

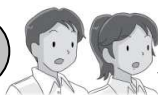
Matter and its properties

物質及其特性

17.1 Matter and its three states

17.1 物質及其三態

Q1



What is matter?

甚麼是物質？

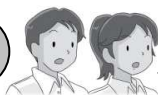
A1



- Everything that takes up **space** and has **mass** is matter.
- For example, your desk, your chair, the water you drink and the air you breathe are matter.

- 凡佔有**空間**及具有**質量**的都是物質。
- 桌子、椅子、水和空氣都是物質。

Q2



Does matter exist in different forms?

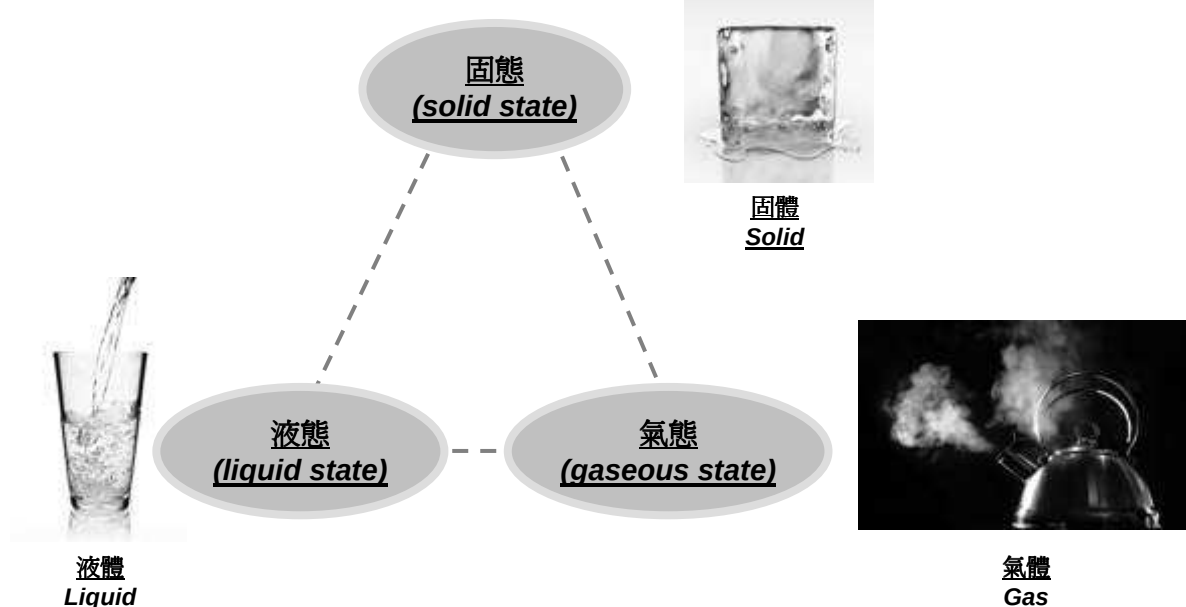
物質會以不同形態存在嗎？

A2



Yes. Matter can exist in three **states**.

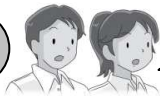
會，物質會以三種不同的**物態**存在。



17.2 How do scientists classify matter into three states?

17.2 科學家如何把物質分類？

Q3



By what criteria do scientists classify matter into three states?

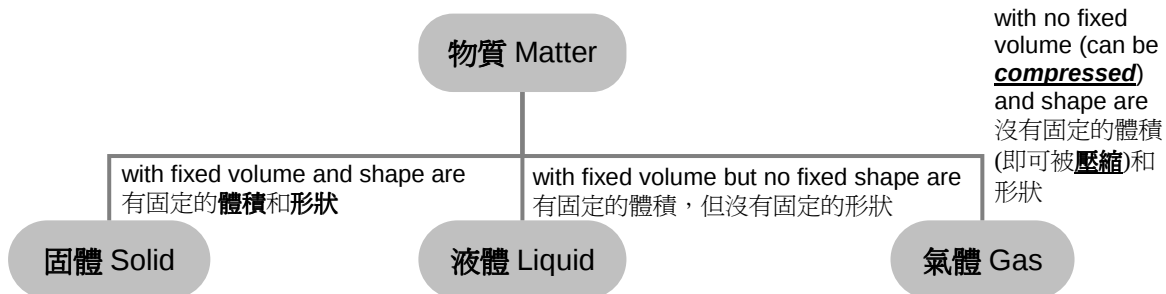
科學家根據甚麼準則來把物質分類成固體、液體及氣體？

A3



Scientists classify matter into three states based on their properties.

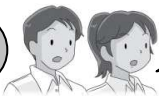
科學家根據物質的特性來把它們分類。



17.3 Changes of matter from one state to another

17.3 物質三態之間的變化

Q4



Can matter change from one state to another?

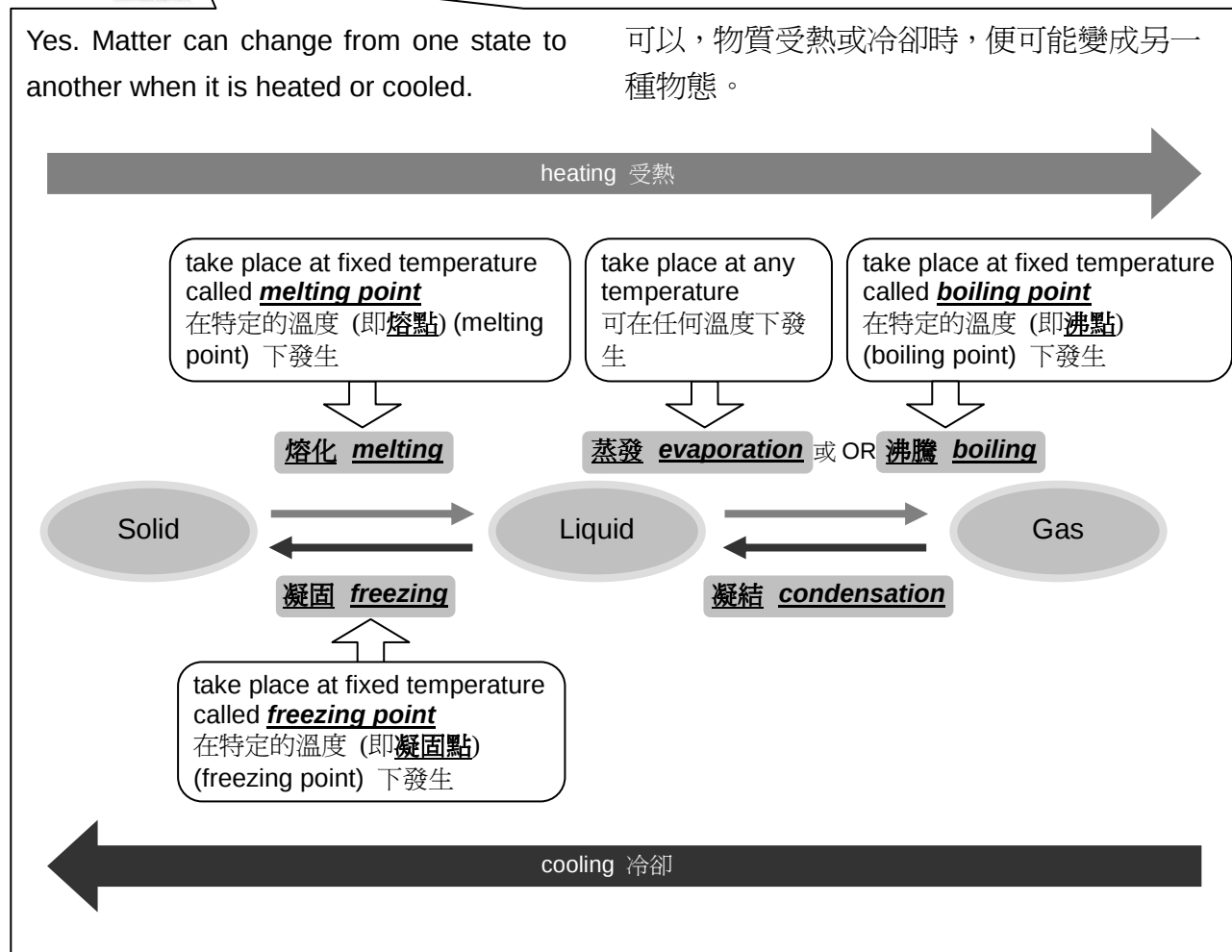
物質可以由一種物態變成另一種物態嗎？

A4



Yes. Matter can change from one state to another when it is heated or cooled.

可以，物質受熱或冷卻時，便可能變成另一種物態。



Q5



How do we find the melting and boiling point of water?

