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Numerical Problems

18.1 The half-life of I*N is 7.3s. A sample of this nuclide of nitrogen is observed for 29.2s. Calculate the fraction of the original radioactive isotope remaining after this time.

Answer

Half-life of $^{16}_{7}N$ = 7.3 s

Time observed = 29.2 s

After the time (half-life), 7.3 s = $\frac{1}{2}$ of sample will decay.

After the time (2nd half-life), 14.6 s = $\left(\frac{1}{2}\right)^2$

= $\frac{1}{4}$th of the sample will be left

After the time (3rd half-life), 21.9 s = $\left(\frac{1}{2}\right)^3$

= $\frac{1}{8}$th of the sample will be left

After the time (4th half-life), 29.2 s = $\left(\frac{1}{2}\right)^4$

= $\frac{1}{16}$th of the sample will be left

[So, after 29. $\frac{1}{16}$th fraction of the original radioactive isotope will remain]

18.2 Cobalt-60 is a radioactive element with half-life of 5.25 years. What fraction of the original sample will be left after 26 years?

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Answer

Half-life of cobalt -60 = 5.25 years

Time observed = 26 years

1st half life After the time 5.25 years = $\frac{1}{2}$ of sample will decay.

2nd half-life: After the time 10.50 years = $\left(\frac{1}{2}\right)^2$

= $\frac{1}{4}$th of the fraction will remain

3rd half-life: After the time 15.75 years = $\left(\frac{1}{2}\right)^3$

= $\frac{1}{8}$th of the fraction will remain

4th half-life: After the time 21 years= $\left(\frac{1}{2}\right)^4$

= $\frac{1}{16}$th of the fraction will remain

5th half-life: After the time 26 years = $\left(\frac{1}{2}\right)^5$

= $\frac{1}{32}$th of the fraction will remain

[So, after 26.25 years or approximately 26 years, 1/32th fraction of the original sample will be left.]

18.3 Carbon-14 has a half-life of 5730 years. How long will it take for the quantity of carbon-14 in a sample to drop to one-eighth of the initial quantity?

Answer

Half-life of carbon-14 = 5730 years

Time required for 1st half-life = 5730 years

Time required for 2nd half-life = 1.14×10^4 years

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Time required for 3rd half-life = 1.72×10^4 years

[It means that, after 3rd half-life, 1 / 8th of the initial quantity is left and 1.72×10^4 years' time is required for this decay.]

18.4 Technetium -99m is a radioactive element and is used to diagnose brain, thyroid, liver and kidney diseases. This element has half-life of 36 minutes. If there is 200 mg of this technetium present, how much will be left in six hours.

Answer

Half-life of Technetium - 99 = 36 minutes

Mass of Technetium-99 = 200 mg

After 36 min = 100mg of Technetium will be left

Within 30 = 50 mg of Technetium will be left

Within 24 = 25 mg of Technetium will be left

Within 18 = 12.5 mg of Technetium will be left

Within 12 = 6.25 mg of Technetium will be left

Within 6 = 3.12 mg of Technetium will be left

[it means that within 6 minutes, 3.12 mg of Technetium may decay.]

18.5 Half-life of a radioactive element is 10 minutes. If the initial count rate is 368 counts per minute, find the time for which count rates reaches 23 counts per minute.

Answer

Half life of radioactive element = 10min

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Initial count rate = 368 c/min

After 10 min = 184 c/min

After 20 min = 92 c/min

After 30 min = 46 c/min

After 40 min = 23 c/min

[So, after 40 minutes we have 23 counts per minute as decay rate]

18.6 In an experiment to measure the half-life of a radioactive element, the following results were obtained:

Count rate	400	200	100	50	25
Time (in minutes)	0	2	4	6	8

Plot a graph between the count rate and time in minutes. Measure the value of the half-life of the element from the graph.

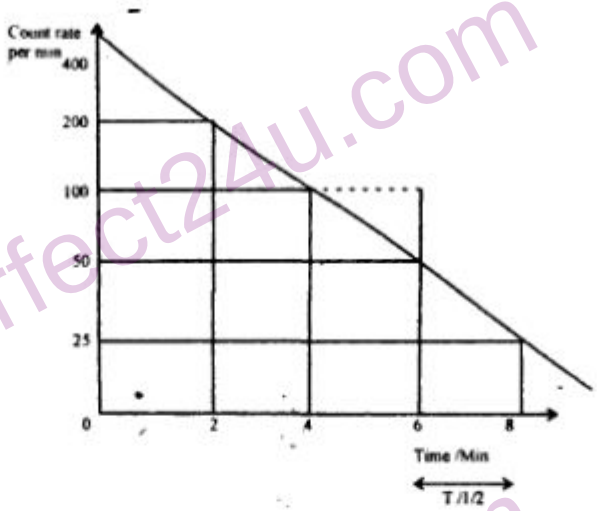
Answer

It clear from the graph that half live of the radioactive element is 2 minutes.

