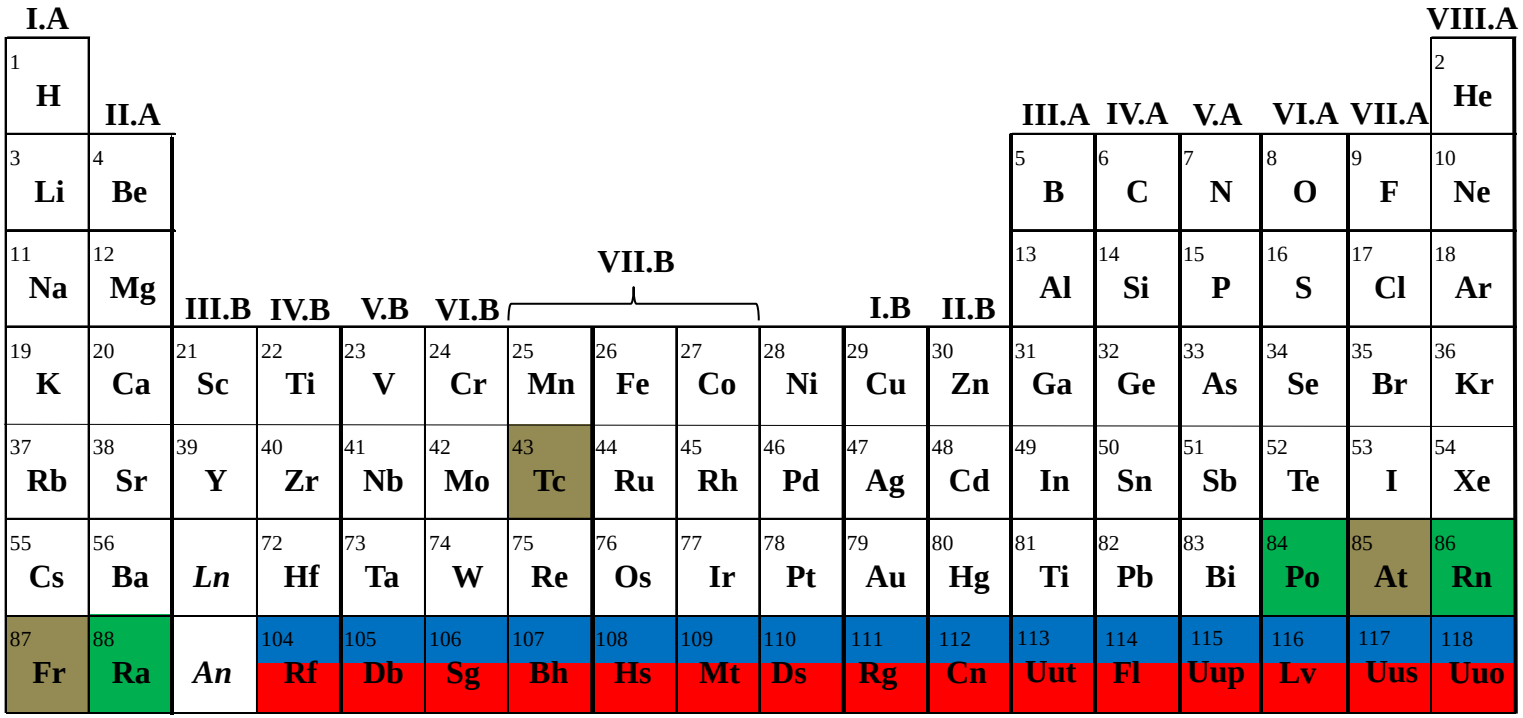
Chemie radioaktivních prvků

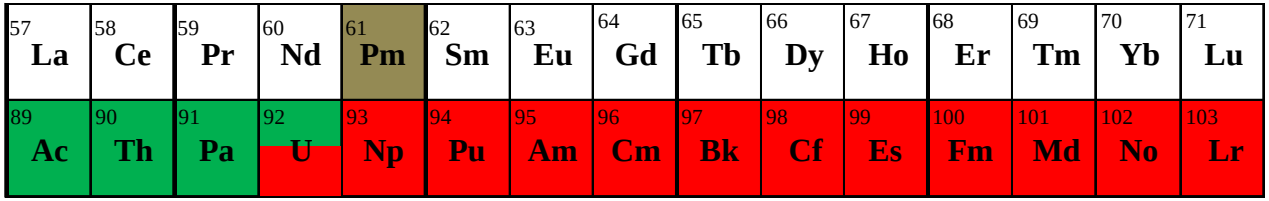
J. John

Periodická tabulka prvků



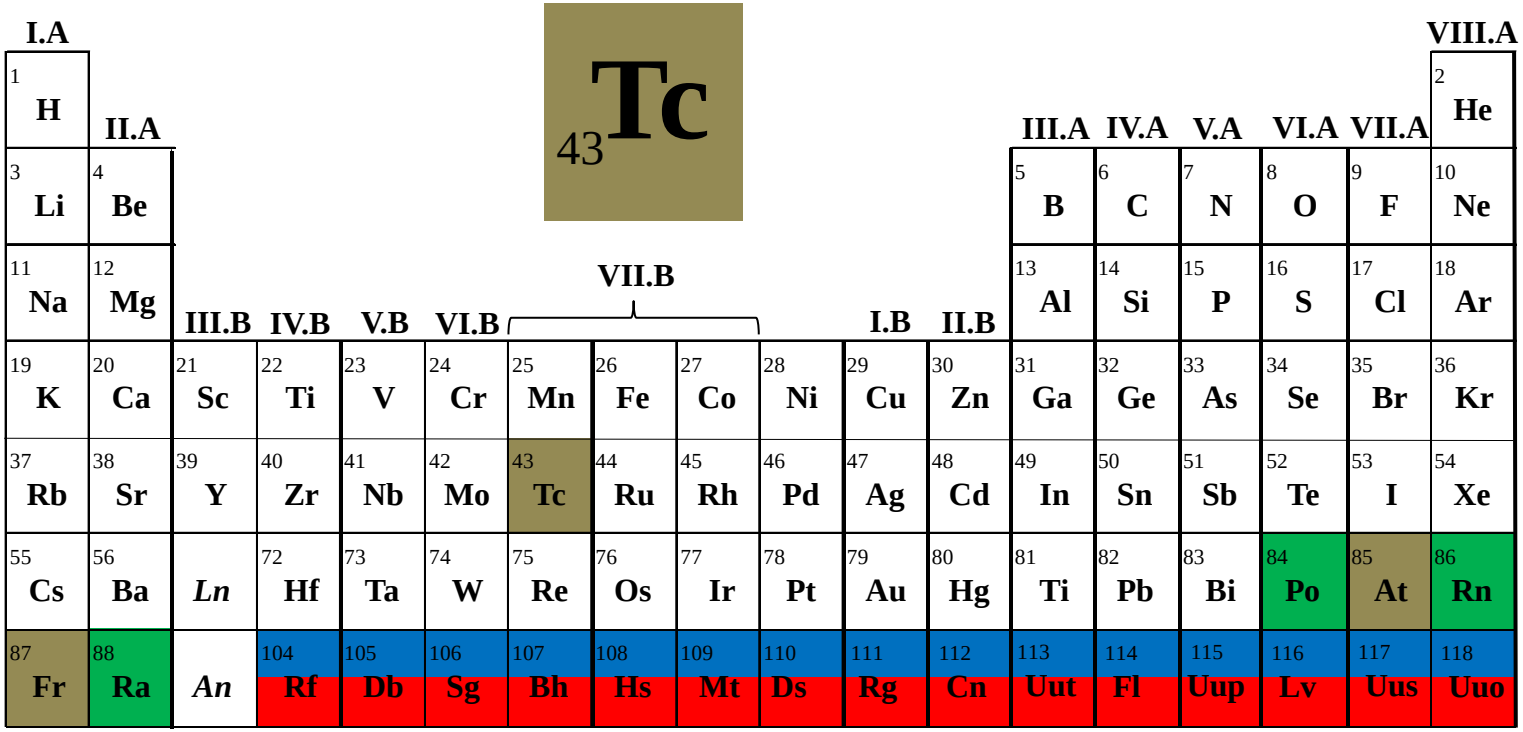
Lanthan(o)idy

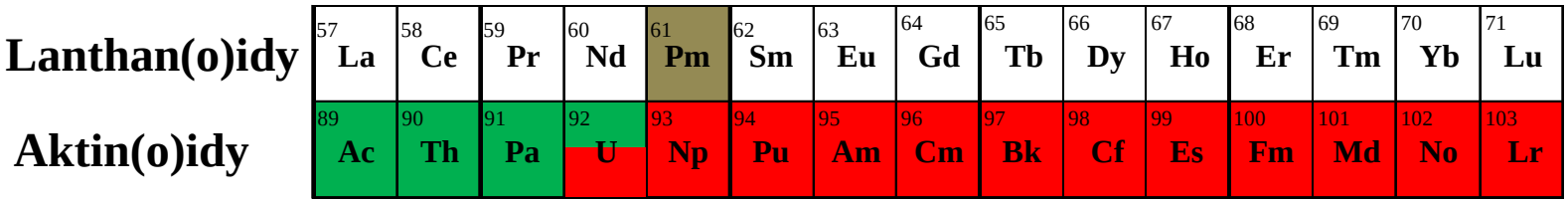
Aktin(o)idy



- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

Technecium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

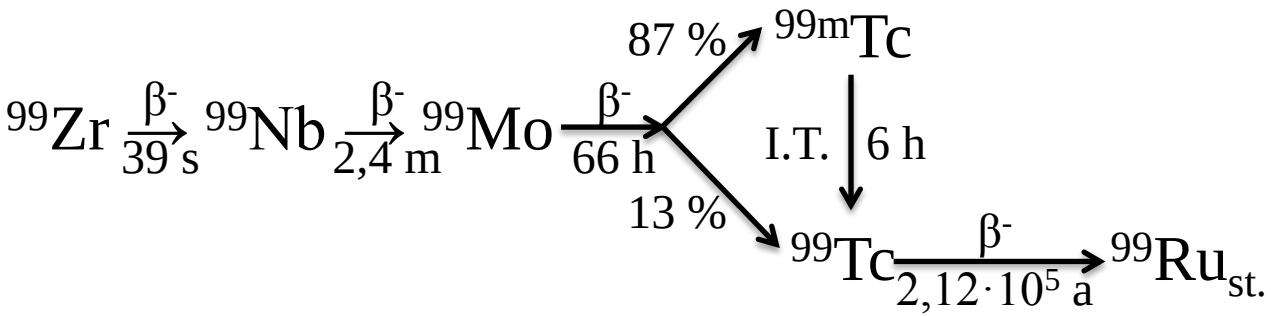
Technecium (1)

A	T	druh záření
90	59 s	β^+, γ
91	3,3 m	β^+, γ
92	4,4 m	EZ, β^+, γ
93m	43 m	I.T. 88 %, EZ 18 %
94	293 m	EZ 89 %, β^+ 11 %, γ
94m	53 m	EZ 34 %, β^+ 34 %, γ
95	20,0 h	EZ, γ
95m	61 d	EZ 95 %, β^+ 0,42 %, I.T. 4 %
96	4,35 d	EZ, γ
96	52 m	I.T., β^+ 0,01 %
97	$2{,}6 \cdot 10^6$ a	EZ
97m	91 d	I.T.
98	$4{,}2 \cdot 10^5$ a	β^-, γ

A	T	druh záření
99	$2{,}12 \cdot 10^5$ a	β^- (σ_{TOT} = 6,2 %)
99m	6,049 h	I.T. (E_γ = 140 keV)
100	15,8 s	β^-, γ
101	14,0 m	β^-, γ
102	5 s	β^-
103	50 s	β^-, γ
104	18 m	β^-, γ
105	7,7 m	β^-, γ
106	37 s	β^- ?
107	29 s	β^- ?
108	5,0 s	β^-, γ
109	1,4 s	β^-
110	0,83 s	β^-, γ

Technecium (2)

$T_T = 2250^oC$ $T_V = 4700^oC$



Techneciový generátor:

$^{98}Mo(n,\gamma)^{99}Mo \xrightarrow[66\ h]{\beta^-} {}^{99m}Tc \xrightarrow[6\ m]{I.T.} {}^{99}Tc$

U(n,f)

Technecium (3)

Disproporcionace:

$3Tc^{V} \rightarrow 2Tc^{IV} + Tc^{VII}$

$3Tc^{VI} \rightarrow Tc^{IV} + 2Tc^{VII}$

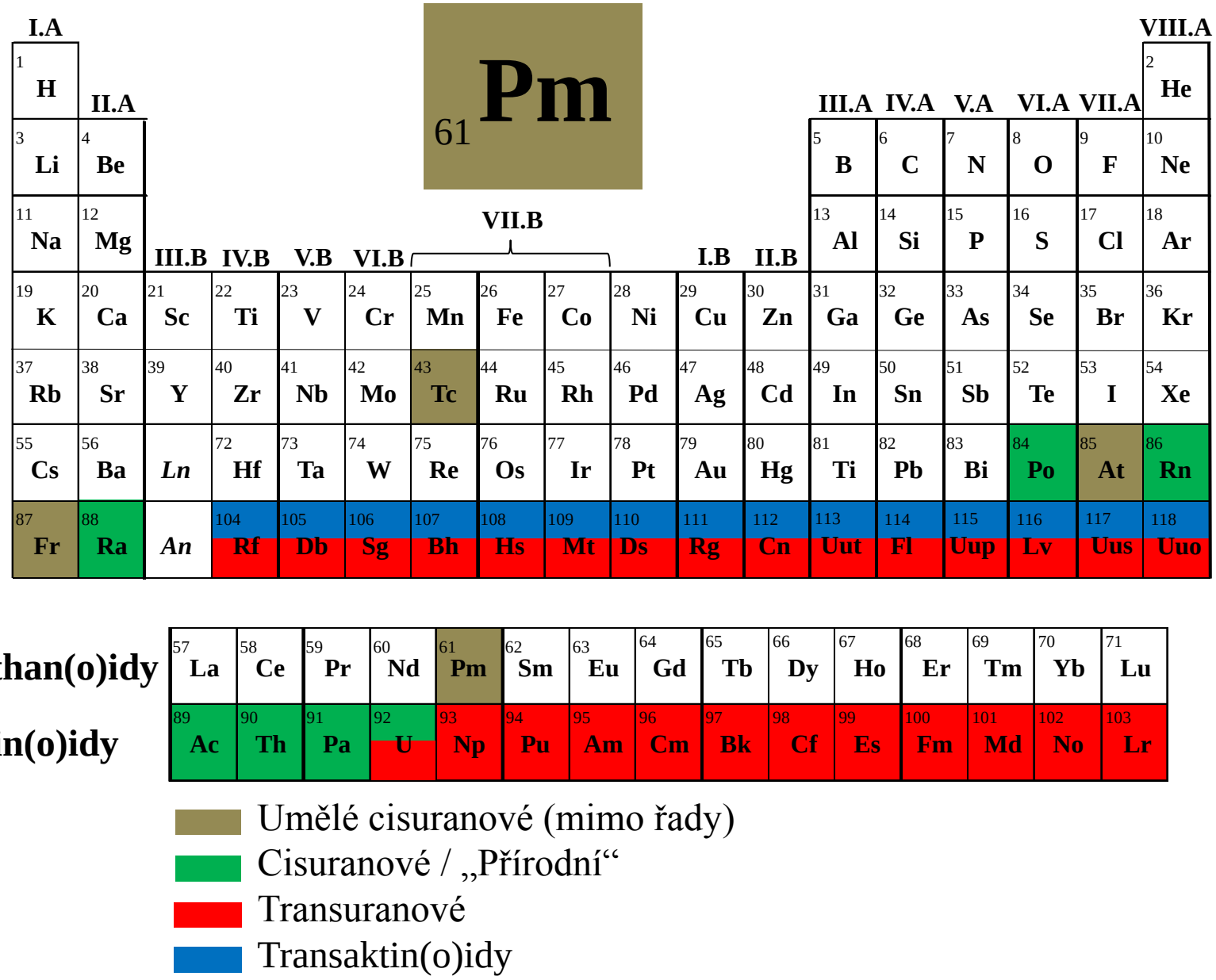
Tc_2O_7	TcF_6	$TcCl_4$	$TcBr_4$	TcO_4^-
TcO_2	TcF_5	$TcOCl_3$	$TcOBr_3$	
Tc_2S_7	TcO_3F	TcO_3Cl		
TcS_2	$TcOF_4$			

Extrakce Tc

činidlo	D	prostředí
pyridin	180	1M NaOH
TBP	44	0,5 M H_2SO_4
TOPO	41	0,5 M H_2SO_4
cyklohexanon	93	0,5 M H_2SO_4
cyklohexanol	36	0,5 M H_2SO_4
HIPK	33	0,5 M H_2SO_4
TOA	110	0,5 M H_2SO_4
TOA	580	1M HCl

činidlo	K_{ex}	prostředí
$\{Ph_4As^+,Cl^-\}$	$3 \cdot 10^6$	kys. alk.; chloroform

Promethium



Lanthan(o)idy

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu

Aktin(o)idy

89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

- Umělé cisuranové (mimo řady)
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Promethium (1)

A	T	druh záření
141	22 m	β^+ 57 %, EZ 43 %
142	40 s	β^+ 95 %, EZ 5 %
143	0,73 a	EZ
144	0,96 a	EZ
145	17,7 a	EZ
145	16 d	β^+
146	4,4 a	β^+
147	2,62 a	β^- 224 keV **žádná γ**, σ = 2,4 %
148	5,4 d	β^-
148m	41,8 d	β^- 93 %, I.T. 7 %
149	53,1 h	β^-
150	2,68 h	β^-
151	27,8 h	β^-

A	T	druh záření
152	6,5 m	β^-
153	5,5 m	β^-
154	2,5 m	β^-

Promethium (2)

T_T = 1080ºC ρ = 7,26 g/cm^3

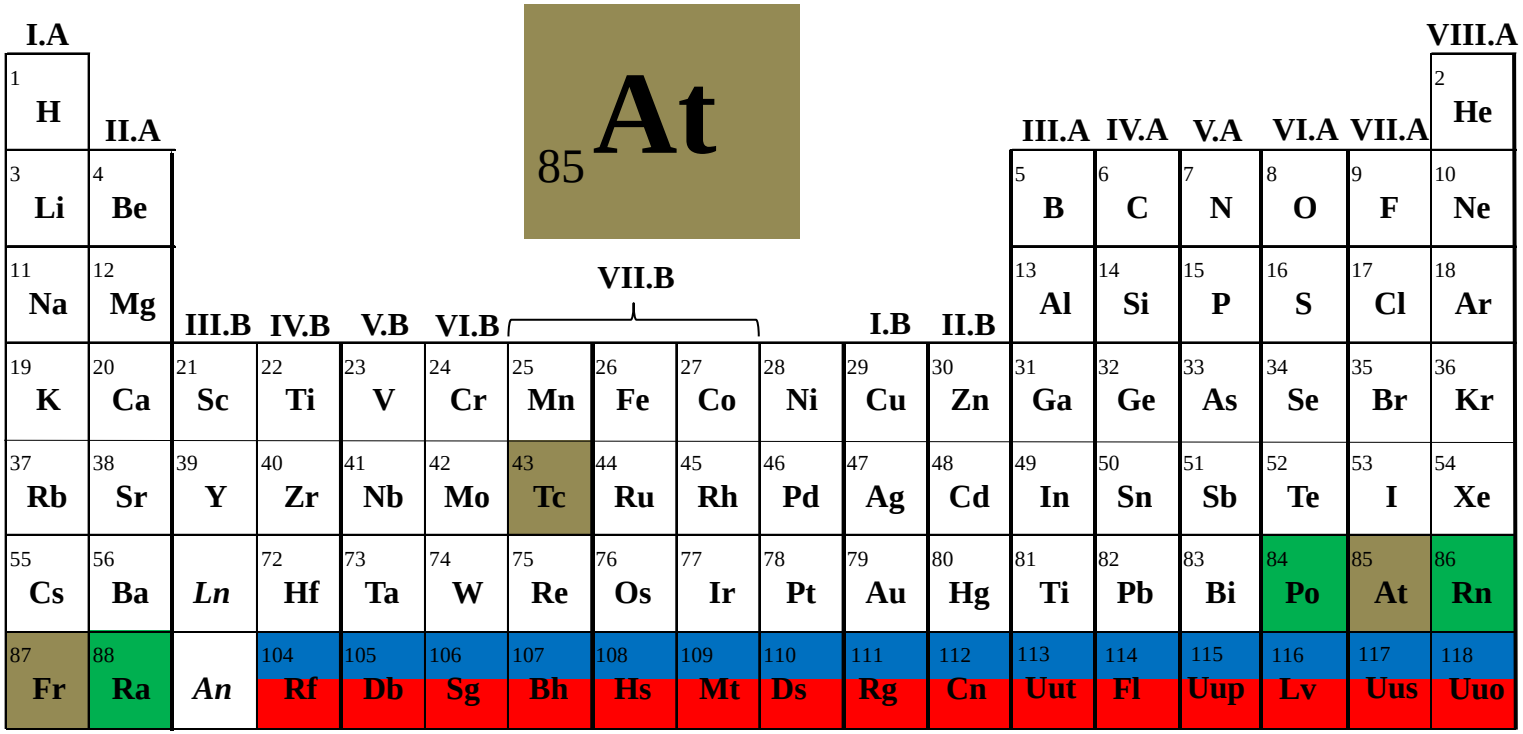
Předpověď: BRAUNER 1902

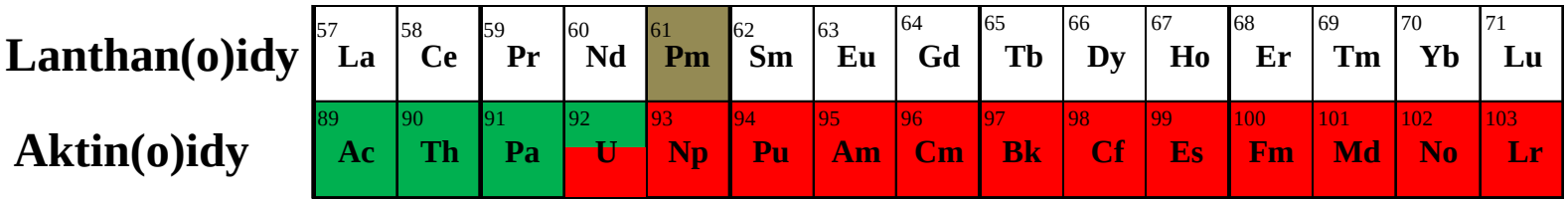
Objev: MARINSKY, GLENDENINOVÁ, a CORRYEL 1945

Elementární: PmF_3 + Li (vakuum)

$PmCl_3$	Pm_2O_3	$Pm(NO_3)_3$	$Pm(OH)_3$
PmF_3			$Pm_2(C_2O_4)_3 \cdot 10H_2O$
$PmBr_3$			
PmI_3			

Astat





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Astat (1)

