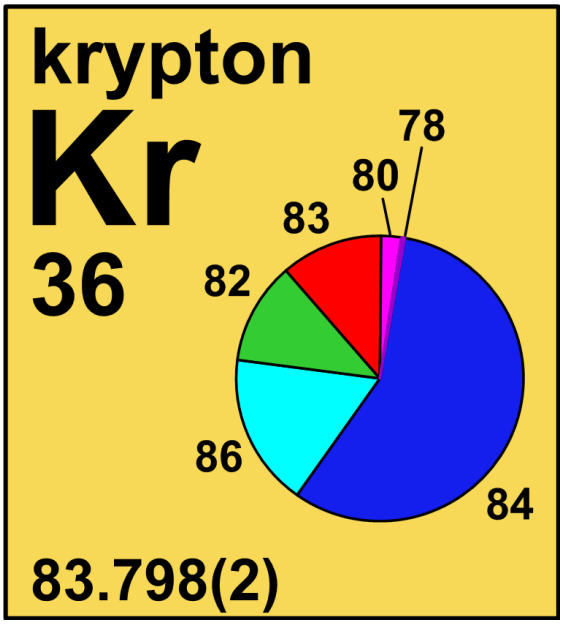
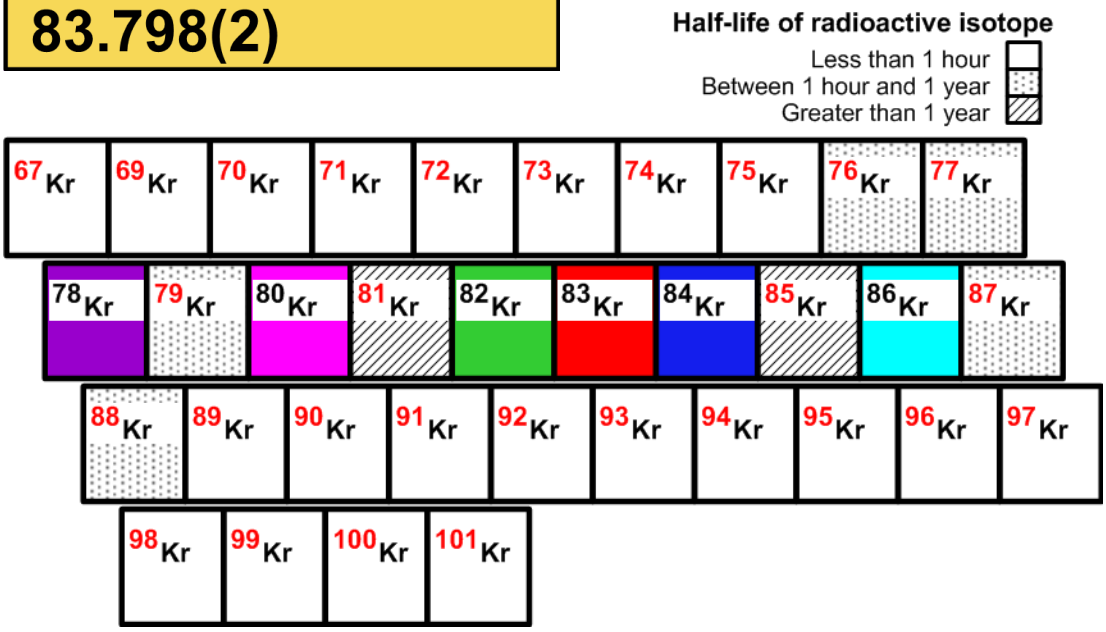
4.36 krypton



Stable isotope	Relative atomic mass	Mole fraction
^{78}Kr	77.920 365	0.003 55
^{80}Kr	79.916 378	0.022 86
^{82}Kr	81.913 483	0.115 93
^{83}Kr	82.914 127	0.115 00
^{84}Kr	83.911 497 73	0.569 87
^{86}Kr	85.910 610 63	0.172 79



4.36.1 Krypton isotopes in forensic science and anthropology

^{85}Kr (with a **half-life** of 12.7 hours) has been used in atmospheric monitoring programs to track the effect of atomic facilities on the surrounding environment. ^{85}Kr is co-generated with plutonium in the fuel elements of nuclear **fission** reactors and can be monitored at short distances (i.e. 1–5 km) from an area of clandestine plutonium separation from spent fuel from the nuclear reactor. The differences in ^{85}Kr levels in the atmosphere have been used to estimate the amount of plutonium separated at weekly intervals. The production of plutonium for nuclear weapons

and the output from commercial reprocessing plants have released large amounts of ^{85}Kr into the atmosphere [280].

4.36.2 Krypton isotopes in geochronology

^{85}Kr has minimal natural production in the Earth, but its concentration in the atmosphere has increased steadily because of human activities related to the nuclear industry. ^{85}Kr enters oceans, lakes, and groundwater through equilibration of the water with air. ^{85}Kr, with a **half-life** of 10.7 years, is produced terrestrially as a fission product of nuclear reactors and released into the atmosphere with the noble gases. It is also produced in the atmosphere via the **cosmic ray neutron**-activation reaction, ^{84}Kr (n, γ) ^{85}Kr. Thus, the ^{85}Kr specific activity can be used to determine the time since water was isolated from the atmosphere (Figure 4.36.1). This approach provides a valuable addition to the use of tritium (^{3}H) as an indicator of ocean circulation and groundwater age on decadal (a period of 10 consecutive years) time scales [281, 282].

Krypton **stable isotopes** react in the upper atmosphere by cosmic-ray-induced **spallation** and neutron activation to produce radioactive ^{81}Kr, with a half-life of approximately 2.1×10^5 years. In the atmosphere, ^{81}Kr is chemically inert and has a long **residence time**; because of these characteristics, it is expected that ^{81}Kr has a relatively constant and well-constrained atmospheric source. Natural **cosmogenic** ^{81}Kr is incorporated from air into infiltrating groundwater and has been used to determine the age of groundwater over time scales ranging to over 10^6 years [283-286].

Fig. 4.36.1: ^{81}Kr has been used to date the groundwater being discharged from springs and wells. The photo shows collection of a ^{81}Kr sample from an artesian well in Farafra Oasis, Egypt [286]. (Photo Source: N. C. Sturchio, University of Delaware, Delaware, USA).

4.36.3 Krypton isotopes in industry

^{85}Kr has been used as the illumination element of indicator lights of appliances and can be combined with phosphors to create materials that glow in the dark. Light is created when radiation from ^{85}Kr strikes the phosphor [95]. ^{85}Kr can be used to detect container leaks by placing the radioactive gas inside a container and measuring (with a radiation detecting device) the amount of radioactive ^{85}Kr that escapes. Because the gas is inert, Kr will not react with anything else in the container [95].

4.36.4 Krypton isotopes in medicine

A patient can inhale gaseous radioactive ^{85}Kr, which is then absorbed in the bloodstream, enabling the blood flow of the patient to be studied. Movement of the ^{85}Kr can be tracked with a radiation detector to reveal pathways followed by the blood and to quantify blood velocity [96, 281, 287].