請考生依指示填寫准考證末兩碼
Fill in the boxes the last 2 digits of exam ID number

基北區臺北市立西松高級中學
111 學年度高級中等學校特色招生考試分發入學測驗

2022 Taipei Municipal XiSong High School Special Enrollment Program Examination for Taipei and Keelung Area

資料判讀測驗 **Source Analysis**

111 年 7 月 3 日（星期日） Sunday 3 July 2022

測驗時間為 **10:40** 到 **12:00**, 共 **80** 分鐘 **10:40-12:00 (80 minutes)**

請閱讀以下測驗作答說明 **Instructions to Examinees：**

- 請先不要翻到次頁，讀完本頁說明，聽從監試委員的指示才開始作答！
  Do not open this examination paper until instructed to do so.
- 請檢視答案卷上**准考證號碼**與**桌面貼條**是否相符。如有不符，請立即向監試委員反映。
  Please carefully check if your **exam ID number** matches **the ID number on the desk**.
  If they do not match, please inform the invigilators immediately.
- **資料判讀分為社會科問答題以及數理科題組。社會科答案卷僅一張(雙面)供社會科作答，數理科答案卷亦僅一張(雙面)供數理科作答，請斟酌使用。若於他科答案卷上應答，不予計分。**
  Source Analysis contains **Individuals and Societies** Section and **Mathematics and Science** Section. Answers to Individuals and Societies Section must be written on the **only ONE double-sided answer sheet.** Answers to Mathematics and Science Section must be written on the **only ONE double-sided answer sheet.** Please use them wisely. **No grades will be awarded to the misuse of answer sheets.**
- 試題本和答案卷請保持清潔完整，**不得**汙損、破壞或塗改准考證號碼及條碼。
  Please make sure your examination paper and answer sheets are clean. **Do not** damage or change the exam ID number and code.
- 考生**不得**於此份題本內書寫考生姓名、准考證條碼或與答案無關之文字符號。
  Please **do not** write your name, your exam ID number or any content unrelated to the answer on the examination paper.

【測驗語言說明 Instructions of Language Use】

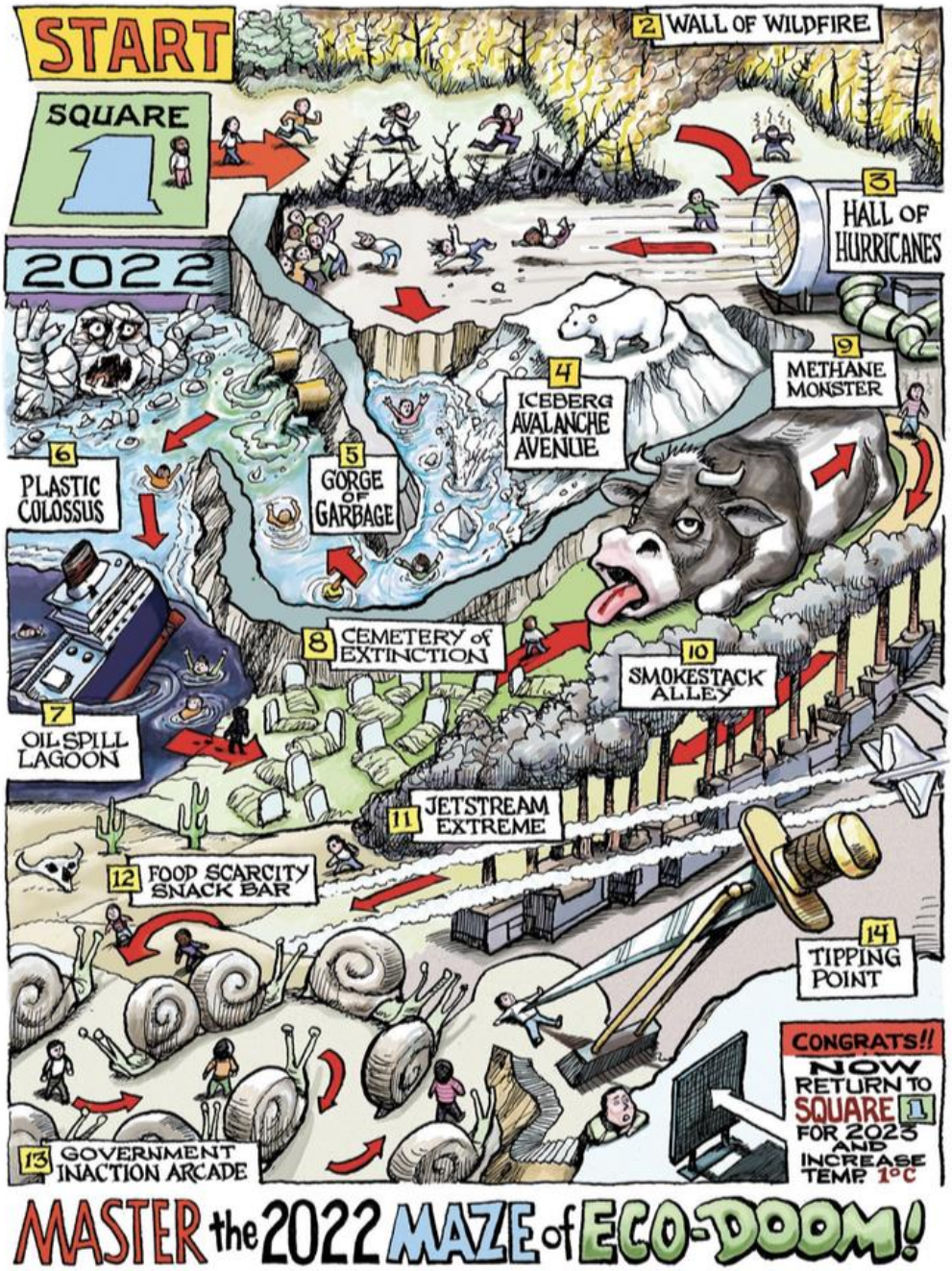
本測驗的所有題目均有中英文翻譯，考生請自行選擇自己擅長之語言來閱讀及作答。但答題時請勿夾雜中文與英文，**請使用同一語言作答。**
All the questions are written in both Chinese and English languages. Please be consistent with language when answering the questions, only in **English** or **Chinese**. **Do not mix up languages.**

