

THERMO DYNAMICS

NEET PHYSICS ESSENTIALS

CONCEPT SUMMARY

KEY CONCEPTS | FORMULAS | RECOGNITION CUES
MISCONCEPTIONS | EXAM TRAPS | QUICK CHECKS



UNDERSTAND
THE PHYSICS



RECOGNIZE
THE PATTERN



SOLVE WITH
CONFIDENCE

**SAME PHYSICS.
A HIGHER SCORE.**

1. Chapter Introduction

Thermodynamics studies heat, work, internal energy, and the direction and limits of energy conversion. For a question, identify the system, determine what changes and what stays fixed, then select a relation whose conditions match the process.

2. Chapter in One View

Central idea: The First Law accounts for energy transfer; the Second Law sets limits on the direction of natural processes and on converting heat into work.

- Choose the system and boundary.
- Identify the state variables P , V and T , and whether the gas is treated as ideal.
- Set the sign convention: $Q > 0$ into the system; $W > 0$ when work is done by the gas.
- Recognize the process: constant V , constant P , constant T , no heat transfer, a cycle, or free expansion.
- Choose the work relation from the actual pressure/path condition.
- Use the First Law to connect Q , ΔU and W .
- For heating, select C_v or C_p according to the process and the ideal-gas model; for devices, identify the useful output and work input. For degrees of freedom, distinguish linear from non-linear molecules.

3. Must-Know Concepts

- System, surroundings and boundary: the system is the part selected for study; the boundary separates it from its surroundings.
- Open system: matter and energy may cross the boundary. Closed system: matter does not cross, but energy may. Isolated system: neither matter nor energy crosses.
- Temperature and thermal equilibrium: bodies in thermal equilibrium have the same temperature and no net heat transfer between them.
- Zeroth Law: if A and B are each in thermal equilibrium with C, they are in thermal equilibrium with each other. This supports temperature measurement.
- Internal energy U : microscopic energy of a system. For a fixed amount of ideal gas, ΔU depends only on ΔT .
- Heat Q and work W are energy-transfer modes, not properties stored in the system.
- Sign convention in this summary: $Q > 0$ when heat enters; $W > 0$ when work is done by the gas; $\Delta U = Q - W$.
- First Law: $Q = \Delta U + W$, for the stated convention and when macroscopic kinetic/potential-energy changes are neglected.
- Isochoric: volume constant. Isobaric: pressure constant. Isothermal: temperature constant. Adiabatic: no heat transfer.
- Cyclic process: final state equals initial state, so ΔU over a complete cycle is zero; net work need not be zero.

- Free expansion into vacuum: external pressure is zero, so boundary work is zero. If insulated, $Q = 0$ too; for an ideal gas, $\Delta U = 0$ and $\Delta T = 0$.
- Heat capacity is defined for a specified process. For gases, C_v and C_p are different; the molar values apply per mole.
- Degrees of freedom describe independent ways molecules store energy. The classical equipartition results apply only to active degrees of freedom in the assumed model. For the usual NEET model, neglect vibrational modes unless the question says otherwise.
- Second Law: it determines the natural direction of processes and limits heat-to-work conversion.
- Reversible process: idealized change that can be reversed with system and surroundings restored without net change. Real friction, free expansion and heat flow across a finite temperature difference are irreversible.
- Heat engine: absorbs heat from a hot reservoir, produces work and rejects some heat to a colder reservoir.
- Refrigerator: uses work to remove heat from a cold space. Heat pump: uses work to deliver heat to a warm space.
- Carnot device: ideal reversible device between two reservoirs; it gives the limiting performance for those reservoir temperatures.

4. Formula + Meaning

Use the sign convention $Q > 0$ for heat entering the gas and $W > 0$ for work done by the gas. With this convention, $\Delta U = Q - W$.

Ideal-gas equation: $PV = nRT$

Meaning: Connects pressure, volume, amount of gas and absolute temperature.

