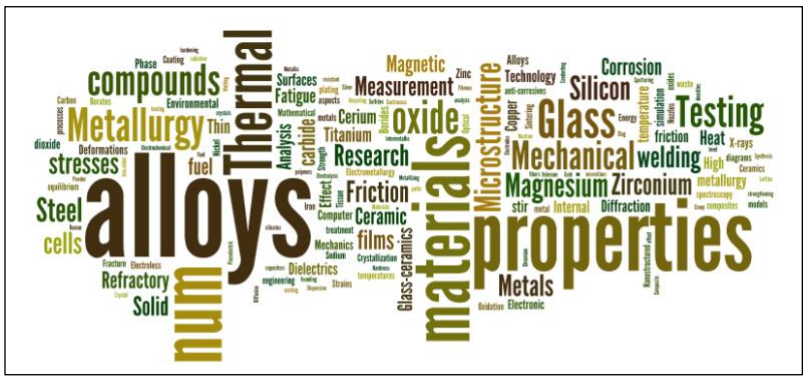
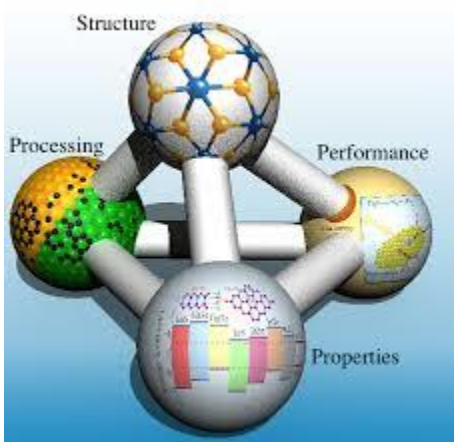
Lesson Title # Materials Classification and Alloys

Subject Area(s) High School Chemistry

Associated Unit Solids and Their Behaviors





Grade Level 11th – 12th

Lesson # 3 of 5

Time Required 90 minutes – block schedule

Summary This 90min lesson is lesson 3 of 5. Students can already classify basic solid material and understand crystal structure and Coulombic attraction. Students will classify materials into subcategories, make their own alloy and experimentally determine its eutectic point. Notes and classwork has been done to a certain extent, this lesson comprises two activities or labs that will be a student lab notebook and graded as such.

Engineering Connection Materials Science is a large field of study within the field of engineering. Identifying and classifying a set of materials with the naked eye is sometimes challenging. Materials can be classified into metals, ceramics, polymers and composites. Alloys fall into the metals category. A percent composition of each metal in an alloy can be experimentally determined. Electrical properties and microstructure can be studied for engineering applications.

Engineering Category

Choose the category that best describes this lesson's amount/depth of engineering content:
1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design

Keywords Materials Science is…..

- Understanding and using the materials in our daily lives
- Study of the materials in our lives and how they can be changed or manipulated
- Describes the understanding of the solids that emerges from the combined viewpoints of chemistry, physics, and engineering
- Involves the generation and application of knowledge relating the *composition, structure* and *processing* of materials to their *properties* and *uses*

Educational Standards

Idaho State Standards as taken from the Next Generation Science Standards:

PSC1-HS-1. Develop models to describe the atomic composition of simple molecules and extended structures.

PSC1-HS-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

PSC1-HS-5. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

ITEEA Standards

Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Pre-Requisite Knowledge

Basic upper classman lab techniques, scientific inquiry, design thinking

Learning Objectives

After this lesson, students should be able to:

- Classify a solid material into metals, ceramics, polymers and composites. Take apart a simple every day material, identify its parts and put it back together.
- Create an alloy that has optimal composition, grain size, crystal structure and electrical traits.

Introduction / Motivation Materials Science is a large field of study within the field of engineering. Identifying and classifying a set of materials with the naked eye is sometimes challenging. Materials can be classified into metals, ceramics, polymers and composites. Alloys fall into the metals category. A percent composition of each metal in an alloy can be experimentally determined. Electrical properties and microstructure can be studied for engineering applications.

Vocabulary / Definitions

Eutectic, alloy, substitutional, interstitial, vacancy, body centered, face centered, simple cubic, hexagonal close packed, heat treat

Associated Activities

Materials ID Lab

GOAL:

- To assess prior knowledge of students.
- To generate interest in types and properties of materials.
- To help students develop their own definition/description of each material category.
- Practice classifying and justifying (critical thinking).
- Allow students to realize that science and classification aren't always perfect and don't always have a "right" answer.

METHOD:

1. Have students do a "free" write in their journal:
   - "List anything and everything you know about the 4 categories of materials including definitions/descriptions, properties, examples of the material, uses of the material, etc."
   - The four materials categories are: metals, ceramics, polymers, and composites.
2. Hand out or have students choose an object(s) until all are taken.
3. Each student's task is to classify their object by putting it into one of the material categories and justify (give reasons) for their choice.

