Set 6: Half Life

Time for Activity to 'Half' is the half life time.
A_0 = Initial Activity
A_T = Activity after a period of time
$t_{1/2}$ = Half life time

Number of nuclei is directly related to the Activity (Bq)

6.1

a. 22 hrs
b. ½
c. After 44 hours 2 half-life would have gone by.
½ × ½ (2 half-lives) = ¼ of original radioisotope remaining.

6.2

In a graph use the Activity on the y axis. If the A_0 = Initial Activity (Bq) = 500 MBq and at an A_T = 250 MBq then one half-life would have gone by. Record the time on the x axis.

a. $t_{1/2}$ = 6 hrs
b. From 500 MBq to 'about 2' MBq would require around 8 half-lifes to have gone by.

6.3

$t_{1/2}$ = 30 years

1 Half-life	2 Half-life's	3 Half-life's	4 Half-life's	4 half life's
1/2	½ × ½ = ¼	½ × ½ × ½ = 1/8	½ × ½ × ½ × ½ = 1/16	

$t = n \times t_{1/2}$
$= 4 \times 30$
$= 120$ years

6.4

$t_{1/2}$ = 14.3 days
A_0 = 2.40 MBq

1 Half-life	2 Half-life's	3 Half-life's
14.3	28.6	42.9

$A_T = A_0 \times ½^n$
$= 2.4 \times ½^3$
$= 0.3$ MBq

6.5

$t_{1/2}$ = ?
A_0 = 2048 Bq
A_T = 128 counts / min = 2.133 Bq
t = 150 mins

Half live n	1	2	3	4	5	6	7	8	9	*10*
A_0 = 2048 Bq	1024	512	256	128	64	32	16	8	4	*2*

or

$A_T = A_0 \times ½^n$
$2.1333 = 2048 \times ½^n$
$n = 9.907$

Half-life = T/n
= 150/9.907
= 15.1 mins (3sf)

6.6

$t_{1/2}$ = 12 hrs
A_0 = ? Bq
A_T = 800000 Bq

a. t = 24 hrs before
n = 2

A_T = $A_0 \times ½^n$
A_0 = $A_T / ½^2$
A_0 = 800000 / ¼
= 3.20×10^6 Bq (3sf)

b. t = 24 hrs after
n = 2

A_T = $A_0 \times ½^2$
A_T = $800000 \times ½^2$
= 2.00×10^6 Bq (3sf)

6.7

Number of atoms = 1.00×10^{24}
$t_{1/2}$ = 2.41×10^4 yrs

a. After 1 half-life $0.5^1 \times 1.00 \times 10^{24} = 5.00 \times 10^{23}$ atoms
b. With Alpha decay ensure the sum of nucleons are conserved and that the number of protons remains the same.

$^{239}Pu_{94} \rightarrow {}^{4}He_2 + {}^{235}U_{92}$

6.8

$t_{1/2}$ = 5.30 yrs
A_0 = 800 GBq
A_T = 128 counts / min = 2.133 Bq

a. t = 26.0 yrs
n = 26/5.3 = 4.90 half-lives

Half live n	1	2	3	4	5
A_0 = 800 GBq	800	400	200	100	50

b. $t_{1/2}$ = 5.3 yrs
A_0 = 800 GBq
A_T = 0.001 × 800 GBq = 0.8 GBq

Half live n	1	2	3	4	5	6	7	8	9	10	11
A_0 = 800 GBq	800	400	200	100	50	25	12.5	6.25	3.125	1.56	0.78

After 10 half-lives

t = n × $t_{1/2}$
= 10 × 5.3 yrs
= 5 decades (1sf)

or

A_T = $A_0 \times ½^n$
0.8 = $800 \times ½^n$
n = 9.965

Half-life = T/n
= 5.3/9.965
= 52.8 (3sf)
= 5 decades (1sf)

6.9
Given that there is the same number of nuclei, Sample X will have the higher activity as it has the lowest half-life. After 8 seconds half of the nuclei should have decayed thus more particles should be emitted and then detected.

