Worksheet 2 – Answers to Critical Thinking Questions

Model 1: Radioactive Decay

1.

	change in number of neutrons (*N*)	change in number of protons (*Z*)
(a)	*reduced by 2*	*reduced by 2*
(b)	*reduced by 1*	*increased by 1*
(c)	*increased by 1*	*reduced by 1*
(d)	*increased by 1*	*reduced by 1*
(e)	*reduced by 1*	*unchanged*
(f)	*unchanged*	*unchanged*

2.
(a) $^{234}_{90}Th$
(b) $^{14}_{7}N$
(c) $^{11}_{5}B$
(d) $^{55}_{25}Mn$
(e) $^{12}_{4}Be$
(f) $^{99}_{43}Tc$

3.

	type of decay	change in mass number	change in *N* / *Z*
(a)	α decay	reduced by 4	(small) increase
(b)	β^- decay	no change	reduced
(c)	β^+ decay	no change	increased
(d)	electron capture	no change	increased
(e)	neutron emission	reduced by 1	reduced
(f)	γ decay	no change	no change

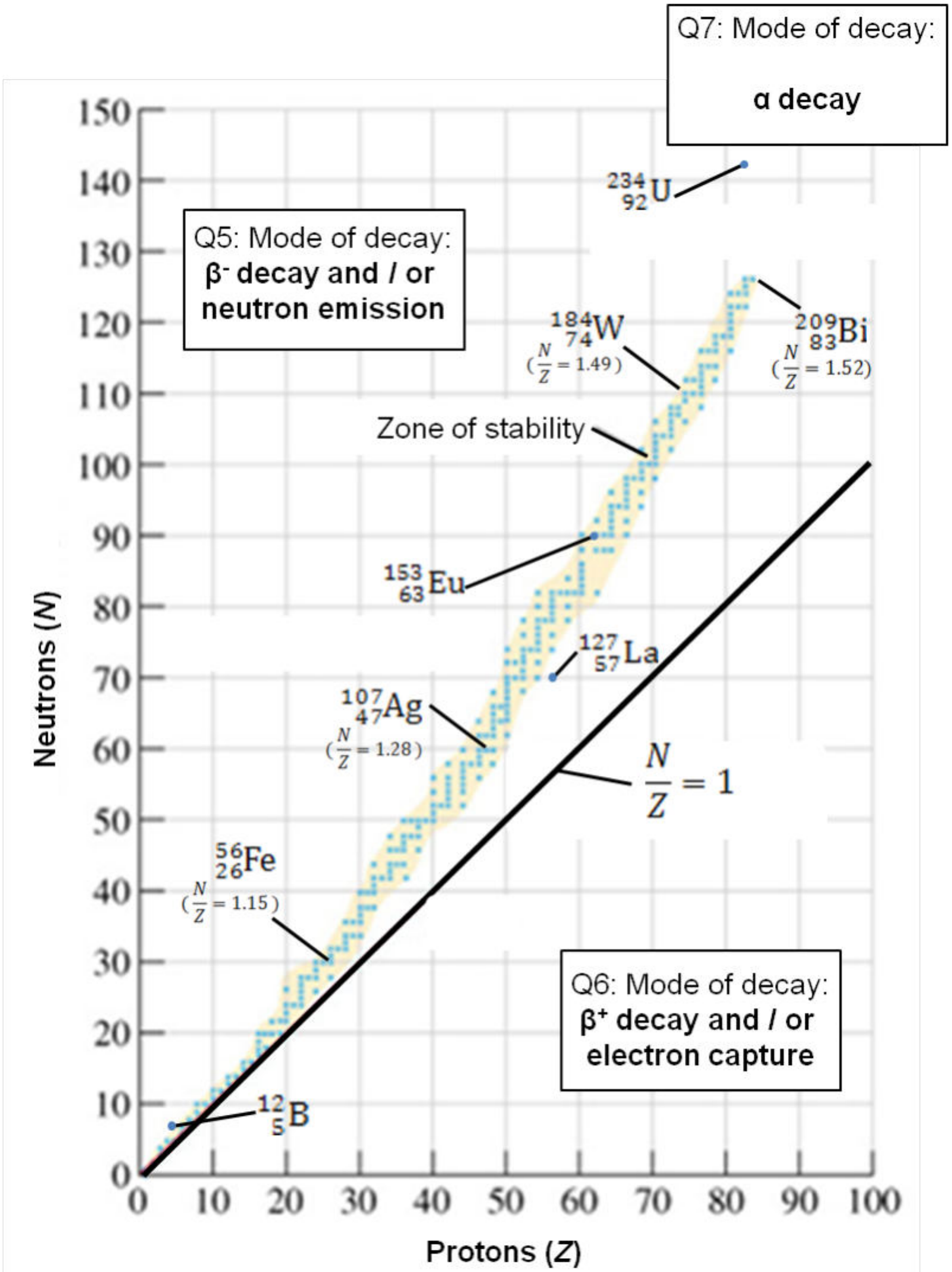
Model 2: Predicting the Mode of Decay

4. $^{31}_{15}P$ has $N = (31 – 15) = 16$ and $Z = 15$. For this nuclide, $N / Z = 1.1$.
$^{30}_{15}P$ has $N = (30 – 15) = 15$ and $Z = 15$. For this nuclide, $N / Z = 1.0$.
After $Z = 10$, the N / Z ratio needs to exceed 1. The extra neutron is needed to stabilize the nucleus.

5. β^- decay and/or neutron emission

6. β^+ decay and/or electron capture.

7. α decay.



8. Sketch each of the following nuclides on figure 1, calculate their *N* / *Z* ratios and hence predict their stability. For the unstable (radioactive) nuclides, predict the mode(s) of nuclear decay they are likely to undergo