怎樣可以找出水的熔點和沸點？

A5

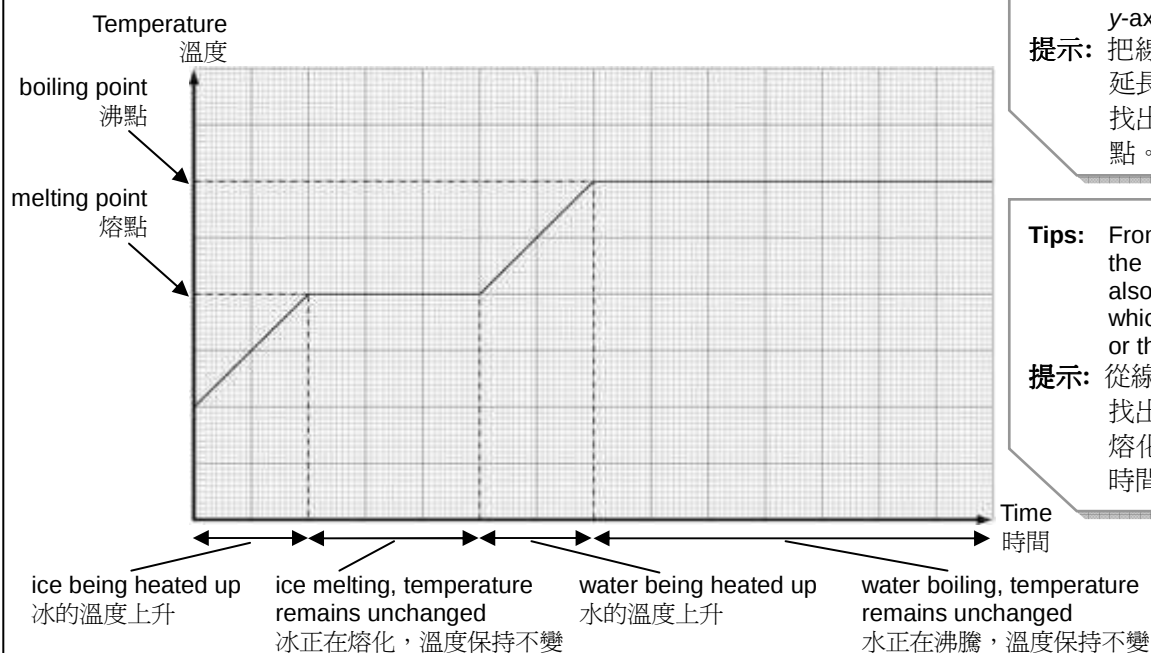


- Heat ice until it melts into water and then boils into steam. Draw a graph to show how the temperature changes.
- The temperature **remains unchanged** when a substance melts or boils. Therefore, the melting and boiling points can be found from the **flat parts** of the graph.

- 把冰加熱，直至冰熔化成水，然後沸騰。過程中量度溫度的變化，並繪畫線圖來表示實驗結果。
- 物質熔化時，其溫度會**保持不變**(remain unchanged)，因此我們可從線圖中平坦的部分找出水的熔點和沸點。

Temperature change of water over time

水加熱時溫度的變化



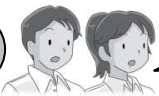
Tips: You can find the melting and boiling points by drawing horizontal lines from the flat parts to the y-axis.

提示: 把線圖平坦的部分延長至 y 軸，便可找出水的熔點和沸點。

Tips: From the x-axis of the graph, you can also find the time at which the ice melts or the water boils.

提示: 從線圖的 x 軸，可找出冰在那段時間熔化，及水在那段時間沸騰。

Q6



How do people make use of changes of state?

物態變化有甚麼應用？

A6



People make use of changes of state in:

物態變化的應用包括：



casting 鑄造金屬製品



soldering 焊接



steam engine 蒸汽火車

Chapter 第18章

The building blocks of matter 物質的基本單位

18.1 What is matter made of?

18.1 物質是由甚麼組成的？

Q7



Why does matter has three states?
Why do different states of matter
have different properties?

爲甚麼物質會有三態？爲甚麼
物質三態各有不同的特性？

A7



- Scientists proposed the **particle theory** to explain these.
- The main points of the particle theory are:

- 科學家發展出**粒子理論** (particle theory)，可用來解釋物質三態的特性。
- 粒子理論的要點如下：

All matter is made up of particles.
所有物質都是由粒子組成

Particles are very small.
粒子非常微小

There are spaces between particles.
粒子之間存有空間

Particle Theory
粒子理論

Different matter is made up of different particles.
不同物質由不同的粒子組成

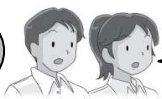
Particles are moving all the time.
粒子不停地運動

Different particles have different sizes.
不同的粒子大小不一

18.2 Evidence for the particle theory?

18.2 支持粒子理論的證據？

Q8



How do scientists prove that matter is made up of particles?

科學家如何證明物質是由粒子組成？

A8



Scientists have found **evidence** from experiments.

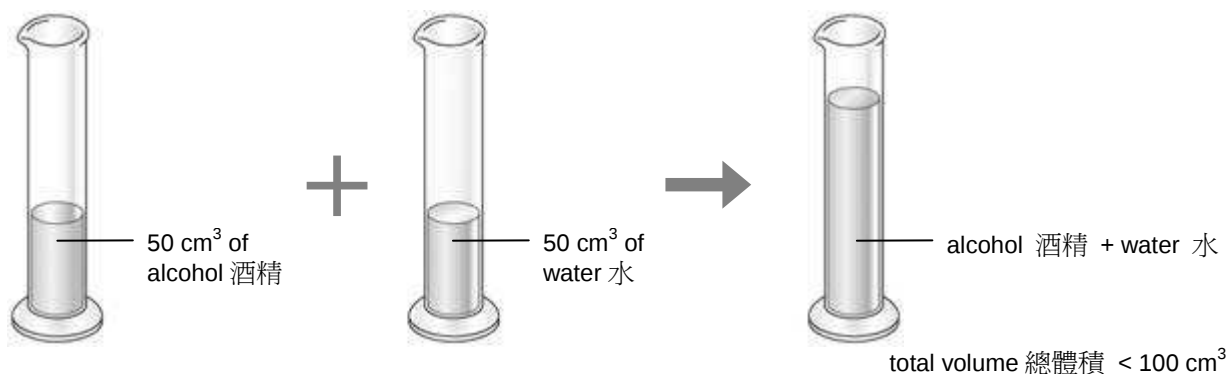
科學家從實驗找出了**證據** (evidence)。

Experiment 1: Mixing alcohol and water

實驗 1：混合酒精和水

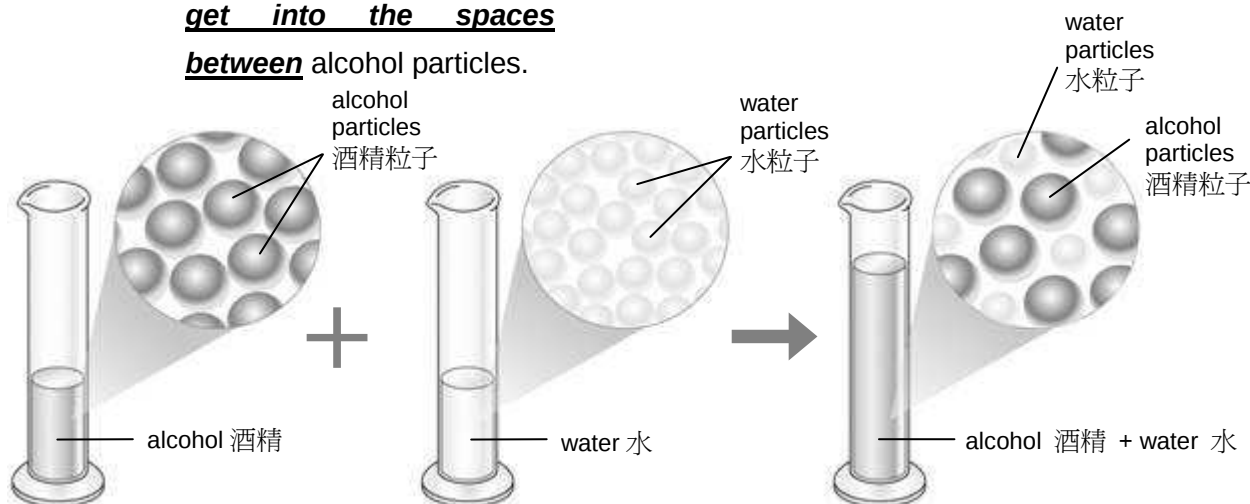
Result: Total volume is smaller than the sum of the two volumes.

結果：兩者混合後的總體積小於兩者混合前體積的和。



Explanation: Alcohol particles are larger than water particles. When alcohol and water are mixed, the water particles **get into the spaces between** alcohol particles.

