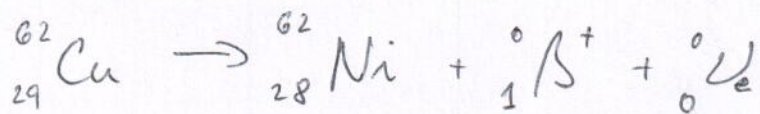
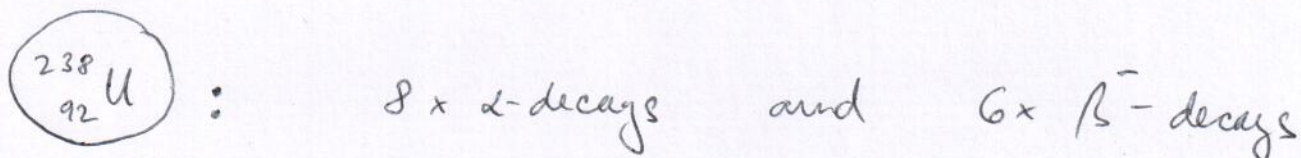


Solution of the Problem 1:



$$\lambda = \frac{\ln 2}{T_{1/2}} \approx \frac{0.693}{9.76 \times 60} = \underline{\underline{1.2 \times 10^{-3} \text{ s}^{-1}}} \quad \therefore$$

Solution of the Problem 2:



$$Z = 92 - 8 \times 2 + 6 = 82$$

$$A = 238 - 8 \times 4 = 206$$

The final product of this decay series is $({}_{82}^{206}\text{Pb}) \therefore$

Solution of the

Problem 3:

Momentum Conservation:

$$\vec{p} = m\vec{v}$$

$$\vec{p}_i = \vec{p}_f$$

gives

$$\Rightarrow (4 \text{ amu}) \times \vec{v}_\alpha = ((210-4) \text{ amu}) \times \vec{v}_D \text{ - daughter}$$

because the mother nucleus is @ rest ($\vec{p}_i = 0$).

We can replace $\vec{v}_D = \frac{4\vec{v}_\alpha}{(210-4)}$ in the equation representing

Energy Conservation:

$$\Rightarrow Q = (\sum M_i - \sum M_f) c^2 = \sum E_f - \sum E_i$$

with $\sum E_i = 0$

and $E_{kin} = \frac{1}{2} m \vec{v}^2$

$$Q = \frac{1}{2} (4 \text{ amu}) \vec{v}_\alpha^2 + \frac{1}{2} ((210-4) \text{ amu}) \vec{v}_D^2$$

$$Q = \frac{1}{2} (4 \text{ amu}) \vec{v}_\alpha^2 + \frac{1}{2} ((210-4) \text{ amu}) \left(\frac{4\vec{v}_\alpha}{(210-4)} \right)^2$$

$$Q = \frac{1}{2} (4 \text{ amu}) \vec{v}_\alpha^2 \cdot \left(1 + \frac{4}{210-4} \right)$$

$$Q = \frac{1}{2} (4 \text{ amu}) \vec{v}_\alpha^2 \cdot \left(\frac{210}{210-4} \right)$$

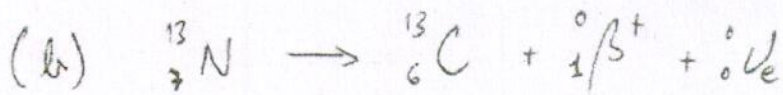
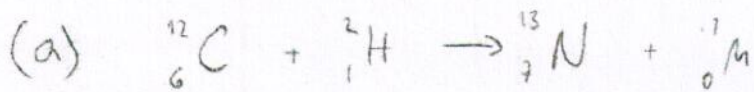
$$\underbrace{\frac{1}{2} (4 \text{ amu}) \vec{v}_\alpha^2}_{\vec{E}_\alpha} \cdot \underbrace{\left(\frac{210}{210-4} \right)}_{\frac{A}{A-4}}$$

$$Q = \vec{E}_\alpha \times \frac{A}{A-4} \Rightarrow \vec{E}_\alpha = \frac{A-4}{A} Q$$

Inserting $A=210$
 $Q = 5.50 \text{ MeV}$

$$\Rightarrow \vec{E}_\alpha \approx 5.4 \text{ MeV} \quad \therefore$$

Solution of the Problem #4:



Solution of the Problem #5:

No. According to the decay law, the number of the radioactive nuclei in the sample is decreasing exponentially. Thus, there are

$\frac{N_0}{2}$ nuclei in the sample in time $T_{1/2}$ and

$\frac{N_0}{4}$ nuclei in time $2 \times T_{1/2}$. The number of

nuclei, which decay in time $2 \times T_{1/2}$ is $\left(\frac{3N_0}{4}\right)$.

Solution of the Problem #6:

$\left({}_{92}^{238}\text{U}\right)$: $5 \times \alpha$ -decays and $2 \times \beta^-$ -decays

$$Z = 92 - 5 \times 2 + 2 = 84$$

$$A = 238 - 5 \times 4 = 218$$

Ra A element is $\left({}_{84}^{218}\text{Po}\right)$.

