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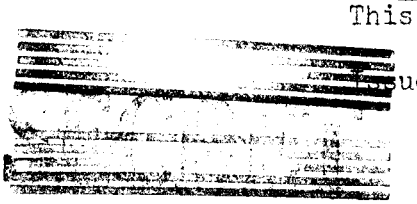

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UNIVERSITY OF CALIFORNIA

Radiation Laboratory

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MONTHLY PROGRESS REPORT NO. 58 FOR FEBRUARY 1948

Berkeley, California

UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

MONTHLY PROGRESS REPORT NO. 58 FOR FEBRUARY 1948

1. 184-inch Cyclotron Program

The cyclotron was used for research experimental ninety-two percent of the 448 hours the crew was on duty during this month. The major part of the time during the early part of the month was spent on the investigation of delayed neutron activities while during the latter part of the month the emphasis was changed to the search for mesotrons. One eight-hour shift was used to install a telescope that projects a light beam along the neutron beam path; this makes it possible to align experimental equipment in a shorter time and with greater accuracy than has been possible up to this time. A leak in the vacuum capacitor was repaired during this shut down.

The cyclotron is now being shut down between 4:00 P.M. and 8:00 P.M. every day to help lower the peak power load that the power company experiences during these hours, hence the cyclotron is operated from 8:00 A.M. to 4:00 P.M. and from 8:00 P.M. to 4:00 A.M.

2. 60-inch Cyclotron Program

The 60-inch cyclotron has operated very satisfactorily during the month of February, there being accomplished a total of approximately 500 hours of bombardment. The performance with deuterons has been especially good. Beam currents on the target have been maintained in the range of 40 to 60 microamperes for prolonged periods of time. This has added further to our already disturbingly high radiation levels both through the shield when the instrument is in operation as well as the ever increasing amounts of induced activity within the cyclotron itself.

A new type of double negative PIG source has been tried and found to operate very successfully for both deuterons and alpha particles. Further developments are now in progress with the source both with the view of exploring its possibilities as a substitute for our present open type source as well as for the production of stripped ions of boron and carbon.

3. Synchrotron Program

Additional development work on the plastic vacuum chamber has resulted in obtaining a pressure of 10^{-4} mm. measured in the vacuum chamber near the pumping ports. According to theoretical calculations this pressure is probably sufficiently low to permit obtaining a usable beam. Development work on the quartz vacuum chamber is continuing in case a lower pressure proves desirable. The synchrotron will be assembled, however, with the plastic vacuum chamber.

During the course of tests on the radio frequency accelerating system, the copper plating on the resonant cavity inner conductor was damaged necessitating removal and repair of the driving stem parts. It is believed that this trouble was caused from sparking due to a local high pressure. The vacuum seal and center conductor support has been redesigned to eliminate a region where gas may be trapped in order to improve the pressure in this vicinity.

It has been found that the oscillator as originally designed will provide sufficient power to obtain a dee voltage of 5 kilovolts. The plan of converting the oscillator to a power amplifier has been abandoned.

The magnet assembly has been completed during the past month and the magnet and its power supply operated at approximately rated current for a short period of time. No difficulties have appeared in this preliminary operation, and the installation of additional metering equipment is nearly completed, after which the complete magnetic measurements will be made.

4. Linear Accelerator Program

Van de Graaff. The ion source filament problem seems to be fairly well in hand now. The filament mentioned in last month's report ran for over 100 hours of operating time in spite of the fact that it was let up to air ten times. Tests are continuing to determine conditions under which maximum life is obtained, both with d.c. operation and with pulsing.

Further trouble has been encountered with rapid commutator deterioration on the d.c. generator which operates the hypervac pump. The two generators have now been paralleled on the theory that most of the damage is done by the high surge of current on starting the pump. The 90^{o} deflecting magnet is complete and field plots are being made on it. It will be ready for installation shortly, so experiments with a deflected proton beam will be possible.

