# $^{186}_{75}\mathrm{Re}_{111}$

## 1 Decay Scheme

Re-186 decays by beta minus emissions mainly to the fundamental and the 137 keV excited levels of Os-186 and by electron capture to the W-186.
*Le rhénium 186 se désintègre par émission bêta moins principalement vers le niveau fondamental et le niveau excité de 137 keV de l'osmium 186 ; et par capture électronique vers le niveau fondamental et vers le niveau excité de 122 keV du tungstène 186.*

## 2 Nuclear Data

| | | | | |
|---|---|---|---|---|
| $T_{1/2}(^{186}\mathrm{Re})$ | : | 3,7186 | (17) | d |
| $Q^-(^{186}\mathrm{Re})$ | : | 1069,5 | (9) | keV |
| $Q^+(^{186}\mathrm{Re})$ | : | 581,6 | (17) | keV |

### 2.1 Electron Capture Transitions

| | Energy keV | Probability × 100 | Nature | lg $ft$ | $P_K$ | $P_L$ | $P_M$ |
|---|---|---|---|---|---|---|---|
| $\epsilon_{0,1}$ | 459,3 (17) | 1,69 (3) | 1st Forbidden | 7,8 | 0,7836 (19) | 0,1638 (13) | 0,0404 (8) |
| $\epsilon_{0,0}$ | 581,6 (17) | 5,84 (12) | 1st Forbidden | 7,5 | 0,7943 (18) | 0,1560 (12) | 0,0382 (7) |

### 2.2 $\beta^-$ Transitions

| | Energy keV | Probability × 100 | Nature | lg $ft$ |
|---|---|---|---|---|
| $\beta^-_{0,4}$ | 159,0 (9) | 0,000027 (9) | unique 1st forbidden | 10,9 |
| $\beta^-_{0,3}$ | 302,0 (9) | 0,0627 (9) | 1st Forbidden | 8,9 |
| $\beta^-_{0,1}$ | 932,3 (9) | 21,5 (3) | 1st Forbidden | 8 |
| $\beta^-_{0,0}$ | 1069,5 (9) | 70,9 (3) | 1st Forbidden | 7,7 |

### 2.3 Gamma Transitions and Internal Conversion Coefficients

| | Energy keV | $P_{\gamma+ce}$ × 100 | Multipolarity | $\alpha_K$ | $\alpha_L$ | $\alpha_M$ | $\alpha_T$ |
|---|---|---|---|---|---|---|---|
| $\gamma_{1,0}$(W) | 122,33 (10) | 1,694 (29) | E2 | 0,585 (12) | 0,927 (19) | 0,234 (7) | 1,81 (4) |
| $\gamma_{1,0}$(Os) | 137,157 (8) | 21,57 (39) | E2 | 0,433 (13) | 0,645 (19) | 0,1648 (49) | 1,290 (39) |
| $\gamma_{4,3}$(Os) | 143,000 (42) | 0,0000021 (7) | M1+E2 | 1,39 (8) | 0,35 (2) | 0,0842 (25) | 1,85 (11) |
| $\gamma_{2,1}$(Os) | 296,933 (31) | 0,000058 (16) | E2 | 0,0609 (12) | 0,0260 (6) | 0,00645 (19) | 0,095 (2) |
| $\gamma_{3,2}$(Os) | 333,390 (42) | 0,000066 (16) | [E2] | 0,0454 (14) | 0,0170 (5) | 0,00418 (13) | 0,0678 (20) |
| $\gamma_{4,2}$(Os) | 476,390 (42) | 0,0000015 (5) | E2+M1 | 0,0193 (6) | 0,00512 (15) | 0,001235 (37) | 0,0259 (8) |
| $\gamma_{3,1}$(Os) | 630,323 (31) | 0,0297 (6) | M1+E2 | 0,0105 (6) | 0,0023 (2) | 0,000538 (16) | 0,0134 (1) |
| $\gamma_{3,0}$(Os) | 767,48 (3) | 0,0330 (6) | E2 | 0,00690 (21) | 0,001342 (40) | 0,000315 (9) | 0,00865 (26) |
| $\gamma_{4,1}$(Os) | 773,323 (31) | 0,000023 (7) | E2+M1 | 0,0189 (6) | 0,00291 (9) | | 0,0266 (7) |

