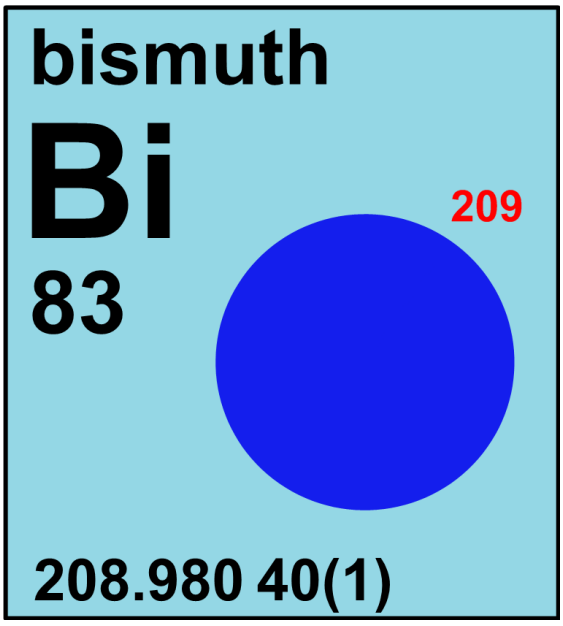
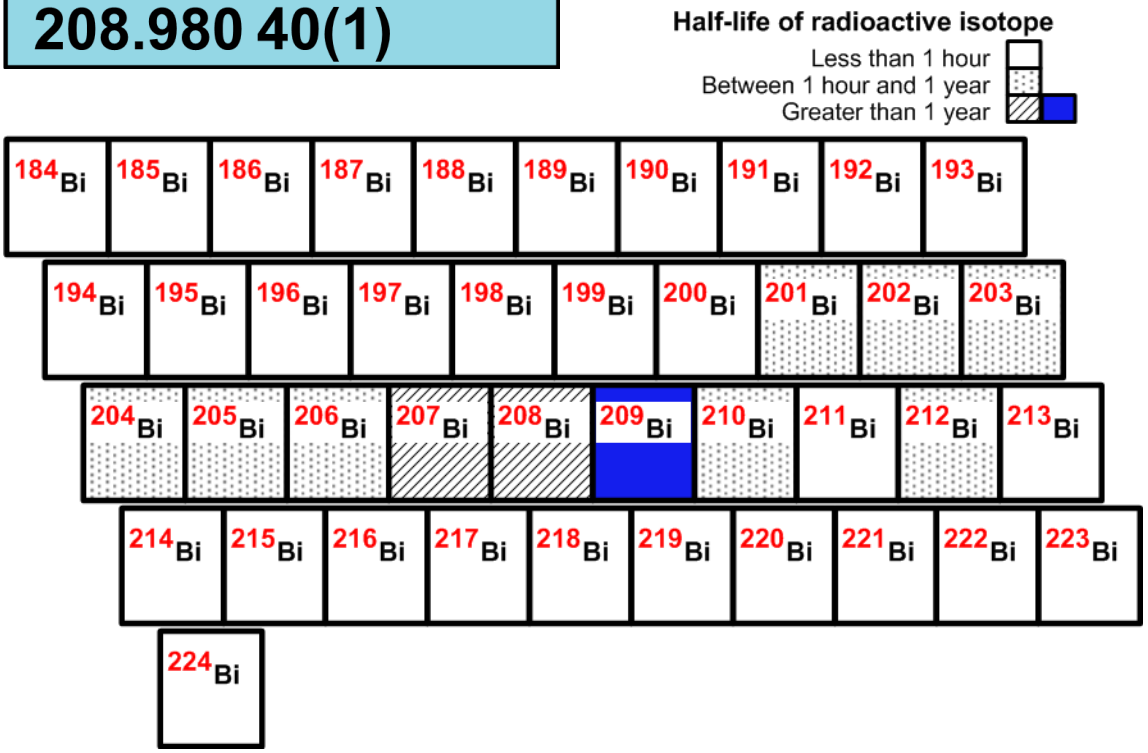
4.83 bismuth



Stable isotope	Relative atomic mass	Mole fraction
^{209}Bi†	208.980 40	1

† **Radioactive isotope** having a relatively long **half-life** (2.0×10^{19} years) and a characteristic terrestrial **isotopic composition** that contributes significantly and reproducibly to the determination of the **standard atomic weight** of the **element** in **normal materials**.



