Copy with Remarks by Dr. P. J. K. July 1961

A PROPOSAL

FOR AEC EQUIPMENT GRANT ASSISTANCE

In

NUCLEAR SCIENCE AND ENGINEERING EDUCATION

Submitted to

THE COORDINATOR OF NUCLEAR EDUCATION AND TRAINING

U. S. ATOMIC ENERGY COMMISSION

WASHINGTON 25, D. C.

By

THE DEPARTMENT OF PHYSICS, GEORGETOWN UNIVERSITY

WASHINGTON 7, D.C.

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PHYSICS 117-NUCLEAR LABORATORY I

1 - Laboratory Orientation.

2 - Survey meters.

3 - Characteristics of Detectors.

4 - Familiarization with Counter Operation and Determination of GM Plateau.

5 - Circuit Sensitivity and Dead Time Determination.

6 - Statistical Fluctuation.

7 - Characteristics of Proportional Counters.

8 - Absorption of Beta Rays.

9 - Determination of Half-life.

PHYSICS 118 - NUCLEAR LABORATORY II

10 - Review of Experiments 2,3,4 & 5 of Phys. 117.

11 - Radiation mapping of laboratory.

12 - Characteristics of a Scintillation Counter.

13 - 14 and 15 - Pulse Height Analysis.

16 - Electrometer Characteristics.

17 - Characteristics of Alpha and Beta Emitters.

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PHYSICS 225 - ADVANCED EXPERIMENTAL NUCLEAR PHYSICS I

19 - Laboratory Orientation.

20 - Absorption of beta-particles, back scattering and self-absorption.

21 - Scintillation spectroscopy.

22 - Neutron Detection.

23 - Activation of Silver by Neutrons.

PHYSICS 226 - ADVANCED EXPERIMENTAL NUCLEAR PHYSICS II

24 - Beta-ray spectrometer.

25 - Determination of absolute activity by beta-gamma coincidence counting.

26 - Determination of decay scheme of Co^{60} by gamma-gamma coincidence.

27 - Angular correlation of gamma-rays

28 - Cosmic Radiation.

C. BRIEF DESCRIPTION OF EXPERIMENTS

PHYSICS 117 - NUCLEAR LABORATORY I

EXPERIMENT 1

Title: LABORATORY ORIENTATION

Purpose: To familiarize the student with laboratory equipment and general procedures.

Method: (1) Demonstration of a simple counting experiment with beta and gamma sources.

(2) Inventory of laboratory equipment and instruction books by students.

Equipment: Beta and gamma sources. End Window GM tube. Integrated Spectrometry System.

EXPERIMENT 2

Title: SURVEY METERS.

Purpose: To familiarize students with capabilities and limitations of various survey meters.

Method: Measure effects of alpha, beta, gamma, and neutron sources on various survey meters.

Equipment: Alpha, beta, gamma, and neutron sources, alpha-beta-gamma survey meter, nuclear Chicago P15 Probe, D-50 GM-tube, cutie pie, neutron survey meter, alpha probe.

EXPERIMENT 3

Title: CHARACTERISTICS OF DETECTORS.

Purpose: To demonstrate to students methods of performing spectrum analysis of alpha, beta, and gamma sources. To give students exercise in coupling detection system components. Calibrate the spectrometer with standard sources.

Method: Demonstration of detection experiment with flow and well-type detectors and 256 channel PHA, student hook-up of electronic circuitry for detection systems. (20 Channel PHA is quite sufficient. This can also be done with a single channel.)

Equipment: Universal shield, Tube Stand, Flow propulsion detector, scintillation probe, preamplifiers, HV power supply, amplifier, scaler, timer, 256 Channel PHA.

EXPERIMENT 4

Title: FAMILIARIZATION WITH COUNTER OPERATION AND DETERMINATION OF G-M COUNTER PLATEAU.

Purpose: Familiarizing students with technique of counting and with capabilities and limitation of GM counting systems.

Method: Students hook up counter circuitry and prepare equipment for experiment with a "calibrating" source. Plot counting rate vs. counter voltage for G-M tube and flow gas counter systems.

Equipment: Source and standards kit, End-window GM tube, Flow proportional detector, preamplifier, amplifier, high voltage supply, scaler, timer.