## 3 Atomic Data

### 3.1 W

$\omega_K$ : 0,954 (4)
$\bar{\omega}_L$ : 0,283 (11)
$n_{KL}$ : 0,825 (4)

#### 3.1.1 X Radiations

| | | Energy keV | | Relative probability |
|---|---|---|---|---|
| $X_K$ | | | | |
| | $K\alpha_2$ | 57,9823 | | 57,57 |
| | $K\alpha_1$ | 59,3189 | | 100 |
| | $K\beta_3$ | 66,952 | } | |
| | $K\beta_1$ | 67,2451 | } | |
| | $K\beta''_5$ | 67,664 | } | 33,15 |
| | $K\beta_2$ | 69,033 | } | |
| | $K\beta_4$ | 69,295 | } | 9,08 |
| | $KO_{2,3}$ | 69,484 | } | |
| $X_L$ | | | | |
| | $L\ell$ | 7,38 | | |
| | $L\gamma$ | – 12,07 | | |

### 3.1.2 Auger Electrons

| | Energy keV | Relative probability |
|---|---|---|
| Auger K | | |
| KLL | 45,109 – 48,882 | 100 |
| KLX | 54,514 – 59,312 | 53,7 |
| KXY | 63,89 – 69,51 | 7,18 |
| Auger L | 4,5 – 12,1 | 27,6 |

## 3.2 Os

$\omega_K$ : 0,957 (4)
$\bar{\omega}_L$ : 0,308 (12)
$n_{KL}$ : 0,821 (4)

### 3.2.1 X Radiations

| | | Energy keV | | Relative probability |
|---|---|---|---|---|
| $X_K$ | | | | |
| | $K\alpha_2$ | 61,4873 | | 58,03 |
| | $K\alpha_1$ | 63,0011 | | 100 |
| | $K\beta_3$ | 71,078 | } | |
| | $K\beta_1$ | 71,414 | } | |
| | $K\beta_5''$ | 71,855 | } | 33,46 |
| | $K\beta_2$ | 73,319 | } | |
| | $K\beta_4$ | 73,615 | } | 9,37 |
| | $KO_{2,3}$ | 73,819 | } | |
| $X_L$ | | | | |
| | $L\ell$ | 7,82 | | |
| | $L\gamma$ | – 12,92 | | |

### 3.2.2 Auger Electrons

| | Energy keV | Relative probability |
|---|---|---|
| Auger K | | |
| KLL | 47,710 – 51,892 | 100 |
| KLX | 57,759 – 62,955 | 54,2 |
| KXY | 67,77 – 73,78 | 7,34 |
| Auger L | 4,7 – 12,9 | 60 |

