Let's Read !

■ Metals

In metals, **positively charged** metal ions and negatively charged **outer shell electrons** of metals are **attracted** to each other by **electrostatic forces**. The electrons which are not attached to the **nucleus** of an **atom** and free to move are called **free electrons**. This **chemical bond** that occurs between atoms of metallic **elements** is called a **metallic bond**. This metallic bond leads to the three-dimensional structure of metal atoms being arranged in a regular pattern. Because electrons are free to move around, metallic bonds explain many physical **properties** of metals.

- **Electrical Conductivity**

  Most metals are excellent electrical **conductors** because these free electrons allow metals to **conduct** an **electric current**. Metals conduct heat for the same reason.

- **Ductility**

  Metals are able to be drawn into thin wires because bonds between atoms can easily break and reform. Entire sheets of atoms can slide past each other and reform bonds, as shown in Figure 1.

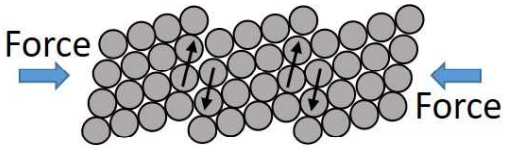


Figure 1. Crystal structure under force

- **Malleability**

  Metals can be **flattened** into thin sheets by hammering or rolling them, again because bonds between atoms can easily break and reform.

- **Metallic Luster**

  Metals tend to be shiny. The free electrons can move freely in the metal causing any light that shines on them to be **reflected** back. In the case of gold or **copper**, it absorbs parts of the visible spectrum and shows particular colors.

Understanding Main Concepts

1. Outer shell electrons of metals are called
   a. protons. **b.** neutrons. **c.** elements **d.** free electrons.

2. A physical property of metals that can be flattened into metal leaf is
   a. an electrical conductivity **b.** a ductility **c.** a malleability **d.** metallic luster

■ Oxidation-Reduction Reaction

If you drop a nail on a road, it will **rust** after a while because it gets wet from the rain. When we use bleach, dirt becomes clean. This is the result of an **oxidation-reduction reaction**.

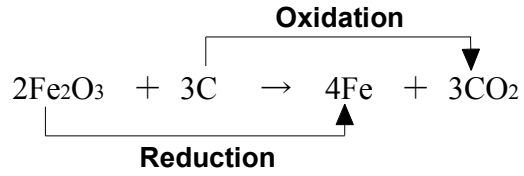
Look back in detail at one of the examples above. When you heat iron, the iron **combines** with **oxygen** to form a mixture of blackish iron(II) and iron(III) **oxides** at its surface. The reaction in which **matter** combines with oxygen is called oxidation.

$2\ Fe + O_2 \rightarrow 2\ FeO$

$2\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$

At room temperature, however, all these reactions are so slow they can often be ignored. Iron rusts only at room temperature in the presence of both oxygen and water.

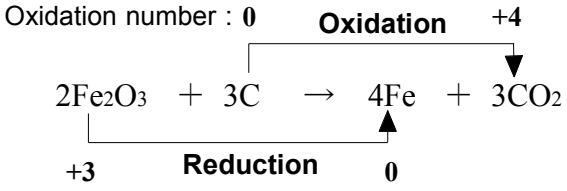
At **steelworks** like Nippon Steel, for example, they take out iron from **iron ores** using a big **furnace** every day. When you **heat** iron oxides with **coke** at a high temperature, iron is obtained. The reaction in which matter loses oxygen is called reduction.



The terms oxidation and reduction can be **defined** in terms of combining or losing oxygen to/from matter. These are old **definitions** which are not used very much these days. Because both oxidation and reduction are occurring at the same time, these Oxidation-Reduction Reactions are defined in terms of electron **transfer**.

- Oxidation is loss of electrons
- Reduction is gain of electrons

This definition can be extended to **chemical reactions** in which a complete electron transfer does not occur. We use an artificial count called the **oxidation number** to keep track of electrons in atoms. Oxidation numbers are not necessarily equal to the **charge** on the atom.



