

# ChemMatters<sup>®</sup>

Demystifying Everyday Chemistry

## Teacher's Guide

**OCTOBER 2020**

<a href="#"><u>Lighting Up the Night Sky</u></a> .....	<b>2</b>
<a href="#"><u>The Search for Hidden Plastics</u></a> .....	<b>12</b>
<a href="#"><u>How Sticky Innovations Changed the World</u></a> .....	<b>24</b>
<a href="#"><u>What is Hand Sanitizer?</u></a> .....	<b>34</b>
<a href="#"><u>About the Teacher's Guide</u></a> .....	<b>42</b>



## Teacher's Guide

### Lighting Up the Night Sky

*October 2020*

#### Table of Contents

<b><u><a href="#">Anticipation Guide</a></u></b>	<b>3</b>
Activate students' prior knowledge and engage them before they read the article.	
<b><u><a href="#">Reading Comprehension Questions</a></u></b>	<b>4</b>
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.	
<b><u><a href="#">Graphic Organizer</a></u></b>	<b>6</b>
This helps 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.	
<b><u><a href="#">Answers</a></u></b>	<b>7</b>
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<b><u><a href="#">Additional Resources</a></u></b>	<b>10</b>
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<b><u><a href="#">Chemistry Concepts, Standards, and Teaching Strategies</a></u></b>	<b>11</b>

# Anticipation Guide

Name: \_\_\_\_\_

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement 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. Plasma is when electrons in an atom move freely around positively charged nuclei.
		2. It takes 8 minutes for solar wind to reach Earth.
		3. Earth’s magnetic field protects us from solar wind.
		4. Light from auroras is produced about 10 km above Earth’s surface.
		5. Auroral colors are produced when electrons transition from higher to lower orbitals.
		6. Nitrogen and oxygen atoms produce the same auroral colors.
		7. You can see the aurora even if the sky is very cloudy.
		8. Electrons stream along magnetic field lines.
		9. Solar flares can cause auroras and disrupt power grids.
		10. Auroras have been seen in Florida.

# Student Reading

## Comprehension Questions

Name: \_\_\_\_\_

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

1. Plasma and gas are both states of matter. How is a plasma different from a gas?
2. What is wind? What makes solar wind different from the wind we experience on Earth?
3. What is the difference between oxygen in the lower atmosphere where we breathe and oxygen in the much higher atmosphere where the aurora occurs?
4. What role does Earth's magnetic field play in protecting Earth from the solar wind?
5. Why does Earth need to be protected from the solar wind?
6. Write the electron configuration for a neutral oxygen atom and for a neutral nitrogen atom.
7. Draw a Lewis structure, showing all bonding and nonbonding electrons, for the oxygen molecule and for the nitrogen molecule.
8. The colors of an aurora are attributed to electron transitions in atomic oxygen and in molecular nitrogen. Why does nitrogen maintain its molecular state in the upper atmosphere while oxygen molecules split into individual atoms?
9. Molecular nitrogen in the upper atmosphere can become ionized. What does this tell you about the magnitude of ionization energy vs. the magnitude of bond energy for  $N_2$ ?
10. Explain, in terms of energy transfer, the process that causes light to be emitted from atoms and molecules causing an aurora.

## Student Reading Comprehension Questions, cont.

11. Use the symbols below to show each stage of the process described in question 10.

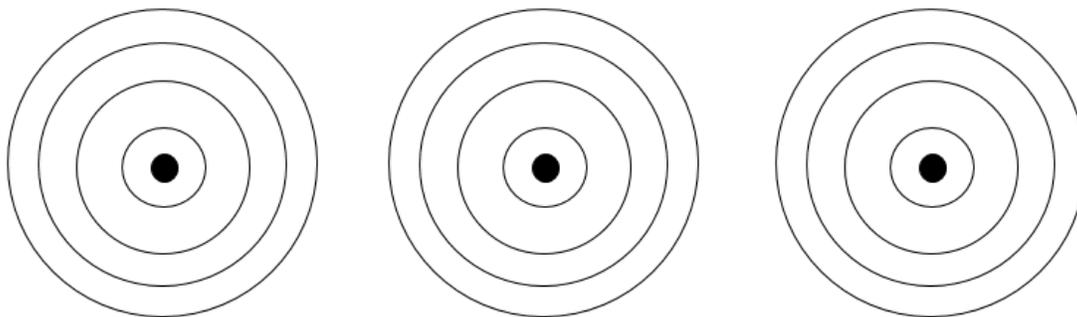
$e^-$  = electron in the atom



= energy from solar wind



= color observed in aurora



12. Write a documentary-style narrative for the animation referenced in the article.

### Questions for Further Learning

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

- The process of excitation and relaxation of electrons by energy absorption and emission is a common phenomenon in nature. Choose one of the phenomena below and explain how this explanation helps us understand it.
  - The glow of fireflies
  - The color and glow of neon lights
  - Fluorescence in Puffins
- Explore the connection between electric charges and magnetism and use this to explain why Earth has a magnetosphere.

# Graphic Organizer

Name: \_\_\_\_\_

**Directions:** As you read, complete the graphic organizer below to describe how each item contributes to the northern lights.

	Contribution to northern lights
Earth's magnetic field	
Solar wind	
Solar flares	
Upper atmosphere	
Why is the study of space weather important?	

**Summary:** What is the most interesting thing you learned about auroras and why do you find it interesting?



9. Molecular nitrogen in the upper atmosphere can become ionized. What does this tell you about the magnitude of ionization energy vs the magnitude of bond energy for  $N_2$ ?

*Since the photons are energetic enough to separate an electron from the molecule, but not to separate the atoms in the molecule, the ionization energy must be lower in magnitude than the bond energy.*

10. Explain, in terms of energy transfer, the process that causes light to be emitted from atoms and molecules causing an aurora.

