The Project Physics Course

Unit 5 Transparencies

Models of the Atom

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Transparencies

UNIT 5

Models of the Atom

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Project Physics
Overhead Projection Transparencies
Unit 5

Periodic Table

Periodic Table

This transparency will be useful in discussions centered around the classification of the elements. Various overlays highlight chemical families and other pertinent groupings.

Overlay A	The modern long form of the Periodic Table. The number below each chemical symbol represents the element's atomic number. The Roman numerals identify the Groups or Families. The numbers to the left of Group I identify the Periods.
Overlay B	This includes the 62 elements which Mendeleef included in his 1872 classification. His grouping was, of course, unlike the present long form. Rather it resembled the modern "short" form of the Table. Remove this overlay.
Overlay C	The Alkali Metal Family (Group I).
Overlay D	The Halogen Family (Group VII).
Overlay E	The Noble Gas Family (Group O).
Overlay F	The elements known as the Transition Elements. Remove Overlays C, D, E, and F.
Overlay G	The Natural Radioactive Elements. Those which undergo β-decay only are tinted lighter. Technetium (Tc, Atomic Number 43) is a synthetic element.
Overlay H	The Transuranium Elements. These have all been synthesized in the laboratory.

Periodic Table of the Elements

Period	I	II											III	IV	V	VI	VII	0
1	H 1																	He 2
2	Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
3	Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
4	K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
5	Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
6	Cs 55	Ba 56		Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
7	Fr 87	Ra 88																

La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lw 103

A
B

Periodic Table of the Elements

Elements Included in 1872 Mendeleef Classification

Period	I	II											III	IV	V	VI	VII	0
1	**H 1**																	He 2
2	**Li 3**	**Be 4**											**B 5**	**C 6**	**N 7**	**O 8**	**F 9**	Ne 10
3	**Na 11**	**Mg 12**											**Al 13**	**Si 14**	**P 15**	**S 16**	**Cl 17**	Ar 18
4	**K 19**	**Ca 20**	Sc 21	**Ti 22**	**V 23**	**Cr 24**	**Mn 25**	**Fe 26**	**Co 27**	**Ni 28**	**Cu 29**	**Zn 30**	Ga 31	Ge 32	**As 33**	**Se 34**	**Br 35**	Kr 36
5	**Rb 37**	**Sr 38**	**Y 39**	**Zr 40**	**Nb 41**	**Mo 42**	Tc 43	**Ru 44**	**Rh 45**	**Pd 46**	**Ag 47**	**Cd 48**	**In 49**	**Sn 50**	**Sb 51**	**Te 52**	**I 53**	Xe 54
6	**Cs 55**	**Ba 56**		Hf 72	**Ta 73**	**W 74**	Re 75	**Os 76**	**Ir 77**	**Pt 78**	**Au 79**	**Hg 80**	**Tl 81**	**Pb 82**	**Bi 83**	Po 84	At 85	Rn 86
7	Fr 87	Ra 88																

La 57	**Ce 58**	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	**Er 68**	Tm 69	Yb 70	Lu 71
Ac 89	**Th 90**	Pa 91	**U 92**	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lw 103

Periodic Table of the Elements

Alkali Metals · Noble Gases · Transition Elements · Halogens

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2	Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
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6	Cs 55	Ba 56		Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
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7	Fr 87	Ra 88																

Radioactive Elements

La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lw 103

Periodic Table of the Elements

Period	I	II											III	IV	V	VI	VII	0
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7	Fr 87	Ra 88																

Radioactive Elements

Transuranium Elements

La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lw 103

T36

Photoelectric Experiment

Photoelectric Experiment

This transparency can be used to help students visualize the mechanism of the photoelectric effect and the method of measuring the stopping voltage.

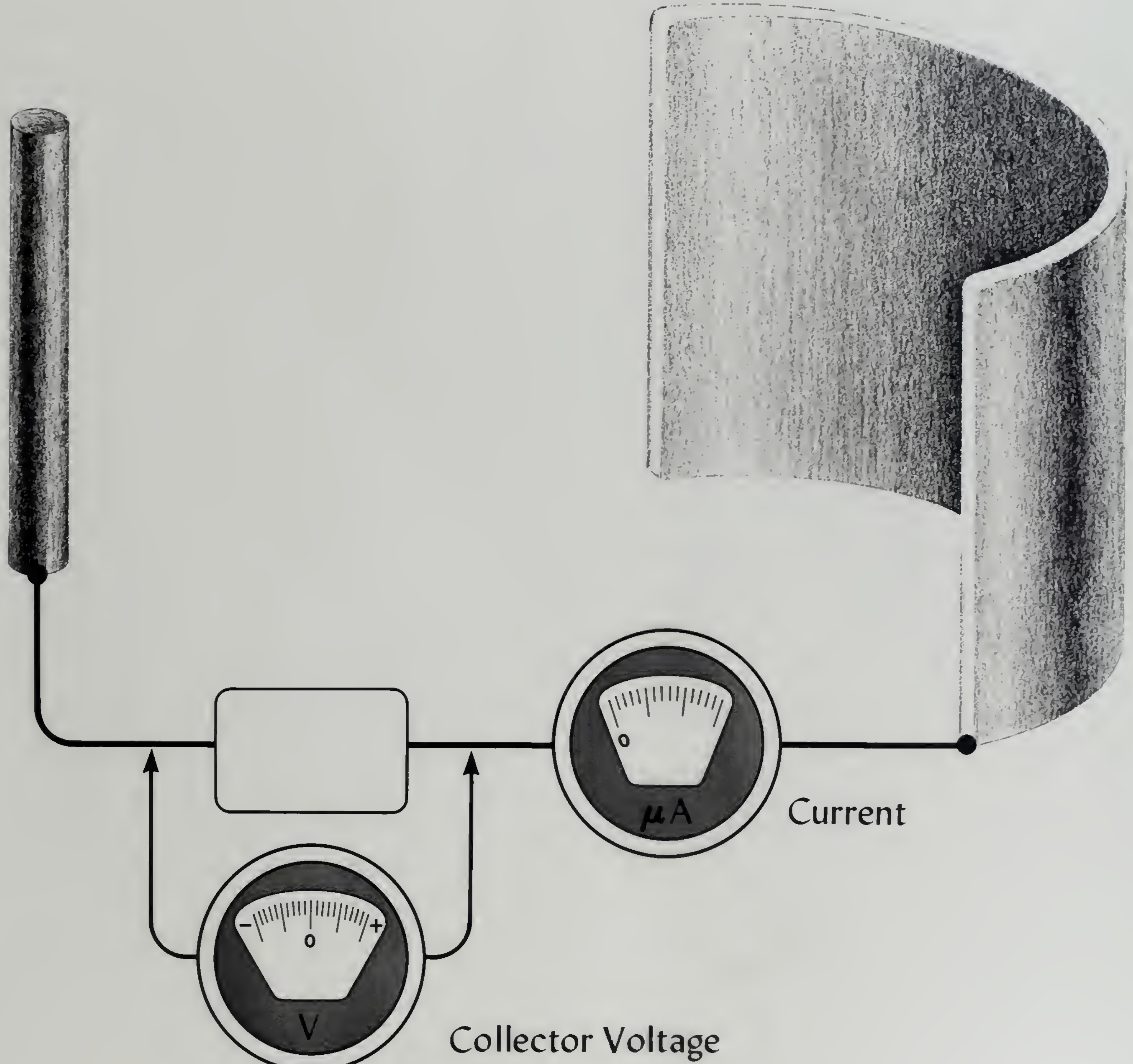
Overlay A A schematic diagram is presented of the photoelectric tube connected to a micro-ammeter, voltmeter, and a power supply (the empty rectangle above the voltmeter) The curved emitter is on the right and the collecting rod is on the left. Note that the circuit is open between the emitter and collector.

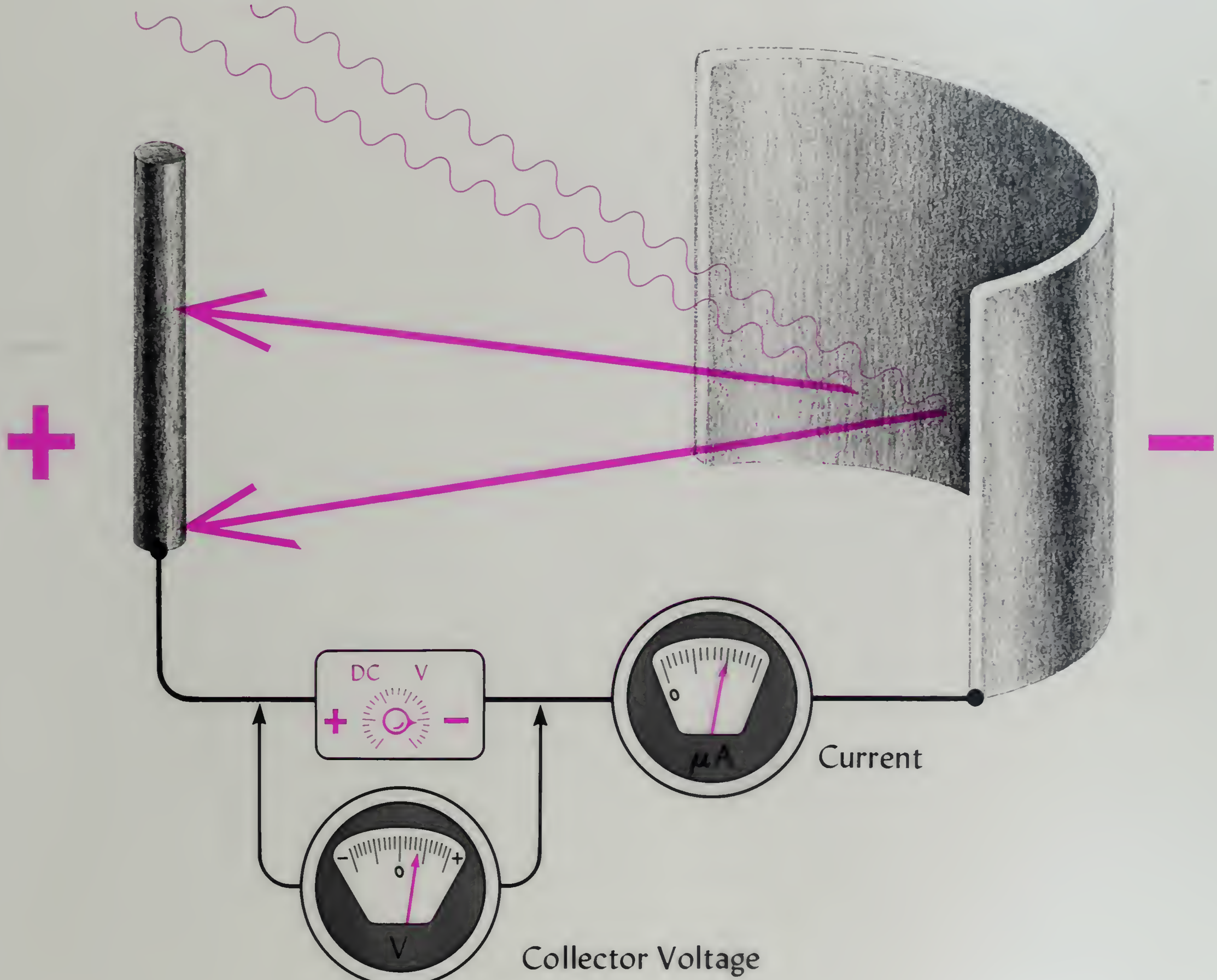
Overlay B When the DC power supply provides a positive bias on the collecting rod, the voltmeter indicates this positive potential. Photons of a particular frequency are depicted coming in to the emitter. These photons eject photoelectrons whose paths are illustrated by arrows. The negative photoelectrons complete the circuit as they accelerate toward the positive collector and register a current on the micro-ammeter. Remove this overlay and introduce overlay C.

