

活動名稱：藍曬圖與普魯士藍的化學反應機制

攤位：E608

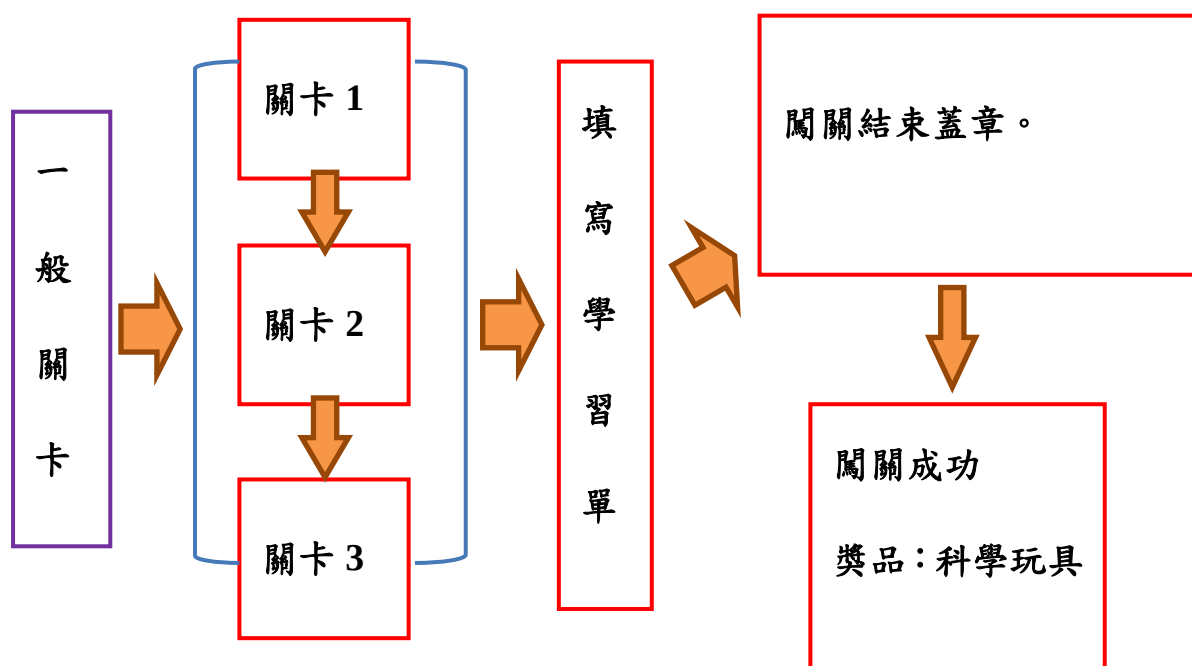
科學家族
Science

校名：陽明國中

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一、活動對象：本市學生及一般民眾

二、闖關流程：



三、闖關活動

第一關 RGB 的變色魔術

可逆的氧化還原反應小遊戲及教學演示

- 1.將綠色檸檬酸鐵銨+橘紅色的赤血鹽以 2:1 比例混合，裝入夾鏈袋中。
- 2.再將氯化銨水溶液加入夾鏈袋中。
- 3.以紫外線驗鈔筆照射混合水溶液，淡綠色的混合液變成藍色。
- 4.再加入氫氧化鈉水溶液，藍色的混合液又變成無色(白色濾紙)。