Understanding Main Concepts

1. The red or orange coating that forms on the surface of iron when it is oxidized is called
   a. an erosion. **b.** a decomposition. **c.** a luster. **d.** rust.

2. What is used as a reducing agent in a furnace to take out iron from iron ore?
   a. coal **b.** coke **c.** charcoal **d.** hydrogen

【Vocabulary】

本文（Metals）			
positively	adv	正（陽）電気で	
charge	verb	帯電する	store electrical energy in
outer shell electron	noun	外殻電子	
attract	verb	引きつける	
electrostatic forces	noun	静電気力	
nucleus	noun	原子核	
atom	noun	原子	the smallest particle of a chemical element
free electron	noun	自由電子	
chemical bond	noun	化学結合	
element	noun	元素	
metallic bond	noun	金属結合	
property	noun	特性、性質	a characteristic of something
electrical conductivity	noun	電気伝導性	
conductor	noun	導体	a substance that allows electricity or heat to pass along it or through it
conduct	verb	〈熱、電気、音などを〉伝える	to allow electricity or heat to pass along it or through it
electric current	noun	電流	
ductility	noun	〈金属などの〉延性	
malleability	noun	〈金属などの〉展性	
flatten	verb	平らにする、平らに伸ばす	
metallic luster	noun	金属光沢	
reflect	verb	反射する	throw back（heat, light）without absorbing it
copper	noun	銅	
本文 (Oxidation-Reduction Reaction)			
rust	verb	〈鉄などが〉さびる	
oxidation-reduction reaction	noun	酸化還元反応	oxidize: 酸化する　reduce: 還元する
combine	verb	結びつける、化合させる	to come together to form a single thing or group
oxygen	noun	酸素	
oxide	noun	酸化物	
matter	noun	物質	physical substance or material in general
steelworks	noun	製鋼所	
iron ore	noun	鉄鉱石	
furnace	noun	溶鉱炉	
heat	verb	加熱する	make or become hot or warm
coke	noun	コークス	
define	verb	定義をする	
definition	noun	定義	an explanation of the meaning of a word or phrase
transfer	noun	移動	
chemical reaction	noun	化学反応	
oxidation number	noun	酸化数	
charge	noun	電荷	
授業			
confirm	verb	確認する、確かめる	to state or show that something is definitely true or correct, especially by providing evidence
product	noun	生成物	a result of an action or process

■ Tatara Iron Making

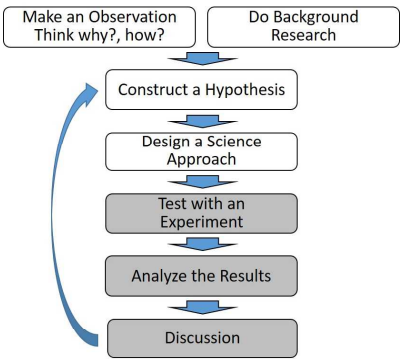
English Science

Words learned through English Science

Point!

Analyze the Results

Scientific Approach



●課題を解決するための科学的手法の１つに、「仮説を検証するために適切な実験、観察、調査等を行うこと」があります。仮説の真偽は、実験等を行い、事実に沿って検証することが重要です。得られた結果は、ありのまま使用しなければいけません。たとえ予想と違った結果となっても事実として受け入れることが大切です。実験結果に影響を与える要因が潜んでいて予想とは違った結果になる場合や失敗だと思っていたことが予想外の新たな発見に繋がる場合もあります。また、条件が違うと異なる結果になる場合もあります。そのため、実験によって得られた結果は、本当に目的としたものなのかを確かめる必要もあります。すなわち、得られたデータの**信頼性**が保証される必要があります。