6.10

$t_{1/2}$ = 2.70 days
A_0 = 8.00 MBq
A_T = ?
t = 7.00 days

Half live n	1	2	3
A_0 = 8.00 MBq	4.00	2.00	1.00

n = 7 / 2.7
= 2.60 half-lives
A_T = 1.5 MBq (2sf)

or

$A_T = A_0 \times \frac{1}{2}^n$
$A_0 = 8.00 \times \frac{1}{2}^{2.6}$
A_0 = 1.32 MBq (3sf)

With Beta the number of protons will increase by 1 proton. The number of nucleons will still remain the same. Remember 1 neutron is changing into a proton and emitting an electron.

$^{198}Au_{79} \rightarrow {}^{0}e_{-1} + {}^{198}Hg_{80}$

6.11

There is less C-14 in old bone compared to new bone due to the fact the animal has long dies and as such stopped absorbing C-14 from the atmosphere.

6.12

A_T / A_0 = 12.5 % = 0.125

Half live n	1	2	3	4
%	50	25	12.5	6.25

n = 3
t = $3 \times t_{1/2}$
= 3 × 5730 yrs
= 1.72×10^4 yrs

6.13

a. Use an Activity vs Time graph to determine half-five. Use the activity decrease to determine 3 half-life times. Average these times.
$t_{1/2}$ = 20-21 mins

b. Likely to be Alpha. Beta and Gamma will still move through the Al foil.

6.14

a. With neutron bombardment add one nucleon on. Ensure remains same element.

$^{24}Mg_{12} + {}^{1}n_{0} \rightarrow {}^{25}Mg_{12}{}^{*}$

$^{25}Mg_{12}{}^{*} \rightarrow {}^{1}n_{0} + {}^{24}Mg_{12} + Y$ (Gamma)

With Beta the number of protons will increase by 1 proton. The number of nucleons will still remain the same. Remember 1 neutron is changing into a proton and emitting an electron.

$^{24}Mg_{12}{}^{*} \rightarrow {}^{0}e_{-1} + {}^{24}Na_{12}$

b. 90% remaining means $A_T / A_0 = 0.9$

$A_T = A_0 \times \frac{1}{2}^n$
$A_T / A_0 = 0.9 \times \frac{1}{2}^n$
$n = 0.152$

$t = 0.152 \times t_{1/2}$
$= 0.152 \times 15.0$ hrs
$= 2.28$ hrs (3sf)

6.15

a. $n = 20$ days / 4 days
$= 5$ half-lives

$A_T = A_0 \times \frac{1}{2}^n$
$= 3.80 \text{ kBq} \times \frac{1}{2}^5$
$= 119$ Bq (3sf)
$= 100$ Bq (1sf)

b.
More harmful?
Both are Alpha which is bad.
With higher activity Polonium would be worse if present in the body. A lot of energy released in a short period of time.
Radon is a gas so it can easily enter the lungs.

6.16

$A_T = A_0 \times \frac{1}{2}^n$
$A_T / A_0 = 0.95 \times \frac{1}{2}^n$
$n = 0.07400$

$t = 0.07400 \times t_{1/2}$
$= 0.07400 \times 28.9$ yrs
$= 2.13$ yrs

6.17

$A_T / A_0 = 15 / 200$

$A_T = A_0 \times ½^n$
$A_T / A_0 = 0.075 \times ½^n$
$n = 3.74$

$t = 3.74 \times t_{1/2}$
$= 3.74 \times 5730$ yrs
$= 21413$ yrs
$= 2.41 \times 10^4$ yrs (3sf)

6.18

a. Because of the short half-lives, they will decay from the natural environment. May be present in extremely small amounts.
b. Because they are naturally occurring and are usually part of a common decay sequence with the environment. Amount is continually being ‘produced’ from the decay of other naturally occurring isotopes.