After each two-minute $\frac{1}{2}$ of Ae remaining specimen is decayed.

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18.7 A sample of certain radioactive element has at half-life of 1500 years. If it has an activity of 32000 counts per hour at the present time then plot a graph of the activity of this sample over the period in which it will reduce to 1/16 of its present value.

Answer

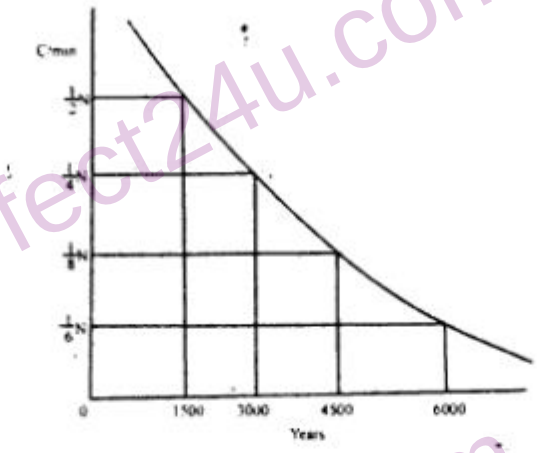
Half 1 life of radioactive element= 1500 years

Rate of activity = 32000 c/min-

It is clear from the graph that 6000 years are required to decay the radioactive element in such a way that only $1/16^{th}$ of this specimen is left.

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18.8 Half-life of radioactive element was found to be 4000 years. The count rates per minute for 8 successive hours were (·>und to be 270, 280, 300, 310, 285, 290, 305, 312. What does the variation in count rates show? Plot graph between the count rates and time in hours. Why the graph is a straight line rather than an exponential?

Answer

Half-life of radioactive element = 4000 years

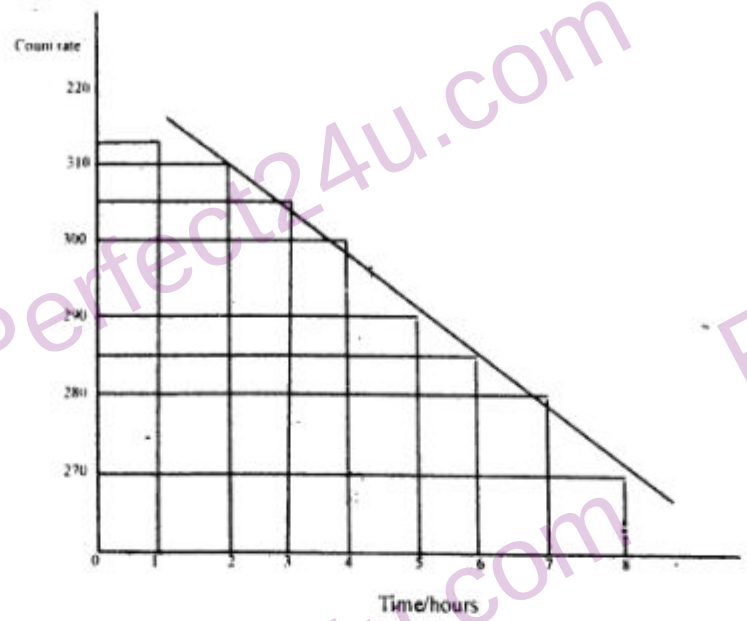
Time for activity = 8 hours.

Variation in count rate shows the random nature of radioactive decay.

Graph as shown below.

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[Graph is almost horizontal line rather than exponential curve which is due to long half-life as compared to 8]

18.9 Ashes from a campfire deep in a cave show carbon-14 activity of only one-eighth the activity of fresh wood. How long ago was that campfire made?

Answer

Activity of carbon - 14 = 1/8 of activity of wood

As we know that:

The half-life of carbon - 14 = 5730 years

Time for carbon - 14 to decay ½ of activity

Time for carbon - 14 to decay 1/4th of activity

of fresh wood = 11460 years

Time for carbon - 14 to decay $\frac{1}{8}^{th}$ of activity

of fresh wood = 17190 years.

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17190 years

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