24.2 Nuclear Stability

Binding Energy

What is the binding energy in kJ/mol nucleons for copper-63?

Masses (g/mol): ${}^{1}_{1}H = 1.00783$; ${}^{1}_{0}n = 1.00867$; ${}^{63}_{29}Cu = 62.92980$? = 8

Speed of Light = $2.998\times10^{8}\ m.s^{-1}$ Eb = X.XXXXx10?

${}^{63}_{29}Cu$: $29({}^{1}_{1}H) + 34({}^{1}_{0}n)$

$29(1.00783) + 34(1.00867)$

$= 63.52185\ g.mol^{-1}$

$\Delta m = 63.52185 - 62.92980$

$= 0.59205\ g.mol^{-1}$

$= 5.9205\times10^{-4}\ kg.mol^{-1}$

$\Delta E = \Delta m c^2$

$= 5.9205\times10^{-4}(2.998\times10^{8})^2$

$= 5.3213\times10^{13}\ J.mol^{-1}$

$= 5.3213\times10^{10}\ kJ.mol^{-1}$

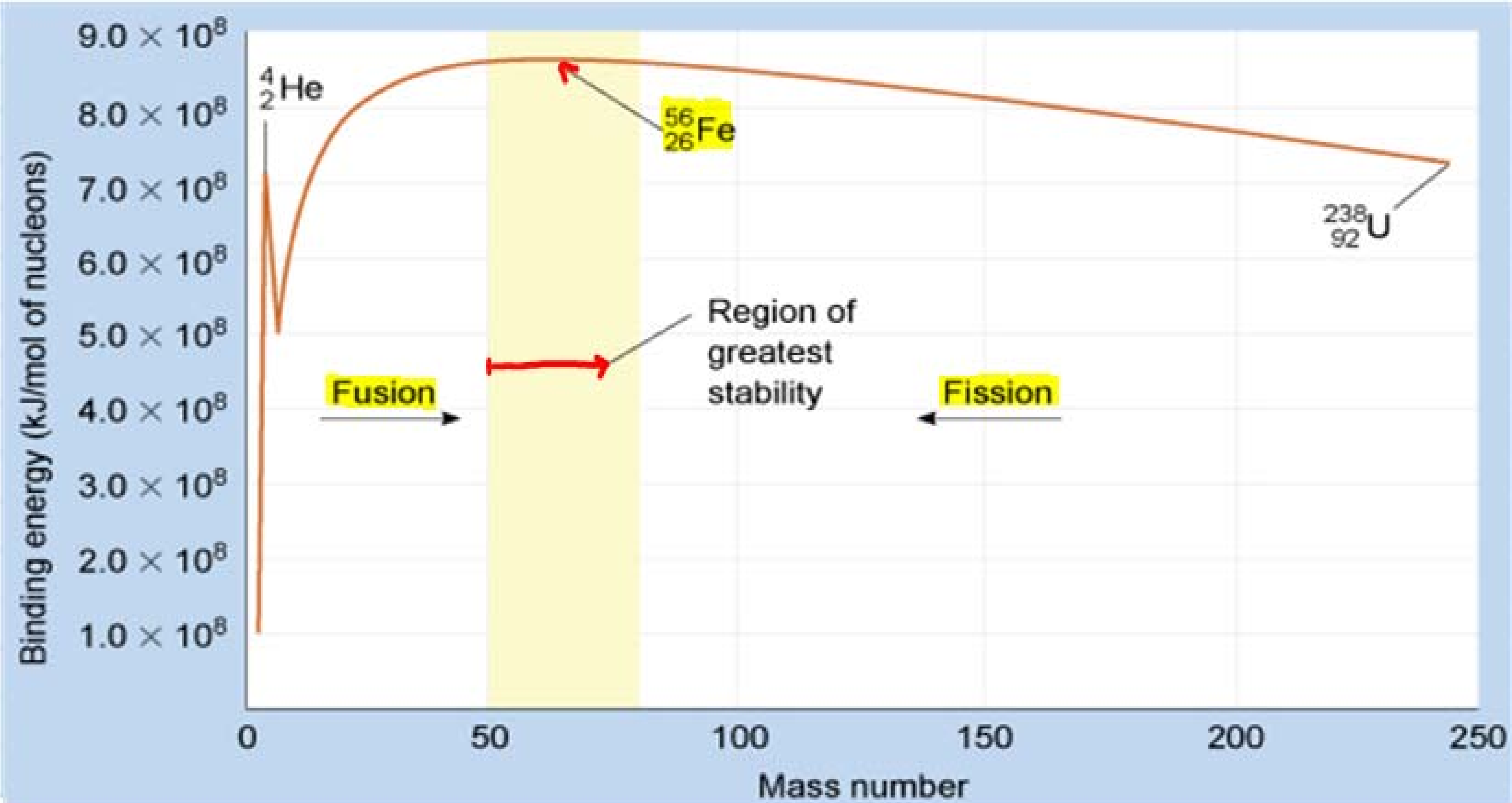
Total nucleons: $29 + 34 = 63$

$E_B = \frac{5.3213\times10^{10}}{63}$

$= 8.4466\times10^{8}\ kJ.mol^{-1}.nucleon^{-1}$

24.2 Nuclear Stability

Relative Binding Energy



24.3 Kinetics of Radioactive Decay

Rate of Decay

Radioactive Decay follows first order kinetics.

