Essential Pre-Uni Physics J2.1

A Level

A ‘mole’ of nuclei contains 6.02×10^{23} nuclei. The mass of one mole of nuclei (the ‘molar mass’) is approximately equal to $0.001\,\text{kg}\times$ the mass number of the nucleus. Use this approximation wherever you have a question and are not given the molar mass explicitly.

Complete the questions in the table:

Half life	Decay constant / s^{-1}
$53\ \text{s}$	(a)
$12\ \text{years}$	(b)

Part A Half life of $53\,\text{s}$

a) What is the decay constant?

Part B Half life of $12\,\text{years}$

b) What is the decay constant?

Essential Pre-Uni Physics J2.8

A Level

A ‘mole’ of nuclei contains 6.02×10^{23} nuclei. The mass of one mole of nuclei (the ‘molar mass’) is approximately equal to $0.001\,\mathrm{kg}\times$ the mass number of the nucleus. Use this approximation wherever you have a question and are not given the molar mass explicitly.

Part A Number of nuclei

$^{238}\mathrm{U}$ has a half life of $4.47 \times 10^{9}\,\mathrm{years}$. How many $^{238}\mathrm{U}$ nuclei would you need in order to have an activity of $5000\,\mathrm{Bq}$? Give your answer to 2 significant figures (strictly the answer to this question should be given to 1 sig fig, but 2 sig figs allows us to check your method is correct)

Part B Mass of the sample

What is the mass of the $^{238}\mathrm{U}$ sample? Give your answer to 2 significant figures (strictly the answer to this question should be given to 1 sig fig, but 2 sig figs allows us to check your method is correct).

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Essential Pre-Uni Physics J2.10

A Level

C C C

A ‘mole’ of nuclei contains 6.02×10^{23} nuclei. The mass of one mole of nuclei (the ‘molar mass’) is approximately equal to $0.001\,\text{kg}\times$ the mass number of the nucleus. Use this approximation wherever you have a question and are not given the molar mass explicitly.

A 'radioactive battery' for a long range space probe uses a radioisotope with a decay constant of $4.4 \times 10^{-12}\,\text{s}^{-1}$, and a molar mass of $0.236\,\text{kg}$. Each time one nucleus decays, $2.5 \times 10^{-12}\,\text{J}$ of electrical energy is `made' by the generator. Calculate the mass of the radioactive sample if the spacecraft requires $200\,\text{J}$ of electricity every second (i.e. this is a $200\,\text{W}$ spacecraft). Give your answer to 2 significant figures.

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Inverse Square Intensity 16.1

A Level

Quantities:

P Power (W)
I Intensity $(\mathrm{W\,m^{-2}})$
C Count rate $(\mathrm{Bq} = \mathrm{s^{-1}})$
Subscripts label different locations, so I_1 is measured at r_1.
A Surface area $(\mathrm{m^2})$
r Distance from source (m)

Equations:

$$A_{\text{sphere}} = 4\pi r^2 \qquad I = \frac{P}{A}$$

For a source which radiates in all directions, use the equations above to derive expressions for:

Part A The intensity I at a distance r from a source of power P

the intensity I at a distance r from a source of power P.

The following symbols may be useful: `I, P, pi, r`

Part B The distance d at which a source P has intensity I

the distance d at which a source P has intensity I.

The following symbols may be useful: `I, P, d, pi`

Part C The intensity I_2 at a distance r_2 from a source

the intensity I_2 at a distance r_2 from a source if the intensity at distance r_1 is I_1.

The following symbols may be useful: `I_1, I_2, r_1, r_2`

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Inverse Square Intensity 16.6

A Level

When dentists take X-rays, they stand by the door, or outside the room. Calculate the intensity at $3.5\,\mathrm{m}$ from the source as a fraction of the intensity $0.32\,\mathrm{m}$ from it.

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Inverse Square Intensity 16.7

A Level

The background count in a laboratory is 36 counts in $40\,\mathrm{s}$. When a gamma source is placed $1.5\,\mathrm{m}$ from the detector, there are 236 counts each minute.

Part A Background-corrected count rate

Calculate the background-corrected count rate in Bq.

Part B Expected background-corrected count rate

Calculate the expected background-corrected count rate $15\,\mathrm{cm}$ from the source.

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Essential Pre-Uni Physics J3.5

A Level

Tritium has a half life of about 12 years. If you put $3.0\ \mu\text{g}$ of tritium into a luminous sign, how much will still be there $50\ \text{years}$ later?

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Physics. You work it out.

Essential Pre-Uni Physics J3.8

A Level

Carbon-14 has a half life of about $5700\,\text{years}$. What fraction of the original amount of carbon-14 would you expect to find in the timbers of a boat built $8000\,\text{years}$ ago? Give your answer as a decimal to 4 significant figures.

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Essential Pre-Uni Physics J3.9

A Level

Uranium-238 has a half life of $4.47 \times 10^9\,\text{years}$ and decays to thorium-234. The thorium decays (by a series of further nuclear processes which are relatively brief) to lead. Assuming that a rock was originally entirely uranium, and that at present, 1.5% of the nuclei are now lead, calculate the age of the rock. Give your answer in years to 2 significant figures.

Gameboard:

STEM SMART Physics 33 - Exponentials in radioactivity

Physics. You work it out.

Exponential Decay - Using Logarithms 35.2

A Level

P P P

How much time is taken for 7.0% of a radioactive rock (containing uranium) to decay if $T_{1/2} = 4.5 \times 10^9 \text{ years}$?