第二關 自製創意藍晒圖

實驗器材：檸檬酸鐵銨、鐵氰化鉀、濾紙、夾鏈袋、麥克筆、氯化銨水溶液及紫外線燈。

藍晒圖（Cyanotype）實驗步驟

將所有材料放入夾鏈袋中，並使用氯化銨水溶液作為溶劑，這個方法屬於極簡化且快速反應的藍晒實驗，與傳統塗布法略有不同，主要利用藥品在夾鏈袋內混合後直接作用。

實驗步驟（夾鏈袋簡化法）

1. 準備感光液材料
 - (1)重要提醒：由於藍晒反應對光線非常敏感，避免藥品提前感光。
 - (2)藥品混合：將兩種粉末「檸檬酸鐵銨:赤血鹽=2:1」比例混合。
 - (3)放入夾鏈袋：藥品和濾紙放入已用麥克筆繪製圖案的透明夾鏈袋中。
2. 加入溶劑與混合
 - (1)加入氯化銨水溶液：將氯化銨水溶液加入夾鏈袋中。
 - (2)排氣與密封：將夾鏈袋內空氣擠出，密封夾鏈袋。
3. 曝光（紫外線驗鈔筆照射）
 - (1)圖案定位：確認濾紙位於繪製圖案下方，使圖案作為遮光底片。
 - (2)陽光照射：使用陽光均勻照射夾鏈袋上繪有圖案的區域。
 - (3)照射時間：觀察濾紙從淡黃綠色逐漸轉變為深藍灰色/青銅色。
4. 顯影與定影（水洗）
 - (1)取出濾紙：小心打開夾鏈袋，取出已曝光的濾紙。
 - (2)清水漂洗：將濾紙放入清水中快速漂洗。

定影：已曝光區 Fe^{2+} 與赤血鹽反應生成普魯士藍。

顯影：未反應感光劑用水洗去，留下白色圖案。
 - (3)乾燥：晾乾乾燥後，藍色會達到最終的深藍色效果。

第三關 藍晒的反應速率

通常藍晒反應的製作方法必須根據陽光照度，照射長達 1~24 小時之久；此外，除了陽光中的紫外線強度會影響藍晒成功率之外，也受到夾鏈袋遮蔽、檸檬酸鐵銨與赤血鹽的完全反應較長所影響。因此，欲加速藍晒反應速率，可加入「雙氧水」並用「美甲機」的紫外線照射。

1. 強制氧化與快速顯色

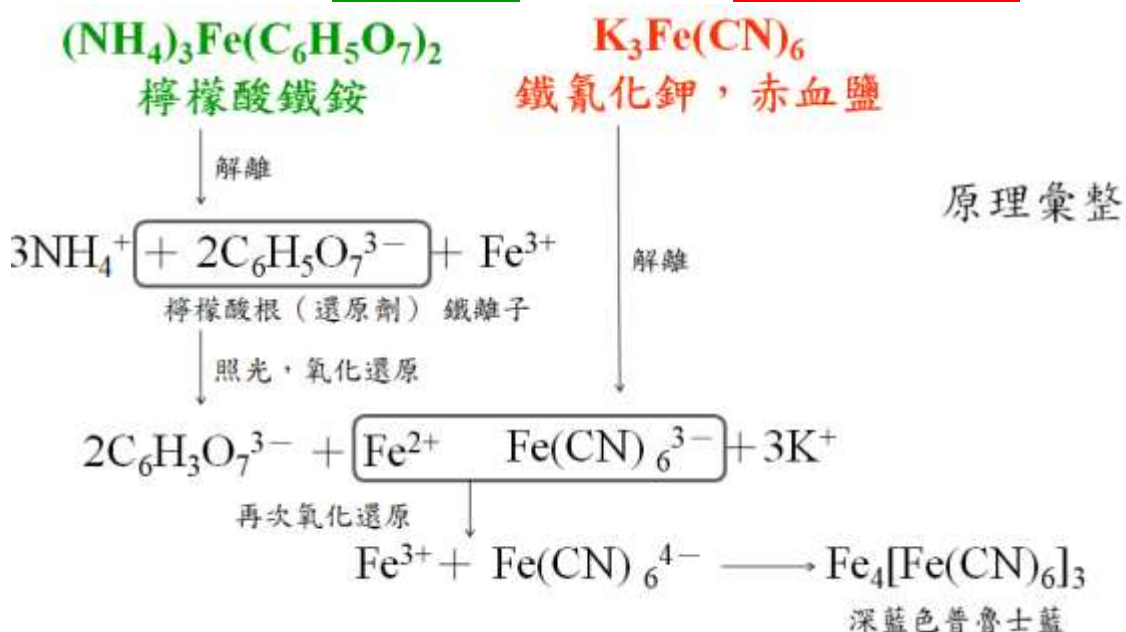
藍晒後將紙張晾乾，讓圖片與空氣中的氧氣接觸自然氧化 24 小時以上，藍色才會達到最深的飽和度。將水洗後的相紙浸泡或噴灑稀釋的雙氧水，雙氧水作為強氧化劑，會在幾秒鐘之內強制完成這個氧化過程，讓「普魯士藍」瞬間形成，省去漫長的等待時間。