実験結果について、①結果の原因は何か、②どうしてそのような結果になるのか（背後に科学的な過程が潜んでいないか）、③結果は一般化できるか、**④結果は正しいのか**、などの考察を行います。

ここでは、実験結果そのものが正しいのかを吟味することに着目して、実験を行いましょう。

It's Your Turn -Activities with TA-

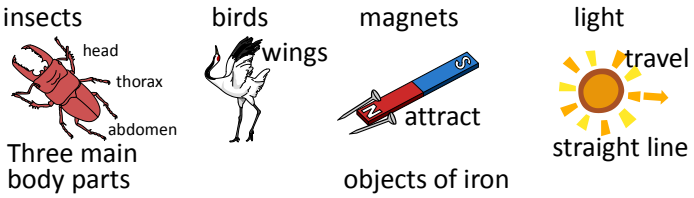
Useful Expression.

property ：特性、固有性 、性質（物質や現象がもともと持っている特性）
characteristics：特性、特色（物、事、人が持つ典型的な特性）

【Role play】

A: What is a characteristic of insects?
What is a characteristic of birds?
What is a property of magnets?
What is a property of light?

B: Insects have three main body parts (head, thorax, and abdomen).
Birds have wings.
Magnets attract objects of iron.
Light travels in a straight line.



Initial Observation & Information Gathering

Observation 1

Let's watch a short video of Tatara iron making. Then discuss what reactions were happening in the furnace. What is the key word to express this event? If necessary, use the chemical reaction equation below to explain.

$2Fe_2O_3 + 3C \rightarrow 2Fe + 3CO_2$

Hypothesis & Science Approach

You already know the method of heating charcoal powder using a microwave oven. Now by looking at this video, you remembered the lecture of last week that people first began to take out copper from ore around 5,000 BC and an interesting idea flashed through your mind "Will it be possible to take out copper from ore using a microwave oven?"

Activity 1

Write down the appropriate words to complete the blanks, and confirm the hypothesis and the science approach of this experiment.

Aim of your research	:	To develop a method to take out metal from ore at a laboratory level.
Research question	:	Can we take out copper from a copper oxide by applying oxidation-reduction reactions using a microwave oven?
Hypothesis	:	_____ will be taken out from copper oxide by heating the oxide with charcoal powder using a microwave oven.
Copper oxide	:	Malachite.
Independent variable	:	Heating time.
Dependent variable	:	Properties (color, shape, etc.) of the product.
The answer I will expect	:	Copper will be taken out from malachite.

Case A

A1 Test with an Experiment & Analyze the Results -Verify Data (Is it true?)-

Describing an Experiment

In this experiment, malachite (0.31g, 0.32g, 0.32g and 0.34g) was put in a ceramic melting dish (inner diameter: 50 mm, height:10 mm) respectively with charcoal powder of half the volume of the ceramic melting dish and covered with a ceramic lid. Then we tested the difference of products' shape for each dish after heating for 1 minute, 2 minutes, 3 minutes and 4 minutes respectively in a microwave oven (600 W).

Now you have a product from the above experiment. You expect the product is copper.

Describing Events

- No significant differences were found between the malachites heated for 1 minute and for 2 minutes.
- The malachite heated for 3 minutes has changed surface color to reddish brown, but the shape has not changed.
- When malachite was heated for 4 minutes, a product shaped sphere was obtained.

A2 Discussion

Interpreting Results

The shape of the obtained product after heating it for 4 minutes was a sphere, this shows that the product melted once. This changing of shape can be understood as copper produced from malachite through the reaction: $Cu_2CO_3(OH)_2 + C \rightarrow 2Cu + 2CO_2 + H_2O$, then the copper melted once because the temperature reached the melting point of copper（1085 ℃）.

Drawing Conclusions

In conclusion, the results **indicated** that our method can take out copper from copper oxide by heating the oxide for 4 minutes with charcoal powder using a microwave oven.