## 4 Electron Emissions

| | | Energy keV | Electrons per 100 disint. |
|---|---|---|---|
| $e_{AL}$ | (W) | 4,5 - 12,1 | 4,11 (4) |
| $e_{AK}$ | (W) | | 0,291 (26) |
| | KLL | 45,109 - 48,882 | } |
| | KLX | 54,514 - 59,312 | } |
| | KXY | 63,89 - 69,51 | } |
| $e_{AL}$ | (Os) | 4,7 - 12,9 | 6,43 (8) |
| $e_{AK}$ | (Os) | | 0,175 (18) |
| | KLL | 47,710 - 51,892 | } |
| | KLX | 57,759 - 62,955 | } |
| | KXY | 67,77 - 73,78 | } |
| $ec_{1,0\ K}$ | (W) | 52,8 (1) | 0,353 (8) |
| $ec_{1,0\ T}$ | (Os) | 63,29 - 137,11 | 12,15 (38) |
| $ec_{1,0\ K}$ | (Os) | 63,29 (1) | 4,08 (13) |
| $ec_{1,0\ L}$ | (W) | 110,23 - 112,12 | 0,559 (13) |
| $ec_{1,0\ M}$ | (W) | 119,51 - 120,52 | 0,1411 (44) |
| $ec_{1,0\ L}$ | (Os) | 124,19 - 126,29 | 6,08 (18) |
| $ec_{1,0\ M}$ | (Os) | 134,11 - 135,20 | 1,552 (47) |
| $ec_{1,0\ N}$ | (Os) | 136,5 - 137,1 | 0,381 (12) |
| $\beta^-_{0,4}$ | max: | 159,0 (9) | 0,000027 (9) |
| $\beta^-_{0,4}$ | avg: | 42,6 (7) | |
| $\beta^-_{0,3}$ | max: | 302,0 (9) | 0,0627 (9) |
| $\beta^-_{0,3}$ | avg: | 84,7 (7) | |
| $\beta^-_{0,1}$ | max: | 932,3 (9) | 21,5 (3) |
| $\beta^-_{0,1}$ | avg: | 306,7 (7) | |
| $\beta^-_{0,0}$ | max: | 1069,5 (9) | 70,9 (3) |
| $\beta^-_{0,0}$ | avg: | 359,6 (7) | |

# 5 Photon Emissions

## 5.1 X-Ray Emissions

| | | Energy keV | | Photons per 100 disint. | |
|---|---|---|---|---|---|
| XL | (W) | 7,38 — 12,07 | | 1,66 (4) | |
| XK$\alpha_2$ | (W) | 57,9823 | | 1,736 (30) | } K$\alpha$ |
| XK$\alpha_1$ | (W) | 59,3189 | | 3,02 (5) | } |
| XK$\beta_3$ | (W) | 66,952 | } | | |
| XK$\beta_1$ | (W) | 67,2451 | } | 1,000 (23) | K$'\beta_1$ |
| XK$\beta''_5$ | (W) | 67,664 | } | | |
| XK$\beta_2$ | (W) | 69,033 | } | | |
| XK$\beta_4$ | (W) | 69,295 | } | 0,274 (8) | K$'\beta_2$ |
| XKO$_{2,3}$ | (W) | 69,484 | } | | |
| XL | (Os) | 7,82 — 12,92 | | 2,99 (7) | |
| XK$\alpha_2$ | (Os) | 61,4873 | | 1,13 (4) | } K$\alpha$ |
| XK$\alpha_1$ | (Os) | 63,0011 | | 1,94 (6) | } |
| XK$\beta_3$ | (Os) | 71,078 | } | | |
| XK$\beta_1$ | (Os) | 71,414 | } | 0,650 (23) | K$'\beta_1$ |
| XK$\beta''_5$ | (Os) | 71,855 | } | | |
| XK$\beta_2$ | (Os) | 73,319 | } | | |
| XK$\beta_4$ | (Os) | 73,615 | } | 0,182 (8) | K$'\beta_2$ |
| XKO$_{2,3}$ | (Os) | 73,819 | } | | |

## 5.2 Gamma Emissions

| | Energy keV | Photons per 100 disint. |
|---|---|---|
| $\gamma_{1,0}$(W) | 122,33 (10) | 0,603 (6) |
| $\gamma_{1,0}$(Os) | 137,157 (8) | 9,42 (6) |
| $\gamma_{4,3}$(Os) | 143,00 (4) | 0,00000074 (25) |
| $\gamma_{2,1}$(Os) | 296,93 (3) | 0,000053 (15) |
| $\gamma_{3,2}$(Os) | 333,39 (4) | 0,000062 (15) |
| $\gamma_{4,2}$(Os) | 476,39 (4) | 0,0000015 (5) |
| $\gamma_{3,1}$(Os) | 630,32 (3) | 0,0293 (6) |
| $\gamma_{3,0}$(Os) | 767,478 (30) | 0,0327 (6) |
| $\gamma_{4,1}$(Os) | 773,32 (3) | 0,000022 (7) |