40-foot Section. During the month of February, the linear accelerator was again inoperative much of the time because of Van de Graaff difficulties. However, in the time that it was running, a total of 42 bombardments were made, and some preliminary results were obtained. Work was done on the activation curve for $C^{12}(p,pn)C^{11}$, the search for exchange reaction at 32 million volts, and the Cl(p,n) activation surge at low energies, with the Van de Graaff. A new short half-lived activity was obtained from protons on nickel.

The rf operation during the month has been remarkably steady The rf level can be brought up to beam voltage in less than ten minutes from a complete shutdown. The maximum beam obtained to date was $.8 \times 10^{-11}$ amperes, and the normal running beam has been approximately

one half of that. The beam current was not reduced by installing the 30° deflecting magnet for monochromatizing the beam. The rf efficiency was improved by tilting the rf level in the tank approximately 10 percent, as measured by the bolometers. It is gratifying that this happens experimentally, since it was predicted in theory some time ago.

5. Experimental Physics

Observation of Mesons in Photographic Emulsions. Negative mesons (of mass 313 ± 16 electron masses) have been observed from the bombardment of carbon with 380 Mev alpha particles. The mass is determined from $H\rho$ measurements in the cyclotron field and from the measured range in the emulsion. The majority of the observed negative mesons produce stars at the end of their range. These particles are apparently identical with the π mesons reported by Powell and coworkers in England from cosmic ray experiments. Since the intensities available are about 10^8 times those from cosmic rays, this discovery will greatly accelerate progress in this field. Mesons have also been observed from beryllium, copper and uranium targets and a greatly reduced, but observable, yield at an alpha particle energy of 300 Mev.

Delayed Neutrons. Experiments have continued on the delayed neutrons produced following the decay of N^{17} (4.1 seconds). Complex decay curves of neutron emission have been observed for cerium, gadolinium, and all elements above iridium under deuteron bombardment. The relative yields for the production of N^{17} from neighboring elements have been determined, together with the excitation curves for some of the reactions.

Neutron-Proton Scattering. Studies have continued on the angular dependence of n-p scattering. The results of measurements in the angular range from 70° to 170° in the CM system give a clear indication of the existence of exchange forces between neutron and proton. A vacuum chamber proportional counter arrangement for extending the measurements to wide angles is being developed. Design, construction, and test work is being done on a fission counter for detecting low energy negative mesons and a proportional counter coincidence-anti-coincidence arrangement for measuring the energy distribution of recoil protons from various substances.

Diffraction of Neutrons. An arrangement of proportional counters in coincidnece has been developed for neutron diffraction measurements. The neutrons produce knock-on protons in paraffin placed in front of the coincidance array. A similar counter system is used to monitor the beam. Measurements of the angular distribution of neutrons diffracted by copper gave results in agreement with earlier measurements using carbon detectors. Attenuation measurements are also being carried out.

6. Theoretical Physics

Work was done on the effect of the range of the forces on n-p scattering; on the yields of the reactions leading to N^{17}; on neutrino cross sections; and on various calculations concerning mesons. Some calculations were made on problems having to do with the bevatron and synchrotron

7. Isotope Research Program

Problems involved in the collection of ions (in particular carbon ions) have been under investigation. A decelerating collector is in use and interpretations of its current readings are being studied. The aim in view is to deposit C^{14} upon a very thin Be foil. An interesting observation on the adherence of deposits of 10 Kev carbon ions was made, in which it appeared that current densities below a certain level permitted the carbon deposit to adhere and build up, whereas for higher densities the carbon was sputtered off and deposited on regions not struck by the beam.

Shop work on the low-mass spectrometer continues, along with efforts at obtaining interpretable results on H and D analyses with the G.E.-Nier instrument. Experiments on evaluating tritium content by the ionization chamber method using water vapor have begun.

A sample of carbon enriched in C^{13} to 52 percent by the Eastman diffusion process was analyzed for C^{14} content. It yielded 2900 c/min per gram carbon. This is in agreement with results by Libby, et al., in their studies of "biocarbon" at Chicago. The source of the carbon used by Eastman in their ion exchange isotope enrichment process is wood charcoal, so the result is in order.

