Chemistry H

Exercise 21.2b

Half-Lives – Answers

Name: _____

Date: _____ Per: _____

A nuclear half-life represents the amount of time required for one-half of a radioactive isotope (radionuclide) to decay. The decay that occurs in each half-life results in a characteristic pattern representing the remaining amount – 1/2,1/4, 1/8, 1/16, 1/32, 1/64, etc. Amounts may be found using a table or using the formula:

amount remaining = starting amount • (1/2)^n or $A_R = A_I(1/2)^n$

where n = the number of half-lives

Sample:

If you start with 200 g of element Y (half-life 150 years), how many grams will be present 600 years from now?

$A_R = 200g \bullet (1/2)^4 = 12.5g$

(n = 4 because 600 years represents 4 150 year half-lives.)

or

Half-Lives	*Time (years)*	*Amount Remaining*
0	*Now*	*200 g*
1	*150 years from now*	*100 g*
2	*300 years from now*	*50 g*
3	*450 years from now*	*25 g*
4	*600 years from now*	*12.5 g*

DIRECTIONS: Solve the following in the space provided:

1. Solve the half-life formula for *n*.

   Base 10: $A_R = A_I(1/2)^n \Rightarrow A_R/A_I = (1/2)^n \Rightarrow \log(A_R/A_I) = \log(1/2)n \Rightarrow$ $n = \log(A_R/A_I)/\log(1/2)$

   Base ½: $A_R = A_I(1/2)^n \Rightarrow A_R/A_I = (1/2)^n \Rightarrow$ $\log_{1/2}(A_R/A_I) = n$

2. Solve the half-life formula for "*starting amount*".

   $A_R = A_I(1/2)^n \Rightarrow$ $A_I = A_R/(1/2)^n$

3. If you currently have 20. g of element *X* (half-life 300 years), how many grams would have been present 1500 years ago?

   1500 years/300 years = 5 half-lives

   $A_R = A_I(1/2)^n \Rightarrow A_I = A_R/(1/2)^n \Rightarrow A_I = 20.g/(1/2)^5 \Rightarrow A_I = 20.g/(1/32)$ $A_I =$ 640g or

   -1500 yr 640 g
   -1200 yr 320 g
   -900 yr 160 g
   -600 yr 80. g
   -300 yr 40. g
   Now 20. g

4. The half-life of plutonium-239 is 24300 years. If a nuclear bomb released 8 kg of this isotope, how many years would pass before the amount is reduced to 1 kg?

   $n = \log_{1/2}(A_R/A_I) \Rightarrow n = \log_{1/2}(1\ kg/8\ kg) \Rightarrow n = 3 \Rightarrow 3 \times 24300\ yr =$ 72900 yr or

   Start 8 kg
   1 HL 4 kg
   2 HL 2 kg
   3 HL 1 kg

   3 x 24300 yr = 72900 yr

5. The half-life of radon-222 is 3.8 days. How much of a 100. gram sample is left after 15.2 days?

   15.2 days/3.8 days = 4 half-lives $\Rightarrow$ $A_R = A_I(1/2)^n \Rightarrow A_R = 100.g(1/2)^4 \Rightarrow$ $A_R =$ 6.25 g or

   Now 100. g
   +3.8 d 50.0 g
   +7.6 d 25.0 g
   +11.4 d 12.5 g
   +15.2 d 6.25 g

6. Carbon-14 has a half-life of 5730 years. If a sample contained 70.0 mg originally, how much is left after 17190 years?

   17190 yr/5730 yr days = 3 half-lives $\Rightarrow$ $A_R = A_I(1/2)^n \Rightarrow A_R = 70.0mg(1/2)^3 \Rightarrow$ $A_R =$ 8.75 mg or

   Now 70.0 mg
   +5730 yr 35.0 mg
   +11460 yr 17.5 mg
   +17190 yr 8.75 mg

7. The half-life of cobalt-60 is 5.26 years. If 50.0 grams are left after 15.78 years, how many grams were in the original sample?

   15.78 years/5.26 years = 3 half-lives

   $A_R = A_I(1/2)^n \Rightarrow A_I = A_R/(1/2)^n \Rightarrow A_I = 50.0g/(1/2)^3 \Rightarrow A_I = 50.0g/(1/8)$ $A_I =$ 400.g or

   -15.78 yr 400. g
   -10.52yr 200. g
   -5.26 yr 100. g
   Now 50.0 g

Answers: 3) 640 g 4) 72900 years 5) 6.25 g 6) 8.75 mg 7) 400 g 8) 2 hours

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8. If you have 200. g of radioactive element *Z* at 12:00noon and have only 12.5g left at 8:00pm that same day, what is the half-life of this element?