A	T	druh záření
200	0,9 m	α
201	1,5 m	α, EZ
202	3,0 m	EZ 88 %, α 12 %
203	7,4 m	EZ 86 %, α 14 %
204	9,3 m	EZ 95,5 %, α 4,52 %
204	-	-
205	26,2 m	EZ 82 %, α 18 %
206	32,8 m	EZ 12 %, α 88 %
207	1,8 h	EZ 90 %, α 10 %
208	6,3 h	EZ
209	5,5 h	EZ 95 %, α 5 %
210	8,3 h	EZ 99 %, α 0,17 %
211	7,21 h	EZ 59,1 %, α 40,9 %
212	0,30 s	α
212m	0,12 s	α, β^-, EZ

A	T	druh záření
213	kr.	α
214	~ $2 \cdot 10^{-6}$ s	α 99 %
215	10^{-4} s	α **AcA ($5 \cdot 10^{-4}$ %)**
216	~ $3 \cdot 10^{-4}$ s	α 97 % **ThA (0,014 %)**
217	0,323 s	α **^{221}Fr (4n+1)**
218	1,5 – 2 s	α > 99 %, β^- **RaA (0,06 %)**
219	0,9 m	α ~ 97 %, β^- ~ 3 % **^{223}Fr (AcK)**

Astat (2)

„astatos“ (řecky) – nestálý

CORSON, MacKENZIE a SEGRÈ – 1940

$^{209}Bi(\alpha,2n)^{211}At$ $E\alpha = 28$ MeV

KARLIK a BERNERT – 1943

jej nalezli v přírodě

-I; 0; I; V; (VII)

Astat (3)

T_T ~ 299ºC T_V ~ 411ºC

$At_2 \rightarrow CCl_4, C_6H_6$

-I: At^- HAt AgI(At) TlI(At)

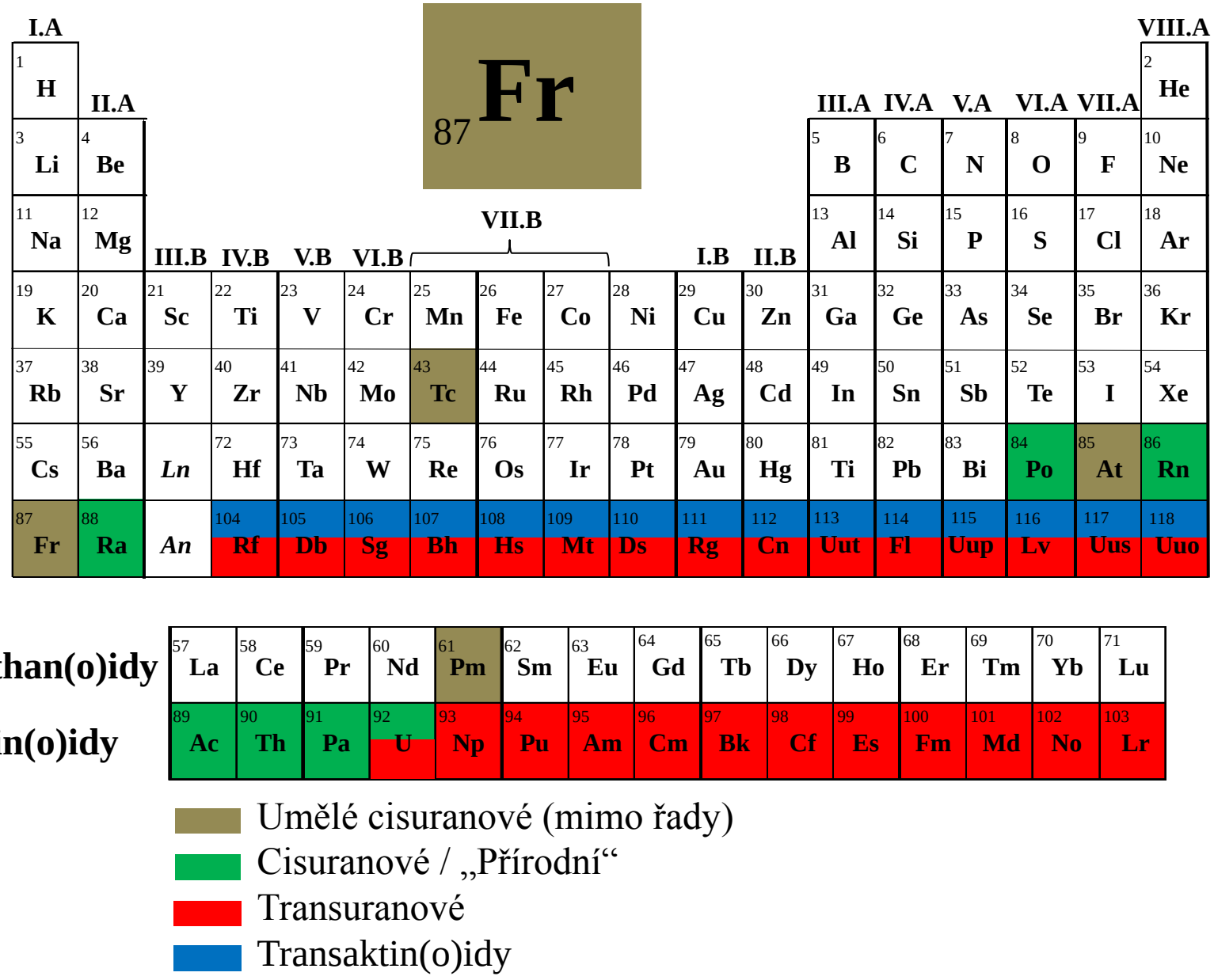
+V: ox.: $At^VO_3^-$

+I: At^+ $Tl(At)_2Cr_2O_7$ $Cs(At)_3PW_{12}O_{40}\cdot nH_2O$

v $H^+ \rightarrow S^{2-}$ (Pb, Po, Bi, Ag)

$[At^ICl_2]^-$; $[At^{III}Cl_4]^-$ - sorpce na anexech

Francium



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Aktin(o)idy

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Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Francium (1)

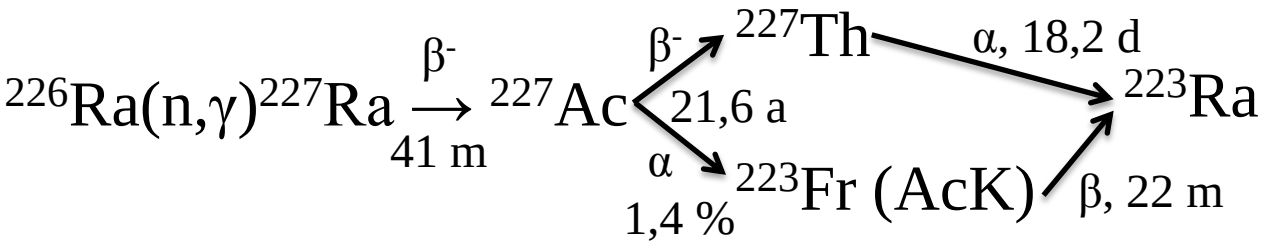
A	T	druh záření
204	2,0 s	α
205	3,7 s	α
206	15,8 s	α
207	19 s	α
208	37 s	α
209	55 s	α
210	2,6 m	α
211	3,1 m	α
212	19,3 m	EZ 56 %, α 44 %
213	34 s	EZ 0,5 %, α > 99 %
214	kr.	α
218	$5 \cdot 10^{-3}$ s	α
219	0,02 s	α
220	27,5 s	α

A	T	druh záření
221	4,8 m	α
222	14,8 m	β^- > 99 % α 0,01 – 0,1 %
223 AcK	22 m	1,15 MeV β^- α ~ $4 \cdot 10^{-3}$ %
224	2 m	?

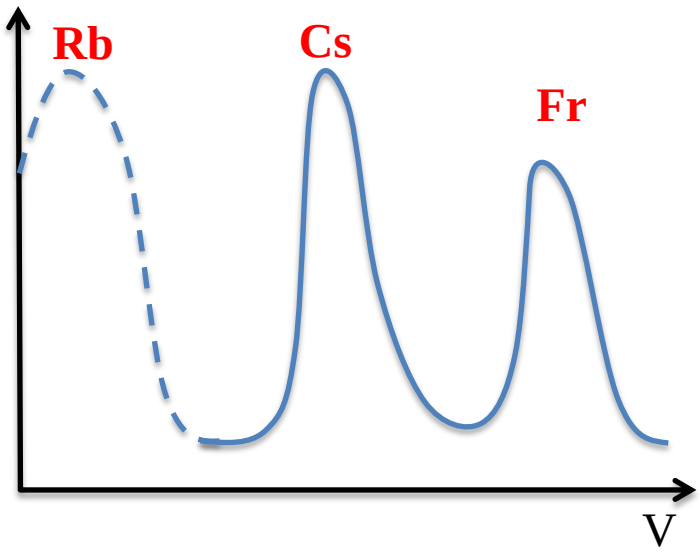
^{232}Th (p,S)

Francium (2)

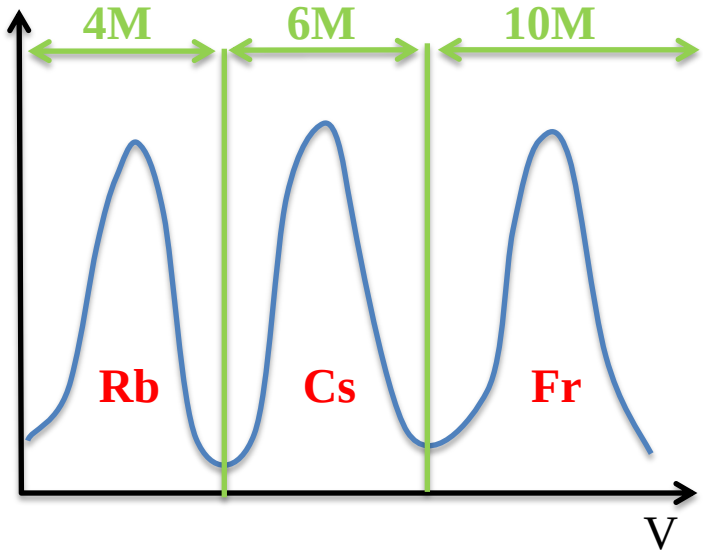
PEREYOVÁ (1939)



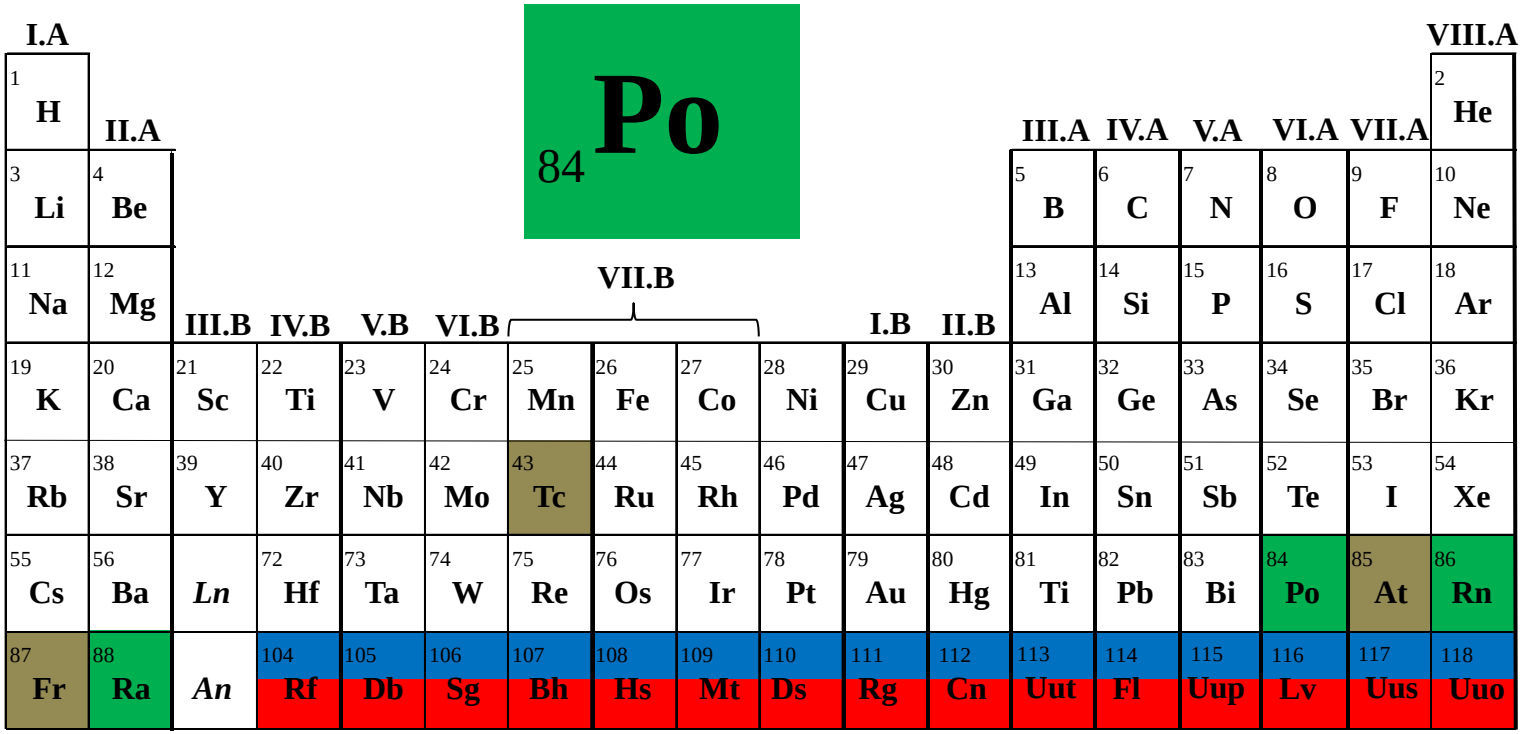
DUOLITE C-3, eluce 4,5 M HCl

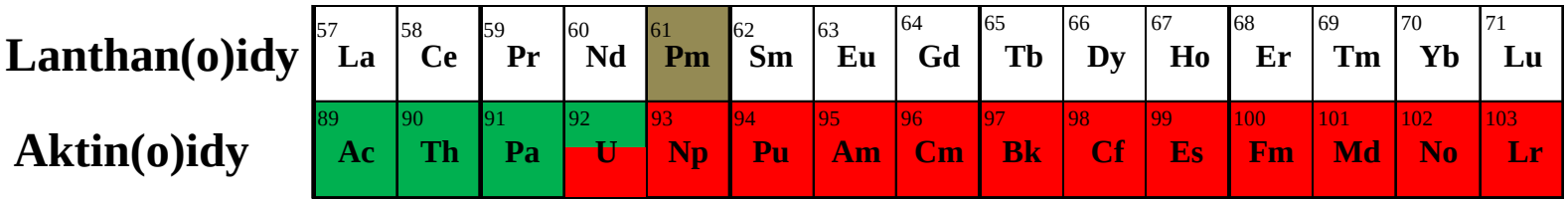


FERROKYANID ZINEČNATÝ, eluce HNO_3



Polonium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Polonium (1)

A	T	druh záření
193	kr.	α
194	0,5 s	α
195	3 s	α
195m	1,4 s	α
196	6 s	α
197	52 s	α
197m	25 s	α
198	1,7 m	α > 34 %
199	5 m	EZ 97,3 %, α 2,7 %
199m	4,2 m	EZ 74 %, α 26 %
200	10,5 m	EZ 88 %, α 12 %
201	15,1 m	EZ 98,8 %, α 1,1 %
201m	8,9 m	EZ 97 %, α 3 %
202	45 m	EZ 98 %, α 2 %
203	42 m	EZ > 99 %, α 0,02 %

A	T	druh záření
204	3,6 h	EZ > 99 %, α 0,6 %
205	1,8 h	EZ > 99 %, α 0,07 %
206	8,8 d	EZ 95 % α 5 %, γ
207	5,7 h	EZ 99 % α ~ 0,01 %, γ
208	2,93 a	EZ ~ 0,006 % α, γ
209	103 a	EZ 0,5 % α > 99 %, γ

Polonium (2)

A	…	T	druh záření
210	RaF	138,4 d	α, 0,8 MeV γ (0,0011 %)
211	AcC´	0,52 s	α, 0,57 MeV γ (0,5 %)
211m		25 s	α, γ
212	ThC´	$3{,}04 \cdot 10^{-7}$ s	α
212m		45 s	α
213		$4{,}2 \cdot 10^{-6}$ s	α
214	RaC´	$1{,}64 \cdot 10^{-4}$ s	α, 0,8 MeV γ (0,014 %)
215	AcA	$1{,}778 \cdot 10^{-3}$ s	α
216	ThA	0,145 s	α
217		< 10 s	α
218	RaA	3,05 m	α

Polonium (3)

$^{209}Bi(n,\gamma)^{210}Bi(RaE) \xrightarrow{\beta^-} {}^{210}Po \xrightarrow[138,\ d]{\alpha}$

$^{209}Bi(d,3n)^{208}Po$

$^{209}Bi(p,n)^{209}Po$

+VI: $[Po^{VI}O_2Cl_4]^{2-}$; PoO_3; s. $PbTeO_4$; $K_2TeO_4 \cdot 3H_2O$

+IV: $PoO(OH)_2 + 2OH^- \rightarrow PoO_3^{2-} + 2H_2O$

v H^+: $PoO_3^{2-} \rightarrow Po(OH)_3^+ \rightarrow PoO^{2+} \rightarrow Po^{4+}$

+II: PoS

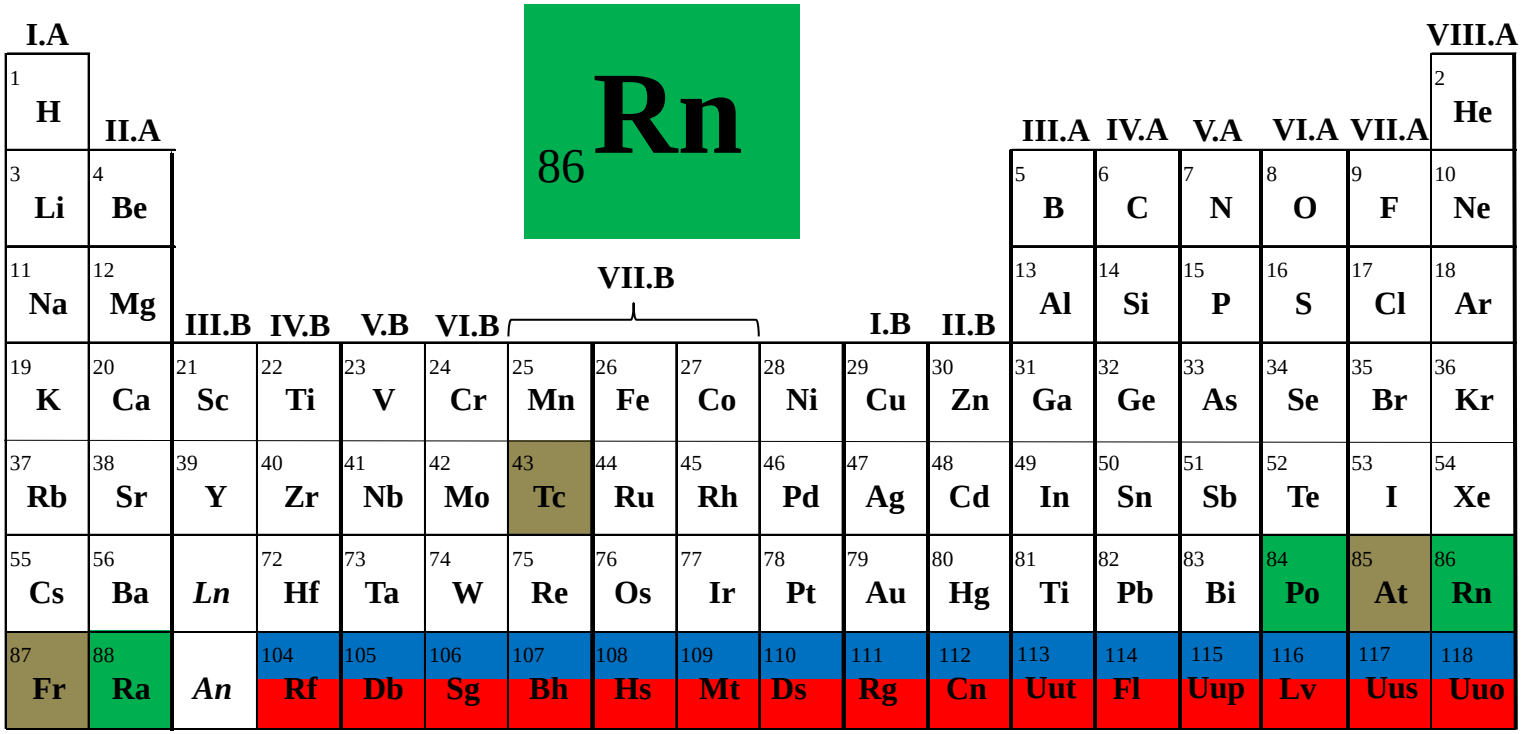
$T_T = 254ºC$ $T_V = 949ºC$ $\rho = 9{,}2\ g/cm^3$

Polonium (4)

PoO	PoF_4	$Po(SO_4)_2 \cdot nH_2O$	$PbPo$	Po_3N_4
PoO_2	$PoCl_4$	$2PoO_2 \cdot SO_3$	$HgPo$	PoS
$Po(OH)_2$	$PoCl_2$	$2PoO_2 \cdot SeO_3$	$ZnPo$	
$PoO(OH)_2$	$PoBr_4$	$2PoO_2 \cdot H_3PO_4$	$NiPo$	
	PoI_4	$Po(IO_3)_4$	H_2Po	$T_T = -36ºC$
	$[PoX_5]^-$	$PoO_2 \cdot nHNO_3$		$T_V = 37ºC$
	$[PoX_6]^{2-}$			

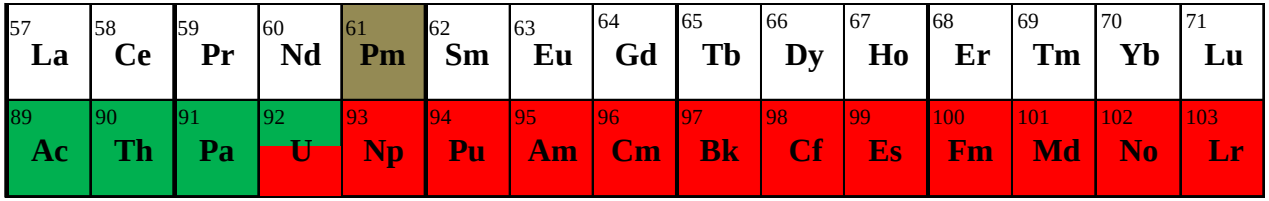
	H_2S	H_2Se	H_2Te	H_2Po
T_V	-60ºC	-41ºC	-2ºC	+37ºC

Radon



Lanthan(o)idy

Aktin(o)idy



Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Radon (1)

A	T	druh záření
222	3,8229 d	E_α = 5,49 MeV E_γ = 0,510 MeV (0,07 %)
220 (Tn)	55,3 s	E_γ = 0,550 MeV (0,07 %)
219 (An)	4 s	E_γ = 0,401 MeV (5 %)
218	0,035 s	E_α = 7,85 MeV

A 202 – 224 (→ 222 α, 221 → β)