- **資料判讀**測驗題目採雙面印刷，共 15 頁
  Source Analysis is printed double-sided, 15 pages in total.

【第一部分—社會科問答題】Individuals and Societies

請先閱讀以下資料，並回答下列問題。
(※試題請統一<u>以同一語言作答</u>，可選擇<u>全部使用</u>中文或英文回答，請勿夾雜英文及中文。)
Read the source given below and answer the question in **English** or **Chinese**.
<u>Language mixing is not allowed</u>.

討論此資料與時事的連結，並說明其欲傳達的觀點（建議文長：350 至 500 字；共 50 分）。
Discuss the connection between the source and current events, and describe what point of view(s) the source is trying to express. (Recommended word count: 300 to 500 words; maximum mark: 50).



【第二部分—數理科計算題組】

請根據題目要求，答題時請詳細寫下解題過程。

(※此部分題組試題請統一以同一語言作答，可選擇全部使用中文或英文回答，請勿夾雜英文及中文。)

第 1 題：共 10 分

當西元年的末兩位數字與月份、日期的數字為直角三角形的三邊長，這樣的日子就稱為畢氏定理日。例如 2020 年 12 月 16 日滿足 $20^2=12^2+16^2$，即稱 2020 年 12 月 16 日為畢氏定理日。這樣的日子並不多見，本世紀也只剩 2024 年有 2 天，2025 年、2026 年各 1 天而已。

(1) 如果 2024 年 m 月 d 日中的 24、m、d 為直角三角形的三邊長，且已知 24 不是斜邊，

(i) 試求 m 和 d 的範圍。 [3]

(ii) 請找出 2024 年的「畢氏定理日」。 [4]

(2) 根據(1)小題，試求 2025 年與 2026 年的畢氏定理日。 [3]

第 2 題：共 15 分

圖 1 為一個正六邊形，$\angle ABC$ 是正六邊形的一個內角。

(1) 試求 $\angle ABC$ 的度數。 [1]

一位藝術家想要利用正多邊形密鋪一個平面。如圖 2 所示，

(2) (i) 利用問題(1)的答案，解釋為什麼藝術家能使用正六邊形密鋪平面。 [2]

(ii) 說明能使正多邊形密鋪平面的內角條件。 [3]

(iii) 說明在邊數小於 6 的正多邊形當中，只有兩種正多邊形能密鋪平面。 [6]