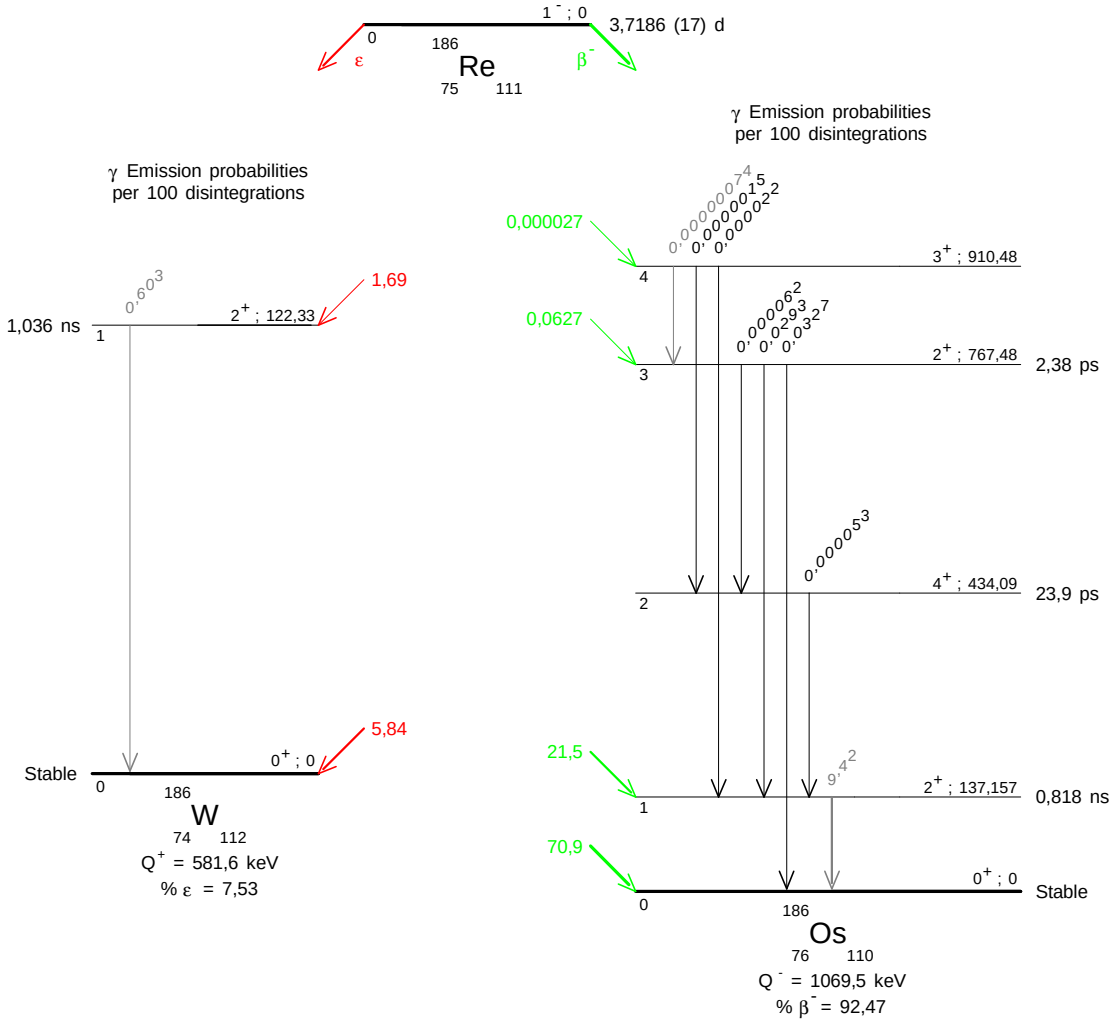
## 6 Main Production Modes

$\left\{ \begin{array}{l} \mathrm{Re-185(n,\gamma)Re-186} \qquad \sigma : 112\ (3)\ \text{barns} \\ \text{Possible impurities :}\ \ \mathrm{Re-186m,\ Re-188,\ Re-188m} \end{array} \right.$

