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Abstract

Radiochemically pure F^{18} has been prepared by three different methods and its decay has been followed with β proportional counters and γ-ray counters in an effort to measure the half-life accurately. Analysis by a computer program that used the method of least squares gave a weighted mean half-life of F^{18} and a weighted standard deviation of the mean as $109.7_4 \pm 0.21$ minutes.

Table I. Reported values of F^{18} half-life.

Half-life (min)	Year	Authors
112±4	1937	Snell[a]
108	1937	Pool, Cork, and Thornton[b]
107±4	1938	DuBridge, Barnes, Buck, and Strain[c]
114	1940	Davidson[d]
115±4	1943	Huber, Lienhard, Scherrer, and Wäffler[e]
112	1948	Perlman and Friedlander[f]
112	1949	Blaser, Boehm, and Marmier[g]
111±1	1955	Jarmie[h]
110±1	1958	Bendel, McElhinney, and Tobin[i]
109.7±0.54	1959	Carlson, Singer, Service, and Armstrong[j]
110.2±0.2	1960	Yule and Turkevich[k]
109.7_4±0.21	1962	This work

(References for Table I)

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Experimental Procedure

F^{18} was prepared and isolated by three different methods.

Method A

Foils of 1/4-mil Mylar, a condensate of terphthalic acid and ethylene glycol containing 33.2% oxygen, were irradiated with He^3 ions of energy 1 to 31 MeV for about 15 min at the Berkeley heavy-ion linear accelerator (Hilac). The foils were left uncounted for about 4 hours to allow their shorter-lived activity time to decay. This represents a period 12 times the half-life of 20.4-min C^{11}, the longest-lived interfering nuclide. During this time the initial activity of C^{11}, approx. 10^7 counts/min, decreased to 2×10^3 counts/min, which is less than 1% of the F^{18} activity counted at that time. The foils were mounted on 1/16-inch aluminum cards with double-faced Scotch tape and covered with a thin plastic foil.

Method B

Ten milligrams of Li_2SO_4 was irradiated with 44-MeV He^4 ions at the Berkeley 60-inch cyclotron. The F^{18}, produced mainly but the (α, d) and (α, np) reactions on O^{16}, was separated by dissolving the target in 1 M KOH and placing the solution on a 12-in.-long anion-exchange column filled with Dowex 1 (100-200 mesh), and eluting with 1 M KOH. The active material, which contained the F^{18}, came off the column within 3.0 to 3.8 ml. To this volume of eluent, which was collected in about 25 min, 0.5 ml of carrier containing about 9 mg of F^- was added. The solution was made acid with HCl and 20 mg of NaH_2PO_4 and 5 mg of Fe^{+++} was introduced. $Fe(H_2PO_4)_3$ and $Fe(OH)_3$ precipitated when the solution was made basic with NH_4OH. (Fe^{+++} was added to scavenge impurities produced by S^{32} (α, 3p) P^{33} and S^{32} (n, p) P^{32} reactions.)

After centrifuging, the supernatant solution was made acid with HCl, basic with KOH, and finally, acid again with acetic acid. Ten ml of 1 M Ca $(NO_3)_2$ was added to the warm solution and the resulting precipitate of CaF_2 was washed with water, alcohol, and acetone. The final acetone slurry was mounted directly on the aluminum cards.

Method C

Twelve milligrams of spectroscopically pure LiOH was irradiated at the Livermore neutron reactor in a flux of 5×10^{12} n/cm^2-sec for 10 min. F^{18} was produced by the two-step reaction, Li^6 (n,α) H^3 and O^{16} (H^3, n) F^{18}. The product was separated and mounted as described in method B except that the scavenging step was omitted.

Counting

The samples were counted with β end-window gas-flow proportional counters whose plateaus were tested for stability. Methane was the counter gas. The counters were periodically checked with a Cl^{36} standard. As an additional control, annihilation radiation emitted by one of the samples was counted with a 3 × 3-in. NaI(Tl) scintillation counter and 256-channel pulse-height analyzer.

Results

The initial activity of the samples was about 10^5 counts/min in most cases. Counting was not stopped until there was no activity above background or, at least, only a very low constant activity (less than 10 counts/min). Since each sample was in the same position and counter during the entire time of measurement, no correction was made for geometry or efficiency. To minimize errors, different counters and different shelf positions were used with various samples.

Each count rate and time datum was rounded to three-digit accuracy and the full set of data for each sample was analyzed with the aid of the FRENIC program (originally written[4] for the IBM-704 computer but adapted for use on the 709-7090). This program yielded a value for λ and also gave its standard deviation. The results of the 16 individual experiments are compiled in Table II. When the standard deviation of the half-life calculated for a particular set of data > 0.7 min, that result was not included in the analysis; because of the small weighting factor in comparison with those listed in Table II, this would have a negligible effect on the weighted mean half-life.

The weighted mean half-life is given by[5]

$$m^w = \sum_{i=1}^{n} w_i x_i \Big/ \sum_{i=1}^{n} w_i$$

where x_i represents the individual half-lives measured for the samples and w_i are the weighting factors given by

$$w_i = 1/s_i^2$$

s_i is the standard deviation of each half-life determination. The weighted standard deviation of the mean is given by[5]

$$s_{m^w} = \left[\sum w_i (x_i - m^w)^2 \Big/ \sum w_i \right]^{1/2}$$

The results of the research presented here give, for the weighted mean half-life of F^{18} and the weighted standard deviation of the mean,

$109.7_4 \pm 0.21$ min.

Table II. Results of individual half-life determinations.

No. of data points	x_i (min)	s_i (min)	$w_i = 1/s_i^2$	Method
5	109.12	0.53	3.56	A
5	109.29	0.30	11.11	A
5	109.36	0.22	20.66	A
95	109.52	0.09	123.46	C
141	109.63	0.08	156.25	C
104	109.66	0.10	100.00	B
165	109.69	0.16	39.06	C
6	109.72	0.12	69.44	A
91	109.86	0.11	82.65	C
5	109.87	0.55	3.31	A
70	110.02	0.09	123.46	B
5	110.03	0.38	6.93	A
6	110.10	0.18	30.86	A
5	110.18	0.37	7.31	A
12	110.27	0.30	11.11	A
16	110.29	0.55	3.31	C (NaI)

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