1. Do the following:

 a. Explain radiation and the difference between ionizing and non-ionizing radiation.

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 b. Explain radiation and the difference between ionizing and non-ionizing radiation.

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 Explain the ALARA principle and the measures required by law to minimize these risks.

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 Describe what safety requirements you will need to consider while performing the requirements in this merit badge.

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 c. Describe the radiation hazard symbol and explain where it should be used.

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 d. Explain how we are exposed to ionizing radiation from outside the earth as well as on earth every day.

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 Ust four examples of Naturally Occurring Radioactive Materials. NORM, that are in your house or grocery store and explain why they are radioactive.

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|  | Type of NORM | Why is it radioactive? |
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 e. Explain the difference between radiation exposure and contamination.

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 Describe the hazards of radiation to humans, the environment, and wildlife.

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| Humans: |  |
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| Environment: |  |
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| Wildlife: |  |
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Calculate your approximate annual radiation dose and compare to that of someone who works in a nuclear power plant.

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2. Do the following:

 a. Tell the meaning of the following: atom, nucleus, proton, neutron, electron, quark, isotope, alpha particle, beta particle, gamma ray, X-ray, ionization, radioactivity, radioisotope, and stability.

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| Atom: |  |
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| Nucleus: |  |
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| Proton: |  |
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| Neutron: |  |
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| Electron: |  |
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| Quark: |  |
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| Isotope: |  |
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| Alpha particle: |  |
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| Beta particle: |  |
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| Gamma ray: |  |
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| X-ray: |  |
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| Ionization: |  |
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| Radioactivity: |  |
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| Radioisotope: |  |
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| Stability: |  |
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 b. Choose an element from the periodic table.

⬜ Construct 3-D models for the atoms of three isotopes of this element, showing neutrons, protons, and electrons.

 Write down the isotope notation for each model including the atomic and mass numbers.

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 In a separate model or diagram, explain or show how quarks make up protons and neutrons.

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3. Do ONE of the following; then discuss modern particle physics with your counselor:

⬜ a. Visit an accelerator (research lab) or university where people study the properties of the nucleus or nucleons.

⬜ List three particle accelerators and describe several experiments that each accelerator performs, including basic science and practical applications.

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4. Do TWO of the following; then discuss with your counselor:

⬜ a. Build an electroscope.

⬜ Show how it works.

Place a radiation source inside and explain the effect it causes.

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⬜ b. Make a cloud chamber.

⬜ Show how it can be used to see the tracks caused by radiation.

Explain what is happening.

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⬜ c. Perform an experiment demonstrating half-life. Discuss decay chains.

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5. Do ONE of the following; then discuss with your counselor the principles of radiation safety.

⬜ a. Using a radiation survey meter and a radioactive source, show how the counts per minute change as the source gets closer to or farther from the radiation detector.

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Place three different materials between the source and the detector, then explain any differences in the measurements per minute.

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Explain how time, distance, and shielding can reduce an individual’s radiation dose.

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⬜ b. Describe how radon is detected in homes.

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Discuss the steps taken for the long-term and short-term test methods, tell how to interpret the results, and explain when each type of test should be used.

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Explain the health concern related to radon gas and tell what steps can be taken to reduce radon in buildings.

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⬜ c. Visit a place where X-rays are used.

Location:

⬜ Draw a floor plan of this room. Show where the unit, the unit operator, and the patient would be when the X-ray unit is operated.



Explain the precautions taken and the importance of those precautions.

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Discuss with your counselor the principles of radiation safety:

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6. Do ONE of the following, then discuss with your counselor how nuclear energy is used to produce electricity:

⬜ a. Make a drawing showing how nuclear fission happens.

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 Observe a mousetrap reactor (setup by an adult) and use it to explain how a chain reaction could be started.

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 Explain how a chain reaction could be stopped or controlled in a nuclear reactor.

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 Explain what is meant by a "critical mass."

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Draw another picture showing how a chain reaction could be started and how it could be stopped.

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Explain what is meant by a “critical mass.”

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⬜ b. Visit a local nuclear power plant or nuclear reactor either in person or online (with your parent's permission). Learn how a reactor works and how the plant generates electricity.

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 Find out what percentage of electricity in the United States is generated by nuclear power plants, by coal, and by gas.

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| Nuclear: |  | Coal: |  | Gas: |  |

7. Give an example of each of the following in relation to how energy from an atom can be used: nuclear medicine, environmental applications, industrial applications, space exploration, and radiation therapy.

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| Nuclear medicine: |  |
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| Environmental applications: |  |
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| Industrial applications: |  |
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| Space exploration: |  |
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| Radiation therapy: |  |
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For each example, explain the application and its significance to nuclear science.

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| Nuclear medicine: |  |
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| Environmental applications: |  |
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| Industrial applications: |  |
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| Space exploration: |  |
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| Radiation therapy: |  |
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8. Find out about three career opportunities in nuclear science that interest you.

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Pick one and find out the education, training, and experience required for this profession.

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| Career: |  |
| Education: |  |
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| Training: |  |
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| Experience: |  |
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Discuss this with your counselor, and explain why this profession might interest you.

**When working on merit badges, Scouts and Scouters should be aware of some vital information in the current edition of the *Guide to Advancement* (BSA publication 33088). Important excerpts from that publication can be downloaded from** [**http://usscouts.org/advance/docs/GTA-Excerpts-meritbadges.pdf**](http://usscouts.org/advance/docs/GTA-Excerpts-meritbadges.pdf)**.**

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