Particle	Symbol	Description
Neutron	$^{1}_{0}n$	Mass approximately equal to proton, but no charge
Proton	$^{1}_{1}H$ or $^{1}_{1}p$	Nuclei of a hydrogen atom
Deuteron	$^{2}_{1}H$ or $^{2}_{1}D$	Nuclei of a hydrogen atom with 2 neutrons
Electron (β particle)	$^{0}_{-1}\beta$ or $^{0}_{-1}e$	(High-energy) electrons
Positron	$^{0}_{+1}\beta$ or $^{0}_{+1}e$	Same mass as electron, but positive charge
α particle	$^{4}_{2}\alpha$ or $^{4}_{2}He$	(High-energy) helium nuclei (2 protons + 2 neutrons)

1. Complete each nuclear reaction given below.

A) $^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + {}^{4}_{2}\alpha$

B) $^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}\beta$

C) $^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{+1}\beta$

D) Electron capture by cadmium-104 ($^{104}_{48}Cd$)

$^{104}_{48}Cd + {}^{0}_{-1}e \rightarrow {}^{104}_{47}Ag$

E) $^{235}U + {}^{1}_{0}n \rightarrow {}^{147}Pm + 2\,{}^{1}_{0}n + {}^{87}_{31}Ga$

2. Mercury-197 has a half-life of 65 hours. What fraction of a mercury sample remains after 6 days?

$$\text{Rate} = kN \quad t_{1/2} = \frac{\ln 2}{k} \quad t = -\frac{1}{k}\ln\frac{N_t}{N_0}$$

$$t = -\frac{1}{k}\ln\frac{N_t}{N_0}$$

$$6\text{ days} \times \frac{24\text{ hr}}{1\text{ day}} = -\frac{65\text{ hr}}{\ln 2}\ln\frac{N_t}{N_0}$$

$$\ln\frac{N_t}{N_0} = -1.53_6$$

$$\frac{N_t}{N_0} = 0.22\ (22\ \%)$$

3. Both carbon-14 and potassium-40 can be used for radiometric dating. The half-life of ^{14}C is 5730 years and the half-life of ^{40}K is 1.28 × 10^{9} years.

$$\text{Rate} = k\text{N} \quad t_{1/2} = \frac{\ln 2}{k} \quad t = -\frac{1}{k}\ln\frac{\text{N}_t}{\text{N}_0}$$

A) If a rock is predicted to be 20,000 years old, which form of radio dating is preferred? Why?

Answer: ^{14}C because it has a shorter half-life, so there is a more appreciable (measurable) decay

Carbon-14	Potassium-40
$\frac{\text{N}_t}{\text{N}_0} = 0.5^{\frac{t}{t_{1/2}}}$	$\frac{\text{N}_t}{\text{N}_0} = 0.5^{\frac{t}{t_{1/2}}}$
$= 0.5^{\frac{20000\text{ yr}}{5730\text{ yr}}}$	$= 0.5^{\frac{20000\text{ yr}}{1.28\times10^{9}\text{ yr}}}$
$\frac{\text{N}_t}{\text{N}_0} = 0.0890\ (8.90\ \%)$	$\frac{\text{N}_t}{\text{N}_0} = 0.999\ (99.9\ \%)$

B) If a rock is predicted to be 200,000 years old, neither method is preferred. Why?

Answer: Too many half-lives have passed for ^{14}C and too few for ^{40}K, so both not measurable.

Carbon-14	Potassium-40
$\frac{\text{N}_t}{\text{N}_0} = 0.5^{\frac{t}{t_{1/2}}}$	$\frac{\text{N}_t}{\text{N}_0} = 0.5^{\frac{t}{t_{1/2}}}$
$= 0.5^{\frac{200000\text{ yr}}{5730\text{ yr}}}$	$= 0.5^{\frac{200000\text{ yr}}{1.28\times10^{9}\text{ yr}}}$
$\frac{\text{N}_t}{\text{N}_0} = 3.11\times10^{-11}\ (3.11\times10^{-9}\ \%)$	$\frac{\text{N}_t}{\text{N}_0} = 0.999\ (99.9\ \%)$

4. Silicon-28 can be made by many different nuclear fusion reactions.

A) Which of the two fusion reactions releases the greater amount of energy?

Recall $\Delta E = \Delta mc^2$ where $c = 3.00\times10^{8}$ m/s and 1 J = 1 kg · m^2/s^2.

i.	$^{14}\text{N} + {}^{14}\text{N} \rightarrow {}^{28}\text{Si}$	^{14}N = 14.00307 amu	^{28}Si = 27.97693 amu
ii.	$^{16}\text{O} + {}^{12}\text{C} \rightarrow {}^{28}\text{Si}$	^{16}O = 15.99491 amu	^{12}C = 12.00000 amu

Answer: Fusion reaction (i)

$^{14}\text{N} + {}^{14}\text{N} \rightarrow {}^{28}\text{Si}$	$^{16}\text{O} + {}^{12}\text{C} \rightarrow {}^{28}\text{Si}$
$\Delta m = m_{\text{Si}} - 2m_{\text{N}}$	$\Delta m = m_{\text{Si}} - m_{\text{O}} - m_{\text{C}}$
$= (27.97693 - 2\times14.00307)$ amu	$= (27.97693 - 15.99491 - 12.00000)$ amu
$\Delta m = -0.02921$ amu $(-4.850\times10^{-29}$ kg$)$	$\Delta m = -0.01798$ amu $(-2.986\times10^{-29}$ kg$)$
$E = 4.850\times10^{-29}\text{ kg}\times\left(3.00\times10^{8}\frac{\text{m}}{\text{s}}\right)^2$	$E = 2.986\times10^{-29}\text{ kg}\times\left(3.00\times10^{8}\frac{\text{m}}{\text{s}}\right)^2$
$E = 4.37\times10^{-12}$ J	$E = 2.69\times10^{-12}$ J

B) Propose a nuclear reaction that could produce an isotope of Si.

Example: $^{24}\text{Mg} + {}^{4}\text{He} \rightarrow {}^{28}\text{Si}$