AP PHYSICS 2 • EXERCISE SHEET

9.4 The First Law of Thermodynamics

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

Objective

Build the skills to answer exam questions on **the first law of thermodynamics**.

You must be able to:

- state the **first law of thermodynamics** 热力学第一定律 as $\Delta U = Q + W$
- analyse the **internal energy** 内能 change of a gas from the heat added and work done
- interpret **work** as the area under a curve on a pressure-volume (PV) diagram
- describe **isothermal**, **isobaric**, **isochoric**, and **adiabatic** processes

1 Worked examples

Study these first. Each one shows the method for a question type used later.

The first law

$\Delta U = Q + W$, where Q is the heat **added to** the gas and W is the work done **on** the gas. It is just conservation of energy for a gas.

Work on a PV diagram

The work is the **area** under the process curve. Compressing a gas (volume decreasing) does **positive** work on it.

Four processes

- **Isothermal** —constant temperature ($\Delta U = 0$).
- **Isobaric** —constant pressure.
- **Isochoric** —constant volume ($W = 0$).
- **Adiabatic** —no heat exchange ($Q = 0$).

2 Practice

2.1 State the first law of thermodynamics. [1]

2.2 A gas absorbs 500 J of heat while 200 J of work is done on it. Find the change in internal energy. [2]

2.3 State which of Q or W is zero in an isochoric (constant-volume) process, and why. [2]

3 Exam-style questions

3.1 In $\Delta U = Q + W$, the quantity Q is the [1]

- **A** work done
- **B** heat added
- **C** internal energy
- **D** temperature

3.2 An adiabatic process is one in which [1]

- **A** $Q = 0$
- **B** $W = 0$
- **C** $\Delta U = 0$
- **D** $\Delta T = 0$

3.3 A gas is compressed: 300 J of work is done on it while it releases 100 J of heat.

(a) Find the change in internal energy. [3]

(b) State whether its temperature rises or falls. [1]

4 Go further

- work through the **9.4 The First Law of Thermodynamics** lesson on the **Learn** page;
- read the **Thermodynamics** section of the AP Physics 2 handout on the **Know** page.

Solutions

2.1 the change in internal energy equals the heat added plus the work done on the gas, $\Delta U = Q + W$.

2.2 $\Delta U = Q + W = 500 + 200 = 700$ J.

2.3 $W = 0$ —no volume change means no work is done on or by the gas.

3.1 B.

3.2 A.

3.3 (a) $\Delta U = Q + W = (-100) + (+300) = +200$ J. (b) it rises ($\Delta U > 0$).