Half-Life Chemistry Questions with Solutions

Q1. An isotope of caesium (Cs-137) has a half-life of 30 years. If 1.0g of Cs-137 disintegrates over a period of 90 years, how many grams of Cs-137 would remain?

a.) 1.25 g
b.) 0.125 g
c.) 0.00125 g
d.) 12.5 g

Correct Answer- (b.) 0.125 g

Q2. Selenium-83 has a half-life of 25.0 minutes. How many minutes would it take for a 10.0 mg sample to decay and only have 1.25 mg of it remain?

a.) 75 minutes
b.) 75 days
c.) 75 seconds
d.) 75 hours

Correct Answer- (a.) 75 minutes

Q3. How long does it take a 100.00g sample of As-81, with a half-life of 33 seconds, to decay to 6.25g?

a.) 122 seconds
b.) 101 seconds
c.) 132 seconds
d.) 22 seconds

Correct Answer- (c.) 132 seconds

Q4. What is the half-life of a radioactive isotope if a 500.0g sample decays to 62.5g in 24.3 hours?

a.) 8.1 hours
b.) 6.1 hours
c.) 5 hours
d.) 24 hours

Correct Answer- (a.) 8.1 hours

Q5. What is the half-life of Polonium-214 if, after 820 seconds, a 1.0g sample decays to 0.03125g?

a.) 164 minutes
b.) 164 seconds
c.) 64 seconds
d.) 160 minutes

Correct Answer- (b.) 164 seconds

Q6. The half-life of Zn-71 is 2.4 minutes. If one had 100.0 g at the beginning, how many grams would be left after 7.2 minutes have elapsed?

Answer.
To begin, we'll count the number of half-lives that have passed. This can be obtained by doing the following:

Half-life ($t\frac{1}{2}$) = 2.4 mins
Time (t) = 7.2 mins

Number of half-lives

Number of half-lives $n = \frac{t}{t_{1/2}}$
n = 7.2/2.4 = 3
Thus, three half-lives have passed.

Finally, we will calculate the remaining amount. This can be obtained by doing the following:
N_0 (original amount) = 100 g
(n) = number of half-lives

Amount remaining (N) =?
N = $\frac{N_0}{N^n}$
N = 100 / 2^3
N = 100 / 8
N = 12.5 g
As a result, the amount of Zn-71 remaining after 7.2 minutes is 12.5 g.

Q7. Pd-100 has a half-life of 3.6 days. If one had 6.02 x 10^{23} atoms at the start, how many atoms would be present after 20.0 days?

Answer.

Half-life = 3.6 days
Initial atoms = 6.02 ×10^{23} atoms
Time = 20days
To calculate the atoms present after 20 days, we use the formula below.

$$N = N_0 \times \frac{1}{2} \times \frac{t}{t_{1/2}}$$

$$N = 6.02 \times 10^{23} \times \frac{1}{2} \times \frac{20}{3.6} = 1.28 \times 10^{22}$$

Thus, the number of atoms available is 1.28 × 10^{22} atoms.

Q8. Os-182 has a half-life of 21.5 hours. How many grams of a 10.0 gram sample would have decayed after exactly three half-lives?

Answer. The amount of the radioactive substance that will remain after 3- half- lives=$(½)^3$ × a, where a = initial concentration of the radioactive element.
a= 10 g
So, amount of the radioactive substance that remains aftet 3- half-lives=$(½)^3$x10 = 10/8= 1.25 g.
Therefore, the number of grams of the radioactive substance that decayed in 3 half-lives = (10 – 1.25) g = 8.75 g

Q9. After 24.0 days, 2.00 milligrams of an original 128.0 milligram sample remain. What is the half-life of the sample?

Answer. The remaining decimal fraction is:
2.00 mg / 128.0 mg = 0.015625
The half-lives that must have expired to get to 0.015625?
$(½)^n$ = 0.015625
n log 0.5 = 0.015625
n = log 0.5 / 0.015625 n = 6
Calculation of the half-life:
24 days divided by 6 half-lives equals 4.00 days

Q10. A radioactive isotope decayed to 17/32 of its original mass after 60 minutes. Find the half-life of this radioisotope.

Answer. The amount that remains
17/32 = 0.53125
$(1/2)^n$ = 0.53125
n log 0.5 = log 0.53125
n = 0.91254
Half-lives that have elapsed are therefore, n = 0.9125
60 minutes divided by 0.91254 equals 65.75 minutes.

Therefore, n = 66 minutes

Q11. How long will it take for a 40 gram sample of I-131 (half-life = 8.040 days) to decay to 1/100 of its original mass?

