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SUMMARY OF THE RESEARCH PROGRESS MEETING OF NOV. 8, 1951.

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S. Shewchuck

December 10, 1951

Berkeley, California

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Mass Spectrometer Gas Analysis. A. Newton

The mass spectrometer has been used to determine very small amounts of impurities in gases. There are two general cases of such gases, first, where separation of impurities is possible as from liquid air, and second, where no separation is possible as O_2 in N_2.

The first case is naturally much the easier. Several experimental tests have been run using sample mixtures with known compositions to determine accuracy of the measurements. The results of the mass spectrometer are quite favorable as the following show:

Gas	Percent Added	Percent Found	Error
CO_2	99.66	99.67 (by difference)	--
Air	0.127	0.129	0.001
CO	0.208	0.197	0.011
Propane	99.74	99.74	--
He	0.1121	0.1143	0.002
H_2	0.1121	0.1170	0.005
O_2	0.0338	0.032	-0.002
CO_2	99.45		--
O_2	0.111	0.109	0.001
N_2	0.222	0.222	0.000
CO	0.216	0.205	0.011

The solubility of CO in CO_2 may account for some of the difference in the CO values, since these values appear to be consistently low by about 5 percent. The stability of the machine is about 1 percent on peaks from run to run. The peaks found are as follows:

Gas	peaks at atomic weights
CO_2	... 12, 16, 28, 32, 44, plus peaks due to isotopes.
CO	... 12, 16, 28
Air	... 14, 28, 32

The peaks are often too small to be able to determine the final component by difference. So, arbitrarily, another gas is added to serve as an interval standard; e.g. 1 percent neon. In the first run there would be determined the ratio of CO_2/Ne; in the second run after freezing out the CO_2 one would get the ratio CO/Ne; and lastly the ratio of air/Ne. In this work it isn't essential to know accurately the amount of neon added. In the same way a condensible gas can be used as an interval standard in noncondensible gases.

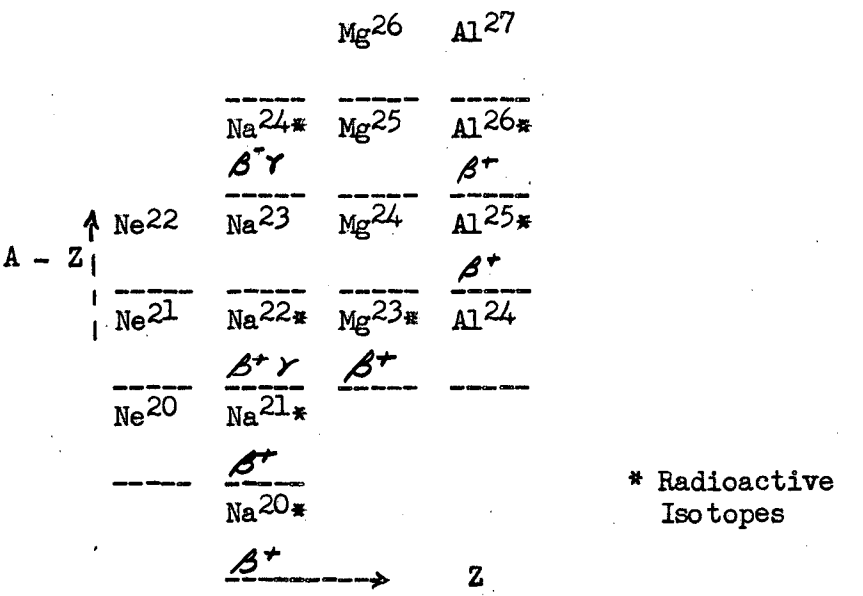
A common request is to find the percent of air impurity in certain concentrated gases. Sometimes the accuracy of the measurement is sensitive and critical depending on the use made of the gas. With helium the limit of detection is one part in 100,000, and for 20 percent accuracy it is one part in 50,000. For argon the limit of detection is one part in 40,000, and for 20 percent accuracy it is one part in 25,000.