EXPERIMENT 5

Title: CIRCUIT SENSITIVITY AND DEAD TIME DETERMINATION.

Purpose: To show difference between beta and alpha particles near beta threshhold; determine dead time and recovery time by direct observation (oscilloscope) and by statistical methods.

Method: (1) Using Ra D,E,F, source and flow gas G-M counter system, interpose a piece of paper between source and detector to screen alpha particles, and determine beta threshhold.

(2) Observe beta and alpha pulse characteristics with oscilloscope and determine dead time by direct observation.

(3) Determine dead time by two source method.

Equipment: Ra D,E,F source, Flow gas counter system, oscilloscope.

EXPERIMENT 6

Title: STATISTICAL FLUCTUATION.

Purpose: To show fluctuation at low and high counting ratio.

Method: (1) Determine fluctuation of background counting rate and apply Chi-square test.

(2) Repeat with source.

Equipment: GM-End tube counting system.

EXPERIMENT 7

Title: CHARACTERISTICS OF PROPORTIONAL COUNTERS.

Purpose: To observe characteristics of G-M counters operating in the proportional region.

Method: (1) Study counting rate as a function of discriminator voltage with P32 source.

(2) Observe pulse height distribution with oscilloscope.

(3) Repeat with Ra D,E,F, source.

(4) Repeat with pure methane gas.

Equipment: G-M Gas Flow Counting system including Linear Non-Loading Amplifier, Oscilloscope.

EXPERIMENT 8

Title: ABSORPTION OF BETA RAYS.

Purpose: To obtain a beta-ray absorption curve for P32 and calculate, from these results, the end point beta-way energy, use two or more standard sources (^{198}Au, ^{137}Cs)

Method: (1) Observe counting rate vs. absorber thickness

(2) Observe backscatter effect

(3) Observe effect of absorber position

Equipment: Tube stand, G-M End Window Counting system, Absorber set.

EXPERIMENT 9

Title: DETERMINATION OF HALF-LIFE.

Purpose: To measure the half-life of a radioactive sample (use at least three samples)

Method: (1) Determine background count with blank planchet in source position.

(2) Count source for appropriate periods.

(3) Determine half-life by graphical method.

Equipment: Source, gas flow counter system. (preferably Scintillation Spectrometer.)

PHYSICS 118 - NUCLEAR LABORATORY II

EXPERIMENT 10

Title: REVIEW OF EXPERIMENTS 2, 3, 4 AND 5 OF PHYSICS 117.

Purpose: To give a review of certain experiments of Physics 117.

Method: The Instructor will put on demonstration of Experiments 117-2, 3, 4 and 5.

Equipment: That required for Experiments 117 - 2, 3, 4 and 5.

EXPERIMENT 11

Title: RADIATION MAPPING OF LABORATORY.

Purpose: (1) To provide an exercise in locating and cleaning up contamination.

(2) To review statistics of low level counting.

(3) To provide a mapping of irreducible residual radioactivity in the laboratory.

Method: (1) Students will perform an "Easter-egg hunt" for a hidden harmless source.

(2) Students will locate and clean up a prepared contaminated surface.

(3) Students will map residual radioactivity after completion of clean-up.

Equipment: Alpha-beta-gamma survey meter, P 15 probe, D-50 GM tube, cutie pie, 2112 N neutron survey meter.

EXPERIMENT 12

Title: CHARACTERISTICS OF A SCINTILLATION COUNTER.

Purpose: (1) To determine the dependence of counting rate on voltage for a scintillation counter with several sources having different gamma-ray energies.

(2) To measure the effect of Bremsstrahlung, the shape of Bremsstrahlung distribution and to see how correction can be made for Bremsstrahlung errors.

Method: Plot counting rates vs. counter voltage of Co^{60} and Cs^{137} without absorber and with 1 mm. lead. Calibrate the spectrometer with different gains in the amplifier (eg. 1, 2, 4, 8, 16)

Equipment: Sources, universal shield, A 18 probe, preamplifier, linear non-overloading amplifier, scaler, timer. High voltage power supply.

(This is same as experiment 11 - 12)

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EXPERIMENT 13, 14 AND 15

Title: PULSE HEIGHT ANALYSIS.

Purpose: (1) To learn to calibrate a scintillation spectrometer.

(2) To analyze spectra of Cs^{137} and Co^{60}.

