Intro HP Problem Set 2 | Radionuclide Scavenger Hunt

Purpose: get familiar with the physical properties of different radionuclides and better understand the implications for radiological protection.

Instructions:

* Save a copy of this document (don’t modify the original, please!)
* [“Sign up” for your radionuclide(s)](https://usepa.sharepoint.com/:w:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/Problem%20Sets/1B%20Radionuclide%20List%20Signups.docx?d=we505e1f88fc241a18125b6749f3b6837&csf=1&web=1&e=iQ4TXg) on the assignment sheet.
* Pick a “common” radionuclide from list A, as well as any radionuclide(s) from list B. Feel free to add to the B-list.

Part 1: Radionuclide Properties

Use an interactive chart of the nuclides ([IAEA](https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html), [BNL](https://www.nndc.bnl.gov/nudat3/), or other) OR another authoritative source of nuclear decay data (e.g., ICRP, NIST) to find the following for your radionuclide(s):

1. Thorium-232 (Th-232)
2. 90 protons, 142 neutrons (232-90), and atomic mass of 232
3. Th-232 and
4. Most abundant (and stable) natural isotope of thorium (99.98%)
5. 14 billion year half life
6. Decay related information:
7. The decay process also emits alpha particles and gamma radiation
8. Gamma ray energy is 186 keV
9. First daughter is Radium-228, then Actinium-228, Thorium-228, Radium-224, Radon-220 (thoron), Polonium-216, Lead-212, Bismuth-212, Polonium-212, Thallium-208 and ends at stable Lead-208 (“Thorium Series”)
10. Quick decay to lead once the series begins. The longest half life of any element in the chain is radium-228 (5.75 years), the next longest is Th-228 (~2 years) and all others under 4 days.

*Extra credit*: determine if the primary decay product is stable. If not, repeat the above for the decay product.

Part 2: Radiation Protection Considerations

Using class resources or an internet search, address these questions. Note: for rare/uncommon radionuclides, information may be limited.

1. Are there practical uses of this radionuclide? What are they?
   1. Thorium-232 is used in gas lantern mantles and welding electrodes.
   2. Thorium-232 is in the news primarily due to China's research and development of thorium-based nuclear power. China has begun building larger demonstration reactors and successfully reloaded their experimental reactor while it was running.
      1. Thorium-fueled molten salt reactor (Gobi desert) achieved full power in 2024 and generates 2 MW of thermal power; refueled without shutdown in late 2024
      2. Thorium reactors produce significantly less long-lived radioactive waste compared to traditional uranium reactors
   3. Thorium-232 can be converted into uranium-233 (²³³U) in a nuclear reactor, which then serves as fuel for the thorium fuel cycle.
      1. Fertile nuclides are able to absorb a neutron and transform to a nuclide that is able to undergo fission (fissile nuclide). Thorium-232 is a fertile nuclide and is used in combination with a fissile nuclide as a fuel source in types of nuclear reactors known as breeder reactors. Breeder reactors are able to continually generate new fuel as fuel is being consumed. The United States does not operate breed reactors.
   4. This cycle is seen as a path to a potentially sustainable, long-term energy supply due to thorium's abundance.
   5. Advanced reactor designs, such as liquid fluoride reactors (LFTRs), are being explored to efficiently utilize the thorium fuel cycle.
2. Where/how might it be encountered by humans?
   1. Soil
3. Under what scenarios and with what likelihood?
   1. Thorium-232 is a naturally occurring radionuclide that is found in the earth’s crust. It is present in low levels throughout the natural environment which makes means everyone is exposed to very low levels from air, food, and water.
   2. Workers in thorium mines may have higher exposure from breathing thorium dust
   3. In the past, between 1930 and 1955, more than 2.5 million people worldwide were exposed to thorium when they received Thorotrast, a thorium-based x-ray contrast agent.
4. Might it affect non-human biota?
   1. Th-232 has a low solubility and low specific activity making it rare to find it in biota
5. Given the information in Part 1, what are radiation protection considerations?
6. Is it more an internal or external hazard?
   1. The main pathways of exposure are inhalation and ingestion
   2. Thorium was found in highest concentrations in the pulmonary lymph nodes and lungs suggesting inhalation of soil particles is the primary route of human exposure
7. What interventions may mitigate exposure?
8. Are there any historical or “fun” facts about this radionuclide?
9. E.g., does it have historical significance? Are there any recent events, news stories, or pop culture references?
10. Thorium dioxide has the highest melting point of all known oxides making it ideal for high temperature ceramics (e.g., laboratory crucibles); alloyed with magnesium to create lightweight, high-strength parts for aircraft, spacecraft, and missiles. Decline in use since the late 20th century due to concerns over handling and disposal related to radioactivity
11. It is the start of one of the 4 primordial decay series: the Thorium series. In this series radon is referred to as “thoron”.

Part 3: Public Communication

For your “common” radionuclide, review the associated draft webpage content and provide any comments. [Radionuclides Webpages – HP Study Group Review](https://usepa.sharepoint.com/:f:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/Problem%20Sets/Radionuclide%20Webpages?csf=1&web=1&e=L4fWbW)

For consideration:

* Do you notice any errors in the text?
* Is the language written in a manner that is accessible to a public audience?
* Is there any key information about the radionuclide that should be included?

If you are making edits or comments directly in word, [please save a **copy** in this folder](https://usepa.sharepoint.com/:f:/r/sites/HealthPhysics/Shared%20Documents/Intro%20HP%20Training/Problem%20Sets/Radionuclide%20Webpages/SAVE%20EDITED%20VERSIONS%20HERE?csf=1&web=1&e=BzfrWI) and use track changes!

