

**Teacher’s Guide**

**Cooking Chemistry: What’s in the Pot?**

***February 2024***

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Activate students’ prior knowledge and engage them before they read the article.

[***Reading Comprehension Questions***](#_3znysh7) ***3***

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[***Graphic Organizer***](#_9f8azrtnp6p5) ***5***

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[***Answers***](#_djipzn7z1r1b) ***6***

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

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Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# Anticipation Guide

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

| **Me** | **Text** | **Statement** |
| --- | --- | --- |
|  |  | 1. The best thermal conductor is diamond. |
|  |  | 2. Thicker pans take less time to heat up than thin pans. |
|  |  | 3. Heat energy is transferred quickly in metals because the atoms are closely packed. |
|  |  | 4. Copper pans hold heat longer than cast iron pans. |
|  |  | 5. Corning Glass Ceramic has a higher thermal conductivity than cast iron. |
|  |  | 6. Well-seasoned cast iron skillets are nonstick due to a polymer coating made from fats and oils used in cooking. |
|  |  | 7. Teflon is a polymer containing fluorine. |
|  |  | 8. Ovens cook food through convection. |
|  |  | 9. Thin metal pans are a good choice for cooking food in an oven. |
|  |  | 10. Microwave ovens use electromagnetic radiation to cook foods containing polar molecules such as fats and water. |

# Student Reading Comprehension Questions

**Directions**: Use the article to answer the questions below.

1. Define thermal conductivity and give two examples of good thermal conductors and thermal insulators.
2. Explain why a metal doorknob feels colder than a wood door in the same room.
3. A piece of copper that is heated to 70 °C is placed next to a piece of aluminum at 25 °C. The two metals are touching. Draw a diagram that shows how heat is transferred from one metal to the other. Use circles to represent the atoms and label your diagram to show the direction of heat flow, which particles are moving fast and which ones are moving relatively slowly before the heat is transferred.
4. Compare metal and glass in terms of their structure and particle arrangement and ability to transfer energy.
5. What is specific heat capacity?
6. Use the Properties of Common Materials table to answer this question. If you have 1 gram of each substance in the table, which one will undergo the greatest temperature change when 100 Joules of energy is added to each substance?
7. What properties make cast iron a good choice for a skillet?
8. What is a polymer? What non-stick polymer has been used on frying pans since the 1950s?
9. Explain the three cooking methods: conduction, convection, and electromagnetic radiation and which type of pan is best for each method.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Examine the image that shows the molecular structure of Teflon, PTFE. What is the full chemical name for PTFE? What part of the name indicates fluorine atoms? What part of the name indicates the number of fluorine atoms? What is the meaning of the letter n in the image? How can you tell from the image that Teflon is a polymer?
2. Research the discovery and uses of Teflon.

# Graphic Organizer

**Directions**: As you read,complete the graphic organizer below examining different considerations when choosing materials for cooking.

|  | | **What is it?** | **Examples from the reading** |
| --- | --- | --- | --- |
| **Thermal Conductivity** | |  |  |
| **Heat Capacity** | |  |  |
| **Nonstick material** | |  |  |
| **Cooking Methods** | **Thermal conduction** |  |  |
| **Heat convection** |  |  |
| **Electromagnetic radiation** |  |  |

**Summary:** On the back of this sheet, write three interesting facts you learned about the chemistry of choosing cooking materials.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Define thermal conductivity and give two examples of good thermal conductors and thermal insulators.  
   Thermal conductivity is a measure of how quickly heat moves through substances. Good conductors include copper and gold. Good insulators include glass and plastic.
2. Explain why a metal doorknob feels colder than a wood door in the same room.  
   Metals tend to transfer heat faster than wood, so heat moves quickly from your hand to the doorknob and more slowly from your hand to the wood. Therefore, the doorknob feels colder than the wood door despite the fact that they are at the same temperature.
3. A piece of copper that is heated to 70 °C is placed next to a piece of aluminum at 25 °C. The two metals are touching. Draw a diagram that shows how heat is transferred from one metal to the other. Use circles to represent the atoms and label your diagram to show the direction of heat flow, which particles are moving fast and which ones are moving relatively slowly before the heat is transferred.
4. Compare metal and glass in terms of their structure and particle arrangement and ability to transfer energy.  
   Metals atoms are close together and organized. As the atoms move, they collide with one another and transfer energy from one atom to its neighbor. In glass, there are more spaces and holes (amorphous structure) in the structure. There are not as many collisions so energy is not transferred as quickly.
5. What is specific heat capacity?  
   Specific heat capacity is the amount of energy it takes to increase the temperature of 1 gram of a substance by 1 °C.
6. Use the Properties of Common Materials table to answer this question. If you have 1 gram of each substance in the table, which one will undergo the greatest temperature change when 100 Joules of energy is added to each substance?  
   The substance with the lowest specific heat in the table, silver, will undergo the greatest change in temperature.
7. What properties make cast iron a good choice for a skillet?  
   Cast iron is a good thermal conductor and because of its high density, it holds more heat than other metals. In addition, fats used in cooking polymerize and fill in the nooks and crannies in the metal’s surface. Over time, the pan becomes “seasoned” and very non-stick if cared for properly. Finally, cast iron is relatively inexpensive.
8. What is a polymer? What non-stick polymer has been used on frying pans since the 1950s?  
   Polymers are long chain molecules made up of repeating units of small molecules, called monomers. Teflon is a non-stick polymer coating used on frying pans.
9. Explain the three cooking methods: conduction, convection, and electromagnetic radiation and which type of pan is best for each method.  
   Thermal conduction is used when food is cooked in a skillet or pan in direct contact with the heat source. When the vibrating particles in the pan collide with the food particles, energy is transferred to the food. Metal pans that hold heat and distribute it evenly are a good choice for the stovetop.

