<table>
<thead>
<tr>
<th>Element</th>
<th>Protons</th>
<th>Neutrons</th>
<th>Half Life</th>
<th>Price</th>
<th>Danger Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americium-241 (Am)</td>
<td>95</td>
<td>146</td>
<td>430 Years</td>
<td>£££££</td>
<td></td>
</tr>
<tr>
<td>Cesium-137 (Cs)</td>
<td>55</td>
<td>82</td>
<td>30 Years</td>
<td>£££££</td>
<td></td>
</tr>
<tr>
<td>Calcium-47 (Ca)</td>
<td>20</td>
<td>27</td>
<td>4.5 Days</td>
<td>£££££</td>
<td></td>
</tr>
</tbody>
</table>
| Emission Type | Alpha, Gamma | Occurrence | Man-Made, Solid | Uses | Household, Medicine | Environmental Impact: 1
| Emission Type | Beta, Gamma | Occurrence | Man-Made, Solid | Uses | Medicine | Environmental Impact: 1
| Emission Type | Beta, Gamma | Occurrence | Natural, Solid | Uses | Scientific | Environmental Impact: 1
| Iodine-131 (I) | 53      | 70       | 13 Hours   | £££££ |    |  |
| Iodine-123 (I) | 77      | 115      | 74 Days    | £££££ |    |  |
| Cobalt-60 (Co) | 32      | 33       | 5 Years    | £££££ |    |  |
| Carbon-14 (C) | 32      | 33       | 5 Years    | £££££ |    |  |
| Calcium-47 (Ca) | 20      | 27       | 4.5 Days  | £££££ |    |  |
| Emission Type | Beta, Gamma | Occurrence | Man-Made, Solid | Uses | Medicine | Environmental Impact: 1
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- **Americium-241 (Am):** Used in fire detectors to detect small amounts of radioactive material. Also used in medicine to treat cancer.
- **Cesium-137 (Cs):** Used in medicine to treat certain types of cancer.
- **Calcium-47 (Ca):** Used in medical research to study bone density in the body.
- **Iodine-131 (I):** Used in medicine to treat certain types of cancer.
- **Iodine-123 (I):** Used in medical research to study the brain and other organs.
- **Cobalt-60 (Co):** Widely used in medicine for cancer treatment.
- **Carbon-14 (C):** Used in medicine for cancer treatment.
- **Iron-55 (Fe):** Used in medicine for cancer treatment.
- **Iridium-192 (Ir):** Used in medicine for cancer treatment.

**Environmental Impact:**
- Low: £££££
- Medium: £££££
- High: £££££
- Very High: £££££

**Danger Rating:**
- Low: 
- Medium: 
- High: 
- Very High: 

- **Americium-241 (Am):** Low
- **Cesium-137 (Cs):** Medium
- **Calcium-47 (Ca):** High
- **Iodine-131 (I):** Medium
- **Iodine-123 (I):** Low
- **Cobalt-60 (Co):** High
- **Carbon-14 (C):** Medium
- **Iron-55 (Fe):** Low
- **Iridium-192 (Ir):** High
### Chemical Elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Protons</th>
<th>Neutrons</th>
<th>Half Life</th>
<th>Price</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Iron-55 (Fe)</strong></td>
<td>26</td>
<td>29</td>
<td>3 years</td>
<td>$0.30/kg</td>
<td>3</td>
</tr>
<tr>
<td><strong>Lead-210 (Pb)</strong></td>
<td>82</td>
<td>128</td>
<td>22 years</td>
<td>$9.55/kg</td>
<td>5</td>
</tr>
<tr>
<td><strong>Nickel-63 (Ni)</strong></td>
<td>59</td>
<td>35</td>
<td>100 years</td>
<td>$5.78/kg</td>
<td>4</td>
</tr>
<tr>
<td><strong>Phosphorus-32 (P)</strong></td>
<td>15</td>
<td>17</td>
<td>14 days</td>
<td>$2.00/kg</td>
<td>2</td>
</tr>
<tr>
<td><strong>Plutonium-238 (Pu)</strong></td>
<td>94</td>
<td>144</td>
<td>88 years</td>
<td>$100.00/kg</td>
<td>5</td>
</tr>
<tr>
<td><strong>Polonium-210 (Po)</strong></td>
<td>84</td>
<td>126</td>
<td>140 days</td>
<td>$150.00/kg</td>
<td>5</td>
</tr>
<tr>
<td><strong>Potassium-40 (K)</strong></td>
<td>19</td>
<td>21</td>
<td>1.3 billion years</td>
<td>$0.50/kg</td>
<td>2</td>
</tr>
<tr>
<td><strong>Promethium-147 (Pm)</strong></td>
<td>61</td>
<td>86</td>
<td>2.6 years</td>
<td>$250.00/kg</td>
<td>5</td>
</tr>
<tr>
<td><strong>Radium-226 (Ra)</strong></td>
<td>88</td>
<td>138</td>
<td>1600 years</td>
<td>$1000.00/kg</td>
<td>5</td>
</tr>
</tbody>
</table>

