1. a) ${}_1^1p$ 2) ${}_0^1n$ 3) ${}_0^1n$ 4) ${}_2^4\mathrm{He}$.

2. ${}_{79}^{197}\mathrm{Au} + {}_0^1n \to {}_{79}^{198}\mathrm{Au} \to {}_{80}^{198}\mathrm{Hg} + e^-$.

3. ${}_{95}^{241}\mathrm{Am} \to {}_{93}^{237}\mathrm{Np} + {}_2^4\mathrm{He}$. The "average lifetime" is $\tau = T_{1/2}/\ln 2 = 623.5$ yrs.

4. Firstly, it would be strange if the ratio ${}^{14}\mathrm{C}/{}^{12}\mathrm{C}$ was of order 10^{12} and increased with time, we consider the given ratio is $r = \mathbf{{}^{12}C/{}^{14}C}$. Due to the decay law, this quantity depends on time as

$$r(t) = r_0 \cdot 2^{-t/T_{1/2}},$$

where r_0 is the value of r at $t = 0$. This equation yields

$$t = T_{1/2} \log_2 \frac{r_0}{r} = 4100 \text{ yrs.}$$

5. Unable to interpret phrase "this yields 66 counts over a period of 12 hours.." ;(

6. Consider that fresh wood always has an activity of $A_0 = 0.105$ Bq. The activity depends on time as

$$A(t) = A_0 \cdot 2^{-t/T_{1/2}}.$$

So, the age of the sample is

$$t = T_{1/2} \log_2 \frac{A_0}{A} = 1240 \text{ yrs.}$$