解釋：酒精粒子比水粒子大，當酒精和水混合後，有些水粒子進入酒精粒子之間的空間。



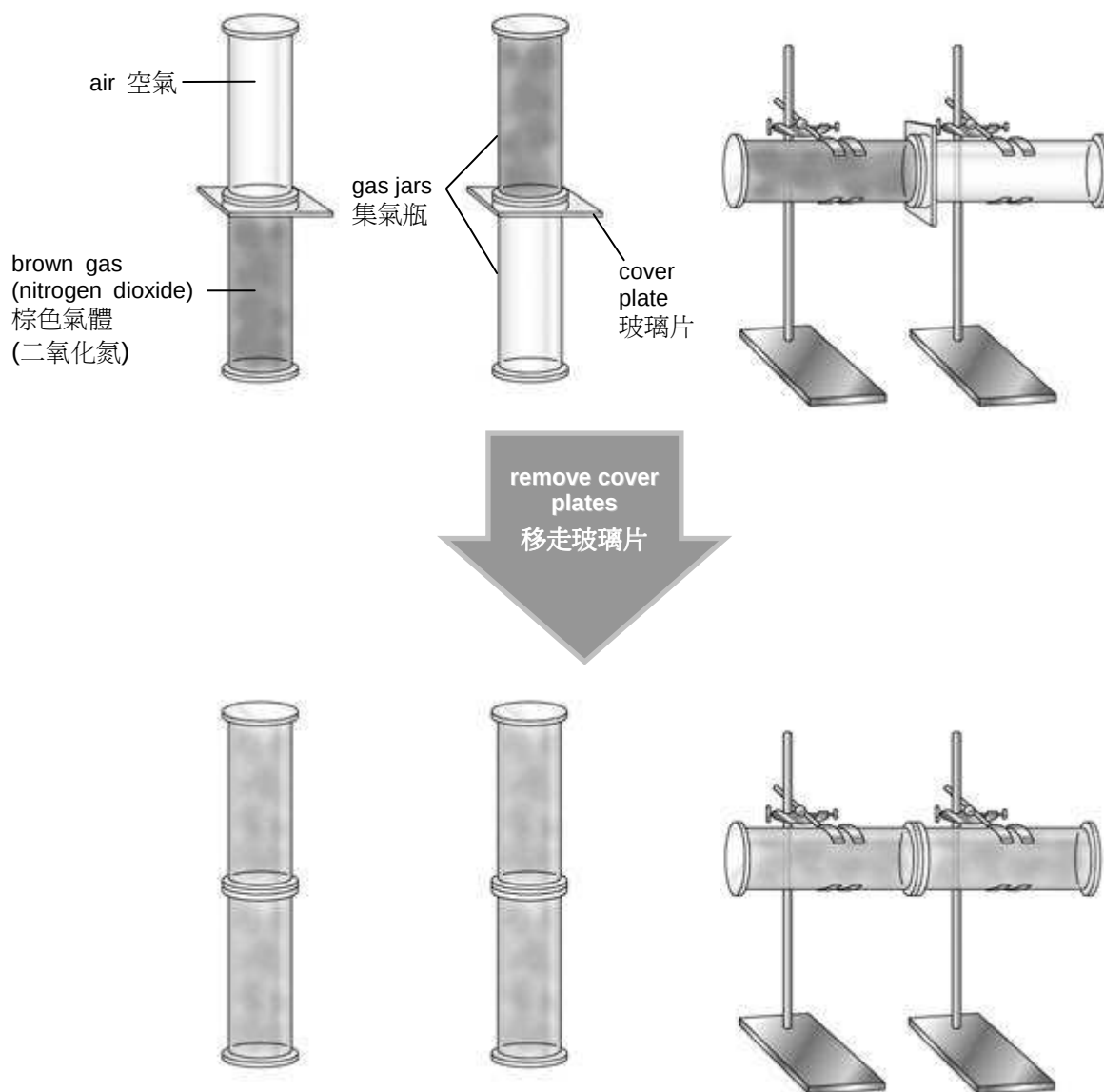


Experiment 2: Mixing gases

實驗 2：混合氣體

Result: The coloured gas can **spread in all directions.**

結果：有色氣體向各個方向擴散。



Explanation: The particles of the brown gas are **moving all the time**, and they **move in all directions.**

解釋：棕色氣體的粒子不停向各個方向運動。



Experiment 3: Perfume in a balloon

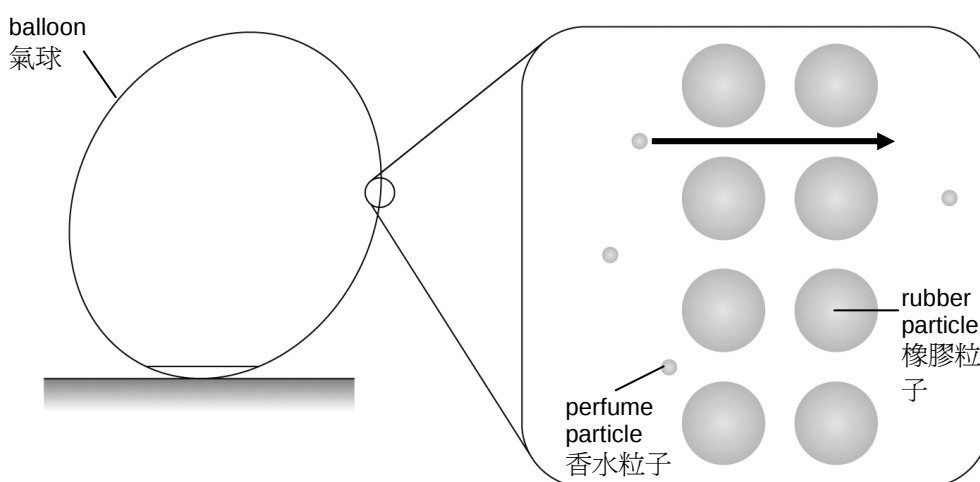
實驗 3：氣球中的香水

Result: The smell of the perfume inside the balloon can spread to the outside.

結果：香水的氣味會擴散至氣球外。

Explanation: There are spaces between the rubber particles of the balloon. The perfume particles are small enough to pass through these spaces to the outside.

解釋：氣球的橡膠粒子之間存有空間，香水粒子能夠穿過這些空間，擴散至氣球外。

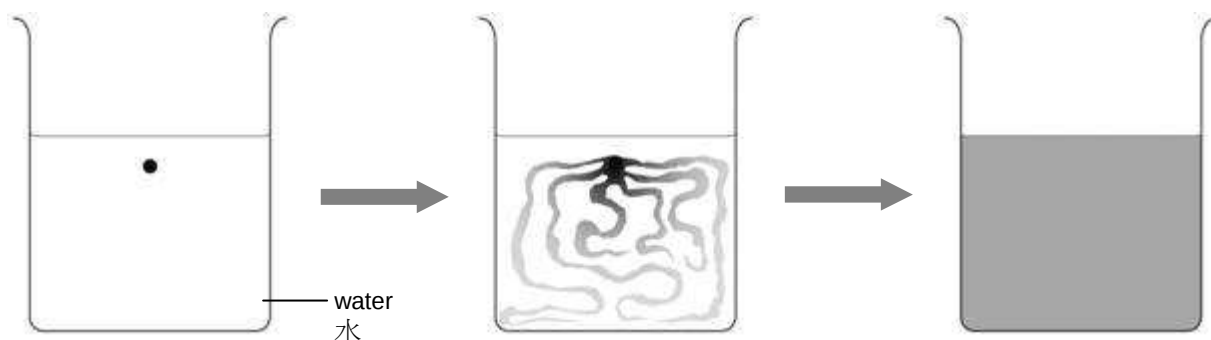


Experiment 4: Mixing liquids

實驗 4：混合液體

Result: The ink spreads throughout the water.

結果：墨水在水中會向四方擴散。



Explanation: The ink particles are moving all the time, and they move in all directions.

解釋：墨水粒子不停向各個方向運動。



Experiment 5: Brownian motion

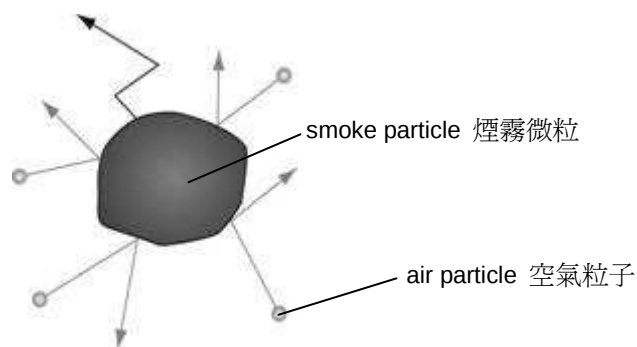
實驗 5：布朗運動 (Brownian motion)

Result: The smoke particles move in zigzag paths.

結果：煙霧微粒會不規則地運動。

Explanation: The smoke particle is hit randomly by air particles from different directions.

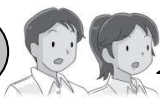
解釋：空氣粒子不停向各個方向運動，並從不同方向撞擊煙霧微粒。



18.3 Describing the three states of matter using the particle model

18.3 利用粒子模型描述物質的三態

Q9



Can the particle theory be used to explain the three states of matter?

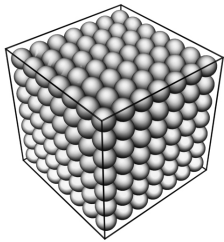
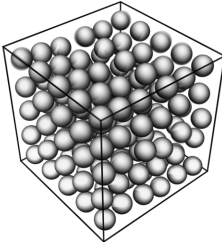
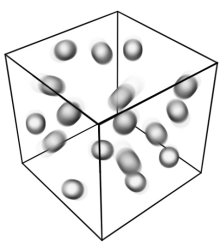
粒子理論可用來解釋物質的三態嗎？

A9



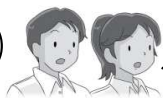
- Yes. Based on the particle theory, scientists proposed a **particle model** to describe how particles behave in solids, liquids and gases.

- 可以，科學家根據粒子理論提出了**粒子模型** (particle model)，可用來描述不同物態下粒子的排列和運動情況。

Solid 固體	Liquid 液體	Gas 氣體
		
- Particles are close together and arranged regularly. 粒子排列緊密而且有規律 - Particles cannot move from one place to another. They only vibrate in fixed positions. 粒子不能由一個位置移動至另一個位置，它們只能在固定位置上振動	- Particles are close together and arranged irregularly. 粒子排列緊密，但沒有規律 - Particles can move from one place to another. 粒子能由一個位置移動至另一個位置	- Particles are far apart. 粒子相距甚遠 - Particles can move freely in all directions. 粒子可向各個方向自由移動

Tip 提示： The particles in solids are not at rest. They can vibrate.
固體中的粒子並非靜止不動，它們會不斷振動。

Q10



Can the particle model be used to explain the properties of solids, liquids and gases?

粒子模型可用來解釋固體、液體和氣體的特性嗎？

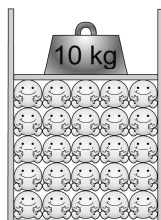
A10



Yes.

可以。

Solid 固體



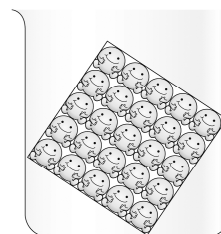
can it be compressed?
可否被壓縮？

No
不可



can its shape be changed?
形狀可否改變？

No
不可



Particles in solids are close together.

固體中的粒子排列緊密

∴ Solids have fixed volume (cannot be compressed).

∴ 固體有固定的體積(不能壓縮)

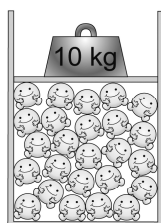
Particles in solids cannot move from one place to another.

固體中的粒子不能由一個位置移動至另一個位置

∴ Solids have fixed shape.