Use when: The gas can be modelled as ideal and a state variable is unknown.

Condition: Use T in kelvin and consistent units.

Do not use blindly when: When non-ideal effects are important.

Exam trap: Celsius temperature cannot be substituted directly.

First Law: $Q = \Delta U + W$

Meaning: Heat supplied is divided between the change in internal energy and work done by the gas.

Use when: Two of Q, ΔU and W are known or one is required.

Condition: Use the sign convention above; assume macroscopic kinetic/potential-energy changes are negligible.

Do not use blindly when: If the question uses work done on the gas as positive, convert signs first.

Exam trap: Expansion work is positive; compression work is negative in this convention.

Work at constant external pressure: $W = P_{\text{ext}} (V_2 - V_1)$

Meaning: Boundary work against a constant external pressure.

Use when: The external pressure remains constant during the volume change.

Condition: Use P in pascals and V in cubic metres for work in joules.

Do not use blindly when: When the external pressure varies or when gas pressure is substituted without justification.

Exam trap: Constant external pressure is not automatically the same as constant gas pressure.

Quasi-static work: $W = \int P \, dV$

Meaning: Work is the signed area under the P – V path.

Use when: Pressure is known along a quasi-static path as a function of volume.

Condition: The path must consist of equilibrium states; expansion gives positive work.

Do not use blindly when: For a strongly irreversible process when no meaningful equilibrium P – V path is specified.

Exam trap: A cycle's net work is the signed area enclosed by the loop.

Reversible isothermal ideal-gas work: $W = nRT \ln(V_2/V_1)$

Meaning: Work done by an ideal gas during a reversible constant-temperature volume change.

Use when: The gas is ideal and the isothermal process is reversible.

Condition: T must be in kelvin; $\ln$ is the natural logarithm.

Do not use blindly when: For an irreversible isothermal process or a non-ideal gas without a suitable model.

Exam trap: Expansion gives $W > 0$; compression gives $W < 0$.

Ideal-gas internal-energy change: $\Delta U = nC_V\Delta T$

Meaning: For a fixed amount of ideal gas, internal-energy change depends on temperature change.

Use when: A fixed amount of ideal gas undergoes a temperature change.

Condition: C_V is molar heat capacity at constant volume; use consistent units.

Do not use blindly when: For a non-ideal gas without an appropriate internal-energy model.

Exam trap: If an ideal gas has $\Delta T = 0$, then $\Delta U = 0$.

Monatomic ideal gas: $U = \left(\frac{3}{2}\right)nRT$; $\Delta U = \left(\frac{3}{2}\right)nR\Delta T$

Meaning: Gives internal energy and its change for a monatomic ideal gas.

Use when: The gas is ideal and monatomic.

Condition: Use absolute temperature.

Do not use blindly when: For a diatomic or polyatomic gas using a different active-degree-of-freedom model.

Exam trap: Do not use the monatomic expression for every ideal gas.

Isochoric ideal-gas heating: $W = 0$; $Q = \Delta U = nC_V\Delta T$

Meaning: At constant volume, there is no boundary work; supplied heat changes internal energy.

Use when: A fixed amount of ideal gas is heated or cooled at constant volume.

Condition: C_V is molar heat capacity at constant volume.

Do not use blindly when: If volume changes or other forms of work are relevant.

Exam trap: Rigid container means zero boundary work, not necessarily zero heat.

Isobaric ideal-gas heating: $W = P\Delta V$; $Q = nC_p\Delta T$

Meaning: At constant pressure, heat changes internal energy and provides expansion work.

Use when: A fixed amount of ideal gas undergoes a quasi-static constant-pressure temperature change.

Condition: C_p is molar heat capacity at constant pressure.

Do not use blindly when: If pressure is not constant or the process is not represented by the stated ideal-gas model.

Exam trap: C_p is not interchangeable with C_v .

