

16.1 Internal energy

Name: _____ Class: _____ Date: _____

Total: 21 marks

KEY WORDS internal energy 内能 • kinetic energy 动能 • temperature 温度 • ideal gas 理想气体
• thermodynamic temperature 热力学温度

Objective

Build the skills to answer exam questions on **internal energy**.

You must be able to:

- describe internal energy as the random **kinetic** + **potential** energy of molecules
- relate a **temperature** rise to an internal-energy rise
- use $U = \frac{3}{2}nRT$ for an ideal gas

1 Worked examples

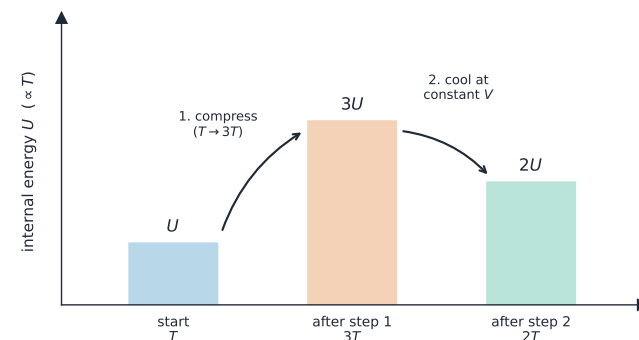
Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Internal energy

The **internal energy** U is the sum of the **random kinetic** energy and the **potential** energy of all the molecules:



= internal energy U



ideal gas: $U = \frac{3}{2}nRT$ • internal energy depends only on T

Internal energy rises with temperature

- U depends only on the **state** (T , p , V , amount) — not the path.
- For an **ideal gas**, intermolecular forces are ignored ($PE = 0$), so U is **all kinetic**: $U = \frac{3}{2}nRT$, directly proportional to T .
- Raising the temperature raises the molecules' KE, so raises U . During **boiling/melting**, U rises through **PE** (bonds breaking) at constant temperature.

2 Practice

Now apply the methods above.

2.1 State the **two** contributions to the internal energy of a substance. [2]

2.2 State what happens to a body's internal energy when its **temperature rises**. [1]

2.3 State why an **ideal gas** has zero molecular potential energy. [1]

2.4 Write the expression for the internal energy of an ideal gas. [1]

3 Exam-style questions

3.1 The internal energy of an **ideal gas** depends only on its: [1]

- A

B

C

D
- A pressure
B volume
C thermodynamic temperature
D mass

3.2 The thermodynamic temperature of an ideal gas is **doubled**. State what happens to its internal energy. [1]

3.3 Explain why a substance's internal energy **increases** during boiling, even though its **temperature** stays constant. [2]

3.4 Explain why the internal energy of a gas is **not** the same as the kinetic energy of the moving container it is in. [2]

3.5 A sealed cylinder contains an ideal gas at thermodynamic temperature T , with internal energy U . A piston compresses the gas, raising its temperature to $4T$, and work W is done on the gas during the compression. The gas is then cooled at **constant volume** until its temperature is $2T$.

(a) **State** what is meant by the internal energy of a system. [2]

(b) **Explain** why, for an **ideal gas**, the internal energy depends only on the thermodynamic temperature. [2]

(c) **Complete** the table, giving each entry in terms of some or all of W and U . [4]

process	work done on the gas	thermal energy supplied to the gas	increase in internal energy
compression to $4T$	W		
cooling to $2T$			

(d) **State and explain** what happens to the mean speed of the molecules during the cooling. [2]