Overlay C The bias on the collecting rod is now made negative by reversing the terminals on the power supply. The voltmeter indicates this reversal. Now as photons eject photoelectrons they are slightly repelled by the negative field surrounding the collecting rod. As a result, only the more energetic photoelectrons get to the collector. The resulting reduction in current is shown as a lower reading on the ammeter. Remove this overlay and introduce overlay D.

Overlay D An increased voltage is applied to the collector. When it is sufficiently high it will stop all photoelectrons (note zero reading on ammeter). This "stopping voltage" can be used as a measure of the maximum kinetic energy of the photoelectrons.

A

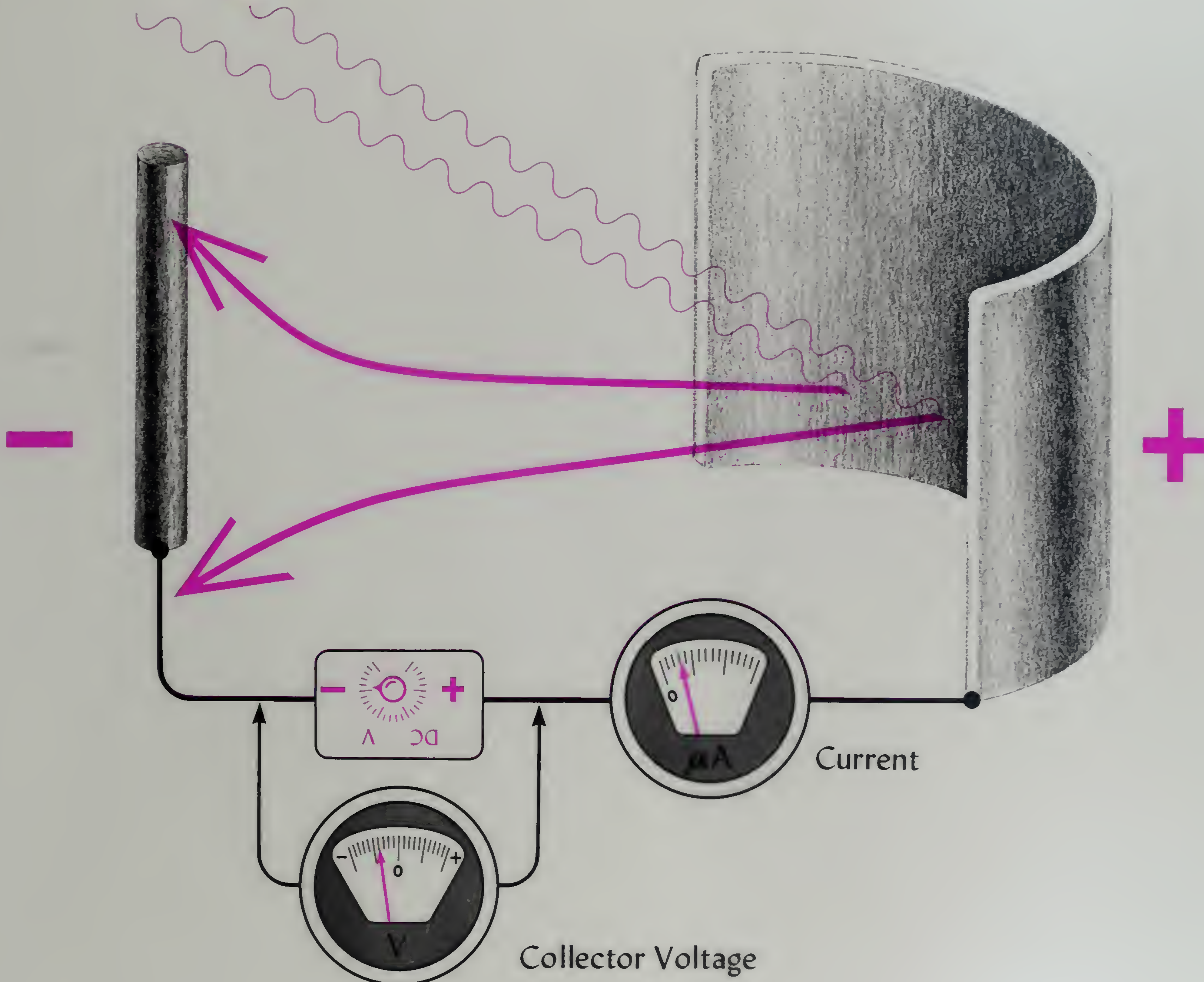



+
−
DC V
+ −
μA
Current
V
Collector Voltage

T-36

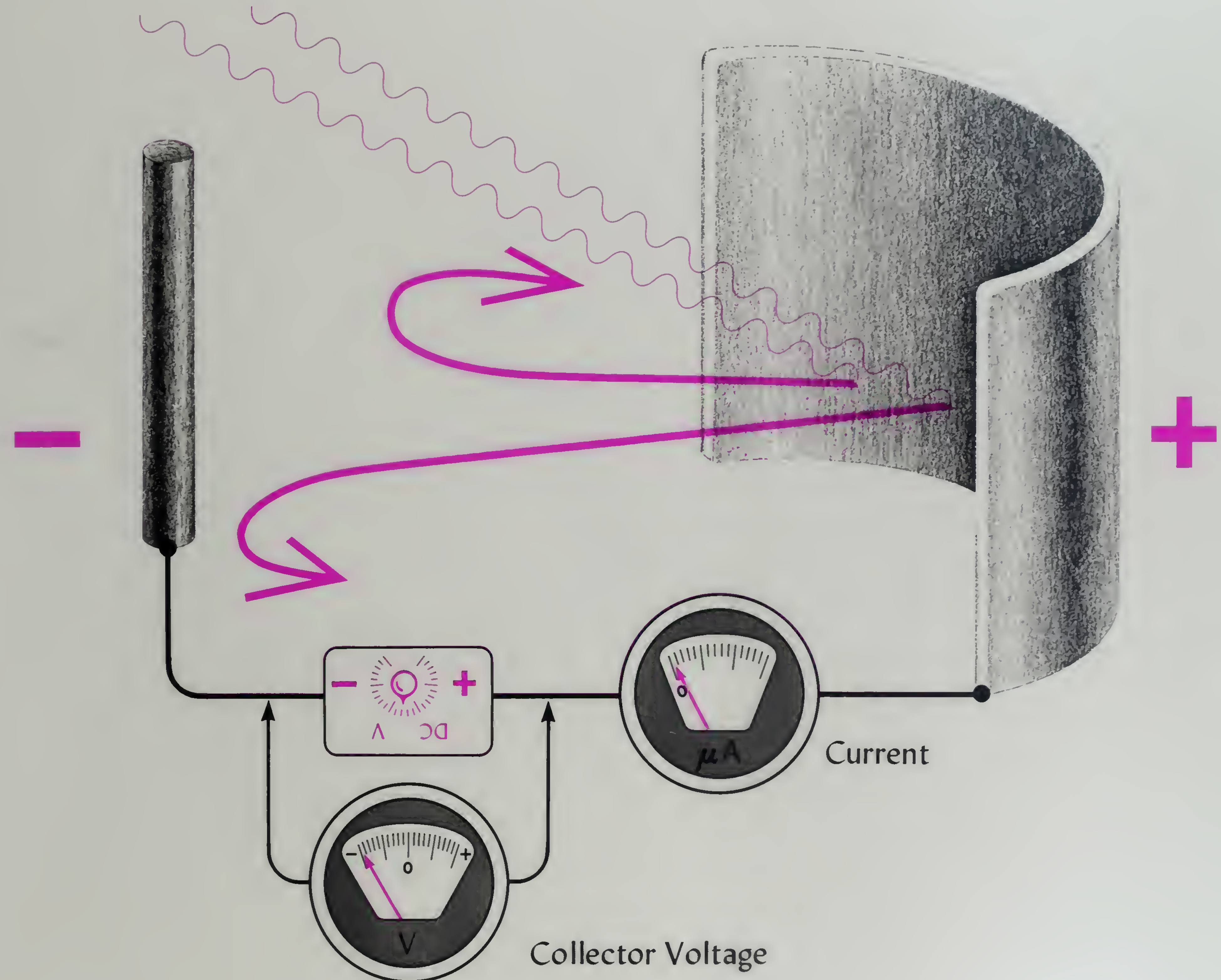
A

C



A

D



T37

Photoelectric Equation

Photoelectric Equation

