Basics of analytical radiochemistry

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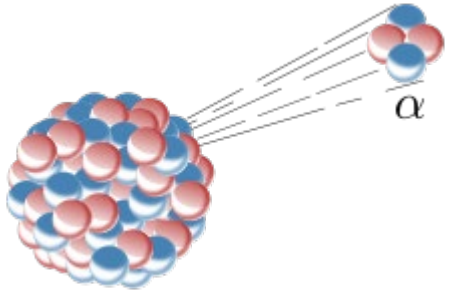
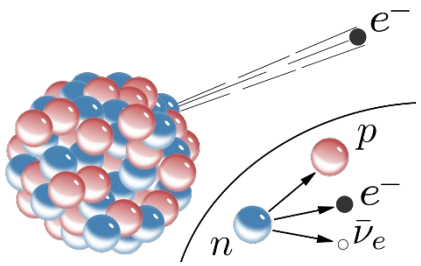
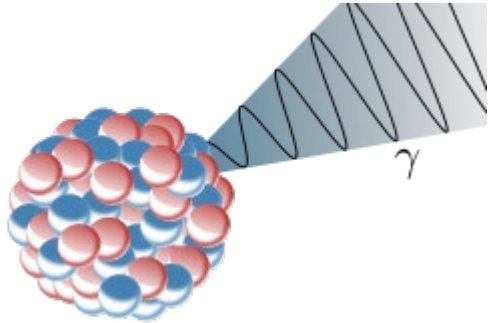
Analytical radiochemistry and radioactivity

- Analytical chemistry dealing with radioactive elements or radionuclides
- Radionuclide = nuclide, which has excess nuclear energy making it unstable
- Alpha, beta, gamma emitters



