**Learning & Teaching Resources**

**for Science (S1-3) Curriculum (2017)**

**Unit 13 From atoms to materials**

**From Mixtures to Alloys**

**Student Version**

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*(Developed by Hong Kong Association for Science and Mathematics Education)*

**Learning Objectives**

After the activities, you are able to:

* recognise that alloys are made by adding other elements into metals for the improvement of the properties of the metals;
* conduct experiments to test the properties of alloy and its constituent metals; and
* give examples of alloys and their common uses.

**Activity 1：To compare the physical properties of two groups of material**

**Materials and Apparatus:**

* Unknown metal samples: X1 and X2 1
* Unknown alloy samples: Y1 and Y2 1
* Multimeter 1

**Safety precautions:**

* Be aware of the sharp edge when handling the materials during the experiments.

**Procedures:**

1. Measure the conductivity of the samples X1, Y1, X2 and Y2 by using a multimeter.
2. Test the hardness of the samples by bending the sample.
3. Record the results in the table below:

|  |  |
| --- | --- |
| **Physical****properties** | **Results** |
| Conductivity | X1: Ω | Y1: Ω |
| X2: Ω | Y2: Ω |
| Hardness | X1 / Y1 is easier to bend.X2 / Y2 is easier to bend. |

**Conclusion:**

1. As compared with that of alloy samples, metal samples have  **higher / lower**  conductivity and are  **harder / softer** .

**Activity 2：To understand the physical properties of alloys**

Alloys are made by adding other elements into metals for improvement of the properties of the metals to fit a certain purpose.

Compare with pure metals, alloys are generally:

(1) of lower melting points;

(2) of lower conductivity;

(3) harder; and

(4) have higher corrosion resistance.

1. Search information about alloys listed from the internet and complete the table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Alloy** | **Constituent elements** | **The properties of alloy and****its constituent metals** | **Example of use** |
| Brass |  | * Stronger than both metal
* With golden colour
 |  |
| Bronze |  | * Stronger than both metals
* Corrosion resistant
 |  |
| Stainless Steel |  | * Harder than iron
* Very corrosion resistant
 |  |
| Leaded solder |  | * Melting point lower than the metals of the constituent elements
 |  |

2. The properties of alloys vary with their percentage compositions of their constituent elements.

 For example, Brass with around 85% copper and 15% zinc is in colour, while Brass with around 60% copper and 40% zinc is in colour.

3. Is brass a mixture or compounds? Why?

**Activity 3：Magnetic property of some alloys**

A few alloys have magnetic properties. Conduct the following experiment to compare the magnetic properties of Alnico magnet and Neodymium magnet.

**Materials and Apparatus:**

|  |  |  |
| --- | --- | --- |
| * Alnico magnet (AlNiCo Alloy)
 | Alnico | 1 |
| * Neodymium magnet (NdFeB Alloy)
 | Neodymium | 1 |
| * Paper clips
 |  | 400 |

**Procedures:**

1. Use the alnico magnet to attract the paper clips. Find out the maximum number of paper clips that can be attracted by the magnet. Record the results in the following table.
2. Repeat step 1 by neodymium magnet.



|  |  |  |
| --- | --- | --- |
|  | **Alnico magnet****(AlNiCo Alloy)** | **Neodymium magnet (NdFeB Alloy)** |
| Base metal | Iron (Fe), 51% | Iron (Fe), 66% |
| Other substances | Cobalt (Co), 24%Nickel (Ni), 14% Aluminium (Al), 8%Copper (Cu), 3% | Neodymium (Nd) ,29% Dysprosium (Dy), 3%Boron (B), 1% |
| Number of paper clips attracted by the magnets |  |  |

**Conclusion:**

1. What conclusion can you draw from this experiment?

**Discussion questions:**

1. Name one possible use of Neodymium magnet in industry.

**Activity 4：Smart Materials**

*Nitinol* (Nickel titanium), known as shape memory alloy, has many applications. Conduct the following experiments to find out the properties of *Nitinol*.

**Materials and apparatus:**

* Samples of *Nitinol* wire with different shapes 1
* 250 ml Beaker 2
* 250 ml hot water (40oC) 1
* 250 ml hot water (55oC) 1

**Procedures:**

1. Deform the shape of the sample of *Nitinol* wire.

2. Put the *Nitinol* wire into a beaker of 40oC water. Record the observation in the table below.

3. Take out the *Nitinol* wire from the beaker. Put the *Nitinol* wire into another beaker containing 55oC water. Record the observation in the table below.

4. Repeat steps 1 to 3 using another sample of *Nitinol* wire.

5. Record the results in the table on the next page.

**Results:**

|  |  |
| --- | --- |
|  | **Observations** |
| ***Nitinol* wire sample 1** | ***Nitinol* wire sample 2** |
| In 40oC water |  |  |
| In 55oC water |  |  |

**Conclusion:**

1. What conclusion can you draw from this experiment?

**Discussion questions:**

1. Name one possible use of *Nitinol*.

**Activity 5：To write an engineering consultant report on the problem related to leaded solder**

**Situation:**

In a developing district, a building project is underway. The project developer are tasked to install pipelines in some new buildings. Recently, it was reported that lead was found in the tap water from the new buildings. It is suspected that the contractors might have used leaded solder for welding the water pipes.

**Task:**

**Your team have to design a tool kit** for performing on-site checking of the solder sample, and to **prepare a proposal using the proposal form** on the next page.

The tool kit will be used to identify lead free solder (99.3% Sn, 0.7% Cu) from Leaded solder (63% Sn, 37% Pb) through testing (i) the density and / or (ii) the conductivity of thesamples.

You may consider the following criteria when designing the tool kit:

|  |  |
| --- | --- |
| **Aspect for consideration** | **Criteria** |
| Applicability | Tests applicable to various forms of sample, e.g. samples in lump, wire and powder forms. |
| Convenience | The lesser the total number of apparatus, instrument and chemical involved will be better. |
| Reliability | Obtain consistent results between repeated tests. |
| Testing time | Shorter testing time, preferably 3 minutes or less, is desirable. |
| Cost | Lower cost, preferably $250 or less, is desirable. |
| Weight | Lighter in weight, preferably 1 kg or less, is desirable. |
| Durability | The materials in the tool kit can be reused. |

Data for reference:

|  |  |  |
| --- | --- | --- |
| **Physical Property** | **Lead free solder** **(99.3% Sn, 0.7%Cu)** | **Leaded Solder** **(63% Sn, 37%Pb)** |
| Melting Point | Higher (232oC)  | Lower (183oC) |
| Density | Lower (7.3 g/cm3) | Higher (8.5 g/cm3) |
| Conductivity | Higher (13 unit) | Lower (11.9 unit) |

**Materials and Apparatus:**

* Common laboratory apparatus
* Solder samples in different forms (bar, wire and powder).

**Proposal Form**

|  |
| --- |
| To measure the density / conductivity of the solder samples |
| Features of the tool kit | The materials and apparatus used for the construction of the tool kit |
| 1. The test can be applied to the bar / wire / powder\* samples.
2. The test can be done within \_\_\_\_ minutes.
3. The test results are reliable because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. The weight of the tool kit is about \_\_\_\_\_\_\_ kg.
5. The test can / cannot\* be easily performed on the construction site because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(\*delete as appropriate.) |  |
| **Procedure:** |
| **The graphical design of the tool kit:** |