1. Starting with a sample of pure ^{66}Cu, 7/8 of it decays into Zn in 15 minutes. The corresponding half-life (in minute) is:

A) 3.75 B) 5 C) 7 D) 10 E) 15

بحكي السؤال أنه اضمحل $\frac{7}{8}$ منه وتحول إلى Zn ب 15 دقيقة :

يعني الباقي من النحاس هو $\frac{1}{8}$ من النحاس

$$\frac{1}{8} N_0 = N_0 e^{-\lambda \times 15}$$

$$\lambda = 0.1386 \text{ min}^{-1} \Rightarrow \lambda = \frac{\ln 2}{t_{\frac{1}{2}}} \Rightarrow t_{\frac{1}{2}} = \frac{\ln(2)}{0.1386} = \boxed{5 \text{ min}}$$

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2. ^{210}Bi (an isotope of bismuth) has a half-life of 5.0 days. The time (in day) for three-quarters of a sample of ^{210}Bi to decay is:

A) 2.5 B) 3.75 C) 10 D) 15 E) 20

* يعني الوقت حتى يضمحل $\frac{3}{4}$ من العنصر

يعني رح يتبقى منه $\frac{1}{4}$ منه

$$\frac{1}{4} N_0 = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln(2)}{t_{\frac{1}{2}}} = \frac{\ln(2)}{5} = 0.1386 \text{ day}^{-1}$$

$$\frac{1}{4} N_0 = N_0 e^{-0.1386 \times t}$$

$$\boxed{t = 10 \text{ days}}$$

3. Radioactive ^{90}Sr has a half-life of 30 years. What percent of a sample of ^{90}Sr will remain after 60 years?

A) 0% B) 14% C) 25% D) 50% E) 75%

30 years → 30 years

$N_0 \rightarrow \frac{1}{2}N_0 \rightarrow \frac{1}{4}N_0 = 0.25\,N_0 = 25\%\,N_0$

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4. The half-life of a radioactive isotope is 6.5 h. If there are initially 48×10^{32} atoms of this isotope, the number of atoms of this isotope remaining after 26 h is:

A) 12×10^{32} B) 6×10^{32} C) 3×10^{32} D) 6×10^{4} E) 3×10^{2}

$N = N_0 e^{-\lambda t}$

$N = 48 \times 10^{32}\, e^{-\frac{\ln 2}{6.5} \times 26}$

$N = 3 \times 10^{32}$ atom

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5. At the end of 14 min, 1/16 of a sample of radioactive polonium remains. The corresponding half-life (in minute) is:

A) (7/8) B) (8/7) C) (7/4) D) (7/2) E) (14/3)

$N_0 \xrightarrow{t_{1/2}} \frac{1}{2}N_0 \xrightarrow{t_{1/2}} \frac{1}{4}N_0 \xrightarrow{t_{1/2}} \frac{1}{8}N_0 \xrightarrow{t_{1/2}} \frac{1}{16}N_0$

$4\,t_{1/2} = 14$

$t_{1/2} = \frac{7}{2}$ min

* طريقة أخرى :-

$\frac{1}{16}N_0 = N_0 e^{-\lambda \times 14}$

$\lambda = 0.198$

$t_{1/2} = \frac{\ln 2}{0.198} = \frac{7}{2}$ min

6. The half-life of a radioactive isotope is 140 days. In how many days does the decay rate of a sample of this isotope decrease to one fourth its initial decay rate?

A) 35 B) 70 C) 105 D) 210 E) 280

$N_0 \xrightarrow{t_{1/2}} \frac{1}{2}N_0 \xrightarrow{t_{1/2}} \frac{1}{4}N_0$

$2t_{1/2} = 2 \times 140 = 280$

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7. ^{40}K decays to ^{40}Ar with a half-life of 1.25×10^9 yr. Assume that rocks contain no ^{40}Ar when they form, and that the only way ^{40}Ar can be present is through the decay of ^{40}K. If the ratio of ^{40}K to ^{40}Ar in a particular rock is found to be 1:3, what is the age (in year) of the rock?

