

# 3.5 Kinetic Molecular Theory

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 11 marks

KEY WORDS kinetic molecular theory 分子运动论 • maxwell-boltzmann 麦克斯韦 • solute 溶质 • solution 溶液

## Objective

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Build the skills to answer exam questions on the **kinetic molecular theory** of gases.

You must be able to:

- state the assumptions of the **kinetic molecular theory** 分子运动论
- link **temperature** to average kinetic energy
- read a **Maxwell-Boltzmann** 麦克斯韦-玻尔兹曼 speed distribution

## 1 Worked examples

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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.

### ■ The assumptions

An ideal gas is modelled as: many tiny particles in constant random motion; negligible volume; no forces between them; and **elastic** collisions (no energy lost).

### ■ Temperature and kinetic energy

The **average kinetic energy** of the particles is proportional to the **absolute temperature**:

$$KE_{\text{avg}} = \frac{3}{2}k_B T.$$

Doubling  $T$  (in kelvin) doubles the average kinetic energy.

### ■ Speed and molar mass

At the same temperature, **lighter** molecules move **faster** (same  $KE$  means smaller mass  $\Rightarrow$  larger speed). So  $\text{H}_2$  moves faster than  $\text{O}_2$  at the same  $T$ .

### ■ The Maxwell-Boltzmann distribution

The curve shows the spread of molecular speeds. Higher temperature shifts the peak **right** and **flattens** it (a wider spread, more fast molecules). The area under the curve is the total number of molecules.

## 2 Practice

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Now apply the methods above.

**2.1** What is proportional to the absolute temperature of a gas? [1]

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**2.2** At the same temperature, which moves faster: He or Ar? Give a reason. [2]

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**2.3** What happens to the Maxwell-Boltzmann curve when temperature rises? [1]

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## 3 Exam-style questions

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**3.1** According to kinetic molecular theory, collisions between ideal-gas particles are [1]

- **A** inelastic (energy lost)
  - **B** elastic (no energy lost)
  - **C** impossible
  - **D** always head-on
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**3.2** Two gases,  $\text{H}_2$  and  $\text{O}_2$ , are at the same temperature.

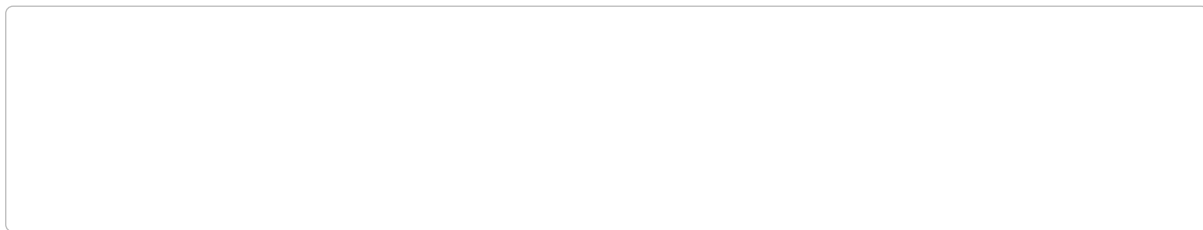
(a) Compare their average kinetic energies. [1]

(b) Compare their average speeds, with a reason. [2]

**3.3** Describe how the Maxwell-Boltzmann speed distribution changes when a gas is

heated, and what stays the same.

[3]



## Solutions

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**2.1** The average kinetic energy of the particles.

**2.2** He — it has a smaller molar mass, so at equal kinetic energy it moves faster.

**2.3** The peak shifts to higher speed and the curve flattens/broadens.

**3.1 B** — elastic collisions.

**3.2** (a) Equal — average kinetic energy depends only on temperature. (b) H<sub>2</sub> is faster; it has a smaller mass, so for the same  $KE = \frac{1}{2}mv^2$  it has a larger  $v$ .

**3.3** Heating shifts the peak to a higher speed and lowers/broadens it (a wider spread with more fast molecules); the total area (number of molecules) stays the same.