$n = \log_{1/2}(A_R/A_I) \Rightarrow n = \log_{1/2}(200.\ g/12.5\ g) \Rightarrow n = 4 \Rightarrow$ 8:00pm-12:00pm/4 half-lives = 2 hrs/half-life

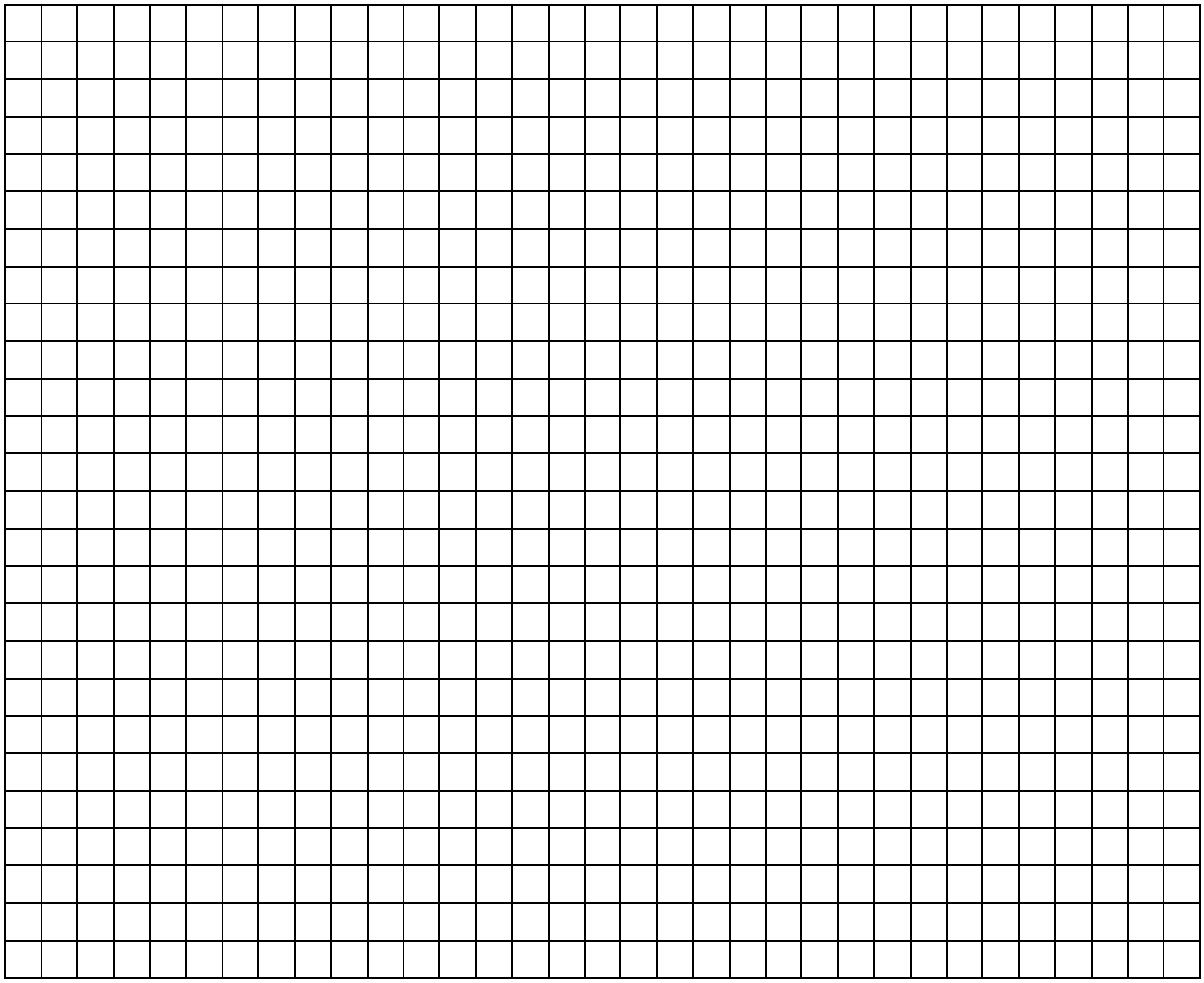
or

Start	200. g
+1 HL	100. g
+2 HL	50.0 g
+3 HL	25.0 g
+4 HL	12.5 g

It takes 4 half-lives for the sample to decay from 200. g to 12.5 g. Since the four half-lives occur over 8 hours, the half-life is 2 hours.

9. Graph the following data on the graph, then use the graph to determine the half-life of this isotope.

Time (years)	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Mass Remaining (grams)	***100***	***75***	***56***	***42***	***32***	***24***	***18***	***13***	***10***	***8***	***6***



Half-life = *about 2.4 years*

DIRECTIONS: Answer the following in the space provided.

10. How are fission & fusion alike: _____

11. How are fission & fusion different: _____

12. What does $E=mc^2$ really mean to us? _____

Answers: 3) 640 g 4) 72900 years 5) 6.25 g 6) 8.75 mg 7) 400 g 8) 2 hours