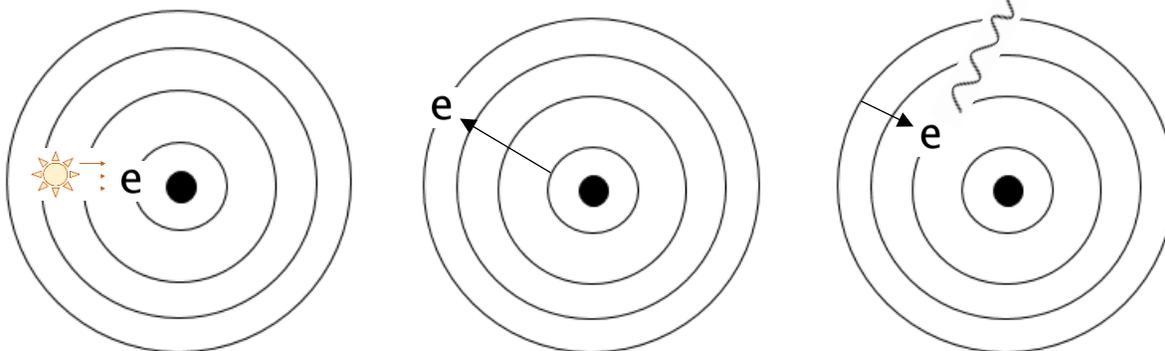
*The particles in the solar wind are moving very fast. When these particles interact with a particle in Earth's magnetic field, they transfer some of their energy, either directly or indirectly, to this new particle. (Indirect transfer happens if this new particle is an electron because it will eventually collide with a molecule and transfer its gained energy to that molecule.) The energy from the solar wind is absorbed by an electron in the atom or molecule, causing it to excite to a higher energy level. It can then release this energy as a photon by relaxing back down to any of the available lower energy levels. If the energy released falls in the visible range, then we would see a color.*

11. Use the symbols below to show each stage of the process described in question 9.

$e^-$  = electron in the atom

 = energy from solar wind

 = color observed in aurora



12. Write a documentary-style narrative for the animation referenced in the article.

*Answers will vary. Look for:*

- *Solar flare or mass ejected from sun*
- *Travels outward and toward Earth*
- *Interacts with Earth's magnetic field*
  - *Distorts Earth's field and is also deflected by it*
  - *Energizes particles in Earth's field which travel to the poles*
- *This then undergoes the process described above to cause the aurora*

## 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

## Additional Resources

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### Labs and demos

Flame tests (Rainbow demo): In this demonstration, students will observe the variety of colors produced when different metals or metallic salts are heated in a flame.

<https://teachchemistry.org/classroom-resources/flame-test-rainbow-demo>

Mystical Fire Investigation: In this lab, students will create several testable questions based upon their observations of a mystical fire. Students then direct their own laboratory experience as they safely investigate these testable questions through the use of multiple flame tests. <https://teachchemistry.org/classroom-resources/mystical-fire-investigation>

### Simulations

PhET – Neon Lights and Other Discharge Lamps: <https://phet.colorado.edu/en/simulation/legacy/discharge-lamps>

Bohr Model of an Electron Simulations: [https://interactives.ck12.org/simulations/chemistry/bohr-model-of-electron/app/index.html?hash=faf0aab26a3c06de33f5f80bb9bf2dd4&source=ck12&artifactID=5658500&referrer=concept\\_details&encodedID=SCI.CHE.206](https://interactives.ck12.org/simulations/chemistry/bohr-model-of-electron/app/index.html?hash=faf0aab26a3c06de33f5f80bb9bf2dd4&source=ck12&artifactID=5658500&referrer=concept_details&encodedID=SCI.CHE.206)

Exciting Electrons simulation: <https://teachchemistry.org/classroom-resources/exciting-electrons-simulation>

### Lessons and lesson plans

Electrons and Orbitals: In this lesson, students will differentiate between energy levels, sublevels, orbitals, and electrons. <https://teachchemistry.org/classroom-resources/electrons-and-orbitals>

Let it Glow: In this lesson students will investigate the fluorescence of a variety of everyday items as well as prepared samples under a black light. <https://teachchemistry.org/classroom-resources/let-it-glow>

### Projects and extension activities

As a project, have students investigate examples of man-made plasma:

- Plasma TV screens
- Fluorescent lamps
- Arc lamp (like welder's torch)
- Tesla coil

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Atomic structure
- States of matter
- Gases

## Correlations to Next Generation Science Standards

This article can be used to achieve the following performance expectations and dimensions of NGSS:

### HS-PS2-5

Plan and conduct an investigation to provide evidence that an electrical current can produce a magnetic field and that a changing magnetic field can produce an electric current.

#### Disciplinary Core Ideas

- PS1.A: Structure and Properties of Matter

#### Crosscutting Concepts:

- Cause and Effect: Mechanism and explanation.
- Systems and System Models
- Stability and Change

#### Science and Engineering Practices:

- Constructing explanations and designing solutions

#### Nature of Science:

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

## Correlations to Common Core State Standards

See how *ChemMatters* correlates to the [Common Core State Standards](http://www.acs.org/chemmatters) at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## 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 have ever seen the northern lights, and where they were at the time. Ask what they think causes the northern lights. As they read, students can find information to confirm or refute their original ideas.
- Use the aurora as a phenomenon for students to question. After questioning, students read the article and see what questions were answered and what new questions arise. Then move to lab observations of spectrum tubes with spectroscopes. Then do flame test lab to see if students can apply the same principles.
- After they read, ask students what causes the northern lights, and what they have seen locally that is similar to the northern lights.
- After the reading, you can show the ACS Reactions Video that summarizes information from the article and has some photos of different aurora colors: “What Causes Auroras (and where you should see them)”: [https://youtu.be/8S\\_LPFOa-zs](https://youtu.be/8S_LPFOa-zs)

## Teacher's Guide

### The Search for Hidden Plastics

*October 2020*

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# Anticipation Guide

Name: \_\_\_\_\_

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement 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
		11. Worldwide, there are five ocean gyres where plastic trash accumulates.
		12. Ocean gyres are caused by pollution.
		13. Almost all of the plastic pollution that enters the oceans remains floating on the surface of the oceans.
		14. Microplastics are defined as plastic pieces smaller than 5 mm.
		15. Microplastics have been found all over the world, including in the air and drinking water.
		16. Scientists do not yet know the effects of microplastics in humans.
		17. Nanoplastics are small enough to enter living cells.
		18. Most lab equipment is made of plastic, increasing the possibility of contamination of experiments to research the effects of nanoplastics.
		19. Unlike plastics, natural debris becomes waterlogged and sinks in water.
		20. Plastics reflect infrared light in the water differently than ocean sediments.