4. Generate lists on the board or overhead as students classify their object and give their reasoning. Be encouraging but do not indicate if their placement is correct or incorrect.
5. After all the objects have been classified, ask the students to count up how many objects they think have been put into the wrong category.
6. Go through the lists and make corrections.
7. As a class, generate a list of properties or descriptions for each category.

BACKGROUND:

- Students generally feel uncomfortable with this at first. They are not used to thinking out loud or having to give reasons for their answers.
- Rephrase what the student says so they can hear their thoughts.
- Do not give any indication if their answer is correct. The students start listening to each other and it is interesting to see how they are accepting of each other's "opinions" as "facts".
- Do not accept "because" as a reason. Insist that they give you more. Give them lead-in questions if they need help.
- If a student places an item into the polymer category and gives their reason as "because it isn't a metal" – request more information, ask "how do you know it isn't a metal?"
- If a student gives a response along the line of "because it looks like a metal" – request more information, "what does a metal look like?"

- Following is a list of sample items. Use whatever you find sitting around the classroom or home. It is a good idea to include some simple items along with some that are "ringers" (have no correct answer).
- Follow up with a discussion about the history of materials use. (see handout)
- Alternative method:
    - assign each material category a different location in the room
    - give each student an object to classify
    - have the students take their object to the material location they think their object belongs in
    - have the students at each material location decide who belongs/stays and who needs to go to a different category
    - have each group write a description and/or list of properties for their material category
    - share group results with entire class
- Alternative method:
    - spread the objects around the room
    - have the students classify each object on their own
    - place the students in small groups to discuss their "answers" and develop a description and/or list of properties for each material category
    - have a class discussion to develop a consensus on the classification of each object and to develop a final description for each material category

Sample Items:

Metals	Ceramics/Glass	Polymers	Composites
stainless steel foil	glass stirring rod	latex balloon	Mylar balloon
metal scoopula	fiberglass (no matrix)	cotton	Formica
copper wire	brick	Tyvek	cardboard
aluminum wire	calcite crystal	preform	plywood
steel wool	glass bottle	PVC pipe	cut up ski
	pumice	acrylic cube	
	talc	rubber stopper	
	shell*	Styrofoam cup	
	glass foam block**	candle***	

Additional items:
Silicon lump – this doesn't fit into any of the categories. The only materials that are elemental are metals, the rest are compounds or mixtures. Silicon isn't a true metal. This item helps to teach the students that no classification system is perfect or will work for every possible sample. An additional category could have been added such as "semiconductor" or "electronic material".
Light bulb – this isn't a single material, it is an "assembly". It is made up of more than one material and each material has its own function. The different materials are joined together but still are separate unlike a composite.

*shell - based on the type of shell, this could be listed under composites because the layers of ceramic are bonded by polymers. Accept it under either category and have a discussion with the students.

**glass foam block – used to clean grills or shave the "pills" off of sweaters
***candle – the students will want to place it under composite because of the wick. Remove the wick if possible or tell them just to consider the wax. Some scientists would not classify the wax as a polymer because the chains are too short. This is a good point of discussion.

Examples of student generated lists of properties for each category:

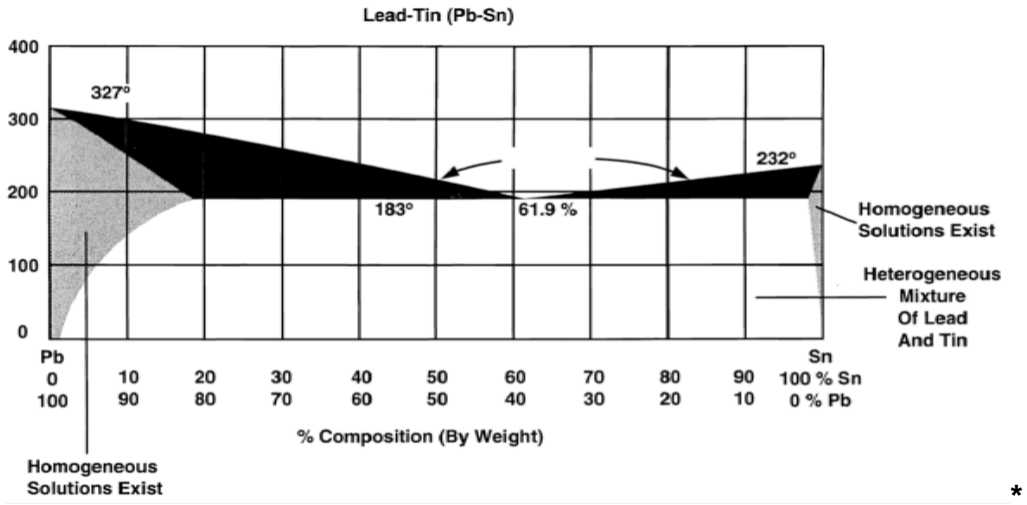
Metals	**Ceramics/Glass**	**Polymers**	**Composites**
hard	not conductors	plastics (synthetic)	mult. materials
shiny (luster)	high melt T°	some are natural	
variable melt T°	brittle	some are absorbent	
flexible	some are transparent	flexible	
malleable	fragile	low melt T°	
ductile	breakable	low density	
good conductors	not workable	many are recyclable	
heavy (dense)	formed by heat	stretchable	
most are dense	sand or clay based	not brittle	
opaque	fairly high density	bendable	
undergo oxidation	poor conductors	rubbery	
bendable	can be formed	expandable	
strong	includes minerals	shrinkable	
can be elements	can be recycled	elasticity	
some are magnetic		some are transparent	
fairly high melt T°		poor conductors	
impermeable		can be easily formed	
workable		long molecules	
corrode easily		some are hard	
come from ores		variety of properties	
can be mixtures (alloys)		made of compounds	

