CHEM1901/3 Worksheet 2 – Answers to Critical Thinking Questions

The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

Model 1: Calculating radioactive decay

1. N is the number of nuclei, t is the time and λ is the decay constant. $N_{(t)}$ is the number of nuclei at time t and $N_{(0)}$ is the number of nuclei at time $t = 0$.

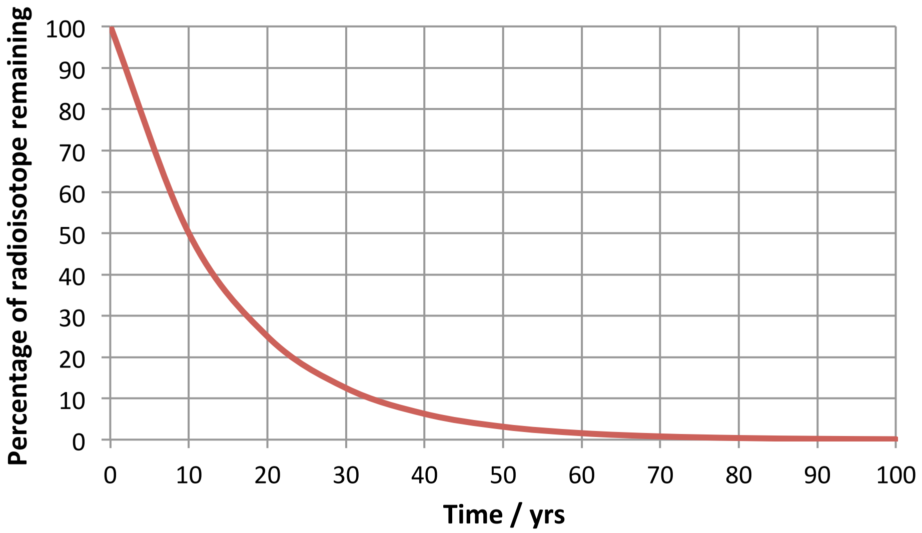
   The SI unit for time is seconds (s) and the SI unit for the decay constant is inverse seconds (s^{-1}).

Model 2: Calculating half life, $t_{1/2}$

1. When $t = t_{1/2}$, $N(t_{1/2}) = 0.5 \times N_{(0)}$:

$$0.5N_{(0)} = N_{(0)}e^{-\lambda t_{1/2}}$$
$$0.5 = e^{-\lambda t_{1/2}}$$
$$\ln(0.5) = -\lambda t_{1/2}$$
$$\ln(2) = +\lambda t_{1/2}$$
$$t_{1/2} = \ln(2) / \lambda$$

2. $t_{1/2}$ is the half life. It is the time taken the number of nuclei to halve. The SI unit for time is seconds (s). λ is the decay constant. The SI unit for the decay constant is inverse seconds (s^{-1}).
3. See below.



Model 3: Calculating activity

1. λ is the decay constant and has SI units of inverse seconds (s^{-1}). N is the number of nuclei. A is the activity and is the number of disintegration per seconds. It has units of disintegration s^{-1} or Bq.
2. Avogadro's constant.
3. 5.37×10^{12} Bq
4. $\lambda = 2.6 \times 10^{-6}\ s^{-1}$ and $t_{1/2} = 2.6 \times 10^{5}$ s

Model 4: Carbon-14 Dating

1. 6330 years before 1950
2. 120 years
3. 99 Bq

Model 5: Working in SI units

1. 4.4 days (using the approximation that the amount of ^{37}Ar does not change significantly).
   4.5 days (allowing for the small decrease in the amount of ^{37}Ar over this period).

Challenge Question – Simultaneous decay

Equation:

$$\frac{\mathrm{d}N_{\mathrm{Ar}}}{\mathrm{d}t} = +\lambda_{\mathrm{K}}N_{\mathrm{K}} - \lambda_{\mathrm{Ar}}N_{\mathrm{Ar}}$$

Explanation:

The first decay route leads to an *increase* in the amount of ^{37}Ar and this is shown by the positive sign. The rate of this increase is equal to the decay constant for ^{37}K multiplied by the amount of ^{37}K left.

The second decay route to a *decrease* in the amount of ^{37}Ar and this is shown by the negative sign. The rate of this decrease is equal to the decay constant for ^{37}Ar multiplied by the amount of ^{37}Ar present.

The decay constant for the second process is much slower than for the first process. The amount of ^{37}Ar grows initially as it is made *much* faster than it decays. As the amount of ^{37}K left decreases, the rate of formation of ^{37}Ar slows until it is comparable to the slow rate of its decay. At this stage, there is little overall change and the graph is level. Once all of the ^{37}K has gone, there is exponential loss of ^{37}Ar.