# Student Reading

## Comprehension Questions

Name: \_\_\_\_\_

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

1. What is a garbage patch?
2. According to the article, what item makes up a large portion of the plastics found in the ocean?
3. List the five ocean gyres in the world.
4. Name two ways that microplastics can travel in the environment.
5. Many fishing nets are made of polyethylene. Write the chemical formula for an ethylene monomer.
6. Compare and contrast microplastics and nanoplastics.
7. What makes nanoplastics difficult to locate in the environment?
8. Explain how Anna Du's underwater remote-operated vehicle uses patterns to locate microplastics.
9. Describe a method that scientists have used to study the impact of microplastics on humans without deliberately exposing humans to microplastics.
10. Explain how and where garbage patches form.
11. Microplastics have been found in honey and table salt. Explain how this could happen.



# Graphic Organizer

Name: \_\_\_\_\_

**Directions:** As you read, complete the graphic organizer below to describe issues related to describe the issues related to microplastics discussed in the article.

<b>Sources of microplastics (list at least four)</b>		
<b>Where microplastics have been found (list at least four places other than the ocean)</b>		
<b>Ongoing research related to microplastics</b>	<b>Albert Koelmans:</b>	<b>Ter Halle:</b>
<b>Possible solutions to microplastic pollution</b>	<b>Ray Aivasian:</b>	<b>Anna Du:</b>

**Summary:** Write one thing you can do to reduce the amount of plastic in the environment, and explain why your choice would help.

## Answers to Reading Comprehension Questions & Graphic Organizer Rubric

**1. What is a garbage patch?**

*An area of the ocean where trash is found in a high concentration.*

**2. According to the article, what item makes up a large portion of the plastics found in the ocean?**

*Fishing nets account for a large portion of plastics in the ocean.*

**3. What type of plastic is most frequently used to make fishing nets?**

*Most fishing nets are made of polyethylene.*

**4. List the five ocean gyres in the world.**

*The five ocean gyres are the North Pacific Gyre, South Pacific Gyre, North Atlantic Gyre, South Atlantic Gyre, and Indian Ocean Gyre.*

**5. Name two ways that microplastics can travel in the environment.**

*Microplastics can travel through water and air.*

**6. Many fishing nets are made of polyethylene. Write the chemical formula for an ethylene monomer.**

*The formula for an ethylene monomer is  $C_2H_4$ .*

**7. Compare and contrast microplastics and nanoplastics.**

*Both are small pieces of plastic. A microplastic is a piece of plastic smaller than 5 mm. A nanoplastic is a piece of plastic smaller than 1 micrometer. Nanoplastics are small enough to cross barriers and enter cells.*

**8. What makes nanoplastics difficult to locate in the environment?**

*Nanoplastics are difficult to locate because they are too small to measure with the instruments and protocols that are typically used for detecting microplastics.*

**9. Explain how Anna Du's underwater remote-operated vehicle uses patterns to locate microplastics.**

*Anna Du's ROV uses infrared LEDs to shine light onto its surroundings and she uses the wavelength patterns in the light that bounces back to distinguish between sediment and plastic.*

**10. Describe a method that scientists have used to study the impact of microplastics on humans without deliberately exposing humans to microplastics.**

*Scientists can use human cells outside of the human body, such as in Lehner's experiment, to study the impact of plastics on humans. Lehner grew a layer of intestinal cells and immune cells to mimic the intestinal wall. Additionally, Koelman utilized artificial intestinal juices to research the impact of microplastics in the digestive system.*

**11. Explain how and where garbage patches form.**

*Garbage patches form at an ocean gyre. A gyre is an area of the ocean where currents meet and swirl in a circle. Plastics that enter the ocean move through the currents and then become trapped in the gyre, creating a patch of garbage.*

**12. Microplastics have been found in honey and table salt. Explain how this could happen.**

*Because they are so small, microplastics move through natural systems through both the air and water. These modes of travel can allow them to come into contact with living organisms and food sources.*

**Questions for Further Learning**

**1. After reading about Aivazian’s idea for separating out microplastics, what is a method you would recommend for separating microplastics? Use scientific principles to support your idea.**

*Student answers will vary and may include ideas that involve mass, density, and/or wavelength of reflected light.*

**2. Use the information you learned about microplastics and nanoplastics to draft a PSA explaining what they are and steps that could be taken to reduce them.**

*Student responses should define microplastics and nanoplastics as well as including at least one possible method for mitigation.*

**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.

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3	Good	Complete; few details provided; demonstrates some understanding.
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1	Poor	Very incomplete; no details provided; many misconceptions evident.
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## Additional Resources

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### Labs and demos

Sampling for Microplastics in Beach Sand: This lab provides students with an opportunity to examine samples of beach sand for microplastics.

<http://sfyl.ifas.ufl.edu/media/sfylifasufledu/flagler/sea-grant/pdf-files/microplastics/Sampling-for-Microplastics-in-Beach-Sand.pdf>

Activity: Identifying Plastics with Density Data <https://teachchemistry.org/classroom-resources/identifying-plastics-with-density-data>

Lab: The Six Big Plastics <https://teachchemistry.org/classroom-resources/the-big-six-plastics>

### Simulations

Garbage Patch Visualization Experiment: This NASA visualization utilizes NOAA buoy data to demonstrate currents and gyres. <https://svs.gsfc.nasa.gov/4174>

### Lessons and lesson plans

Microplastics: It All Comes Out in the Wash: In this lesson students learn about the various sources of microplastics as well as analyze citizen science data.

[http://masweb.vims.edu/bridge/datatip.cfm?Bridge\\_Location=archive1019.html](http://masweb.vims.edu/bridge/datatip.cfm?Bridge_Location=archive1019.html)

Mitigating Microplastics – Teacher Lesson Plans: This curriculum unit includes lessons to help students identify and mitigate microplastics from a variety of sources.