Case B

B1 Test with an Experiment & Analyze the Results -Verify Data (Is it true?)-

Thinking Critically

Activity 2

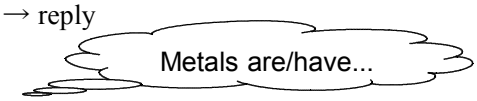
You expect the product is copper. How do you know? What knowledge can you use?

【TAs Question】

Q1.

【Your Answer】

→ reply



★ Remember what you have studied in junior high school.

Activity 3 What experiment can you do to be sure that the product is metal?

【TAs Question】

What experiment will you design?

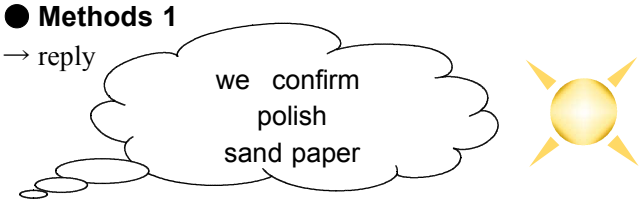
● **What is known** -How to use your knowledge-

1. Metals have (　　).

【Design an Experiment and Let's Try It】

● **Methods 1**

→ reply



Describing Events

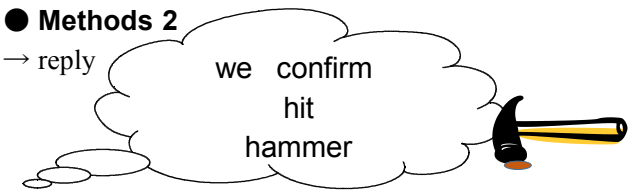
・ When the product was polished with sand paper, the product showed a _____ _____.

● **What is known** -How to use your knowledge-

2. Metals have (ductility and _____).

● **Methods 2**

→ reply



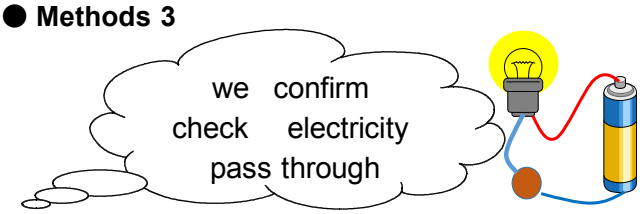
Describing Events

・ When the product was hit with a hammer, the product showed a _____.

● **What is known** -How to use your knowledge-

3. Metals have (　　).

● **Methods 3**



Describing Events

- When wires were connected in series to a battery, a bulb and the product, the product showed _____ _____.

B2 Discussion

Interpreting Results

The shape of the obtained product after heating it for 4 minutes was a sphere, this shows that the product melted once. This changing of shape can be understood as copper produced from malachite through the reaction: $Cu_2CO_3(OH)_2 + C \rightarrow 2Cu + 2CO_2 + H_2O$, then the copper melted once because the temperature reached the melting point of copper（1085 ℃）.

Making Predictions & Evaluating Results

If the obtained product after heating for 4 minutes is a metal, this product must have typical properties of metal: metallic luster, malleability and electrical conductivity. In order to confirm whether this obtained product is metal, we tested three properties. The results confirmed three properties.

Drawing Conclusions

In conclusion, the results **showed** that our method can take out copper from copper oxide by heating the oxide for 4 minutes with charcoal powder using a microwave oven.

Case C

C1 Test with an Experiment & Analyze the Results -Verify Data (Is it true?)-

Describing an Experiment

In this experiment, malachite（0.31g, 0.32g, 0.32g and 0.34g） was put in a ceramic melting dish（inner diameter: 50 mm, height:10 mm） respectively with charcoal powder of half the volume of the ceramic melting dish and covered with a ceramic lid. First, we tested the difference of products' shape for each dish after heating for 1 minute, 2 minutes, 3 minutes and 4 minutes respectively in a microwave oven（600 W）. Then, we measured the mass of the obtained product after heating for 4 minutes. Finally, flame test carried out on the small particle taken out from the product.