## 7 References


- K.Sinma, H.Yamasaki. Phys. Rev. 55 (1939) 320
  (Half-life)
- K.Fajans, W.H.Sullivan. Phys. Rev. 58 (1940) 276
  (Half-life)
- J.M.Cork, R.G.Shreffer, C.M.Fowler. Phys. Rev. 74 (1940) 1657
  (Half-life)
- H.Yamasaki, K.Sinma. Sci. Pap. Inst. Phys. Chem. Res. 37 (1940) 10
  (Half-life)
- P.J.Grant, R.Richmond. Proc. Phys. Soc. 62A (1945) 573
  (Half-life)
- L.J.Goodman, M.L.Pool. Phys. Rev. 71 (1947) 288
  (Half-life)
- A.T.Dybvig, M.L.Pool. Phys. Rev. 80 (1950) 126
  (Half-life)
- T.C.Chu. Phys. Rev. 79 (1950) 582
  (Half-life)
- D.Guss, L.Killion, F.T.Porter. Phys. Rev. 95 (1954) 627
  (Gamma ray energies, lg ft)
- F.T.Porter, M.S.Freedman, T.B.Novey, F.Wagner Jr. Phys. Rev. 103 (1956) 921
  (Gamma ray energies,Beta emission probabilities)
- T.B.Novey, M.S.Freedman, F.T.Porter, F.Wagner Jr. Phys. Rev. 103 (1956) 942
  (Beta emission probabilities, Gamma ray energies,angular correlation)
- M.W.Johns, C.C.MacMullen, I.R.Williams, S.V.Nablo. Can. J. Phys. 34 (1956) 69
  (Beta emission probabilities)
- E.L.Chupp, A.F.Clark, J.W.M.Dumond, F.J.Gordon, H.Mark. Phys. Rev. 107 (1957) 745
  (Gamma ray energies)
- G.Gueben, J.Govaerts. Monographie Nr.2, Inst. Inter univ. Sciences Nucleaires (1958)
  (Half-life)
- G.T.Emery, W.R.Kane, M.MacKeown, M.L.Perlman, G.Scharff-Goldhaber. Phys. Rev. 129 (1963) 2597
  (Gamma ray energies, Gamma-ray emission probabilities)
- I.Marklund, B.Lindström. Nucl. Phys. 40 (1963) 329
  (Gamma ray energies)
- L.Maly, Z.Plajner, J.Jursik, M.Finger. Czech. J. Phys. B14 (1964) 240
  (Gamma-ray emission probabilities, Gamma ray energies, Beta emission energies, Beta emission probabilities, Conv. Elec. emission probabilities)
- B.Harmatz, T.H.Handley. Nucl. Phys. 56 (1964) 1
  (Gamma ray energies)
- J.D.Kurfess, R.P.Scharenberg. Phys. Rev. 161 (1967) 1185
  (Half-life, of the 122 keV level)
- J.O.Newton, F.S.Stephens, R.M.Diamond, K.Kotajima, E.Matthias. Nucl. Phys. A95 (1967) 357
  (Gamma ray energies)
- J.A.Bearden. Rev. Mod. Phys. 39 (1967) 78
  (Gamma ray energies)
- K.V.R.Rao, P.Jagam, A.R., D.L.Sastry. Nuclear Physics and Solid StatePhysics Symposium (1969)
  (anagular correlation, decay scheme)
- S.Andre, P.Liaud. Comp. Rend. Acad. Sci. (Paris) 268 (1969) 270
  (Beta emission energies)
- S.Andre, P.Liaud. J. Phys. 31 (1970) 155
  (Beta emission energies)