Reversible adiabatic ideal-gas relations:

$PV^\gamma = \text{constant}$; $TV^{(\gamma-1)} = \text{constant}$; $TP^{(1-\gamma)} = \text{constant}$

Meaning: Connects equilibrium states for a reversible adiabatic change of an ideal gas.

Use when: The process is adiabatic and reversible, with ideal-gas behaviour.

Condition: $\gamma = C_p/C_v$ is treated as constant for the process.

Do not use blindly when: For an irreversible adiabatic process or when the ideal-gas assumptions fail.

Exam trap: Adiabatic alone does not guarantee $PV^\gamma = \text{constant}$.

Reversible adiabatic work:

$$W = \frac{(P_1 V_1 - P_2 V_2)}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

Meaning: Work done by an ideal gas in a reversible adiabatic change.

Use when: Initial and final states are known and the reversible adiabatic ideal-gas model applies.

Condition: Use $W > 0$ for expansion and $\gamma > 1$.

Do not use blindly when: For an irreversible adiabatic process.

Exam trap: $Q = 0$, so $\Delta U = -W$.

Heat capacity: $C = dQ/dT$ for a specified process; if C is constant, $Q = C\Delta T$

Meaning: Measures heat needed per unit temperature change under the stated process condition.

Use when: Heat transfer and temperature change are related for a specified process.

Condition: If heat capacity varies, account for its variation; for gases distinguish C_v and C_p .

Do not use blindly when: Across phase changes or large temperature ranges without accounting for the relevant changes.

Exam trap: Heat capacity is process-dependent for a gas.

Specific heat capacity: $c = C/m$; **molar heat capacity:** $C_m = C/n$

Meaning: Expresses heat capacity per unit mass or per mole.

Use when: The required mass or mole basis is specified.

Condition: Use consistent units and the relevant process condition.

Do not use blindly when: Do not mix total, specific and molar heat capacities.

Mayer's relation: $C_{p,m} - C_{v,m} = R$

Meaning: For an ideal gas, molar heat capacity at constant pressure exceeds that at constant volume by R .

Use when: Molar heat capacities of an ideal gas are involved.

Condition: Use molar heat capacities.

Do not use blindly when: For arbitrary substances or specific heat capacities without unit conversion.

Exam trap: $C_p > C_v$ for an ideal gas.

Degrees of freedom (ideal gas):

$$C_v = \frac{f}{2}R; \quad C_p = \frac{f+2}{2}R; \quad \gamma = \frac{C_p}{C_v} = \frac{f+2}{f}$$

Meaning: Connects active degrees of freedom to ideal-gas heat capacities and their ratio.

Use when: The classical ideal-gas model and active degrees of freedom are specified (for standard NEET questions, vibrational modes are usually neglected unless stated).

Condition: Assumes the stated quadratic degrees of freedom are active; for the common NEET model, neglect vibrational modes unless the question specifies otherwise.

Do not use blindly when: When the active degrees of freedom are unknown or the model assumptions fail.

Exam trap: Monatomic: $f = 3$, $\gamma = 5/3$. Rigid diatomic or linear molecule with vibration neglected: $f = 5$, $\gamma = 7/5$. Non-linear molecule with vibration neglected: $f = 6$, $\gamma = 4/3$.

Heat-engine energy balance: $W = Q_H - Q_C$

Meaning: Over a complete cycle, absorbed heat minus rejected heat equals work output.

Use when: A cyclic heat engine absorbs Q_H and rejects Q_C .

Condition: Q_H and Q_C are positive magnitudes.

Do not use blindly when: For refrigerator or heat-pump sign/purpose without redefining the useful output.

Exam trap: The engine must reject some heat; it cannot convert all absorbed heat into work.

Heat-engine efficiency: $\eta = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$

Meaning: Fraction of absorbed heat converted into work output.

Use when: Heat input, heat rejected or work output of a cyclic engine is known.

Condition: Use heat magnitudes and a complete cycle.

