

FISPACT-II Extended exercises: answers

Thomas Stainer, Mark Gilbert, Greg Bailey, Andrew Davis
UKAEA

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1 Waste Classification with FISPACT-II : Answers

1. Question 1

- (a) 250 years. $\alpha = 0.0$ Bq/kg $\beta + \gamma = 10052494.699$ Bq/kg
- (b) 75 years. $\alpha = 0.0$ Bq/kg $\beta + \gamma = 31805804.449$ Bq/kg
- (c) For nuclides:
 - ^{60}Co 5 years
 - ^{99}Tc 1 year
 - ^{55}Fe 20 years
- (d) ^{99}Tc , ^{93}Zr , ^{10}Be , ^{93m}Nb , ^{91}Nb , ^{92}Nb , ^{94}Nb . 6 nuclides.

2. Question 2

- (a) Total activity higher than previously but only affects Spain's time frame.
 - UK: 250 years, $\beta + \gamma = 9965133.014$ Bq/kg
 - Spain : 50 years, $\beta + \gamma = 34891945.151$ Bq/kg
- (b) The nuclides difference shown in the table. What is possibly surpris-

Nuclide	Comp 1	Comp 2	$\Delta_{activity}$
^{14}C	961408.86	1009330.88	47922.02
^{94}Nb	7369.79	7472.74	102.95
^{63}Ni	1462125.03	23219040.96	21756915.92

ing is that the nuclides whose percentage amounts did not change show large changes in activity. This will be explored in the pathways exercises.

- (c) Carbon-14 as risen in prominence now second dominant. Several Sn isotopes are now present.

- 500 years for β activity to be 100 times UK $\beta + \gamma$ limit
- For nuclides:
 - ^{60}Co 50 years
 - ^{99}Tc Never meets limit
 - ^{55}Fe 50 years
- ^{14}C activity = 368587749.48 Bq/kg, approximate increase of 3.67×10^8 .
Its long half-life allows it to persist.
- Unlikely, impossible.

1. Question 1

- (a) $62 - 5 = 57$
(b) $\bullet 3$

Target nuclide Fe 59 100.000% of inventory given by 3 paths

path 1 2.714% Ni 58 ---(R)--- Co 58 ---(b)--- Fe 58 ---(R)--- Fe 59 ---(S)-
100.00%(n,p) 99.89%(b+) 100.00%(n,g)
0.11%(n,p)

path	2	1.815% Ni 58 ---(R)---	Co 58m---(b)---	Co 58 ---(b)---	Fe 58 ---(R)---
		100.00%(n,p)	100.00%(IT)	99.89%(b+)	100.00%(n,g)
			0.00%(n,E)	0.11%(n,p)	
			0.00%(n,n)		

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path 3 95.736% Ni 62 --- (R) --- Fe 59 --- (S) ---
      100.00% (n,a)
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- Pathway 1

Target nuclide Co 60 99.272% of inventory given by 2 paths

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path 1 60.552% Ni 60 --- (R) --- Co 60m --- (b) --- Co 60 --- (L) ---
      100.00%(n,p)      100.00%(IT)
                        0.00%(n,E)
                        0.00%(n,n)

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```
path  2  38.720% Ni 60 ---(R)--- Co 60 ---(L)---
      100.00%(n,p)
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2

	Quantity	Dominant	Reaction	Parent
	Activity	^{55}Cr	(n, γ)	^{54}Cr
(a)	Dose Rate	^{52}V	(n, p)	^{52}Cr
	Ingestion	^{56}Mn	(n, p)	^{56}Fe
	Inhalation	^{62}Co	(n, p)	^{62}Ni

(b) Total number of ^{55}Fe atoms = 1.22199×10^{14}

- 1.082×10^{14} atoms
- 1.361×10^{13} atoms
- 3.89×10^{11} atoms

3. Question 3

(a) Added additional pathway, 3.081% created via $^{64}\text{Ni}(n, \alpha)^{61}\text{Fe}$ then β^- decay to ^{61}Co .

(b) ^{52}Cr is used to create:

- 99.547% of ^{52}V via $^{52}\text{Cr}(n, p)^{52}\text{V}$
- 1.557% of ^{51}Cr via $^{52}\text{Cr}(n, 2n)^{51}\text{Cr}$

3 Self-shielding with FISPACT-II : Answers

1. Question 1

- After 10 years, there will be approximately 3.5 atomic % Re, and 1.4 atm.% Os in the material, with W almost all of the remainder.

2. Question 2

- With self-shielding included, the amount of Re after 10 years should fall to around 2.4 atm.%, while Osmium will be under 1 atm.%.

3. Question 3

- Estimating the secondary self-shielding factors for Re using the final composition from part 2 (SSFCHOOSE with W, Re, and Os) and re-running will not alter the final concentration of W, but the Re concentration should increase by around 0.1-0.2 atm.%, while Osmium should decrease.

These concentrations are small, but the performance of tungsten (particularly its thermal conductivity) could be significantly altered even at these percentages, and so accurate predictions will have engineering relevance.