T_T = -71 °C
T_V = -61,8 °C

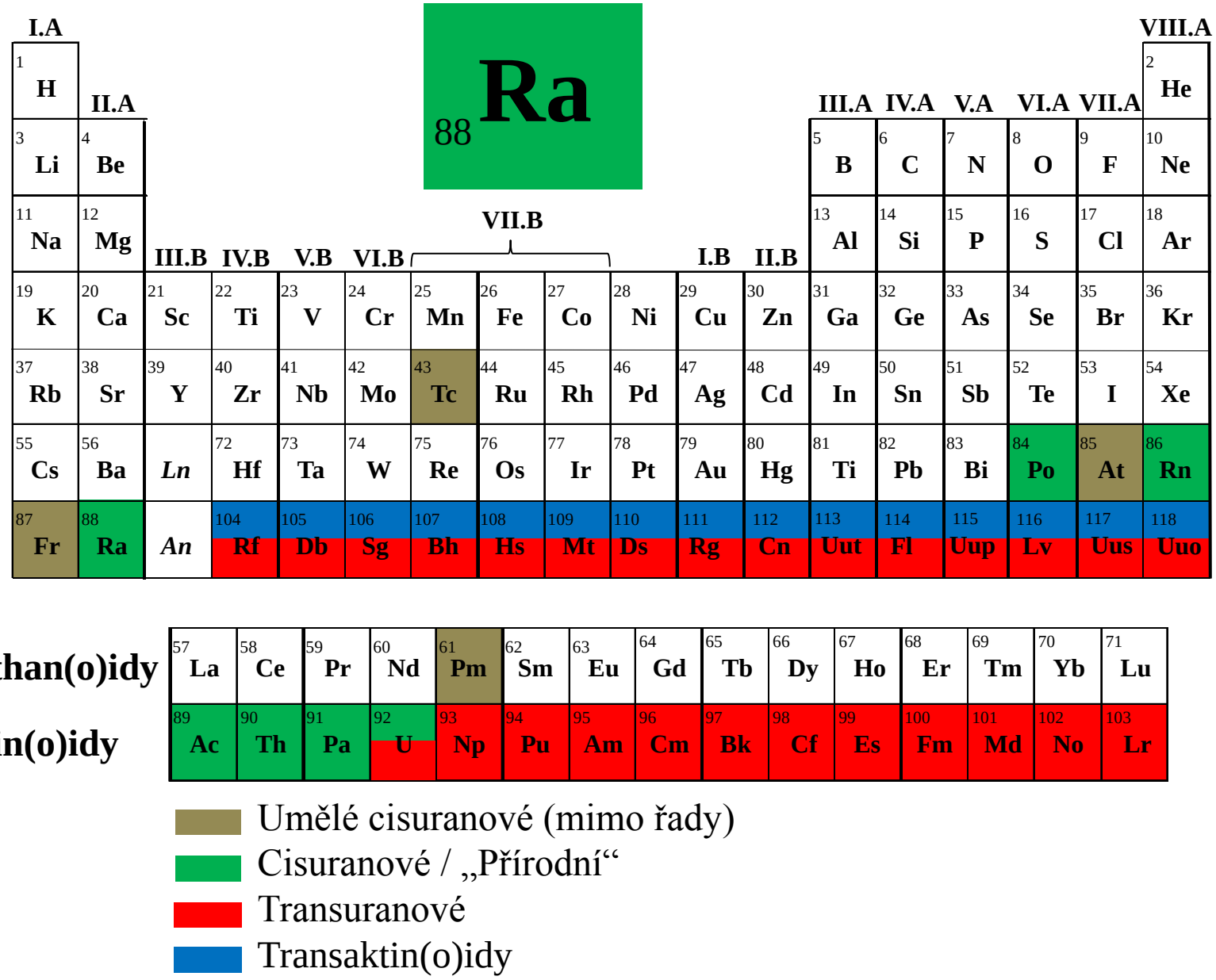
RnF_2 ($RnF_2 + H_2O \rightarrow Rn + 1/2O_2 + 2HF$)
$Rn + 2ClF \rightarrow RnF_2 + Cl_2$

KLATHRÁTY: $Rn \cdot 6H_2O$
$Rn \cdot 2C_6H_5OH$
$Rn \cdot 2C_6H_5CH_3$

Radon (2)

Rozpouštědlo	$\frac{[Rn] v\ kapalině}{[Rn]\ v\ plynné\ fázi}$		
	18 ºC	0 ºC	-18 ºC
voda	0,285	0,52	-
aceton	6,30	7,99	10,8
anilin	3,80	4,43	-
benzen	12,12	-	-
CS_2	23,14	33,4	50,3
$CHCl_3$	15,08	20,5	28,5
Et_2O	15,08	20,9	29,1
octan ethylnatý	7,35	9,41	13,6
EtOH	6,17	8,28	11,4
glycerin	0,21	-	-
hexan	16,56	23,4	35,2
toluen	13,24	18,4	27,0
xylen	12,75	-	-

Radium



Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

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Transaktin(o)idy

Radium (1)

A	T	druh záření
213	2,7 m	α
219	10-3 s	α
220	0,023 s	α
221	30 s	α
222	38 s	α
223 (AcX)	11,435 d	α
224 (ThX)	3,64 d	α
225	14,8 d	β^-
226	1602 a	E_α = 4,48 MeV (95 %) 4,60 MeV E_γ = 0,186 MeV (4 %) 0,26 MeV (0,007 %) 0,42 MeV ($2 \cdot 10^{-4}$ %
227	41,2 m	β^-
228 ($MsTh_1$)	6,7 a	β^-
229	kr.	[β^-]
230	1 h	β^-

Radium (2)

T_T = 700-960 ºC T_V = 1140 ºC ρ = 5,5 g/cm^3

$3RaO + 2Al \rightarrow 3Ra + Al_2O_3$

RaO	RaF_2	$RaSO_4$	$Ra(NO_3)_2$	$Ra(N_3)_2$
$Ra(OH)_2$	RaI_2	$RaCO_3$	RaS	
	$RaCl_2 \cdot 2H_2O$	$RaCrO_4$		
	$RaBr_2 \cdot 2H_2O$			

$RaSO_4 + 2C \rightarrow RaS + 2CO_2$

JÁCHYMOV	1906 – 1913	7,3 g
	1906 – 1940	~ 100 g

DOWEX50, EDTA, HCit, HLact, α-HIM Ra:Ba > 1:4900

EXTRAKCE 0,1M TBP + 0,1M HTTA v CCl_4, pH = 8
(pH = 5 – Ac, Th, Po, Bi, Tl, Pb, Rn)

ORGANISMUS – max 0,1 μg

20, Décembre

Dosage du chlore dans le chlorure actif a = 227

Creuset	12.5447
Creuset + matière	12.9816
Chlorure	0.4370
Subs + AgCl	5.2166 ~~5.2157~~
Subs	4.6178
AgCl =	0.5988 = 0.5988

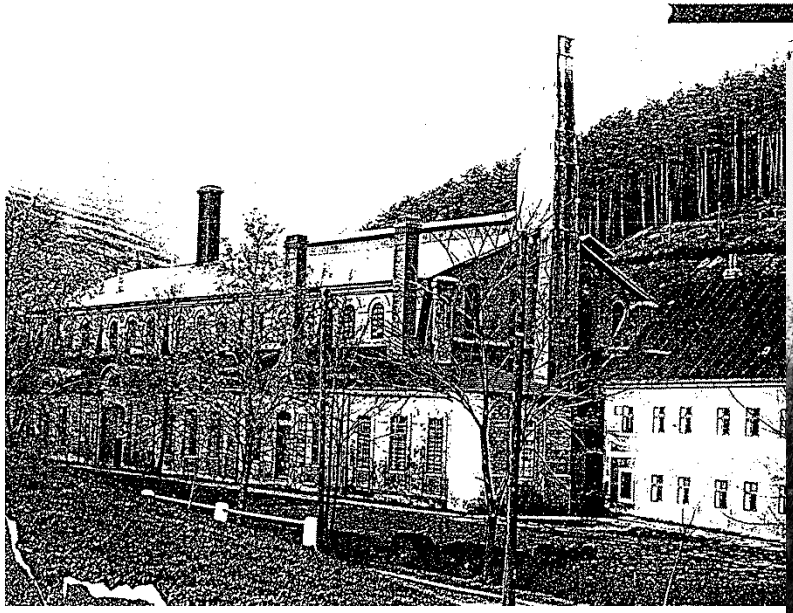
Cl = 0.1481 m = 0.2890

P m = 138.7


KUNGLIGA SVENSKA
VETENSKAPS-AKADEMIEN

ALFRED NOBEL


MARIE
SKLODOWSKA CURIE



Radium and Radio-Active Substances.

RADIUM

ON SALE AND LET ON HIRE.—Write for Terms.

The following can be had by return of post.

PITCHBLENDE, direct from Joachimsthal, very radio-active, from 1/- to 30/- per piece.

ITACOLOMITE, or flexible sandstone. 10/- to 25/- per piece (very rare).

KUNZITE, 1/- per gramme. Selected, clear, 2/-.

SPARTEITE (*see* "NATURE" 31/3/04, fol. 523), 2/- and upwards.

CHLOROPHANE, 2/- and upwards. BARIUM PLATINO CYANIDE IN LARGE CRYSTALS in course of manufacture. (ORDERS BOOKED.)

ZINC SULPHIDE. Phosphorescing a beautiful Green, 2/6 per tube.
" " " " Yellow, 2/6 "
CALCIUM SULPHIDE " " Violet, 1/- "

RADIO-ACTIVE RESIDUE from which Radium is made; very scarce, 2/- per tube.

POLONIUM SULPHIDE, in tubes of one gramme, 21/-
" on Bismuth Rod or Disc 25/-
" on Copper " " 25/-

RADIO-ACTIVE SCREENS (Willemite). 6d. per sq. inch. Plat. Bar. Cyan Screen, 9d. per sq. inch.
" " (Zinc. Sulph.), 10 × 10 cm. 7/6.

SAMARSKITE, THORITE, BLACK and YELLOW
CARNOTITE, ARRBRENITE, WÜCKITT,
EUXENITE, ORANGITE, URANITE,
URACONITE, AUTUNITE, FERGUSSONIT,
BROGGERITE, ALVITE, FORBERITE,
SIPILITE, URAN GLIMMER, CHALCOLITE, &c.

RADIOMETERS, ELECTROSCOPES, SPINTHARISCOPES,

VACUUM TUBES.

All may be had at reasonable prices.

Professional Men, Universities, Schools, &c., allowed special terms.

OUR NEWLY INVENTED THORIUM INHALERS MAY BE HAD ON HIRE.

ARMBRECHT, NELSON & CO.,

71 & 73, DUKE ST., GROSVENOR SQ., LONDON, W.

Telephone: GERRARD 4942.

N.B.—We have received a consignment of the New Zealand Vegetable Caterpillar; it is from 2 to 3 inches long, with a stem showing fructification growing out of its head. Scientific name of the insect is *Hepialus virescens*; the name of the fungus is *Sphæria Robertsiana*. Specimens may be had from 10/6 to 21/-, according to quality and size.

TERMS, CASH WITH ORDER.

Goods may be returned if not approved of, when money will be refunded.

TWO SPACIOUS DARK ROOMS TO SHOW RADIUM ACTIVITY.

RADIUM-OPLOSSINGEN

voor Drink- en Badkuren.

I. Aqua Radium Sol. **bestendig radioactief.**
1 Carton met 3 fleschjes à 20 gr. Activiteit 116000 Volt = 1000 Mache-eenheden *f* 1.60

II. Radium-water, genomen uit den emanator:
Voor een drinkkuur gedurende een maand . . . . . „ 25.—
(Het water uit den emanator moet dagelijks getapt en denzelfden dag gedronken worden).

Voor BADEN:
Aqua Rad. Sol. **eveneens bestendig radioactief.**
1 Carton à 1 flesch à 200 gr. Activiteit 350000 Volt = 3000 Mache-eenheden . *f* 2.50

Meet-Instrumenten.

Meet-Instrument naar ENGELER en SIEVEKING met alle benoodigdheden, verpakt in reiskist zijn bij ons verkrijgbaar . . . . . Prijs „ 100.—
Spintariscopen (Instrumenten voorzien van Loupe en Radiumwijzer, die de werking der Radiumstralen duidelijk aangeven) . . . . . „ 30.—

Onderzoekingen.

Het onderzoeken van bronnen, bronbezinksels, radiumhoudende ertsen enz., wordt in ons Laboratorium of wel op de plaats zelf gedaan. Zoo werden de bronnen in IJverdom, op de Mont Pélérin bij Vevey, Disentis in Graubünden, Römerbad in Zofingen, Aarau enz. gemeten, die gedeeltelijk zeer sterk radioactief bevonden werden.

Gedeponeerd Handelsmerk „ALLRADIUM"

AMSTERDAM.

BERLIJN, BRUSSEL, LONDEN, ST. PETERSBURG, ZURICH, PARIJS, MADRID.

Agentschappen: BOLOGNA, MILAAN, BUDAPEST, HELSINGFORS, STOCKHOLM, WEENEN, KOPENHAGEN, BATAVIA.

Instituut voor Radium Therapie, WIESBADEN, Frankfurterstrasse 34
onder Geneeskundig toezicht van Sanitätsrat Dr. Maijer.
Instituut voor Radium Therapie „Allradium", BUDAPEST Elisabethring 51
onder Geneeskundig toezicht van Dr. Vándor.
Instituut voor Radium Therapie „Allradium", DEN HAAG Bazarstraat 8
onder Geneeskundig toezicht van Dr. Baéza.
Eerste Radiumpolikliniek, BERLIN W, Steglitzer Strasse 19.

Als het nieuwste op het gebied der moderne therapie is het ons gelukt

nauwkeurig gedoseerde, bestendig radioactieve

Radium-Oplossingen

samen te stellen.

Aqua Radium Sol. wordt op grond van talrijke wetenschappelijke werken uit Universiteits-klinieken en Ziekenhuizen voorgeschreven bij:

I. Chronische en subakute Gewrichtsrheumatiek, Spierrheumatiek en alle vormen van Arthritiden.
II. Jicht.
III. Neuralgieën, vooral Ischias.
IV. Lancineerende Pijnen bij Tabes.
V. Catarrhale aandoeningen der Ademhalingsorganen, evenals der voorhoofd- en kaakholten.
VI. Chronische Vrouwenziekten.
VII. Etteringen en Ontstekingen.

Onze praeparaten zijn verkrijgbaar bij alle apothekers en grossiers en bij

DE ALGEMEENE RADIUM MAATSCHAPPIJ, Keizersgracht 369, Amsterdam,
Telefoon 6095.

Door deze prijscourant vervallen alle vorige.

PRIJS-COURANT.

Radium Pur:

1 mgr. zuiver Radium-Bromide, gegarandeerd gehalte van 90 % tegen marktprijs (momenteel *f* 220)

De huurprijs van 1 mgr. Radium per maand bedraagt . . . . *f* 16.50 *Vrijblijvend*

Het vervaardigen van alle soorten Radium-praeparaten geschiedt in den kortst mogelijken tijd.

Radium Schlamm „Allradium".

1 Kistje Radium-Schlamm voor het bereiden van 5 KG. aangemaakte Schlamm	*f*	2.50
1 „ „ „ „ „ „ 1¾ „ „ „ „	„	1.50
Bij groote hoeveelheden (voor Ziekenhuizen en Sanatoria):		
1 Zak, voor het bereiden van 75 KG. aangemaakte Schlamm	„	25.—
1 „ „ „ „ „ 150 „ „ „	„	40.—

Radium-Compressen „Allradium".

1 Compres A (voor vinger en polsgewricht, grootte 12 X 15 cM.)	„	1.—
1 Carton, inhoudende 5 Compressen A	„	4.50
1 Compres B (voor elleboog, knie en enkel, grootte 24 X 15 cM.)	„	2.—
1 Carton, inhoudende 5 Compressen B	„	8.75
1 Compres C (voor rug, schouder enz., grootte 36 X 15 cM.)	„	3.—
1 Carton, inhoudende 5 Compressen C	„	13.—
5 Stuks Compressen D (speciaal voor oogbehandeling, grootte 7 X 10 cM.)	„	2.50
I. Kleine bandage, voorzien van hospitaallinnen (behoorende bij Compres A)	„	1.50
II. Middelsoort bandage, voorzien van hospitaallinnen (behoorende bij Compres B)	„	1.75
III. Groote bandage, „ „ „ „ „ C)	„	2.—

Radium-Ampullen „Allradium".

Deze Ampullen bevatten een onoplosbaar Radiumzout (ongeveer 2 cM.³ vloeistof).

Iedere Ampul is voldoende voor 2 inspuitingen en wordt voornamelijk bij Kanker, Sarkomen enz. aangewend.

1 Ampul A (ca. 0.01 mgr. Radium bevattend)	*f*	6.—
1 doosje à 5 ampullen.	„	27.—
1 Ampul B (ca. 0.05 mgr. Radium bevattend)	„	30.—
1 doosje à 5 ampullen.	„	135.—

Radium-Injecties in Phiolen à 2 cM.³ „Allradium".

Volgens advies van Dr. Gudzent in 3 verschillende sterkten, opgelost in eene physiologische oplossing van keukenzout.

Deze injecties naar Dr. Gudzent worden aangewend voor de plaatselijke behandeling van door jicht en arthritis aangedane gewrichten ter versterking van inhalatie of drinkkuur.

De ziektehaard en zijne omgeving wordt om den anderen dag ingespoten met 1—3 Ampullen naar gelang van de ziekte tot totaal 10—30 Ampullen.

De sterkte der Ampullen moet verband houden met de hevigheid van de ziekte en de gevoeligheid van den patient.

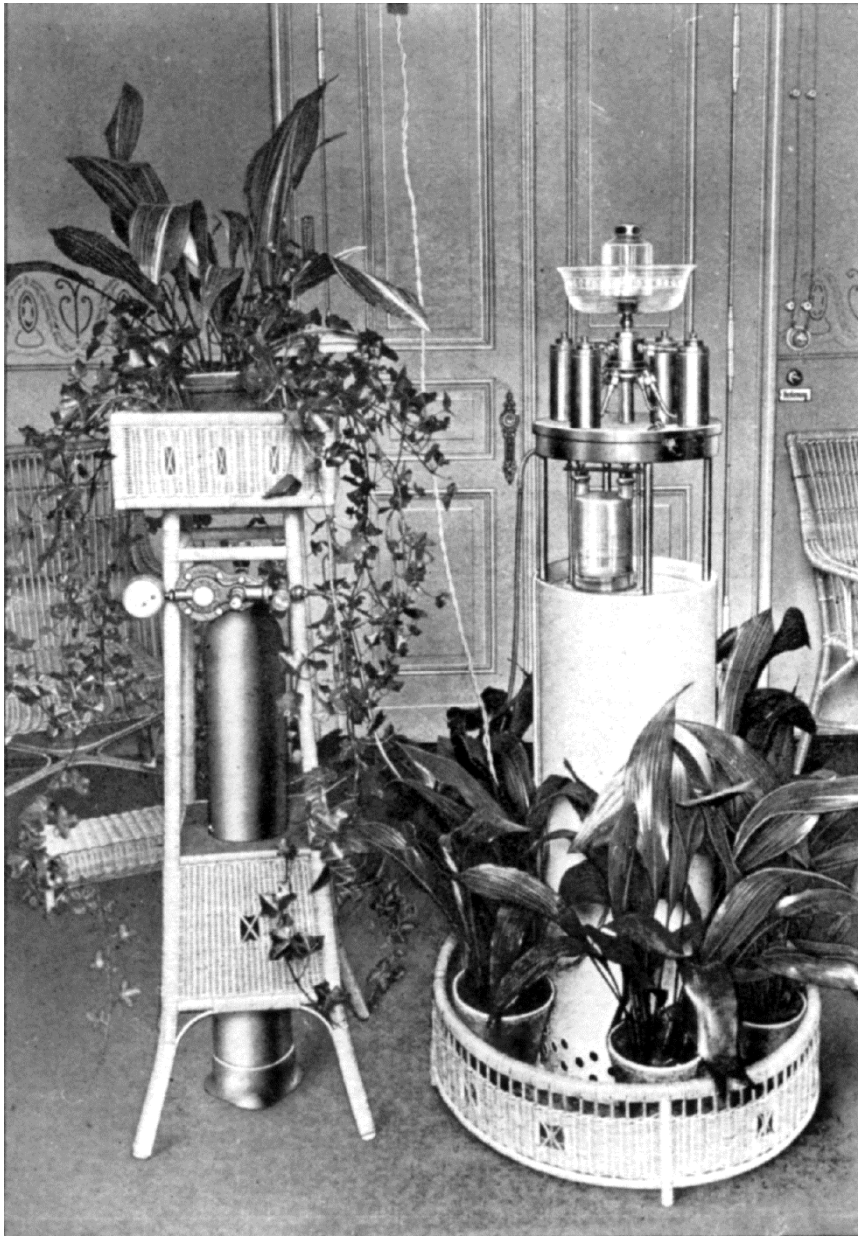
		1 st.	1 cart. à 5 st.
I.	Oplossing (activiteit 116000 Volt — 1000 Mache-eenheden	*f* 1.50	*f* 6.50
II.	„ „ 232000 „ — 2000 „	„ 2.50	„ 10.50
III.	„ „ 514000 „ — 4600 „	„ 5.—	„ 21.50

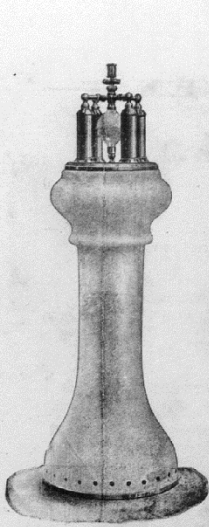
Radium-drinkapparaat „Allra".

Klein apparaat, voor eigen gebruik, gegarandeerde radioactiviteit gedurende 10 jaren.

Capaciteit 1000 M. E. per dag — 1 kuren per dag	„	100.—
„ 2000 „ „ „ — 2 „ „ „	„	150.—
„ 3000 „ „ „ — 3 „ „ „	„	200.—

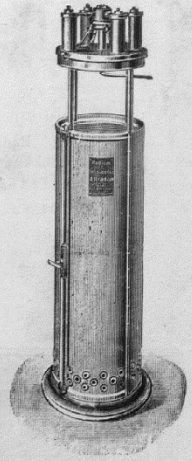
(Bovengenoemde prijzen zijn vrijblijvend).