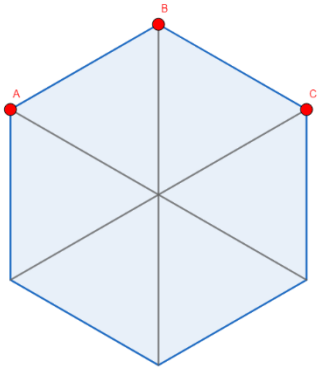


圖 1

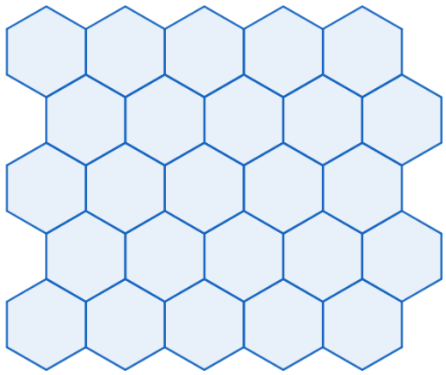


圖 2

圖 3 為某個鋪設正方形磁磚的地板，每個正方形磁磚由四個等腰直角三角形與一個正八邊形所組成，如圖 4 所示。

(3) 若每塊正方形磁磚的邊長為 16 公分，試求正八邊形的邊長。 [3]

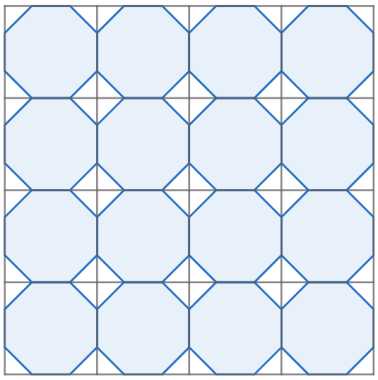


圖 3

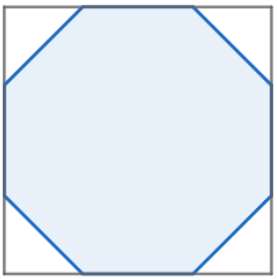


圖 4

第 3 題：共 25 分

請閱讀下列文本後回答問題：

燃燒理論與熱

普通的燃燒現象會釋放出許多煙，這似乎顯示有「物質」被釋放進入空氣中，那這是什麼物質呢？燃燒同時也會使周圍的溫度升高，古代科學家一直把「溫度」與「熱」視為相同的東西，溫度高就是熱多、溫度低就是熱少。

1703 年，德國科學家史塔爾提出「**燃素說**」，可以燃燒的物質內部皆含有「燃素」，當這些物體燃燒時，燃素便釋出至空氣中，剩下質量較輕的灰燼，而物質燃燒後剩下的灰燼因為已經沒有燃素了，所以無法再燃燒。但科學家發現，有些金屬在燃燒後質量反而變重了，這使得燃素說受到了嚴重的挑戰。

1760 年，英國科學家布萊克提出「潛熱」的概念，他認為物質在三態轉換時需要吸收或放出額外的熱，來讓物質達到狀態的轉變。在克服潛熱之前物質的溫度並不會變化，所以溫度其實並不直接等於熱，溫度僅代表物質表現出來的熱狀態或是強度，我們可以感受到冷熱在物質之間會流動。

1777 年，法國科學家拉瓦節提出燃燒是物質與氧結合的反應，否定了燃素的存在。他在鵝頸瓶中置入純汞和空氣，反應期間汞的表面會逐漸生成紅色的氧化汞，在加熱 12 天後，氧化汞不再產生，這時候罩子內空氣體積減少了五分之一，但裝置的總質量並沒有改變。這個實驗稱為鐘罩實驗，實驗裝置如圖 5。他接著發現，在真空密封容器中加熱鉛時，質量會維持不變，但在打開容器後，卻發現質量迅速增加。因此認為物質的燃燒是可燃物與空氣中某種物質結合的結果，這樣可以同時解釋燃燒需要空氣和金屬燃燒後質量變重的問題，也支持了後來的熱質說。