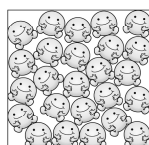
∴ 固體有固定的形狀

Liquid 液體



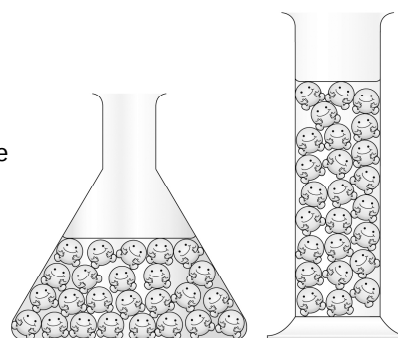
can it be compressed?
可否被壓縮？

No
不可



can its shape be changed?
形狀可否改變？

Yes
可以



Particles in liquids are close together.

液體中的粒子排列緊密

∴ Liquids have fixed volume.

∴ 液體有固定的體積

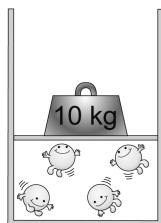
Particles in liquids can move from one place to another.

液體中的粒子能由一個位置移動至另一個位置

∴ Liquids have no fixed shape.

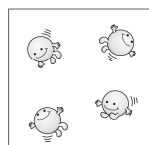
∴ 液體沒有固定的形狀

Gas 氣體



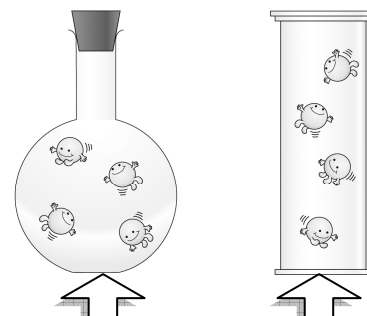
can it be compressed?
可否被壓縮？

Yes
可以



can its shape be changed?
形狀可否改變？

Yes
可以



Particles in gases are far apart.

氣體中的粒子相距甚遠

∴ Gases have no fixed volume (can be compressed).

∴ 氣體沒有固定的體積 (能被壓縮)

Particles in gases can move from one place to another.

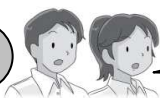
氣體中的粒子能自由移動

∴ Gases have no fixed shape.

∴ 氣體沒有固定的形狀

18.4 Atom — the 'smallest' unit of matter 18.4 物質的「最小」單位 — 原子

Q11



What is the smallest unit of matter?

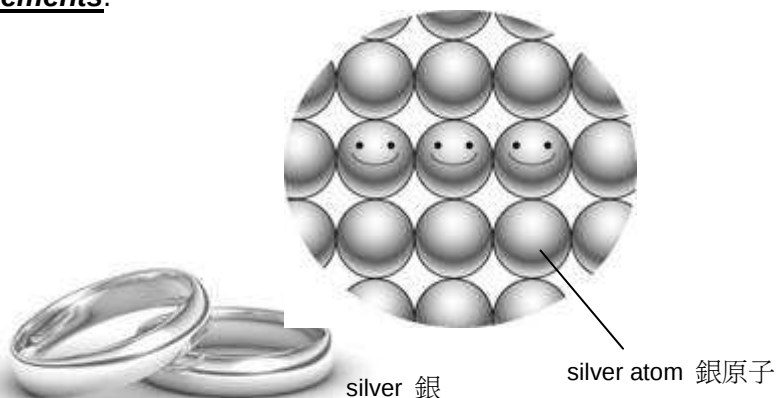
甚麼是物質的最小單位？

A11



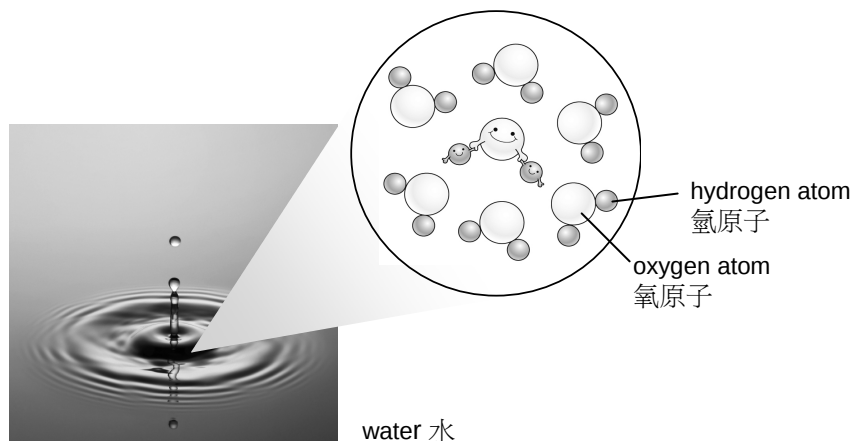
- **Atoms** are the smallest unit of matter. There are more than 100 different kinds of atoms in the world.
- Some substances, such as silver and golden, are made up of only one kind of atoms. They are **elements**.

- **原子 (atom)** 是物質的最小單位，世界上有多於 100 種原子。
- 有些物質 (例如金和銀) 是由單一種原子組成，它們稱為**元素 (element)**。



- Some substances, such as water and carbon dioxide, are made up of more than one kind of atoms. They are **compounds**.

- 有些物質 (例如水和二氧化碳) 由多於一種原子組成，它們稱為**化合物 (compound)**。



Chapter 第19章

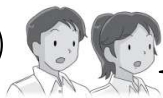
Explaining the properties of matter

解釋物質的特性

19.1 Explaining the properties of gas

19.1 解釋氣體的特性

Q12



What is gas pressure?

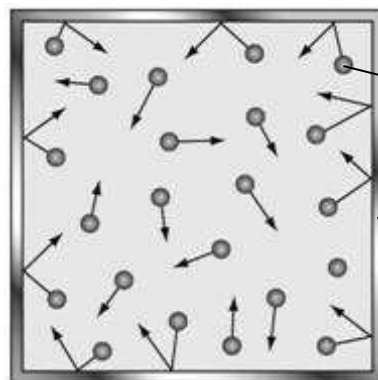
氣壓是甚麼？

A12



- Gas particles are moving all the time. They hit the walls of a container and produce a **gas pressure**.

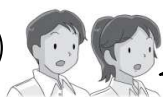
- 氣體粒子不停地移動，撞擊容器的內壁時會產生**氣壓** (gas pressure)。



gas particle 氣體粒子

container 容器

Q13



What happens when a gas is compressed?

把氣體壓縮時會發生甚麼變化？

A13



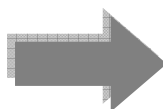
- When a gas is compressed, the gas particles hit the walls of the container **more frequently**. As a result, the gas pressure **increases**.

- 把氣體壓縮，氣體粒子撞擊容器內壁的頻率增加，令氣壓上升。

air particles hit the wall of the container
空氣粒子撞擊容器內壁



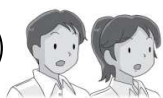
gas compressed
把氣體壓縮



air particles hit the wall of the container more frequently
空氣粒子撞擊容器內壁的頻率增加



Q14



How do we measure gas pressure?

怎樣量度氣壓的大小？

A14



- We can measure gas pressure using :

- 我們可利用以下儀器量度氣壓。



a **Bourdon gauge**
布爾登氣壓計(Bourdon gauge)

or 或

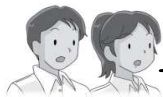


a **pressure sensor** connected to a **datalogger**
連接至數據記錄器 (datalogger)
的壓力感應器 (pressure sensor)

- The unit of gas pressure is **pascal** (**Pa**).

- 氣壓的單位是**帕斯卡** (pascal, Pa)。

Q15



What is air pressure?

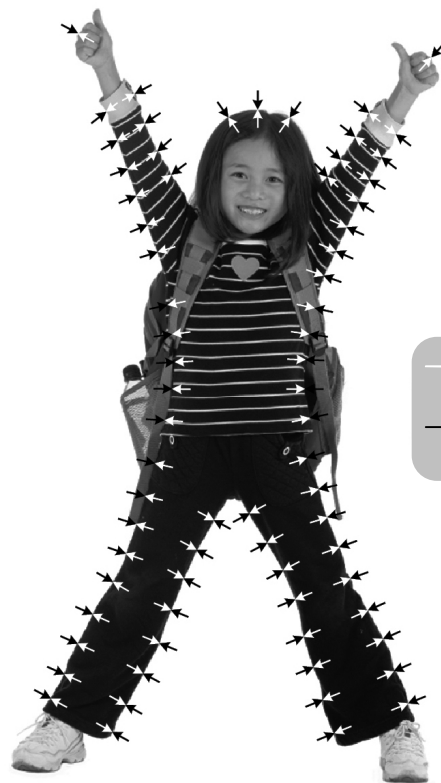
大氣壓強是甚麼？

A15



- **Air pressure** is the gas pressure exerted by the atmosphere.
- We cannot feel it because there is a pressure inside our bodies which balances the air pressure outside.

- **大氣壓強** (atmospheric pressure) 是大氣層施加在我們身上的氣壓。
- 人體內的壓力和體外的大氣壓強互相抵消，因此我們感受不到大氣壓強。



- pressure inside the body
體內的壓力
- air pressure
大氣壓強

Q16



How do we know if air pressure exists?

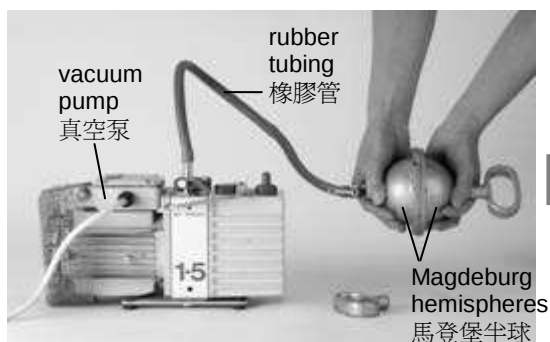
我們怎樣體驗到大氣壓強存在？

A16



- We can see it in action in the following experiments.