(3) To identify an unknown gamma source by analysis of the energy spectrum.

Method: (1) Use Cs^{137} and Co^{60} sources to calibrate spectrometer and study spectra of given nuclides.

(2) Observe a given spectrum and identify unknown elements. To be accomplished in three experiments.

Equipment: Well type scintillation detector and shield, 256 channel Pulse Height Analyzer, Sources, High Voltage power supply, Linear Amplifier.

EXPERIMENT 16 of experiment 17.

Title: ELECTROMETER CHARACTERISTICS.

Purpose: To determine operational characteristics of an electrometer counting circuit.

Method: (1) Perform range vs. counting rate of electrometer.

(2) Observe performance characteristics of electrometer circuit on oscilloscope.

EXPERIMENT 17

Title: CHARACTERISTICS OF ALPHA AND BETA EMITTERS.

Purpose: To observe difference in straggling of Beta and Alpha emitters.

Method: Measure Counts vs. range for pure Beta and Alpha emitters in electrometer detector.

Equipment: Sources, electrometer, scaler, timer, linear amplifier.

EXPERIMENT 18

Title: SPECIAL PROBLEM.

Purpose: To permit students to develop an experiment of own choosing.

Method: Students plan and execute an experiment of own design under supervision of instructor.

Equipment: As appropriate.

PHYSICS 225 - ADVANCED EXPERIMENTAL NUCLEAR PHYSICS I

EXPERIMENT 19

Title: LABORATORY ORIENTATION.

Purpose: To familiarize the student with laboratory and general procedures.

Method: (1) Demonstration of basic experimental techniques.

(2) Inventory of laboratory equipment and instruction books by students.

Equipment: As needed.

EXPERIMENT 20 (this is listed as experiment 8)

Title: ABSORPTION OF BETA RAYS.

Purpose: To study the beta ray absorption curve for beta particles and investigate the corrections needed for back scatter and self absorption.

Method: Using calibrated absorber foils the transmission as absorber thickness is determined for a thin P^{32} source. The backing thickness is then increased and the effect on the transmission is observed. From this, corrections for back scattering are reduced.

Equipment: End window geiger counter and preamplifier, high voltage power supply, scaler, set of calibrated absorbers, lead shield and tube stand.

(Same as Experiment 12)

EXPERIMENT 21

Title: SCINTILLATION SPECTROSCOPY

Purpose: To familiarize the student with scintillation counter techniques.

Method: The pulse height distribution of pulses from Cs^{137} is measured with both integral and differential discrimination. The total absorption peak is used as an energy calibration point. The differential pulse height distributions of Na^{22}, P^{32} and other isotopes are taken and the origin of all features in these distributions is explained.

Equipment: Scintillation counter and preamplifier, Linear amplifier, single channel pulse height analyzer, scaler, electronic timer, high voltage power supply, 256 channel pulse height analyzer, oscilloscope.

EXPERIMENT 22

Title: NEUTRON DETECTION

Purpose: To familiarize the student with the specific detectors used to detect both thermal and fast neutrons.

Method: Boron proportional counters as well as plastic scintillators are used to detect neutrons from a plutonium-beryllium source both with and without a paraffin moderator. Cadmium is used to demonstrate the relative sensitivities of the two types of counters to thermal and fast neutrons. The sensitivity to gamma rays is shown by use of a Co^{60} source. Pulse height distributions in the plastic scintillator for neutrons and gamma rays are compared.

Equipment: Boron proportional counter and preamplifer, plastic scintillation detector and preamplifer, linear amplifier, single channel pulse height analyzer, scaler, electronic timer, high voltage power supply, oscilloscope.

EXPERIMENT 23

Title: ACTIVATION OF SILVER BY NEUTRONS.

Purpose: Illustrate some of the techniques of neutron physics, activation by thermal neutrons, moderation of neutrons by paraffin and the use of cadmium to separate the effects of thermal and resonance neutrons. Also some of the methods of separating and measuring decays involving several half-lives will be illustrated.

Method: A bare silver foil is activated by neutrons in a paraffin moderating geometry and the activity vs. time is measured. This allows separation of the 2.3 min. and 24.2 sec. activities. The activation is then repeated with cadmium covers over the silver and finally without cadmium but with the source removed from the moderator.