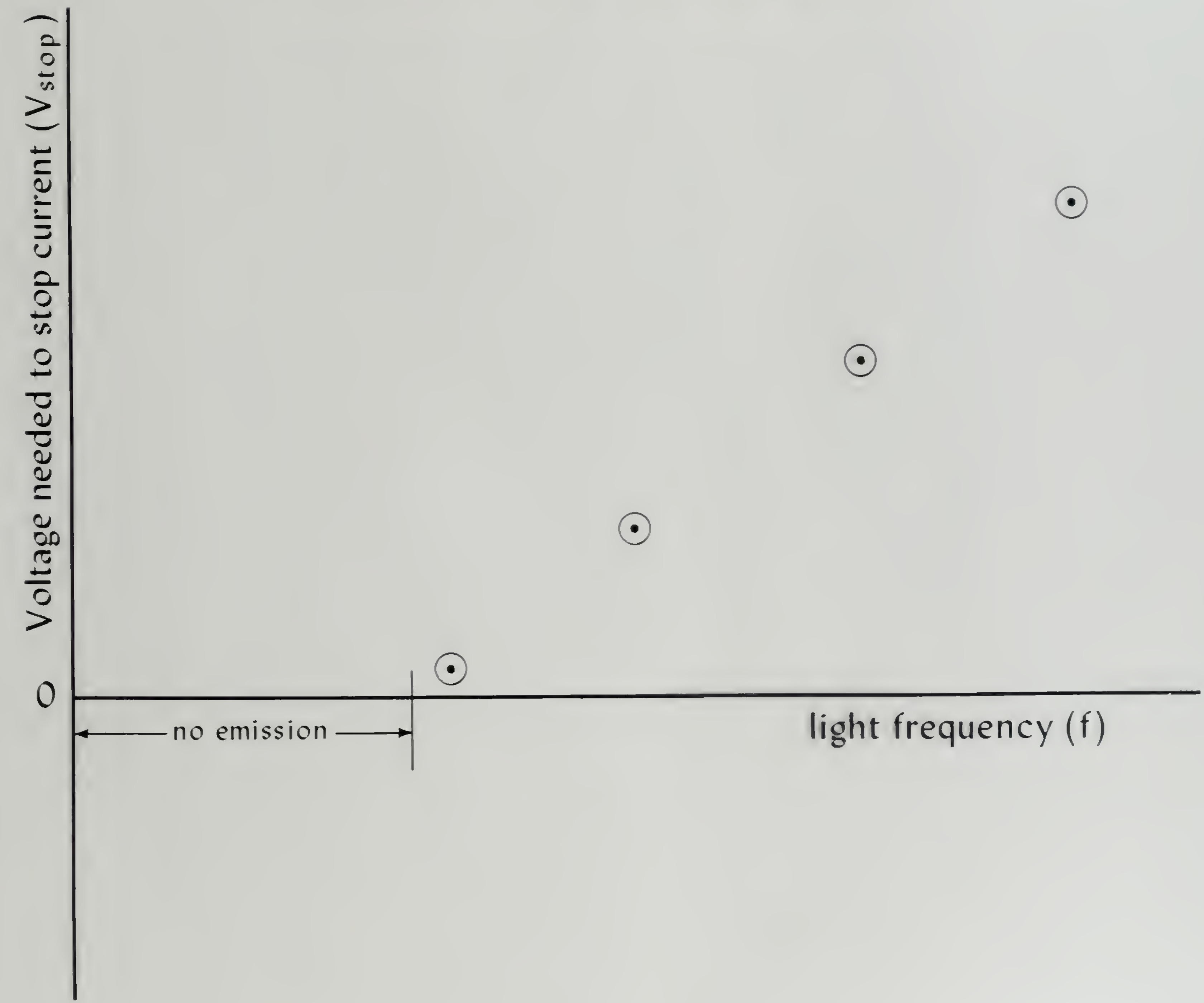
This transparency will be useful in analyzing data obtained from experiments dealing with stopping voltage (see T36). With it you can arrive at the Einstein photoelectric equation.

Overlay A A plot of typical experimental data on the voltage required between the terminals of a vacuum phototube to reduce the tube current to zero. Remove this overlay and introduce overlay B.

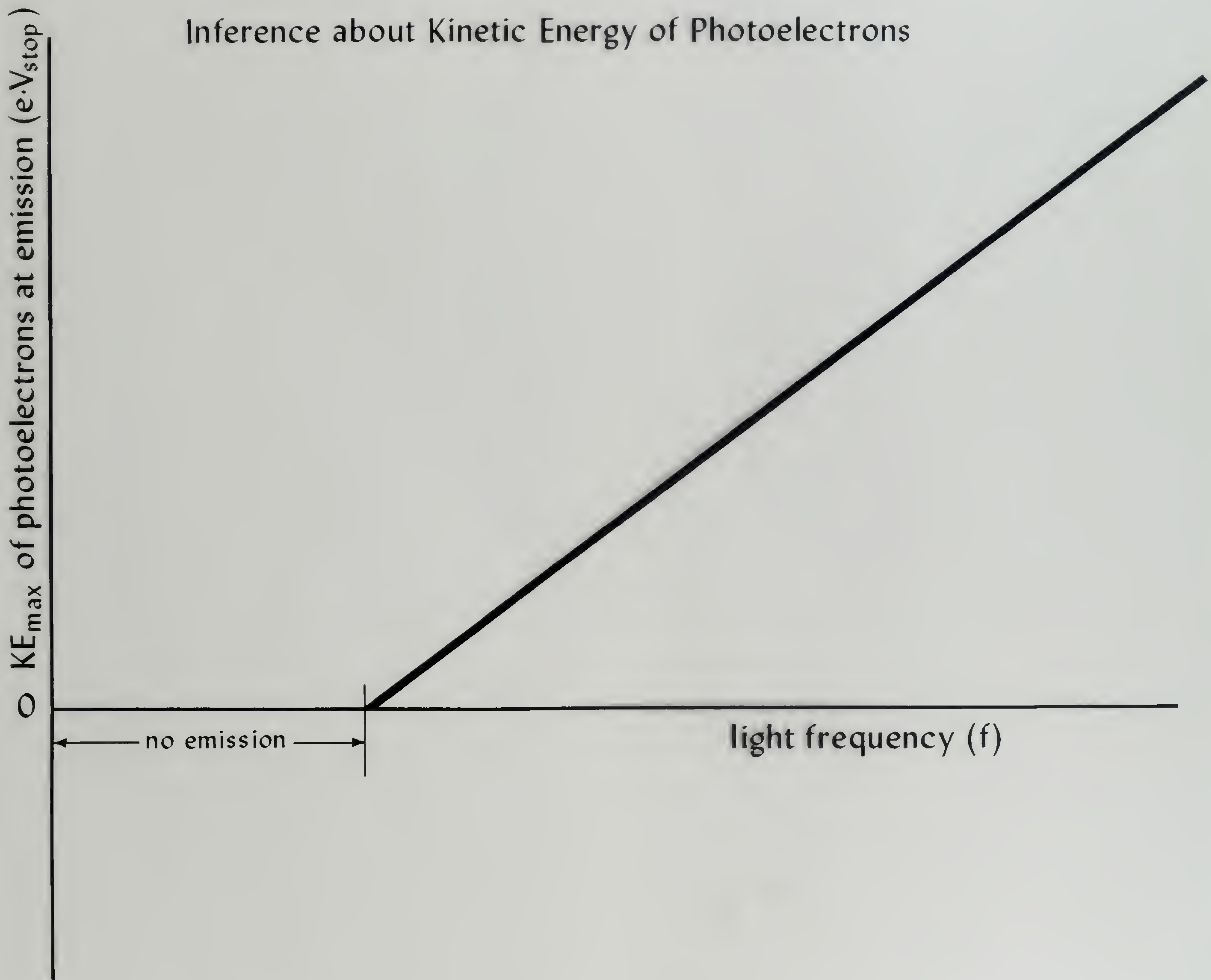
Overlay B Such data imply that the maximum kinetic energy of the emitted photoelectrons is proportional to the frequency of the incident photons. Remove this overlay and introduce overlay C.

Overlay C This shows Einstein's interpretation of the data in terms of a "work function" W, an amount of energy that must be supplied to the electrons before they can escape the surface. The energy supplied to the electron by the photon is hf, so the emission energy $KE_{max} = hf - W$.

