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:

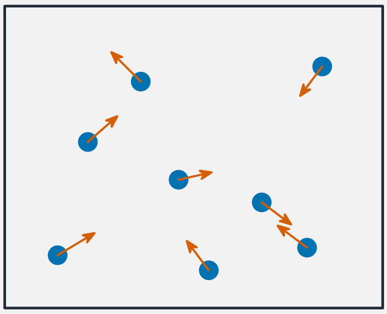
- Hot things feel hot because their tiny particles move fast; cold things move slowly.
- A gas pushes out on its container –a balloon stays full because the air pushes on it.
- Heat always flows from the hot object to the cold one, never the other way.

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

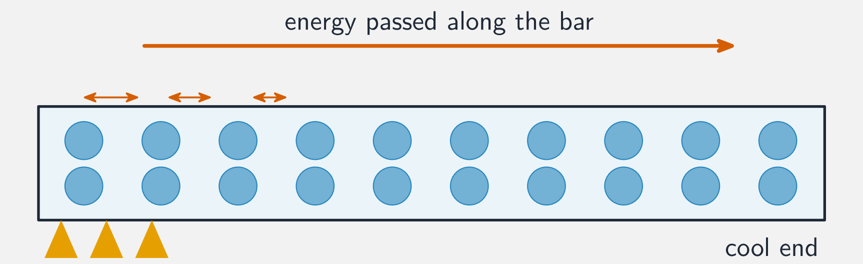
$$PV = nRT,$$

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 $1\,°\mathrm{C}$:

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

Worked example. Heating 2.0 kg of water ($c = 4200$) from $20\,°\mathrm{C}$ to $80\,°\mathrm{C}$ 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 $27\,°\mathrm{C}$ 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 $30\,°\text{C}$? [2]

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