圖 5 鐘罩實驗裝置圖

在探究熱的本質歷程中，荷蘭科學家布爾哈夫有相當大的貢獻，他提出熱應該是一種藏在物體身上的一種物質，這種代表熱的物質，簡稱為熱質(caloric)，具有相當高的可塑性與穿透性，而且沒有重量，甚至會互相排斥。基於這樣的假設，後來的布萊克與拉瓦節也利用這樣的概念成功的發展出了「**熱質說**」並解釋許多熱學現象：熱傳導是熱質的流動、熱對流是帶有熱質的載體在流動、輻射則是熱質的散播，甚至用相斥的特性解釋了為何氣體加熱會膨脹。其中熱質最重要的假設便是「熱質不會憑空出現或是消失」，熱質具有守恆的特性。拉瓦節之後還將熱列為化學元素的一種，其中熱量的名字卡路里，就是他幫熱質取的。可見「熱是一種物質」的概念在當時的熱學領域中，佔有主宰性的地位。

隨著科學的發展，人們開始注意到一些熱質說無法解釋的現象，或是對於熱質的定義開始產生遲疑，其中熱質說最難以解釋的現象便是「摩擦生熱」，當時科學家發展出「**熱動說**」的理論解釋其現象。1798 年，英國熱動派物理學家倫福德發表了一份名為「論摩擦激起熱源」的報告，他在報告中設計了幾個實驗，駁斥了熱質說，其中最有名的就是大砲鑽孔實驗。倫福德將已經被磨鈍的鑽孔放入裝有 8.5 公斤水的水缸中，利用馬帶動圓筒旋轉，在鑽頭旋轉了兩個半小時後，水竟然沸騰了。他認為「能夠產生熱的並不是其他的物質，而是運動」，也證明熱在運動中可以無限量地被產生。

1840 年，英國科學家焦耳，提出大膽的想法，電、運動、熱，彼此是能量的轉換。為了突破傳統卡路里的熱質說，焦耳設計熱功當量實驗，證明運動與熱的能量轉換關係。此實驗裝置（如圖 6）為一個有扇葉的轉軸，加水放進隔熱箱中，並且以溫度計量測水溫，接著讓質量 m 的砝碼自由下降高度 h。重複操作之後，果然水的溫度上升了。轉軸中的轉槳在水中與水摩擦產生的熱量，可由水溫的提高測得，將溫度的改變與水的比熱相乘後，焦耳發現單位機械作功所產生的熱量是一個定值，稱之為「熱功當量」，這是一個前所未有的常數，從實驗所得到運動與熱互相轉換的數據，正式宣告熱質說被捨棄。

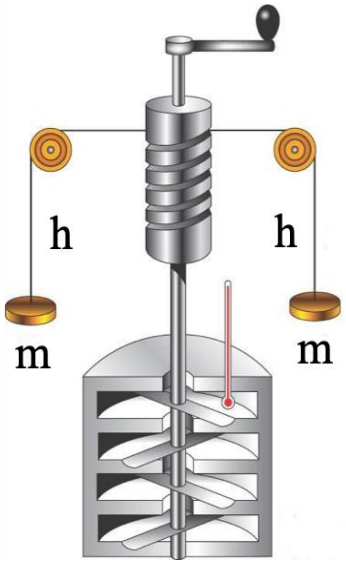


圖 6 熱功當量實驗裝置

資料來源：

a. LIS 情境科學教材

b. 科學 Online 高瞻自然科學資源平台

c. 臺灣化學教育月刊

(1) 雖然燃素說可以解釋大部分物質燃燒時物質減輕的現象，但關於有些金屬在燃燒後質量反而變重，科學家提出了新的主張：「因為有些燃素具有負的質量，所以當金屬失去燃素後，質量反而變重了。」根據科學研究的方法，支持燃素說的科學家應該提出什麼證據來支持此主張？[2]

(A) 金屬和非金屬燃燒時，火焰的顏色並不相同，表示可能存在不同的燃素

(B) 金屬和非金屬燃燒的容易程度並不相同，表示可能存在不同的燃素

(C) 金屬和非金屬燃燒時，質量的變化並不相同，表示可能存在不同的燃素

(D) 金屬和非金屬燃燒後，產生的灰燼溶於水後酸鹼性不同，表示可能存在不同的燃素

(E) 不同物質在相同體積密閉容器燃燒時，所消耗的氣體體積大約相同，表示燃素為所有物質共同含有的元素。

(2) 試說明拉瓦節的鐘罩實驗結果為什麼否定燃素的存在？ [4]

(3) 以下何者現象**無法**用熱質說來說明？ [2]

(A) 熱傳導 (B) 熱對流 (C) 熱輻射 (D) 摩擦生熱 (E) 燃燒

(4) 根據文章，試說明「熱質說」與「熱動說」最大的矛盾之處，並說明熱質說被捨棄的關鍵為何？ [4]

