Grade 12 Physics, Explained

Unit 4 · First Law of Thermodynamics

HARDER PRACTICE QUESTIONS

Full marks 31

Write your answers on separate paper. Show your working. Take R = 8.31 J/(mol K).

1 Spot the error [3]

Find the mistake in the working and correct it.

Air at 47 °C expands adiabatically to three times its volume ($\gamma = 1.4$). Pratik finds its new temperature:

"$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 47 \times \left(\frac{1}{3}\right)^{0.4} = \mathbf{30}\ ^\circ\mathbf{C}$."

2 Read the cycle [4]

Answer from the data.

A gas goes round the cycle A → B → C → A. A is at (2.0 L, 1.0×10^5 Pa), B at (2.0 L, 3.0×10^5 Pa) and C at (5.0 L, 3.0×10^5 Pa); from C it returns to A along a straight line on the P–V diagram.

i. Sketch the cycle and name the processes A → B and B → C.
ii. Find the work done by the gas in each of the three steps.
iii. Find the net work in one cycle, and check it from the area of the loop.

3 Predict, then explain [3]

Write your prediction first, then explain it.

Two equal samples of the same ideal gas start in the same state. One expands isothermally to twice its volume, the other adiabatically to twice its volume.

i. Predict: which ends at the lower pressure?
ii. Which does more work? Explain with a P–V sketch.

4 Show that [3]

Show that when a monatomic ideal gas is heated at constant pressure, two fifths of the heat it takes in goes into work and three fifths into internal energy.

5 A real setting [4]

The numbers are made up.

A tyre holds 0.012 m^3 of air at 3.0×10^5 Pa (absolute) and 300 K. Parked in the sun, the air warms to 330 K; the tyre's volume hardly changes.

i. Find the new pressure.
ii. Find the number of moles of air in the tyre.
iii. Find how much the air's internal energy rose. (Air is a diatomic gas: $C_V = \frac{5}{2}R$.)

6 What if? [3]

A monatomic gas ($\gamma = 5/3$) and a diatomic gas ($\gamma = 1.4$), both at 300 K, are each compressed adiabatically to half their volume. Which ends hotter? Find both final temperatures.

7 Work backwards [2]

One mole of an ideal gas expands isothermally at 400 K and does 2000 J of work. By what factor did its volume grow?

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Riya wrote: “Heat is a state variable, like temperature: a gas in a given state contains a definite amount of heat. In an adiabatic process the temperature stays constant, because no heat goes in or out. And C_P is less than C_V, because at constant pressure the gas can expand freely.”

9 Think [3]

A gas in one half of an insulated, rigid box expands suddenly into the other half, which was empty, when a wall between them is broken. Use the first law to find the change in its internal energy. What happens to the temperature of an ideal gas? Is the process reversible?

10 Make your own [3]

Design a cycle made of two isobaric and two isochoric steps in which a gas does a net work of 500 J. Give the pressure and volume of its four corners, and say in which direction it must be traced.