Answer. $(1/2)^n = 0.01$
n log 0.5 = log 0.01
n = 6.64
6.64 x 8.040 days = 53.4 days
Therefore, it will take 53.4 days to decay to 1/100 of its original mass.

Q12. At time zero, there are 10.0 grams of W-187. If the half-life is 23.9 hours, how much will be present at the end of one day? Two days? Seven days?

Answer.
24.0 hr / 23.9 hr/half-life = 1.0042 half-lives
One day = one half-life; $(1/2)^{1.0042}$ = 0.4985465 remaining = 4.98 g
Two days = two half-lives; $(1/2)^{2.0084}$ = 0.2485486 remaining = 2.48 g
Seven days = 7 half-lives; $(1/2)^{7.0234}$ = 0.0076549 remaining = 0.0765 g

Q13. 100.0 grams of an isotope with a half-life of 36.0 hours is present at time zero. How much time will have elapsed when 5.00 grams remains?

Answer.
The afraction amount remaining will be-
5.00 / 100.0 = 0.05
$(1/2)^n = 0.05$
n log 0.5 = log 0.05
n = 4.32 half-lives
36.0 hours x 4.32 = 155.6 hours

Q14. How much time will be required for a sample of H-3 to lose 75% of its radioactivity? The half-life of tritium is 12.26 years.

Answer.
If you lose 75%, then 25% remains.
$(1/2)^n = 0.25$

n = 2 (Since, $(1/2)^2$ = 1/4 and 1/4 = 0.25)
12.26 x 2 = 24.52 years

Therefore, 24.52 years of time will be required for a sample of H-3 to lose 75% of its radioactivity

Q15. The half-life for the radioactive decay of ^{14}C is 5730 years. An archaeological artifact containing wood had only 80% of the ^{14}C found in a living tree. Estimate the age of the sample.

Answer. Decay constant, k = 0.693/$t_{1/2}$ = 0.693/5730 years = 1/209 × 10^{-4}/year

$$t = \frac{2.303}{k} log\frac{[R]_0}{[R]}$$

$$t = \frac{2.303}{1.209 \times 10^{-4}} log\frac{100}{80}$$

= 1846 years (approx)

Practise Questions on Half-Life

Q1. A newly prepared radioactive nuclide has a decay constant λ of 10^{-6} s^{-1}. What is the approximate half-life of the nuclide?

a.) 1 hour
b.) 1-day
c.) 1 week
d.) 1 month

Correct Answer- (c.) 1 week
Explanation- $t_{1/2}$ = ln2/λ = 693147.18 s
693147.18/3600 hours = 192 hours
192 hours/ 24= 8.02 days which is nearly 1 week.

Q2. If the decay constant of a radioactive nuclide is 6.93 x 10^{-3} sec^{-1}, its half-life in minutes is:

a.) 100
b.) 1.67
c.) 6.93
d.) 50

Correct Answer - (b.) 1.67

Q3. A first-order reaction takes 40 min for 30% decomposition. Calculate $t_{1/2}$.

Answer. Let a be the initial concentration. After 40 minutes, the concentration is -30a/100 = 0.70 a.

$$k = \frac{2.303}{t} log\frac{[A]_0}{[A]}$$

$$k = \frac{2.303}{40} log \frac{a}{0.70a}$$
K = 8.92×10^{-3}/min
The half life period, $t_{1/2}$ = 0.0693/k
$$= \frac{0.693}{8.92 \times 10^{-3}/min} = 77.7min$$

Q4. What will be the time for 50% completion of a first-order reaction if it takes 72 min for 75% completion?

Answer.
For a first order reaction, the ratio of $t_{0.75}$:$t_{0.5}$ = 2
It is unaffected by the initial concentration.
$t_{0.75}$ = 72 min.
Hence, $t_{0.5}$ = 72/2 = 36 min.
Therefore, it will take 36 minutes for the completion of 50% of the first-order reaction.

Q5. How much time will it take for 90% completion of a reaction if 80% of a first-order reaction was completed in 70 min?

Answer. Using the relation-
$$k = \frac{2.303}{t} log \frac{a}{a-x}$$
The time required for a 90% reaction can be calculated using K.
We can solve the above equation by substituting values into it.
$$k = \frac{2.303}{70} log \frac{1}{0.2} = 0.023$$
We can now calculate the time using the same equation as before, but this time for 90% completion.
$$t = \frac{2.303}{0.023} log \frac{1}{0.1} = 100min$$
It would take 100 minutes for 90% completion of a reaction if 80% of a first-order reaction was completed in 70 min.