4.83.1 Bismuth isotopes in medicine

^{212}Bi and ^{213}Bi (with half-lives of 1 hour and 0.76 hours, respectively) are both used in medicine for **radioimmunotherapy** as bismuth-labeled **monoclonal antibodies** to treat cancer cells from melanoma (skin cancer) (Figure 4.83.1) and ovarian cancer [556]. Figure 4.83.2 compares the biologic effect of ^{131}I and ^{213}Bi using a specific monoclonal antibody, B-B4, coupled to ^{213}Bi by

a chelating agent (a substance that can form multiple bonds to a single metal ion). ^{213}Bi is a mixed alpha and beta emitter having a **half-life** of 46 minutes. The primary mode of decay is by beta emission to the very short-lived, alpha emitter ^{213}Po. The 8.4 MeV **alpha particle** emitted by ^{213}Po has a path length of 76 μm in human tissue and is responsible for its cytotoxic effects (toxic to living cells). ^{213}Bi is produced from the decay of ^{225}Ac, which is a pure alpha emitter with a half-life of 10 days. A schematic of the Institute for Transuranium Elements (ITU) Standard ^{225}Ac/^{213}Bi Radionuclide Generator is shown in Figure 4.83.3.

^{212}Bi has been used for radioimmunotherapy of leukemia and for targeting the vascular endothelial cells (thin layer of simple squamous cells that forms the interface between circulating blood or lymph and the remainder of the vessel wall) of tumors [557].

Fig. 4.83.1: Melanoma (skin cancer) on a patient's foot. ^{212}Bi and ^{213}Bi are both used as bismuth-labeled **monoclonal antibodies** to treat cancer cells from melanoma. (Photo Source: Kelly Nelson, National Cancer Institute) [558].

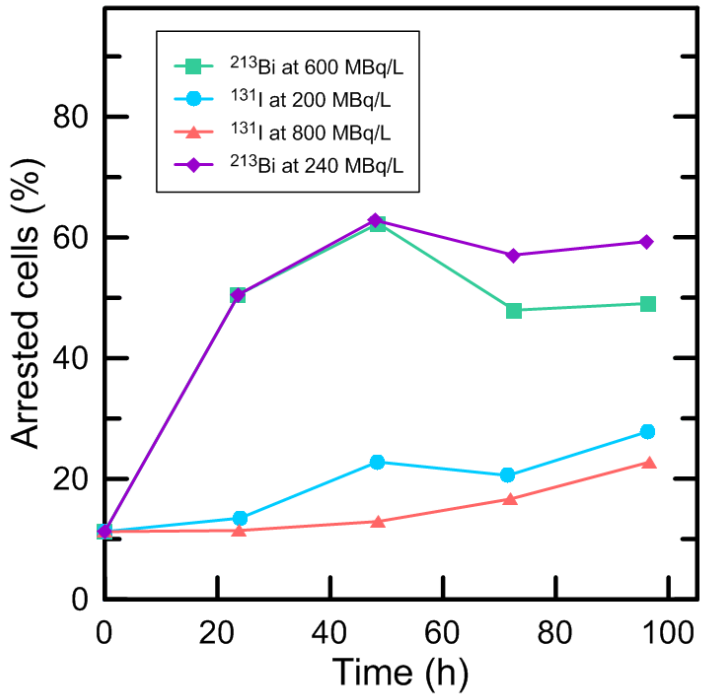


Fig. 4.83.2: Comparison of biological effectiveness of ^{213}Bi and ^{131}I when coupled to the specific **monoclonal antibody** B-B4 (modified after [559]; MBq/L, million becquerels per liter.

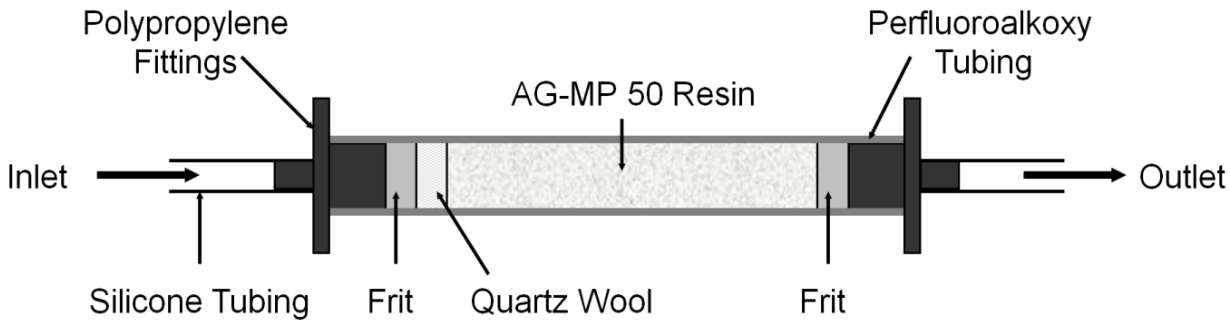


Fig. 4.83.3: Schematic of the Institute for Transuranium Elements (ITU) Standard ^{225}Ac/^{213}Bi Radionuclide Generator. Image kindly provided by Dr. Alfred Morgenstern, European Commission, Joint Research Centre – Institute for Transuranium Elements, Karlsruhe, Germany.

4.83.2 Bismuth isotopes used as a source of radioactive isotope(s)

^{209}Bi is bombarded with **neutrons** in a nuclear reactor to form radioactive ^{210}Bi, which decays to ^{210}Po, which is used in static eliminators in machinery [72].