2. 增強視覺對比度

使用雙氧水沖洗可以讓藍色部分顯得更加鮮明、艷麗，同時能豐富畫面的中間調。因為顯色速度極快，能讓創作者在現場立刻確認最終的曝光與顯色效果，非常適合教學或需要快速定影的場合。

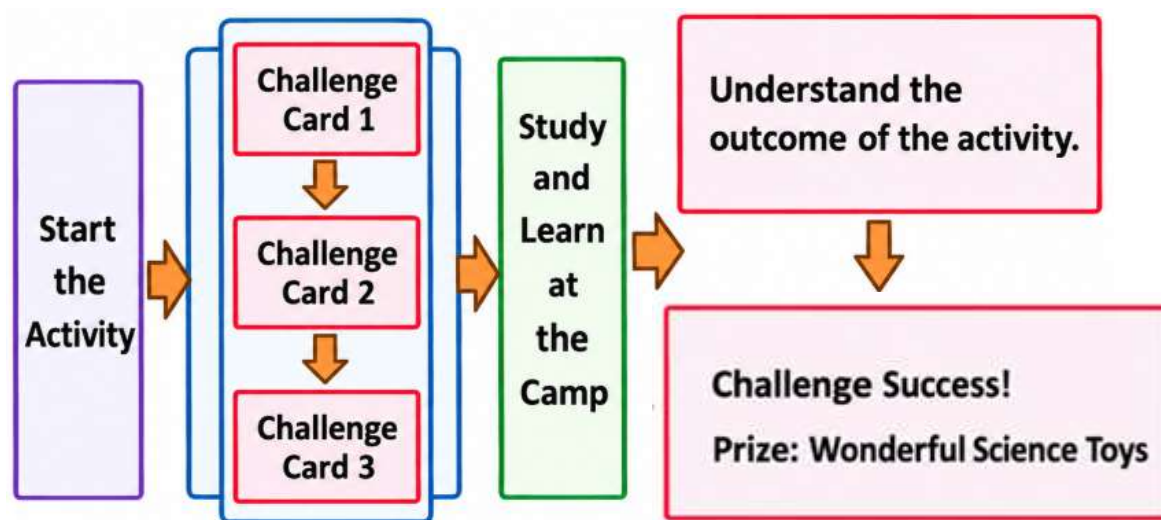
關卡原理

$(\text{NH}_4)_3\text{Fe}(\text{C}_6\text{H}_5\text{O}_7)_2$ 檸檬酸鐵銨 + $\text{K}_3\text{Fe}(\text{CN})_6$ 鐵氰化鉀(赤血鹽)



Chemical Reaction Mechanism of Cyanotype and Prussian Blue

Challenge Activity Procedure:



Science Challenge Stations

Station 1: RGB Color-Changing Magic

A reversible redox reaction game and demonstration

1. Mix **green ammonium ferric citrate** and **orange-red potassium ferricyanide** at a ratio of **2:1**, and place the mixture into a resealable plastic bag.
 2. Add **ammonium chloride solution** to the bag.
 3. Shine a **UV counterfeit-money detector pen** on the mixed solution. The light green solution will change to **blue**.
 4. Add **sodium hydroxide solution**. The blue solution will change back to **colorless** (or appear white when viewed against white filter paper).
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Station 2: Make Your Own Creative Cyanotype

Materials:

Ammonium ferric citrate, potassium ferricyanide, filter paper, resealable plastic bag, marker, ammonium chloride solution, and a UV lamp.