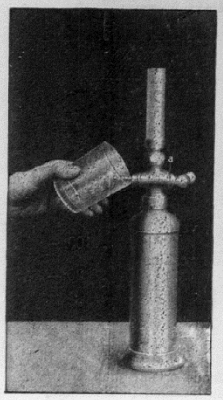


Inhalatorium voor Ziekenhuizen
type A

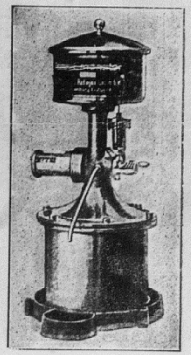
Inhalatorium voor Ziekenhuizen type B



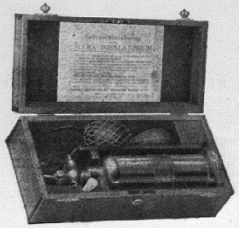
Inhalatorium voor Ziekenhuizen
type C



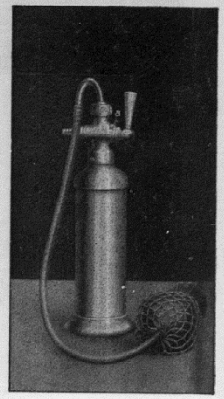
Drinkapparaat voor privégebruik



Drinkapparaat voor Ziekenhuizen

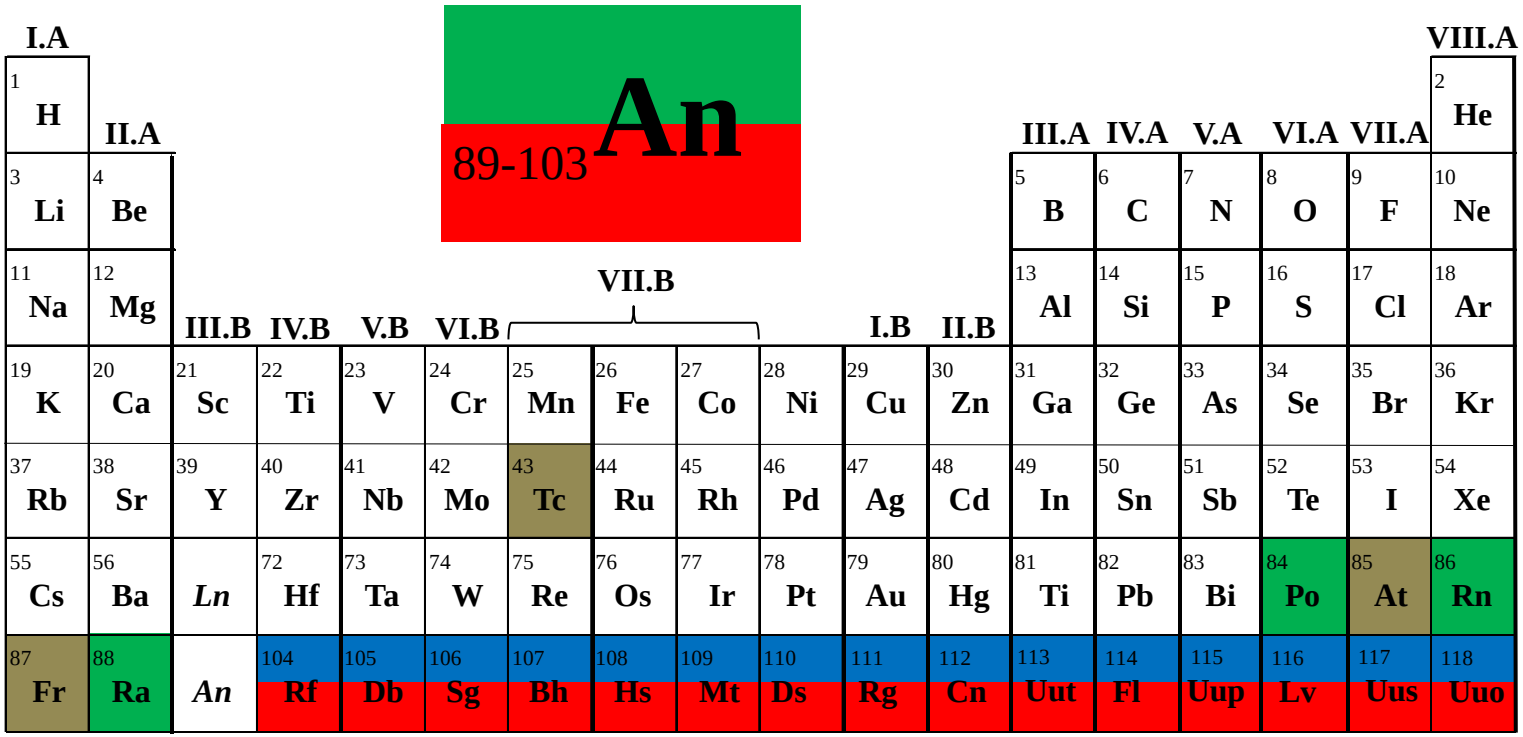


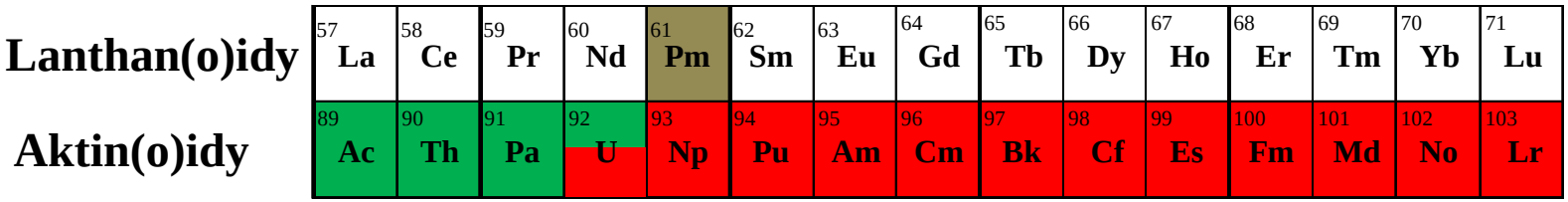
Inhalatieapparaat voor privégebruik



Inhalatieapparaat voor privégebruik

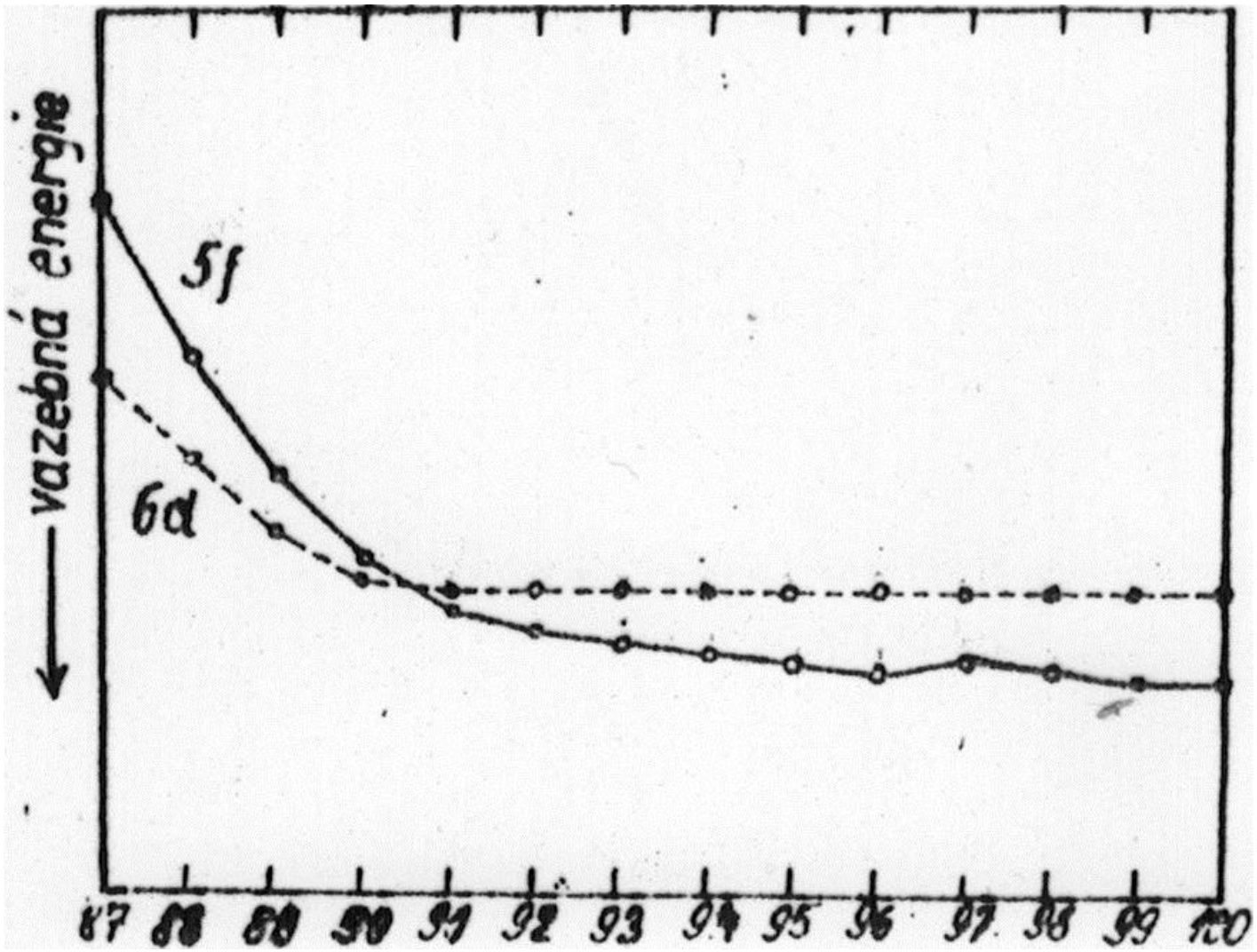
Aktin(o)idy





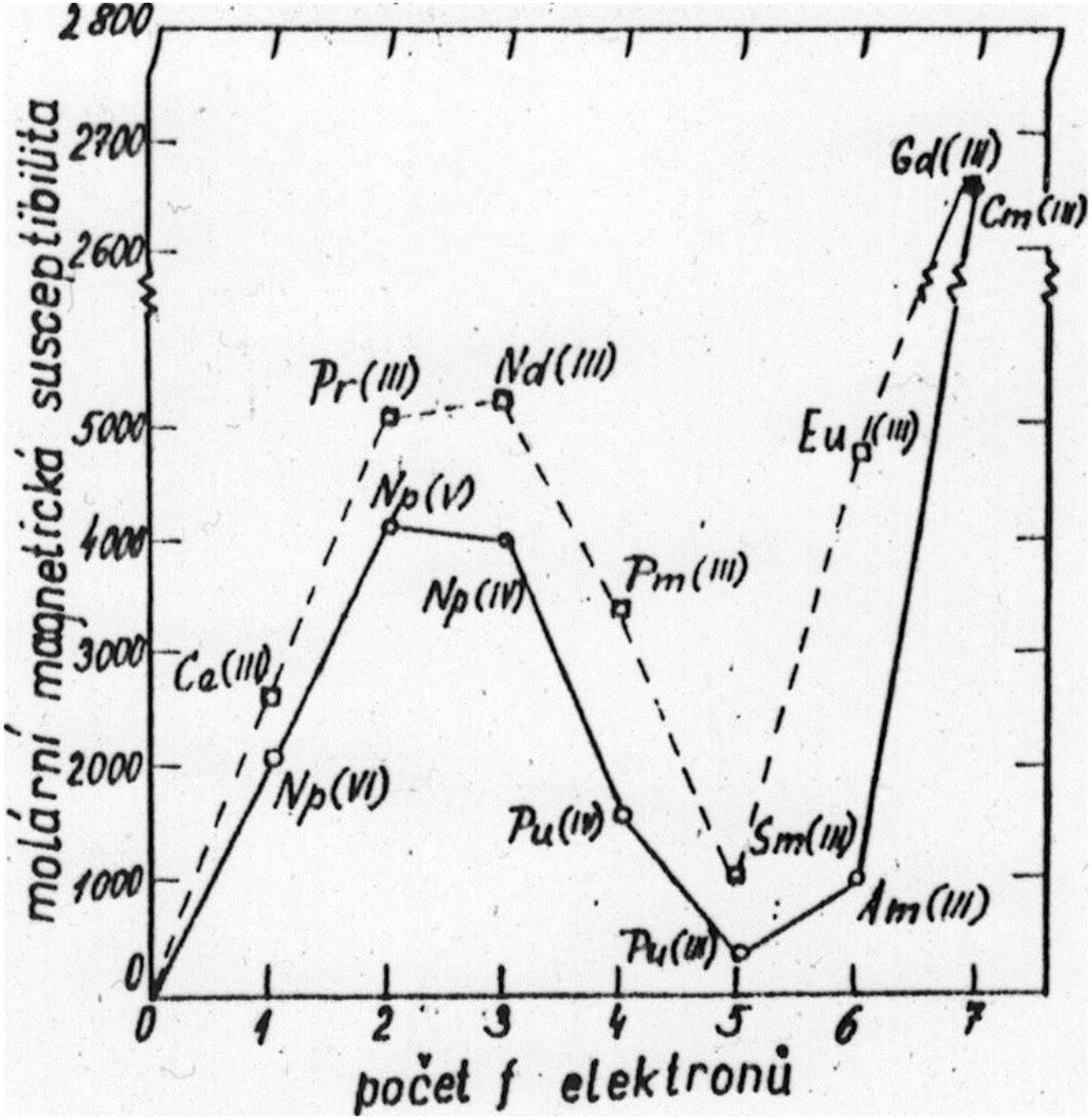
- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

Lns vs. Ans (1)

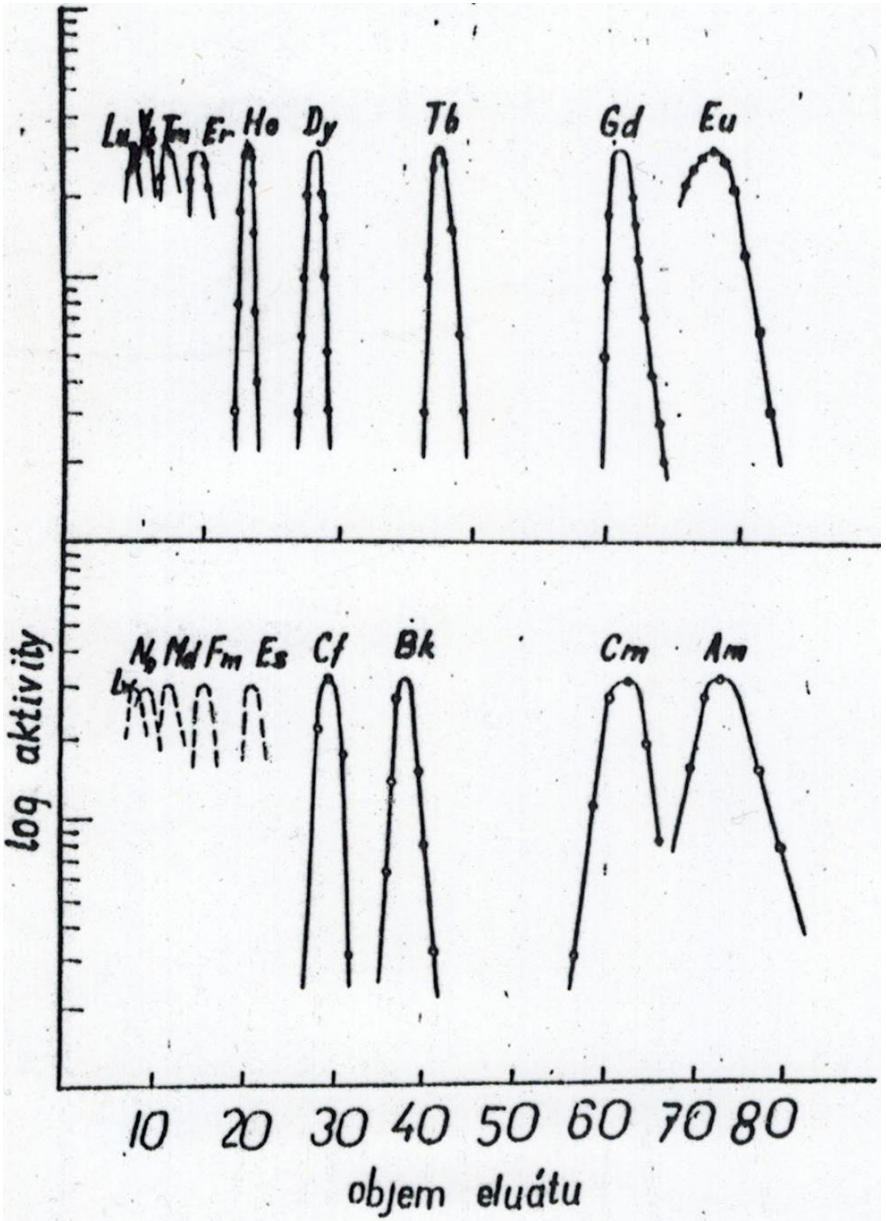


A

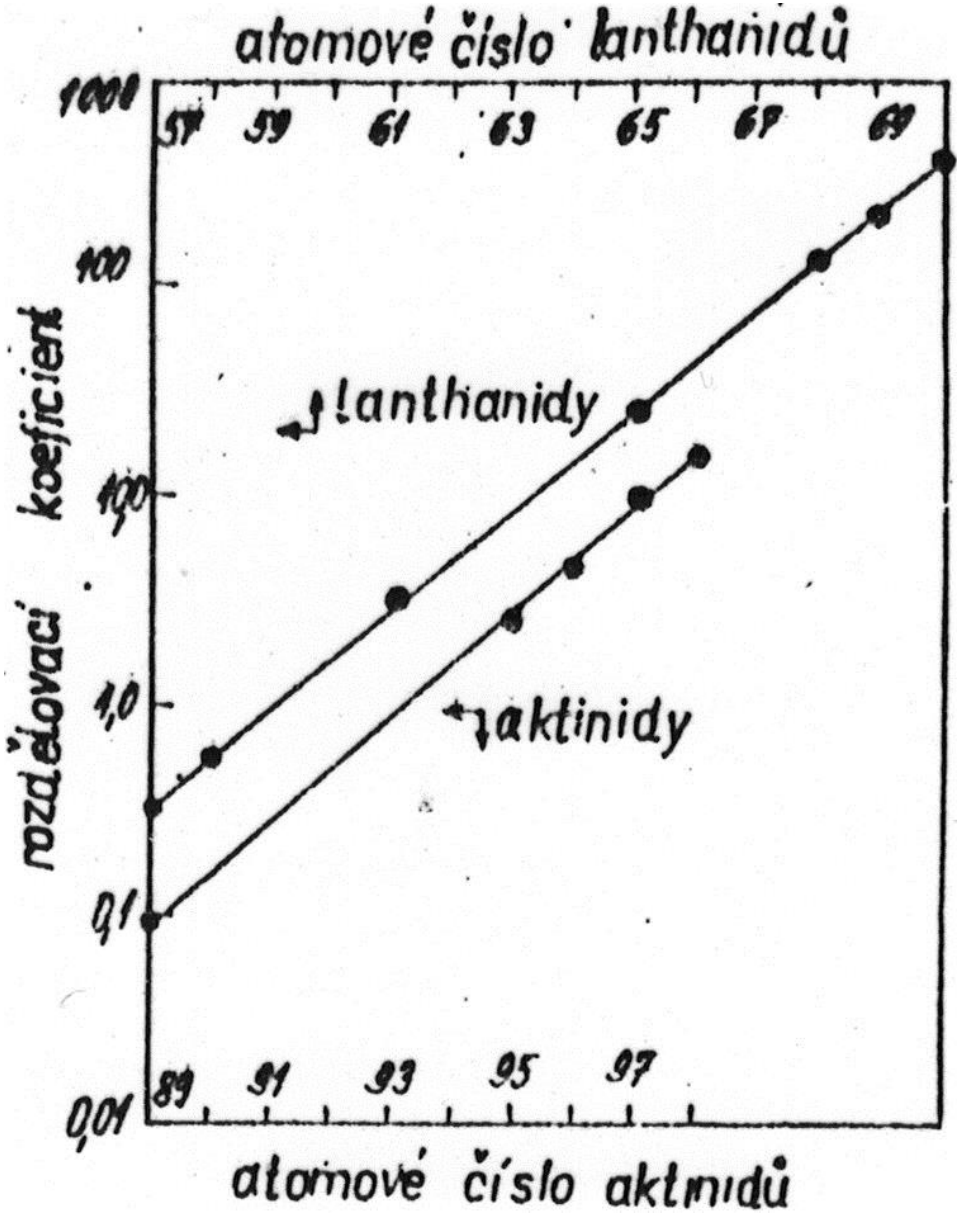
Lns vs. Ans (2)


molární magnetická susceptibilita
2800
2700
2600
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
7
počet f elektronů
Gd(III)
Cm(III)
Pr(III)
Nd(III)
Eu(III)
Np(V)
Pm(III)
Np(IV)
Ce(III)
Np(VI)
Pu(IV)
Sm(III)
Am(III)
Pu(III)

Lns vs. Ans (3)


Lu Yb Tm Er Ho Dy Tb Gd Eu
No Md Fm Es Cf Bk Cm Am
log aktivity
10 20 30 40 50 60 70 80
objem eluátu

Lns vs. Ans (4)


atomové číslo lanthanidů
1000
100
10
1,0
0,1
0,01
57
59
61
63
65
67
69
lanthanidy
aktinidy
rozdělovací koeficient
89
91
93
95
97
atomové číslo aktinidů

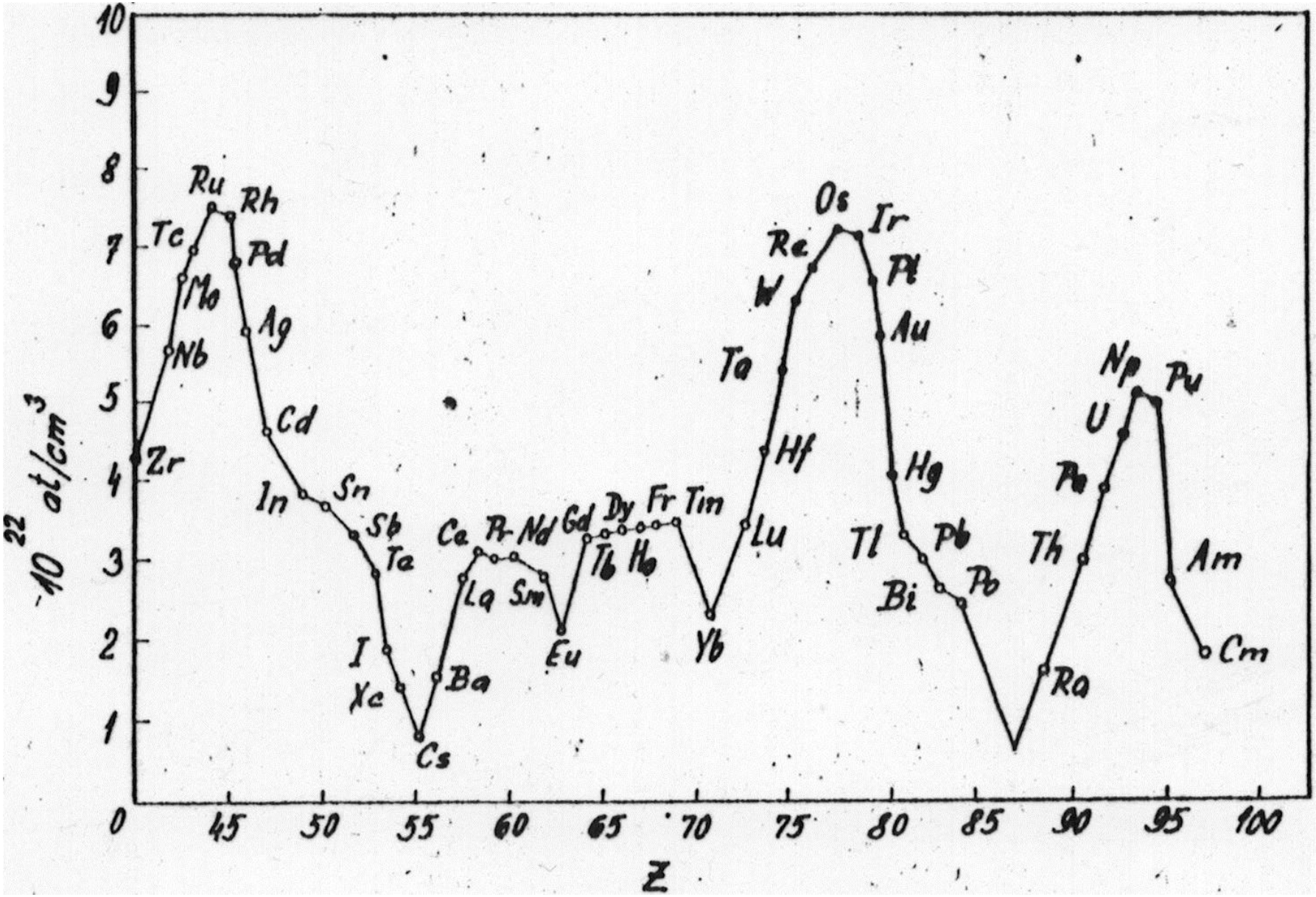
Lns vs. Ans (5)