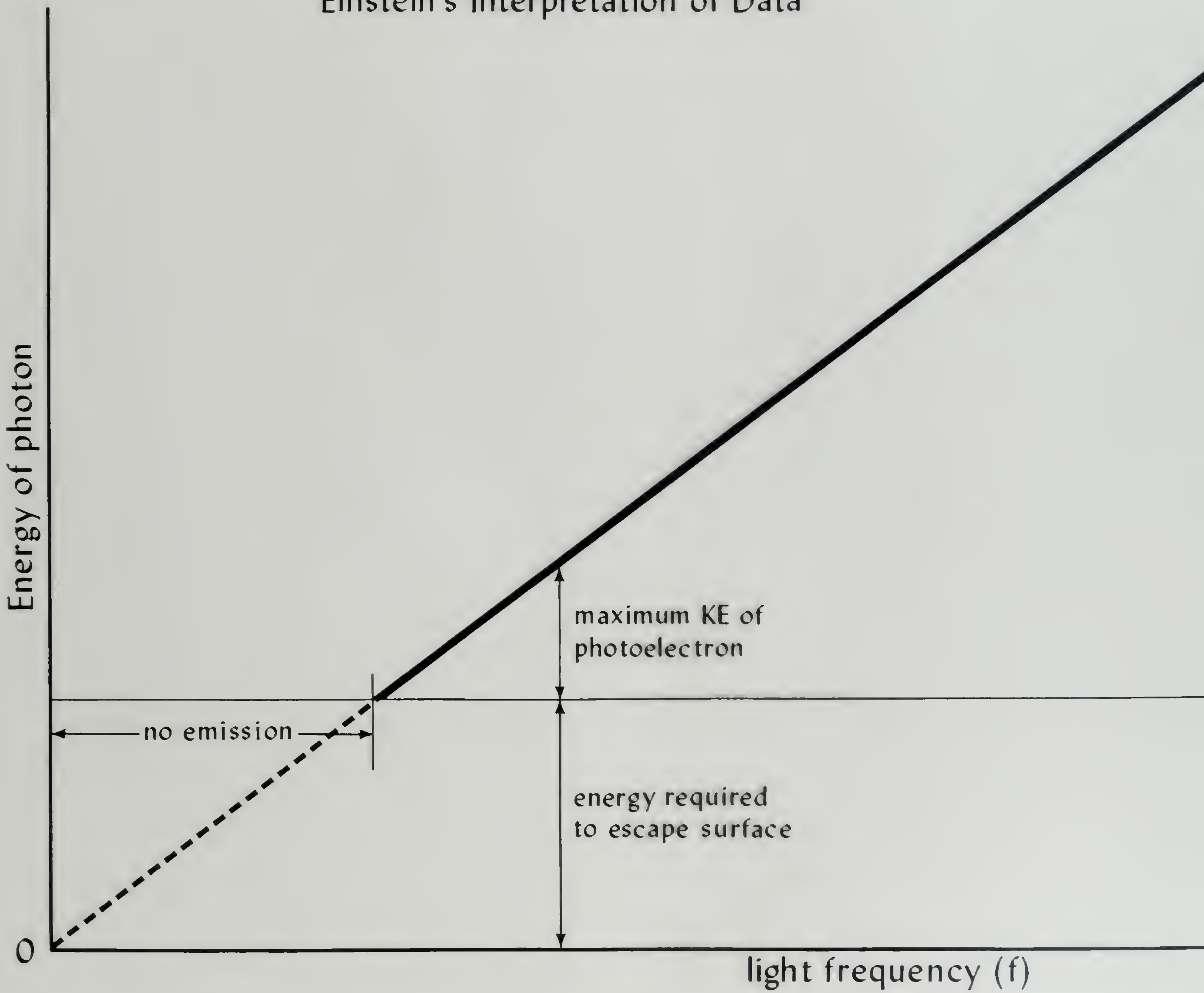
Experimental Data on "Stopping Voltages"



B


Inference about Kinetic Energy of Photoelectrons
KE$_{max}$ of photoelectrons at emission (e·V$_{stop}$)
0
no emission
light frequency (f)

Einstein's Interpretation of Data



Alpha Scattering

Alpha Scattering

This transparency is useful in discussing Rutherford's alpha particle scattering experiment and in contrasting the Thomson and Rutherford models.

Overlay A — A diagrammatic sketch of the Rutherford scattering experiment. A magnifying glass (not shown) could be moved around the ZnS screen to detect flashes produced by the alpha particles as they strike the screen.

Overlay B — Shows the expected results of the scattering experiment under the assumption that matter is composed of Thomson atoms. Note that there is very little deflection. Remove this overlay and add overlay C.

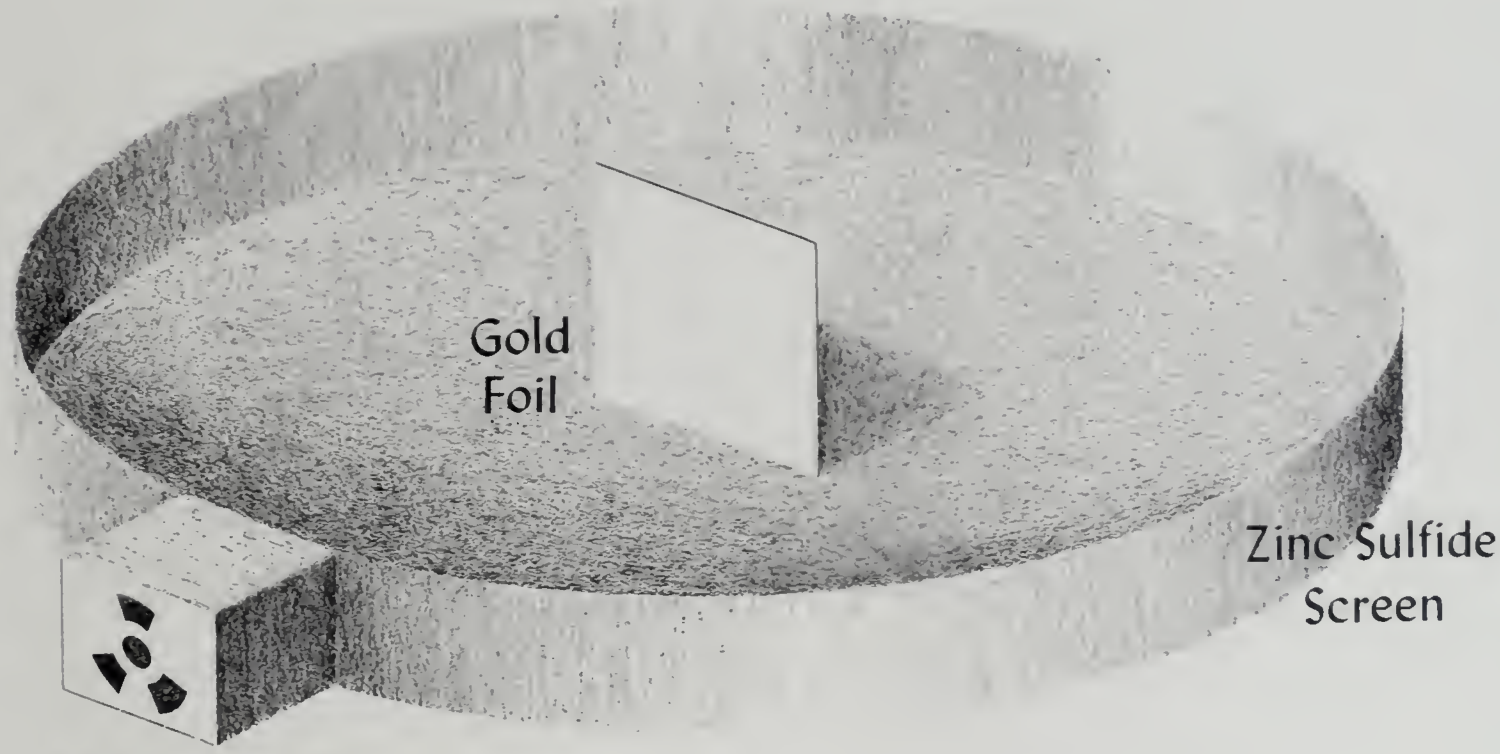
Overlay C — These are the results which Rutherford and his co-workers actually observed. The large deflections required a completely new explanation of the structure of the atom. Remove overlays A and C and introduce overlay D.

Overlay D — Two representations of the Thomson model are shown. The left side depicts large (1Å diameter) spheres of positive electrification with negative electrons imbedded in them "like raisins in a muffin". The right side shows a "potential hill" which positive alpha particles encounter like marbles rolling up a slope. Relatively small deflections will be caused by this hill.

Overlay E — The paths of alpha particles would be only slightly deviated as they pass through Thomson atoms.

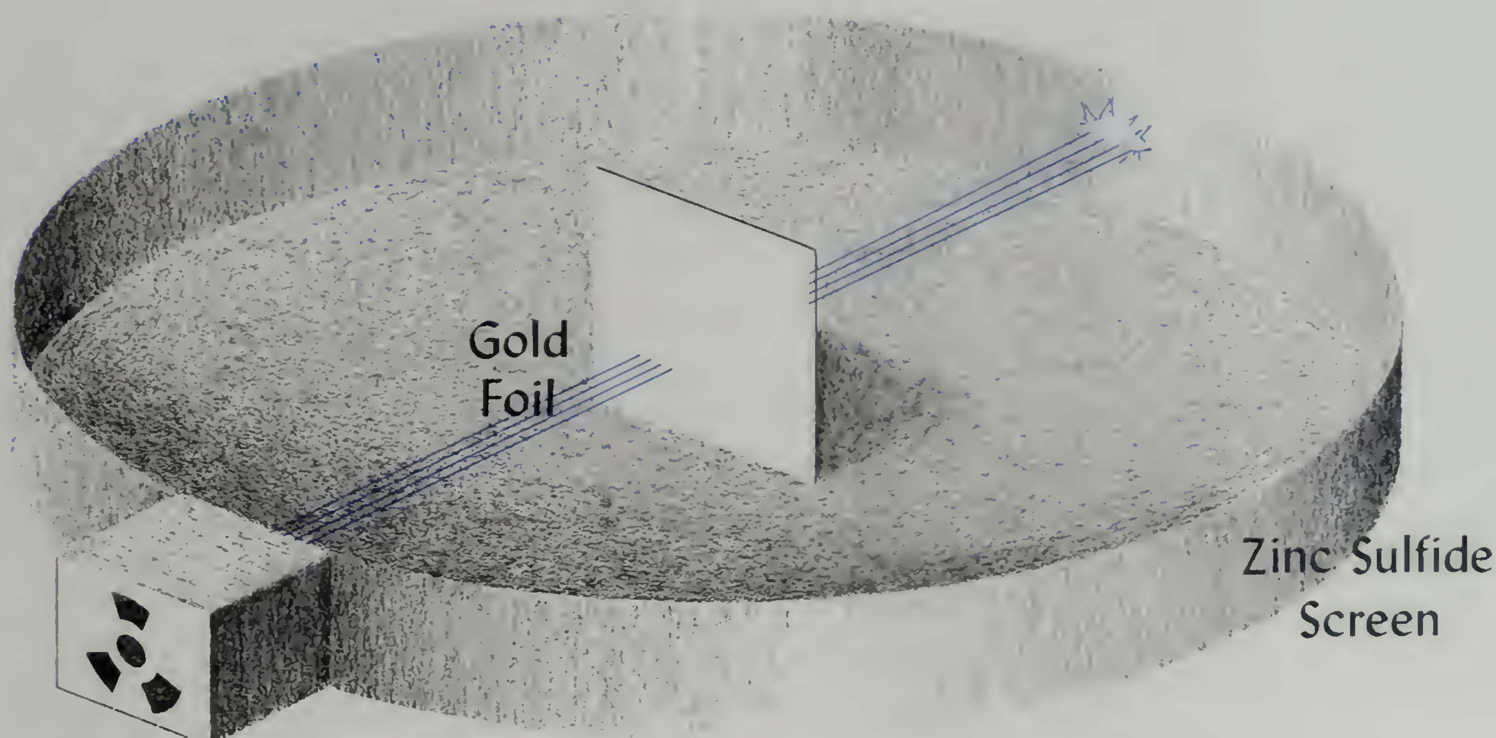
Overlay F — The Rutherford modification on the Thomson model will account for the large deflections actually observed in experiments. The new model contains a very small positive nucleus with negative electrons surrounding it. This allows a close approach by alpha particles and a consequent large deflection. The "potential hill" model is also adapted to a very steep slope (greatly broadened in the diagram) causing sharp deflections the closer the particles approach the center. Remove overlays D and E and introduce overlay G.