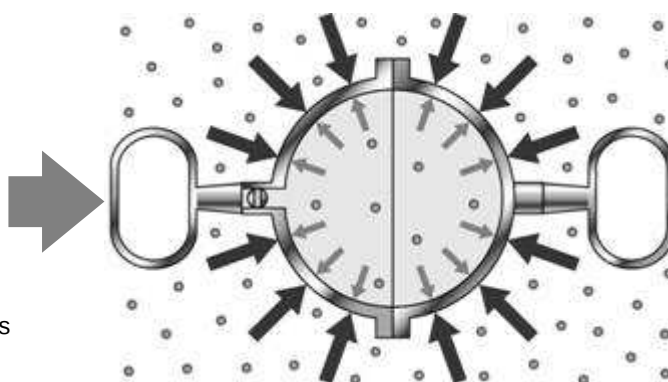
Experiment 1



Use a vacuum pump to remove the air inside the **Magdeburg hemispheres**.
把一對馬登堡半球(Magdeburg hemispheres)內的空氣抽走。

- 從以下實驗可體驗到大氣壓力存在。

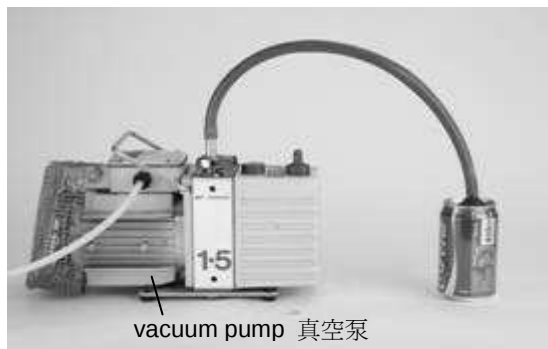
實驗 1



- The air pressure inside decreases as there are less air particles to hit the wall of the hemispheres
球內有較少空氣粒子撞擊球的內壁，令球內的氣壓下降
- The air pressure outside becomes higher than that inside
球外的氣壓比球內的為高
- Therefore, it is difficult to pull the hemispheres apart
因此兩個半球難以被分開



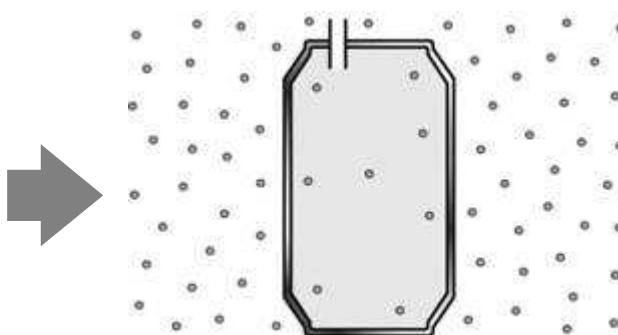
Experiment 2



Use a vacuum pump to remove the air inside a can.

把汽水罐內的空氣抽走。

實驗 2

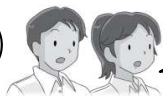


- The air pressure inside decreases as there are less air particles to hit the wall of the can
罐內有較少空氣粒子撞擊罐壁，令罐內的氣壓下降
- The air pressure outside becomes higher than that inside
罐外的氣壓比罐內的為高
- Therefore, the wall of the can **collapses**.
罐壁因而凹陷

19.2 Explaining what happens when matter is heated and cooled

19.2 解釋物質受熱和遇冷時的變化

Q17



What happens when matter is heated and cooled?

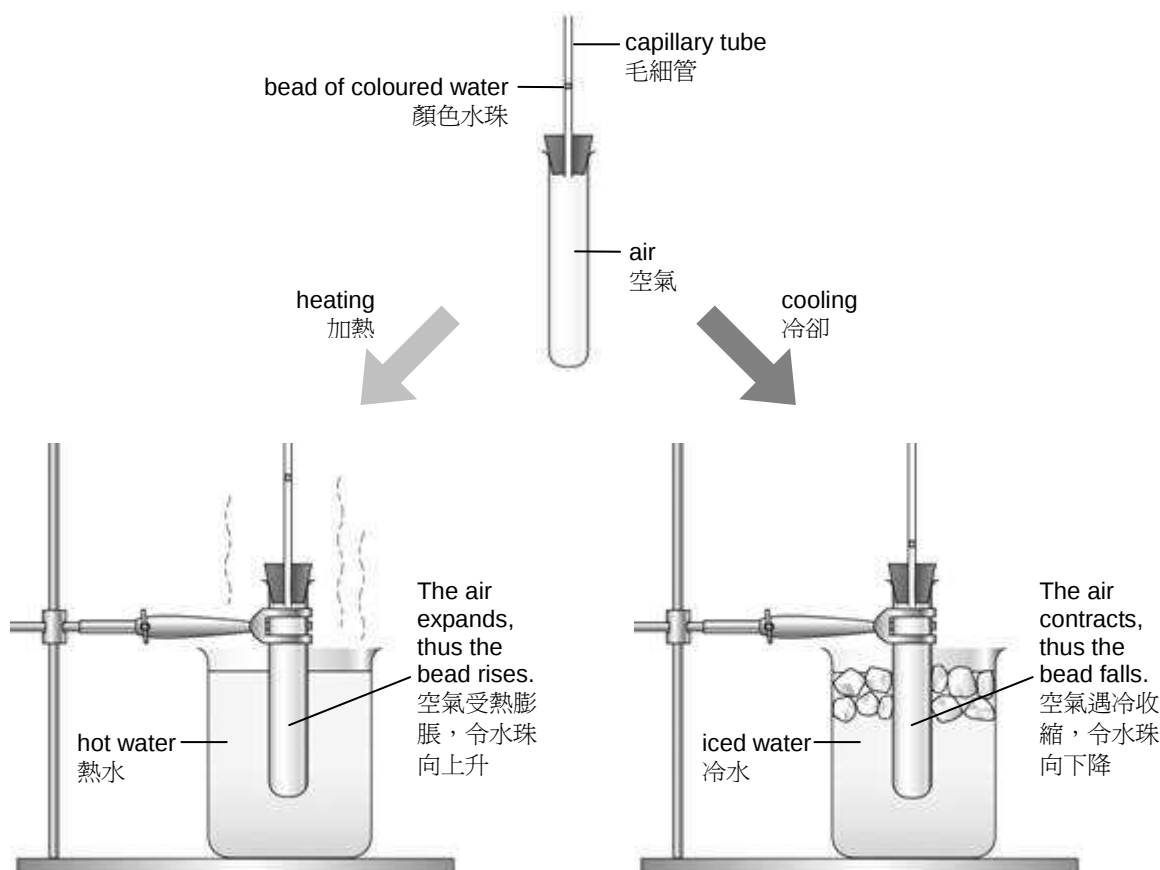
物質受熱或遇冷時會有甚麼變化？

A17



- Substances **expand** when heated and **contract** as they cool.
- This is called **thermal expansion** and **thermal contraction**.
- Gases expand or contract the most, while solids expand or contract the least.

- 物質受熱時會**膨脹** (expand)，遇冷時會**收縮** (contract)。
- 這種現象稱為**熱脹冷縮** (thermal expansion and contraction)。
- 氣體熱脹冷縮的程度最大，而固體則最小。



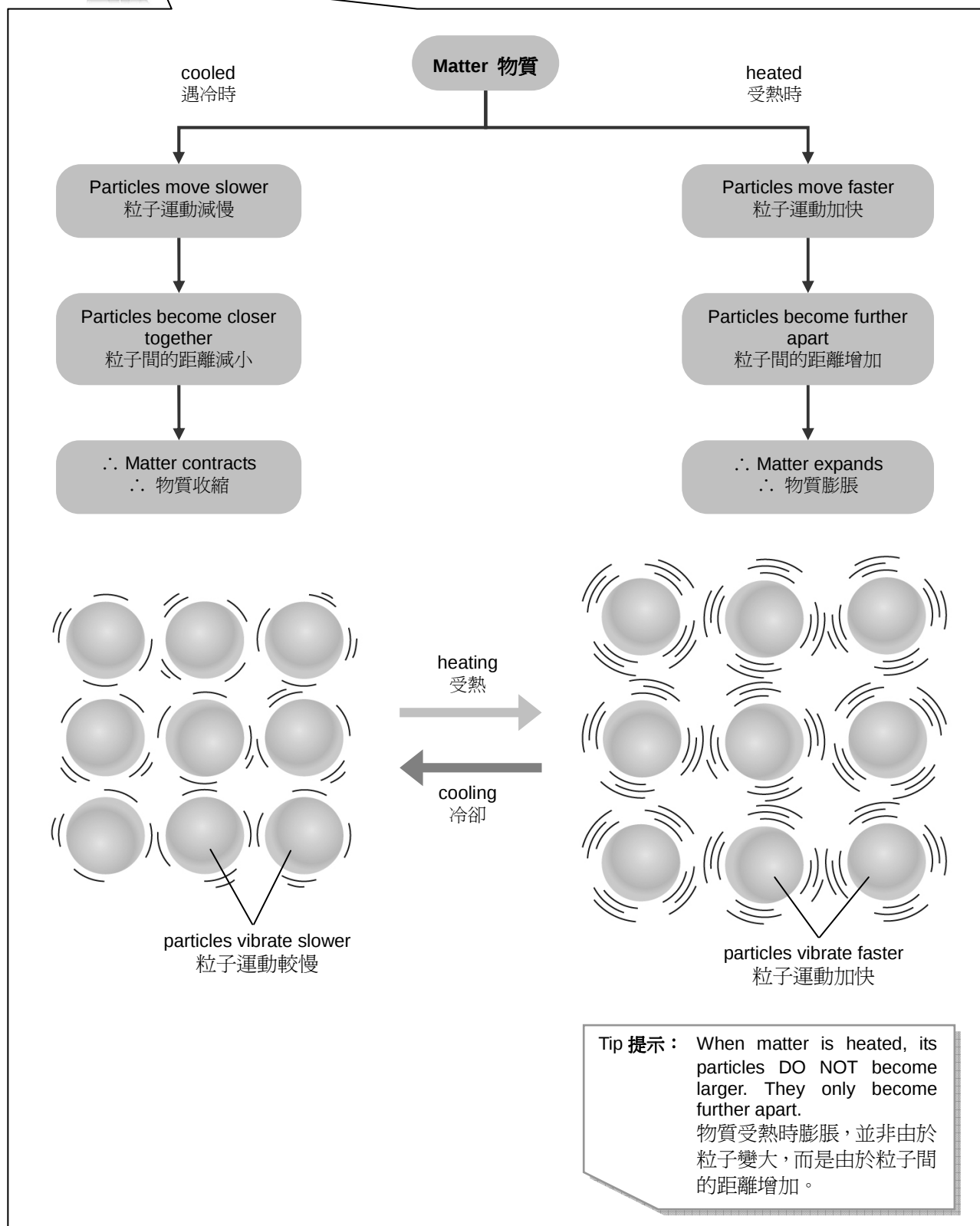
Q18



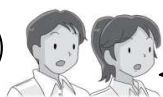
Why does matter expand or contract?

