Exponential Decay

Radioactive decay:

Initial number of nuclei is N_0

Rate of decay = $-\lambda N$ ✓

This is the ***activity*** of the nuclei.

The same proportion of nuclei decay in the same period of time ✓

This is the same as saying that the probability of a nucleus decaying is λ, where

$$\frac{dN}{dt} = -\lambda N$$

λ is the decay constant ✓

there is a '-' sign because the number is falling ✓

The solution of this differential equation is:

$N = N_0 e^{-\lambda t}$ ✓ from this, we can use the log relationship to obtain

$\ln N - \ln N_0 = -\lambda t$ ✓

Half-life

When the number of nuclei has dropped to half, $N = 0.5\ N_0$ ✓

The half-life, $t_{1/2} = \frac{0.693}{\lambda}$ ✓

Eg There were 100 dice in the experiment. The probability of a 'decay' was 1/6 ✓

$\lambda = 1/6$ ✓

a) What is the predicted 'half-life', $t_{1/2}$? t1/2 = 0.693 ÷ 1/6 = 4.2 throws ✓

b) How many throws are likely to be needed for 20 dice to remain?

ln(0.2) = -1.61 ⇒ no of throws = -1.61 ÷ 1/6 = 9.66 (i.e. between 9 and 10) ✓

c) If there were 10 000 dice to start with, how many dice would be likely to remain after 10 throws?

$N = 10\,000 \times e^{-1/6\times10} = 1900$ ✓

Straight Line Graph

The solution of $N = N_0 e^{-\lambda t}$ is

$\ln N - \ln N_0 = -\lambda t$ or $\ln N = -\lambda t + \ln N_0$

This will give a straight line graph:

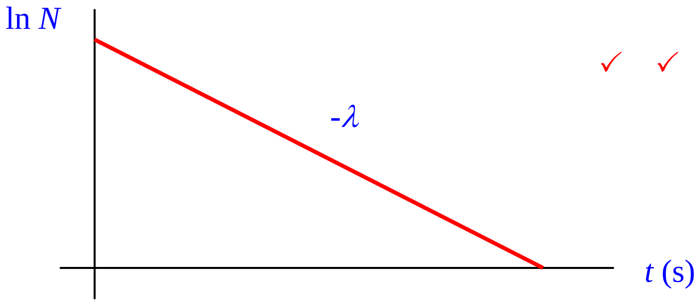
$$y = mx + c$$

the y axis will be $\ln N$ ✓

the x axis will be t ✓

the value of the y-intercept will be $\ln N_0$ ✓

the value of the gradient will be $-\lambda$ ✓



✓ ✓ ✓

20 marks