Cyanotype Experiment

Place all the materials into a resealable plastic bag and use **ammonium chloride solution** as the solvent.

This is a **simple and fast cyanotype method**. It is slightly different from the traditional coating method because the chemicals are mixed directly inside the plastic bag and react with the filter paper.

Experimental Steps – Simplified Plastic Bag Method

1. Prepare the Light-Sensitive Materials

(1) Important Reminder:

Cyanotype chemicals are very sensitive to light. **Avoid exposing the chemicals to light before the experiment.**

(2) Mix the Chemicals:

Mix **ammonium ferric citrate** and **potassium ferricyanide** at a ratio of 2:1.

(3) Place Materials in the Bag:

Put the chemicals and filter paper into a **transparent resealable plastic bag**. Draw a design on the bag using a **marker**.

2. Add the Solvent and Mix

(1) Add Ammonium Chloride Solution:

Pour the **ammonium chloride solution** into the plastic bag.

(2) Remove Air and Seal:

Gently squeeze out the air inside the bag and **seal it tightly**.

3. Exposure to UV Light

(1) Position the Design:

Make sure the filter paper is directly under the drawn design. The design will act as a **light-blocking mask**.

(2) Exposure to Sunlight:

Place the area with the design under **even sunlight**.

(3) Exposure Time:

Watch the filter paper change gradually from **light yellow-green** to **dark blue-gray / bronze**.

4. Developing and Fixing – Washing

(1) Remove the Filter Paper:

Carefully open the plastic bag and take out the exposed filter paper.

(2) Rinse with Clean Water:

Place the filter paper in **clean water** and rinse it **quickly**.

Fixing:

In the exposed areas, Fe^{2+} reacts with ferricyanide to form Prussian blue.

Developing:

The unreacted light-sensitive chemicals are washed away with water, leaving the **white image**.

(3) Drying:

Hang the paper up to dry. After drying, the blue color will gradually become **deep blue**.

Station 3: Cyanotype Reaction Rate

Normally, cyanotype printing depends on the intensity of sunlight, and exposure may take **1 – 24 hours**.

In addition to the intensity of UV light from sunlight, the reaction can also be affected by the plastic bag blocking some light and by the time required for **ammonium ferric citrate** and **potassium ferricyanide** to react completely.

Therefore, to speed up the cyanotype reaction, **hydrogen peroxide (H_2O_2)** can be used together with a **UV nail lamp**.

1. Forced Oxidation and Rapid Color Development

After cyanotype exposure, the paper is usually allowed to dry and **contact oxygen in the air for more than 24 hours**. This natural oxidation process allows the blue color to reach its deepest saturation.

If the washed print is soaked in or sprayed with **diluted hydrogen peroxide**, the hydrogen peroxide acts as a strong oxidizing agent and can **accelerate the oxidation process within seconds**.

As a result, **Prussian blue develops rapidly**, greatly reducing the waiting time.

2. Enhance Visual Contrast

Rinsing the print with hydrogen peroxide can make the blue areas appear **brighter and more vivid**, while also enhancing the mid-tones of the image.

Because the color develops very quickly, participants can see the final exposure and color effect immediately. This makes the method especially suitable for science education activities, demonstrations, and situations where rapid development is needed.

Principle of the Activity

$(\text{NH}_4)_3\text{Fe}(\text{C}_6\text{H}_5\text{O}_7)_2$ (Ammonium Ferric Citrate)

$\text{K}_3\text{Fe}(\text{CN})_6$ (Potassium Ferricyanide (Red Prussiate of Potash))

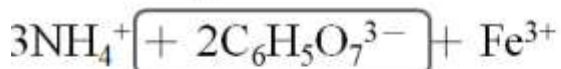


檸檬酸鐵銨



鐵氰化鉀，赤血鹽

解離



檸檬酸根（還原劑） 鐵離子

解離

原理彙整

照光，氧化還原



再次氧化還原



深藍色普魯士藍