16.1 Internal energy

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

Objective

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

You must be able to:

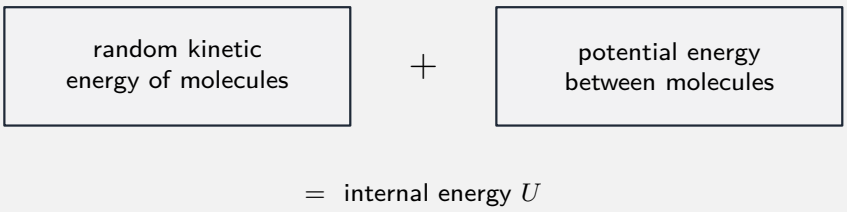
- describe internal energy as the random **kinetic + potential** energy of molecules
- relate a **temperature** rise to an internal-energy rise
- use $U = \frac{3}{2}nRT$ for an ideal gas

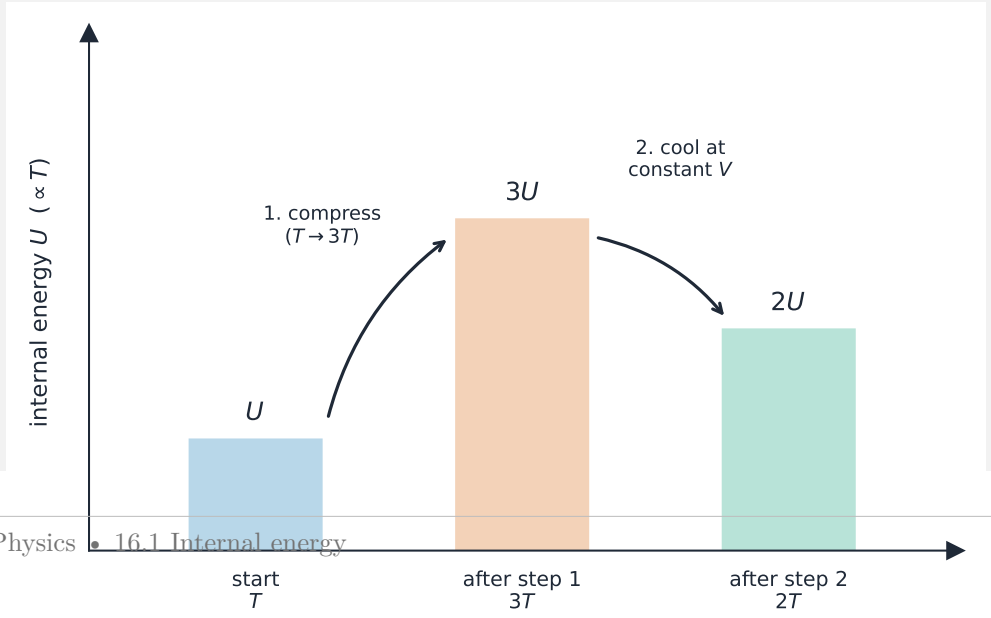
1 Worked examples

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:





- 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** 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]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **16.1 Internal energy** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/43 N25 —Q2 (internal energy and its changes)
- 9702/41 J25 —Q4 (internal energy)
- 9702/43 J25 —Q3 (internal energy, structured)
- 9702/44 J25 —Q3 (ideal-gas internal energy)
- 9702/43 J25 —Q4 (internal energy and temperature)

Solutions

2.1 The **random kinetic energy** of the molecules and the **potential energy** between the molecules.

2.2 It **increases** (the molecules' random kinetic energy rises).

2.3 Its molecules are assumed to have **no forces** between them (except during collisions), so there is no intermolecular potential energy.

2.4 $U = \frac{3}{2}nRT$ (or $\frac{3}{2}NkT$).

3.1 C —thermodynamic temperature.

3.2 It **doubles** ($U \propto T$ for an ideal gas).

3.3 Energy goes into increasing the molecular **potential energy** as bonds are broken/molecules separated; the kinetic energy (temperature) stays the same, so U rises with constant T.

3.4 Internal energy is the energy of the **random** molecular motion; the container's motion is **bulk/ordered** kinetic energy of the whole body, which is separate from U.