(a) $^{12}_{5}B$ has $N / Z = 7 / 5 = 1.4$. As this ratio is too high for this region, it will probably undergo β^- decay.

(b) $^{153}_{63}Eu$ has $N / Z = 90 / 63 = 1.43$ which fits into the stability region (no decay).

(c) $^{234}_{92}U$ has $N / Z = 142 / 92 = 1.5$. As $Z > 83$, it is too heavy to lie within the band and will probably undergo α decay to decrease its total mass.

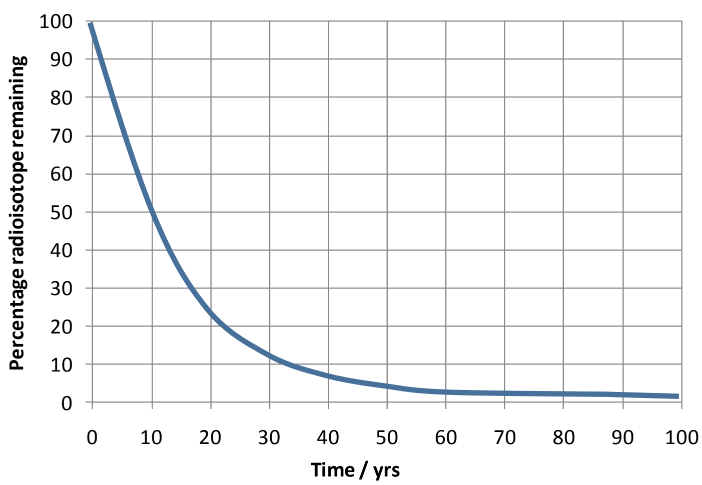
(d) $^{127}_{57}La$ has $N / Z = 70 / 57 = 1.2$. As this ratio is too low for this region, it will probably undergo either β^+ emission or electron capture (or both).

Model 3: Calculating radioactive decay and half life, $t_{1/2}$ and activity

9. N is the number of nuclei, t is the time and k 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})

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

11.



12. *$t_{1/2} = \ln 2/(1.0 \times 10^{-6}\ s^{-1}) = 6.9 \times 10^{5} s = 8.0$ days*

13. k 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.

14. Avogadro's number

15. 10.0 mg $^{201}Tl = 4.975 \times 10^{-5}$ mol $= 3.00 \times 10^{19}$ nuclei
$k = A/N = 7.9 \times 10^{13} / 3.00 \times 10^{19} = 2.6 \times 10^{-6}\ s^{-1}$
$t_{1/2} = \ln 2/k = \ln 2/2.6 \times 10^{-6} = 2.6 \times 10^{5}$ s