

16 Work and the first law – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word *three times*.

English

Write it 3 times (English)

work

first law of thermodynamics

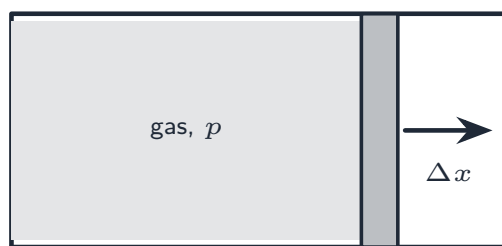
Recall

Internal energy can change when heat is added, or when **work** is done on or by the gas.

New ideas

Read these first. Each idea has a short worked example. Then do the Practice.

■ 1 Work done by a gas



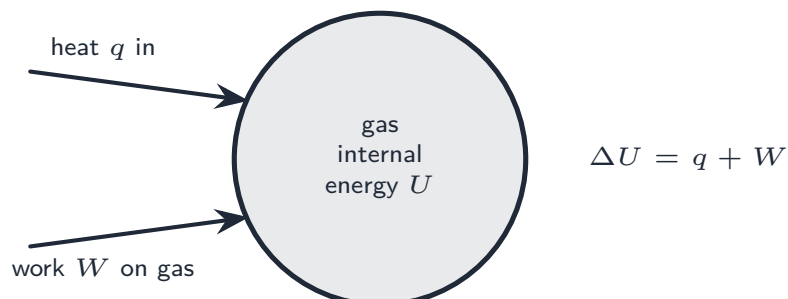
$$W = p \Delta V$$

When a gas expands against an outside pressure p by a small volume ΔV , it does work $W = p \Delta V$ on the surroundings.

Worked example. A gas at $p = 1.0 \times 10^5$ Pa expands by $\Delta V = 2.0 \times 10^{-3}$ m³:

$W = p \Delta V = (1.0 \times 10^5)(2.0 \times 10^{-3}) = 200 \text{ J}$ of work done on the surroundings.

■ 2 The first law



The **first law of thermodynamics** : $\Delta U = q + W$ – the change in internal energy equals the heat added plus the work done *on* the gas.

Worked example. 100 J of heat is added to a gas while it pushes a piston out, doing 30 J of work on the surroundings. Work done *on* the gas is $W = -30 \text{ J}$, so $\Delta U = q + W = 100 + (-30) = 70 \text{ J}$.

Watch out: in $\Delta U = q + W$, the symbol W is the work done *on* the gas. If the gas expands (doing work on the surroundings), W is *negative*.

Practice

Try these in order.

16.1 Write the work done when a gas changes volume at constant pressure. [1]

16.2 When a gas *expands*, does it do work on the surroundings or have work done on it? [1]

16.3 Write the *first law of thermodynamics*. [1]

16.4 Heat $q = 50 \text{ J}$ is added and $W = 20 \text{ J}$ of work is done on a gas. Find ΔU . [1]

16.5 A gas at 2.0×10^5 Pa expands by 1.5×10^{-3} m³. Find the work it does on the surroundings ($W = p \Delta V$). [2]

16.6 80 J of heat is added to a gas while it does 50 J of work on the surroundings. Find the change in internal energy, and explain the signs. [2]

16.7 Challenge. A gas is compressed quickly, so fast that no heat escapes ($q = 0$). Explain what happens to its internal energy and temperature. [2]