Do not use blindly when: For refrigerator or heat-pump performance.

Exam trap: A real engine has efficiency below 100%.

Carnot efficiency: $\eta_C = 1 - \frac{T_C}{T_H}$

Meaning: Maximum possible heat-engine efficiency between two fixed reservoir temperatures.

Use when: A reversible Carnot engine operates between hot and cold reservoirs.

Condition: T_H and T_C must be in kelvin, with $T_H > T_C$.

Do not use blindly when: As an exact efficiency for an arbitrary real engine.

Exam trap: Use absolute temperature, not Celsius.

Refrigerator COP: $\text{COP}_R = \frac{Q_C}{W}$; **heat-pump COP:** $\text{COP}_{HP} = \frac{Q_H}{W}$

Meaning: Measures the desired heat transfer per unit work supplied.

Use when: Work input and the useful heat transfer are known for a cyclic device.

Condition: Energy balance: $Q_H = Q_C + W$; COP is not an efficiency.

Do not use blindly when: Do not use heat-engine efficiency for these devices.

Exam trap: COP can exceed 1.

Carnot refrigerator and heat-pump limits:

$$\text{COP}_{R,C} = \frac{T_C}{T_H - T_C}; \text{COP}_{HP,C} = \frac{T_H}{T_H - T_C}$$

Meaning: Gives the ideal reversible COP between two reservoirs.

Use when: A reversible Carnot refrigerator or heat pump operates between fixed-temperature reservoirs.

Condition: Temperatures must be in kelvin.

Do not use blindly when: For real devices as exact performance values.

Exam trap: The heat-pump COP equals the refrigerator COP plus 1 for the same ideal reservoirs.

5. Formula Selection Guide

Situation	Think This Model	Use This Relation / Check
Gas state variables P, V, T, n	Ideal-gas state	$PV = nRT$; T in kelvin
Rigid container; volume fixed	Isochoric process	$W = 0$; $Q = \Delta U = nC_v\Delta T$ (ideal-gas heating)
Gas heated at constant pressure	Isobaric ideal gas	$W = P\Delta V$; $Q = nC_p\Delta T$
Temperature fixed for an ideal gas	Isothermal ideal gas	$\Delta U = 0$; $Q = W$; reversible work: $W = nRT \ln \left(\frac{V_2}{V_1} \right)$
No heat transfer	Adiabatic process	$Q = 0$; $\Delta U = -W$
Reversible adiabatic ideal-gas path	Adiabatic state relation	$PV^\gamma = \text{constant}$; check reversibility and ideal-gas assumptions
Gas against fixed external pressure	Constant external-pressure work	$W = P_{\text{ext}}\Delta V$
Pressure known along quasi-static path	P - V work	$W = \int P \, dV$; signed area under path

Situation	Think This Model	Use This Relation / Check
Gas expands into vacuum	Free expansion	$W = 0$; if insulated, $Q = 0$; ideal gas then $\Delta T = 0$
Initial state returns at end	Complete cycle	$\Delta U = 0$; $Q_{\text{net}} = W_{\text{net}}$
Degrees of freedom f specified	Classical ideal-gas model	$C_v = \frac{f}{2}R$; use active modes; distinguish linear/non-linear molecules
Heat engine absorbs and rejects heat	Cyclic heat engine	$W = Q_H - Q_C$; $\eta = \frac{W}{Q_H}$
Work input removes heat from cold space	Refrigerator	$\text{COP}_R = \frac{Q_C}{W}$
Work input supplies heat to warm space	Heat pump	$\text{COP}_{HP} = \frac{Q_H}{W}$
Reservoir temperatures and reversible engine	Carnot limit	$\eta_C = 1 - \frac{T_C}{T_H}$; use kelvin
Reservoir temperatures and reversible fridge/heat pump	Carnot COP limit	$\text{COP}_{R,C} = \frac{T_C}{T_H - T_C}$; $\text{COP}_{HP,C} = \frac{T_H}{T_H - T_C}$

Degrees-of-freedom model check (vibration neglected):

monatomic $f = 3$; diatomic/linear molecule $f = 5$; non-linear molecule $f = 6$. Therefore $\gamma = 5/3, 7/5$ and $4/3$, respectively.

