



# Essential Pre-Uni Physics J2.1

A Level

P

P

P

A ‘mole’ of nuclei contains  $6.02 \times 10^{23}$  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 / $\text{s}^{-1}$
53 s	(a)
12 years	(b)

## Part A   Half life of 53 s

a) What is the decay constant?

## Part B   Half life of 12 years

b) What is the decay constant?

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# Essential Pre-Uni Physics J2.8

A Level



A 'mole' of nuclei contains  $6.02 \times 10^{23}$  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.

## Part A Number of nuclei

$^{238}\text{U}$  has a half life of  $4.47 \times 10^9$  years. How many  $^{238}\text{U}$  nuclei would you need in order to have an activity of 5000 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  $^{238}\text{U}$  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).

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# Essential Pre-Uni Physics J2.10

**A Level**

A 'mole' of nuclei contains  $6.02 \times 10^{23}$  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.

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# Inverse Square Intensity 16.1

A Level



Quantities:

$P$  Power (W)

$I$  Intensity ( $\text{W m}^{-2}$ )

$C$  Count rate ( $\text{Bq} = \text{s}^{-1}$ )

Subscripts label different locations, so  $I_1$  is measured at  $r_1$ .

$A$  Surface area ( $\text{m}^2$ )

$r$  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  $I_1$ .

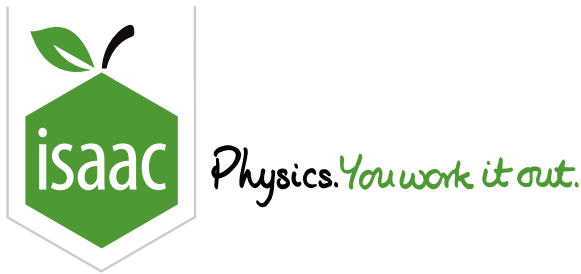
The following symbols may be useful:  $I_1$ ,  $I_2$ ,  $r_1$ ,  $r_2$

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# Inverse Square Intensity 16.6

A Level

P

P

P

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

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# Inverse Square Intensity 16.7



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

## Part A Background-corrected count rate

Calculate the background-corrected count rate in Bq.

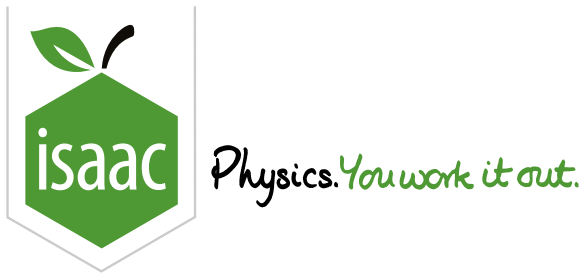
## Part B Expected background-corrected count rate

Calculate the expected background-corrected count rate 15 cm from the source.

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# Essential Pre-Uni Physics J3.5



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 years later?

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# Essential Pre-Uni Physics J3.8

A Level

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

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# Essential Pre-Uni Physics J3.9

A Level



Uranium-238 has a half life of  $4.47 \times 10^9$  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.

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# Exponential Decay - Using Logarithms 35.2

A Level



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

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