- **Fe**: Used in many metals, specifically steel, and their corrosion ever time and in construction analysis.
- **Pb**: Used to determine how old soils, rocks and other environmental things are, particularly from lakes and the sea floor useful in determining how long ago ice ages were.
- **Ni**: Used in airport scanners to detect likely explosives, and in scientific analysis.
- **P**: Used in medicine, biology, etc. to track DNA in the body (DNA contains phosphorus).
- **Pu**: Probably the most dangerous element in the earths crust. Grow radioactive, toxic, but also very useful. It can power spacecraft engines or be turned into weapons if generated, and can be used in nuclear weapons and power.
- **Po**: Used in geoscientists to improve image quality (in much higher doses it was also used by Russian security to kill one of their double agents. Alexander Litvinenko, in 2006).
- **K**: Most of the radioactivity in humans comes from potassium-40. Also present in bananas, etc. The ratio of potassium to lead is about 100 million because in one go or the form radiation.
- **Pm**: Historically in search electric blankets stay at the correct temperature. It grows thanks to its radioactivity and is sometimes used in night-vision, video scopes.
- **Ra**: Used in paints to make glow-in-the-dark watches. Marie and Pierre Curie first isolated the element by heating uranium deposits in a mixture around the 1890s.
HOUSEHOLD QUESTION

Some 25-30% of food harvested is lost as a result of spoilage before it can be consumed. This problem is particularly prevalent in hot, humid countries. Food irradiation is the process of exposing foodstuffs to gamma rays to kill bacteria that can cause food-borne disease, and to increase shelf-life. It has the same benefits as when food is heated, refrigerated, frozen, or treated with chemicals, but does not change the temperature or leave residues. What radionuclide would you use for this purpose and why?

NUCLEAR POWER QUESTION

Nuclear power is particularly suitable for vessels which need to be at sea for long periods without refuelling, or for powerful submarine propulsion. Over 160 ships are powered by more than 200 small nuclear reactors. Most are submarines, but they range from icebreakers to aircraft carriers. Which radionuclide would you choose to power a submarine and why?

NUCLEAR POWER QUESTION

Advanced gas-cooled reactors (AGR) are the second generation of British gas-cooled reactors, using graphite moderator and carbon dioxide as primary coolant. These reactors like other nuclear technology uses the energy released by splitting the atoms of certain elements. What is the best radionuclide to use as a fuel for an AGR and why?
**SCIENTIFIC QUESTION**

Analysing the relative abundance of particular naturally-occurring radioisotopes is of vital importance in determining the age of rocks and other materials that are of interest to geologists, anthropologists, hydrologists, and archaeologists, among others. What radionuclide would you use to measure the age of wood and why?

**SCIENTIFIC QUESTION**

The ability to use radioisotopes to accurately measure thickness is widely used in the production of sheet materials, including metal, textiles, paper, plastics, and others. They measure the amount of radiation from a source which has been absorbed in materials. What radionuclide would you use to measure the thickness of an extruded metal pipe for constructing a new research reactor, why did you choose this radionuclide?

**SCIENTIFIC QUESTION**

Efficient use of fertilisers is a concern to both developing and developed countries. It is important that as much of the fertiliser as possible finds its way into plants and that a minimum is lost to the environment. Fertilisers ‘labelled’ with a particular isotope, provide a means of finding out how much is taken up by the plant and how much is lost, allowing better management of fertiliser application. Which radionuclide would you use for this purpose and why?

**MEDICINE QUESTION**

Diagnostic techniques in nuclear medicine use radiopharmaceuticals (or radiotracers) which emit particles or rays from within the body. These tracers are generally short-lived isotopes. Dependent on the type of examination, radiotracers are either injected into the body, swallowed, or inhaled in gaseous form. The emissions from the radiotracers are detected by the imaging device, which provides pictures and molecular information. A patient needs to have the gas exchange in their lungs investigated, what radionuclide would you use to carry out these investigations and why?

**MEDICINE QUESTION**

Radionuclide therapy has progressively become more successful in treating persistent disease and doing so with low toxic side-effects. With any therapeutic procedure the aim is to confine the radiation to well-defined target volumes of the patient. Many of these therapeutic procedures are palliative, usually to relieve pain. For instance, there are several radionuclides that are used for the relief of cancer-induced bone pain. Which radionuclides would you use to target cancerous growths in the bone and why? *Hint what is bone mostly made out of?*

**MEDICINE QUESTION**

Nuclear medicine is also used for therapeutic purposes. What radionuclide would you use to treat a cancerous tumour affecting the thyroid gland? Please explain your choice!