Iontové poměry lanthanidových a aktinidových iontů

ion	Å	ion	Å	ion	Å
La^{3+}	1,061	Ac^{3+}	1,11	-	-
Ce^{3+}	1,034	/Th^{3+}/	/1,08/	Th^{4+}	0,99
Pr^{3+}	1,013	/Pa^{3+}/	/1,05/	Pa^{4+}	0,96
Nd^{3+}	0,995	U^{3+}	1,03	U^{4+}	0,93
Pm^{3+}	0,979	Np^{3+}	1,01	Np^{4+}	0,92
Sm^{3+}	0,964	Pu^{3+}	1,00	Pu^{4+}	0,90
Eu^{3+}	0,950	Am^{3+}	0,99	Am^{4+}	0,89

Å = 10^{-10} m

Lns vs. Ans (6)


10
9
8
7
6
5
4
3
2
1
0
45
50
55
60
65
70
75
80
85
90
95
100
Z
10^{22} at/cm^3
Zr
Nb
Mo
Tc
Ru
Rh
Pd
Ag
Cd
In
Sn
Sb
Ta
I
Xe
Cs
Ba
La
Ce
Pr
Nd
Sm
Eu
Gd
Tb
Dy
Ho
Fr
Tm
Yb
Lu
Hf
Ta
W
Re
Os
Ir
Pt
Au
Hg
Tl
Pb
Bi
Po
Ra
Th
Pa
U
Np
Pu
Am
Cm

Lns vs. Ans (7)

Aktinidy		Lanthanidy	
Ac	$/_{86}Rn/ + 6d^{1}7s^{2}$	La	$/_{54}Xe/ + 5d^{1}6s^{2}$
Th	$/_{86}Rn/ + 6d^{2}7s^{2}$	Ce	$/_{54}Xe/ + 4f^{2}6s^{2}$
Pa	$/_{86}Rn/ + 5f^{2}6d^{1}7s^{2}$	Pr	$/_{54}Xe/ + 4f^{3}6s^{2}$
U	$/_{86}Rn/ + 5f^{3}6d^{1}7s^{2}$	Nd	$/_{54}Xe/ + 4f^{4}6s^{2}$
Np	$/_{86}Rn/ + 5f^{4}6d^{1}7s^{2}$	Pm	$/_{54}Xe/ + 4f^{5}6s^{2}$
Pu	$/_{86}Rn/ + 5f^{6}7s^{2}$	Sm	$/_{54}Xe/ + 4f^{6}6s^{2}$
Am	$/_{86}Rn/ + 5f^{7}7s^{2}$	Eu	$/_{54}Xe/ + 4f^{7}6s^{2}$
Cm	$/_{86}Rn/ + 5f^{7}6d^{1}7s^{2}$	Gd	$/_{54}Xe/ + 4f^{7}5d^{1}6s^{2}$
Bk	$/_{86}Rn/ + 5f^{8}6d^{1}7s^{2}$	Tb	$/_{54}Xe/ + 4f^{9}6s^{2}$
	$/_{86}Rn/ + 5f^{9}7s^{2}$		
Cf	$/_{86}Rn/ + 5f^{10}7s^{2}$	Dy	$/_{54}Xe/ + 4f^{10}6s^{2}$
Es	$/_{86}Rn/ + 5f^{11}7s^{2}$	Ho	$/_{54}Xe/ + 4f^{11}6s^{2}$
Fm	$/_{86}Rn/ + 5f^{12}7s^{2}$	Er	$/_{54}Xe/ + 4f^{12}6s^{2}$
Md	$/_{86}Rn/ + 5f^{13}7s^{2}$	Tm	$/_{54}Xe/ + 4f^{13}6s^{2}$
No	$/_{86}Rn/ + 5f^{14}7s^{2}$	Yb	$/_{54}Xe/ + 4f^{14}6s^{2}$
Lr	$/_{86}Rn/ +5f^{14}6d^{1}7s^{2}$	Lu	$/_{54}Xe/ + 4f^{14}5d^{1}6s^{2}$

$/_{2}He/ = 1s^{2}$

$/_{10}Ne/ = /_{2}He/ + 2s^{2}2p^{6}$

$/_{18}Ar/ = /_{10}Ne/ + 3s^{2}3p^{6}$

$/_{36}Kr/ = /_{18}Ar/ + 4s^{2}3d^{10}4p^{6}$

$/_{54}Xe/ = /_{36}Kr/ + 5s^{2}4d^{10}5p^{6}$

$/_{86}Rn/ = /_{54}Xe/ + 6s^{2}5d^{10}4f^{14}6p^{6}$

Lns vs. Ans (8)

prvek	ρ [g/cm^3]	T_T [ºC]	prvek	ρ [g/cm^3]	T_T [ºC]
Ti	4,4	1800	Cr	6,9	1920
Zr	6,5	1860	Mo	10,2	2622
Hf	13,3	2230	W	19,3	3380
Th	11,7	1827	U	18,9	1133

Lns vs. Ans (9)

prvek	ionizační potenciál [V]	prvek	ionizační potenciál [V]	prvek	ionizační potenciál [V]
Ti	6,81	Cr	6,71	Al	5,95
Hf	7,3	W	7,6	Sc	6,7
Th	5,7	U	5,7	Y	6,5
				La	5,5
				Ac	5,5

Lns a Ans v PTP (1)

	I	II	III	IV	V	VI	VII	VIII			0
6	Cs	Ba	[La*]	[Hf]	[Ta]	[W]	[Re]	[Os]	[Ir]	[Pt]	
	[Au]	[Hg]	Tl	Pb	Bi	Po	At				Rn
7	Fr	Ra	[Ac*]	[Rf]	[Ha]	[Sg]	[Bh]	[Hs]	[Mt]	[Ds]	
	[Rg]	[Cn]	113	Fl	115	Lv	117				118

104 – 121 „TRANSAKTINOIDY“ [ ] prvky vedlejších skupin
(6d, 7p, 8s)

	I	II	III	IV	V	VI	VII	VIII			0
8	119 $8s^1$	120 $8s^2$	[121]* $8s^2d^1$	EkaRf [154]	[155]	[156]	[157]	[158]	[159]	[160]	
	[161]	[162]	163	164	165	166	167				168

*) 122 – 153 „SUPERAKTINOIDY“ (5g, 6f) (18+14)
154 – 168 „TRANSSUPERAKTINOIDY“ (7d, 8p)

(Výpočty elektronové konfigurace: 5g až od Z=126)

Lns a Ans v PTP (2)

Lanthanidy

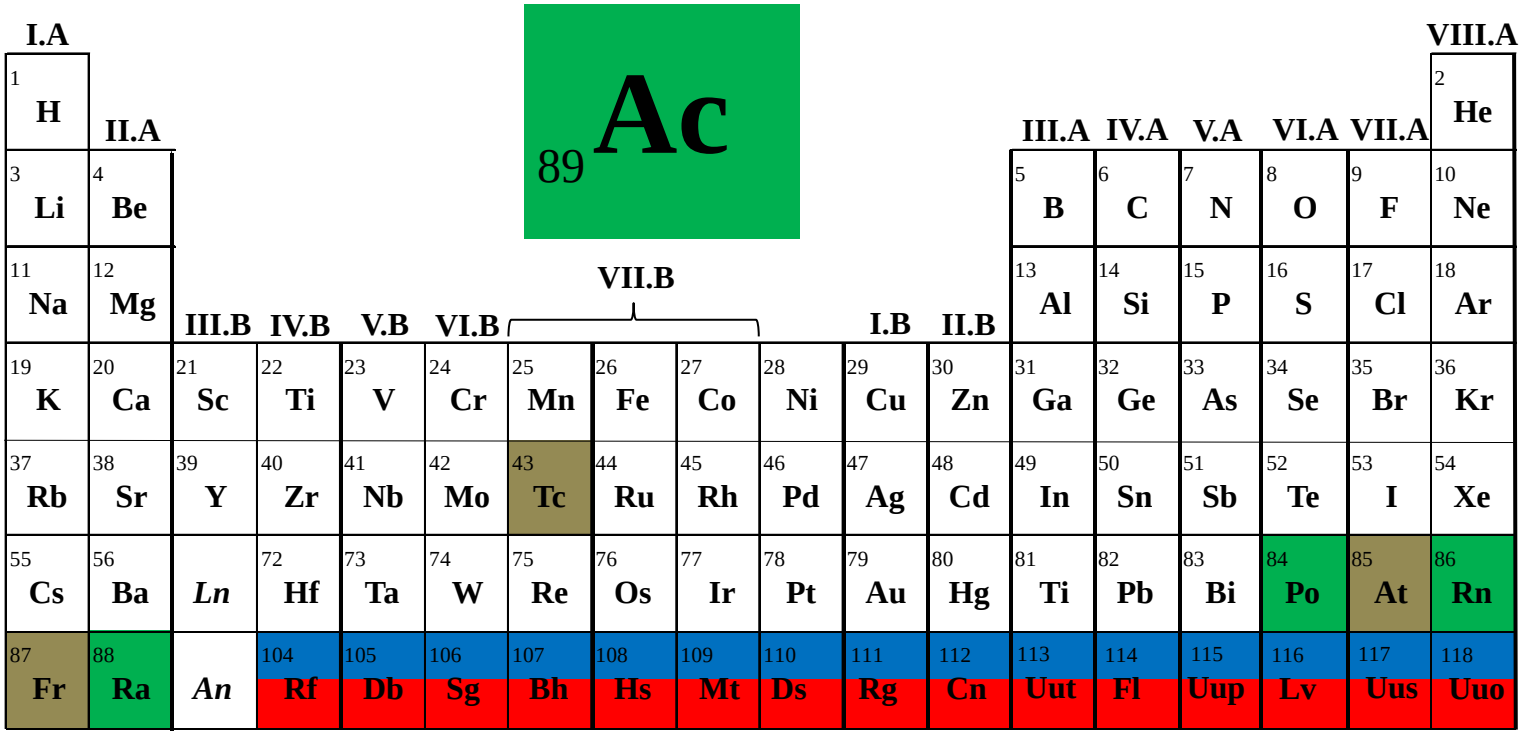
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
3	3, 4	3, 4	3	3	2, 3	2, 3	3	3, 4	3	3	3	3	3

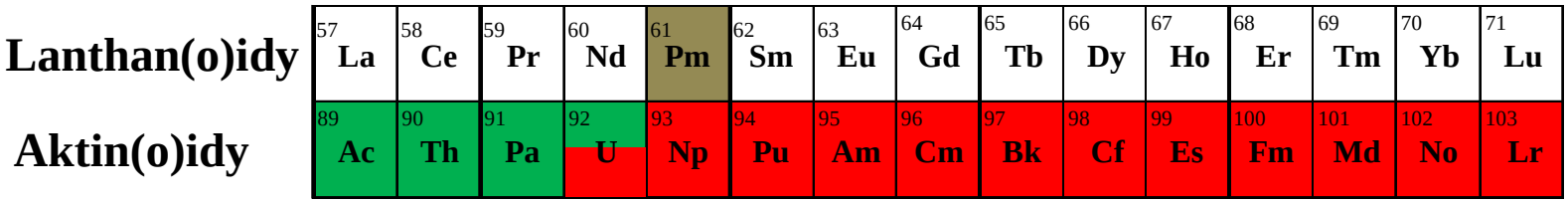
Aktinidy

Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
3	4	4, 5	3, 4 6, 5	3, 4 5, 6, 7	3, 4 5, 6, 7	3, 4 5, 6, 7	3, 4	3, 4	2, 3, 4	2, 3	2, 3	2, 3	2, 3

- nejstálejší mocenství
- neobvyklé nebo nestále mocenství

Aktinium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Aktinium (1)

A	T	druh záření
221	0,1 s	α
222	5,5 s	α
223	2,2 m	α 99 %, EZ 1 %
224	2,9 h	α 10 %, EZ 90 %
225	10 d	α
226	29 h	β^- 80 %
229	66 m	β^-
230	< 1 m	β^-
231	15 m	β^-
227	22 a	β^- 98,8 %, α 1,2 %
228	6,13 h	β^-

Aktinium (2)

$$^{226}\mathrm{Ra}\ \underset{20\ b}{(n,\gamma)}\ ^{227}\mathrm{Ra}\xrightarrow[41{,}2\ \mathrm{m}]{\beta^-}\ ^{227}\mathrm{Ac}\left(\ \underset{762\ b}{(n,\gamma)}\ ^{228}\mathrm{Ac}\xrightarrow[6{,}13\ \mathrm{h}]{\beta^-}\ ^{228}\mathrm{Th}\right)$$

$T_T = 1050\ ^{o}C$ $T_V = 3300\ ^{o}C$

1950 FRIED, ZACHARIASEN, HAGERAN

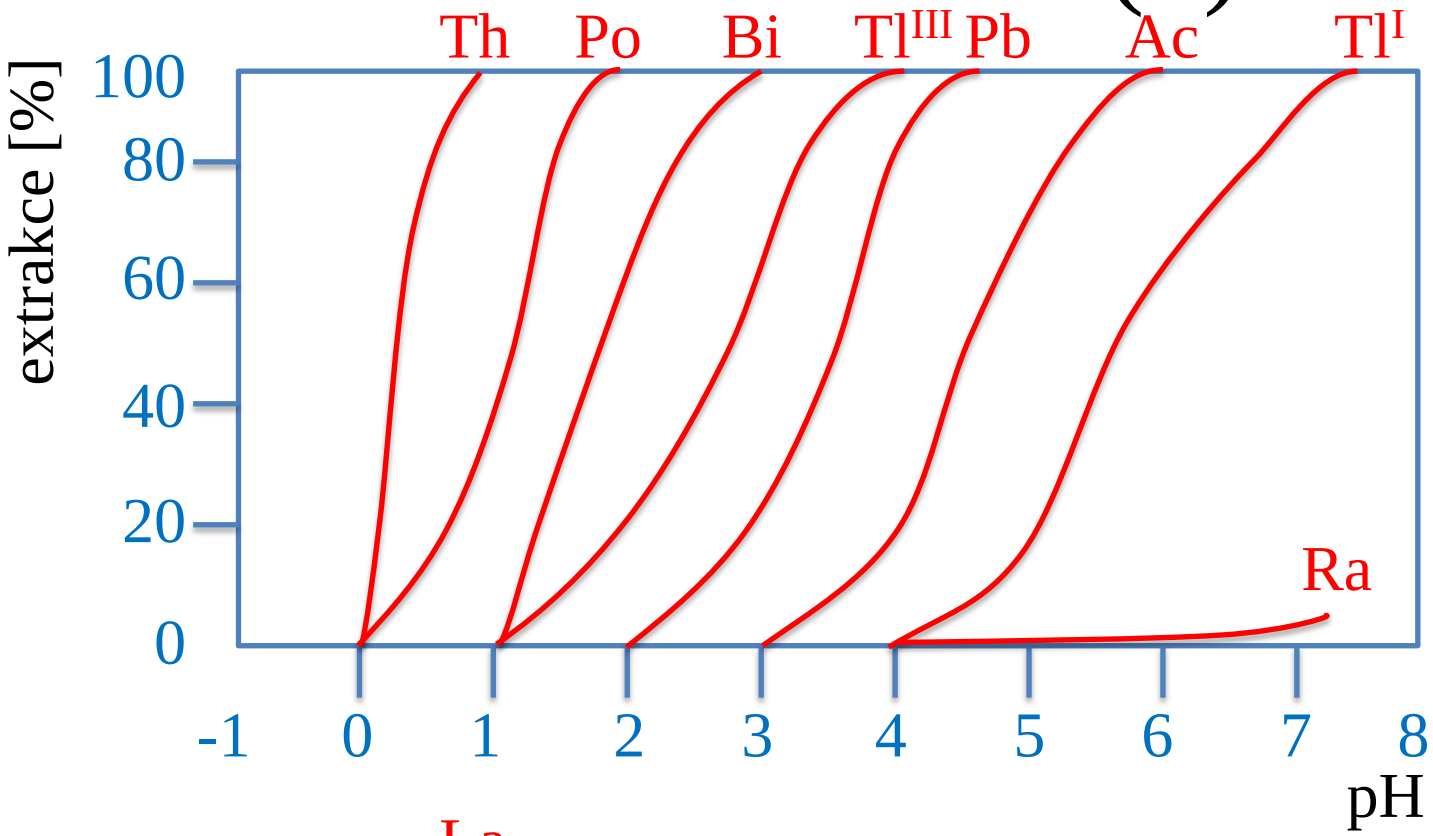
m ~ 10 μ g

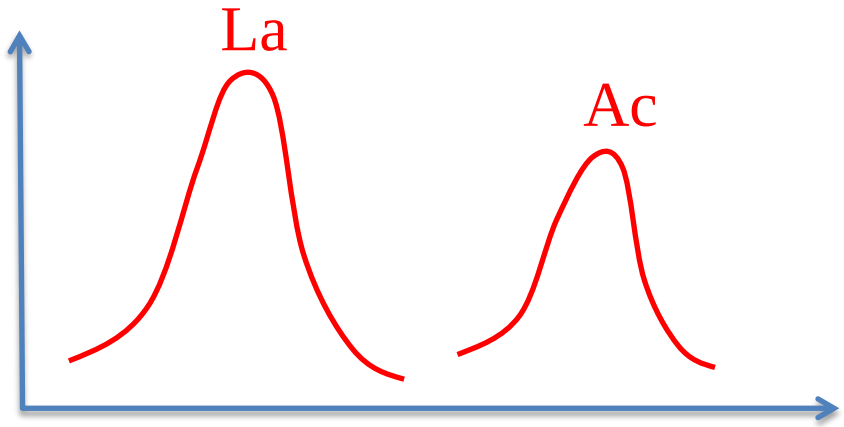
AcF_3
AcOF
$AcCl_3$
AcOCl
AcBr
AcOBr
AcI_3
AcOI

$Ac(OH)_3$
Ac_2O_3
Ac_2S_3

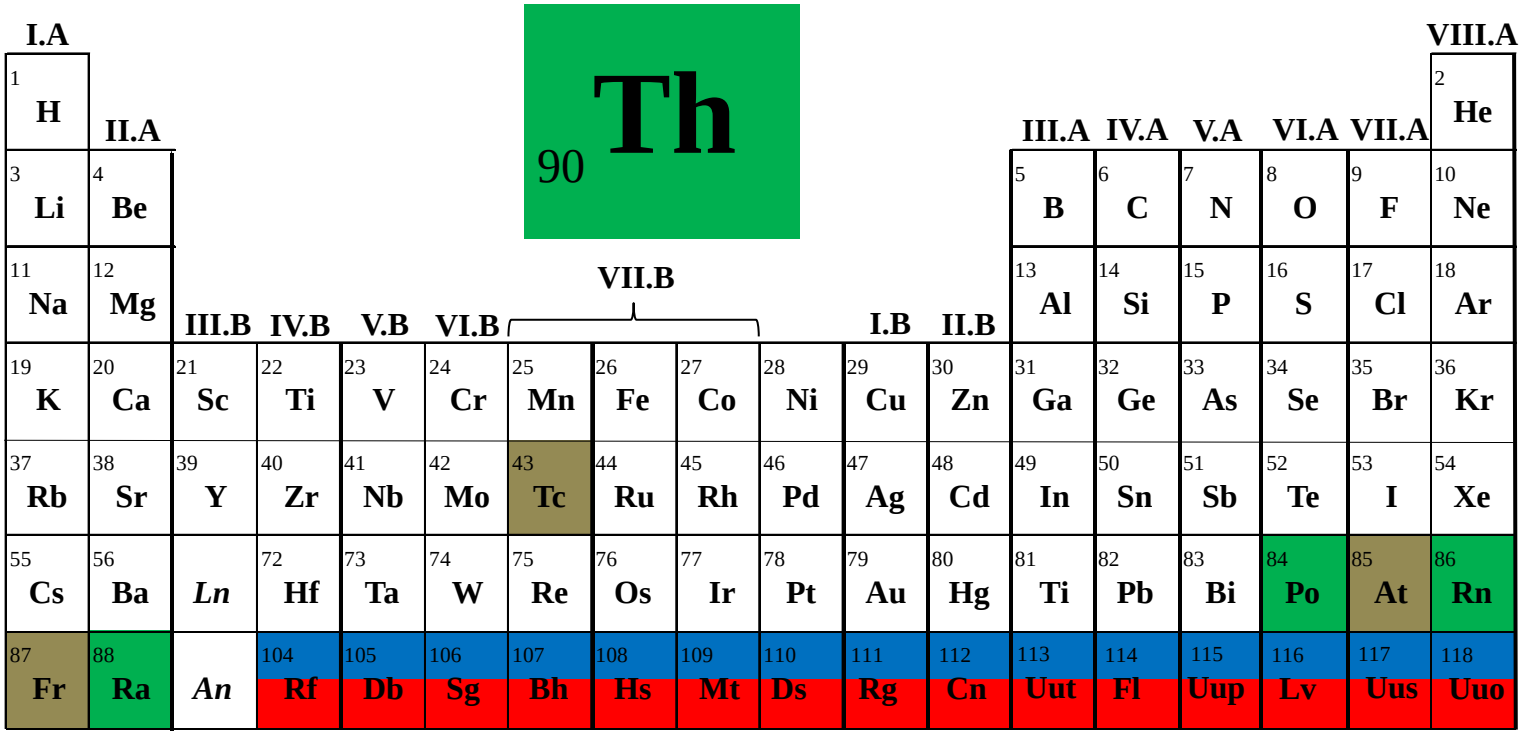
$AcPO_4 \cdot ½H_2O$ $KAc(SO_4)_2$
$Ac(C_2O_4)_3$

Aktinium (3)


Th
Po
Bi
Tl^{III} Pb
Ac
Tl^{I}
Ra
extrakce [%]
100
80
60
40
20
0
-1
0
1
2
3
4
5
6
7
8
pH


La
Ac

Thorium



Lanthan(o)idy

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu

Aktin(o)idy

89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

Thorium (1)