[https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/e-16-001\\_kowalski\\_conway\\_m-a-02.pdf](https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/e-16-001_kowalski_conway_m-a-02.pdf)

The Great Pacific Garbage Patch: In this lesson students learn about how the Great Pacific Garbage Patch developed and explore how environmental engineers are working to help mitigate the problem.

[https://www.teachengineering.org/lessons/view/uoh\\_dig\\_mapping\\_less3](https://www.teachengineering.org/lessons/view/uoh_dig_mapping_less3)

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Physical properties and physical change
- Density
- Separating mixtures
- Polymers
- Measurement

## Correlations to Next Generation Science Standards

This article can be used to achieve the following performance expectations of NGSS:

### HS-ESS3-4

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

### HS-ETS1-3

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

#### Disciplinary Core Ideas:

- ESS3.c: Human Impacts on Earth Systems
- ETS1.B: Developing Possible Solutions

#### Crosscutting Concepts:

- Cause and Effect: Mechanism and explanation.
- Scale, Proportion, and Quantity
- Systems and System Models
- Stability and Change

#### Science and Engineering Practices:

- Analyzing and interpreting data
- Constructing explanations and designing solutions

#### Nature of Science:

- Scientific investigations use a variety of methods.

## Correlations to Common Core State Standards

See how *ChemMatters* correlates to the [Common Core State Standards](http://www.acs.org/chemmatters) at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## 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 have heard of the huge garbage patches in the ocean, and what they might be made of. Ask where they think microplastics have been found in the environment. As they read, students can find information to confirm or refute their original ideas. *Do not tell students the answers prior to reading.*
- As an alternative to the graphic organizer summary, have students write a letter to their community or to their major identifying one thing that the community can do to reduce the amount of plastic in the environment, and explain why their choice would help.

### The Batter Against Body Odor, December 2019

- After they read, ask students what surprised them about the article. Ask them what ideas they have about removing microplastics from the environment.
- If students want to know more about what is being done to solve the plastics pollution problem, you can show the ACS Reactions Video: “Can Plastic Be Composted?” URL: <https://youtu.be/Q02Xi7S5PTM>
  - Ask students what problems must be overcome to compost plastics.
- Do the “Hidden Plastics” puzzle with your students for a fun activity. See the printable version and accompanying answer key in the next pages.

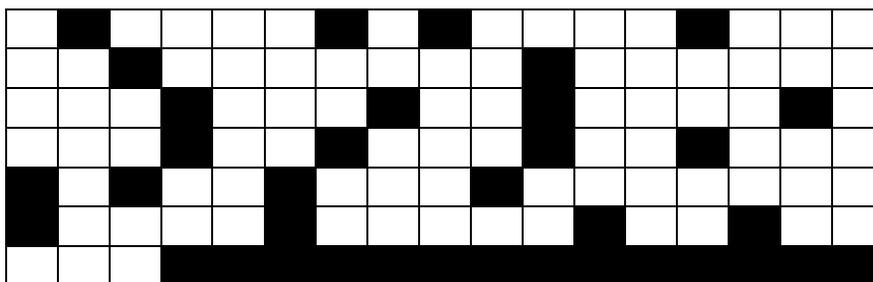
## Hidden plastics

Hidden in the sea of letters below are 11 polymers found in plastic waste and 13 everyday items that use them. After you find all of those, the remaining letters, when read from left to right and top to bottom, may or may not spell out a joke.

I	H	A	T	O	O	T	H	P	A	S	T	E	V	P	C	P
S	G	A	B	Y	R	E	C	O	R	G	E	A	J	O	O	O
P	K	E	C	A	W	B	O	L	U	T	T	E	F	L	O	N
O	P	O	A	L	A	Y	B	Y	E	M	E	R	Y	Y	K	C
L	C	H	R	E	T	M	U	E	N	I	P	V	S	U	W	T
Y	H	R	P	Y	E	B	R	T	E	O	I	U	T	R	A	N
C	E	G	E	I	R	T	C	H	L	N	L	J	U	E	R	E
A	W	N	T	S	B	T	S	Y	Y	S	G	Y	S	T	E	O
R	I	I	E	O	O	E	E	L	P	P	S	O	N	H	T	P
B	N	H	N	R	T	S	C	E	O	U	A	N	A	A	T	R
O	G	T	D	O	T	H	A	N	R	C	N	A	C	N	I	E
N	G	O	N	E	L	S	F	E	P	R	D	I	A	E	L	N
A	U	L	R	O	E	A	Y	M	Y	E	N	O	D	T	G	E
T	M	C	R	T	O	T	A	L	L	P	L	L	O	Y	S	U
E	C	I	R	C	U	I	T	B	O	A	R	D	S	R	E	W
H	D	R	E	B	B	U	R	E	P	P	R	E	I	T	E	N
E	D	S	S	G	A	B	P	I	H	C	O	T	A	T	O	P

Products Containing Polymers		Polymers	
1)	8)	1)	8)
2)	9)	2)	9)
3)	10)	3)	10)
4)	11)	4)	11)
5)	12)	5)	
6)	13)	6)	
7)		7)	

### Remaining letters



## Hidden plastics – ANSWER KEY

Hidden in the sea of letters below are 11 polymers found in plastic waste and 13 everyday items that use them. After you find all of those, the remaining letters, when read from left to right and top to bottom, may or may not spell out a joke.

