Comments on evaluation of decay data
by M.M. Bé

References can be found in the "Table de Radionucléides" volume, only additional references are given here.
This evaluation was completed in April 1994 with a review done in April 1998, the literature available by March 1998 was taking into account.

1. Decay scheme

An Internal Bremsstrahlung electron capture spectrum was measured by Isaac et al., the intensity was found to be $3.24(6) \times 10^{-5}$ relatively to K capture. 
The $J^\pi$ value and level energy are from NDS 64,4 (1991). From other decay modes, the excited level energy has been determined to be 125,949 (10) keV.

2. Nuclear Data

- The Q value is from Audi and Wapstra (1995)
- The half-life values taking into account are, in days :

  (1) 977.9 2.3 Lagoutine 1982
  (2) 1000.4 1.3 Houtermans 1980
  (3) 1009.0 1.7 Hoppes 1982
  (4) 996.8 6.0 Morel 1994
  (5) 1003.0 3.0 Siegert 1995
  (6) 995.0 3.0 Karmalitsyn 1998

The (1) value is rejected because it is discrepant by Chauvenet’s criteria. With this value deleted none of the other values has a relative weight greater than 50 % ; the relative weights are 49 %, 29 %, 3 %, 9 % and 9 % respectively. The LRSW calculation gives the value of 1003,0 d, with an external uncertainty of 0,9 and a reduced-$\chi^2$ of 6,1.

As the recent measurements of Siegert and Karmalitsyn are supposed to be of comparable accuracy of the older ones, the uncertainty of the (2) and (3) values were increased by a factor of 2, then each of the four values (2), (3), (5) and, (6) have a relative weight comprised between 20 and 30 %.

The weighted average value is then $1001,0 \pm 6$ with a reduced-$\chi^2$ of 2,6 ; LRSW uses the external uncertainty of 2,3.

The adopted value is $1001,0 (23) \pm 2,741 (6) \pm 2$.

T.D. MacMahon calculated the half-life value from the set of the 6 values ;
- by using the Normalised Residuals : 1000,4 (18) d ;
- by using the Rajeval technique : 1000,7 (18) d.

These values are consistent among themselves and also with the adopted value.

Other references not used in this evaluation due to their discrepancy or their great uncertainty comparing with the set of recent values retained :
2.1. Electron Capture transitions

- The EC transition energies are from \( Q(\text{EC}) = 231,38 \) (10) and from the individual level energies.
- The transition probabilities are deduced from the total gamma-ray transition probability balances at each level.
- The electron capture coefficients were calculated by using the EC-capture program:
  \[ P_K = 0,8853 \) (16) ; \( P_L = 0,0983 \) (13) ; \( P_M = 0,0157 \) (6) ; \( P_N = 0,0006 \) (2)
  The LOGFT program gives:
  \[ P_K = 0,885 \) (9) ; \( P_L = 0,0974 \) (10) ; \( P_M = 0,0161 \) (2) ; \( P_N+ = 0,00106 \) (1)
  Measurements were carried out by Pengra et al.:
  \[ P_K = 0,881 \) (4) ; \( P_L = 0,103 \) (4) ; \( P_M+ = 0,0161 \) (8)

Results from calculations and measurements are in good agreement, nevertheless the measured values are dependent on \( \omega_K \) (= 0,314) and on the intensity of the Ka X-ray (= 0,89). So, the recommended values are those of the EC-capture program.
- Several measurements or calculations were done to study the double K-shell ionization process. One can quoted Campbell at al., where the total probability for double vacancies in the K shell was found to be \( 1,3 \) (2) \( 10^{-4} \), or Kitahara et al. where the probability for the ejection of another K electron during the K-capture decay was estimated to be \( 1,01 \) (27) \( 10^{-4} \). As these phenomena have very small probabilities, these results are only quoted here as a matter of interest.

2.2. Gamma transitions

A weak gamma transition is deduced from the observation of a 126 keV gamma emission. The energy is derived from the level energy.

3. Atomic Data

Several data for \( \omega_K \) are deduced from measurements:

- from Smith, \( \omega_K = 0,320 \) (3) (\( P_K = 0,885 \) (2))
- from Konstantinov et al., \( \omega_K = 0,312 \) (3)
- from Dobrilovic et al., \( \omega_K = 0,322 \) (5)
- from Kuhn et al., \( \omega_K = 0,310 \) (23)
- from Hubbell et al., \( \omega_K = 0,321 \) (7) (deduced from photoionization cross-section measurements)

A theoretical value was also calculated by Chen : \( \omega_K = 0,323 \).

These values are in good agreement (except Konstantinov et al. and Kuhn et al.) with the recommended value of \( \omega_K = 0,321 \) (5) from the semi-empirical fit of Bambynek 1984.

\( \omega_L \) and \( \eta_{KL} \) are from Schöpfeld et al.
3.1.1. X Radiations

- The X-ray energies were obtained by conversion of the wavelength values from Bearden into energies with $1 \, \text{Å} = 1,000,014,812 \, 10^{-10} \, \text{m}$.
- The emission intensities are calculated by the EMISSION program from PTB with $\omega_K$, $\omega_L$ and $\eta_{KL}$ quoted above and, $K\beta/K\alpha = 0.1359 (14)$, $K\alpha_2 / K\alpha_1 = 0.5099 (25)$ (Schönfeld et al.).

3.1.2. Auger Electrons

Complete measurements of the K Auger spectrum of manganese was performed by Kovalik et al., they found for the relative intensities of the K Auger groups:

<table>
<thead>
<tr>
<th>Group</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLM/KLL</td>
<td>0.26 (2)</td>
</tr>
<tr>
<td>KMM/KLL</td>
<td>0.018 (2)</td>
</tr>
</tbody>
</table>

These values are in good agreement with the recommended values calculated with the EMISSION program:

<table>
<thead>
<tr>
<th>Group</th>
<th>Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLM/KLL</td>
<td>0.272 (3)</td>
</tr>
<tr>
<td>KMM/KLL</td>
<td>0.0185 (4)</td>
</tr>
</tbody>
</table>

The energies were taken from Larkins or, for the missing lines, calculated from the electron binding energies. Kovalik et al. also measured the energies and found a good agreement for the KLM spectrum but observed discrepancies for the KLL and KMM groups.

4.2. Gamma emissions

A weak gamma emission superimposed on the intense inner-bremsstrahlung was observed by Zlimen et al. and interpreted as the deexcitation of the first excited state of Mn-55. The $\gamma$-ray energy is given as 126.0 (1) keV and the $\gamma$-ray intensity as $1.3 \times 10^{-7}$ %.

From the level energy 125,949 (10) keV and with a recoil energy of 0.2 eV, the retained $\gamma$-ray energy is 125,949 (10) keV.

References

See “Table de Radionucléides” - volume 5, 02-99, ISBN 2 7272 0200 8, DAMRI/LPRI, BP 2, 91193 Gif-sur-Yvette Cedex, France.
The same file can be found on : http://www.bnm.fr/bnm-lnhb/NucData.htm