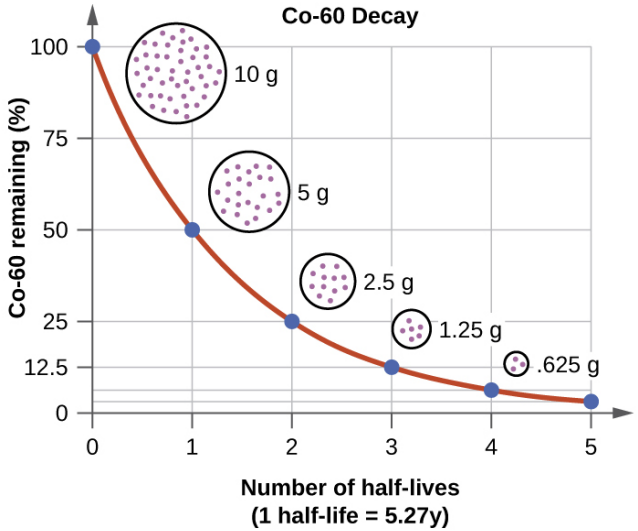




- We can use radioacivity to detect them
- Radionuclides are present everywhere

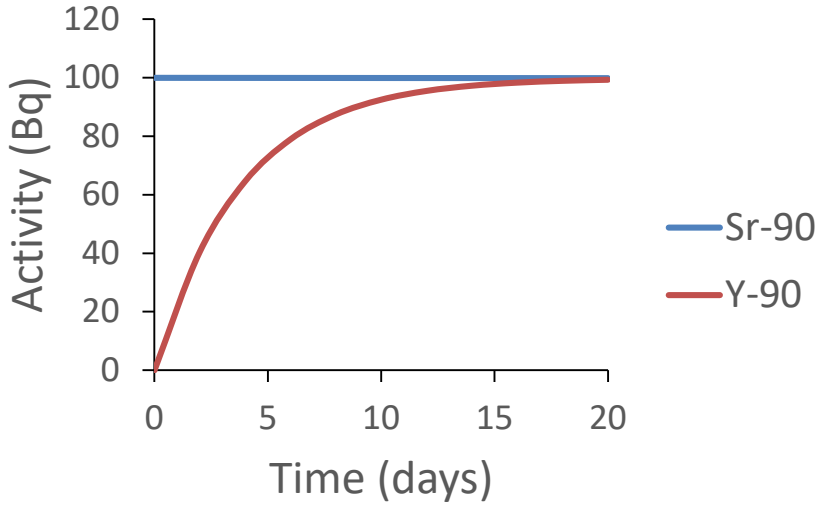
Radioactive decay

- Radionuclide can decay and/or gow up



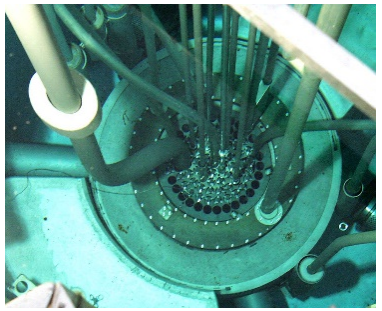
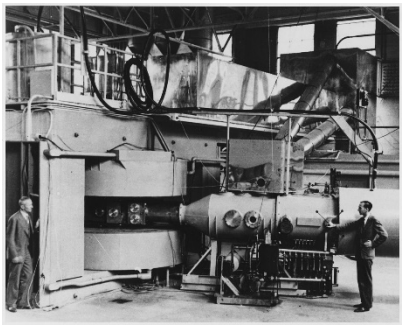
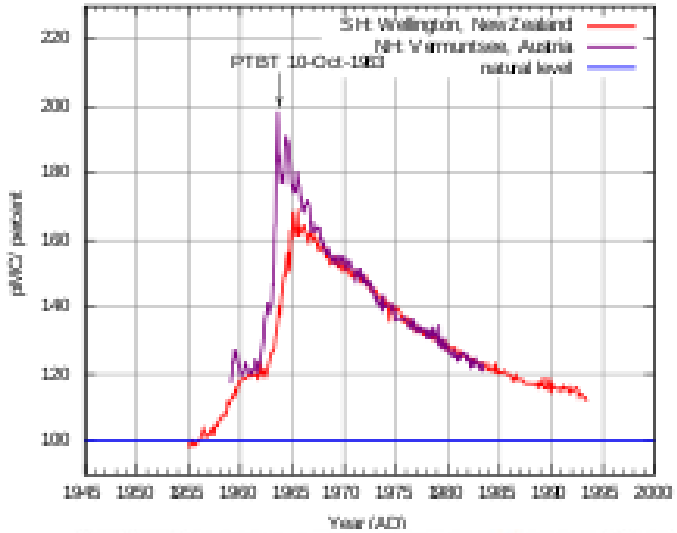
$$A_t = A_0 e^{\left(\frac{-ln(2)t}{t_{1/2}}\right)} \quad [\mathrm{Bq}] \qquad (1)$$

- Radioactive equilibrium

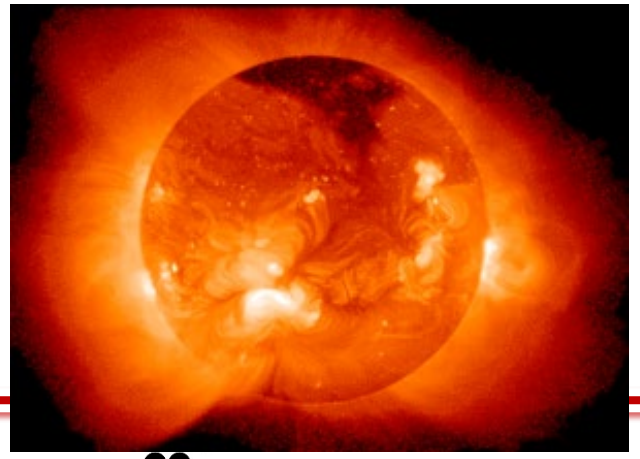
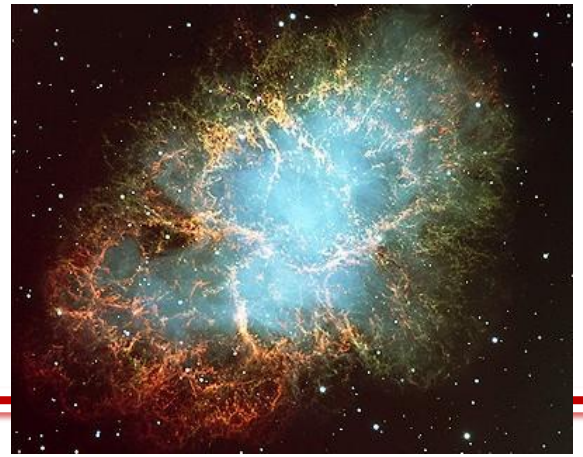
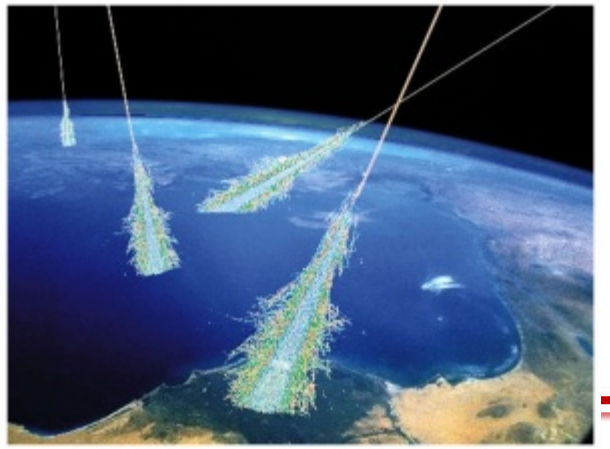