Describing Events

- The mass of the product obtained after heating for 4 minutes was 0.19 g
- The color of the flame was green.

C2 Discussion

Interpreting Results

The shape of the obtained product after heating it for 4 minutes was a sphere, this shows that the product melted once. This changing of shape can be understood as copper produced from malachite through the reaction: $Cu_2CO_3(OH)_2 + C \rightarrow 2Cu + 2CO_2 + H_2O$, then the copper melted once because the temperature reached the melting point of copper（1085 ℃）.

Making Predictions & Evaluating Results

If the obtained product after heating for 4 minutes is a metal, this product must have typical properties of metal: metallic luster, malleability and electrical conductivity. In order to confirm whether this obtained product is metal, we tested three properties. The results confirmed three properties. Moreover, the color of metallic luster was reddish-brown.

Making Predictions & Evaluating Results

The molar mass of $Cu_2CO_3(OH)_2$ and Cu are 223 g/mol and 63.5 g/mol respectively. Using the reaction: $Cu_2CO_3(OH)_2 + C \rightarrow 2Cu + 2CO_2 + H_2O$, 0.19 g of Cu can be calculated to obtain from 0.34 g of malachite. This value coincided with our result.

Making Predictions & Evaluating Results

If the obtained product after heating for 4 minutes is copper, the color of its flame during a flame test should be green. The color coincided with our result.

Drawing Conclusions

In conclusion, the results **demonstrated** that our method can take out copper from copper oxide by heating the oxide for 4 minutes with charcoal powder using a microwave oven.

Activity 4

In a scientific research, you conduct an experiment to identify the hypothesis that "Copper will be taken out from minerals by applying oxidation-reduction reactions". Discuss with your group what is the difference between the cases below. Then write down the best single English word which represents the difference.

Case A: Finish your experiment when you got the product.
Case B: Finish your experiment when you checked the product for the three properties of metal.
Case C: Finish your experiment when you identified the product is copper.

Case C has more（　　）than Case A in order to conclude that the product is copper.

Manufacturing Technology and Culture

Primitive iron-making was started with iron ore and iron sand as raw materials. This iron-making technique developed as "tatara iron making" in Japan in the 6th century. The people who worked to make tatara iron all lived together in a little iron town.

The iron produced from iron sand with this method is called "tamahagane" and contains two products which are hard iron and soft iron. Japanese swords are made by repeatedly heating, hammering and folding these two irons.

This is the starting point of manufacturing technology and culture in Japan.

Scientific Communication

方法（Methods）で使う英語表現

1　結果の吟味を説明する表現

We verified/confirmed whether ..., We verified ... as ... by several/additional experiments/test.
In order to verify/confirm ..., we tested/carried out several experiments.,
To verify this method, ... was compared with ... ., Finally, additional tests were performed on the ....

Exercise 1

1. Using the underlined phrases above, explain how we confirmed the product as metal in case 3 to a partner of your group. Then write down the sentences.

In order to verify (　　), (　　) was compared with (　　).

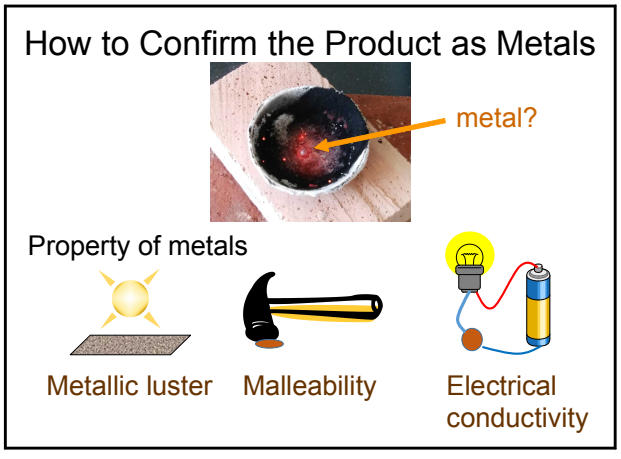
2. Rewrite the following sentence using the passive voice.