Solution of the Problem #7:

@ $t=0$ there are N_0 radioactive nuclei

@ $t>0$ there are $N(t) = N_0 e^{-\lambda t}$ rad. nuclei

The number of nuclei, which decay:

$$\Delta N = N_0 - N(t) = N_0 (1 - e^{-\lambda t})$$

$$\lambda = \frac{\ln 2}{T_{1/2}}$$

$$t = 1s, 1min, 3min, 6min$$



∴

$$\Delta N = 3.84 \times 10^9, 2.1 \times 10^{11}, 5.0 \times 10^{11}, 0.75 \times 10^{12}$$

nuclei

Solution of the Problem #8:

as in the previous problem:

$$\Delta N (3T_{1/2}) = N_0 (1 - e^{-\frac{\ln 2}{T_{1/2}} 3T_{1/2}}) = \underline{\underline{\frac{7}{8} N_0}}$$

The sample emitted $\frac{7}{8} N_0$ particles in time $3 \times T_{1/2}$.

Solution of the Problem 19:

The number of neutrons, which will decay in time t is given as $\Delta N(t) = N_0 - N(t) = N_0 (1 - e^{-\lambda t})$, where N_0 is the number of neutrons in time $t=0$ and $N(t)$ is the number of neutrons in time $t > 0$, which have passed the length $l = v \cdot t$

The speed of neutrons can be determined from their kinetic energy $\Rightarrow v = \sqrt{\frac{2E_{kin}}{m_n}}$

Relative number of neutrons, which will decay in length l is equal:

$$\eta = \frac{\Delta N}{N_0} = \frac{N_0 (1 - e^{-\lambda t})}{N_0} = 1 - e^{-\lambda t} = 1 - e^{-\frac{\ln 2}{T_{1/2}} l \sqrt{\frac{m}{2E}}}$$

The exponent in the expression above has a value:

$$\frac{\ln 2}{T_{1/2}} l \sqrt{\frac{m_n}{2E_{kin}}} = \frac{0.693}{1037 \times 60} \times 1 \times \sqrt{\frac{1.67 \times 10^{-27}}{2 \times 0.025 \times 1.6 \times 10^{-19}}} =$$
$$\approx \underline{5.1 \times 10^{-7}} \ll 1 \Rightarrow \boxed{1 - e^{-x} \approx x}$$

Thus,

$$\boxed{\eta = 5.1 \times 10^{-7}} \therefore$$

In length of one meter there will be $5.1 \times 10^{-7} N_0$ neutrons, which will decay

Solution of the Problem 10:

The initial volume activity of ^{24}Na after the injection into the blood of a man is

$$a_0 = \frac{A_0}{V}, \text{ where } V \text{ is the volume of the blood.}$$

Activity is decreasing exponentially with the time. Thus,

$$a_v(t) = \frac{A_0}{V} e^{-\lambda t}$$

$$\therefore V = \frac{A_0}{a_v} e^{-\lambda t} = \frac{2 \times 10^3}{265 \times 10^3} e^{-\frac{\ln 2}{15} \cdot 5} = \underline{\underline{6 \text{ l}}}$$

The volume of the blood of a man was 6 l.

Solution of the Problem 11:

The highest X-ray energy is $E_{\text{max}} = 195 \text{ keV}$
with $E = h \cdot \nu$ and $c = \nu \cdot \lambda$ one obtains:

$$\lambda_{\text{min}} = \frac{hc}{E_{\text{max}}} \approx \underline{\underline{6.36 \times 10^{-12} \text{ m}}} \therefore$$

Note:

$$\begin{aligned} h &= 6.62606957(29) \times 10^{-34} \text{ J} \cdot \text{s} \\ &= 4.135667516(91) \times 10^{-15} \text{ eV} \cdot \text{s} \\ &= 6.62606957(29) \times 10^{-27} \text{ erg} \cdot \text{s} \end{aligned}$$

$$c = 299792485 \text{ m} \cdot \text{s}^{-1}$$

Solution of the

Problem 12: The specific activity S is given by:

$$S = \frac{1}{A} \times \frac{1}{T_{1/2}} \times \ln 2 \times N_A / \text{g}$$

$$S = \frac{1}{A} \times \frac{1}{T_{1/2}} \times 4.175 \times 10^{23} / \text{g}$$

\Rightarrow with $A \approx 3 \frac{\text{g}}{\text{mol}}$ and $T_{1/2} = 12.26 \text{ years} \approx 3.87 \times 10^8 \text{ s}$

the result: $S \approx 3.6 \times 10^{14} \text{ Bq/g} \therefore$ can be obtained.

Solution of the

Problem 13: As energy = charge \times voltage

$$E = Q \times U$$

we get with $Q = +2e$ and $U = 3 \text{ MV}$

the result:

$$E = 2e \times 3 \text{ MV} = 6 \text{ MeV} \therefore$$

NB: α -particle (electric charge $2e$)

$\alpha, \alpha^{2+}, \text{He}^{2+}, {}^4_2\text{He}^{2+}, {}^4_2\text{He} \rightarrow$ as it is possible that the ion gains e^- s from the environment. Also, e^- s are not important in nuclear chemistry

The nomenclature is not well defined, and therefore, not all high-velocity helium nuclei are considered by all as α -particles. Some use "doubly ionized helium nuclei" (He^{2+})