Overlay G — Alpha particle deflections now match observations.


Gold
Foil
Zinc Sulfide
Screen
Alpha Particle
Source

A
B

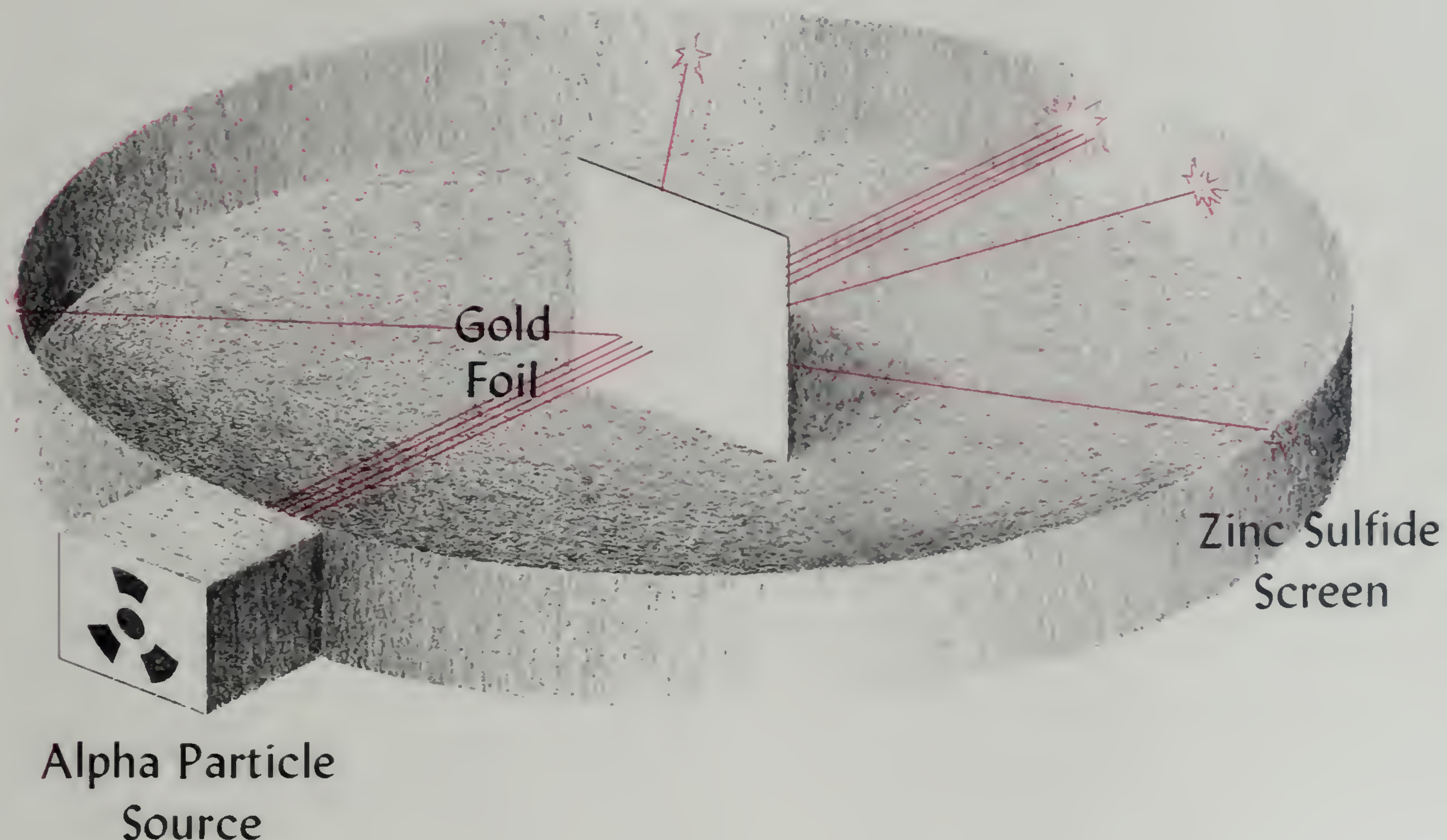
Results expected
with Thomson Model



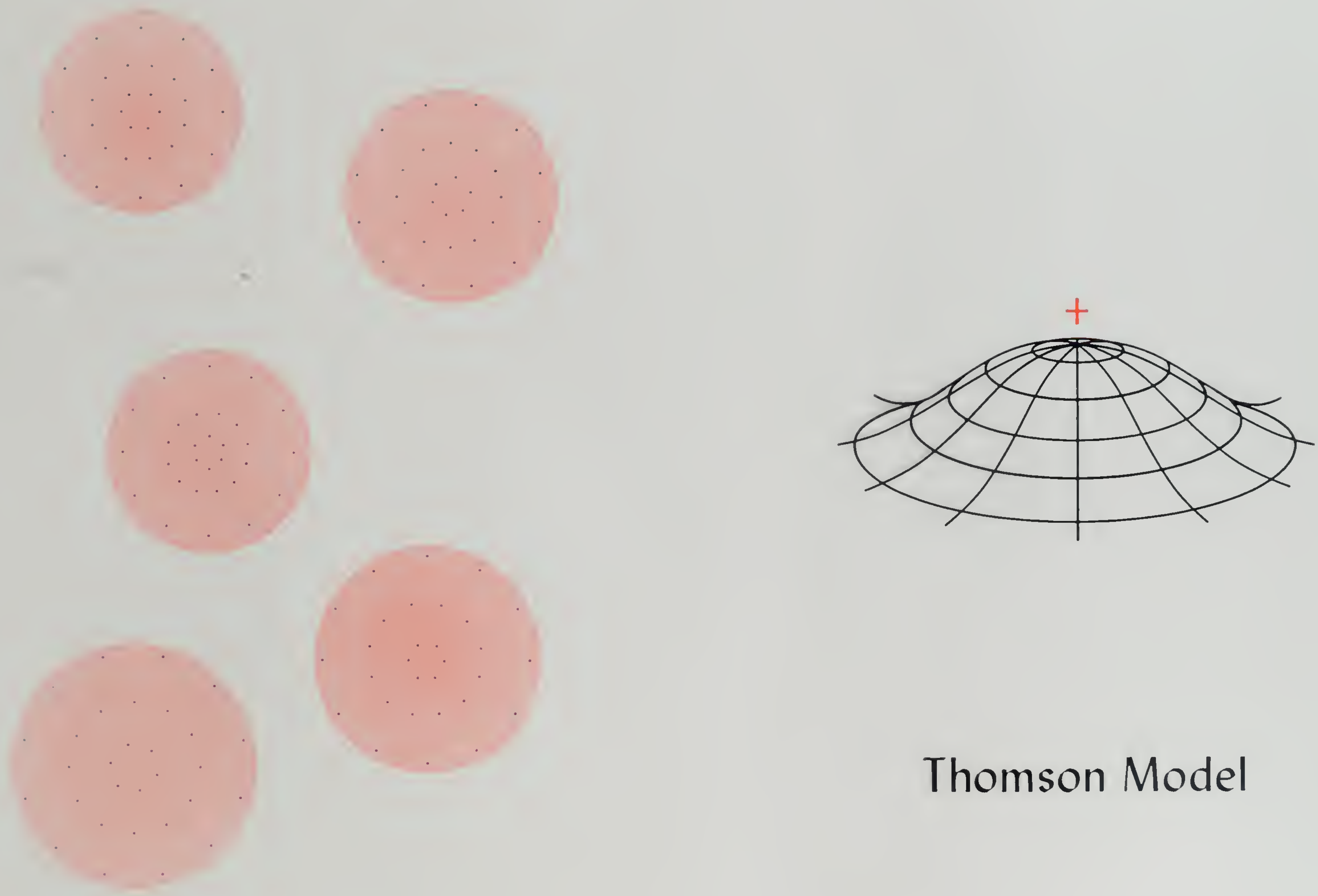
A

C

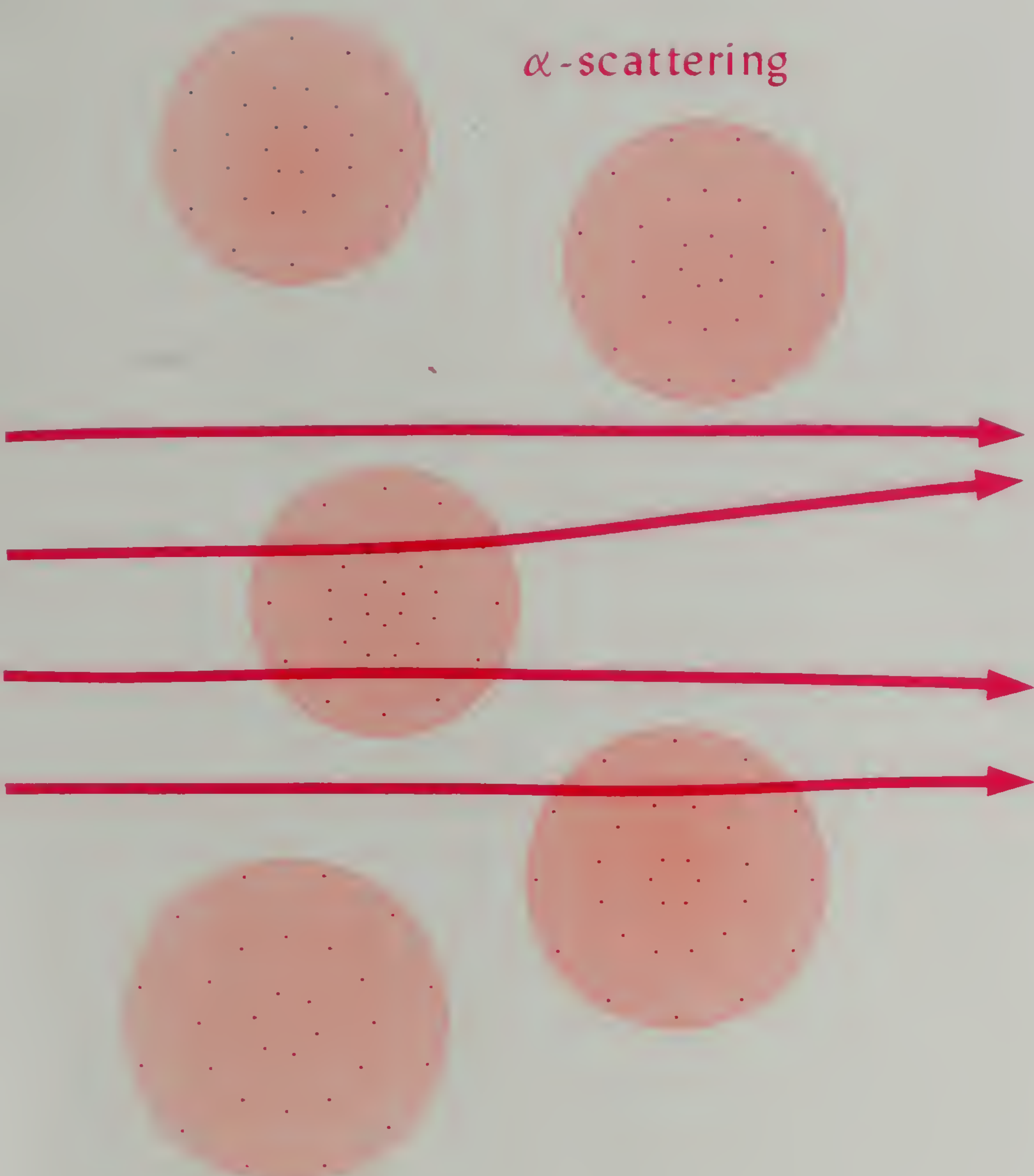
Results obtained
by Rutherford

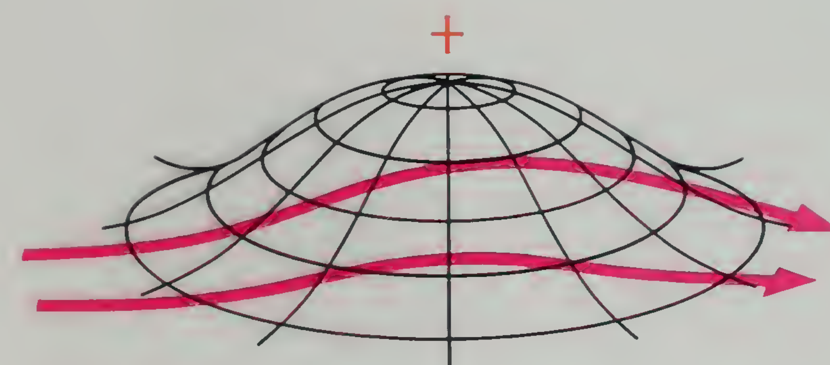


D

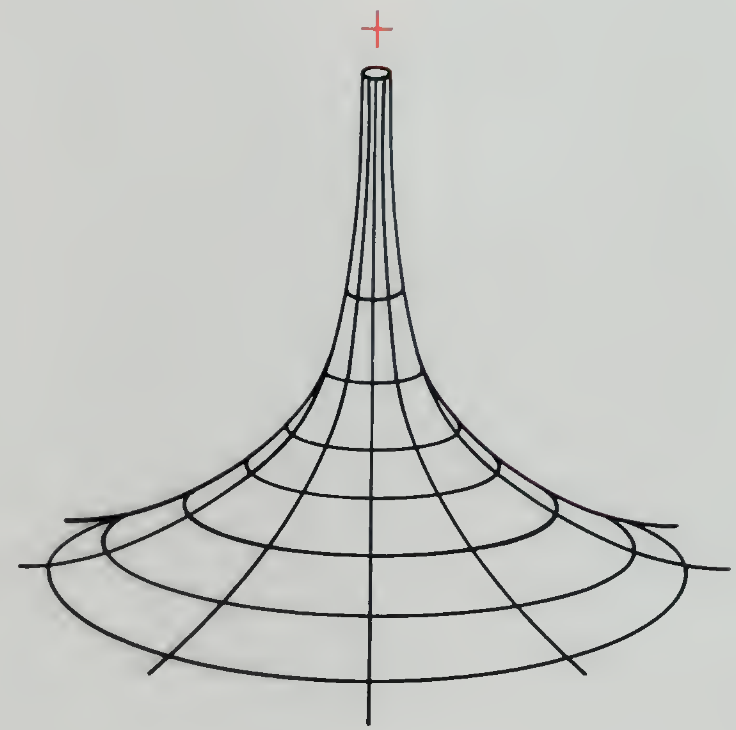


Thomson Model

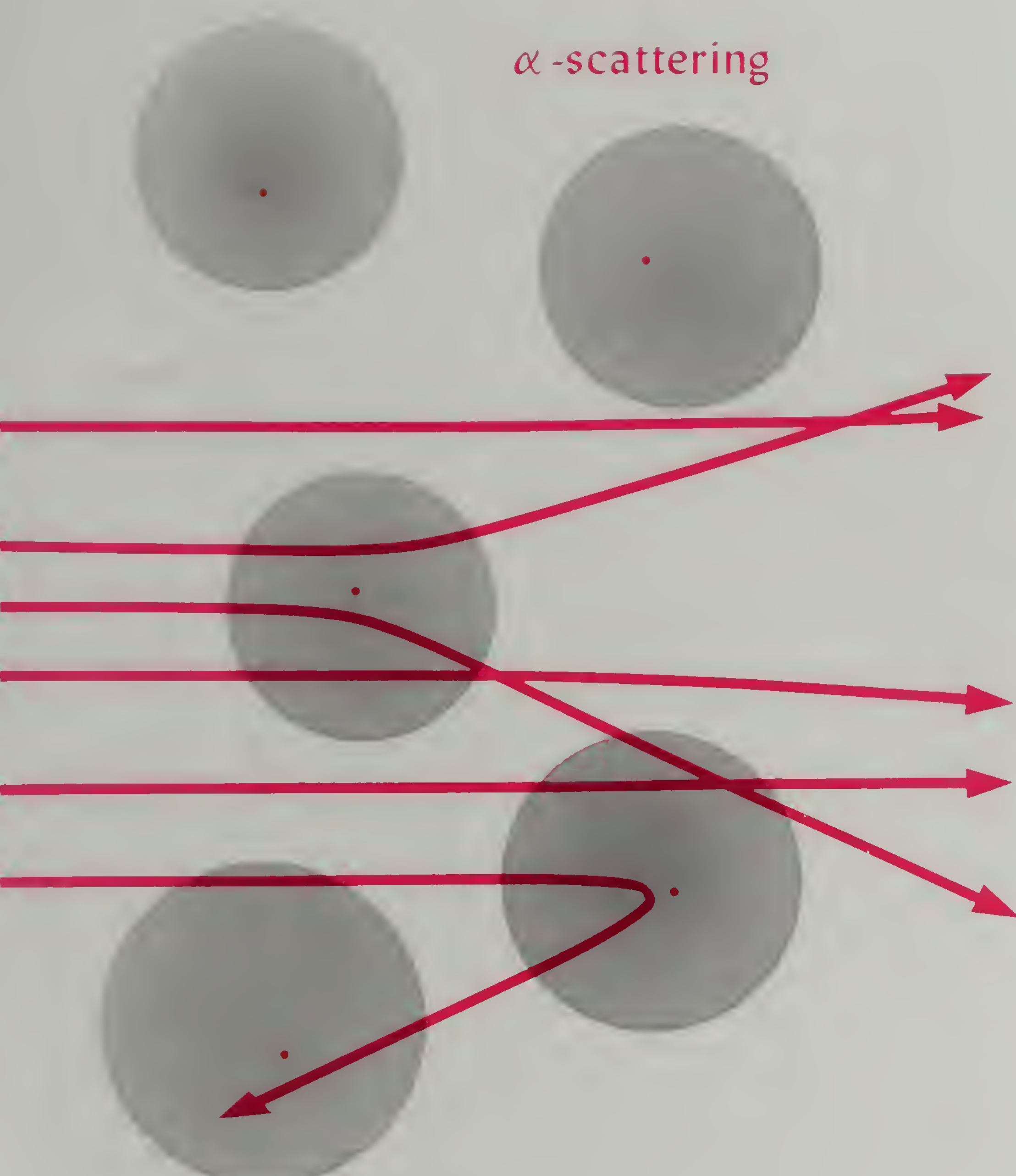


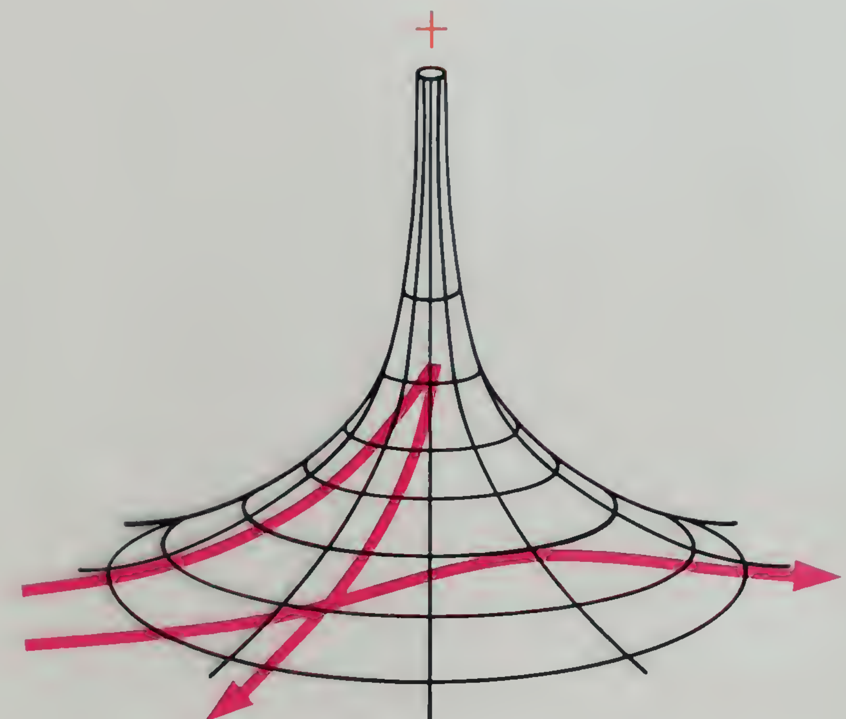


Thomson Model



Rutherford Model





Rutherford Model

Energy Levels — Bohr Theory

Energy Levels — Bohr Theory

This transparency will be useful in relating the Bohr theory of energy levels to the spectrum of hydrogen. It includes a general treatment of the Lyman, Balmer and Paschen Series with a more detailed coverage of the Balmer Series.

