1 Eat more bananas! – the body's potassium flux

An interesting question someone once asked was, "How much potassium (^{40}K) decays from our bodies[1]?"

The beta decay of ^{40}K, a natural constituent of the body, makes all humans slightly radioactive. From Oxtoby, a 70.0 kg person contains about 170 g of K.

The following calculation is immature and unspecified, but within reason nonetheless. Besides, piddling around with expressions and deriving joy from them is the credo of science.

Let the relative abundance of ^{40}K be 0.0118 percent, its half-life by $1.28{\cdot}10^9$ years, and its average kinetic energy (T) be 0.55 million electron-volts (MeV).

To attain the total activity of a person, we calculate the decay constant, number of ^{40}K atoms disintegrated, and the energy produced annually in the body if all is absorbed (which it is not) for simplicity's sake. The decay constant, k, is then

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{1.28 \cdot 10^9 \text{ years} \cdot 365 \cdot 24 \cdot 3600 \text{ s / year}} = -1.72 \cdot 10^{-17} \text{ s}^{-1},$$

where the second part of the denominator is a conversion factor of total seconds per year. The units of the decay constant are *decays per second* and is a negative quantity.

The number of K atoms present is then

$$\frac{170 \text{ g}}{40 \text{ g/mol}} \cdot 1.18 \cdot 10^{-4} \cdot 6.023 \cdot 10^{23} \text{atoms / mole} = 3.02 \cdot 10^{20} \text{ atoms},$$

where the denominator in the first term is the molar weight of K, and where the third term is Avogadro's number.

Thus it follows that the activity is

$$A = -\frac{dN}{dt} = kN = 1.72 \cdot 10^{-17} \text{ s}^{-1} \cdot 3.02 \cdot 10^{20} = \mathbf{5.19 \cdot 10^3 \text{ atoms per second}}$$

Each disintegration of ^{40}K emits on average 0.55 MeV of energy and we assume that all of this energy is deposited within the body (not an unreasonable assumption). From above we determined that about five thousand potassium atoms decay per second, then it follows that the total energy deposited per year is

$$5.19 \cdot 10^3 \text{ atoms / s} \cdot 365 \cdot 3600 \cdot 24 \text{ s/ year} \cdot 0.55 \text{ MeV / atom} = 9.0 \cdot 10^{10} \text{ MeV / yr},$$

or about 0.00144 joules. One strike of a match yields about a joule.

Advice? EAT MORE BANANAS!

[1]See D.W. Oxtoby et al. *Principles of Modern Chemistry* (2002)