A	T	druh záření
223	~ 0,9 s	α
224	~ 1 s	α
225	8,0 m	α 90 %, EZ 10 %
226	30,9 m	α
227	18,17 d	α
228	1,91 a	α
229	7340 a	α
230	$8{,}0 \cdot 10^4$ a	α
231	26,64 h	β^-
232	$1{,}39 \cdot 10^{10}$ a	α (+ $T_{SF} > 10^{21}$ a)
233	22,12 m	β^-
234	24,10 d	β^-
235	7,1 m	β^-

Thorium (2)

T_T = 1750 °C T_V = 3000 - 4000 °C ρ = 11,5 g/cm^3

Thotit – $ThSiO_4$
Thorogummit
Thorianit – ThO_2

$^{232}Th(n,\gamma)^{233}Th \rightarrow {}^{233}U$

$ThO_2 + 2Ca \rightarrow Th + 2CaO$
$4Al(BH_4)_3 + 3ThF_4 \rightarrow 3Th(BH_4)_4 + 4AlF_3$

EXTRAKCE:

$C_4H_9O\text{-}(CH_2\text{-}CH_2O)_4\text{-}C_4H_9$ (pentaether)
H_3C
H_3C > $C{=}HC\text{-}CO\text{-}CH_3$ (mesityloxid)

} zř. HNO_3
NH_4NO_3; $LiNO_3$

TBP; c(HNO_3) > 5M
MIBK; c(HNO_3) = 1-3M; $Ca(NO_3)_2$, $Mg(NO_2)_2$, $Al(NO_3)_3$
HTTA v benzenu (0,25 M); pH = 1-2

Analytická chemie Th (1)

III.A

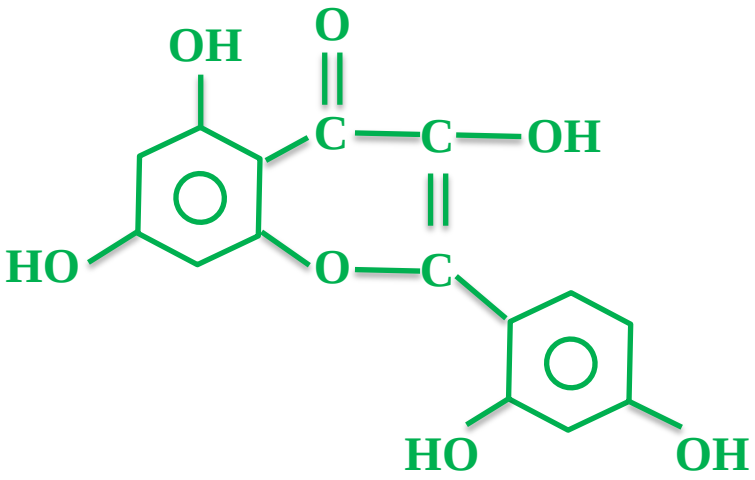
F^-	ThF_4 x ZrF_6^{2-}
$(COOH)_2$	$Th(C_2O_4)2\cdot 6H_2O + (NH_4)_2C_2O_4 \rightarrow Th(C_2O_4)_4^{4-}$
$(NH_4)CO_3$	$\rightarrow Th(CO_3)_2 \rightarrow (NH_4)_4[Th(CO_3)_4]$
KIO_3	$\rightarrow KIO_3\cdot 4Th(IO_3)\cdot 18H_2O$
H_3PO_4	$\rightarrow Th_3(PO_4)_4$, $Th(HPO_4)_2\cdot H_2O$, $Th(HPO_4)_2\cdot H_3PO_4$
CrO_4^{2-}	$\rightarrow Th(CrO_4)_2\cdot 3H_2O$
H_2SeO_4	→ dělení od Be
org.	– kyselina jantarová, kyselina m-nitrobenzoová, …

Analytická chemie Th (2)

KVALITA

MORIN:

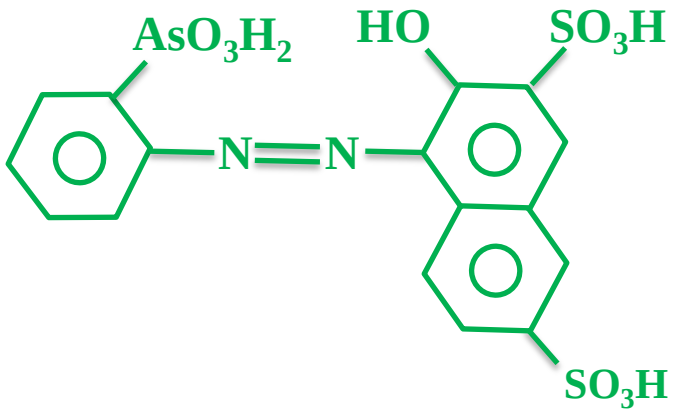
(pentahydroxyflavon)



THORIN:

(thoron) kyselina 1-(*o*-arzofenylazo)-2-naftol-3,6-disulfonová)

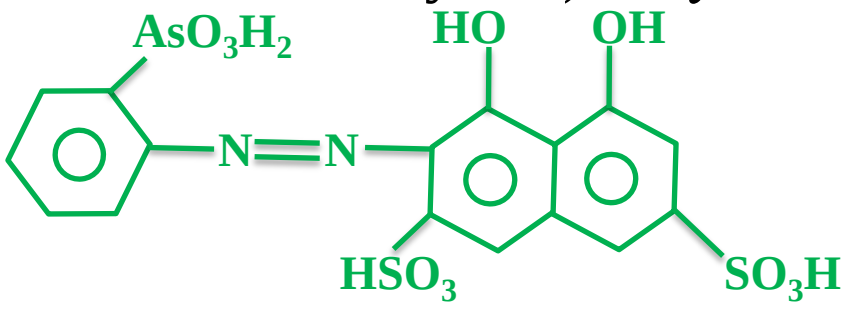
(dvojsodná sůl)



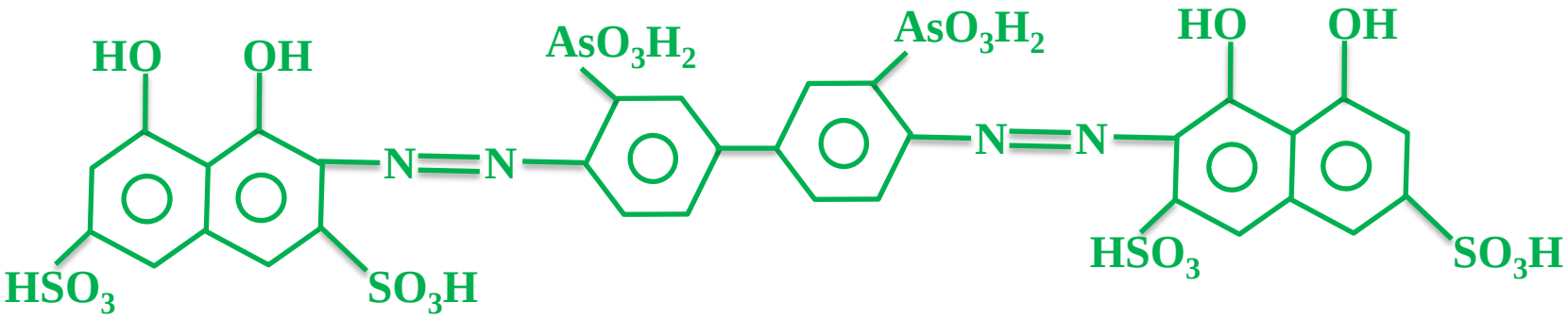
Analytická chemie Th (3)

ARSENAZO I:

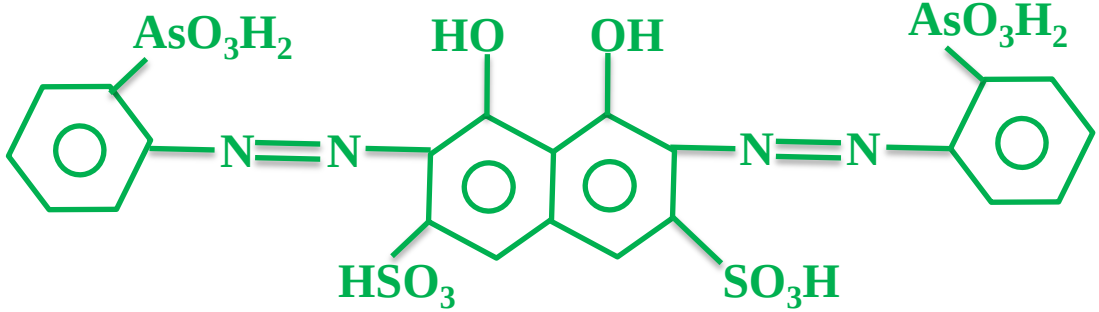
kyselina 2-(1,8-dihydroxy-3,6-disulfo-2-naftylazo)-fenylarseničná



ARSENAZO II:



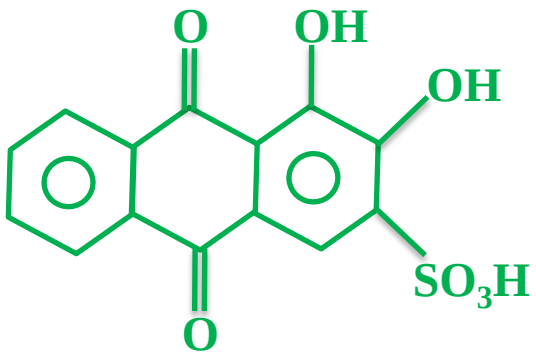
ARSENAZO III:



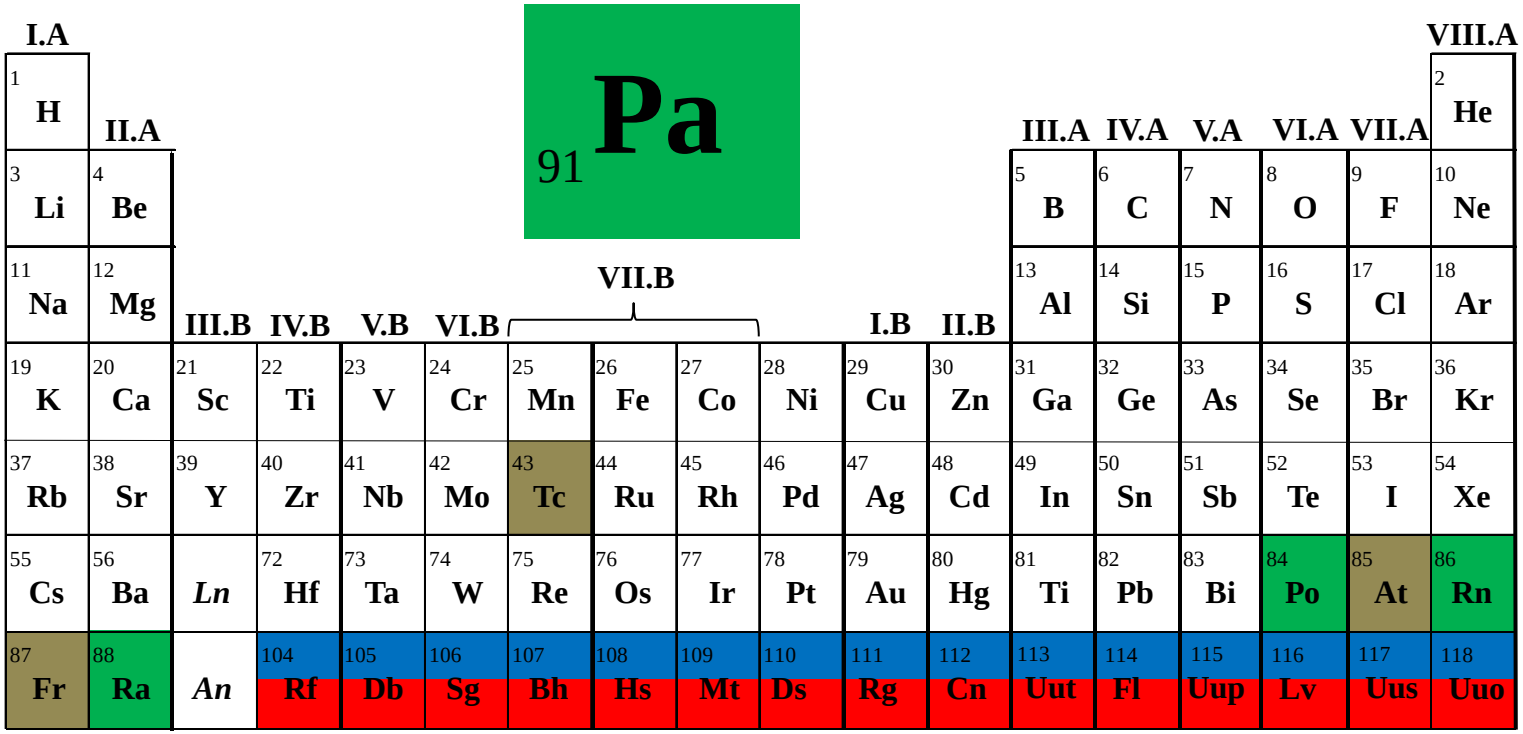
Analytická chemie Th (4)

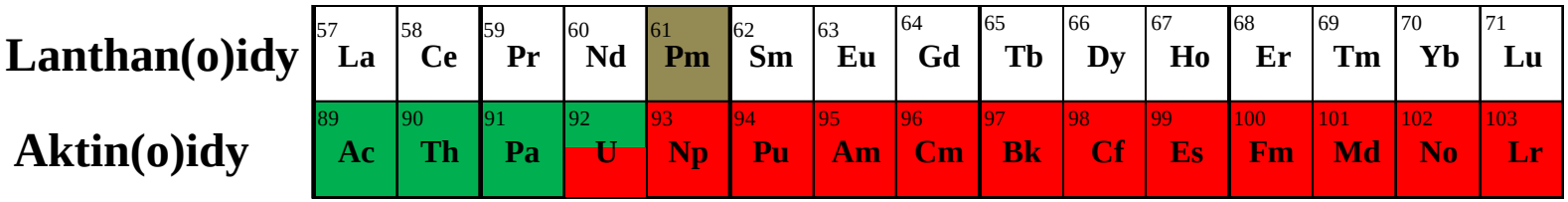
KVANTITA

Alizarin-S:



Protaktinium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Protaktinium (1)

A	T	druh záření
225	2 s	α
226	1,8 m	α
227	38,3 m	α 85 %, EZ 15 %
228	22 h	α 2 %, EZ 98 %
229	1,5 d	α 1 %, EZ 99 %
230	17,7 d	EZ 85 %, β^- 15 %
231	$3{,}43 \cdot 10^4$ a	α
232	1,39 d	β^-
233	27,0 d	β^-
234 (UZ)	6,7 h	β^-
234m (UX_2)	1,175 m	β^-, I.P.
235	23,7 m	β^-
237	11 m	β^-

Protaktinium (2)

T_T = 1560 °C ρ = 11,5 g/cm^3

1918 HAHN, MEITNEROVÁ
SODDY, CRANSTON

1913 – „BREVIUM“ FAJANS

$^{230}Th(=Io)(n,\gamma)^{231}Th \xrightarrow[25,6\ h]{\beta^-} {}^{231}Pa$ (σ = 27 b)

$^{232}Th(n,\gamma)^{233}Th \xrightarrow[22,1\ m]{\beta^-} {}^{233}Pa \xrightarrow[27\ d]{\beta^-} {}^{233}U$

„PROTAKTINIČNANY“ ≡ TERNÁRNÍ OXIDY *(tavení s alkáliemi)*

$MePaO_3$
Me_3PaO_4
Me_7PaO_6
} *Me = Li, Na, Rb, K*

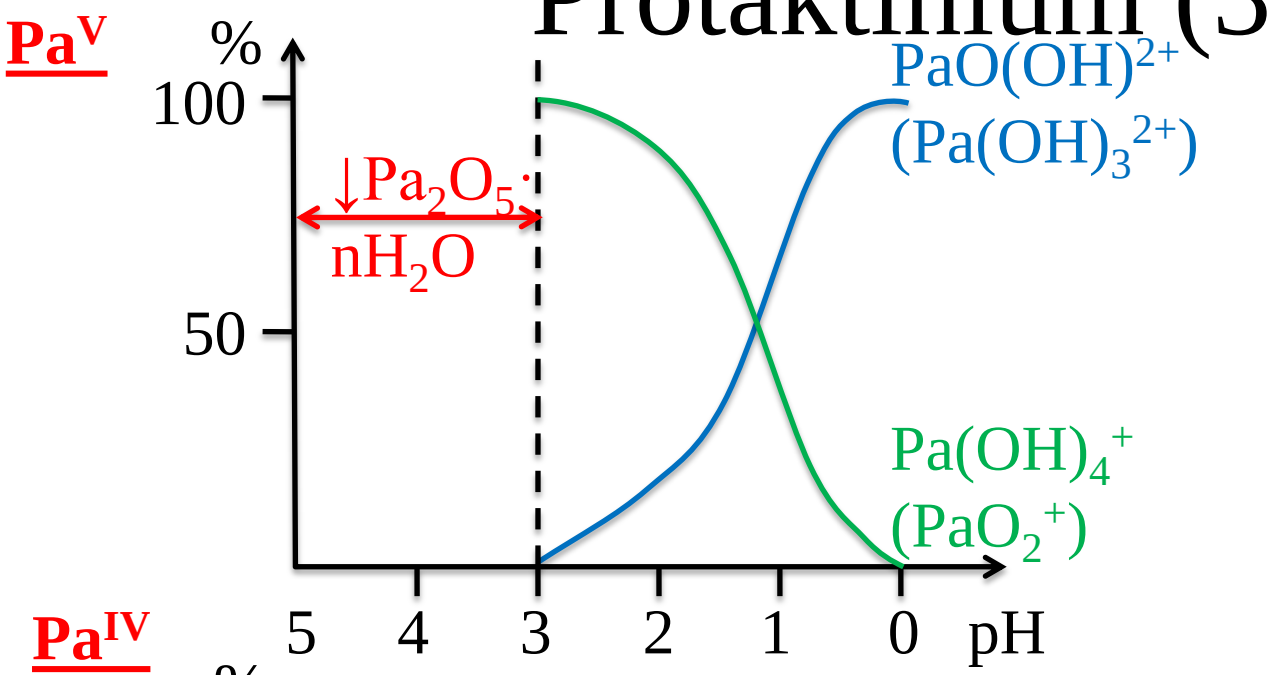
$PaGeO_4$ $PaO_2 \cdot 2Ta_2O_5$
$PaSiO_4$

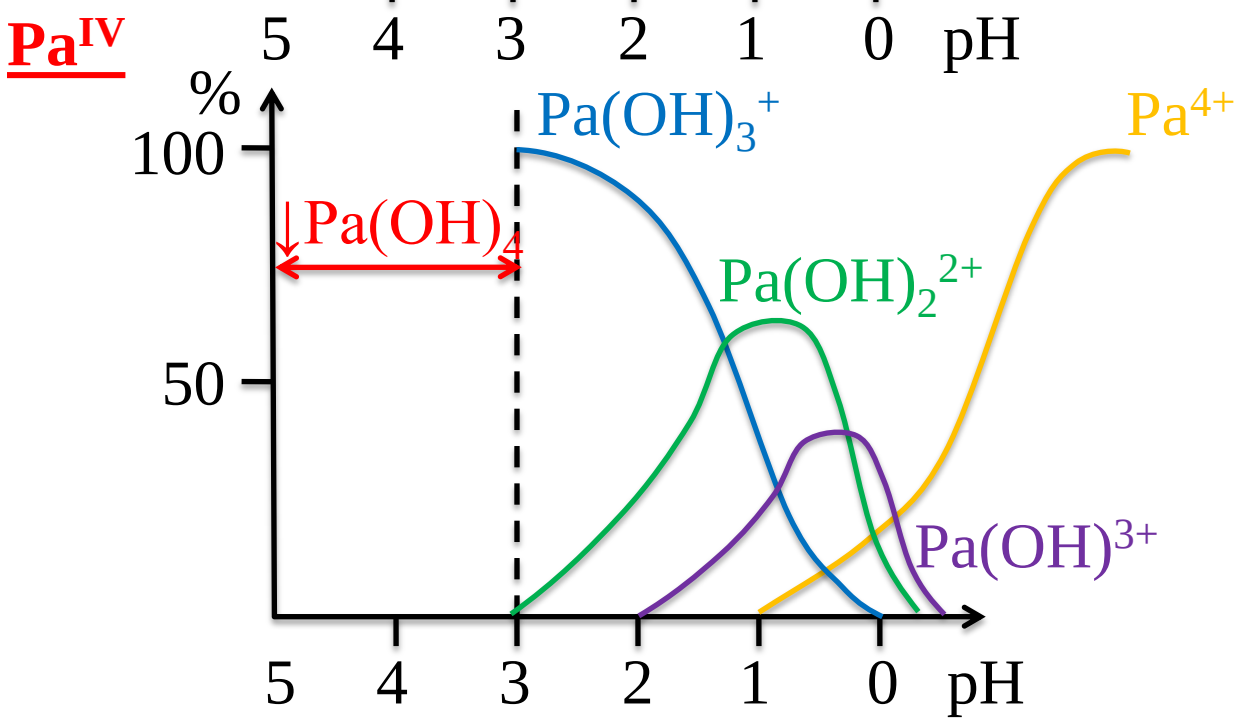
$[PaF_7]^{2-}$

$PaO_x(OH)_yCl_z^{5-2x-y-z}$

x = 0, 1, 2
y = 0 → 4
z = 0 → 8
$x + y + z \leq 8$

Protaktinium (3)





Protaktinium (4)