6. When to Use / When Not to Use**Work relations**

- Use $W = P_{\text{ext}}\Delta V$ only when external pressure remains constant.
- Use $W = \int P \, dV$ when a quasi-static P – V path is known.
- Use $W = nRT \ln \left(\frac{V_2}{V_1} \right)$ only for a reversible isothermal ideal-gas process.
- Do not confuse constant external pressure with constant gas pressure.

Adiabatic vs isothermal

- Adiabatic means $Q = 0$; temperature can change.
- Isothermal means temperature is constant; for an ideal gas, $\Delta U = 0$, but heat transfer can be non-zero.
- $PV^\gamma = \text{constant}$ requires a reversible adiabatic ideal-gas process with γ treated as constant.

Heat capacities

- Use C_v for ideal-gas heating at constant volume and C_p for ideal-gas heating at constant pressure.
- $C_p - C_v = R$ is a molar ideal-gas relation; do not apply it directly to arbitrary substances.

- Degrees-of-freedom formulas rely on the assumed classical model and active modes. Do not group linear CO_2 and non-linear H_2O into the same f -value row when vibration is neglected.

Engines, refrigerators and heat pumps

- Use efficiency for work output divided by heat absorbed by an engine.
- Use COP for the desired heat transfer divided by work input.
- Use Carnot formulas only for reversible limits and use kelvin.

Second Law: two exam statements

- Kelvin–Planck: no cyclic engine can absorb heat from a single reservoir and convert all of it into work.
- Clausius: heat cannot be transferred from a colder body to a hotter body as the sole effect of a cyclic device without work input.
- For the same reservoirs, no real engine exceeds Carnot efficiency; no real refrigerator or heat pump exceeds the corresponding Carnot COP.

7. Common Misconceptions

- A body contains internal energy, not “heat.” Heat is energy transferred because of a temperature difference.
- Closed system does not mean isolated system; heat and work may cross a closed-system boundary.
- Adiabatic does not mean constant temperature; isothermal does not mean zero heat transfer.

- Same temperature does not imply the same total internal energy for different amounts or models of gas.
- At constant volume, boundary work is zero; at constant pressure, expansion work may be non-zero.
- Free expansion into vacuum has zero boundary work, but temperature remains unchanged only for an insulated ideal gas under the stated assumptions.
- A refrigerator and heat pump require work input; their COP is not engine efficiency.

8. Exam Traps

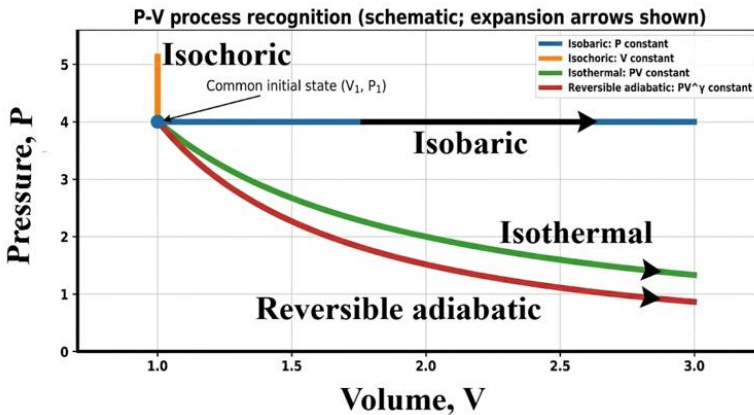
- Writing the First Law before fixing the sign convention.
- Using gas pressure instead of external pressure in irreversible boundary work.
- Applying $W = P\Delta V$ when the relevant pressure is not constant.
- Using the isothermal logarithmic work formula for an irreversible process.
- Applying $PV^\gamma = \text{constant}$ to every adiabatic process.
- Treating $Q = 0$ as a consequence of constant temperature.
- Forgetting $\Delta U = 0$ over a complete cycle.
- Using Celsius in $PV = nRT$ or Carnot relations.
- Using C_v instead of C_p for constant-pressure ideal-gas heating, or mixing molar and specific heat capacities.
- Assuming free expansion always leaves the temperature unchanged.
- Confusing engine efficiency with refrigerator or heat-pump COP.