We verified whether this obtained product is metal, we tested three properties; metallic luster, ductility and malleability, and conductivity.

In order to verify whether this obtained product is metal, (　　).

Exercise 2

Let's try to have a presentation using the follwong slide in order to explain how to confirm the product as metals.



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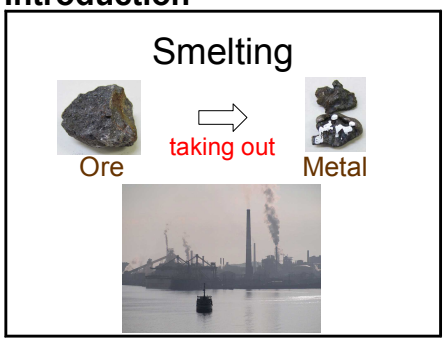
【Presentation Exercise】 Let's try to have a presentation using the follwong slides and script.

Introduction



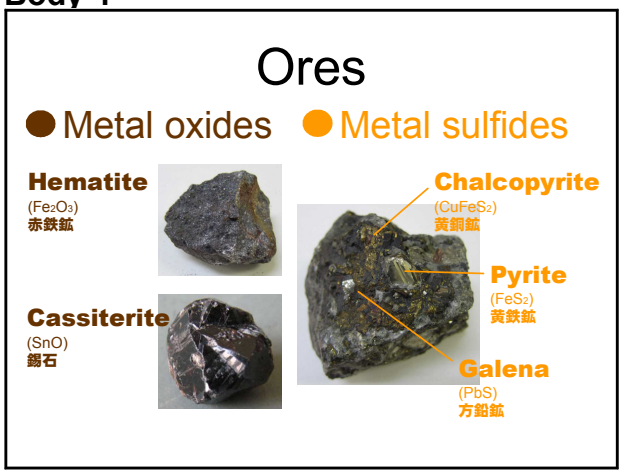
・Today I' m going to talk about smelting.

・Smelting is a process of taking out a metal from an ore.

・Do you know how to take out a metal?

Smelting:製錬
ore:鉱石

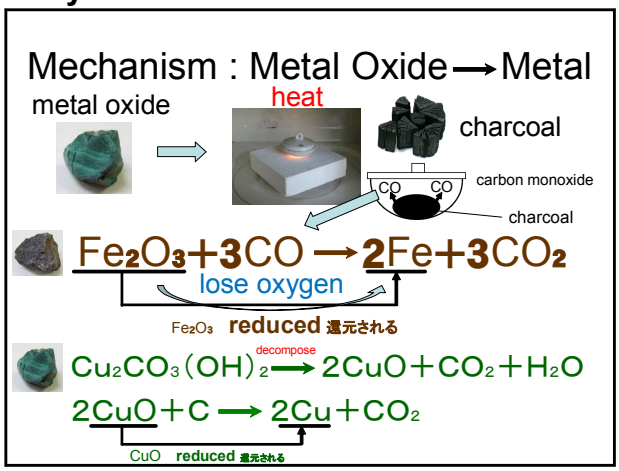
Body 1



・Generally, most metals exist in nature as ores of metal oxides or metal sulfides.

oxide:酸化物
sulfide:硫化物

Body 2

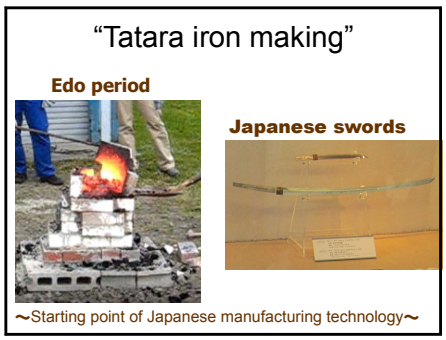


・Look at this chemical equation.