Baking a cake or roast in the oven involves convection. Hot air in the closed oven rises, as gases expand when they are heated and become less dense. At the top of the oven, the air cools, becomes more dense and sinks. This circulation of air cooks the food. Glass pans that can withstand long cooking times and don’t transfer heat too quickly are good choices so the outside of the food doesn’t get overcooked while the inside is undercooked.

Microwave ovens make use of electromagnetic radiation to heat up polar molecules like water. The water molecules move to align their positive and negative ends with the poles of the electromagnetic waves. Some food particles do not align with the microwaves, which is why some foods are not recommended to be cooked in the microwave oven. In addition, some containers are “microwave safe” because they don’t absorb microwave radiation. Otherwise, the container might melt.

1. Examine the image that shows the molecular structure of Teflon, PTFE. What is the full chemical name for PTFE? What part of the name indicates fluorine atoms? What part of the name indicates the number of fluorine atoms? What is the meaning of the letter n in the image? How can you tell from the image that Teflon is a polymer?  
   The full name for PTFE is polytetrafluoroethylene. The fluorine atoms are represented in the name with the component “fluoro”. The four fluorine atoms are represented by the component “tetra”. The letter n represents the number of "tetrafluoroethylene" units that make up the long polymer chain of PTFE. In this case, the value of n is greater than one million.
2. Research the discovery and uses of Teflon.  
   Answers will vary depending on student research. Teflon was accidentally discovered in 1938 by Dr. Roy Plunkett when a sample of frozen tetrafluoroethylene spontaneously polymerized. This inert, slippery substance is used in many industries including aerospace, architecture, and electronics in addition to its use as a coating for cookware and as a stain repellent for fabrics. Today, there are additional compounds in the Teflon “family”. These compounds changed the plastics industry leading to many applications used today. Plunkett was recognized with several awards for his contributions.

Source: <https://www.teflon.com/en/news-events/history>

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

| **Score** | **Description** | **Evidence** |
| --- | --- | --- |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

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# Additional Resources and Teaching Strategies

**Additional Resources**

* **Labs and demonstrations**
  + Popcorn is popped using three different methods of heat transfer: conduction, convection, and microwave radiation.
    - <https://teachchemistry.org/classroom-resources/hot-popcorn>
  + Students investigate specific heat by mixing different solutions.
    - <https://teachchemistry.org/classroom-resources/understanding-specific-heat>
  + Students explore what happens when three different metals of equal mass change the temperature of a sample of water.
    - <https://www.flinnsci.com/specific-heat/dc11005/>
* **Simulations**
  + Students investigate how water molecules interact with microwave radiation.
    - <https://phet.colorado.edu/en/simulations/microwaves>
* **Lessons and lesson plans**
  + Students learn how polymers are made and how cross-linking molecules are utilized. There is also an opportunity for students to collect various types of plastic and collect data regarding the plastics we use every day.
    - <https://www.teachengineering.org/lessons/view/csu_polymer_lesson01>
  + Infographic on the chemistry of Teflon
    - <https://www.compoundchem.com/2016/02/04/teflon/>

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students if they enjoy cooking. Ask them if they have ever considered the material they use to cook their food, and why it works for that recipe choice. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
  + As they read, students can find information to confirm or refute their original ideas.
  + After they read, ask students what they learned about choosing the best cookware for the cooking task. Ask what questions they still have about the materials used in cookware.
* After students have read and discussed the article, ask students what information they would like to share with friends and family about cookware choices.

# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Heat
* Specific heat
* Heat Transfer
* Electromagnetic radiation

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS1-3.** 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.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**Disciplinary Core Ideas:**

* PS.1.A: Structure and Properties of Matter
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Cause and effect
* Energy and matter
* Structure and function

**Science and Engineering Practices:**

* Constructing explanations (for science) and designing solutions (for engineering)

**Nature of Science:**

* Science models, laws, mechanisms, and theories explain natural phenomena.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).