Lead/Tin Solder Lab

1. Select a labeled cup(s) and sign your names on the table of lead/tin percentages.
2. Mass out 50 grams total of your assigned lead and tin alloy.
3. Melt the metals together in an evaporating dish using a hot plate
4. Mix with a glass stirring rod and gently scrape the oxidation to the side. Hold the evaporating dish with needle-nose pliers.
5. Using pliers, pour the molten metal into one depression in the spot plate – try to make the metal level with the surface of the spot plate. CAUTION: Make sure the spot plate is absolutely dry!!!!!!!!!!
6. Pour the remaining metal into the warm sinker mold.
7. Quench the metal pieces in a can of water.
8. Put the metal spot into a labeled plastic bag and give it to the teacher. You may keep the sinkers.

Tin–Lead Solder – Observations

1. Cup #1:
   - Percentage of tin – lead _____
   - mass of tin used _____
   - mass of lead used _____



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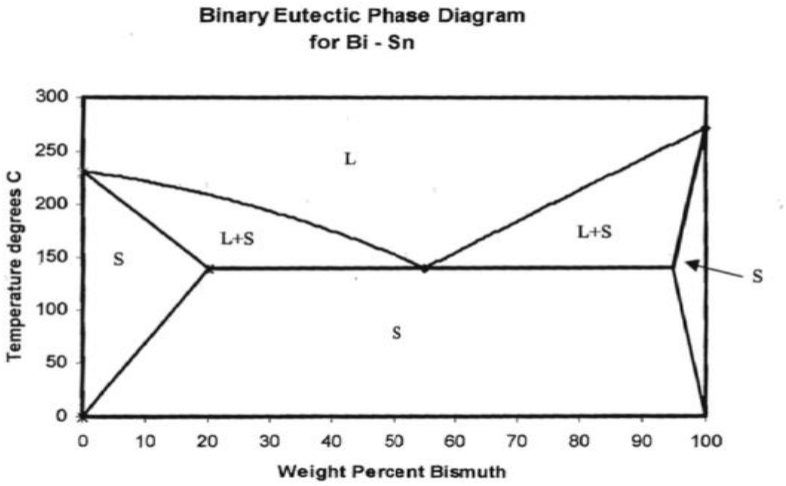
2. Cup #2:
   - Percentage of tin – lead _____
   - mass of tin used _____
   - mass of lead used _____
3. Describe the appearance of tin:
4. Describe the appearance of lead:
5. Which metal melted first?
6. Color of the oxidation:
7. Is the oxidation more or less dense than the metal?
8. Describe the appearance of the solidified solder:
9. Describe the flow characteristics of molten metal:
10. Additional observations and impressions.

- Since lead is a no-no, you can substitute bismuth!



Lesson Closure and Extensions to the Lesson

Assign each lab group or partnership a different percentage make-up of the 2 metal alloy system. An extension activity would be to have different steel casting forms on hand and have the groups choose which shape they want to cast. When they are cooled, line all the percentage mixtures up on a pancake griddle. Turn it up and watch. Introduce terms like liquidous, solidous, as the percentages are melting. Students will be able to visually determine the best % based on the visual melting properties. Lesson 4, or the next days lesson will be polishing the alloy pieces as much as you can with fine grit sandpaper and viewing them under the microscopes. Students can also etch and/or anodize their samples for viewing grain boundaries. The eutectic alloy will also be used as an electrode to measure the voltage potential of the alloy compared to the element.

Assessment

Lab notebooks will be graded with the accompanying rubric.

Vocab and classification assessed during the chapter test.