8. Chemistry

Part A

Electronic Structure of the Actinide Elements. Magnetic susceptibilities of cations of uranium, neptunium, plutonium and americium in aqueous solution were measured on the semi-micro scale by means of a bifilar suspension method. The effective magnetic moments at 20°C as calculated from the observed χ by the equation $\mu_{eff} = 2.84\sqrt{\chi T}$ are: Np (VI), 2.40; U(IV), 2.95; NP(V), 3.08; Pu(VI), 2.91; Np (IV), 3.03; Pu (IV), 1.85; Pu (III), 0.90; Am (III), about 0.8. It is concluded that all of the ions have electron configurations beyond the radon structure of the type $(5f)^{1-6}$ since the calculated values for these structures are in agreement with the measured values and complete disagreement is obtained with calculated values assuming "6d" electrons. Good agreement between values for the isoelectric ions U(IV), Np(V) and Pu(VI) is noted.

Radioactive Isotopes of the Rare Earth Elements. Using deuterons up to 20 Mev and helium ions up to 40 Mev identification of a number of new rare earth isotopes has been accomplished. In general, pure rare earths were irradiated and the activities were separated into chemical fractions with Dowex 50 resin columns. Until this work was begun there were no well established positron emitters known among the heavy rare earths. This appears now to be due only to the fact that no isotopes were produced sufficiently far removed from stability. The following table lists the isotopes observed with tentative isotopic assignments, radiation characteristics and modes of production. Some of these activities have been reported by others and those which are new are indicated by an asterisk.

Isotope	Half-life	Particles	Electromagnetic Radiation	Produced by	Remarks
71 Lu^{176}	3.75 hr.	β^- 1.04	γ 0.45	Lu-d-p	
Lu^{177}	6.9 days	β^- 0.46	γ	Lu-d-p	
69*Tm^{166}	7.7 hr.	β^+ 2.1 e^- 0.24,1.0	γ 1.7 x-rays	Ho-α-3n	
*$Tm^{167(?)}$	~40 days			Ta-d-5z15a Ho-α-2n(?)	
*Tm^{168}	8.6 days	β^- or e^-0.22	γ,x-rays	Ho-α-n	
67*Ho^{160}	20 min.			Tb-α-3n	
*Ho^{161}	4.55 hr.	β^+ ~2 e^-, 0.3	γ 1.12 x-rays	Tb-α-2n	almost 100% K
*Ho^{162}	~ 50 days	β^-(?) 0.6 e^- 0.16	γ, x-rays	Tb-α-n	β^- & K branching probable

Evidence of Mesotron Production Deduced from Nuclear Reaction Products. Following the recent observation by Lattes and Gardner of cyclotron produced mesotrons as tracks in photographic emulsions another attempt has been made to obtain chemical evidence for mesotron formation by a method which previously gave inconclusive results. This method consists of the bombardment of a target nucleus, Z, with a projectile of charge, z, and searching for a product of atomic number Z+z+1. The particular reaction chosen for observation was the formation of $_{85}At^{211}$ following the irradiation of lead (element 82) with high energy helium ions. This could presumably be formed by the reaction:

$$Pb^{208}(\alpha, n\mu^-)\ At^{211}$$

Lead was irradiated in different experiments with helium ions of 400, 200 and 150 Mev. Parallel irradiations were carried out with bismuth as the target. In the lead targets as well as in the bismuth targets, At^{211} was identified in all cases. However, the yield in lead decreased with decreasing helium ion energy while the yield in bismuth increased sharply with decreasing energy. The yield of astatine from lead may be expressed in terms of the concentration of bismuth which would produce that yield. At 400 Mev there would have had to be 2000 ppm bismuth in the lead, at 200 Mev, 80 ppm and at 150 Mev, 5 ppm. Since spectrographic analysis indicated that the lead used contained 1-10 ppm bismuth, the astatine produced with 150 Mev helium ions could be explained by the bismuth content. At 200 Mev and particularly at 400 Mev the At^{211} could not have been produced from bismuth.

Such a mechanism as the formation of lithium nuclei from the reaction of the high energy particles on lead followed by a reaction of the type, Pb(Li,xn)At, has not yet been ruled out.

