Additional exercises

1. A mass spectrometer has a radius of 0.3 m and an acceleration voltage of 10 000 V. The magnetic field is adjusted to the various masses to be measured. Calculate the atomic mass corresponding to a field of 0.5 T.
2. What types of radioactivity are involved in the following reactions: ${}^{146}_{62}\mathrm{Sm} \rightarrow {}^{142}_{60}\mathrm{Nd}$, ${}^{53}_{25}\mathrm{Mn} \rightarrow {}^{53}_{23}\mathrm{Cr}$, ${}^{230}_{90}\mathrm{Th} \rightarrow {}^{226}_{88}\mathrm{Ra}$?
3. Rb has two isotopes, ^{85}Rb and ^{87}Rb, which exist in a constant ratio in our Solar System: $^{85}\mathrm{Rb}/^{87}\mathrm{Rb} = 2.5933$. The molar mass of Rb is 85.4678. A rock contains 10pm of Rb. How many mol/g of ^{87}Rb does that correspond to?
4. Following up from the previous question: ^{87}Rb is radioactive with a half-life $t_{1/2} = 48.8$ Gyr. What was the $^{85}\mathrm{Rb}/^{87}\mathrm{Rb}$-ratio 2 billion years ago?
5. The half-life of ^{14}C is 5730 years. The ^{14}C content of the atmosphere is 13.2 disintegrations per minute and per gram (dpm g^{-1}) of carbon (initial activity A_0). We wish to date an Egyptian artefact dating from approximately 2000 BC. What is the approximate activity (A) of this artefact? If our method can measure 1 dpm, what mass of the (probably precious) sample will have to be destroyed?
6. Consider the Rb-Sr composition of three aliquots from the same sample:

	$^{87}\mathrm{Rb}/^{86}\mathrm{Sr}$	$^{87}\mathrm{Rb}/^{86}\mathrm{Rb}$
mineral A	0.05	0.70108
mineral B	0.10	0.70215
mineral C	0.20	0.70431

   How old is the sample?
7. What is the expected $^{207}\mathrm{Pb}/^{206}\mathrm{Pb}$-ratio of a 4.57 billion year old meteorite? Assume that the meteorite contained no initial Pb. The half-lives of ^{238}U and ^{235}U are 4.468 and 0.704 Gyr, respectively. The present-day $^{238}\mathrm{U}/^{235}\mathrm{U}$-ratio is 137.818. What is the expected $^{207}\mathrm{Pb}/^{206}\mathrm{Pb}$-ratio for modern uranium-ores?
8. ^{210}Pb is a short lived ($t_{1/2}$=22.3 yr) intermediate daughter of the ^{238}U decay chain. This natural radioactive lead is incorporated into ice deposited in Greenland by forming successive layers of ice which can be studied like sedimentary strata. The activity of ^{210}Pb is measured at four levels in disintegrations per hour per kilogram of ice.

	1	2	3	4
depth (m)	0	1	1.5	2.5
^{210}Pb (dph/k)	75	32	24.0	10.0

   Calculate the sedimentation rate of the ice. Assuming a constant rate and a compaction factor of 5, how thick will the glacier be in 5000 years? Calculate the ^{210}Pb-content of fresh ice (in mol/kg or atoms/kg).
9. ^{129}I is an extinct nuclide of Iodine with a half-life of 15.7 million years. It decays (or rather: decayed!) to the noble gas ^{129}Xe. Although there is no (natural) ^{129}I in the Solar System today, the nuclide did

exist during its earliest stages. Iodine-rich meteorites that within the first few 10s of millions of years of Solary System history contain measurable amounts of excess of ^{129}Xe.

Consider two meteorites with ^{129}Xe/^{127}I ratios of 13×10^{-5} and 8×10^{-5}, respectively. What is the age difference between the two meteorites? Assume that all the ^{129}Xe is radiogenic, and that the early Solar System had a homogeneous ^{129}I/^{127}I-composition.

10. The silicate Earth weighs approximately 4×10^{24} kg and contains 250 ppm potassium. How much ^{40}Ar is created in 4.5 billion years? Given that ^{40}Ar cannot escape from the Earth and the quantity of ^{40}Ar in the atmosphere is 66000 Gt, what is the "K–Ar age of the Earth's atmosphere"? K has three isotopes with ^{39}K/^{40}K = 7771 and ^{41}K/^{40}K = 561. ^{40}K is radioactive and undergoes branched decay to ^{40}Ar (10.72%) and ^{40}Ca (89.28%) with a half-life of 1.248 billion years. The molar mass of K is 39.1 g/mol.