(5) 圖 7 為水在大氣壓下的加熱曲線，哪些線段可以說明「溫度其實不直接等於熱」？（全對才給分） [2]

(A) $\overline{AB}$ (B) $\overline{BC}$ (C) $\overline{CD}$ (D) $\overline{DE}$ (E) $\overline{EF}$

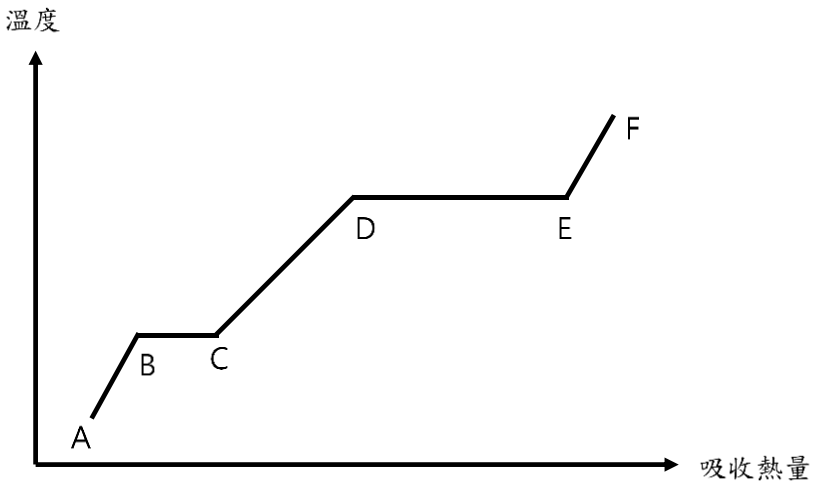


圖 7

(6) 圖 8 為水在不同壓力下與溫度的關係圖，圖中的 P 點為水的三相點，此時水的溫度為 0.01 ℃、壓力為 0.006 atm。

(i) 試說明 T_1 與 T_2 的科學意義。 [2]

(ii) 試說明箭頭 K 的物理變化。 [2]

(iii) 試說明兩種方法，可使氣體與液體共存的溫度點下降。 [4]

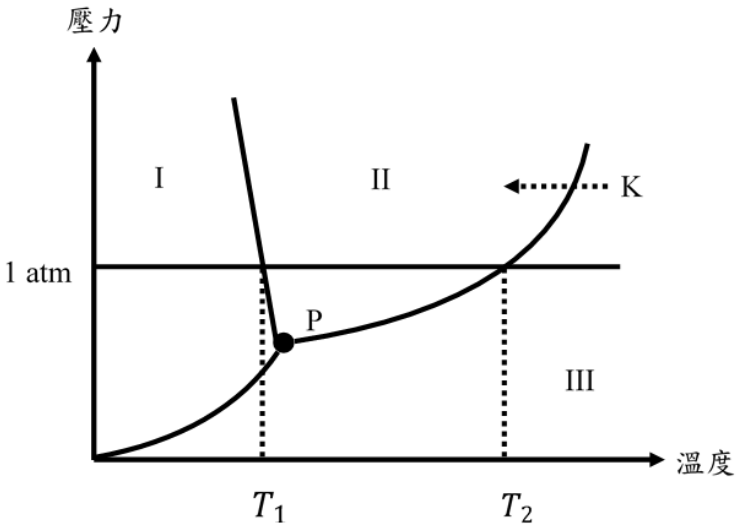


圖 8

(7) 試排列在「熱功當量」實驗中，能量轉變的形式依序為何？（請以代號作答） [3]

(A) 位能 (B) 電能 (C) 生質能 (D) 動能 (E) 核能 (F) 熱能 (G) 太陽能

【Section 2—Mathematics and Science】

Answer all questions and show your working process.

Please answer the following questions in **English** or **Chinese**. You must show the relevant stages in the working. **Language mixing is not allowed**.

Question 1. [Maximum mark: 10]

If the month, the date, and the last two digits of the year form the three sides of a right-angled triangle, we call that day a "Pythagorean Theorem Day". For example, 12/16/2020 is the Pythagorean Theorem Day as $20^2 = 12^2 + 16^2$. There are only two Pythagorean Theorem Days in 2024 and one in 2025 and 2026.

(1) If $m/d/2024$ is a Pythagorean Theorem Day, it means 24, m and d form the three sides of a right-angled triangle, and 24 is not the hypotenuse.