The value for the cross section for the formation of At^{211} from 400 Mev helium ions on lead is 10^{-31} cm^2.

Chemistry

Part B

Synthetic and Experimental Organic Chemistry. Heptene-1, 1-C^{14} is being prepared. In conjunction with the Chemistry Department of the University of California, this compound will be catalytically cyclized at high temperatures to toluene and hydrogen, and the toluene will be degraded to determine the position of the label.

In conjunction with the Dentistry College of the University of California, Amidone has been synthesized from labeled ethyl bromide, 1-C^{14}. The yield of ethyl bromide is about 70 percent based on CO_2 and the yield of Amidone is about 35 percent based on ethyl bromide, making the overall yield about 25 percent.

Carbon fourteen carboxyl labeled malonic acid has been synthesized in about 85 percent yield based on cyanide, which corresponds to a yield of about 50 percent based on barium carbonate. Experiments are being undertaken with regard to the effect of the isotopic carbon on the strengths of the carboxyl carbon-methylene carbon bond energy.

The synthesis of indole-3-acetic acid labeled with C^{14} in the alpha position has been accomplished. The specific activity of the product is about 1 $\mu c/mg$. The work on the synthesis of hydroxyanthranilic acid is still in progress.

Biological Chemistry. The biological work on the metabolism of the following C^{14} labeled compounds has continued: dibenzanthracene 9,10-C^{14}, beta labeled tyrosine, and beta labeled tryptophane.

Photosynthetic Chemistry. In algae photosynthesizing with radiocarbon dioxide for 30 seconds, 80 percent of the radioactivity fixed is anionic in character and non-ether extractable. This material has been shown to be approximately half triosephosphates and half 3-phosphoglyceric acid. The two phosphates are separated by selective elution with ammonium hydroxide from an anionic exchange resin. In pre-illuminated algae fed radiocarbon dioxide, the dark fixation product is largely alanine and this is the only labeled amino acid synthesized in large amounts under the conditions of the experiment.

Work has continued on the role of chlorophyll in photosynthesis using deuterium to determine if chlorophyll acts as a hydrogen carrier. Analyzed chlorophyll from algae that has been exposed to heavy water in the light and in the dark shows that chlorophyll treated in the light has a higher deuterium content, but the interpretation is not yet certain. It may be that this is the result of a hydrogen carrier action, or it may be due to some other process such as the synthesis of new chlorophyll.

Experiments have been carried out to determine the role of acetate in photosynthesis, both in the light and in the dark. That acetate which is assimilated is rapidly metabolized to material of no charge. The evidence indicates that more of the acetate is so metabolized in the light than in the dark, even on short exposures. It may be that sugar is formed from the acetate by a process which is the result of some relationship to the photosynthetic cycle.

Chemistry

Part C Subproject 48B

Metals and High Temperature Thermodynamics. Work is in progress on the thermodynamics of the CN molecule, the thermodynamics of gaseous halides, absorption coefficients of C_2 and other molecules stable at high temperature, refractories and liquid metal systems.

Basic Chemistry. Solvent Extraction. Equilibrium constants for the complexing of Zr(IV) by F^-, $SO_4^=$, OH^-, etc. have been calculated and a report summarizing the results is being written.

The analytical method for the determination of water in ether has been worked out and will now be applied to the water-ether-uranyl nitrate system.

Work is continuing on the extraction of uranyl ion and La(III)

by TTA into benzene.

9. Medical Physics

Part A. Project 48A - 1

Radioautographic studies of the distribution in bone of yttrium, zirconium, columbium, cerium, actinium, element 61, americium and plutonium are continuing.

Incomplete tracer studies with carrier-free radio-tin reveal that this fission product is excreted principally by way of the urine but there is considerable accumulation and retention in the liver and skeleton. Carrier-free radio-germanium is excreted with extraordinary rapidity following intramuscular administration, 90 percent being eliminated within 24 hours. With the exception of the kidney, there is no appreciable accumulation in any of the organs and tissues of the body, including the blood. The latter point is of interest since it has been alleged that germanium may have a role in a normal formation of red blood cells. The 256 day tracer studies with U^{233} have been completed and it is found that .06 percent of the administered dose was left in the kidneys and .075 percent in the skeleton. The value for the skeleton at 64 days is 9.2 percent indicating that in the rat, uranium is released from the skeleton at a far more rapid rate than thorium, plutonium, americium, and curium. Preliminary tracer studies with actinium indicate that this radioelement is handled in the body in a manner almost indistinguishable from americium, curium, and the lanthanide group of rare earths.