Overlay A — On the left the Bohr orbits for hydrogen are drawn to scale (since the radii should increase according to the expression $R_n = 0.5\text{Å}\, n^2$). An energy level diagram is included on the right, and a space for spectral lines across the bottom. Introduce overlays B, C and D in order.

Overlay B — Representations of electron quantum "falls" from higher energy levels to the ground state. The resulting emission of the Lyman Series is shown in the spectrum window.

Overlay C — The Balmer Series is produced by excited electrons falling back to the second energy level.

Overlay D — The Paschen Series is produced by excited electrons falling back to the third energy level. Remove overlays B, C and D. Add the remaining overlays in order.

Overlay E — The H_α line in the Balmer Series is produced by an excited electron falling from the third energy level to the second. Note that the scale of the spectral line representation has been changed.

Overlay F — The H_β line in the Balmer Series is produced by an excited electron falling from the fourth energy level to the second.

Overlay G — The H_γ line in the Balmer Series is produced by an excited electron falling from the fifth energy level to the second.

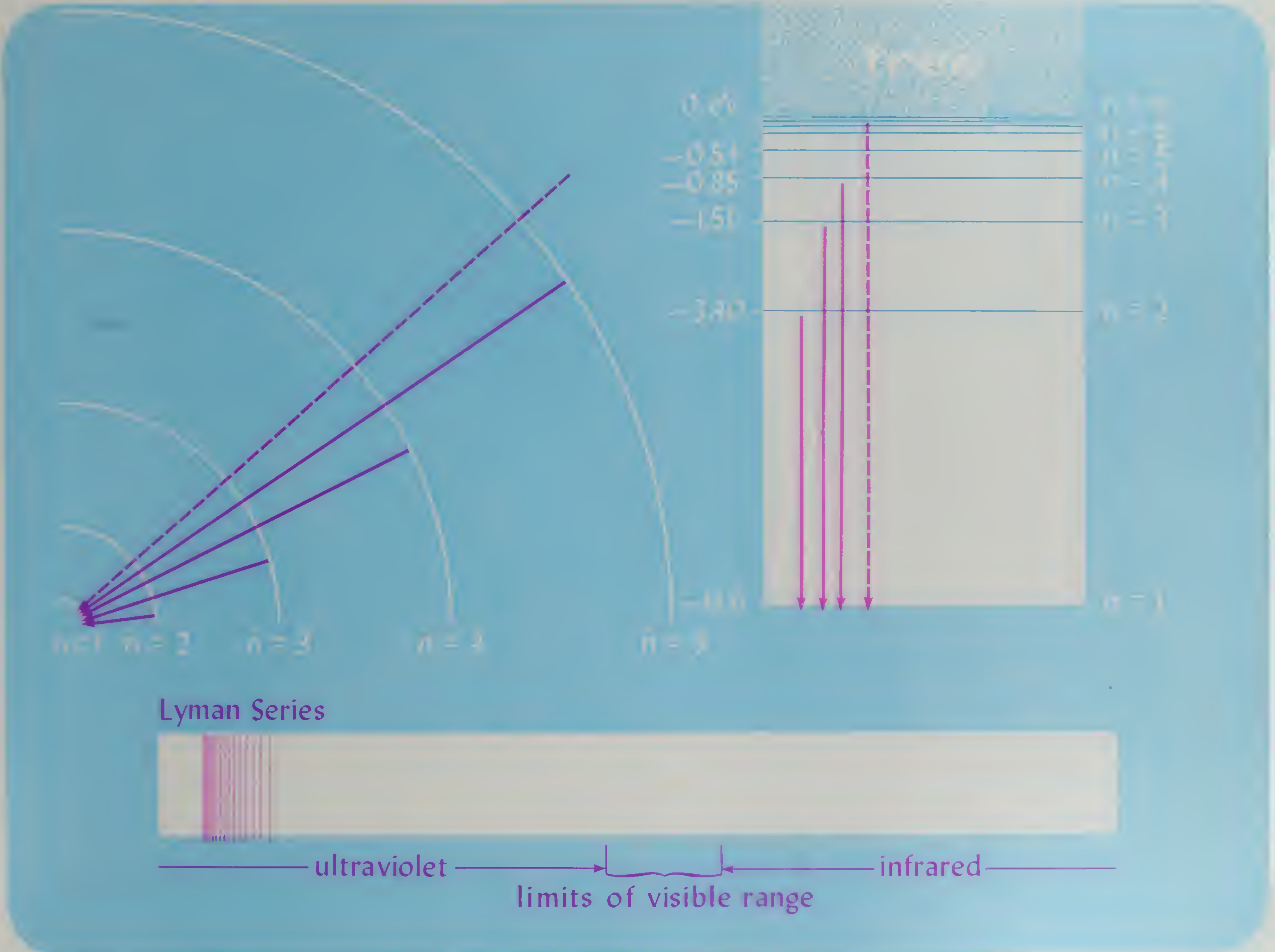
Overlay H — The H_γ line in the Balmer Series is produced by an excited electron falling from the sixth energy level to the second.

Overlay I — The limit of the Balmer Series is approached as excited electrons from energy levels higher than $n = 6$ fall back to energy level 2.

