

How to use this worksheet. Thirty questions, about 35 minutes, with the answer key at the end. Identify which quantity is held constant first. Check dimensions on formula questions — nR times a volume is not an energy.

Formula sheet

First law: $\Delta Q = \Delta U + \Delta W$ | $W = \int P dV = \text{area under the P-V curve}$

Isothermal: $\Delta U = 0$, $Q = W$ | **Adiabatic:** $Q = 0$, PV^γ constant | **Isobaric:** $W = P\Delta V = nR\Delta T$ |

Isochoric: $W = 0$

$C_p - C_v = R$ | $\gamma = C_p/C_v$ | **Carnot $\eta = 1 - T_2/T_1$ (kelvin)**

Section A · Level 1 — The laws and the four standard processes

Ten questions. None should take more than twenty seconds.

- The first law of thermodynamics is a statement of the conservation of:
(1) Momentum (2) Energy (3) Mass (4) Charge
- In an isothermal process, the change in internal energy of an ideal gas is:
(1) Maximum (2) Zero (3) Equal to the work done (4) Negative
- In an adiabatic process, the heat exchanged with the surroundings is:
(1) Maximum (2) Zero (3) Equal to the work done (4) Equal to the internal energy
- In an isochoric process, the work done by the gas is:
(1) $P\Delta V$ (2) Zero (3) $nR\Delta T$ (4) Maximum
- The work done by a gas at constant pressure is:
(1) $P / \Delta V$ (2) $P\Delta V$ (3) $\Delta V / P$ (4) $P^2\Delta V$
- For an ideal gas, $C_p - C_v$ equals:
(1) Zero (2) R (3) γ (4) $2R$
- The ratio C_p/C_v is denoted by:
(1) R (2) γ (3) η (4) μ
- The efficiency of a Carnot engine depends only on:
(1) The working substance (2) The temperatures of the source and sink (3) The pressure (4) The volume of the gas
- The work done in a complete cyclic process equals:
(1) Zero always (2) The area enclosed by the cycle on a P-V diagram (3) The internal energy change (4) The heat absorbed only
- The second law of thermodynamics implies that no engine can:
(1) Do any work (2) Convert all the absorbed heat into work (3) Have an efficiency above zero (4) Operate in a cycle

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — First law calculations and engine efficiency

Ten questions. Convert all temperatures to kelvin before dividing.

- A gas absorbs 500 J of heat and does 200 J of work. Its internal energy changes by:
(1) 700 J (2) 300 J (3) -300 J (4) 200 J

- 12.** A gas at constant pressure of 100 Pa expands from 2 m³ to 5 m³. The work done by the gas is:
(1) 100 J (2) 300 J (3) 500 J (4) 700 J
- 13.** A Carnot engine operates between 500 K and 300 K. Its efficiency is:
(1) 20% (2) 40% (3) 60% (4) 80%
- 14.** A Carnot engine has a source at 600 K and a sink at 300 K. Its efficiency is:
(1) 25% (2) 50% (3) 60% (4) 75%
- 15.** An engine absorbs 800 J and delivers 200 J of useful work. Its efficiency is:
(1) 20% (2) 25% (3) 40% (4) 75%
- 16.** For a monatomic ideal gas, the value of γ is:
(1) 1.4 (2) 1.67 (3) 1.33 (4) 1.0
- 17.** In an isothermal expansion of an ideal gas, the heat supplied is:
(1) Zero (2) Equal to the work done by the gas (3) Equal to the internal energy change (4) Negative
- 18.** During an adiabatic expansion, the temperature of a gas:
(1) Rises (2) Falls (3) Stays constant (4) Becomes zero
- 19.** Which of the following is an example of an approximately adiabatic process?
(1) Slow compression of a gas in a conducting cylinder (2) Sudden bursting of a tyre (3) Boiling water at constant temperature (4) Heating a gas at constant volume
- 20.** On a P-V diagram, an isochoric process appears as:
(1) A horizontal line (2) A vertical line (3) A curve (4) A closed loop

Working space — Questions 11 to 20 *Write the formula before you substitute.*

Section C · Level 3 — Reversibility, entropy and P-V behaviour

Eight questions. Ask which quantity is held constant in each process.

- 21.** Two bodies in thermal equilibrium with a third are in equilibrium with each other. This is:
(1) The first law (2) The second law (3) The zeroth law (4) The third law
- 22.** For the same rise in temperature, the heat required at constant pressure is greater than at constant volume because:
(1) The gas is denser (2) Extra heat is needed for the work of expansion (3) The pressure changes (4) The mass increases
- 23.** An adiabatic curve on a P-V diagram is:
(1) Flatter than an isothermal curve (2) Steeper than an isothermal curve (3) Identical to an isothermal curve (4) A straight line
- 24.** The efficiency of a Carnot engine can be 100% only if the sink temperature is:
(1) Equal to the source temperature (2) Absolute zero (3) 300 K (4) Infinite
- 25.** A refrigerator works by:
(1) Destroying heat (2) Transferring heat from a colder to a hotter body using external work (3) Converting heat entirely into work (4) Lowering the entropy of the universe
- 26.** In a cyclic process, the change in internal energy over one complete cycle is:
(1) Positive (2) Negative (3) Zero (4) Equal to the work done
- 27.** Entropy of an isolated system in any spontaneous process:
(1) Decreases (2) Increases or stays the same (3) Stays constant always (4) Becomes zero

28. A process that can be exactly reversed with no net change to the system or surroundings is called:

- (1) Isothermal (2) Adiabatic (3) Reversible (4) Cyclic

Working space — Questions 21 to 28 Write the formula before you substitute.

Section D · Previous year questions — Straight from the AAI ATC papers

Two questions from the 2023 evening paper, recovered by optical character recognition of the scanned answer sheets and independently checked.

29. Suppose n moles of an ideal gas go isobarically, at pressure P , from an initial state (T_1, V_1) to a final state (T_2, V_2) . The work done during the process is (R = gas constant): **[PYQ 2023 · Evening]**

- (1) $W = nR(V_2 - V_1)$ (2) $W = nR(V_1 - V_2)$ (3) $W = nRP(T_2 - T_1)$ (4) $W = nR(T_2 - T_1)$

30. Identify the option that arranges the following in chronological order for the Carnot cycle. A. Isothermal expansion B. Isothermal compression C. Adiabatic expansion D. Adiabatic compression **[PYQ 2023 · Evening]**

- (1) A, C, B, D (2) A, D, C, B (3) B, C, D, A (4) A, B, C, D

Working space — Questions 29 to 30 Write the formula before you substitute.

Answer key

Check only after you have attempted every question. Full worked solutions for each one are on the worksheet page at aviatelearnings.com.

1. (2)	7. (2)	13. (2)	19. (2)	25. (2)
2. (2)	8. (2)	14. (2)	20. (2)	26. (3)
3. (2)	9. (2)	15. (2)	21. (3)	27. (2)
4. (2)	10. (2)	16. (2)	22. (2)	28. (3)
5. (2)	11. (2)	17. (2)	23. (2)	29. (4)
6. (2)	12. (2)	18. (2)	24. (2)	30. (1)

Stuck on any of these? Bring them to a live class.

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