I	H	A	T	O	O	T	H	P	A	S	T	E	V	P	C	P
S	G	A	B	Y	R	E	C	O	R	G	E	A	J	O	O	O
P	K	E	C	A	W	B	O	L	U	T	T	E	F	L	O	N
O	P	O	A	L	A	Y	B	Y	E	M	E	R	Y	Y	K	C
L	C	H	R	E	T	M	U	E	N	I	P	V	S	U	W	T
Y	H	R	P	Y	E	B	R	T	E	O	I	U	T	R	A	N
C	E	G	E	I	R	T	C	H	L	N	L	J	U	E	R	E
A	W	N	T	S	B	T	S	Y	Y	S	G	Y	S	T	E	O
R	I	I	E	O	O	E	E	L	P	P	S	O	N	H	T	P
B	N	H	N	R	T	S	C	E	O	U	A	N	A	A	T	R
O	G	T	D	O	T	H	A	N	R	C	N	A	C	N	I	E
N	G	O	N	E	L	S	F	E	P	R	D	I	A	E	L	N
A	U	L	R	O	E	A	Y	M	Y	E	N	O	D	T	G	E
T	M	C	R	T	O	T	A	L	L	P	L	L	O	Y	S	U
E	C	I	R	C	U	I	T	B	O	A	R	D	S	R	E	W
H	D	R	E	B	B	U	R	E	P	P	R	E	I	T	E	N
E	D	S	S	G	A	B	P	I	H	C	O	T	A	T	O	P

Products Containing Polymers			Polymers	
1) CARPET	8) GROCERY BAGS		1) NEOPRENE	8) POLYURETHANE
				POLYVINYL
2) GUM	9) PAPER CUPS		2) NYLON	9) CHLORIDE
3) BOARDS	10) POTATO CHIP		3) POLYCARBONATE	10) RUBBER
	BAGS			
4) CLOTHING	11) SODACANS		4) POLYESTER	11) TEFLON
5) COOKWARE	12) TOOTHPASTE		5) POLYETHYLENE	
6) FACE SCRUB	13) WATER BOTTLE		6) POLYPROPYLENE	
7) GLITTER			7) POLYSTRENE	

### Remaining letters

I		H	A	V	E		A		J	O	K	E		A	B	O
U	T		P	O	L	Y	M	E	R		C	H	E	M	I	S
T	R	Y		B	U	T		I	T		J	U	S	T		G
O	E	S		O	N		A	N	D		O	N		A	N	D
	I		A	M		N	O	T		T	O	T	A	L	L	Y
	S	U	R	E		W	H	E	R	E		I	T		E	N
D	S	.														

# ChemMatters™

Demystifying Everyday Chemistry

## Teacher's Guide

### How Sticky Innovations Changed the World

*October 2020*

#### Table of Contents

<b><u><a href="#">Anticipation Guide</a></u></b>	<b>25</b>
Activate students' prior knowledge and engage them before they read the article.	
<b><u><a href="#">Reading Comprehension Questions</a></u></b>	<b>26</b>
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.	
<b><u><a href="#">Graphic Organizer</a></u></b>	<b>28</b>
This helps 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.	
<b><u><a href="#">Answers</a></u></b>	<b>29</b>
Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.	
<b><u><a href="#">Additional Resources</a></u></b>	<b>32</b>
Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.	
<b><u><a href="#">Chemistry Concepts, Standards, and Teaching Strategies</a></u></b>	<b>33</b>

# Anticipation Guide

Name: \_\_\_\_\_

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement 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
		21. The idea for duct tape came from a woman working in an ammunition plant during World War II.
		22. Archaeologists have found evidence that early humans made adhesives.
		23. Mortar made from limestone has lasted for thousands of years.
		24. Early adhesives were made from plant and animal materials.
		25. Most adhesives today are made of polymers.
		26. Adhesion and cohesion are the same.
		27. Van der Waals forces are as strong as covalent bonds.
		28. Most synthetic adhesives work well under water.
		29. Unwanted nonpolar adhesives can be removed by using polar products.
		30. Scientists look to nature to develop synthetic adhesives.

# Student Reading

## Comprehension Questions

Name: \_\_\_\_\_

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

1. What was the original use for duct (duck) tape? What was the problem with the tape previously used?
2. Explain the differences between a monomer and a polymer.
3. Briefly state the process of making lime mortar. What other substances were added to make the mortar stronger?
4. What monomer is polymerized to make acrylate? What is the chemical name for this popular polymer?
5. Why is it a good idea to press on tape to make it stick to a surface?
6. State the components of the first two adhesives made by humans.
7. Consider two main differences between the terms cohesive and adhesive. Why are adhesive forces needed for tape? Why are cohesive forces needed?
8. Briefly describe ionic and covalent bonds. Compare the strength of these bonds to van der Waals forces, and explain any differences.
9. Consider the phrase "like dissolves like." What makes a nonpolar substance better at dissolving sticky polymers than water? What type of substances dissolve well in water?

## Student Reading Comprehension Questions, cont.

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10. If you read the directions on commercial adhesives, they typically state that the surface must be clean and dust free. How would a dirty surface affect the adhesive properties?
11. Why would adhesives like DOPA work better than other adhesives underwater?
12. What makes carbon an ideal element to make polymers?

### **Questions for Further Learning**

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

1. Research popular adhesives and some of their ingredients. What are some of the additives used to increase the strength of the adhesives?
  
  
  
  
  
  
  
  
  
  
2. Teflon is the brand name for a chemical coating that is found on many typical cookware items. It's popular because cooked food does not stick to the Teflon coating, making the cookware very easy to clean. Look up the composition of Teflon, and explain why it has low adhesive properties.

# Graphic Organizer

Name: \_\_\_\_\_

**Directions:** As you read, complete the graphic organizer below to describe adhesives

Adhesive	Description and Chemical Formula (if in the article)	Approximately when invented and why
Duct tape		
Tar		
Lime mortar		
Acrylate polymer		
Biomimetic polymer		

**Summary:** In the space below or on the back of this sheet, write three interesting new things you learned about adhesives.