First Order Kinetics Recall:

A → products

Integrated rate law:

$$\ln \frac{[A]_t}{[A]_0} = -kt$$

Half life:

$$t_{1/2} = \frac{\ln 2}{k}$$

Radioactive Decay:

Substitute N - the number of nuclei - for A

$$\ln \frac{[N]_t}{[N]_0} = -kt$$

$$t_{1/2} = \frac{\ln 2}{k}$$

24.3 Kinetics of Radioactive Decay

Rate of Decay

Radioactive radon-222, found in many homes, is a potential health hazard. The half-life of radon-222 is 3.82 days. How much time is required for the activity of a sample of radon-222 to fall to 19.5 percent of its original value?

→ 9

? days

$$t_{1/2} = \frac{\ln 2}{k}$$

$$3.82 = \frac{0.693}{k}$$

$$3.82k = 0.693$$

$$k = \frac{0.693}{3.82} = 0.1815$$

$$\ln \frac{[N]_t}{[N]_0} = -kt$$

$[N]_t = 0.195$ $\quad [N]_0 = 1$

$$\ln 0.195 = -0.1815t$$

$$-1.6348 = -0.1815t$$

$$t = \frac{-1.6348}{-0.1815} = 9 \text{ days}$$

Radioactive Dating

An artifact classified as seeds, found in a site at Newlands Cross, Ireland, is found to have a ^{14}C radioactivity of **9.71×10^{-2} counts per second** per gram of carbon. If living carbon-containing objects have an activity of **0.255 counts per second** per gram of carbon, estimate the age of the artifact?

The half-life of ^{14}C is **5730 years**

$t_{1/2} = \frac{\ln 2}{k}$

$t_{1/2}$ = 5730 years

$t_{1/2} k = \ln 2$

$5730 k = 0.6931$

$k = \frac{0.6931}{5730} = 1.21 \times 10^{-4}$

$\ln \frac{[N]_t}{[N]_0} = -kt$

$[N]_t = 9.71 \times 10^{-2}$ $\quad [N]_0 = 2.55 \times 10^{-1}$

$\ln \frac{9.71 \times 10^{-2}}{2.55 \times 10^{1}} = -1.21 \times 10^{-4} t$

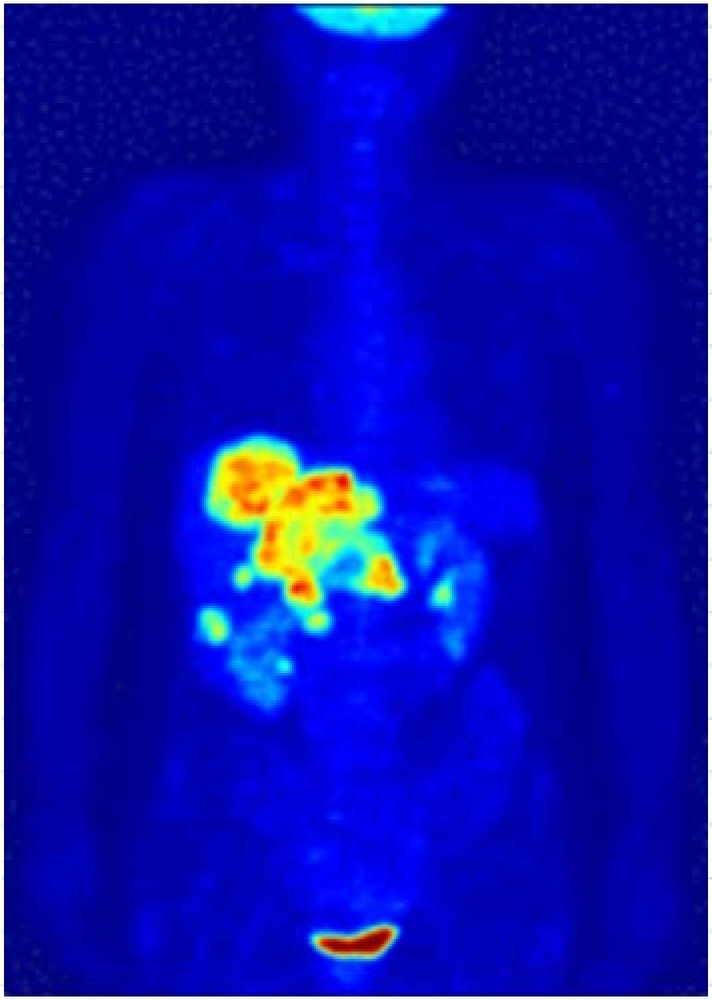
$\ln 0.381 = -1.21 \times 10^{-4} t$

$-0.965 = -1.21 \times 10^{-4} t$

$t = \frac{-0.965}{-1.21 \times 10^{-4}} = 7.98 \times 10^{3} = 7980$ years

24.5 Applications and Uses of Nuclear Chemistry

Nuclear Medicine – Positron Emission Tomography



Short lived isotopes:

$^{11}_{6}C$: ~ 20 minutes
$^{13}_{7}N$: ~ 10 minutes
$^{15}_{8}O$: ~ 2 minutes
$^{18}_{9}F$: ~ 110 minutes
↳ most common.

24.5 Applications and Uses of Nuclear Chemistry

Nuclear Medicine – Positron Emission Tomography

24.5 Applications and Uses of Nuclear Chemistry

Radioactivity in the Home

PROBLEM:

$^{222}_{86}Rn = ^{218}_{84}Po + ^{4}_{2}He$

↳ adheres to lung tissue.

$^{218}_{84}Po = ^{214}_{82}Pb + ^{4}_{2}He$

SOLUTION:

Seal all cracks.
Ventilate the basement.