Equipment: NaI scintillator and photomultiplier, preamplifier, linear amplifier, scaler, electronic timer, neutron "Howitzer" (paraffin moderator), plutonium-beryllium neutron source.

PHYSICS 226 - ADVANCED EXPERIMENTAL NUCLEAR PHYSICS II

EXPERIMENT 24

Title: BETA RAY SPECTROMETER.

Purpose: To measure the distribution of beta ray energies from various isotopes and determine the end point energies.

Method: A simple thin lens beta ray spectrometer is used. The spectrometer is calibrated with the internal conversion beta ray from Cs^{137}. Other energies are a linear function of the magnet current. The data is analyzed in terms of a Curie-plot.

Equipment: Thin lens beta ray spectrometer, end window geiger counter and preamplifier, scaler.

EXPERIMENT 25

Title: DETERMINATION OF ABSOLUTE ACTIVITY BY BETA-GAMMA COINCIDENCE COUNTING.

Purpose: To illustrate the use of beta-gamma coincidence counting as a method of absolute determination of the disintegration rate of a source, in this case Co^{60}.

Method: A thin end window geiger counter and a NaI scintillator are used respectively for detection of beta and gamma. The pulse from the geiger counter is clipped very short. Both are amplified and integral discriminator outputs are applied to a coincidence circuit. The single and coincidence counting rates are determined simultaneously for a Co^{60} source and the absolute disintegration rate is calculated.

Equipment: 1 end window geiger counter and cathode follower, 1 scintillation counter and preamplifier, 2 linear amplifiers, 1 high voltage power supply, 1 coincidence circuit, 3 scalers, 1 oscilloscope, dual trace.

EXPERIMENT 26

Title: DETERMINATION OF THE DECAY SCHEME OF Co^{60} BY GAMMA-GAMMA COINCIDENCE.

Purpose: To show how gamma-gamma coincidence measurements can be used to resolve an ambiguity in the determination of a decay scheme.

Method: Single channel pulse height analyzers are set to select the total absorption peaks of the two gamma-rays of Co^{60} in two different scintillation counters. Coincidences between the two are compared with the expected accidental coincidence rate.

Equipment: 2 scintillation counters and preamplifiers, 1 high voltage power supply, 2 linear amplifiers, 2 single channel pulse height analyzers, 1 coincidence circuit, 1 scaler, 1 oscilloscope, dual trace.

EXPERIMENT 27

Title: ANGULAR CORRELATION OF GAMMA-RAYS.

Purpose: To measure the angular correlation between successive gamma-rays in a decay and show how the angular momentum change can be deduced for this.

Method: The coincidence count rate is recorded as a function of the angle between two scintillation counters held at a fixed distance from the source. First the angular correlation is measured for Na^{22} annihilation gamma-rays and then for Co^{60} annihilation gamma-rays. The observed correlation is compared with theory.

Equipment: 2 scintillation counters and preamplifiers, 1 high voltage power supply, 2 linear amplifiers, 2 single channel pulse height analyzers, 1 coincidence circuit, 3 scalers, 1 oscilloscope, dual trace.

EXPERIMENT 28

Title: COSMIC RADIATION.

Purpose: To measure the attenuation coefficient of cosmic radiation and resolve the hard and soft components and to observe the variation of intensity with azimuth angle.

Method: The pulse from two Geiger counters are fed to a coincidence circuit and the coincidences are then scaled. The coincidence requirement eliminates counts from the residual radioactivity in the laboratory. Lead absorbers are then introduced and the reduction in count rate is plotted vs. absorbed thickness. The two components of cosmic radiation are thus observed.

Equipment: 2 geiger counters and preamplifiers, 1 high voltage power supply, 1 coincidence circuit, 1 scaler.