## Answers to Reading Comprehension Questions & Graphic Organizer Rubric

- 1. What was the original use for duct (duck) tape? What was the problem with the tape previously used?**  
*Duct tape was originally designed during World War II to keep ammunition boxes closed with a waterproof seal, but can be easily opened. The previous tape was waterproof, but the pull tab was easily broken.*
- 2. Explain the differences between a monomer and a polymer.**  
*A polymer is a long chain of similar molecules, typically containing carbon atoms. Each individual part of the chain is called a monomer.*
- 3. Briefly state the process of making lime mortar. What other substances were added to make the mortar stronger?**  
*When limestone is heated, it decomposes into calcium oxide and carbon dioxide. Water is added to the calcium oxide to make lime putty (calcium hydroxide). This putty is mixed with sand or other hardening agents, and allowed to react with the carbon dioxide in the air to harden into limestone again, as it bonds with the other materials.*
- 4. What monomer is polymerized to make acrylate? What is the chemical name for this popular polymer?**  
*The monomer n-butyl acrylate forms the polymer chain poly n-butyl acetate. This polymer is the sticky substance in tape.*
- 5. Why is it a good idea to press on tape to make it stick to a surface?**  
*When you press on the tape, the adhesive will go into and adhere to the insides of the cracks. This extra surface area creates a better adhesion.*
- 6. State the components of the first two adhesives made by humans.**  
*The first two types of adhesives made by humans composed of heated birch that made a sticky tar, and limestone.*
- 7. Consider two main differences between the terms cohesive and adhesive. Why are adhesive forces needed for tape? Why are cohesive forces needed?**  
*Cohesive forces are forces between molecules of a substance. This keeps the substance together. Adhesive forces are the forces that attract one substance to another. Tape needs adhesive forces to stick to other objects, but it also needs strong cohesive forces to stay together and not come apart on the other object.*
- 8. Briefly describe ionic and covalent bonds. Compare the strength of these bonds to van der Waals forces, and explain any differences.**  
*Ionic bonds are positive and negative ions attracted to each other by opposite charges. Covalent bonds are bonds formed by sharing of valence electrons between two atoms. These bonds are much stronger than van der Waals forces. Van der Waals are weak attractions between atomic or molecular particles, and are only effective when the particles are close to each other.*

- 9. Consider the phrase “like dissolves like.” What makes a nonpolar substance better at dissolving polymers than water? What type of substances dissolve well in water?**

*Non-polar substances will dissolve polymers better than water because polymers are long carbon chained molecules that have little to no polarity. Water molecules are small and polar. Water will dissolve other polar molecules (like sugars) as well as ionic compounds (like salt).*

- 10. If you read the directions on commercial adhesives, they typically state that the surface must be clean and dust free. How would a dirty surface affect the adhesive properties?**

*A dirty surface would prevent the sticky part of the tape to adhere in the grooves of the surface of the object. The dirt would instead be attracted to the adhesive, which means less attraction to the surface.*

- 11. Why would adhesives like DOPA work better than other adhesives underwater?**

*DOPA type adhesives contain molecules that have hydrogen bonding in them. Hydrogen bonding is much stronger than van der Waals forces. Since water and other materials have polar or ionic bonds, the hydrogen bonding of the adhesive will form a stronger attractive force with the surface of the object.*

- 12. What makes carbon an ideal element to make polymers?**

*Carbon has four valence electrons, which gives it the ability to covalently bond with up to 4 other atoms. This could create a long chain of covalently bonded carbon atoms which would produce a strong, stable polymer.*

### **Questions for Further Learning**

- 1. Research popular adhesives and some of their ingredients. What are some of the additives used to increase the strength of the adhesives?**

*Duct (Duck) Tape: Contains rubber compounds that increase the strength and longevity of the adhesion.*

*Elmers glue: contains polyvinyl acetate, a common bonding agent. When it dries, it forms the sticky bonds between the surfaces.*

*Super glue: cyanoacrylate is the main bonding ingredient. It bonds instantly with trace amounts of water present. <https://home.howstuffworks.com/question695.htm>*

*Gorilla glue: Polyurethane is the main ingredient. Water activates its bonding properties (which is why you should moisten the area first). [www.gorillatough.com](http://www.gorillatough.com)*

- 2. Teflon is the brand name for a chemical coating that is found on many typical cookware items. It's popular because cooked food does not stick to the Teflon coating, making the cookware very easy to clean. Look up the composition of Teflon, and explain why it has low adhesive properties.**

*The formula for Teflon is polytetrafluoroethylene (PTFE). The molecule is a chain of carbon atoms surrounded by bonded fluorine atoms. The bond between carbon and fluorine is very strong. This makes Teflon extremely non-reactive, and can withstand high temperatures. The intermolecular forces of Teflon are very weak, which means the adhesive properties of Teflon is also very weak. Additionally, the composition of Teflon gives the substance very low friction, which helps food slide off easily during cooking.*

*You can find more information here: <https://lifelife.com/why-nothing-sticks-to-teflon-pans-and-cookware-1790527904>*

*YouTube video: <https://youtu.be/uXaP43Zbz7U>*

## 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

## Additional Resources

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### Lessons and lesson plans

**Intermolecular Forces Activity:** In this activity, students will represent molecules and energy to investigate the different types of intermolecular forces. They will interact with each other to model the relative strengths of the three types of intermolecular forces.

<https://teachchemistry.org/classroom-resources/intermolecular-forces-activity>

**Testing Tape Stickiness:** In this activity, students will test the stickiness of different adhesive tapes.

<https://www.acs.org/content/acs/en/education/outreach/celebrating-chemistry-editions/2020-ncw/testing-tape.html>

**How Many Times Can You Stick a Post-It Note?** In this activity, students investigate the stickiness of Post-It notes. <https://www.acs.org/content/acs/en/education/outreach/celebrating-chemistry-editions/2020-ncw/post-it-note.html>

**Exploring Intermolecular Forces:** In this lab, students will investigate the idea that “like dissolves like” by discovering which liquids are best suited for dissolving various substances. This can serve as a great inquiry lab prior to teaching intermolecular forces.

<https://teachchemistry.org/classroom-resources/exploring-intermolecular-forces>

**Making Homemade Glue:** Make your own glue from common household items. Discover how easy it is—all you need is milk, vinegar and baking soda!

<https://www.flinnsci.com/making-homemade-glue/dc10207/>

### Other Resources

**Celebrate National Chemistry Week** October 18–24, 2020 with the theme, "Sticking with Chemistry." Find more educational resources at [www.acs.org/ncw](http://www.acs.org/ncw).