Natural and anthropogenic radionuclides

- Anthropogenic = produced by human activities

- Natural = produced by other activities

Natural radionuclides

- Primordial = half life long enough to not decay since creation of Earth
  U-238, U-235, Th-232, K-40



- Secondary = decay products of primordial, but with shorter half life
  Ra-226, Pb-210, Po-210,…

- Cosmogenic = produced with interaction with cosmic rays
  H-3, C-14, Be-7, Be-10…

Typical analysis steps in analytical radiochemistry

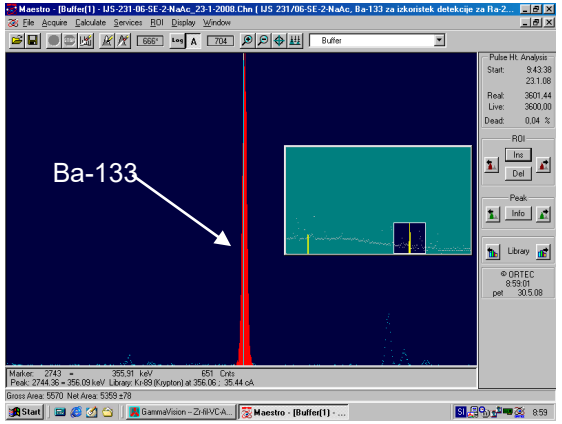
- **Sample pre-treatment** (filtration, sieving, homogenisation, digestion, dissolution, pre-concentration,…)
- **Separation of analyte** (precipitation, liqud extraction, extraction chromatography, spontaneous deposition, distillation,…)
- **Preparation of counting source** (micro-coprecipitation, electrodeposition, precipitation, mixing with scintillation cocktail,…)
- **Measurement** (radiometry, mass spectrometry,…)
- **Data treatment and calculation of results**

Concept of tracers in analytical radiochemistry

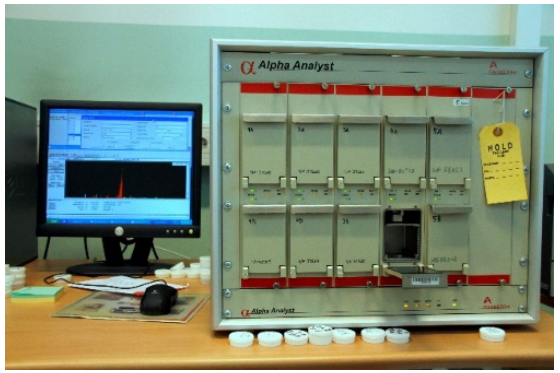
- To trace lossess during analytical procedure
- Ideal tracer should:
  - behave the same as our analyte
  - not be present in our sample
  - have sufficiently long half live
  - have known concentration traceable to SI units
  - be readily available
- Some examples of tracers:
  U-232 (uranium), Th-229 (thorium), Ba-133 (radium), Po-209 (Po-210), stable Pb (Pb-210), stable Sr or Sr-85 (Sr-90)