7. LISTING OF EQUIPMENT BEING REQUESTED

Ref. No. (Sequential)	Priority.	Item	Experiments	Manufacturer & Model	Quantity	Unit Price	Institutional contribution	Requested from AEC
delete ~~1~~	A	Universal Shield	3,4,5,6,7,8,9,10,12, 13,14,15,20	Hamner, A-500	4	$ 600	-	$ 2,400
2	A	Tube Stand	3,4,5,6,7,8,9,10,12, 20	Hamner A-500	4	35	-	140
3	A	Scintillation Probe with 6292 PM Tube & 1-3/4" x 2" Wall Crystal	3,10,12,13,14,15,21, 22,23,25,26,27	Hamner A-18	4	225	-	900
4	A	Scintillation Probe with Preamplifier	3, 10,12,13,14,15, 21,22,23,25,26,27	Hamner N-352A	4	135	-	540
5	A	Proportional Counter Remplifier	3, 7, 10	Hamner N-351	4	135	-	540
6	-	Non-overloading Amplifier	3,7,10,12,13,14,15	Baird Atomic 215	1	650	650	-
7	-	Linear Amplifier	3,4,7,10,16,17,21, 22,23,25,27	Atomic 218	1	550	550	-
8	-	Preamplifier	3,4,10,20,23	B.A., 255-C	5	225	705	-
9	-	Scintillation Counters & Stands	3,10,12,13,14,15, 21,24,25,26	B.A., 810	3	895	2,685	-
10	A	End Window GM tube (1.4 to 2 mg/cm^2)	1,4,6,8,10,20,24, 25,28	Hamner EG-2T	4	62.50	-	250
11	-	GM Counter & Stand	1,4,6,8,10,28	Nue. Chi 3031	2	500	1,000	-

(This can be easily built by the students

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Ref.No. (Sequen-tial)	Prior-ity.	Item	Experiments	Manufac-turer & Model	Quan-tity	Unit Price	Institu-tional contri-bution.	Reques-ted from AEC.
12	A	Absorber Set	8, 20	Hamner,AA-1	2	$ 62.50	-	125
13	-	Absorber Set	8, 20	Nue.Chi,C-101	1	105	105	-
14	A	H.V.Power Supply	All	Fluke, 412A	4	455	-	1,820
15	-	H.V.Power Supply	All	B.A., 319	1	390	390	-
16	-	H.V.Power Supply	All	B.A., 312	1	455	455	-
17	A	Linear Amplifier with P.H.A.	7, 12	Hamner, N-328	4	1,070	-	4,280
18	-	Single Channel PHA	7,12,21,22,27	Atom.Inst.510	1	685	685	-
19	A	Scaler	All	TMC, SG3A	4	470	-	1,880
20	A	Scaler	All	TMC, SG3A2	2	600	-	1,200
21	-	Scaler	All	B.A., 132	2	985	1,970	-
22	A	Electronic Timer	3,4,5,6,7,8,9,10, 12,16,17,21,22,23	Hamner, N804	4	425	-	1,700
23	-	Timer	3,4,5,6,7,8,9,10, 12,16,17	B.A., 960	3	110	330	-
24	-	Glow Tube, timer	3,4,6,7,8,9,10, 12,16,17	B.A., 630	1	395	395	-
25	-	Single Channel Scintil-lation Spectrometer	12	B.A., 8200	1	2,670	2,670	-

Ref. No. (Sequential)	Priority	Item	Experiments	Manufacturer & Model	Quantity	Unit Price	Institutional contribution	Requested from AEC.
26	B	Oscilloscope with Hand C^a Plug-ins plus table	5,7,10,12,16,21, 23,25,27	Textronix 531A	2	$1,540	-	3,080
27	-	Oscilloscope	5,7,10,12,16,21, 23,25,27	Textronix 541	1	1,145	1,145	-
28	-	Plug-in Unit	5,7,10,12,16,21, 23,25,27	Textronix 53/54C	1	275	275	-
29	-	Plug-in Unit	5,7,10,12,16,21, 2,3,25,27	Textronix 53/54L	1	185	185	-
30	-	Table	5,7,10,12,16,21, 23,25,27	Textronix	1	108	108	-
31	B	Flow Proportional Detector	3,4,5,7,9,10	Hamner, DP-1	4	75	-	300
32	-	Flo-Counter	3,4,5,7,9,10	Packard 210	2	270	540	-
33	-	Flow Counter	3,4,5,7,9,10	B.A., 821A	1	225	225	-
34	-	4 Pi Counter	3,4,5,7,9,10	Homemade	1	75	75	-
35	B	Pulse Crossover Pick-off Gate	25,27,28	Hamner, N-670	4	250	-	100
36	B	Multi-Channel Coincidence Units	25,27,28	E-H, 101N	~~4~~ 2	725	-	2,900
37	B	Sources & Standards Kit	4,5,6,7,9,10,12, 13,14,15,16,17	Nuc. Chi., Sk-1	2	399	-	798