K 0.25 و 0.75 Ar

A) 1.25×10^9 B) 2.50×10^9 C) 3.75×10^9 D) 5.00×10^9

E) cannot be determined without knowing how much ^{40}K was in the rock to begin with

$\frac{1}{4}N_0 = N_0 e^{-\frac{\ln(2)}{1.25\times10^9} \times t}$

بقي عندي $\frac{1}{4}$ من K (اللي هو الأصل)

$t = 2.5 \times 10^9$ years

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8. An isotope of Tc having a half-life of 6.0 h is used in bone scans. If a certain amount of this Tc is injected into the body, how long (in hour) does it take for its initial decay rate to decrease BY 99%?

A) 0.060 B) 3.3 C) 33 D) 40 E) slightly more than a month

decrease by 99% = the remaining is 1% = 0.01

$0.01 N_0 = N_0 e^{-\frac{\ln 2}{6} \times t} \Rightarrow t = 39.86$ hour ≈ 40 hour

9. The ratio of the radius of a classical electron (2.8×10^{-15} m) to the radius of a ^{4}He nucleus is

A) 2.0 B) 0.68 C) 1.47 D) 0.92 E) 2.4

* radius of electron = 2.8×10^{-15} m
* radius of He nucleus = $1.2 \times 10^{-15} \times \sqrt[3]{4}$ = 1.90488×10^{-15}

$$\frac{r_e}{r_{He}} = \frac{2.8 \times 10^{-15}}{1.90488 \times 10^{-15}} = 1.4699 \approx 1.47$$

10. A certain isotope has a half-life of 32.4 hour and a relative biological effectiveness of 3.50. A sample of this isotope initially delivers an absorbed dose of 0.240 Gy to 250 g of tissue.

$t_{\frac{1}{2}}$ RBE AD m

(a) What was the initial equivalent dose to the tissue in rem and in Sv?
(b) What energy (in J) did the 250-g sample initially receive from the isot

(a) $Ed = AD \times RBE$

$= 0.24 \times 3.5 = 0.84$ Sv $= 84$ rem

(b) $AD = \frac{E}{m} \Rightarrow 0.24 = \frac{E}{0.25} \Rightarrow E = 0.06$ J

11. The maximum permissible workday dose for occupational exposure to radiation is 26 mrem. A 55-kg laboratory technician absorbs 3.3 mJ of 0.40-MeV gamma rays in a workday. The relative biological effectiveness (RBE) for gamma rays is 1.00. What is the ratio of the equivalent dosage received by the technician to the maximum permissible equivalent dosage?

A) 0.23 B) 0.25 C) 0.28 D) 0.30 E) 0.32

Ed (absorbed) $= \dfrac{3.3\times10^{-3}}{55} \times 1$

$\dfrac{Ed_{absorbed}}{Ed_{maximum}} = \dfrac{6\times10^{-5}\ Sv}{26\times10^{-3}\times10^{-2}\ Sv} = 0.23$

maximum Ed per day $= 26\times10^{-3}$ rem

$m = 55$ kg

Absorbed energy $= 3.3\times10^{-3}$ J

gamma ray energy per day $= 0.4\times10^{6}\times1.6\times10^{-19}$ J

مش مستخدمة

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12. A 70-kg laboratory technician absorbs 2.9 mJ of 0.50-MeV gamma rays in a workday. How many gamma-ray photons does the technician absorb in a workday?

A) 3.6×10^{10} B) 3.6×10^{9} C) 3.6×10^{8} D) 1.0×10^{9} E) 1.0×10^{8}

number of photons $= \dfrac{\text{Absorbed energy}}{\text{Energy of gamma rays}} = \dfrac{2.9\times10^{-3}}{0.5\times10^{6}\times1.6\times10^{-19}}$

$= 3.625\times10^{10}$ photon

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13. A 57-kg researcher absorbs 6.3×10^{8} neutrons in a workday. The energy of the neutrons is 2.6 MeV. The RBE for fast neutrons is 10. What is the equivalent dosage of the radiation exposure (in mrem) of this worker?

