

**Teacher’s Guide**

**Radium Girls: Dialing Up Trouble**

***October 2023***

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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***](#_fbh2674qb7v5) ***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.

[***Additional Resources***](#_8qbtv1wio6jt) ***9***

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

***[Chemistry Concepts and Standards](#_gy1yjx1c39og) 10***



# 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. Paint containing pure radium was used to make watch dials glow in the dark. |
|  |  | 2. Radioactivity is a natural process. |
|  |  | 3. Alpha particles can penetrate a piece of paper. |
|  |  | 4. If radium enters the body, it can replace calcium in the bones. |
|  |  | 5. The Radium Girl painters sometimes painted their teeth and faces as a game. |
|  |  | 6. Safety procedures for the painters were in place prior to the 1920s. |
|  |  | 7. Promethium was used as a substitute for radium because it is not radioactive. |
|  |  | 8. Luminescent watch dials today are not radioactive. |
|  |  | 9. Radium is found in all uranium minerals. |
|  |  | 10. Marie Curie knew about the health problems suffered by the Radium Girls. |

# Student Reading Comprehension Questions

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

1. List the two components in the powdered base of the paint used by the watch dial painters and the two ingredients the powder was mixed with to produce paint.
2. What type of radiation particles are released when radium salts decompose?
3. Define the term radioactivity.
4. What are the three most common types of radioactive emissions?
5. What is a scintillator?
6. Explain why the watch-dial painters’ clothes and bodies would glow in the dark even if they did not directly touch the radium powder.
7. Explain why radium is deposited in bones when it is absorbed in the body.
8. Why is it safer to use promethium than radium when making luminescent objects?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. How does using a breathalyzer to measure radon levels help determine someone’s level of radium exposure?
2. What unit of measure is named after Marie Curie and what does it measure?
3. List the elements used in the Indiglo Night-light and describe how they emit light.
4. Identify at least three workplace reforms instituted to try and protect the radium girls and explain why each reform was implemented.
5. The article lists some benefits and drawbacks of exposure to radiation. Perform some additional research to identify and analyze two benefits and two drawbacks of radioactivity.

# Graphic Organizer

**Directions**: As you read, complete the graphic organizer below to describe problems that caused the Radium Girls to suffer.

|  |  |  |
| --- | --- | --- |
|  | **Description** | **Safety Issues** |
| **Radium Paint** |  |  |
| **Alpha particles** |  |  |
| **Radium** |  |  |
| **Painting method used by Radium Girls** |  |  |
| **Radium Paint Substitutes** |  |  |
| **Marie Curie’s discoveries** |  |  |

**Summary:** On the back of this sheet, write a short summary (20 words or less) of the article.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. List the two components in the powdered base of the paint used by the watch dial painters and the two ingredients the powder was mixed with to produce paint.  
   The two components of the powder are radium salts and zinc sulfide. The powder was mixed with glue and water.
2. What type of radiation particles are released when radium salts decompose?  
   Alpha particles are released when radium salts decompose.
3. Define the term radioactivity.  
   Radioactivity is the spontaneous emission of particles or electromagnetic radiation of high energy from the nucleus of an atom.
4. What are the three most common types of radioactive emissions?  
   The three most common types of radioactive emissions are alpha particles, beta particles, and gamma radiation.
5. What is a scintillator?  
   A scintillator is a material that emits visible light in response to ionizing radiation.
6. Explain why the watch-dial painters’ clothes and bodies would glow in the dark even if they did not directly touch the radium powder.  
   The radium powder would become airborne and land on them.
7. Explain why radium is deposited in bones when it is absorbed in the body.  
   Radium is deposited in bones as a substitute for calcium because both elements are alkaline earth elements.
8. Why is it safer to use promethium than radium when making luminescent objects?  
   Promethium is less hazardous because it decomposes into beta particles which are less able to ionize than alpha particles.
9. How does using a breathalyzer to measure radon levels help determine someone’s level of radium exposure?  
   When radium-226 decays, it decays into atoms of radon-222 and helium-4. Because radium breaks down into radon, measuring radon levels can help to determine the amount of radium a worker may have been exposed to.
10. What unit of measure is named after Marie Curie and what does it measure?  
    The curie is named after Marie Curie and it is used to measure radioactivity.
11. List the elements used in the Indiglo Night-light and describe how they emit light.  
    The Indiglo Night-light uses ZnS and Cu. An electrical charge is applied to the ZnS and Cu which excites their electrons. When the electrons return to their ground state, energy is released as light.
12. Identify at least three workplace reforms instituted to try and protect the radium girls and explain why each reform was implemented.  
    One reform was to ban eating in the work area. This would help prevent the workers from ingesting radium.

The workers were required to wear gloves to wash their paint equipment. This would also prevent contact with radium.

Weighing and mixing the paint was performed under a fume hood to reduce the amount of powder that became airborne.

The amount of time a worker was able to be in the painting department was limited to limit exposure.

1. The article lists some benefits and drawbacks of exposure to radiation. Perform some additional research to identify and analyze two benefits and two drawbacks of radioactivity.  
   Student responses will vary based on their research. Two benefits are that radioactivity can be used to slow or destroy cancer and can sterilize foods. Two drawbacks are that it can cause sickness and death.

**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**

* **Simulations**
  + [Radioactivity Simulation](https://www.farlabs.edu.au/radioactivitysimulation/) – Students can use this simulation to explore four different radioactive sources and materials that can be used to block radiation.
* **Lessons and lesson plans**
  + [Detecting Radiation in our Radioactive World](https://assets-global.website-files.com/5ed97259050e9609486076e1/5ed977227025a348a1925667_ANS-Teacher_Resource_Guide_web.pdf) – This resource developed by the American Nuclear Society includes a variety of lesson plans and activities on topics related to radiation including half-life, irradiation, fission, decay chains, radiation types, and waste.
  + [Radium Girls](https://orise.orau.gov/resources/k12/documents/lesson-plans/radium-girls-cedr-lesson-plan.pdf) - This lesson plan utilizes graphing to help students understand the impacts of radiation exposure.
* **Projects and extension activities**

* + [Marie Curie Video Questions](https://teachchemistry.org/classroom-resources/marie-curie-video-questions) – This video resource and accompanying questions from the American Association of Chemistry Teachers website enables students to learn more about Marie Curie and her work.
  + [Primary Sources in Science Classrooms](https://blogs.loc.gov/teachers/2019/10/primary-sources-in-science-classrooms-asking-science-and-social-studies-questions-about-radium-girls/) - This post includes links to a variety of primary source documents to provide students with historical context about the uses of radium.

**Teaching Strategies**

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

* **Alternative to Anticipation Guide:** Before reading, ask students how watch dials are made to glow in the dark. Also ask students if they have heard of the Radium Girls and what happened to them. 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 radioactivity and how the suffering of the Radium Girls lead to safety regulations in industry.
* After reading, ask students how they might use information from the article to make decisions about the safe use of radioactive substances.
* There are photos of radium watches and clocks as well as quotes from some of the Radium Girls at the National Museum of American History website: <https://americanhistory.si.edu/girlhood/work/radium-girls>

# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* History and Safety
* Alpha/Beta/Gamma decay
* Radiation

**Correlations to Next Generation Science Standards**

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

**HS-PS1-8.** Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

**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:**

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

**Crosscutting Concepts:**

* Cause and effect
* Structure and Function

**Science and Engineering Practices:**

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

**Nature of Science:**

* Science is a human endeavor.

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).