4.28 nickel

Because molecules, atoms, and ions of the **stable isotopes** of nickel possess slightly different physical and chemical properties, they commonly will be fractionated during physical, chemical, and biological processes, giving rise to variations in **isotopic abundances** and in **atomic weights**. There are measurable variations in the isotopic abundances of nickel in terrestrial silicate rocks (Figure 4.28.1) [225].
Fig. 4.28.1: Variation in isotope-amount ratio $n(\text{\textsuperscript{60}Ni})/n(\text{\textsuperscript{58}Ni})$ of terrestrial nickel-bearing silicate rocks (modified from [225], assuming a measured $n(\text{\textsuperscript{60}Ni})/n(\text{\textsuperscript{58}Ni})$ isotope-amount ratio of 0.385 198 [226].

4.28.2 Nickel isotopes in geochronology

Anomalies in $\text{\textsuperscript{60}Ni}$ abundance caused by decay of now extinct $\text{\textsuperscript{60}Fe}$ have been used to study the early history of our Solar System (see Iron isotopes in Earth/planetary science). $\text{\textsuperscript{59}Ni}$ is a cosmogenic radionuclide with a half-life of $7.6 \times 10^4$ years. Decay of $\text{\textsuperscript{59}Ni}$ has been used to assess the terrestrial age of meteorites and to determine abundances of extraterrestrial dust in ice and sediment [227].

4.28.3 Nickel isotopes in industry

$\text{\textsuperscript{63}Ni}$ (with a half-life of 99 years) is produced from stable $\text{\textsuperscript{62}Ni}$ and is a beta-emitting radionuclide that serves as an electron source together with $\text{\textsuperscript{55}Fe}$ in electron-capture detectors. Electron-capture detectors are used as thickness gauges or as detectors for organic analytes in gas chromatography (Figure 4.28.2) [105]. $\text{\textsuperscript{63}Ni}$ is also used to ionize substances in ion mobility spectrometry—the basis of the instrument used in airports to screen passengers for drugs and
bombs [228]. $^{63}$Ni is also used as a fluorescence-inducing source in elemental analysis by X-ray fluorescence spectroscopy and in miniaturized long-lived nuclear batteries [105]. Until the mid-1980s, nuclear batteries were used in pacemakers, but then they were replaced by long-lasting lithium batteries [229].

Fig. 4.28.2: Shimadzu GC-8A Gas Chromatograph (GC) with an Electron-Capture Detector (ECD). (Image Source: The Reston Chlorofluorocarbon Laboratory, U.S. Geological Survey) [230, 231].

4.28.4 Nickel isotopes used as a source of radioactive isotope(s)

$^{61}$Ni is used as a radiation target for production of the radioactive isotope $^{61}$Cu (with a half-life of 3.3 hours), which emits positrons for positron emission tomography (PET) applications using the $^{61}$Ni (p, n) $^{61}$Cu reaction. $^{64}$Ni is used as a radiation target for production of $^{64}$Cu (with a half-life of 12.7 hours), which is used in radioimmunotherapy by attaching it to an antibody for delivery of cytotoxic radiation (toxic to living cells) to a target cell via the $^{64}$Ni (p, n) $^{64}$Cu reaction [232]. $^{60}$Ni is used for the production of $^{57}$Co (with a half-life of 0.75 year), which is used as a reference source for gamma cameras that are used in nuclear medicine via the $^{60}$Ni (p, $^4$He) $^{57}$Co reaction [232].