9. See This → Think This

- Sealed gas container is heated → Closed system; energy can enter, matter does not.
- Two bodies reach thermal equilibrium → Same temperature; no net heat transfer between them.
- Rigid vessel → Constant volume; $W = 0$.
- Piston against a fixed load → Check whether external pressure is constant.
- Temperature remains constant for an ideal gas → Isothermal; $\Delta U = 0$.
- Insulated system → Often modelled as adiabatic; check that no heat crosses the boundary.
- Reversible adiabatic ideal-gas process → $PV^\gamma = \text{constant}$.
- Gas expands into vacuum → Boundary work is zero.
- Returns to the initial state → Complete cycle; $\Delta U = 0$.
- Engine between hot and cold reservoirs → Track Q_H , Q_C and W .
- Work input moves heat from cold to hot → Refrigerator or heat pump; calculate COP.
- Two reservoir temperatures for an ideal reversible engine → Carnot efficiency; use kelvin.

10. Key Diagrams / Graphs

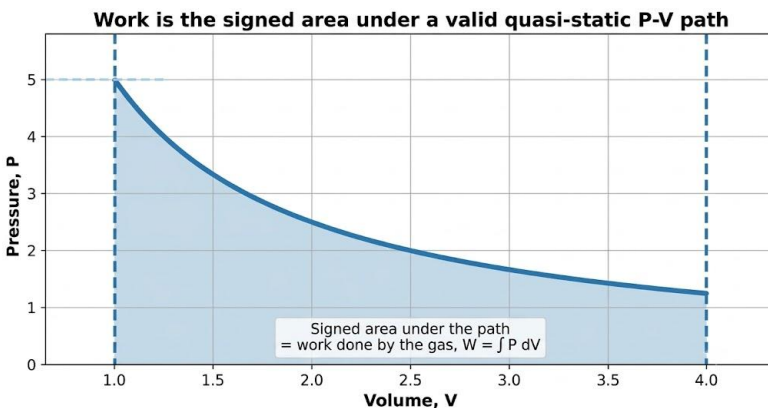
P–V process paths



Notice: The curves are schematic and share an initial state. The reversible adiabatic curve is steeper than the isothermal curve for a comparable ideal-gas expansion.

Exam use: The signed area under a valid quasi-static P–V path gives work. Constant volume gives zero boundary work; a complete cycle gives net signed area enclosed.

Work graph: area under a path

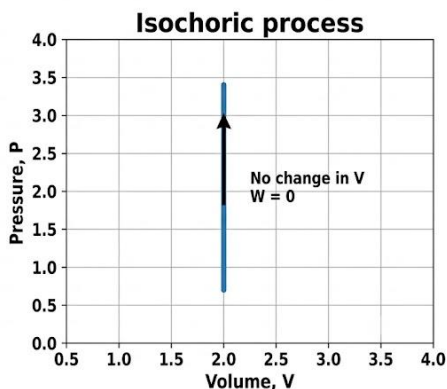
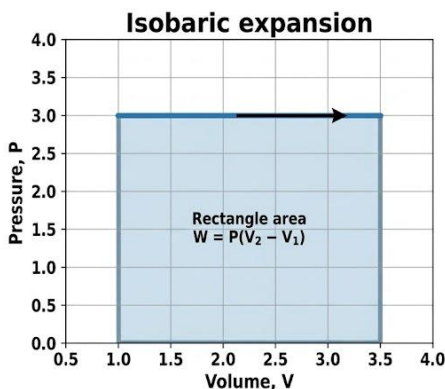


Notice: The area is signed. Expansion ($V_2 > V_1$) gives positive work by the gas; compression gives negative work under this chapter's sign convention.

