Exercise walk-through

Kinetic Theory of Temperature and Pressure ▪ 9.1

eXercise

You must be able to

- describe a gas as many particles in **random motion 无规则运动** with negligible volume
- relate **absolute temperature 绝对温度** to the average **kinetic energy 动能** of the particles
- explain gas **pressure 压强** as the result of particle collisions with the walls
- use $\overline{KE} = \frac{3}{2} k_B T$

Method — The kinetic-theory picture

A gas is a huge number of tiny particles in random motion, with negligible volume and no forces except during brief collisions.

Method — Temperature and energy

$\overline{KE} = \frac{3}{2} k_B T$, where $k_B = 1.38 \times 10^{-23}$ J K^{-1} and T is the **absolute** temperature (in kelvin). Doubling T doubles the average kinetic energy.

Method — Pressure

Particles collide with the container walls; faster or more frequent collisions mean a larger force per unit area, i.e. a higher pressure.

Practice 2.1 ▪ 1 mark

State what causes the pressure a gas exerts on its container.

Solution 2.1

Method: Pressure

Worked steps

the collisions of the gas particles with the container walls B1.

Practice 2.2 ▪ 1 mark

The absolute temperature of a gas doubles. State what happens to the average kinetic energy of its particles.

Solution 2.2

Method: Temperature and energy

Worked steps

it also doubles ($\overline{KE} \propto T$) B1.

Practice 2.3 ▪ 2 marks

Find the average kinetic energy of a particle at $T = 300$ K (take $k_B = 1.38 \times 10^{-23}$ J K^{-1}).

Solution 2.3

Method: Temperature and energy

Worked steps

$\overline{KE} = \frac{3}{2}k_B T = \frac{3}{2}(1.38 \times 10^{-23})(300) = 6.2 \times 10^{-21}$ J M1 A1.

Exam-style 3.1 ▪ 1 mark

The absolute temperature of a gas is a measure of the

A total volume

B average kinetic energy of its particles

C number of particles

D pressure

Solution 3.1

Method: Temperature and energy

A total volume

B average kinetic energy of its particles ✓

C number of particles

D pressure

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

If the average kinetic energy of the gas particles triples, the absolute temperature

A stays the same

B doubles

C triples

D falls to one third

Solution 3.2

Method: Temperature and energy

A stays the same

B doubles

C triples ✓

D falls to one third

Worked steps

C.

Exam-style 3.3 ▪ 1 mark

A gas in a sealed rigid container is heated from 300 K to 600 K.
(a) State the ratio of the new average kinetic energy to the old.
(b) Explain, in terms of particle motion, why the pressure rises.

Solution 3.3

Method: Temperature and energy

Worked steps

(a) $2:1$ B1. (b) higher temperature means faster particles B1, which hit the walls harder and more often, raising the pressure B1.