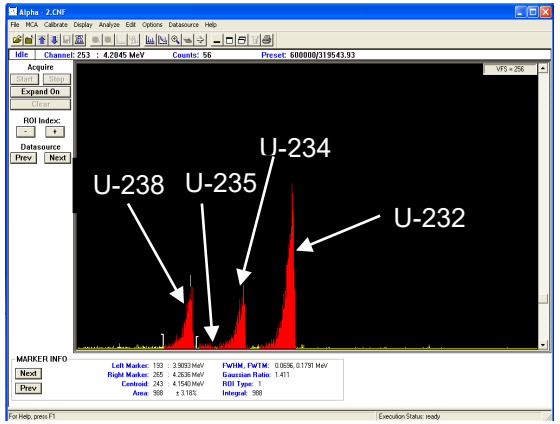
Radiometry

Gamma spectrometry

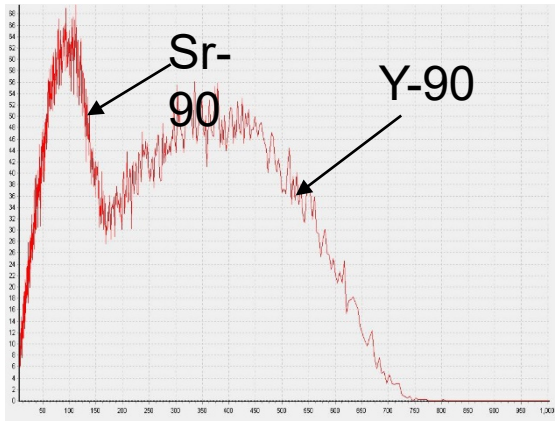


Alpha spectrometry

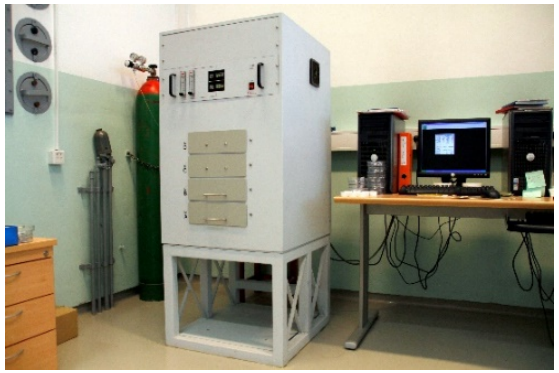




Liquid scintillation counting



Proportional counting

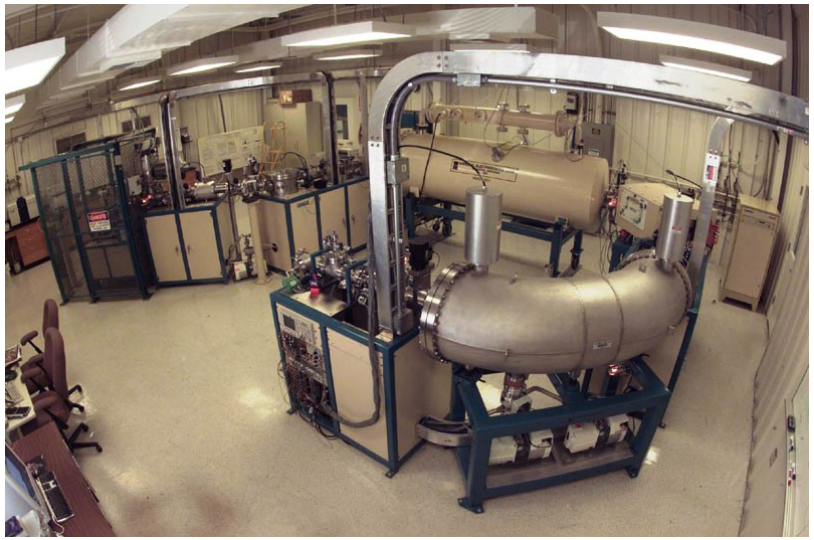


Mass spectrometry

ICP-QQQ-MS

MC-ICP-MS

AMS



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