Pa_2O_5
PaO_2
$Pa_2O_5 \cdot nH_2O$

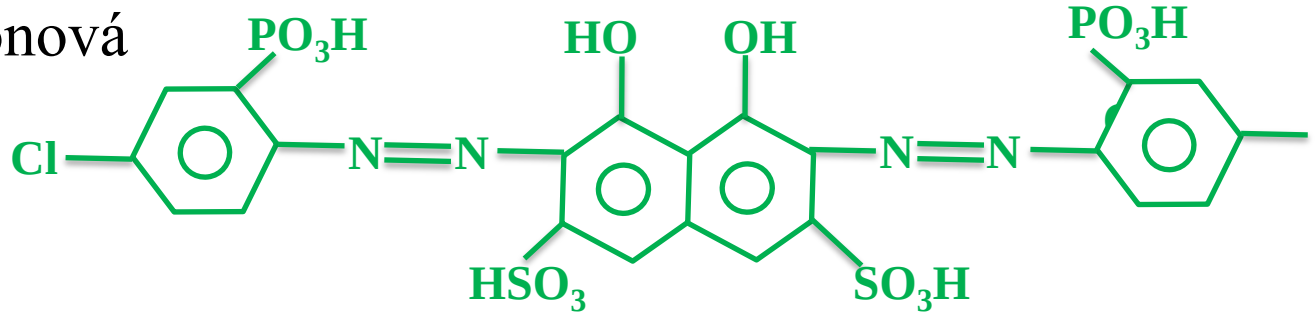
PaF_5
$PaCl_5$
$PaBr_5$
PaI_5

PaF_4
$PaCl_4$
K_2PaF_7
NH_4PaF_6

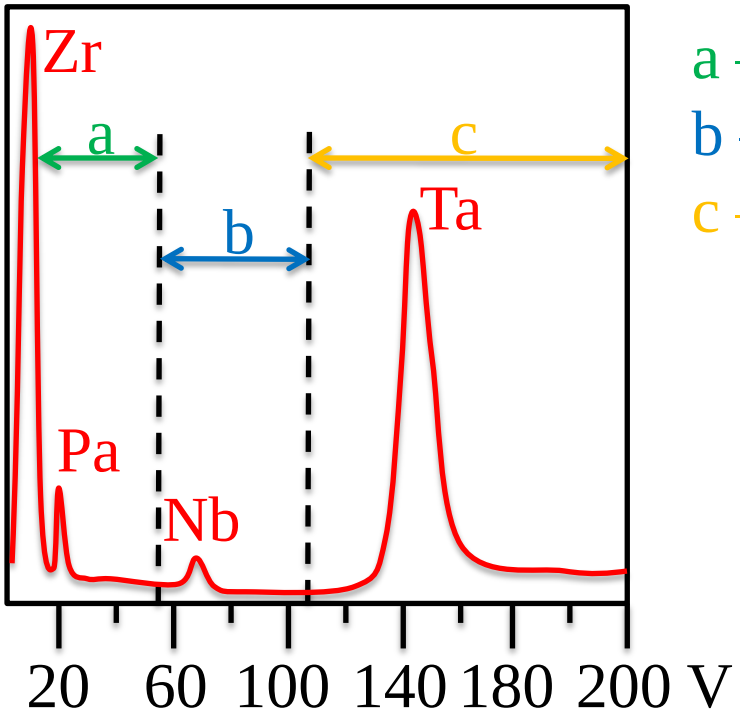
PaH_3
PaN_2
PaC
$Pa_2O_9 \cdot 3H_2O$

CHLORFOSFONAZO III:

kyselina 2,7-bis-(4-chloro-2-fosfobenzenazo)-1,8-dihydroxynaftaen-3,6-disulfonová



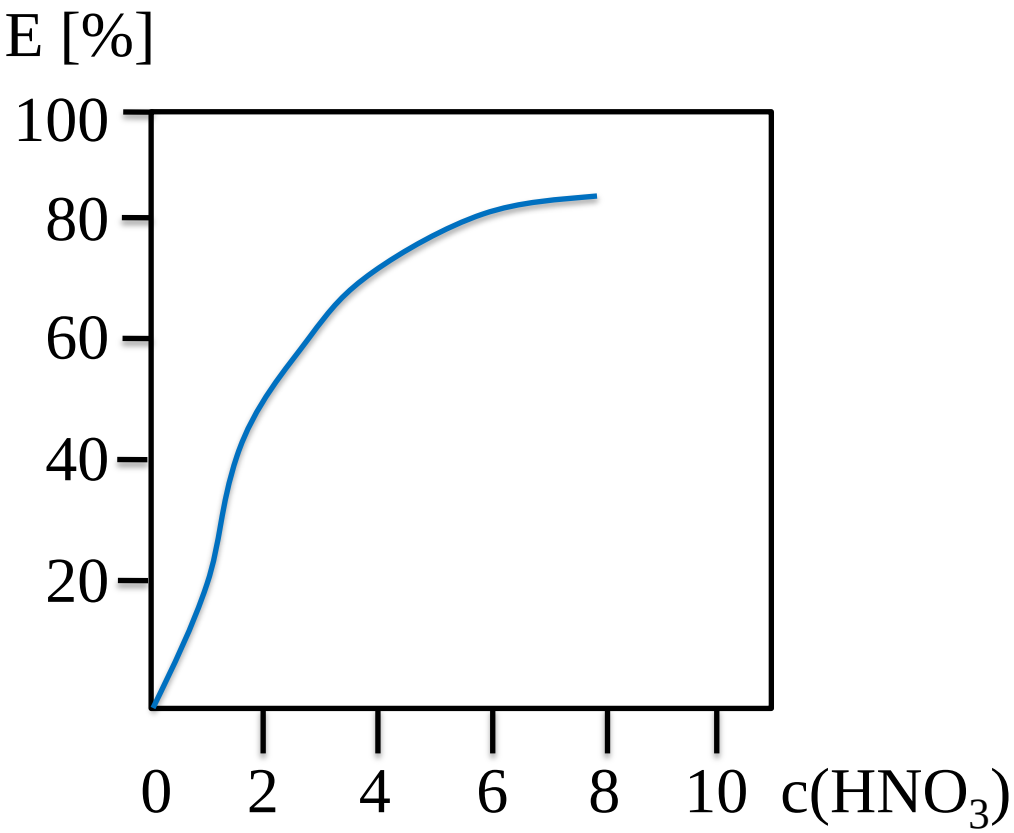
Protaktinium (5)



a – 9mol/L HCl + 0,004mol/L HF

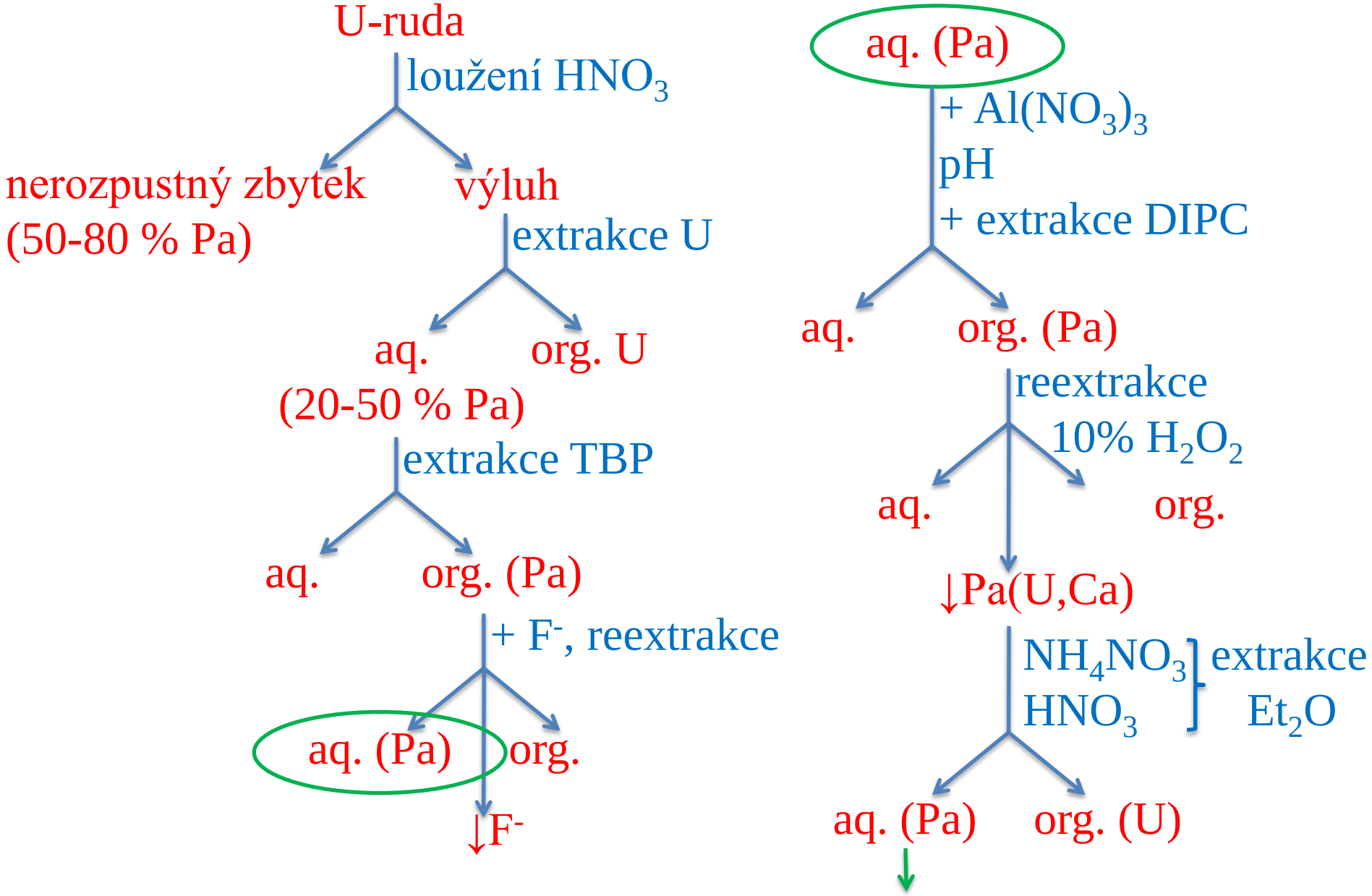
b – 9mol/L HCl + 0,18mol/L HF

c – 1mol/L HF + 4mol/L NH_4Cl



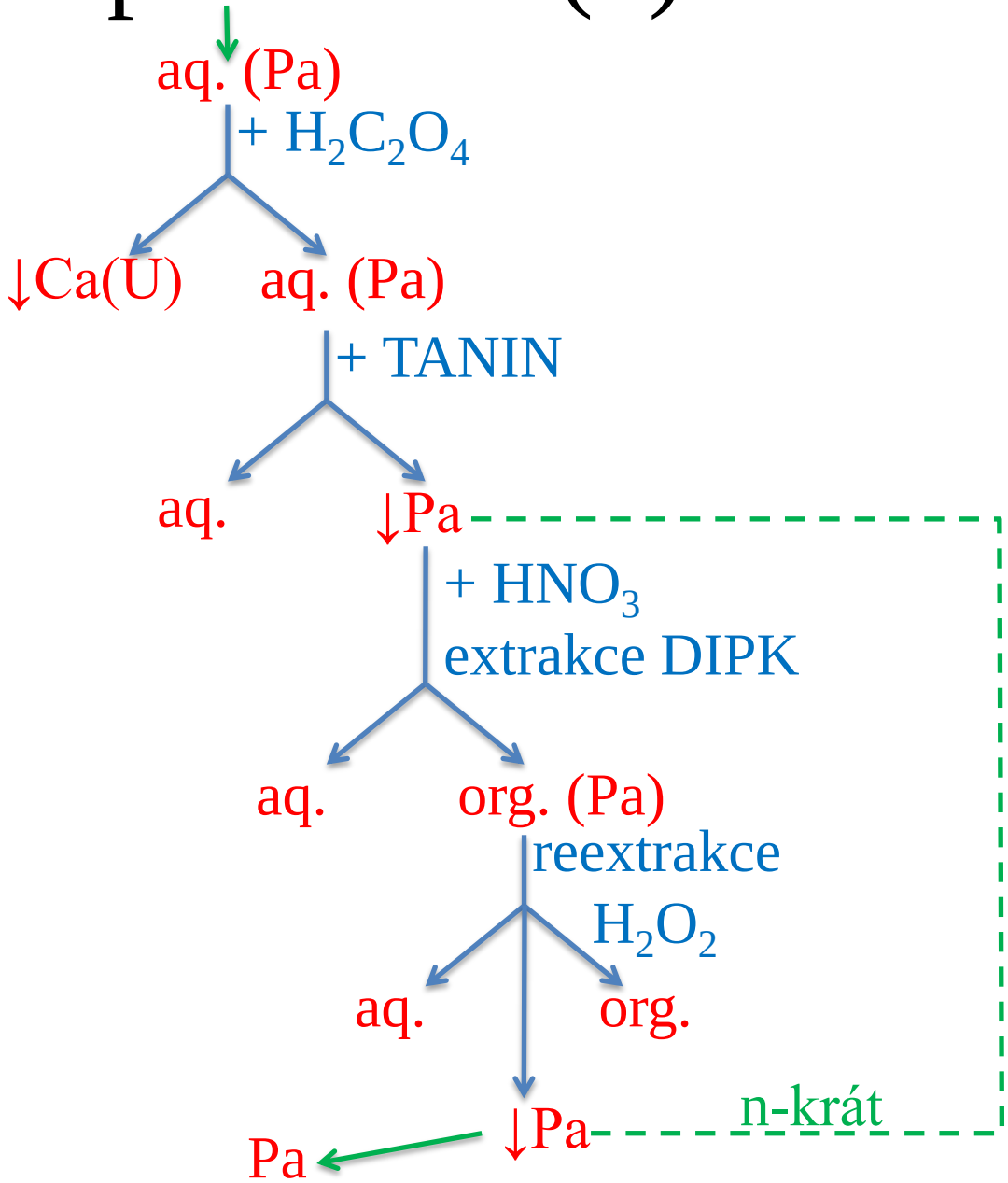
Separace Pa (1)

ELSON

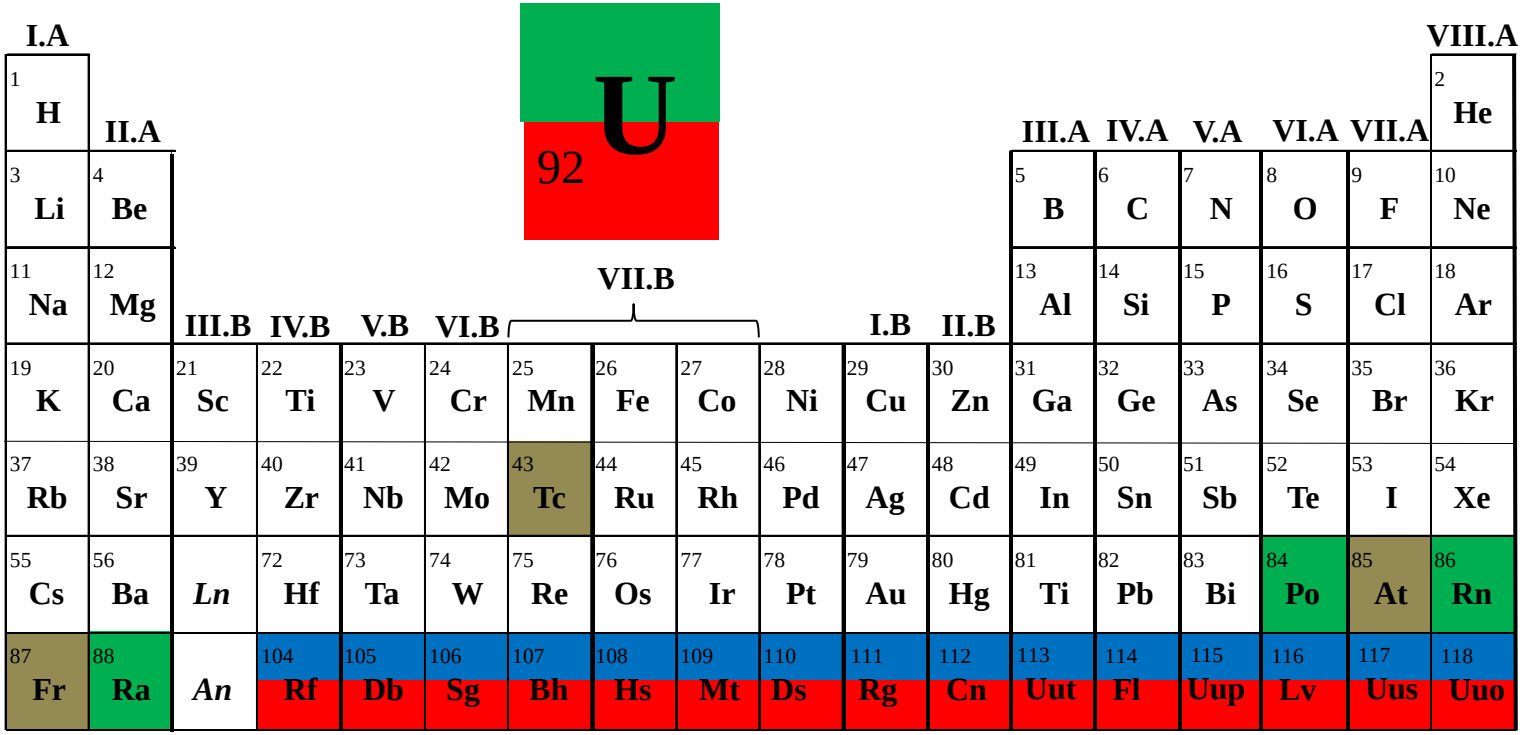


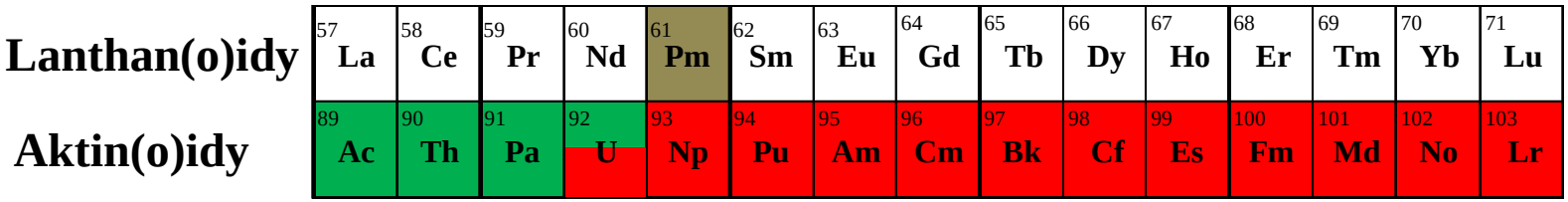
ELSON pokračování

Separace Pa (2)



Uran





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Uran (1)

A	př. zastoupení	T	druh záření	T_{SF}
227		1,3 m	α	
228		9,3 m	α 80 %, EZ 20 %	
229		58 m	α 20 %, EZ 80 %	
230		20,8 d	α	
231		4,2 d	α $6 \cdot 10^{-3}$ %, EZ > 99 %	
232		73,6 a	α	$8 \cdot 10^{13}$ a
233		$1{,}62 \cdot 10^{5}$ a	α	
234 (UII)	0,0057 %	$2{,}48 \cdot 10^{5}$ a	α	$2 \cdot 10^{16}$ a
235(AcU)	0,7204 %	$7{,}1 \cdot 10^{8}$ a	α	$2 \cdot 10^{17}$ a
236		$2{,}39 \cdot 10^{7}$ a	α	$2 \cdot 10^{16}$ a
237		6,75 d	β^-	
238(UI)	99,2739 %	$4{,}51 \cdot 10^{9}$ a	α	10^{16} a
239		23,54 m	β^-	
240		14,1 h	β^-	

Uran (2)

roztok U^{III}

$$2U^{3+} + 2H^{+} \rightarrow 2U^{4+} + H_2$$

roztok U^{V}

$$2UO_2^{+} + 4H^{+} \overset{K = 1,7\cdot 10^{6}}{\leftrightarrow} UO_2^{2+} + U^{4+} + 2H_2O$$

Hydrolýza:

0,02mol/L roztok

U^{IV}…… pH = 1,3

U^{III}…… pH = 1,3

UO_2^{2+}…… pH = 1,3

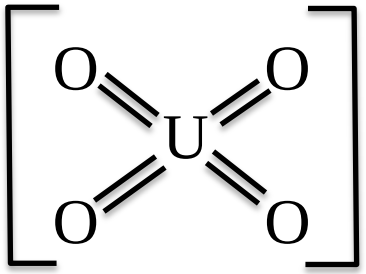
U^{IV}: $U^{IV} + H_2O \overset{K = 0,21}{\leftrightarrow} U(OH)^{3+} + H^{+}$

UO_2^{2+}: $2UO_2^{2+} + H_2O \overset{K = 1,1\cdot 10^{6}}{\leftrightarrow} U_2O_5^{2+} + 2H^{+}$

$U_2O_5^{2+} + UO_2^{2+} + H_2O \overset{K = 5\cdot 10^{-9}}{\leftrightarrow} U_3O_8^{2+} + 2H^{+}$ $(1,5 < pH < 4)$

Uran (3)

$UO_4 \cdot 2H_2O$:



$\cdot 2H_2O$ *nebo* $UO_3 \cdot H_2O_2 \cdot H_2O$

F^-: UF_3 – fialovočervený: $2UF_4 + H_2 \rightarrow 2UF_3 + 2HF$

$UF_4 + Al \rightarrow UF_3 + AlF$

$T > 1000\ ^oC$ $4UF_3 \rightarrow 3UF_4 + U$

UF_4 – zelený: srážení roztoků U^{IV} $_{550\ ^oC}$

$UO_2 + 4HF \rightarrow UF_4 + 2H_2O$

UF_5 – bílý

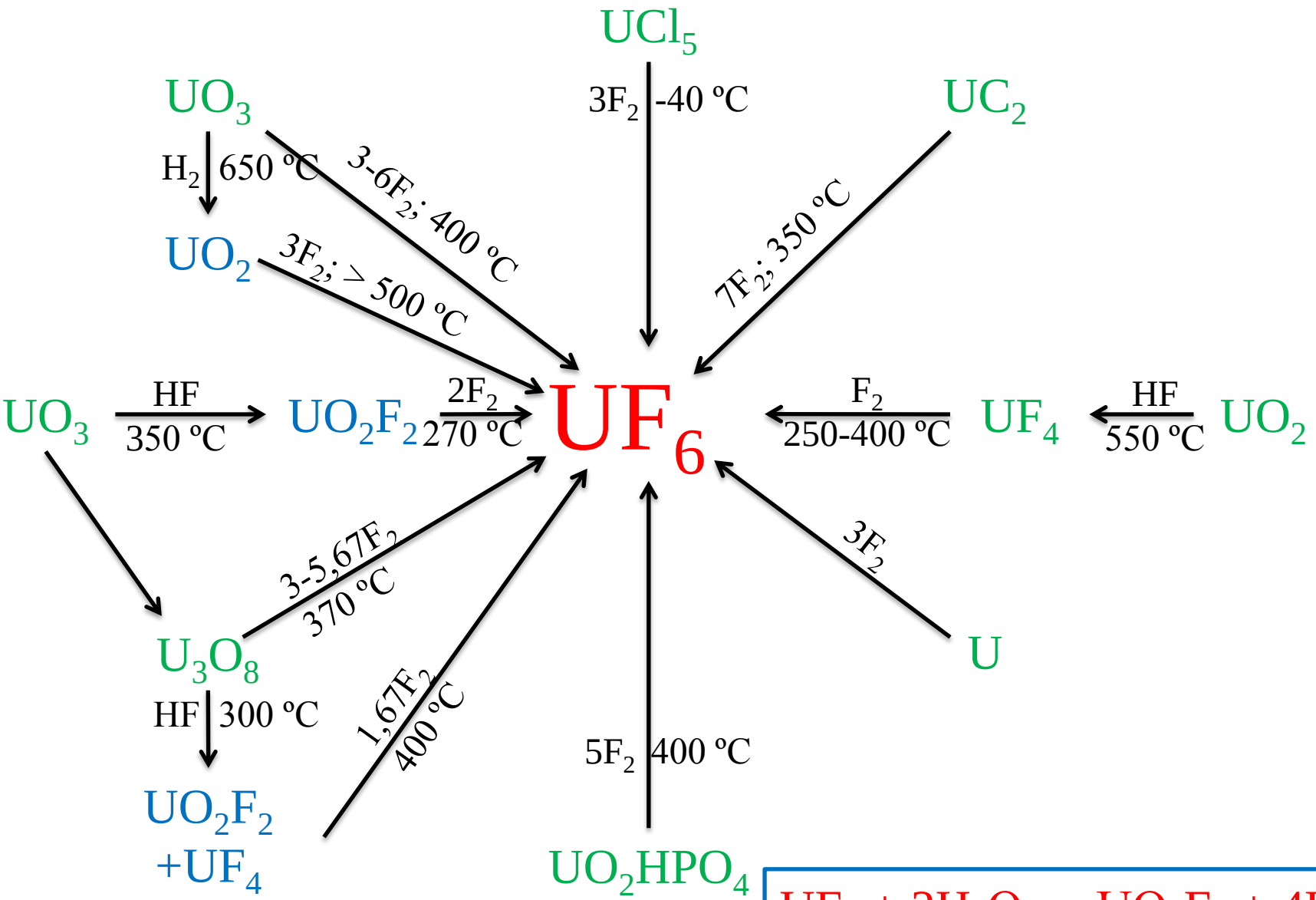
U_4F_{17}; U_2F_9 – temná

$\rightarrow UF_4 + UF_6$

$\xrightarrow{T} UF_4 + UF_6$

UF_6 – bezbarvý, sublimace 56,6 °C

Uran (4)



$$UF_6 + 2H_2O \rightarrow UO_2F_2 + 4HF$$

Uran (5)