An interesting point that arises in this connection is that in CO_2 there is a peak of 32 which must be due to O_2^+. However, how can such a molecule be formed from CO_2? This 32 peak is a nuisance in determining the CO_2 component and exists to the extent of one to 5000. One theory for its formation was suggested as follows:

$$CO_2 \rightarrow CO + O$$
$$\downarrow$$
$$C + O$$

Perhaps one could account for the O_2^+ from the recombination of O, a second order process. If this were so, then the peak should vary according to the square of the pressure. Actually, though, it varies linearly with the pressure, i.e., a first order reaction. It can't be explained by any reasonably simple mechanism how to get O_2^+ in a first order reaction.

Al^{24} Delayed Heavy Particle Emitter. A. C. Birge.



The above reproduces a part of the nuclear chart in the vicinity of Al^{24}, which is the isotope under consideration in this article.

In the low mass elements Alvarez reported about a year ago several heavy particle emitters as follows:

B^8	$\xrightarrow{\beta^+}$	Be^8	$\xrightarrow{\alpha}$	He	0.65 sec. half life
N^{12}	$\xrightarrow{\beta^+}$	C^{12}	$\xrightarrow{\alpha}$	Be^8	0.0125 sec. half life
F^{16}	(discovered later)				
Na^{20}	$\xrightarrow{\beta^+}$	Ne^{20}	$\xrightarrow{\alpha}$	O^{16}	0.39 sec. half life

The half life is that of the β^+ emission, while the α emission is immediate.

The relationships, $Z = 2K - 1$, and, $A = 4K$, hold true in each case. The isotope identification was by energy arguements each time. Hence, by postulation the next expected case is Al^{24} as an α emitter. Some of the general conclusions to be drawn are:

$Al^{24} < Mg^{23} + p = 24.0083$ atomic mass units.

" $\geq Mg^{24} + 2me = 23.9935$ " " " , or,

$= 23.9925$ " , if by K capture.

If decay is by α emission,

$He^4 + Ne^{20} = 24.0038$ atomic mass units.

Therefore, the maximum energy for the α particle is 4.2 Mev plus the possible gain of 1 Mev from K capture.

A search was made for the isotope Al^{24}. Since the energy was low a special counter lined with Mg was used having a thin Al window. The proton beam passed through the Al window and hit the Mg wall. As a result two heavy particle emitters were observed. One had a threshold at 29 Mev and a half life of 0.42 sec. This was probably due to the reaction Mg^{24} (p,nα) Na^{20}. The other had a threshold at 15.4 ± 0.3 Mev and a half life of 2.3 ± 0.2 sec. The reaction here was probably Mg^{24} (p,n) Al^{24}. The time intervals in this range are difficult to measure accurately. The arrangement for measuring the half life makes use of a four channel gating circuit. The timing pulser was gated to the scales of four channels set up in a binary system thus: 0 1 2 4 8 .

The second emitter appears to be consistent with energy arguements. This reaction, Mg^{24} (p,n) Al^{24}, has a calculated mass of 24.0075 atomic mass units, which is about 1 Mev below the available maximum energy. Since there is no chemical means to prove that this is an α emitter, then one has to resort to mass and energy arguements. Therefore, in a reaction suggested

earlier by Alvarez, Mg^{24} (p,T) Mg^{22}, one does not find enough energy for a He^3 or other heavy particle emission. Hence there can be no other heavy particle emitter. On the other hand, a proton emission can not be ruled out entirely in our case. It is thought that an α particle in the reaction $Al^{24} \xrightarrow{\beta^+} Mg^{24} \xrightarrow{\alpha} Ne^{20}$ of 3.4 Mev is not as probable as a proton emission in the reaction $Al^{24} \xrightarrow{\beta^+} Mg^{24} \xrightarrow{a} Na^{23}$ at 2.0 Mev. As yet it has been difficult to prove this by pulse height analysis. It may be possible that both reactions might be taking place. Some means will be devised to try and settle this point.

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