846.

Problem 54.61 (RHK)

After long effort, in 1902, *Marie and Pierre Curie succeeded in separating from uranium ore the first substantial quantity of radium,* 1 decigram (dg) *of pure* $RaCl_2$. *The radium was the radium isotope* ^{226}Ra, *which decays with a half-life of* 1600 y. *We have to answer the following*: (a) *how many radium nuclei they had isolated*? (b) *What was the decay rate of their sample, in* Bq? $(1\ \text{Bq} = 1\text{decay per second.})$ (c) *What was the decay rate in curies*? *The molar mass of* Cl *is* 35.453 g *per mol*; *the atomic mass of the radium isotope is* 226.03 u.

Solution:

(a)

The molar mass of Cl is 35.453 g per mol; the atomic mass of the radium isotope is 226.03 u. From this data we note that the mass of one molecule of $RaCl_2$ will be

$$m_{\mathrm{RaCl_2}} = \frac{2\times 35.453}{6.02\times 10^{23}}\ \mathrm{g} + 226.03\times 1.6605\times 10^{-24}\ \mathrm{g}$$
$$= \left(117.78 + 375.32\right)\times 10^{-24}\ \mathrm{g}$$
$$= 493.1\times 10^{-24}\ \mathrm{g}.$$

Therefore, the number of radioactive isotopes of $^{226}\mathrm{Ra}$ contained in 1 dg of pure $\mathrm{RaCl_2}$ will be

$$N = \frac{1.0\times 10^{-1}\ \mathrm{g}}{493.1\times 10^{-24}\ \mathrm{g}} = 2.03\times 10^{20}.$$

(b)

The half-life of radium isotope $^{226}\mathrm{Ra}$ is 1600 y.

Therefore, its disintegration constant is

$$\lambda = \frac{\ln 2}{1600\times 3.156\times 10^{7}\ \mathrm{s}} = 0.137\times 10^{-10}\ \mathrm{s^{-1}}.$$

The decay rate of Marie and Pierre Curie's sample therefore was

$$R = 0.137\times 10^{-10}\times 2.03\times 10^{20} = 2.78\times 10^{9}\ \mathrm{Bq}.$$

(c)

The decay rate in curies was

$$R = \frac{2.78\times 10^{9}}{3.7\times 10^{10}}\ \mathrm{Ci} = 75.1\ \mathrm{mCi}.$$