

Thermodynamics — CBSE Pattern Test 2

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 2 — CBSE Pattern (90 minutes, 40 marks)

Class 11 Physics · Thermodynamics · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.
 (2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
 (3) For MCQ questions choose the single correct option; for VSA answers write a single line.
 (4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

1. In an isothermal process, the quantity that remains constant is
 - (A) temperature
 - (B) volume
 - (C) pressure
 - (D) internal energy
2. For an adiabatic process of an ideal gas
 - (A) PV^γ is constant
 - (B) PV is constant
 - (C) P/V is constant
 - (D) V/T is constant
3. A process carried out at constant volume is called
 - (A) isochoric
 - (B) isobaric
 - (C) isothermal
 - (D) adiabatic
4. The work done by an ideal gas in an isothermal expansion from V_1 to V_2 is
 - (A) $nRT \ln(V_2/V_1)$
 - (B) $nRT \ln(V_1/V_2)$
 - (C) $P\Delta V$
 - (D) 0
5. Mayer's relation for an ideal gas is
 - (A) $C_P - C_V = R$
 - (B) $C_P + C_V = R$
 - (C) $C_P/C_V = R$
 - (D) $C_P - C_V = 2R$
6. For a diatomic gas (neglecting vibrations), γ is approximately
 - (A) $7/5$
 - (B) $5/3$
 - (C) $9/7$
 - (D) $3/2$
7. C_P is greater than C_V for a gas because
 - (A) at constant pressure the gas does external work

- (B) at constant volume the gas expands
 (C) C_V excludes temperature
 (D) the gas is compressed at constant pressure
8. For a monatomic gas, C_V is approximately
 (A) $3R/2$
 (B) $5R/2$
 (C) $7R/2$
 (D) R
9. What is the value of ΔU in an isothermal process for an ideal gas?
10. State the first law of thermodynamics.

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. In a certain process 1000 J of heat is supplied to a gas and it does 600 J of work. Find the change in its internal energy.
12. Compute the Carnot efficiency of an engine operating between 400 K and 300 K.
13. A gas is compressed at constant pressure of 2×10^5 Pa from 4 m^3 to 2 m^3 . Find the work done on the gas and state its sign.
14. A heat engine absorbs 1000 J from a hot reservoir and rejects 600 J to the cold reservoir. Find its efficiency.

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. A gas absorbs 400 J of heat and does 250 J of work. Find the change in internal energy. If the gas instead expands doing 400 J of work while absorbing 600 J, find the new ΔU .
16. One mole of an ideal gas expands isothermally at 300 K from 1 m^3 to 3 m^3 . Find the work done and the heat absorbed. ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$)
17. Find the change in internal energy of 2 moles of a monatomic gas heated from 300 K to 400 K. ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$)
18. A diatomic gas of 3 moles is heated at constant pressure from 300 K to 400 K. Find the heat supplied, given $C_P = 7R/2$ and $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Explain, using the second law, why a heat engine cannot be 100% efficient. A Carnot engine works between 500 K and 300 K and absorbs 4000 J per cycle — find its efficiency, the heat rejected and the work done.
20. Distinguish between isothermal and adiabatic processes with a p - V illustration and the equations of state of each, and explain why the adiabatic curve is steeper.

Answer Key (Marking Scheme)

- Q1 — (A) temperature. Q2 — (A) PV^γ is constant. Q3 — (A) isochoric. Q4 — (A) $nRT \ln(V_2/V_1)$.
 Q5 — (A) $C_P - C_V = R$. Q6 — (A) $7/5$. Q7 — (A) at constant pressure the gas does external work. Q8 — (A) $3R/2$.
 Q9 — $\Delta U = 0$ for an ideal gas in an isothermal process (U depends only on T).
 Q10 — $\Delta U = Q - W$: the change in internal energy equals the heat supplied minus the work done by the system.
 Q11 — $\Delta U = Q - W = 1000 - 600 = 400 \text{ J}$.
 Q12 — $\eta = 1 - T_2/T_1 = 1 - 300/400 = 25\%$.

Q13 — $W_{\text{by gas}} = P\Delta V = 2 \times 10^5 \times (2 - 4) = -4 \times 10^5 \text{ J}$; work done ON the gas = $+4 \times 10^5 \text{ J}$.

Q14 — $\eta = W/Q_1 = (1000 - 600)/1000 = 40\%$.

Q15 — $\Delta U = 400 - 250 = 150 \text{ J}$; second case $\Delta U = 600 - 400 = 200 \text{ J}$.

Q16 — $W = 1 \times 8.31 \times 300 \times \ln 3 \approx 2.74 \times 10^3 \text{ J}$; $\Delta U = 0$ $\Rightarrow W \approx 2.74 \times 10^3 \text{ J}$.

Q17 — $\Delta U = (3/2)nR\Delta T = 1.5 \times 2 \times 8.31 \times 100 \approx 2.49 \times 10^3 \text{ J}$.

Q18 — $Q = nC_P\Delta T = 3 \times (7R/2) \times 100 = 3 \times 29.1 \times 100 \approx 8.73 \times 10^3 \text{ J}$.

Q19 — A heat engine cannot convert all heat into work (Kelvin–Planck). $\eta = 1 - 300/500 = 40\%$; $Q_2 = 4000 \times 300/500 = 2400 \text{ J}$; $W = 4000 - 2400 = 1600 \text{ J}$.

Q20 — Isothermal: $PV = \text{constant}$; temperature constant, slow expansion. Adiabatic: $PV^\gamma = \text{constant}$; no heat exchange, so the curve falls more steeply for the same volume change.