為甚麼物質受熱時會膨脹，遇冷時會收縮？

A18



Q19



Why do solids, liquids and gases expand or contract by different amounts?

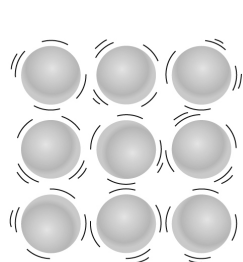
爲甚麼固體、液體和氣體熱脹冷縮的程度不同？

A19

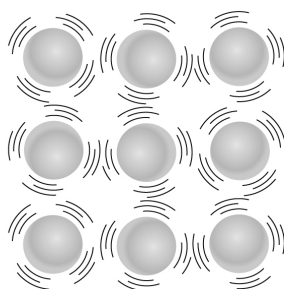


- We can use the particle model to explain.
- 我們可利用粒子模型來解釋此現象。

Solids 固體



heating
受熱

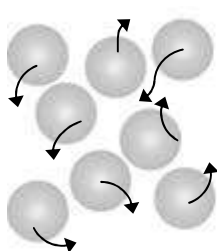


Particles can only vibrate in fixed positions
粒子只能在固定位置上振動

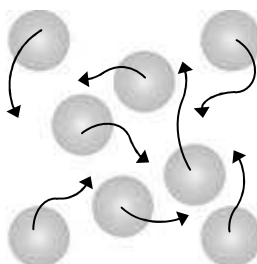
Particles only move a bit further
因此受熱時粒子間的距離只會增加少許

∴ Solids expand the least
∴ 固體受熱時膨脹最少

Liquids 液體



heating
受熱



Particles can move more freely
粒子運動比較自由

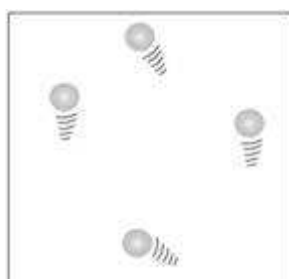
Particles can move slightly further apart
受熱時粒子間的距離增加較多

∴ Liquids expand more than solids
∴ 液體受熱時膨脹得比固體多

Gases 氣體



heating
受熱

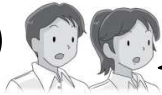


Particles can move most freely
粒子運動最自由

Particles can move further apart
受熱時粒子間的距離增加最多

∴ Gases expand the most
∴ 氣體受熱時膨脹最多

Q20



What are the problems caused by thermal expansion and contraction?
What are the solutions?

熱脹冷縮會引起甚麼問題？
有甚麼解決方法？

A20



Problem: Rails expand in hot weather and may bend.

問題：天氣太熱時路軌會膨脹，可能變得彎曲。



Solution

解決方法

Gaps are left between rails.
路軌間留有空隙。

Problem: Road sections expand in hot weather and may cause damage.

問題：炎夏時路段膨脹，可能會造成破壞。



Solution

解決方法

Gaps are left between road sections.
路段之間留有空隙。

Problem: Overhead wires contact in winter and may break.

問題：電纜在冬天收縮時可能會斷開。

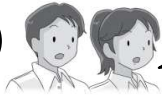


Solution

解決方法

Overhead wires are slack.
安裝架空電纜時讓電纜鬆弛。

Q21



Do scientists make use of thermal expansion and contraction?

熱脹冷縮有甚麼應用？

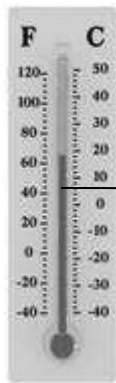
A21



- Yes. They are used in:

- 科學家利用物質熱脹冷縮的特性製成了以下的工具。

Liquid-in-glass thermometer 溫度計



liquid
液體

How it works 運作原理

Temperature
increases
溫度上升

Liquid
expands
液體膨脹

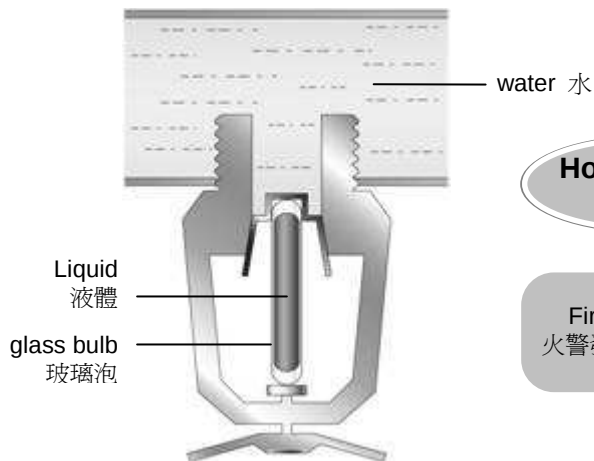
Liquid level
rises
液面上升

Temperature
falls
溫度下降

Liquid
contracts
液體收縮

Liquid level
falls
液面下降

Fire sprinkler 火警灑水器



How it works 運作原理

Fire
火警發生

Liquid
expands
液體膨脹

Glass bulb
breaks
玻璃泡破裂

Water
flows out
水灑出



Bimetallic strip

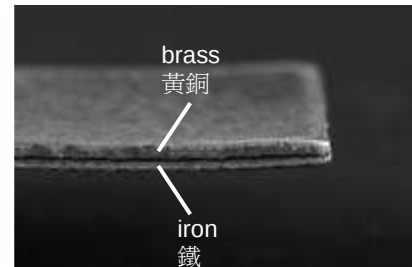
雙層金屬片 (Bimetallic strip)

What is it?

構造

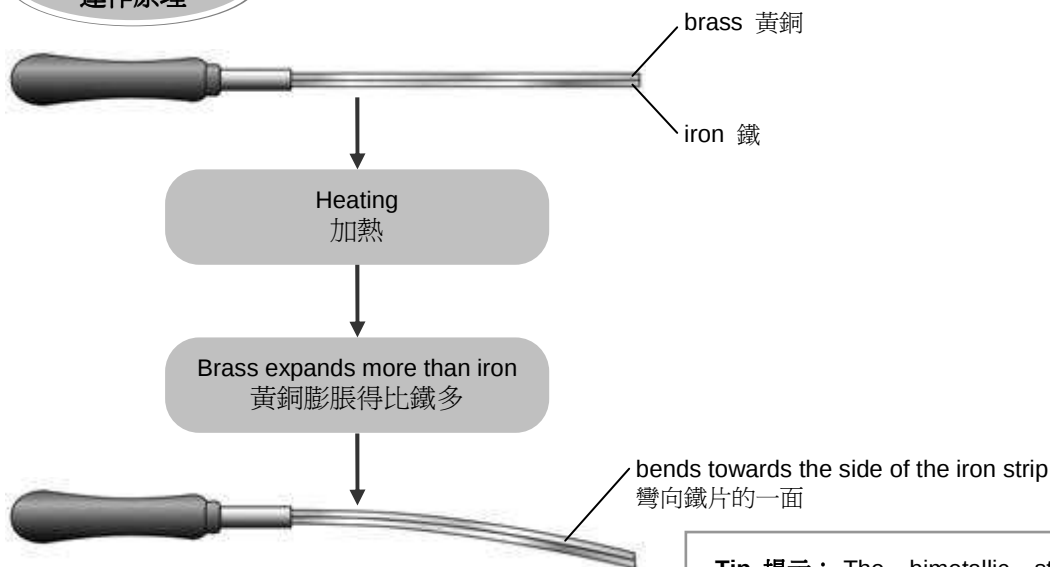
It is made of two strips of different metals joined together.

由兩塊不同的金屬片接合而成。



How it works

運作原理



Tip 提示: The bimetallic strip bends towards the side that expands less.
雙層金屬片彎向膨脹得較少的一面。

Where is it used?

用途

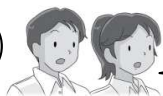
It is used in **thermostats**, which are commonly used in electric irons and ovens to maintain temperature at a set value.

用於電器中的**恆溫器** (thermostat)，用來把電器維持在某個設定的溫度。

19.3 Explaining some phenomena related to density

19.3 解釋與密度相關的現象

Q22



What is density?

密度是甚麼？

A22



- **Density** is the mass per unit volume of a substance.
- Its unit is **g/cm^3** or **kg/m^3** .

- **密度** (density) 是物質每單位體積的質量。
- 密度的單位是 **g/cm^3** 或 **kg/m^3** 。

Q23



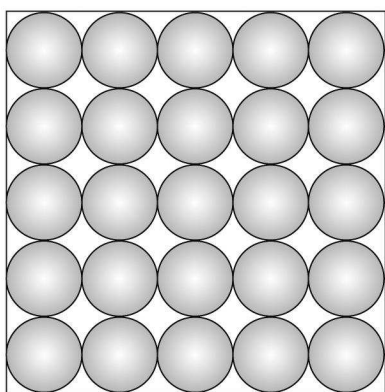
Why do different substances have different densities?

