = \Delta U$

Therefore: $Q_1 - W_1 = Q_2 - W_2$ $Q_2 = Q_1 - W_1 + W_2 = Q_1 - (W_1 - W_2)$ $Q_2 = 1000 - 100 = 900$ J

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14. If a refrigerator's door is kept open, will the room become cool or hot? Explain.

Answer: The room will become hot. A refrigerator removes heat from inside and rejects it to the surroundings along with the work done by the compressor. When the door is kept open, the refrigerator tries to cool the entire room, but the heat rejected to the room ($Q_1 = Q_2 + W$) is greater than the heat absorbed (Q_2). The net effect is heating of the room.

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15. Is it possible to increase the temperature of a gas without adding heat to it? Explain.

Answer: Yes, this is possible through adiabatic compression. During adiabatic compression:

- $Q = 0$ (no heat exchange)
- $W < 0$ (work done on the gas)
- From first law: $\Delta U = Q - W = 0 - W = -W > 0$

- Since $\Delta U > 0$, temperature increases

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16. Air pressure in a car tyre increases during driving. Explain.
Answer: During driving, friction between tyre and road generates heat, increasing the temperature of air inside the tyre. Since the volume remains approximately constant (rigid tyre), this follows Gay-Lussac's law:
P/T = constant (at constant V)
As temperature T increases, pressure P increases proportionally.

Short Answers

17. Consider a Carnot's cycle operating between T_1 = 500K and T_2 = 300K producing 1 kJ of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs.
Solution: Given:

- T_1 = 500 K (source temperature)
- T_2 = 300 K (sink temperature)
- W = 1 kJ = 1000 J

Efficiency of Carnot engine: $\eta = 1 - T_2/T_1 = 1 - 300/500 = 1 - 0.6 = 0.4 = 2/5$
Sinc[illegible]$/\eta = 1000/(2/5) = 1000 \times 5/2 = 2500$ J
F[illegible] $Q_2 = Q_1 - W = 2500 - 1000 = 1500$ J
[illegible] sou[illegible]e = [illegible]00 J, [illegible] 1500 J

[illegible]ants to lose 5 [illegible]g by going up and down a 10 m high stairs. [illegible]uch fat while going up than coming down. If 1 kg of fat is b[illegible]lo calories, how many times must he go up and down to reduce his [illegible]
Solution: [illegible]

- Mass = 60 kg
- Height = 10 m
- Energy to burn 5 kg fat = $5 \times 7000 \times 10^3 \times 4.2 = 147 \times 10^6$ J
- $g = 10\ m/s^2$

Work done in one complete trip:

- Going up: $W_1 = mgh = 60 \times 10 \times 10 = 6000$ J
- Coming down: $W_2 = W_1/2 = 3000$ J
- Total per trip = $W_1 + W_2 = 6000 + 3000 = 9000$ J

Number of trips required: $N = (147 \times 10^6)/(9 \times 10^3) = 147 \times 10^3/9 \approx 16.3 \times 10^3$ trips

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19. Consider a cycle tyre being filled with air by a pump. Let V be the volume of the tyre and at each stroke of the pump ΔV of air is transferred to the tube adiabatically. What is the work done when the pressure in the tube is increased from P_1 to P_2?
Solution: For adiabatic process: PV^γ = constant

Before stroke: P_1V_1^γ = P_2V_2^γ After stroke: P(V + ΔV)^γ = (P + ΔP)V^γ

For small changes: PV^γ(1 + γΔV/V) ≈ PV^γ(1 + ΔP/P)

This gives: γΔV/V = ΔP/P

Therefore, work done: W = $(P_2 - P_1)V/\gamma$

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20. In a refrigerator one removes heat from a lower temperature and deposits to the surroundings at a higher temperature. In this process, mechanical work has to be done, which is provided by an electric motor. If the motor is of 1kW power, and heat is transferred from -3°C to 27°C, find the heat taken out of the refrigerator per second assuming its efficiency is 50% of a perfect engine.

Solution: Given:

- $T_1 = 27 + 273 = 300$ K
- $T_2 = -3 + 273 = 270$ K
- W = 1 kW = 1000 J/s
- Efficiency = 50% of Carnot

Carnot COP: $(COP)_{xarnot} = T_2/(T_1 - T_2) = 270/(300 - 270) = 270/30 = 9$

Actual COP = 0.5 × 9 = 4.5

For r Q_2/W $Q_2 = COP \times W = 4.5 \times 1000 = 4500$ J/s

H rator = 4.5 kJ/s

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rature inside the refrigerator.

om temperature)

For refrige COP = $T_2/(T_1 - T_2)$

$5 = T_2/(300 - T_2)$ $5(300 - T_2) = T_2$ $1500 - 5T_2 = T_2$ $1500 = 6T_2$ $T_2 = 250$ K = -23°C

Answer: Temperature inside refrigerator = -23°C

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22. The initial state of a certain gas is P_i, V_i, T_i. It undergoes expansion till its volume becomes Vf. Consider the following two cases:

a) The expansion takes place at constant temperature

b) The expansion takes place at constant pressure

Plot the P-V diagram for each case. In which of the two cases, is the work done by the gas more?

Solution:

Case (a) - Isothermal expansion:

- Process equation: PV = constant = P_iV_i
- Final pressure: Pf = P_iV_i/Vf
- Work done: $W_1 = \int PdV = P_iV_i \ln(Vf/V_i)$

Case (b) - Isobaric expansion:

- Process equation: $P = P_i$ = constant
- Work done: $W_2 = P_i(Vf - V_i)$

Comparison: For the same volume change, isothermal work $W_1 = P_iV_i \ln(Vf/V_i) > W_2 = P_i(Vf - V_i)$ when $Vf > V_i$.

This can be seen geometrically - the area under the isothermal curve is greater than under the isobaric line.

Answer: Work done is more in isothermal expansion.