Exam use: Read the path first, then identify the pressure function.
Do not treat the area as ΔU ; it represents work.

Constant-pressure and constant-volume work

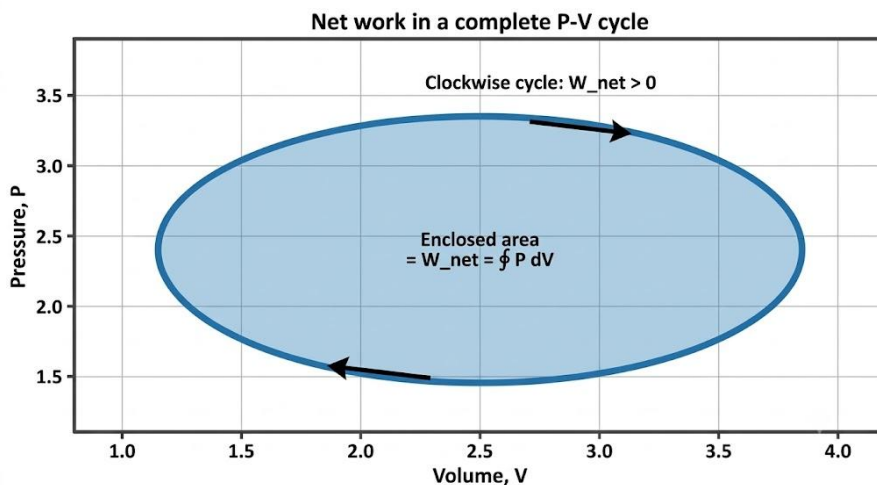
How the P-V graph gives boundary work



Notice: For an isobaric path, the rectangular area is $P(V_2 - V_1)$.
For an isochoric path, $dV = 0$ throughout, so boundary work is zero.

Exam use: Constant volume means zero boundary work, not zero heat transfer or zero change in internal energy.

Work in a complete cycle



Notice: The net work is the signed area enclosed by the loop.

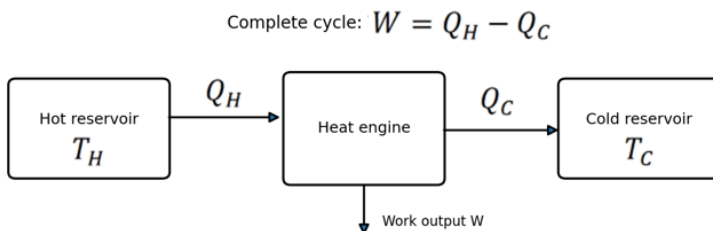
With W positive for work done by the gas, a clockwise cycle has positive net work; an anticlockwise cycle has negative net work.

Exam use: Over a complete cycle, $\Delta U = 0$, so $Q_{\text{net}} = W_{\text{net}}$. The heat-engine energy-flow diagram below is a separate energy-balance picture, not a P – V work graph.

Process	What is fixed?	P – v cue	Key result
Isochoric	V	Vertical line	$W = 0$
Isobaric	P	Horizontal line	$W = P\Delta V$ for quasi-static constant pressure
Isothermal ideal gas	T	Curved path	$\Delta U = 0$

Adiabatic	$Q = 0$	Curved path	$\Delta U = -W$
Cyclic	Initial state = final state	Closed loop	$\Delta U = 0$; $Q_{\text{net}} = W_{\text{net}}$

Heat engine and reservoirs



Notice: Q_H enters from the hot reservoir; the engine delivers work W and rejects Q_C to the cold reservoir.

