AP Physics 2 Thermodynamics Review Sheet (With Formulas)

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1. Thermodynamic Systems

- **Open System**
  Exchanges both energy and matter with the surroundings.
  Example: Boiling pot of water (heat and steam escape).

- **Closed System**
  Exchanges only energy, not matter.
  Example: Gas inside a sealed piston.

- **Isolated System**
  No exchange of energy or matter.
  Example: A Thermos bottle with a lid.

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2. Laws of Thermodynamics

- **Zeroth Law of Thermodynamics**
  If A is in thermal equilibrium with B, and B with C, then A and C are in thermal equilibrium.
  Used to define temperature.

- **First Law of Thermodynamics (Energy Conservation)**

  $\Delta U = Q - W$

  - ΔU: Change in internal energy
  - Q: Heat added to the system
  - W: Work done **by** the system

- **Second Law of Thermodynamics (Entropy)**
  Total entropy of an isolated system always increases.
  Heat flows naturally from hot to cold.
- **Third Law of Thermodynamics**
  As temperature approaches absolute zero (0 K), entropy of a perfect crystal approaches zero.

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3. Heat Transfer and Specific Heat

- **Heat Transfer Formula**:

  $Q = mc\Delta T$

  - Q: Heat energy (Joules)
  - m: Mass (kg)
  - c: Specific heat capacity (J/kg·K)
  - ΔT: Temperature change (K or °C)
- **Heat Transfer Methods**:
  - **Conduction**: Heat by direct contact
  - **Convection**: Heat by fluid movement
  - **Radiation**: Heat by electromagnetic waves

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4. Ideal Gas Law

- **Equation**:

  $PV = nRT$

  - P: Pressure (Pa)
  - V: Volume (m^3)

- n: Moles of gas
- R: Ideal gas constant (8.31 J/mol·K)
- T: Temperature (Kelvin)

- **Application**: Used to describe how gases behave under different conditions of pressure, volume, and temperature.

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5. Work, Pressure, and Volume

- **Work Done by a Gas**:

  $W = P\Delta V$

  - W: Work (Joules)
  - P: Constant pressure (Pa)
  - ΔV: Change in volume (m^3)

Thermodynamic Processes:

Process	Constant	Work Done?	Heat Involved?	Formula Highlights
Isothermal	Temperature	Yes	Yes	$\Delta U = 0$, $Q = W$
Adiabatic	No heat (Q=0)	Yes	No	$\Delta U = -W$
Isobaric	Pressure	Yes	Yes	$Q = \Delta U + W$
Isochoric	Volume	No	Yes	$W = 0$, $Q = \Delta U$

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6. Pressure and Force

- **Pressure Formula**:

  $P = \frac{F}{A}$

- P: Pressure (Pa)
- F: Force (N)
- A: Area (m²)

- **Origin**: Caused by gas molecules colliding with container walls. Higher temperature = more collisions = more pressure.

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7. Entropy and Equilibrium

- **Entropy (S)**: A measure of disorder in a system.

$$\Delta S = \frac{Q_{rev}}{T}$$

- ΔS: Change in entropy
- Q_{rev}: Heat added reversibly
- T: Temperature (K)

- **Key Idea**:
  Natural processes tend to increase the total entropy of the universe.
  Example: Ice melting, gas spreading out.

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8. Heat Engine Efficiency

- **Efficiency Formula**:

$$\eta = 1 - \frac{T_C}{T_H}$$

- T_C: Temperature of cold reservoir (K)
- T_H: Temperature of hot reservoir (K)

- **Implication**: No engine is 100% efficient due to unavoidable entropy increases.

9. Key Units to Remember

Quantity	Unit	Symbol
Heat / Work / Energy	Joule	J
Pressure	Pascal	Pa
Temperature	Kelvin	K
Volume	Cubic meter	m^3
Force	Newton	N
Specific Heat	J/kg·K	c

Quick Recap: Must-Know Formulas

Concept	Formula
First Law	$\Delta U = Q - W$
Heat Transfer	$Q = mc\Delta T$
Ideal Gas Law	$PV = nRT$
Work by a Gas	$W = P\Delta V$
Pressure	$P = \frac{F}{A}$
Entropy Change	$\Delta S = \frac{Q_{rev}}{T}$
Efficiency of Engine	$\eta = 1 - \frac{T_C}{T_H}$