・If metal oxide is heated with charcoal, the metal oxide loses oxygen, and is therefore reduced and the metal can be obtained.

chemical equation:化学反応式

Conclusion & Reference



・In the Edo period, we took out iron through "Tatara iron making".

・This iron has been used for producing Japanese swords. This is the starting point of Japanese manufacturing technology.

・Thank you for listening.

Extensions -Integrating Mineralogy-

It's Your Turn -Activities with TA-

Useful Expression.

identify … : … 同定する、見極める

【Role play】

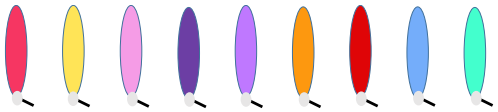
A: What does the mother identify?

B: She/He identifies the voice of children.
The doctor identifies the disease.
The geologist identifies the fossils.
The earth scientist identifies the cause of earthquake.

mother	doctor	geologist	earth scientist
			
voice of children	disease	fossil	cause of earthquake

● Scientific Methods

In chemistry, there is a method called flame reaction to detect the presence of certain elements, primarily metal ions. The following is the color of the flame when the metals were heated in a flame.



Applying Scientific Methods

Discussion 1

Observe and compare the samples of celestite, malachite and halite. Talk about what you think and wonder about in groups and what questions you can solve if you apply this scientific method.

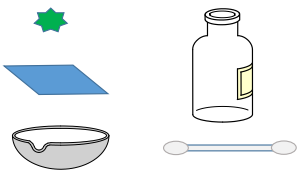
celestite malachite halite

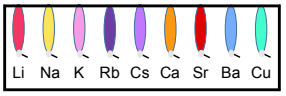
Activity 1

In this experiment, we already know that a flame reaction is useful to identify the metallic elements. Design an experiment using the materials and apparatus on the desk and explain the process of how to identify the elements contained in the minerals. Then try the experiment and identify the elements contained in the minerals.

Research question : What is the chemical composition of the samples?
Aim of you research : To identify the elements contained in the minerals.

Explain your idea how to identify the elements:





Mineral	Color of the flame	Identified elements
Celestite		
Malachite		
Halite		

Fireworks

The beautiful colors of fireworks are using the flame reaction

Red : lithium carbonate, Li_2CO_3 = red
strontium carbonate, $SrCO_3$ = bright red
Orange : calcium chloride, $CaCl_2$
calcium sulfate, $CaSO_4 \cdot xH_2O$
Gold : incandescence of iron（with carbon）, charcoal,
Yellow : sodium nitrate, $NaNO_3$
cryolite, Na_3AlF_6
Green : barium chloride, BaCl+ = bright green
Blue : copper（I） chloride, CuCl = turquoise blue

吹管分析 blowpipe analysis

18 世紀の古典的な分析法の一つ。鉱物の粉末を木炭のくぼみに詰め、息を L 字型のパイプの先端からアルコールランプなどの炎に吹きつけ、その炎が鉱物の粉末に当たったときの吹管炎の色や溶融状態を観察して、鉱物の成分元素を判定する方法。19 世紀にブンゼンらが確立した分光分析法に置き換わっていった。

ただし、研究結果を応用することをテーマとした今回の実験と歴史的な研究の流れとは一致していない。

Scientific Communication

考察（Discussion）で使う英語表現 1

1 発展の可能性を提案する表現

In our opinion / view, this method could be used in...,
We believe / think that our findings / approach could / might be useful for...,
This results in the present investigation suggest that this approach could also be useful for ...,
The technique/approach/result is applicable to .

Exercise 1

Using the underlined parts above, suggest possible application of flame reaction to a partner of your group. Then write down the sentences.

We believe that ( ) could be useful for ( ).

