

Exercise walk-through

9.1

Thermodynamic systems and energy accounts

International Baccalaureate · IB Diploma · Physics · HL

9.1 Thermodynamic systems and energy accounts

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS internal energy • adiabatic

Objective

Thermodynamic systems and energy accounts. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

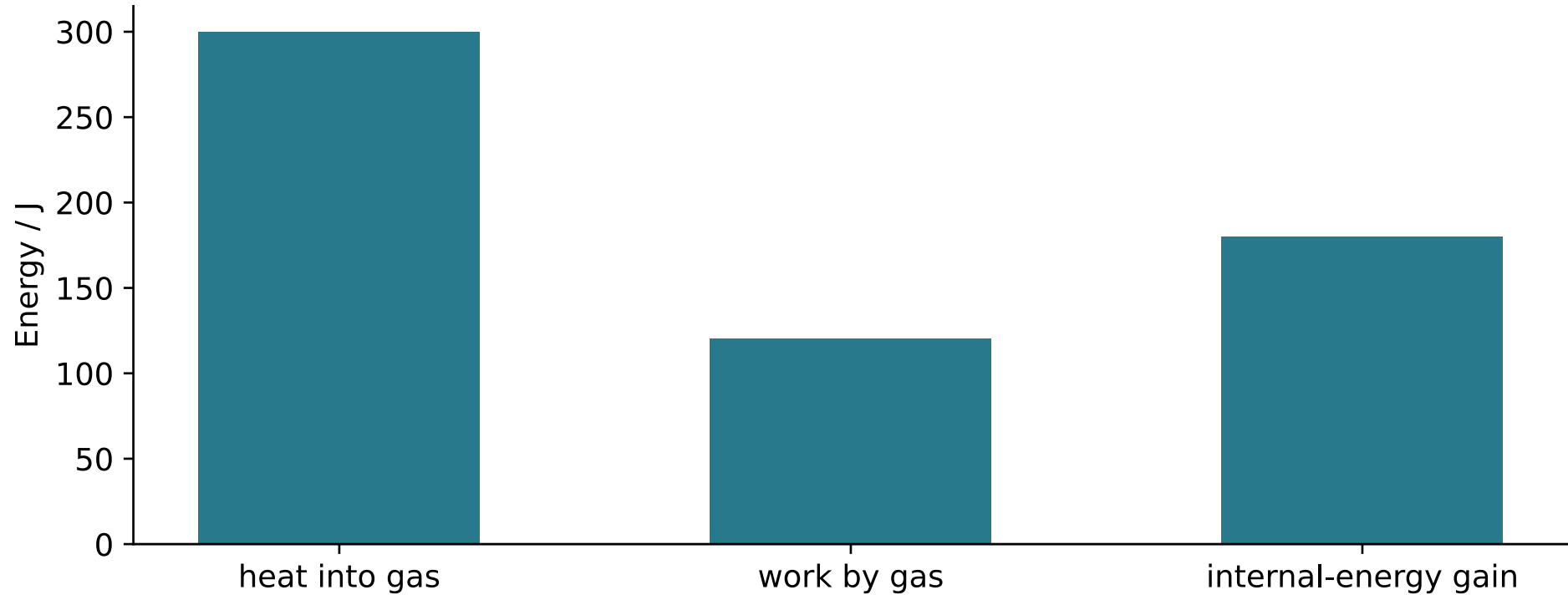
■ What would explain this observation?

- Compressing a gas can warm it even without a heater. Work is another path for energy transfer into the system.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- **Internal energy** is a property of the chosen system. Heat and work describe energy transfer across its boundary. For an ideal monatomic gas, internal energy depends on temperature and amount.

- **adiabatic** : A process with no heat transfer; internal energy: Total microscopic kinetic and potential energy of a system.



■ Choose evidence that can test it

- State a sign convention before using the first law. Here change in internal energy equals heat into the system minus work done by the system. Expansion work can reduce internal energy when no heat enters.
- Identify whether a process is isothermal, adiabatic or at constant volume. On a pressure-volume graph, area under the process curve gives work done by the gas. The path matters for work even when endpoints match.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions

fit this case, then rearrange before substitution.

- Known: gas gains 300 J by heating and does 120 J of work. With $\Delta U = Q - W$, $\Delta U = 300 - 120 = 180$ J. For adiabatic compression, $Q = 0$ and work done by the gas is negative, so ΔU is positive.

Example:

A gas gains 500 J of heat and does 200 J work. Find internal-energy change. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- Adiabatic does not mean constant temperature. Use the stated sign convention; some

courses write work done on the gas with the opposite sign.

- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

Every adiabatic process has constant temperature. This claim is false: Adiabatic does not mean constant temperature. Use the stated sign convention; some courses write work done on the gas with the opposite sign.

Key:

Thermodynamic systems and energy accounts: State a sign convention before using the first law. Here change in internal energy equals heat into the system minus work done

by the system. Expansion work can reduce internal energy when no heat enters.

Exercises 2.1·2.3

2.1 In this convention, what happens during adiabatic compression? Choose one answer.

- **A** Internal energy increases
- **B** Heat must enter
- **C** Work done by the gas is positive

[1]

2.2 A gas gains 500 J of heat and does 200 J work. Find internal-energy change. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: Every adiabatic process has constant temperature.

[2]

Exercises 2.1·2.3

2.1 In this convention, what happens during adiabatic compression? Choose one answer.

- **A** Internal energy increases
- **B** Heat must enter
- **C** Work done by the gas is positive

[1]

2.1 A State a sign convention before using the first law. Here change in internal energy equals heat into the system minus work done by the system. Expansion work can reduce internal energy when no heat enters.

2.2 A gas gains 500 J of heat and does 200 J work. Find internal-energy change. Show the relation, substitution and units.

[2]

2.2 With work done by gas positive, $\Delta U = Q - W = 500 - 200 = 300$ J.

2.3 Decide whether this claim is true and justify: Every adiabatic process has constant temperature.

[2]

2.3 False. Adiabatic does not mean constant temperature. Use the stated sign convention; some courses write work done on the gas with the opposite sign.

Exercises 2.4·3.1

2.4 A process with no heat transfer: write the technical term. [1]

3 Exam-style questions

3.1 A gas is compressed adiabatically by 150 J, then releases 40 J heat at fixed volume. Find total internal-energy change using work done by gas positive. [4]

Exercises 2.4·3.1

2.4 A process with no heat transfer: write the technical term. [1]

3 Exam-style questions

2.4 adiabatic. adiabatic means A process with no heat transfer.

3.1 A gas is compressed adiabatically by 150 J, then releases 40 J heat at fixed volume. Find total internal-energy change using work done by gas positive. [4]

3.1 Compression has $Q=0, W=-150$ J, giving +150 J. Cooling has $Q=-40$ J, $W=0$, giving -40 J. Total change = +110 J. Keep one sign convention throughout.