**How Adhesive Tape Works** article: <https://science.howstuffworks.com/innovation/everyday-innovations/adhesive-tape.htm>

**The Different Types of Adhesives** YouTube Video: <https://youtu.be/6qutTkJ4rO8>

**Periodic Graphics – Chemistry of Glue** Infographic: <https://cen.acs.org/content/dam/cen/95/36/09536-sci2.pdf>

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Molecules & Bonding
- Intermolecular forces
- Polymers
- Solubility rules

## Correlations to Next Generation Science Standards

This article can be used to achieve the following performance expectations and dimensions of NGSS:

### HS-PS1-2

Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

### HS-PS2-6

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

### HS-ETS1-2

Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

### Disciplinary Core Ideas

- PS1.A: Structure and Properties of Matter
- PS2.B: Types of Interactions
- ETS1.B: Developing Possible Solutions

### Crosscutting Concepts:

- Cause and Effect: Mechanism and explanation
- Structure and Function

### Science and Engineering Practices:

- Analyzing and interpreting data
- Constructing explanations and designing solutions

### Nature of Science:

- Science is a human endeavor.

## Correlations to Common Core State Standards

See how *ChemMatters* correlates to the [Common Core State Standards at www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## Teaching Strategies

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

- **Alternative to Anticipation Guide:** Before reading, ask students where they use adhesives in their everyday lives, and how they think adhesives are developed. After they read, ask students to give examples of adhesives manufactured throughout history, as well as the future of adhesive development.

## Teacher's Guide

### What is Hand Sanitizer, and Does it Keep Your Hands Germ-Free?

*October 2020*

#### Table of Contents

<b><u><a href="#">Anticipation Guide</a></u></b>	<b>35</b>
Activate students' prior knowledge and engage them before they read the article.	
<b><u><a href="#">Reading Comprehension Questions</a></u></b>	<b>36</b>
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.	
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<b><u><a href="#">Additional Resources</a></u></b>	<b>41</b>
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<b><u><a href="#">Chemistry Concepts, Standards, and Teaching Strategies</a></u></b>	<b>42</b>

## Anticipation Guide

Name: \_\_\_\_\_

**Directions:** *Before reading the article*, in the first column, write “A” or “D,” indicating your Agreement or Disagreement 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
		31. Hand sanitizer works better against viruses than soap and water.
		32. Doctors knew that handwashing was important for health before they fully understood the effects of germs.
		33. SARS-CoV-2 virus is soluble in water.
		34. Both soap molecules and alcohols have a polar and a nonpolar region.
		35. Hydrogen peroxide is in hand sanitizer to kill viruses.
		36. Gel is added to hand sanitizer to slow the evaporation of alcohol.
		37. Alcohol-free hand sanitizers are not effective.
		38. Lipid fragments can be washed away by using soap and water, but not hand sanitizer.
		39. Hand sanitizers work on noroviruses like those that cause the stomach flu.
		40. Hand sanitizers work well when your hands are dirty or greasy.

# Student Reading

## Comprehension Questions

Name: \_\_\_\_\_

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

1. Briefly describe the meaning behind each part of the term COVID-19 (i.e. CO, VI, D, 19).
2. Explain why alcohol is used in hand sanitizer?
3. Give two examples of chemicals other than ethanol or isopropanol found in hand sanitizer and give their purpose.
4. Briefly explain the difference between polar and nonpolar molecules.
5. Explain why soap is more effective than hand sanitizer in protecting individuals from bacterial and viruses.
6. Suppose you went to all the local stores in your area and the premade hand sanitizer were completely sold out. How could you create your own hand sanitizer?
7. The efficacy of masks has become a very polarizing topic. Design a simple experiment you could perform to prove or disprove the idea that masks help prevent the spread of viruses.
8. Another popular chemical used as a disinfectant is bleach. What is the chemical formula of the main ingredient in bleach and how does it work to kill viruses?
9. Draw the chemical structure of soap and label the polar and nonpolar parts. Briefly explain why soap is an effective substance for cleaning and disinfecting surfaces, citing particular properties of its structure.



# Graphic Organizer

Name: \_\_\_\_\_

**Directions:** As you read, complete the graphic organizer below to describe ingredients in hand sanitizers.

Ingredients	Formula	Purpose
Ethanol		
Isopropanol		
Hydrogen peroxide		
Water		
Glycerol		
Polyacrylate	(no formula given in the article)	

**Summary:** Write a sentence or two stating what you would tell a friend who wanted to use hand sanitizer instead of soap and water to protect against SARS-CoV-2 viruses.

## Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Briefly describe the meaning behind each part of the term COVID-10 (i.e. CO, VI, D, 19)**

*CO is Covid*

*VI is Virus*

*D is Disease*

*19 is the year the virus originated – 2019*

2. **Explain why alcohol is used in hand sanitizer?**

*Alcohols have a polar and nonpolar region which allows them to effectively dissolve the lipid membranes of viruses, killing the virus.*

3. **Give two examples of chemicals other than ethanol or isopropanol found in hand sanitizer and give their purpose.**

*Glycerol and propylene glycol both act as moisturizers to prevent the alcohols in the hand sanitizer from drying out your skin.*

4. **Briefly explain the difference between polar and nonpolar molecules.**

*Polar molecules have permanent net dipole which is caused by an unequal sharing of electrons in the molecules. Permanent net dipole cause electrostatic attraction between adjacent molecules. Nonpolar molecules lack a permanent net dipole due to the equal sharing of electrons within the molecule. The electronegativities of the elements within the molecule determines if a polar or nonpolar bond covalent bond will form.*

5. **Explain why soap is more effective than hand sanitizer in protecting individuals from bacterial and viruses.**

*Similar to alcohols, soap has both a polar and nonpolar end. However, soap molecules form spheres called micelles, with the nonpolar region of the molecules facing outwards which attracts and disrupts the lipid membrane of the virus, both killing the virus and washing it away when you rinse your hands. If not used effectively hand sanitizer can leave live virus on your skin because they are unable to “wash” them off. The combined attraction, dissolving, and rinsing by using soap makes it more effective.*

6. **Suppose you went to all the local stores in your area and the premade hand sanitizer were completely sold out. How could you create your own hand sanitizer?**