The experiment on the effect of zirconium treatment on the metabolism of intravenously injected radio-yttrium has now been completed. Rats treated with 40 mg. zirconium at the same time as the radio-yttrium was injected, excreted 68 percent of the dose in the first 24 hours, in urine as compared to 8.8 percent excreted by the controls. A single zirconium treatment two days prior to, or two days following the administration of yttrium had no apparent effect on body distribution or urinary excretion. The evidence points to a "carrier" action of zirconium in increasing yttrium excretion. The amount of radioyttrium deposited in the liver was reduced from 28.5 percent in the control animals to 1.7 percent in the rats given zirconium at the same time as the yttrium was administered. There was a similar reduction in the kidney uptake of radio-yttrium. Reduction of liver uptake, if also true for plutonium, may be of value in preventing liver damage from radiation. In vitro studies with decalcified bone show a marked reduction in plutonium uptake when zirconium citrate is added to the solution. The excretion of radio-strontium by adult rats has been followed for over 150 days. After the first month, the excretion levels off at a low value. Changing the animals to a phosphate

deficient diet resulted in an increase in urinary excretion of radio-strontium, but no effect on fecal strontium.

An experiment has been set up to compare the metabolism of Ca^{45} and Sr^{90} in young growing rats to determine the validity of strontium as an indicator for calcium metabolism.

Carrier-free preparations of radio-calcium, radio-scandium, radio-vanadium, radio-yttrium, radio-zirconium, radio-germanium, radio-silver, and radio-tin have either been made or are in progress.

Medical Physics

Part B. Project 48A - II

The lethal effect of the direct beam of 180 Mev deuterons is being studied on Bagg Albino mice. It is too early to know the final results as yet. It appears, however, that the 50 percent acute lethal dose will be somewhat lower than the previously reported results would indicate. (Quarterly Progress Report for October - December, 1947) The time required for acute lethal effects is about fifteen seconds exposure to the deflected beam at the beam port. An apparatus is being built to enable us to deliver any desired dose to selected regions of the animal body, varying the depth and specific ionization. Preliminary experiments are in progress to study the carcinogenic effects of the most ionizing part of the beam on the skin of Bagg Albino mice.

A set of experiments is in progress to study sodium ion exchange in rabbits before and after irradiation. At the present time sodium 24 is being used. There is some indication that the sodium space as measured by the dilution technique changes after X-ray irradiation. This effect and the mechanisms involved will be studied in detail.

The first 24 neutron irradiated tissue ash samples arrived from Hanford to be used in trace analysis by induced radioactivity. Several of the active isotopes are being quantitatively separated with the aim of determining the microcomposition of tissue ash of various organs and blood. (Monthly Progress Report for June, 1947)

10. Health Physics and Chemistry

In addition to routine monitoring during the month, continuous monitoring over the weekend of February 21-22 was carried out on some work that was being done on bombarded tissue and blood samples from Hanford. Remote-control unpackaging of the samples was carried out in the cave in Room 107, Building 5. The activity of the

individual samples ranged from 20 mr/hr to 500 mr/hr. All handling was by four-foot tongs, which gave adequate protection from the soft beta radiation emitted.

New alpha hand counters were installed on the main floors of Buildings 4 and 5, while the air velocities on all hoods in Building 4 were determined by anaemometer. A system for filling neutron counters with $B^{11}F_3$ has been set up and put into successful use, and the preparation of a calibrated apparatus for measuring slow neutron flux densities by indium foils has been completed. Work has progressed on the construction of the beta-gamma gloved box and on the installation of a high temperature furnace for the spectral analysis of radio-isotopes.

LMB/ 3-8-48
Information Division

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