為甚麼不同物質有不同的密度？

A23

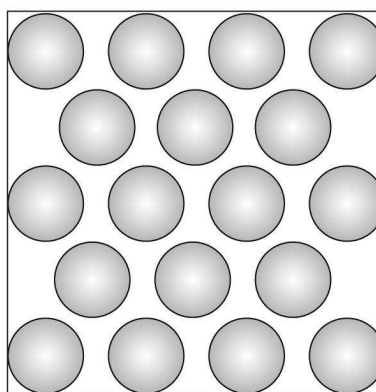


- Some substances have higher density because
 - their particles have greater mass, or
 - their particles are more closely packed



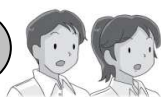
particles closely packed → higher density
粒子排列緊密 密度較高

- 有些物質的密度較高，是因為
 - 其粒子的質量較大，或
 - 其粒子的排列較緊密



particles loosely packed → lower density
粒子排列鬆散 密度較低

Q24



How do we find the density of a substance? 我們如何找出物質的密度?

A24



- First, measure the mass of a certain volume of a substance. 首先量度已知體積物質的質量。
- Then calculate the density using the formula: 再利用以下公式計算其密度：

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{密度} = \frac{\text{質量}}{\text{體積}}$$

Tip: When using this formula to calculate density, always remember to write down the units in each step of the calculation.

提示：運用公式計算時，緊記寫上單位。

Q25

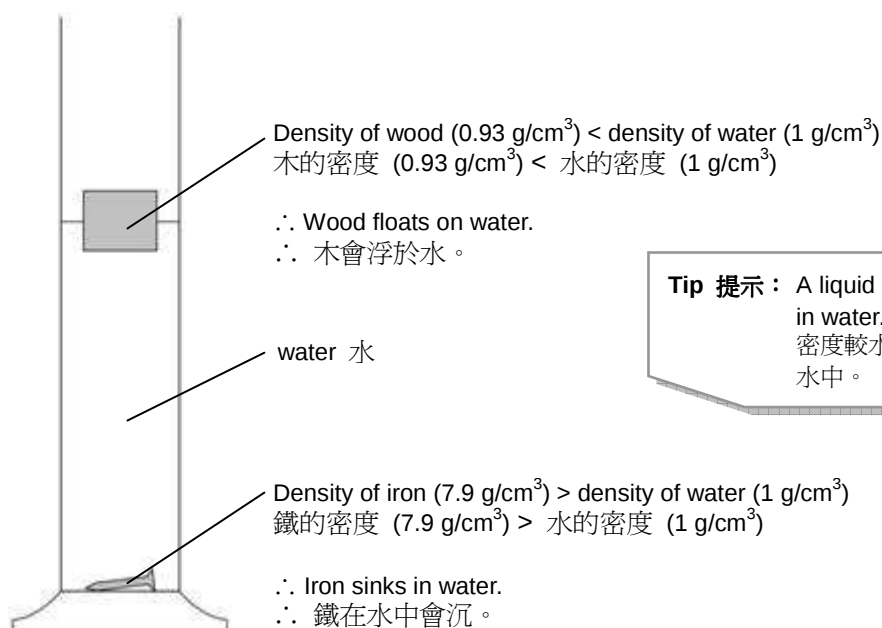


What determines whether an object floats or sinks in water? 甚麼因素決定物件在水中是浮還是沉?

A25

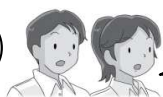


- An object floats if its density is lower than that of water. 密度比水低的物件在水中會浮。
- An object sinks if its density is higher than that of water. 密度比水高的物件在水中會沉。



Tip 提示： A liquid can also float or sink in water.
密度較水為低的液體亦可浮於水中。

Q26



Why can a steel ship float on water?

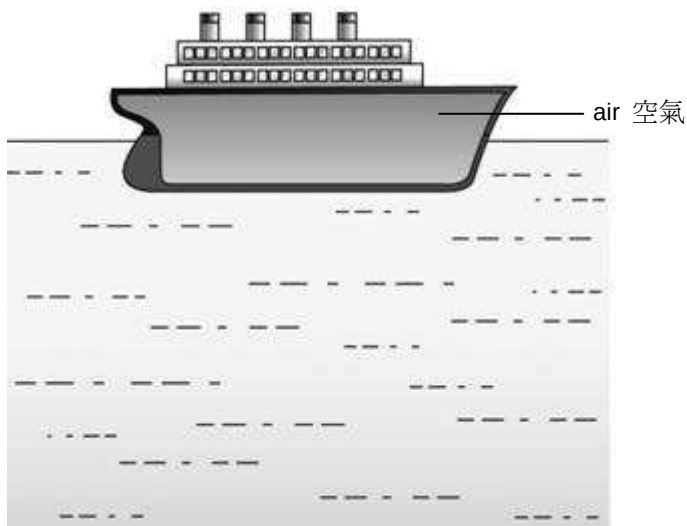
為甚麼以鋼造的船可浮於水？

A26



- A steel ship contains a large volume of air.

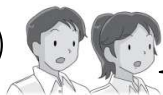
- 船身內的空間載有大量空氣。



- Therefore, the **overall density** of the ship is lower than that of water.

- 因此整艘船的密度較水為低。

Q27



Why can a hot air balloon rise?

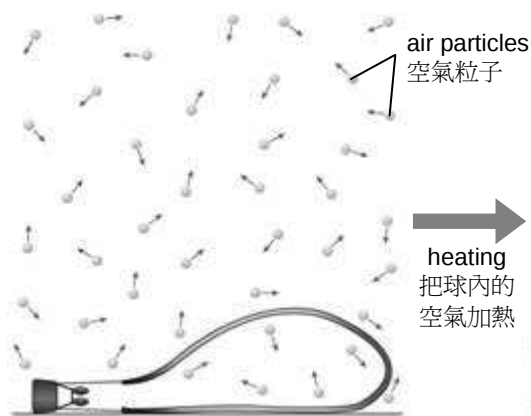
為甚麼熱氣球會上升？

A27



At the beginning
加熱空氣前

When the air inside becomes hot
空氣加熱後



Particles move faster and become further apart.
空氣粒子運動加快，
粒子間的距離增加。

Density of air inside < density of air outside
球內的空氣密度 < 球外的空氣密度

∴ the hot air balloon rises
∴ 熱氣球上升。

A. True or false questions

是非題

Write 'T' for a true statement or 'F' for a false statement in each box provided.

細閱以下句子，正確的在方格內填上「T」，不正確的則填上「F」。

1. Gases do not take up space. ☐
2. The freezing point and the boiling point of a substance are the same. ☐
3. Evaporation can take place at any temperature. ☐
4. When ice is melting, its temperature increases. ☐
5. All substances are made up of the same kind of atoms. ☐
6. When a gas is compressed, the gas pressure increases. ☐
7. When a substance is heated, it expands because its particles become larger. ☐
8. A larger iron block has a higher density than a smaller iron block. ☐

B. Multiple-choice questions

多項選擇題

Choose the correct answer for each of the following questions.

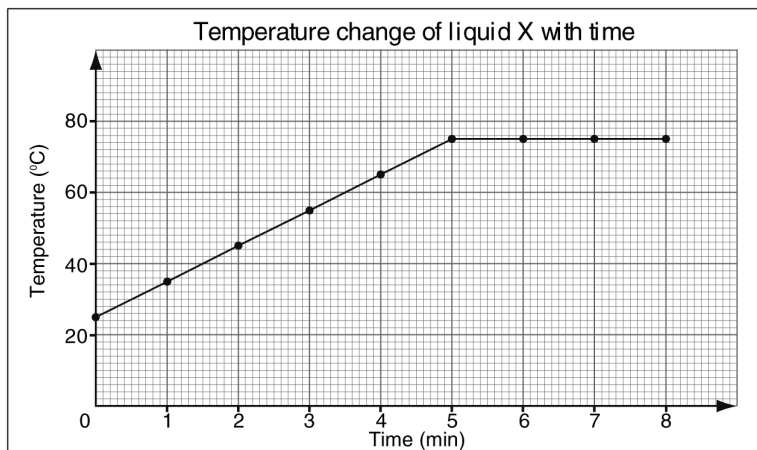
選出正確的答案，然後在空格內填上代表該答案的英文字母。

1. Which of the following is/are matter?
 (I) energy
 (II) cloud
 (III) air
 A. (I) only
 B. (III) only
 C. (II) and (III) only
 D. (I), (II) and (III) ☐

2. Which of the following changes of state take place at a fixed temperature?
 (I) melting
 (II) evaporation
 (III) boiling
 A. (I) only
 B. (I) and (III) only
 C. (II) and (III) only
 D. (I), (II) and (III) ☐

3. Which of the following is an example of change of state?
 A. Sugar dissolves in water.
 B. Crystals form in a beaker of saturated solution.
 C. A piece of paper burns into ash.
 D. Water drops form on a mirror when we breathe onto it. ☐

4. Alice heats up a liquid X and measures the temperature of the liquid every minute. The results are shown below.



What is the boiling point of X?

- A. 25 °C
- B. 75 °C
- C. 90 °C
- D. Cannot be determined

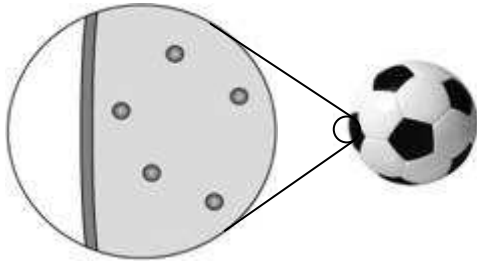


5. If you took all of the atoms out of a chair, what would be left?
- A. The chair would still be there, but it would weight less.
 - B. The chair would be exactly the same as it was before.
 - C. There would be nothing left of the chair.
 - D. Only a pool of liquid would be left on the floor.

