# Unit 4 · First Law of Thermodynamics

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

## 1 Key words [4]

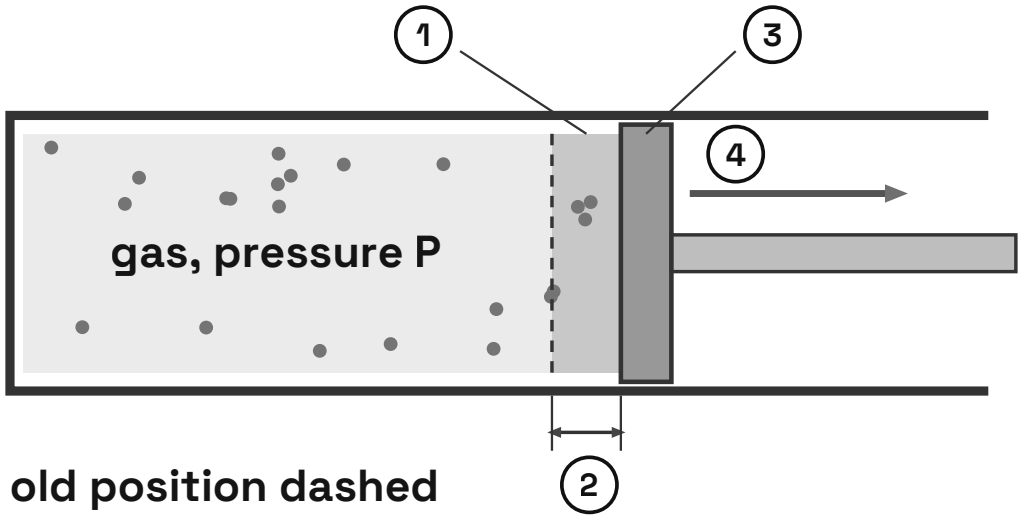
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

| | | | | | |
|---|---|---|---|---|---|
| **adiabatic** | **degrees of freedom** | **enthalpy** | **indicator diagram** | **internal energy** | **isobaric** |
| **isochoric** | **isolated system** | **isothermal** | **reversible** | | |

A system that exchanges neither energy nor matter with its surroundings is an _____. The sum of the kinetic and potential energies of all the molecules of a system is its _____. A graph of the pressure of the working gas against its volume is an _____. A process at constant temperature is _____; one in which no heat is exchanged is _____; one at constant volume is _____. The number of independent ways in which a molecule can store energy is its number of _____. A process that can be run backwards so that the system and its surroundings both return to their first states is _____.

## 2 Label the diagram [2]

The diagram shows a gas pushing a piston out by a small distance. Write the label that belongs in place of 1 to 4. Each carries 0.5 mark.




**1.** _____ **2.** _____

**3.** _____ **4.** _____

## 3 Multiple choice [5]

Choose the correct option for each of the following questions.

**i.** When an ideal gas expands isothermally: [1]

**a.** its internal energy falls by the work it does

**b.** its internal energy doesn't change, and the heat it takes in equals the work it does

**c.** it takes in no heat

**d.** it does no work

**ii.** For a monatomic ideal gas, $\gamma = C_P/C_V$ is about: [1]

**a.** 1.67 **b.** 1.40

**c.** 1.33 **d.** 1.00

**iii.** A gas takes in 250 J of heat while 100 J of work is done on it. Its internal energy: [1]

**a.** rises by 150 J **b.** rises by 350 J

**c.** falls by 150 J **d.** falls by 350 J

**iv.** A gas at a steady pressure of $1.5 \times 10^5$ Pa expands from 4.0 L to 10.0 L. The work it does is: [1]

**a.** 600 J **b.** 900 J

**c.** 1500 J **d.** $9.0 \times 10^5$ J

**v.** Through any point on a P–V diagram, the slope of the adiabat compared with the slope of the isotherm is: [1]

**a.** the same **b.** $\gamma$ times as steep

**c.** $1/\gamma$ times as steep **d.** $(\gamma - 1)$ times as steep

## 4 Short answers [7]

Write short answers to the following questions.

**a.** Why does the end of a bicycle pump get warm when you pump up a tyre quickly? [2]

**b.** Write any two differences between a reversible and an irreversible process. [2]

**c.** 3 moles of a monatomic ideal gas are heated from 290 K to 340 K, first at constant volume. Find the heat needed. How much more heat would the same rise in temperature need at constant pressure, and where does the extra heat go? (R = 8.31 J/(mol K)) **[3]**

## 5 Long answer **[4]**

Write a long answer to the following question.

Show that, at any point on a P–V diagram, the adiabat through that point is $\gamma$ times as steep as the isotherm through it.

## 6 Numerical problems **[8]**

Solve the following problems. Show your working. Take R = 8.31 J/(mol K).

**a.** In an engine, air at 290 K and $1.0 \times 10^5$ Pa is compressed quickly (adiabatically) to one fifteenth of its volume. Taking $\gamma = 1.4$, find i. its final temperature, ii. its final pressure, and iii. the work done on each mole of the air. **[4]**

**Answer:**

**b.** 0.50 mol of an ideal gas at 350 K is compressed slowly and isothermally from 6.0 L to 2.0 L. Find i. the work done by the gas, ii. the heat it gives out, and iii. its pressure before and after. **[4]**

**Answer:** _____

## 7 Think [3]

A gas is taken from state A to state B along two different paths on a P–V diagram. Of the heat taken in, the work done and the change in internal energy, which must be the same for both paths, and which need not? Explain.

## 8 Activity: Squeeze the air, feel the change (not marked)

Use a bicycle pump and a plastic syringe. Pump a tyre hard for a minute and feel the pump's end. Close the syringe's nozzle with a finger and push the plunger in quickly, then let it spring back.

| What you did | What you felt or saw | The kind of process |
|---|---|---|
| Pumped hard for a minute | | |
| Pushed the plunger in fast | | |
| Let the plunger spring back | | |

Who did work on whom each time?