A) 4.6 B) 1.4 C) 2.9 D) 14 E) 46

$Ed = AD \times RBE$

$= \dfrac{E_{tot}}{m} \times RBE$

$= \dfrac{6.3\times10^{8}\times2.6\times10^{6}\times1.6\times10^{-19}}{57} \times 10$

$= 4.5\times10^{-5}$ Sv $\Rightarrow 4.5\times10^{-3}$ rem

$\Rightarrow 4.5$ mrem

14. The radioactive nuclei ^{60}Co is widely used in medical applications. It undergoes beta decay, and the total energy of the decay process is 2.82 MeV per decay event. The half-life of this nucleus is 272 days. Suppose that a patient is given a dose of 6.9 μCi of ^{60}Co. If all of this material decayed while in the patient's body, what would be the total energy deposited there? (1 Ci = 3.70×10^{10} decays/s)

A) 11 J B) 8.6 GJ C) 3.9 J D) 24 J E) 4.15 MJ

total energy = number of decays × energy per decay

$8.65 \times 10^{12} \times 2.82 \times 10^{6} \times 1.6 \times 10^{-19}$

$= 3.9$ J

$A = \lambda N$

$6.9 \times 10^{-6} \times 3.7 \times 10^{10} = \frac{\ln 2}{272 \times 24 \times 3600} \times N$

$N = 8.65 \times 10^{12}$ decay.

15. A laboratory experiment uses a 10 μCi ^{137}Cs source. Each decay emits a 0.66 MeV gamma ray. A 60 kg person standing nearby absorbs 10 % of the gamma rays.

Activity of source; /decay; m

(a) What is his absorbed dose in rads in 1 hour? 2.34×10^{-5} rad

(b) Find his effective dose in rems (take RBE = 0.8). 0.0187 mrem

Energy per sec $= 3.7 \times 10^{5} \frac{\text{decay}}{\text{sec}} \times 1.056 \times 10^{-13} \frac{\text{J}}{\text{decay}}$

$= 3.9072 \times 10^{-8}$ J/sec

(A)

Energy absorbed per hour $= 3.9072 \times 10^{-8} \frac{\text{J}}{\text{sec}} \times \frac{60 \times 60 \text{ sec}}{1 \text{ hour}} \times 10\% =$

$= 1.4 \times 10^{-5}$ J/hour

AD per hour $= \frac{1.4 \times 10^{-5} \text{ J/hour}}{60} = 2.34 \times 10^{-7} \frac{\text{Gy}}{\text{hour}} = 2.34 \times 10^{-5}$ rad/sec

(B)

Ed = AD × RBE

$= 2.34 \times 10^{-5}$ rad $\times 0.8 = 1.87 \times 10^{-5}$ rem $= 0.0187$ mrem

16. Suppose your last **physical exam** included a chest X-ray, during which you received a dose of 60 μSv. *Eq*

(a) What was your dose in mrem? 6 mrem *$60\times10^{-6}\times10^{2} = 60\times10^{-4}$ rem $=$ 6 mrem*

(b) What was the absorbed dose in μGy and mrad? 60 μGy , 6 mrad. *= RBE = 1*

(c) How much energy did you absorb, assuming that the X-rays illuminated 15 kg *(m)* of your body? 9 × 10-4 J *60×10^{-6} Gy $\times 15 = 9\times10^{-4}$ J*

Assignment 4

1] $N = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$\frac{1}{8} N_0 = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$\rightarrow t = 3t_{\frac{1}{2}} = 15$ m

$\rightarrow t_{\frac{1}{2}} = 5$ minutes

2] $t_{\frac{1}{2}} = 5$ days

$N = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$\frac{1}{4} N_0 = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$\rightarrow t = 2t_{\frac{1}{2}} = 10$ days

3] $t_{\frac{1}{2}} = 30$ years

$N\Big|_{t = 2t_{\frac{1}{2}}} = N_0 \left(\frac{1}{2}\right)^{\frac{2t_{\frac{1}{2}}}{t_{\frac{1}{2}}}}$

