Disintegration Scheme of Copper-62 and its Relation to Recent Mass Measurements

SEVERAL nuclear data tables[1,2] report the existence of a 0·56-MeV. γ-ray in the disintegration scheme of the positron-emitting isotope copper-62, the evidence advanced being an unpublished absorption measurement. We have lately had occasion to examine the spectrum of γ-rays emitted by copper-62, and have failed to find any evidence to confirm the existence of such a γ-ray.

A sheet of copper 3 in. × 4 in. × $\frac{1}{4}$ in. was irradiated with X-rays from a 23-MeV. synchrotron. Copper-62 was produced by (γ,n) reactions. This source was then placed 2 cm. from the end of a large cylindrical sodium iodide crystal 1$\frac{3}{4}$ in. in diameter and 2 in. long, which was mounted on a DuMont type 6292 photomultiplier. This crystal was large enough for secondary quanta from Compton collisions and photoelectric absorption processes occurring in its interior to have an appreciable probability of being themselves absorbed. A copper absorber $\frac{1}{4}$ in. thick was placed in front of the source to prevent positrons reaching the crystal. The output pulses were amplified and fed into a 100-channel amplitude analyser.

The resulting spectrum showed a single well-defined 'total capture' peak and Compton edge from the annihilation quanta superposed on the usual crystal background. The width of the peak at half-height was 14 per cent, that is, 0·066 MeV. No other peaks were observed in the channels corresponding to 0·6–1·2 MeV. We estimate, having regard to the background, that a peak containing 0·25 per cent of the counts in the total capture peak and of comparable width would have been detected.

The simultaneous absorption by the crystal of a 0·56-MeV. γ-ray and an annihilation quantum would have produced a 'coincidence' peak in the vicinity of 1 MeV. From the above upper limit to the detectable peak, and from the efficiency of crystal detection and solid angle subtended at the source, it follows that not more than 5 per cent of the positrons can be in coincidence with a 0·56-MeV. γ-ray.

Further, the absence of a peak in the observed spectrum in the range 0·6–1·2 MeV. means that there is no evidence for a γ-ray in the range 0·1–1·2 MeV., since γ-rays in the range 0·1–0·7 MeV. would have produced a 'coincidence' peak between 0·6 and 1·2 MeV., while γ-rays of energy between 0·6 and 1·2 MeV. would have produced the usual total-capture peak in the range 0·6–1·2 MeV. The upper limit of intensity allowed by our observations for a γ-ray in coincidence with the positrons is 5 per cent of the total number of disintegrations. No evidence exists that there is a γ-ray of energy greater than 1·2 MeV., and we conclude that there is no γ-ray in coincidence with the positrons. The total release of energy in the copper-62 disintegration can therefore be obtained from the maximum energy of the positron spectrum[3,4] and is 3·88 ± 0·1 MeV.

The spectrum of copper-62 is important for two reasons. First, the production of this isotope by (γ,n) reactions is very commonly used in the monitoring of X-ray beams in the energy range 10–30 MeV. Absolute monitoring is best done by irradiating a thick specimen and detecting the annihilation quanta. The estimation of the activity requires a knowledge of whether or not there are γ-rays emitted.

Secondly, the value of the total energy released calculated above throws doubt on the accuracy claimed for some recent mass measurements. Using the mean of two accurately measured values of the $^{63}Cu(\gamma,n)$ threshold[5,6], namely, 10·67 MeV., we find that the (^{62}Ni + ^1H) − ^{63}Cu mass difference is 6·43 ± 0·12 m.m.u. This is significantly different from the value of 5·7 ± 0·1 m.m.u. obtained from the mass spectrometer measurements by Collins et al.[7] of the doublets $^{62}Ni − C_5H_2$ and $^{63}Cu − C_5H_3$. In the same region of the Periodic Table, the $^{64}Zn − ^{64}Ni$ doublet shows a similar discrepancy, the value obtained from the decay scheme of ^{64}Cu[2] being 1·18 ± 0·03 m.m.u. and that obtained by Collins et al. being 2·01 ± 0·08 m.m.u. In view of the second discrepancy, it is not justifiable to attempt to explain the first discrepancy on some basis such as the (γ,n) cross-section of copper-63 being negligible in an energy region immediately above the neutron-binding energy. Until these discrepancies are explained, it would appear that the mass measurements in this region should be used with caution.

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Thermal Diffusion Potentials and the Soret Effect

IN a recent communication[1], Tyrrell and Colledge have directed attention to the possibility of studying the Soret effect in solutions of electrolytes by observations of the e.m.f. of non-isothermal cells. In such cells, two reversible electrodes are maintained at different temperatures; owing to thermal diffusion, the concentration of solute around one electrode increases and that around the other decreases. In consequence, an additional e.m.f. should gradually be set up, which, for small temperature differences, is simply the e.m.f. of an isothermal concentration cell (with transport) operating at the mean temperature.

During the past two years, we have succeeded in demonstrating and measuring such changes of e.m.f. in various aqueous solutions, using the following electrodes, all of which give very reproducible potentials : platinum/tri-iodide, iodide ; cadmium amalgam/cadmium ion ; thallium amalgam/thallous ion. In our experiments, the temperature gradient has been established in sintered glass diaphragms, which prevent convection but may possibly give anomalous results in very dilute solutions owing to surface effects. Most of our observations have therefore been made at concentrations of 0·1 molal and upwards, it being known[2] that the presence of a sintered diaphragm does not affect the isothermal diffusion coefficients of 1–1 electrolytes in this concentration-range.

Experiments using the platinum/tri-iodide, iodide electrode in lithium iodide, potassium iodide and hydrogen iodide were carried out in a modified diaphragm diffusion cell, fitted with magnetic stirrers[2] and with water jackets, whereby the upper and lower compartments could be maintained at different temperatures. Clear evidence of the expected effect was obtained ; but the method was found unsuitable for quantitative work because it was not possible to