Ref.No. (Sequen -tial	Prior -ity.	Item	Experiment	Manufac- turer & Model	Quan- tity	Unit Price	Institu -tional contri- bution	Reques -ted from AEC.
38 ✓	B	Radionuclide Set		Nuc.-Chi., RNS-10	4	$ 60	-	$ 240
39 ✓	B	Alpha-Beta-Gamma Survey Meter	2, 10, 11	Nuc.-Chi., 2612P	1	299	-	299
40 ✓	B	Probe	2, 10, 11	Nuc.-Chi., P15	1	36	-	36
41 ✓	B	GM-tube	2, 10, 11	Nuc.-Chi, D-50	1	16	-	16
42 ✓	B	Cutie Pie Survey Meter	2, 10, 11	Nuc.-Chi, 2586-S	1	480	-	480
43 ✓	B	Pocket Chamber	All	Nuc.-Chi, L-65	24	8	-	192
44 ✓	B	Charger-Reader	All	Nuc.-Chi, L-60	1	136	-	136
45 ✓	B	Radiation Warning Tape	All	Nuc.-Chi. N-2	1	7	-	7
46 ✓	B	Radiation Warning Signs	All	Nuc.-Chi, N-5A	12	-	-	3
47 ✓	B	Radiation Warning Stickers	All	Nuc.-Chi, N-5B	6	-	-	2
not absolutely necessary ~~*48~~	C	256 Channel PHA Complete with readout and printant	3,10,13,14,15, 21,27	Nuc. Data, ND102	1	12,205	-	12,205
49 ✓	C	Neutron Howitzer	22, 23	Nuc.-Chi. NH-3	1	1,268	-	1,268
50 ✓	C	BF3 Neutron Detector	22, 23	Nuc.-Chi, NC-206	2	215	-	430
✓✓ 51	C	Preamplifier	22, 23	Nuc.-Chi., 1062	1	218	-	218

This can be built

Ref.No. (Sequen-tial)	Prior-ity	Item	Experiment	Manufac-turer & Model	Quan-tity	Unit Price	Institu-tional contri-bution	Requested from AEC.
52	C	Foil Kit		Nuc.-Chi., FHK-1	1	$ 455	-	$ 455
53	C	High Range Chamber, 5cc	11	Nuc.-Chi. P18	1	151	-	151
54	C	Neutron Survey Meter	11	Nuc.-Chi,2112-N	1	676	-	676
55	C	Alpha Probe		Nuc.-Chi.,AP4	1	156	-	156
56	C	Gas Pressure Regulator	3,4,5,7,9,10	Nuc.-Chi.,VK3	4	44	-	176
57	C	"Q" Gas and Cylinder	3,4,5,7,9,10	Nuc.-Chi.,GQ-1	5	71	71	284
58	C	"R" Gas and Cylinder	3,4,5,7,9,10	Nuc.-Chi.GP-100	4	81	-	324
59	-	Argon-Methane Gas &Cylinder	3,4,5,7,9,10	-	2	75	150	-
60	-	Methane Gas and Cylinder	3,4,5,7,9,10	-	3	75	225	-
61	-	"P-10" Gas and Cylinder	3,4,5,7,9,10	-	3	75	225	-
*62	D	Integrated Spectrometry System	3,10,13,14,15, 21,27	Nuc.-Chi.,803	1	7,020	-	7,020
*63	D	Linear Count Ratemeter	3,10,13,14,15, 21,27	Nuc.Chi.8350	1	1,092	-	1,092
*64	D	Single Channel Graphic Recorder	3,10,13,14,15, 21,27	Nuc.Chi,8410	1	1,187	-	1,187
65	D	1 Year Film Badge Service	All	Nuc.Chi,X-B-G	30	7.20	-	216
66	C	Pu-Be Neutron Source,1Curie	22, 23	Numec	3	840	-	2,520
67	C	Pu-Be Neutron Source, 2 Curie	22, 23	Numec	1	930	-	930
							$15,814	$53,672

Can be omitted

For starred items, 48,62,63 & 64, see explanatory note at the end of section 7 (page 35)

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