$= \frac{N_0}{4}$

percent $= \%25$

4] $t_{\frac{1}{2}} = 6,5$ h , $t = 4t_{\frac{1}{2}}$, $N_0 = 48 * 10^{32}$ atom

$N = N_0 \left(\frac{1}{2}\right)^{\frac{4t_{\frac{1}{2}}}{t_{\frac{1}{2}}}}$

$= \frac{48 * 10^{32}}{16} = 3 * 10^{32}$ atoms

5] $t = 14$ min $\rightarrow N = \frac{1}{16} N_0$

$t = 4t_{\frac{1}{2}}$

$4t_{\frac{1}{2}} = 14$ min $\rightarrow t_{\frac{1}{2}} = \frac{7}{2}$ min

6] $t_{\frac{1}{2}} = 140$ days , $A = A_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$\frac{1}{4} A_0 = A_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}} \rightarrow t = 2t_{\frac{1}{2}} = 280$ days

7] ${}^{40}K \rightarrow {}^{40}Ar$, $t_{\frac{1}{2}} = 1,25 * 10^{9}$ yr

$1\, {}^{40}K : 3\, {}^{40}Ar$

$\rightarrow {}^{40}K = \frac{1}{4}$ of the sample

$\rightarrow \frac{1}{4} N_0 = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}} \rightarrow t = 2t_{\frac{1}{2}} = 2,5 * 10^{9}$ yr

8] $t_{\frac{1}{2}} = 6$ h

$A = A_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}} \rightarrow \frac{1}{100} A_0 = A_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$

$\rightarrow \frac{t}{t_{\frac{1}{2}}} = \frac{\ln 100}{\ln 2} \Rightarrow t = 40$ h

9] $\frac{R_{\bar{e}}}{R_{He}} = \frac{2,8 * 10^{-15}}{1,2 * 10^{-15}\ 4^{\frac{1}{3}}} = 1,47$

10] a) $ED = AD * RBE = ,240 * 3,5$

$= ,84$ Sv or 84 rem

b) $AD = \frac{E}{m}$

$E = ,240 * ,250 = 0,06$ J

Assignment 4

11] $AD = \frac{E}{m} = \frac{3,3 mJ}{55kg}$

$= 6 * 10^{-5}$ Gy

$ED = AD * RBE = 6 * 10^{-5}$ SV

$= 6$ mrem

$\rightarrow \frac{6mrem}{26mrem} = ,23$

12] $E = n E_{photon}$

$n = \frac{2,9 * 10^{-3}}{,5 * 10^{6} * 1,6 * 10^{-19}} = 3,625 * 10^{10}$

13] $E = n E_{neutron}$

$= 6,3 * 10^{8} * 2,6 * 10^{6} * 1,6 * 10^{-19}$

$AD = \frac{E}{m} = 4,6 * 10^{-6}$ Gy

$ED = AD * RBE = 4,6 * 10^{-5}$ SV

$= 4,6$ mrem

14] $\frac{\Delta N}{\Delta t} = 6,9 * 10^{-6} * 3,7 * 10^{10}$

$= 25,53 * 10^{4}$

$\frac{\Delta N}{\Delta t} = \lambda N$

$\lambda \rightarrow \frac{Ln 2}{t_{\frac{1}{2}}} \rightarrow 272 * 24 * 3600$

$N = 8,65 * 10^{12}$

$E = N * 2,82$ Mev

$E = 3,9$ J

15] a] $A = 37000$ decay/s $\rightarrow 37 * 10^{3} * 36 * 10^{2}$ decay/h

$\rightarrow$ decay $E = ,66$ Mev

$\rightarrow AD = \frac{E}{m} = \frac{,66 Mev * 37 * 36 * 10^{5}}{60} = 2,34 * 10^{-5}$ Rad

b] $ED = AD * RBE = 2,34 * 10^{-7} * ,8$

$= 1,87 * 10^{-7}$ SV

$= 0,0187$ mrem

16] a] 60μ SV $= 6$ mrem

b] $AD = \frac{ED}{RBE} = 60 \mu$ Gy $= 6$ mrad

c] $E = AD * m = 9 * 10^{-4}$ J