*Homemade hand sanitizer can be made by combining two parts rubbing alcohol with one part aloe vera, both of which are commonly in stock at stores in which hand sanitizers are sold out.*

7. **The efficacy of masks has become a very polarizing topic. Design a simple experiment you could perform to prove or disprove the idea that masks help prevent the spread of viruses.**

*Answers may vary, but a very simple test could involve trying to blow out a candle with and without a mask on. More complex tests could use sensors to measure the flow of air or pressure through the mask. Bacteria samples and swabs could also be used by having someone breath on a petri dish with and without a mask on.*

8. **Another popular chemical used as a disinfectant is bleach. What is the chemical formula of the main ingredient in bleach and how does it work to kill viruses?**

*Bleach is NaClO (sodium hypochlorite). Bleach kills bacteria and viruses by reacting with the proteins and destroying them.*

9. **Draw the chemical structure of soap and label the polar and nonpolar parts. Briefly explain why soap is an effective substance for cleaning and disinfecting surfaces, citing particular properties of its structure.**

*Students should use the diagram of soap in the article to guide their response. The polar and nonpolar regions of soap make it a good chemical to wash both polar and nonpolar substances.*

### Questions for Further Learning

1. **The unfortunate reality is that another pandemic will most likely happen sometime in the not so distant future. Suppose you were tasked with creating a pandemic kit. Based on your experiences, what items would you include in the kit and why?**

*Answers will vary, but some items may include masks, toilet paper, sanitizing wipes, etc.*

2. **Create a 30 second to 1 minute commercial video explaining benefits of soap and handwashing. Be sure to include the chemistry of soap in your video. You may also explain why soap is more beneficial than hand sanitizer.**

*Answers will vary*

## 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

## Additional Resources

### Labs and demos

The Chemistry of Hand Sanitizer and Soap: In this lab, students will model the interaction between hand sanitizer particles and virus particles, as well as between soap particles and virus particles.

<https://teachchemistry.org/classroom-resources/the-chemistry-of-hand-sanitizer-and-soap>

Hand Sanitizer Lab related to the Mole: It's Mole Time! In this lab, students determine the number of moles of chalk used to write their name, the moles of sucrose ingested while chewing gum, and the moles of alcohol evaporated when using hand sanitizer.

<https://teachchemistry.org/classroom-resources/it-s-mole-time>

Designing an Effective Respiratory Cloth Mask: In this activity students will use unit conversion to help compare sizes of molecules, viruses, and droplets and then use them to interpret graphical data. They will then use their findings to design a cloth mask that helps protect its wearer against infection by SARS-CoV-2, the coronavirus that causes COVID-19.

<https://teachchemistry.org/classroom-resources/designing-an-effective-respiratory-cloth-mask>

Modeling Polarity: In this activity, students will model the pull of electrons in a bond between two elements, demonstrating covalent bonding. In particular differentiating between polar and nonpolar bonds.

<https://teachchemistry.org/classroom-resources/modeling-bond-polarity>

### Simulations

Intermolecular Forces Simulation: Students will review the three major types of intermolecular forces – London dispersion forces, dipole-dipole interactions, and hydrogen bonding – through short video clips and accompanying text. The simulation is designed as a five question quiz for students to use multiple times.

<https://teachchemistry.org/classroom-resources/simulation-activity-intermolecular-forces-2>

Comparing Attractive Forces: In this activity, students will use a simulation to investigate different types of intermolecular forces (London dispersion and dipole-dipole). In the analysis that follows the activity, they will relate IMFs (including hydrogen bonding) to physical properties (boiling point and solubility).

<https://teachchemistry.org/classroom-resources/simulation-activity-intermolecular-forces>

### Lessons and lesson plans

This lesson plan is a review of intermolecular forces concepts.

<https://teachchemistry.org/classroom-resources/intermolecular-forces-review>

### Other Resources:

Infographic – Coronavirus: How hand sanitizers protect against infections:

<https://www.compoundchem.com/tag/hand-sanitizer/>

World Health Organization's formula for creating your own hand sanitizer:

[https://www.who.int/gpsc/5may/Guide\\_to\\_Local\\_Production.pdf?ua=1](https://www.who.int/gpsc/5may/Guide_to_Local_Production.pdf?ua=1)

# Chemistry Concepts, Standards, and Teaching Strategies

## Connections to Chemistry Concepts

The following chemistry concepts are highlighted in this article:

- Molecules & bonding
- Molecular structure
- Intermolecular forces

## Correlations to Next Generation Science Standards

This article can be used to achieve the following performance expectations and dimensions of 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 constraint, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

#### Disciplinary Core Ideas:

- PS1.A: Structure and Properties of Matter
- ETS1.C: Optimizing the Design Solution

#### Crosscutting Concepts:

- Cause and Effect: Mechanism and explanation
- Structure and Function

#### Science and Engineering Practices:

- Analyzing and interpreting data
- Constructing explanations and designing solutions

#### Nature of Science:

- Science addresses questions about the natural and material world.

## Correlations to Common Core State Standards

See how *ChemMatters* correlates to the [Common Core State Standards](http://www.acs.org/chemmatters) at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

## 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 use hand sanitizer, and how they think it works to protect them from getting sick. As they read, students can find information to confirm or refute their original ideas.
- After they read, ask students what they learned about the efficacy of using hand sanitizers.
- There are several good ACS Reactions videos that complement the information in this article. Consider showing one or more of these after students have read the article:
  - How Do Hand Sanitizers Work? <https://youtu.be/245jz3ZqZqM>
  - You're Using Disinfectants Wrong: <https://youtu.be/kbScdUwo7K4>
  - Can Soap REALLY "Kill" the Coronavirus? <https://youtu.be/K2pMViml2bw>

# About the Teacher's Guide

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Teacher's Guide team editors Dusty Carroll, Scott Hawkins, Matt Perekupka, and Jennifer Smith created the Teacher's Guide article material. Susan Cooper prepared the anticipation, reading guides, and connections to standards.

Christine Suh (Managing Editor), Emily Abbott (Administrative Editor), and Lis Gallegos (Production Editor) coordinated the production and development of the Teacher's Guides.

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