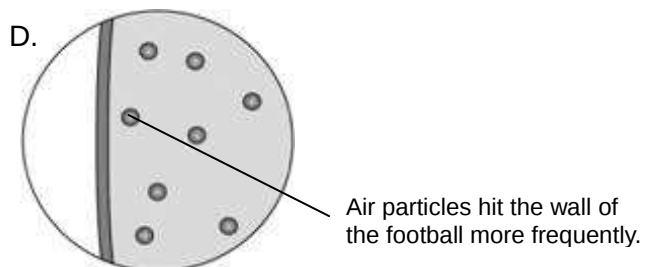
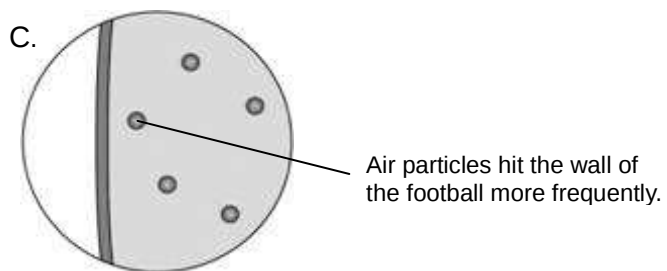
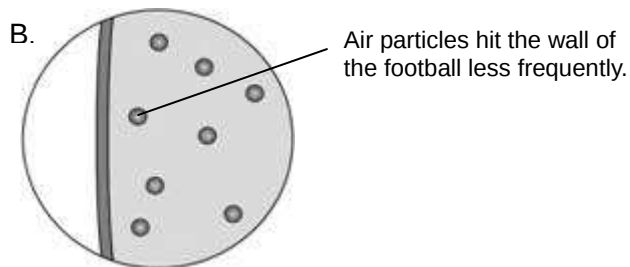
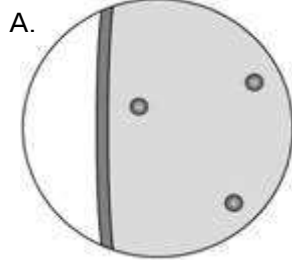


(TIMSS 2003)

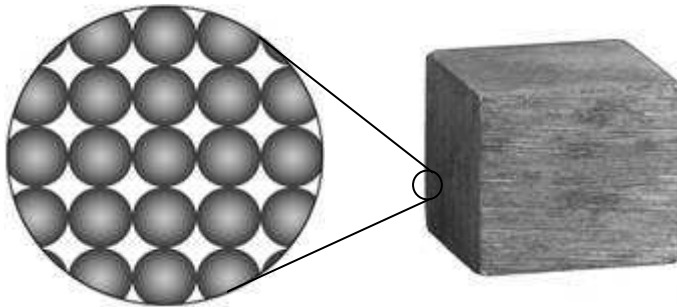
6. The diagram below shows the air particles inside a football.



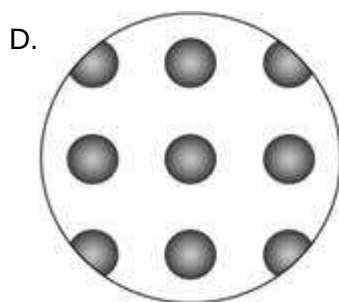
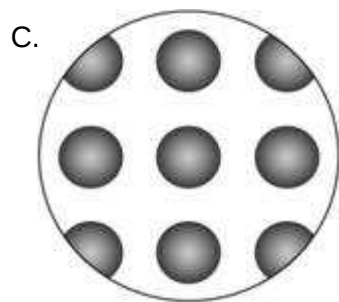
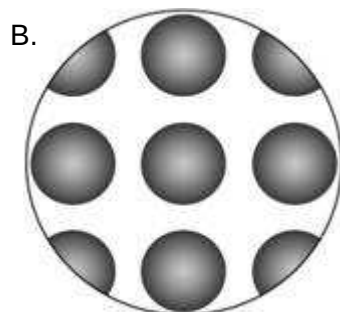
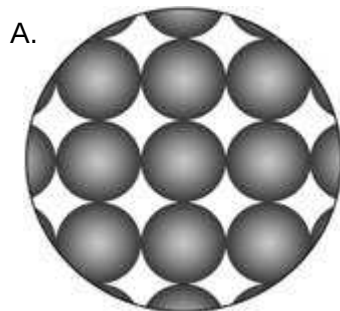
Which of the diagrams below best shows what happens when more air is pumped into the football?



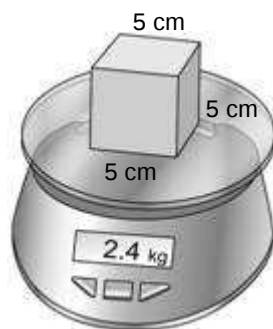
7. The diagram below shows the particles of a metal block.



Which of the diagrams below best shows what happens when the metal block is heated?



8. A scientist measures the mass of a block made of metal X as shown below.



Refer to the table below, what is metal X?

Substance	Density (g/cm^3)
copper	8.9
gold	19.3
lead	11.3
steel	7.9

- A. copper
- B. gold
- C. lead
- D. steel



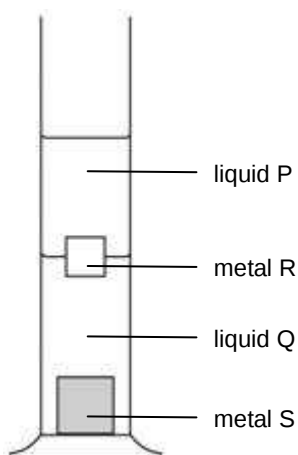
9. Which object listed in the table below has the highest density?

Object	Mass	Volume
P	2.4 kg	120 cm^3
Q	500 g	50 cm^3
R	700 g	50 cm^3
S	1.1 kg	100 cm^3

- A. P
- B. Q
- C. R
- D. S



10. John pours liquids P and Q into a measuring cylinder. Then, he puts two blocks of metals R and S into the liquids. The result is shown below.



Arrange the substances P, Q, R and S in descending order of their densities.

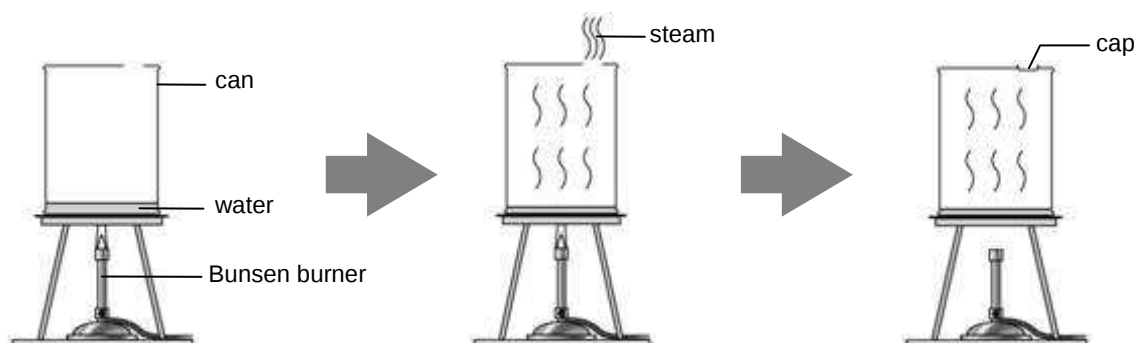
- A. P, R, Q, S
- B. S, Q, R, P
- C. S, R, Q, P
- D. Cannot be determined because blocks R and S have different size.



C. Short questions

短問題

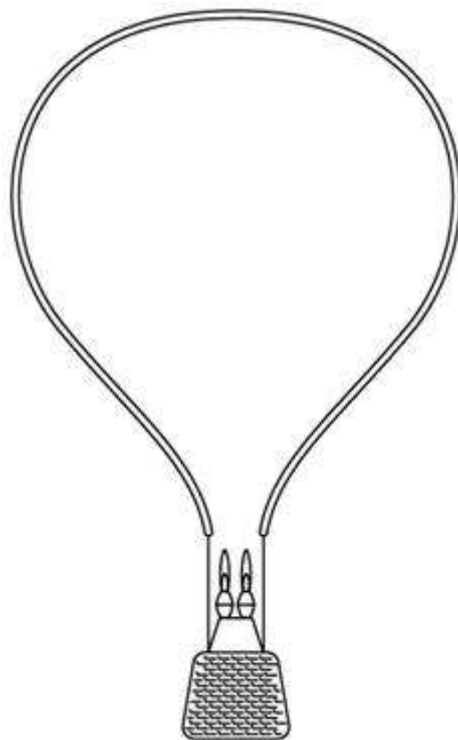
1. In an experiment, Tommy pours a small amount of water into a can. Then he heats up the water using a Bunsen burner. When he sees a large amount of steam coming out from the can, he removes the can from the Bunsen flame and put the cap on. After a while, the can collapses.



Briefly explain why the can collapses.

The steam drives air particles out of the can. When Tommy puts the cap on, the steam _____ . As a result, the gas pressure inside the can _____ .

2. A hot air balloon rises when the air inside is heated. Draw a diagram to show the air particles inside and outside the hot air balloon.



Answers 答案

A. True or false questions 是非題

1. F
2. F
3. T
4. F
5. F
6. T
7. F
8. F

B. Multiple-choice questions 多項選擇題

1. C
2. B
3. D
4. B
5. C
6. D
7. C
8. B
9. A
10. B

C. Short questions 短問題

1. The steam drives air particles out of the can. When Tommy puts the cap on, the steam inside the can cools down and condenses into water. As a result, the gas pressure inside the can becomes lower than the air pressure outside. The wall of the can cannot withstand the air pressure and so it collapses.

2.

