9 Temperature, gases, and heat – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	**中文**	**Write it 3 times** (English)		
Thermodynamics	热力学			
kinetic theory	分子运动论			
Temperature	温度			
pressure	压强			
ideal gas	理想气体			
Heat	热量			
thermal equilibrium	热平衡			
conduction	传导			
convection	对流			
radiation	辐射			
specific heat	比热容			

Recall

You already know a lot about heat and gases:

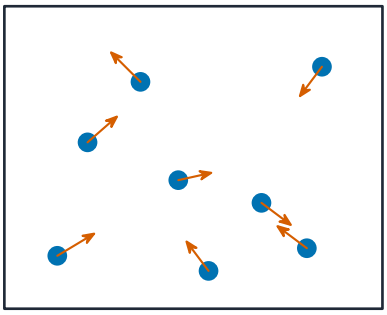
- Hot things feel hot because their tiny particles move fast; cold things move slowly.
- A gas pushes out on its container – a balloon stays full because the air pushes on it.
- Heat always flows from the hot object to the cold one, never the other way.

This sheet gives these ideas exact formulas. Each idea has a worked example.

New ideas

1 Temperature and moving particles

Thermodynamics 热力学 is the study of heat and energy in large groups of particles. The **kinetic theory** 分子运动论 says a gas is countless tiny particles in fast, random motion.



1. many identical molecules, in continuous **random motion**
2. their own volume is **tiny** next to the container
3. straight lines between hits - intermolecular forces **ignored**
4. collisions are **elastic**: no kinetic energy is lost

poor at very high pressure (volume matters) or very low temperature (forces matter)

Temperature 温度 measures the **average kinetic energy** of those particles: hotter means faster-moving. The **pressure** 压强 a gas makes comes from its particles hitting the container walls.

2 The ideal gas law

An **ideal gas** 理想气体 obeys

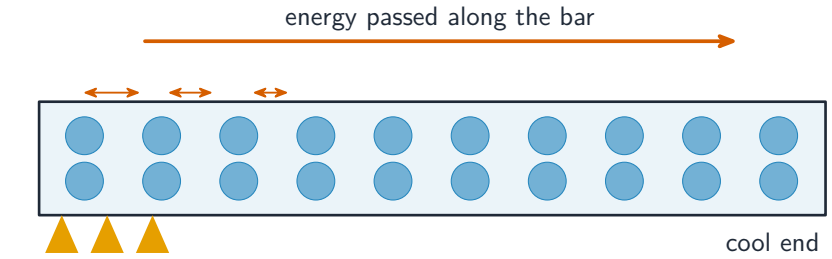
$$PV = nRT,$$

linking pressure P, volume V, amount n, and temperature T (always in **kelvin**). Change one quantity and the law tells you how another responds.

Worked example. A sealed rigid can of gas is at 1.0×10^5 Pa and 300 K. Heated to 450 K at fixed volume, $\dfrac{P}{T}$ stays constant, so $P_2 = P_1\dfrac{T_2}{T_1} = 1.0 \times 10^5 \times \dfrac{450}{300} = 1.5 \times 10^5$ Pa.

■ 3 Heat and how it moves

Heat 热量 Q is energy that flows because of a temperature difference – always from hot to cold. When two objects reach the same temperature they are in **thermal equilibrium** 热平衡 and the flow stops. Heat travels by **conduction** 传导 (through solids), **convection** 对流 (moving fluids), and **radiation** 辐射 (waves, even through empty space).



particles vibrate more at the hot end and pass the energy to their neighbours

■ 4 Specific heat

The **specific heat** 比热容 c is the heat needed to warm 1 kg of a substance by 1 °C:

$$Q = mc\,\Delta T.$$

Worked example. Heating 2.0 kg of water ($c = 4200$) from 20 °C to 80 °C needs $Q = mc\,\Delta T = 2.0 \times 4200 \times 60 = 5.0 \times 10^5$ J.

Watch out: always convert temperatures to **kelvin** ($T_\mathrm{K} = T_\mathrm{C} + 273$) before using a gas law – using Celsius gives nonsense.

Practice

Try these in order. The methods are all above.

2.1 State what temperature measures, in terms of the particles of a gas. [1]

2.2 Convert 27 °C to kelvin. [1]

2.3 A rigid can of gas at 2.0×10^5 Pa and 300 K is cooled to 150 K. Find the new pressure. [3]

2.4 Name the three ways heat can travel, and give the one that works through empty space. [2]

2.5 How much heat warms 0.50 kg of water ($c = 4200$) by 30 °C? [2]

2.6 Explain why coastal towns have milder temperatures than inland ones (think about water's specific heat). [2]