QUESTION ON RADIUM POWER

Horace Heffner July 1997

Tim Vaughn asks how much radium is required to produce 1000 watts?

Assuming purified Ra226 with half life of 1599 y and energy of 4.870 MeV. A mole of Ra (or anything) contains Avogadro's no. of atoms, or 6.022x10^23 atoms. A mole of Ra weighs 226.02 g.

When considering an interval less than 1% of the half-life we can handily use the Rutherford-Soddy law of radioactive decay, which says if we have N atoms to begin with:

No. decays = D = 0.69x(timeinterval/half-life)xN

This is just an approximation based of the slope of the logarithmic decay curve at time zero.

One year has 365.25 days/year x 24 hours/day x 60 min/hr x 60 sec/min = 3.156x10^7 seconds. A radium half life thus has 3.156x10^7 seconds x 1599 = 5.05x10^10 sec.

A mole of radium is therefore consumed at the rate of

Dm = 0.69(1 sec/5.05x10^10 sec)6.022x10^23 atoms/sec per mole
Dm = 8.23x10^12 dps/mole

The decays per second (dps) per gram is thus:

Dg = (8.23x10^12 dps/mole)/(226.02 g/mole) = 3.64x10^10 dps/g.

However, 1 eV = 1.602x10^-19 J, so we get a power density P:

P = Dg(1.602x10^-19 J/eV)(4.87x10^6 eV/decay)
P = 2.787x10^-2 (J/s)/g = 0.02787 W/g.

So, to get 1000 W we need a mass m:

m = (1000 W)/(0.02787 W/g.) = 35.88 kg.