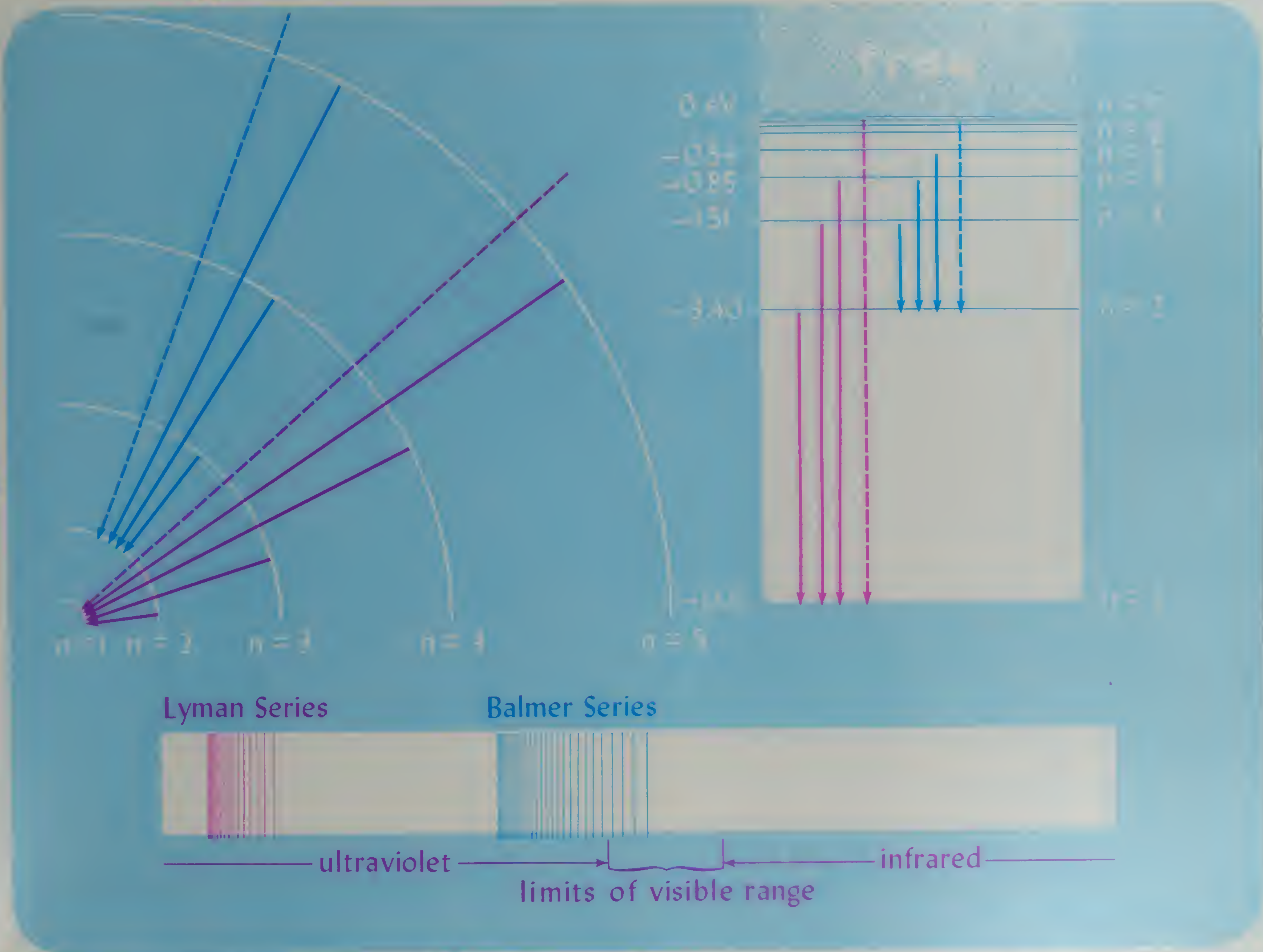

0 eV
−0.54
−0.85
−1.51
−3.40
n = 3
n = 2
n = 1
n=1
n = 2
n = 3
n = 4
n = 5

A

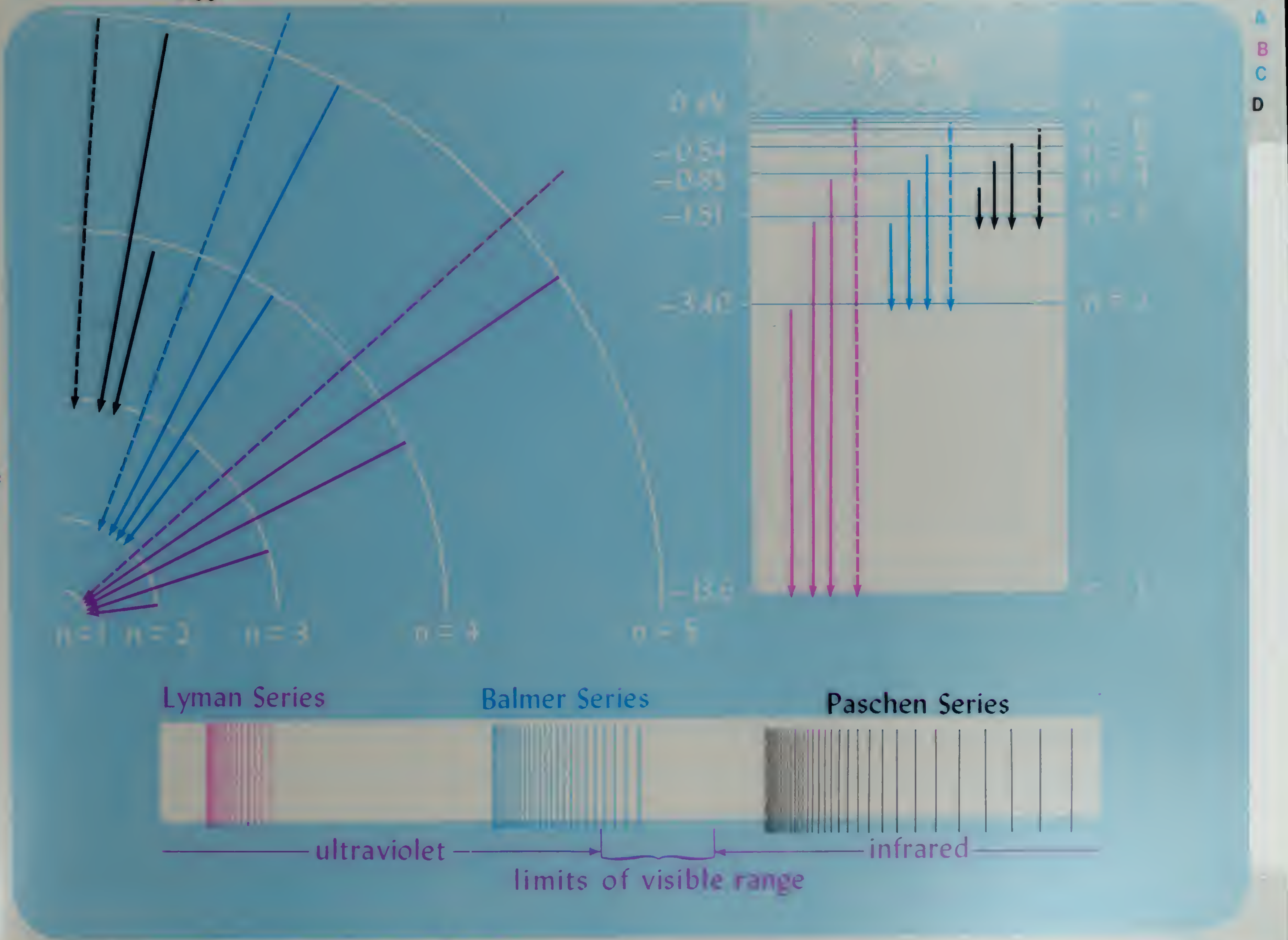
B



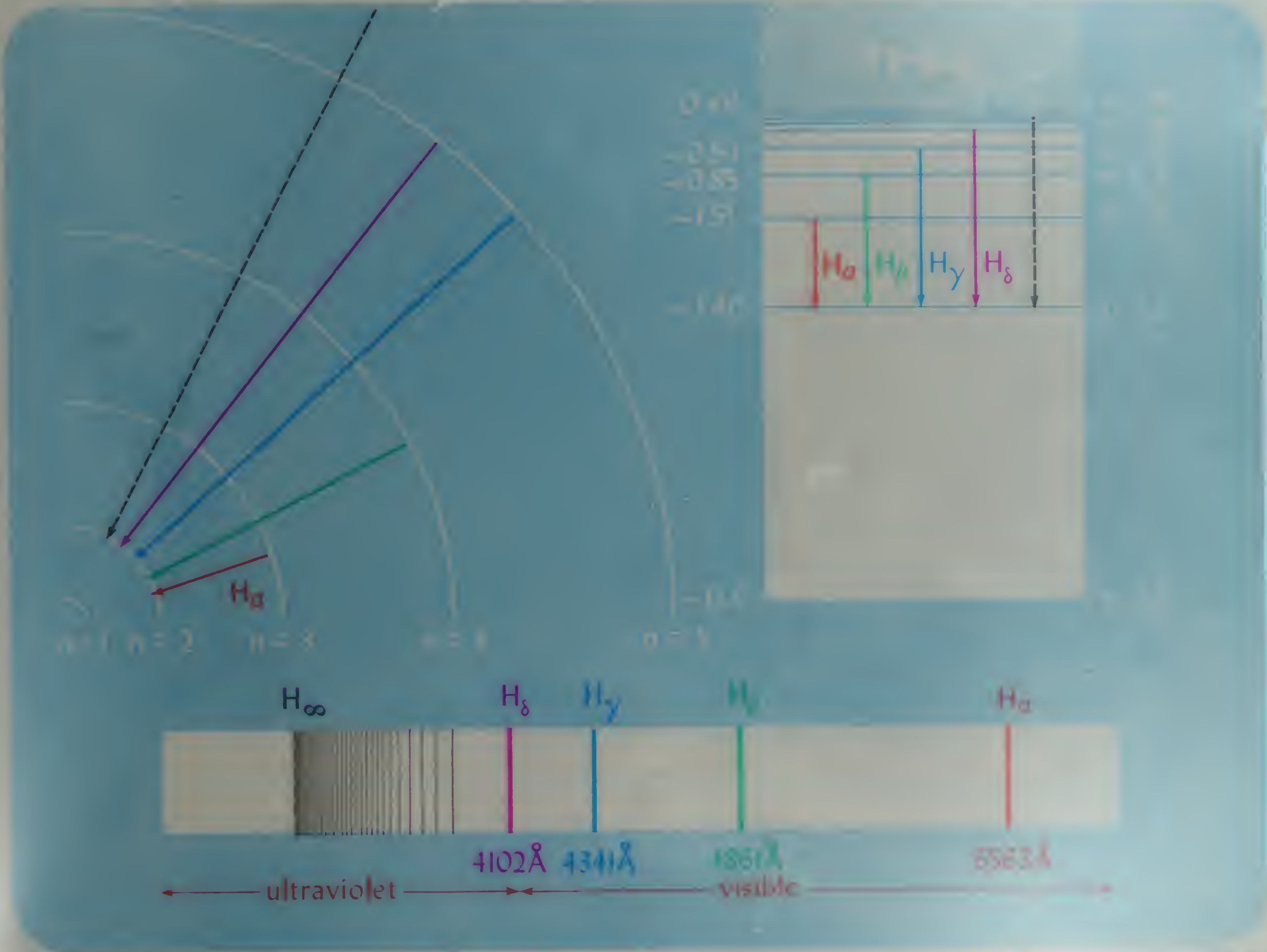
−0.54
−0.85
−1.51
Lyman Series
ultraviolet
infrared
limits of visible range


Lyman Series
Balmer Series
ultraviolet
infrared
limits of visible range

A
B
C


0 eV
−0.54
−0.85
−1.51
−3.40
−13.6
n = 1 n = 2
n = 3
n = 4
n = 5
Lyman Series
Balmer Series
Paschen Series
ultraviolet
infrared
limits of visible range

T-39



0 eV
−0.85
−1.51
Hα
Hβ
Hγ
Hδ
n = 2
n = 3
n = 4
n = 5
H∞
Hδ
Hγ
Hβ
Hα
4102Å
4341Å
4861Å
6563Å
ultraviolet
visible