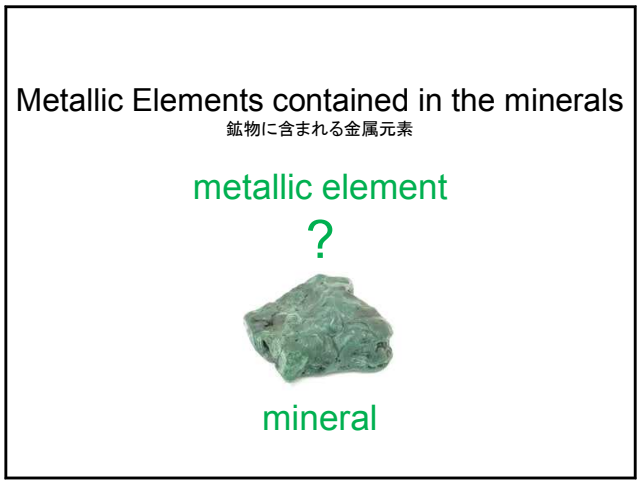
Exercise 2 Rewrite the following sentences using the wavyline parts above.

We believe that flame reactions could be useful for identifying elements from minerals.

( ) are applicable to ( ).

【Presentation Exercise】 Let's try to have a presentation using the following slides and script.

Introduction



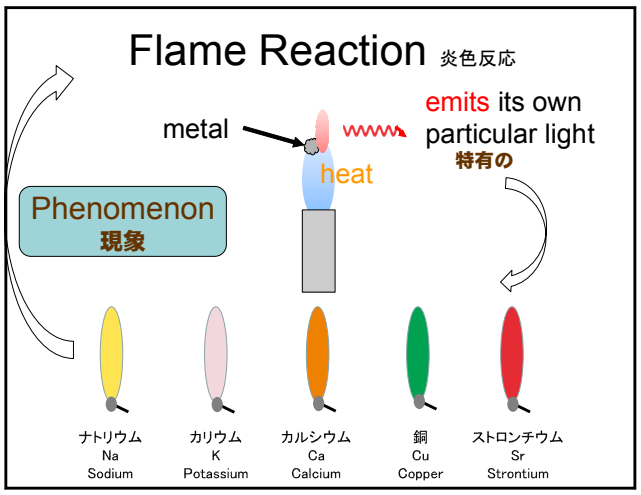
・My name is

・Today, I will be talking about "Metallic Elements" contained in the minerals.

・Do you know what a Flame Reaction is?

・OK. I'll explain it to you.

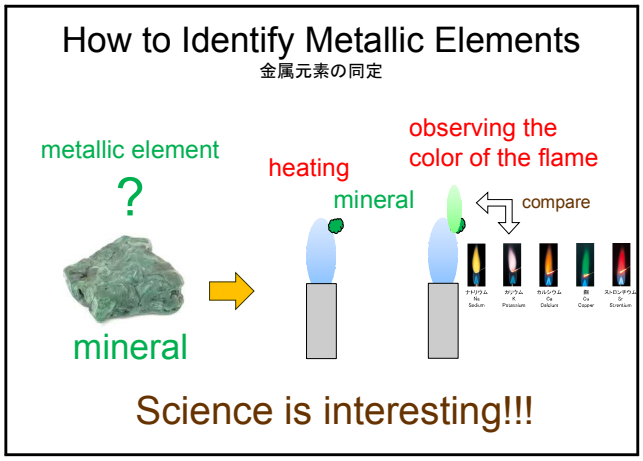
Body



・If a metal is heated, the metal emits its own particular light.

・This phenomenon is called a Flame Reaction.

Conclusion & Reference



・So, by heating the mineral and observing the color of the flame, we can check the metallic element contained in the minerals.

・I think science is interesting.

・Don't you think so?

・Thank you for listening.

Exercise 3

Let's try to have a presentation using the following slide in order to explain the methods of your experiment.