(i) Find the range of m and d. [3]

(ii) Find the Pythagorean Theorem Days in 2024. [4]

(2) According to (1), find the Pythagorean Theorem Days in 2025 and 2026. [3]

Question 2. [Maximum mark: 15]

A regular hexagon is made up of 6 equilateral triangles as shown.

Angle $A\hat{B}C$ is an interior angle of the hexagon.

(1) Find the degree of $A\hat{B}C$. [1]

An artist wishes to create a pattern using regular polygons to tessellate a flat wall.

(2) (i) Use your answer from (1) to explain why it is possible for the artist to use hexagons to tessellate the wall as shown. [2]

(ii) **State** the condition(s) of the interior angle in which a regular polygon can fully tessellate the wall. [3]

(iii) **Show** how only two types of regular polygons amongst all regular polygons with side less than 6 can fully tessellate the wall. [6]

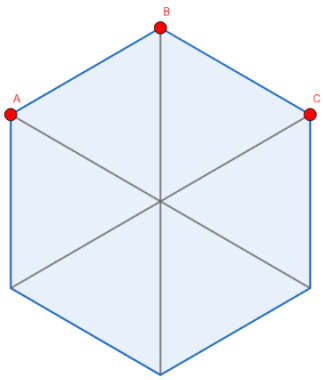


Figure 1

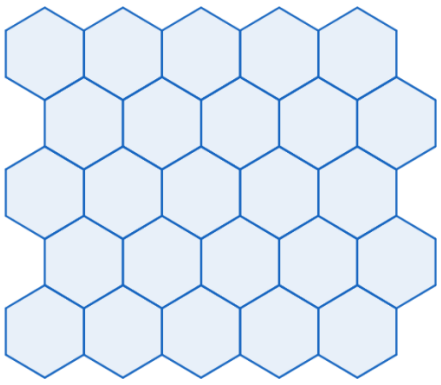


Figure 2

This diagram (as shown in figure 3) represents the floor of a room covered with square tiles. Each square (as shown in figure 4) tile consists of four isosceles right triangles and a regular octagon.

(3) Suppose the length of a side of each square tile is 16 cm. Find the length of the side of the regular octagon. [3]

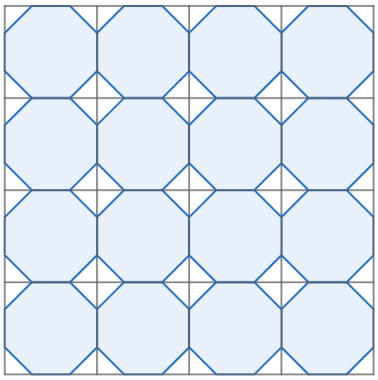


Figure 3

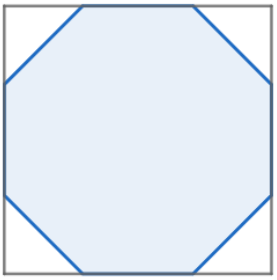


Figure 4

Question 3. [Maxmimum mark: 25]

Read the following article and answer the questions:

The Theory of Combustion and Heat

Smoke occurs when a substance undergoes combustion and the temperature of the surrounding increases in the meantime. What is the substance that is released into the air? Ancient scientists see temperature and heat as synonymous: objects with higher temperature contain more heat.

In 1703, Stahl proposed the phlogiston theory, all combustible substances contain phlogiston. Combustion releases the phlogiston from the substance into the air and left the lighter ashes behind. The residue cannot be burned anymore since there is no phlogiston. However, the theory is challenged that a metal calx is heavier than the metal.

In 1760, Scottish physician and chemist Joseph Black proposed the concept of latent heat. The absorbtion and removal of heat are required in state-changes but the temperature stays the same. This attempts to understand that heat and temperature are seemingly decoupled. Temperature only represents the intensity of hotness and coldness. We can experience the heat flowing between the substances.

In 1777, Lavoisier presented his theory that combustion means the combination with oxygen and disproved the phlogiston theory. Figure 5 shows the Lavoisier's apparatus for studying mercury oxidation in a closed system. The system contained mercury in the resort and normal air sealed by a bell jar placed in the mercury reservoir. After heating the mercury in the resort for 12 days, red mercury oxide was observed on the mercury surface. About one-fifth of the air in the flask was removed during calcination, but the mass of the system was conserved. He discovered the reacting gas volume by measuring the change in the volume of gas throughout this experiment. He also burned lead in a closed container; the mass of the system remained the same until he opened the system, and the mass of the system increased rapidly. The result shows that combustion needs oxygen and the increasing mass after the combustion of metal, and support caloric.