- M.Trudel, E.E.Habib, H.Ogata. Phys. Rev. C1 (1970) 643
  (Beta emission energies)
- R.Michel, U.Herpers. Radiochim. Acta 16 (1971) 115
  (Half-life)
- K.V.Ramana Rao, V.Lakshminarayana. Current Science-Bangalore, India 40 (1971) 1
  (K X-ray emission probabilities, K X-ray energies, angular correlation)
- D.W.Seegmiller, M.Lindner, R.A.Meyer. Nucl. Phys. A185 (1972) 94
  (Gamma-ray emission probabilities, Conv. Elec. emission probabilities)
- B.Fogelberg. Nucl. Phys. A197 (1972) 497
  (Gamma ray energies, Gamma-ray emission probabilities)
- B.N.Subba Rao. Proceedings of the Nuclear Physics and Solid State Symposium, Bombay (1972) 1344
  (Conv. Elec. emission probabilities)
- H.Karwowski, S.Majewski, B.Pietrzyk, L.Wencel, J.Jastrzebski. J. Phys. 36 (1975) 471
  (Half-life, of the 122 keV level)
- D.Bogdan, Tr.Cretu, H.Fuia, G.Macarie, D.G.Popescu. Bul. Inst. Politehnic Gheorghe Gheorghiu-Dej Bucuresti Seria Electrtehnika (1977) 18
  (Betta decay)
- F.Rösel, H.M.Fries, K.Alder, H.C.Pauli. At. Data. Nucl. Data Tables 21 (1978) 92
  (Conv. Elec. emission probabilities)
- D.Oertel, W.D.Brewer. Phys. Rev. C23 (1981) 2751
  (Betta branches)
- R.B.Firestone. Nucl. Data Sheets 55 (1988) 583
  (levels)
- A.Abzouzi, MS.Antony, V.B.NdockoNdongue. J. Radioanal. Nucl. Chem. 137 (1989) 381
  (Half-life)
- J.Goswami, B.Chand, D.Mehta, N.Singh, P.N.Trehan. Appl. Rad. Isotopes 42 (1991) 1033
  (Gamma-ray emission probabilities)
- B.M.Coursey, J.Cessna, E.Garcia-Torano, D.B.Golas, A.GrauMalonda, D.H.Gray, D.D.Hoppes, J.M.LosArcos, M.T.Martin-Casallo, F.J.Schima, M.P.Unterweger. Appl. Rad. Isotopes 42 (1991) 865
  (Half-life)
- M.P.Unterweger, D.D.Hoppes, F.J.Schima. Nucl. Instrum. Methods Phys. Res. A312 (1992) 349
  (Half-life)
- E.Schönfeld, H.Janssen, U.Schötzig, E.Günther, H.Schrader. Nucl. Instrum. Methods Phys. Res. A339 (1994) 174
  (Gamma-ray emission probabilities, Half-life, Conv. Elec. emission probabilities)
- G.Audi, A.H.Wapstra. Nucl. Phys. A595 (1995) 409
  (Q)
- E.Schönfeld, H.Janssen. Nucl. Instrum. Methods Phys. Res. A369 (1996) 527
  (K fluorescence yield, K X-ray emission probabilities, L vacancies)
- C.M.Baglin. Nucl. Data Sheets 82 (1997) 1
  (Spin and Parity, Half-life, excited levels)
- E.Schönfeld. Appl. Rad. Isotopes 49 (1998) 1353
  (X-ray emission probabilities)
- H.Miyahara, G. Wurdiyanto, H. Nagata, A. Yoshida, K. Yanagida, C. Mori. Appl. Rad. Isotopes 52 (2000) 573
  (Gamma-ray emission probabilities)
- D.H.Woods, M. Ciocanel, L. J. Husband, J. D. Keightley, P. de Lavison, S. Lineham, M. J. Woods, S. A. Woods. Appl. Rad. Isotopes 52 (2000) 581
  (Gamma-ray emission probabilities)
- H.Schrader. Appl. Rad. Isotopes 60, 2-3 (2004) 317
  (Half-life)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β -
γ Emission probabilities
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γ Emission probabilities
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0,000027
0,0627
3+ ; 910,48
2+ ; 767,48
2,38 ps
4+ ; 434,09
23,9 ps
21,5
2+ ; 137,157
0,818 ns
70,9
0+ ; 0
Stable
186
Os
76 110
Q - = 1069,5 keV
% β - = 92,47
1,036 ns
2+ ; 122,33
1,69
5,84
Stable
0+ ; 0
186
W
74 112
Q+ = 581,6 keV
% ε = 7,53