Exam use: For a complete cycle, $W = Q_H - Q_C$ and $\eta = W/Q_H$.

11. Quick Checks

- Q: Does a closed system exchange energy? → Yes, as heat and/or work may cross its boundary.
- Q: What does the Zeroth Law support? → Temperature comparison and thermometer use.
- Q: At constant volume, what is boundary work? → Zero.
- Q: For an ideal gas in an isothermal process, what is ΔU ? → Zero.
- Q: In an adiabatic process, what is Q ? → Zero.
- Q: When is $PV^\gamma = \text{constant}$ valid? → Reversible adiabatic ideal-gas process with γ treated as constant.

- Q: Over a complete cycle, what is ΔU ? $\rightarrow$ Zero.
- Q: In free expansion into vacuum, what is boundary work? $\rightarrow$ Zero.
- Q: For an ideal gas, which is larger, C_p or C_v ? $\rightarrow C_p$.
- Q: What is the maximum engine efficiency between two reservoir temperatures? $\rightarrow$ Carnot efficiency.
- Q: Can refrigerator COP exceed 1? $\rightarrow$ Yes.
- Q: Which temperature scale is used in Carnot relations? $\rightarrow$ Kelvin.

12. Mini Exam Reasoning

Clue: A gas absorbs 500 J of heat and does 200 J of work. $\rightarrow$

Situation: First Law for a closed system. $\rightarrow$ Relation: $\Delta U = Q - W$
 $= 500 - 200 = 300$ J. $\rightarrow$ Check: Internal energy increases.

Clue: An ideal gas expands isothermally. $\rightarrow$ Situation: Constant temperature. $\rightarrow$ Model: Ideal gas. $\rightarrow$ Relation: $\Delta U = 0$, so $Q = W$.
 $\rightarrow$ Check: Heat absorbed can become work even though temperature does not change.

Clue: An insulated gas expands and does 120 J of work. $\rightarrow$
 Situation: Adiabatic. $\rightarrow$ Relation: $\Delta U = -W = -120$ J. $\rightarrow$ Check:
 Internal energy decreases.

Clue: A reversible engine operates between 600 K and 300 K. $\rightarrow$
 Model: Carnot limit. $\rightarrow$ Relation: $\eta_c = 1 - 300/600 = 0.50$. $\rightarrow$
 Check: Maximum efficiency is 50%.

Clue: A refrigerator removes 300 J of heat while receiving 100 J of work. $\rightarrow \text{COP}_R = 300/100 = 3$. $\rightarrow$ Energy balance: $Q_H = Q_C + W = 400 \text{ J}$. (COP_R : Coefficient of Performance of a Refrigerator.)

13. One-Minute Recall

- Choose the system and boundary first.
- Heat Q and work W are energy transfers; internal energy U is a property.
- First Law: $Q = \Delta U + W$, with W positive for work done by the gas.
- Ideal gas: ΔU depends only on temperature change.
- Isochoric: $W = 0$; $Q = nC_V\Delta T$ for ideal-gas heating.
- Isobaric ideal gas: $W = P\Delta V$; $Q = nC_P\Delta T$.
- Isothermal ideal gas: $\Delta U = 0$; $Q = W$.
- Adiabatic: $Q = 0$; $\Delta U = -W$.
- Reversible adiabatic ideal gas: $PV^\gamma = \text{constant}$.
- Cycle: $\Delta U = 0$; $Q_{\text{net}} = W_{\text{net}}$.
- P – V area: signed work along a valid quasi-static path.
- Mayer's relation: $C_p - C_v = R$ for an ideal gas on a molar basis.
- Heat engine: $\eta = W/Q_H$; some heat must be rejected.
- Refrigerator/heat pump: work input; use COP .
- Carnot relations: use kelvin and interpret them as reversible limits.

Want to Go Deeper?

The complete NEET Physics Essentials Concept Book develops concepts step by step with detailed diagrams, microquestions

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