Figure 5. Lavoisier's experiment

Through the process of investigating the nature of heat, Boerhaave made a significant contribution. After a series of experiments, Boerhaave claimed that heat can be treated as a substance that lies within the object. Based on the material theories, heat was an all-pervasive, weightless and elastic fluid, most commonly called *caloric*.

Based on such assumption, Black and Lavoisier employed similar concepts to propose the caloric theory to explain different kinds of phenomenon of thermal physics. For example, thermal conduction was the flow of caloric. Thermal convection was the flow of carriers with caloric. Thermal radiation came from the spread of caloric. They even assumed the repulsive force between two adjacent calorics to explain the reason why the heat caused gas expansion.

More importantly, caloric cannot be created and destroyed. It was conservative. Lavoisier labeled caloric as one of the chemical elements, and named the term calorie after *caloric*. Obviously, the concept that heat is a substance was dominant in the area of thermodynamic at that time.

With the development of science, people started to notice that caloric theory has its limitations and doubt the definition of caloric. The most inexplicable phenomenon is friction heat and the scientists developed another theory which heat consisted in motion to explain it.

In 1789, British physicist Count Rumford, the advocate for kinetic theory of heat, published a report "An Inquiry Concerning the Source of the Heat which is Excited by Friction". In the report, the most famous experiment directed against the caloric theory was the *cannon-boring experiment*, which a solid brass cylinder was hollowed out by a horse-driven drill in the manufacture of cannons. After cannons rotated in the tank of water for 2.5 hours, the 8.5 kg water was boiling. He argued that heat consisted in motion and indefinite amount of heat could be generated by movement.

In 1840, Joule conducted an experiment to prove the heating effect of motion. In this most famous experiment, Joule attached some weights to strings and pulleys and connected them to a paddle wheel inside an insulated container of water. Then he raised the m-kilogram weights to an appropriate h-meter height and slowly dropped them. As they fell, the paddle wheel began to turn and stir up the water. This friction generated heat, and the temperature of the water began to increase.

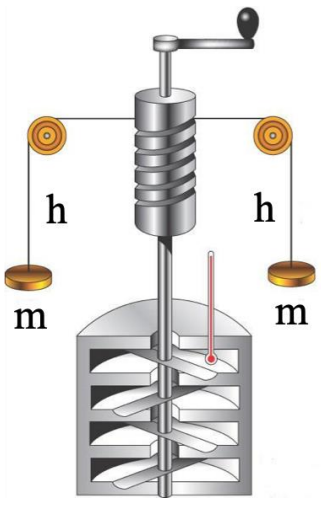


Figure 6. Joule's experiment

He discovered that the heat generated from mechanical work is an absolute value called *mechanical equivalent of heat*. This is an unexpected constant derived from mutual transfer between motion and heat in the experiment. This result further confirmed the relationship of energy transfer between motion and heat and was viewed as the overturn of caloric theory.

Source:

a. Learning in Science, LIS

b. Science Online 高瞻自然科學資源平台

c. Chemistry Education in Taiwan

(1) The phlogiston theory can explain why the mass of most substances decreases after combustion. To the phenomenon that a metal calx is heavier than the metal, scientists have proposed a new claim that some phlogiston has negative mass, so metal calx is heavier after losing the phlogiston. According to the method of scientific research, what evidence should scientists provide to support this claim? [2]

(A) Colours of the flame are different between combustion of metal and non-metal; this means there are different phlogiston.

(B) The reactivity between combustion of metal and non-metal are different; this means there are different phlogiston.

(C) The change of mass between combustion of metal and non-metal are different; this means there are different phlogiston.

(D) The acidity of the solution between the metal and non-metal ashes are different; this means there are different phlogiston.

(E) The consumed volume gas of combustion of different substances are same in the container; this means the phlogiston coexists in all substances.

(2) Explain why the result of Lavoisier's experiment disproves the phlogiston theory. [4]

(3) Which of the following phenomenon cannot be described by the caloric theory? [2]

(A) Thermal Conduction (B) Thermal Convection (C) Radiation

(D) Friction Heat (E) Combustion

(4) According to the article, explain the most significant contradiction between caloric theory and kinetic theory of heat, and explain the reason why the caloric theory was discarded. [4]

(5) The graph below is a heating curve of an air pressure on water. Which line segment illustrates that the temperature does not necessarily equal to heat? (Full score for exactly correct answers.) [2]

(A) $\overline{AB}$ (B) $\overline{BC}$ (C) $\overline{CD}$ (D) $\overline{DE}$ (E) $\overline{EF}$

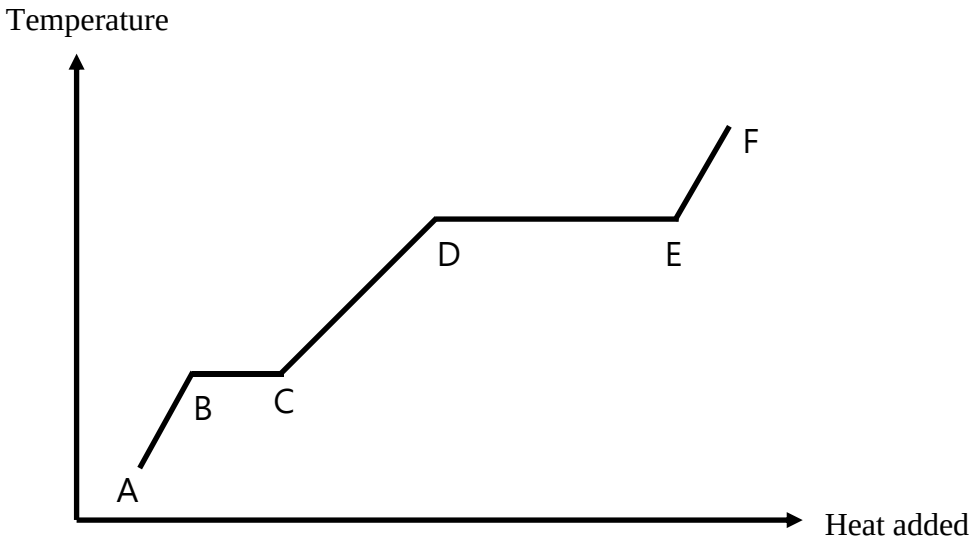


Figure 7

(6) The diagram below is the pressure-temperature relationship for pure water. It shows water boiling at different pressures. Point P is the triple point of water, which the temperature is 0.01 ℃ and the pressure is 0.006 atm.

(i) Explain the scientific meaning of T_1 and T_2. [2]

(ii) Explain the physical changes of K. [2]

(iii) Suggest two methods of lowering the temperature point where gases and liquids can coexist. [4]

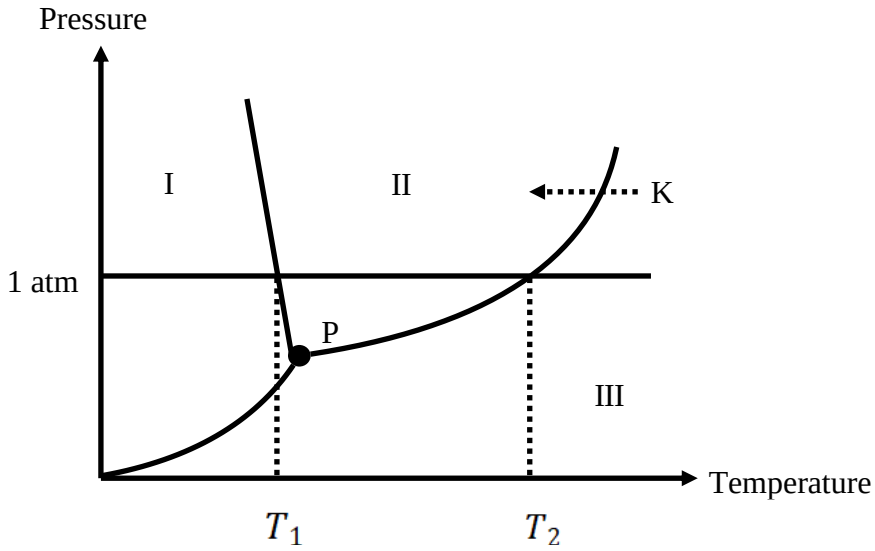


Figure 8

(7) What is the energy transformation in Joule's experiment? (Please answer the question by code.) [3]

(A) Potential energy (B) Electric energy (C) Biomass Energy (D) Kinetic energy

(E) Nuclear energy (F) Thermal energy (G) Solar energy