Cl⁻: UCl_3 – červený v zelený

$$2UCl_4 + H_2 \xrightarrow{550\,^{\circ}C} UCl_3 + 2HCl$$

$$UH_3 + 3HCl \xrightarrow{350\,^{\circ}C} UCl_3 + 3H_2$$

$$3UCl_4 + Al \xrightarrow{400\,^{\circ}C} 3UCl_3 + AlCl_3$$

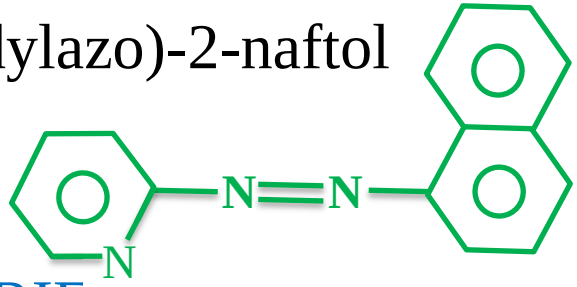
UCl_4 – zelený, chlorace UO_2 (hexachlorpropen $CCl=CCl-CCl_3$)

UCl_5 – červeno-hnědý

UCl_6 – černý, nestálý

Analytická chemie U

PAN: 1-(2-pyridylazo)-2-naftol



570 nm

REDUKTOMETRIE:

$$5U^{4+} + 2MnO_4^- + 2H_2O \rightarrow 5UO_2^{2+} + 2Mn^{2+} + 4H^+$$

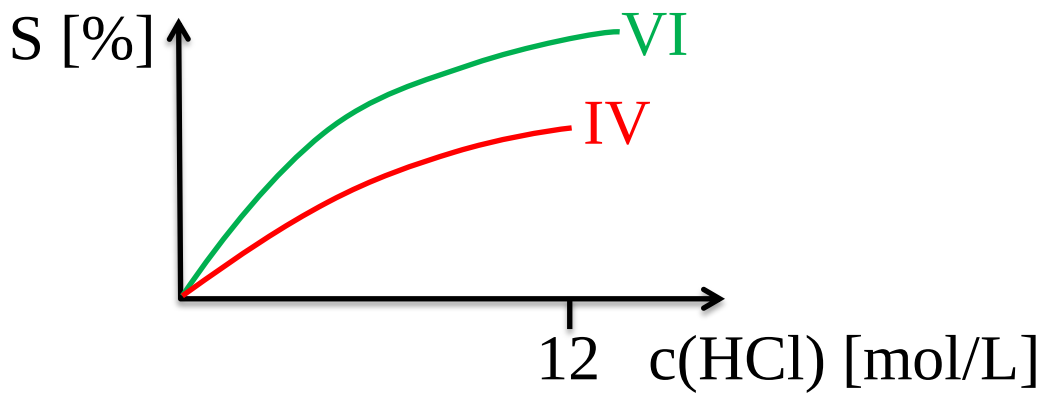
KOMPLEXOMETRIE:

$$U^{4+} + H_4Y \rightarrow UY + 4H^+$$

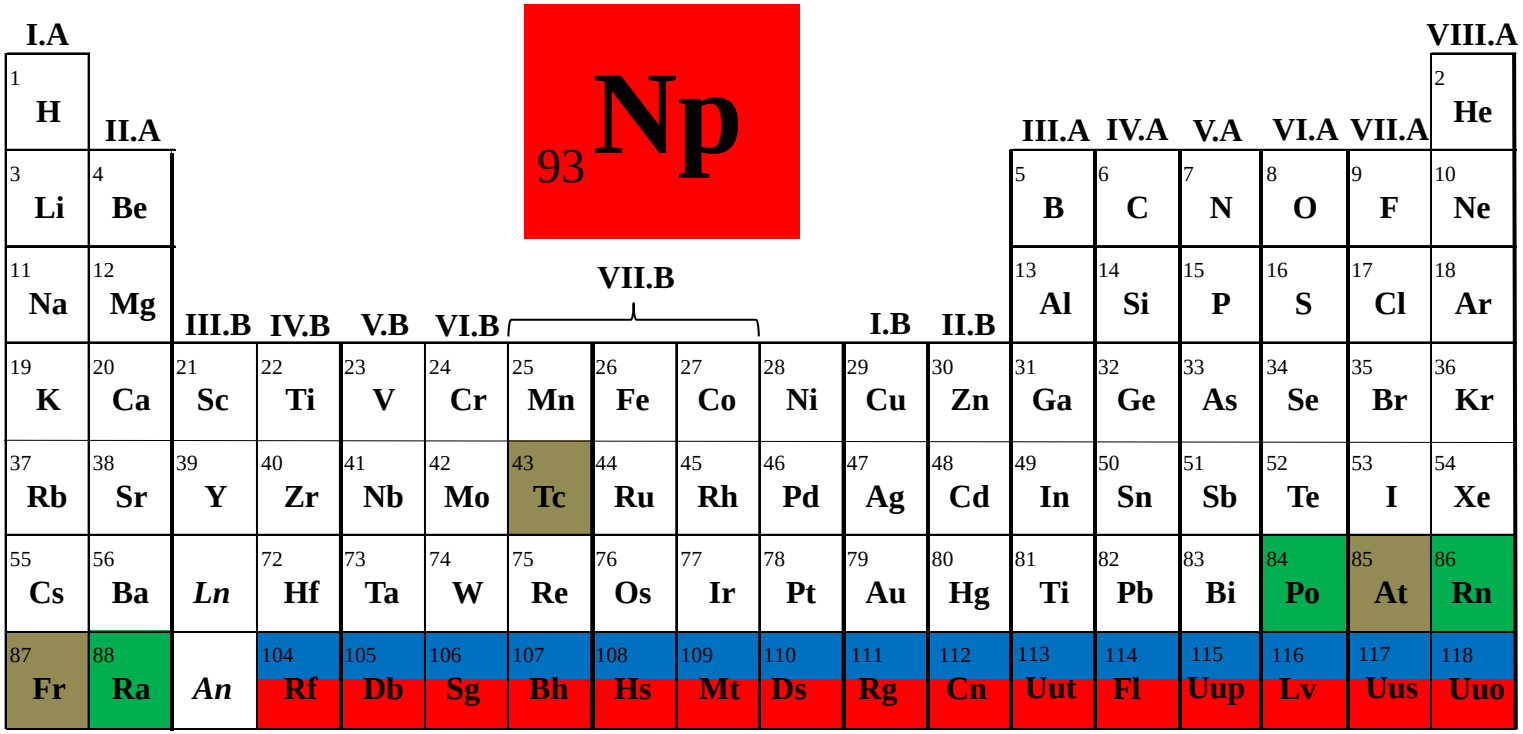
SRÁŽENÍ:

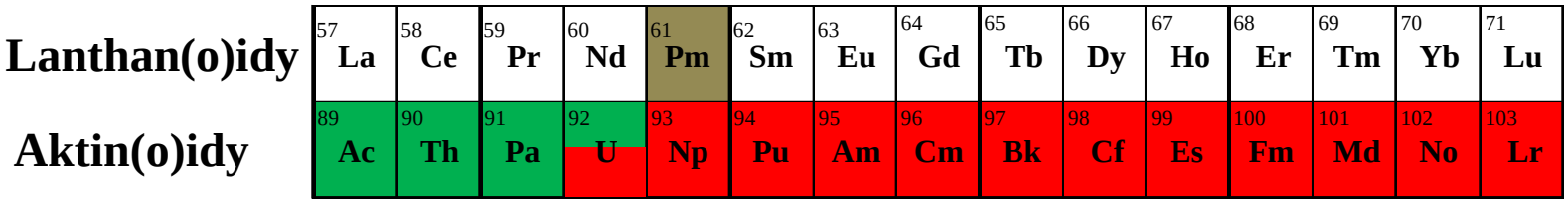
$[UO_2(SCN)_3]^-$ + methylviolet'… spálení 500ºC

ANEXY:



Neptunium





- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

Neptunium (1)

A	T	druh záření	příprava
229	4,0 m	α, EZ	^{233}U(p,5n)
230	4,6 m	EZ 97 %, α 3 %	^{233}U(p,4n)
231	50 m	EZ 99 %, α 1 %	^{235}U(d,6n)
232	13 m	EZ	^{235}U(d,5n)
233	35 m	EZ > 99 %	^{233}U(d,2n); ^{234}U(d,3n)
234	4,4 d	EZ > 99 %, α < 0,1 %, β	^{235}U(d,3n)
235	396,1 d	EZ > 99 %, α < 10^{-3} %	^{235}U(d,2n)
236	> 5000 a	β^-	^{238}U(d,4n)
236m	22 h	β^- 52 %, EZ 48 %	^{235}(d,n)
237	2,14·10^6 a	α	^{238}U(n,2n); ^{235}Np(n,γ)^2
238	2,1 d	β^-	^{237}Np(n,γ)
239	2,35 d	β^-	^{238}U(n,γ)^{239}U$\xrightarrow{\beta^-}$
240	67 m	β^-	^{238}U(α,pn)
240m	7,5 m	β^-	^{238}U$\xrightarrow{\beta^-}$
241	16 m	β^-	^{238}U(α,p)

Neptunium (2)

1940 McMILLAN, ABELSON

$^{238}U(n,\gamma)^{239}U \xrightarrow[23{,}5\ m]{\beta^-} {}^{239}Np \xrightarrow[2{,}3\ d]{\beta^-} (^{239}Pu)$

WAHL, SEABORG, G. T.

$^{238}U(n,2n)^{237}U \xrightarrow[6{,}8\ d]{\beta^-} {}^{237}Np \xrightarrow[2{,}2\cdot 10^6\ a]{\alpha} (^{233}Pu \rightarrow 4n+1\ !)$

$(^{235}U(n,\gamma)^{236}U(n,\gamma)^{237}U \xrightarrow[6{,}8\ d]{\beta^-} {}^{237}Np)$ (0,1 % ^{239}Pu)

Neptunium (3)

T_T = 637 ºC T_V = 3902 ºC ρ = 19,5 g/cm^3

NpO_2
NpO_3
Np_2O_5
$NpO_4 \cdot 2H_2O$

NpF_3
NpF_4
KNp_2F_9
NpF_6
(T_T = 53 ºC)

$NaCl_3$
NpOCl
$NpCl_4$
$NpOCl_2$

$NpBr_3$
$NpBr_4$
NpI_3

$Np(NO_3)_4$
NpO_2NO_3
$NpO_2(NO_3)_2$

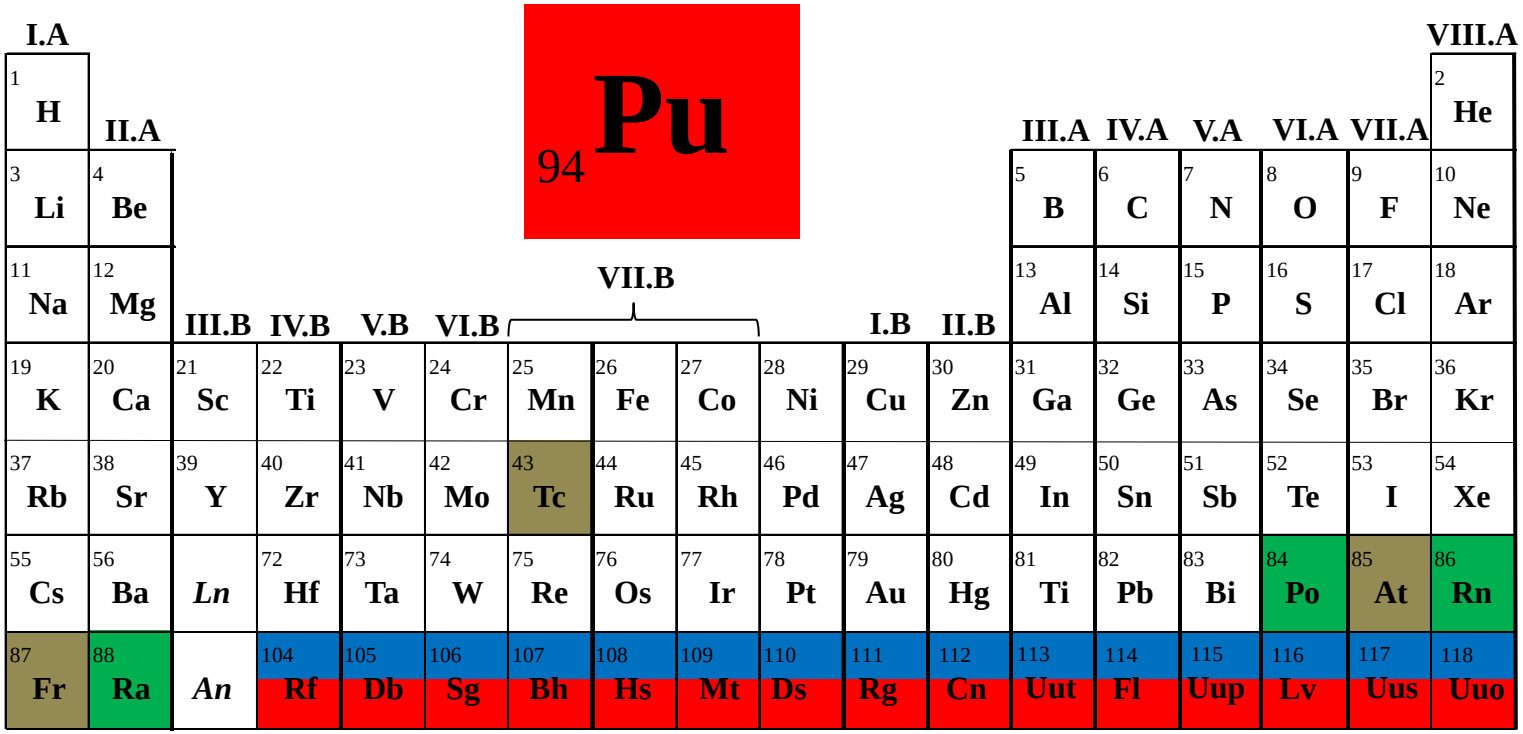
$Np(HPO_4)_2$
$Np(IO_3)_4$
$Np(C_2O_4)_2 \cdot 6H_2O$

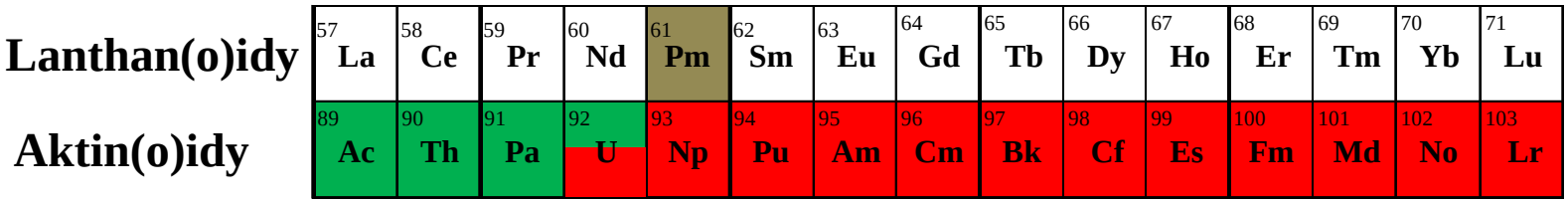
$Na[NpO_2(CH_3COO)_3]$
$Me_2^{I}Np_2O_7$

$NpH_{3,7}$
NpC_2
NpH

$NpSi_2$
Np_2S_3
NpOS

Plutonium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Plutonium (1)

A	T	druh záření	příprava
232	36 m	EZ 98 %, α 2 %	$^{233}U(\alpha,5n)$
233	20 m	EZ 99 %, α 1 %	$^{233}U(\alpha,4n)$
234	9,0 h	EZ 94 %, α 6 %	$^{233}U(\alpha,3n)$
235	26 m	EZ > 99 %, α $3 \cdot 10^{-3}$ %	$^{235}U(\alpha,4n)$
236	2,85 a	α, ($T_{SF} = 3,5 \cdot 10^{9}$ a)	$^{235}U(\alpha,3n)$
237	45,63 d	EZ, α $3,3 \cdot 10^{-3}$ %	$^{235}U(\alpha,2n)$
238	86,4 a	α	$^{237}Np(n,\gamma)^{238}Np \xrightarrow{\beta^-}$
239	24360 a	α	$^{238}U(n,\gamma)^{239}Np \xrightarrow{\beta^-}$
240	6580 a	α, ($T_{SF} = 1,2 \cdot 10^{11}$ a)	$^{239}Pu(n,\gamma)$
241	14,1 a	β^- > 99 %, α $2,3 \cdot 10^{-3}$ %	$^{240}Pu(n,\gamma)$
242	$3,87 \cdot 10^{5}$ a	α, ($T_{SF} = 7,1 \cdot 10^{10}$ a)	$^{241}Pu(n,\gamma)$
243	4,96 h	β^-	$^{242}Pu(n,\gamma)$
244	$8,28 \cdot 10^{7}$ a	α, ($T_{SF} = 2,5 \cdot 10^{10}$ a)	$^{244}U \xrightarrow{\beta^-} {}^{244}Np \xrightarrow{\beta^-}$
245	10,5 h	β^-	$^{245}U \xrightarrow{\beta^-} {}^{245}Np \xrightarrow{\beta^-}$
246	10,85 h	β^-	$^{246}U \xrightarrow{\beta^-} {}^{246}Np \xrightarrow{\beta^-}$

Plutonium (2)

T_T = 639,5 ºC T_V = 3235 ºC ρ = 19,816 g/cm^3

1940 SEABORG, McMILLAN, KENNEDY, WAHL

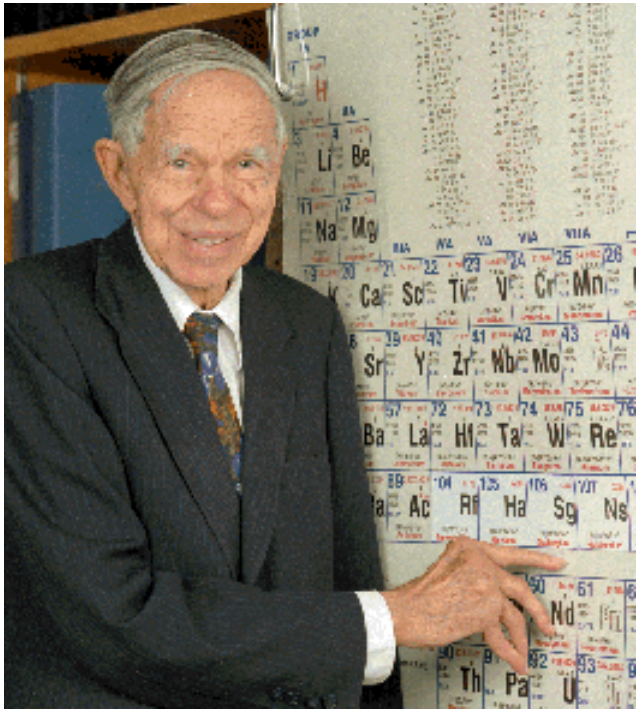
$$^{238}U(d,2n)^{238}Np \xrightarrow[2,1\,d]{\beta^-} {}^{238}Pu \xrightarrow[86,4\,a]{\alpha} (^{234}U \rightarrow 4n+2)$$

1941 KENNEDY, SEABORG, SEGRÈ, WAHL

$$^{238}U(n,\gamma)^{239}U \xrightarrow[23,5\,m]{\beta^-} {}^{239}Np \xrightarrow[2,3\,d]{\beta^-} {}^{239}Pu \xrightarrow[24360\,a]{\alpha} (^{235}U \rightarrow 4n+3)$$

MANHATTAN PLUTONIUM PROJECT (Hanford)

2,77 μg PuO_2!!!



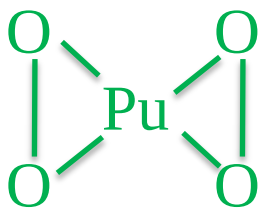
Hanford site 1960

Hanford reprocessing plant 1960

Hanford site 2008

Plutonium (3)

PuO_2
Pu_2O_3
PuO
$Pu(OH)_3 \cdot nH_2O$
$Pu(OH)_4$
$Pu(O_2)_2$



$Pu_2(C_2O_4)_3 \cdot 9H_2O$
$Pu(C_2O_4)_2 \cdot 6H_2O$
$Pu(IO_3)_3$
$Pu(IO_3)_4$
$PuPO_4 \cdot nH_2O$
$Pu(HPO_4)_2 \cdot nH_2O$

PuF_3
PuF_4
PuF_6 (T_V = 62,3 °C)
PuO_2F_2
$PuCl_3$
$PuOCl$

$Pu(CO_3)_2$
PuO_2CO_3
$KPu^{III}[Fe^{II}(CN)_6] \cdot 7H_2O$
$Pu^{IV}[Fe^{II}(CN)_6] \cdot 3{,}5H_2O$
$Pu^{III}[Fe^{III}(CN)_6] \cdot 7H_2O$
$Pu_3^{IV}[Fe^{III}(CN)_6]_4$
$(Pu^{IV}O_2)_3[Fe^{III}(CN)_6]_2$
$P_4OCrO_4 \cdot 2H_2O$
$Pu(MoO_4)_2$

$Pu(NO_3)_4 \cdot 5H_2O$
$PuO_2(NO_3)_2 \cdot 6H_2O$
$Pu(SO_4)_2$

$PuBr_3$
PuI_3

$Na_2Pu_2O_6 \cdot 4H_2O$
$(NH_4)_2Pu_2O_6 \cdot 4H_2O$
$(NH_4)_2Pu_2O_7$

PuH_2; PuH_3
PuC; Pu_2C_3
PuN
$PuSi$; Pu_2Si_3; $PuSi_2$
PuS; Pu_2O_2S; …

Hydrolýza Pu

IV $Pu^{4+} + H_2O \rightarrow Pu(OH)_3^{+} + H^{+}$ $c(H^{+}) < 0{,}3N$

VI $PuO_2^{2+} + H_2O \rightarrow PuO_2(OH)^{+} + H^{+}$

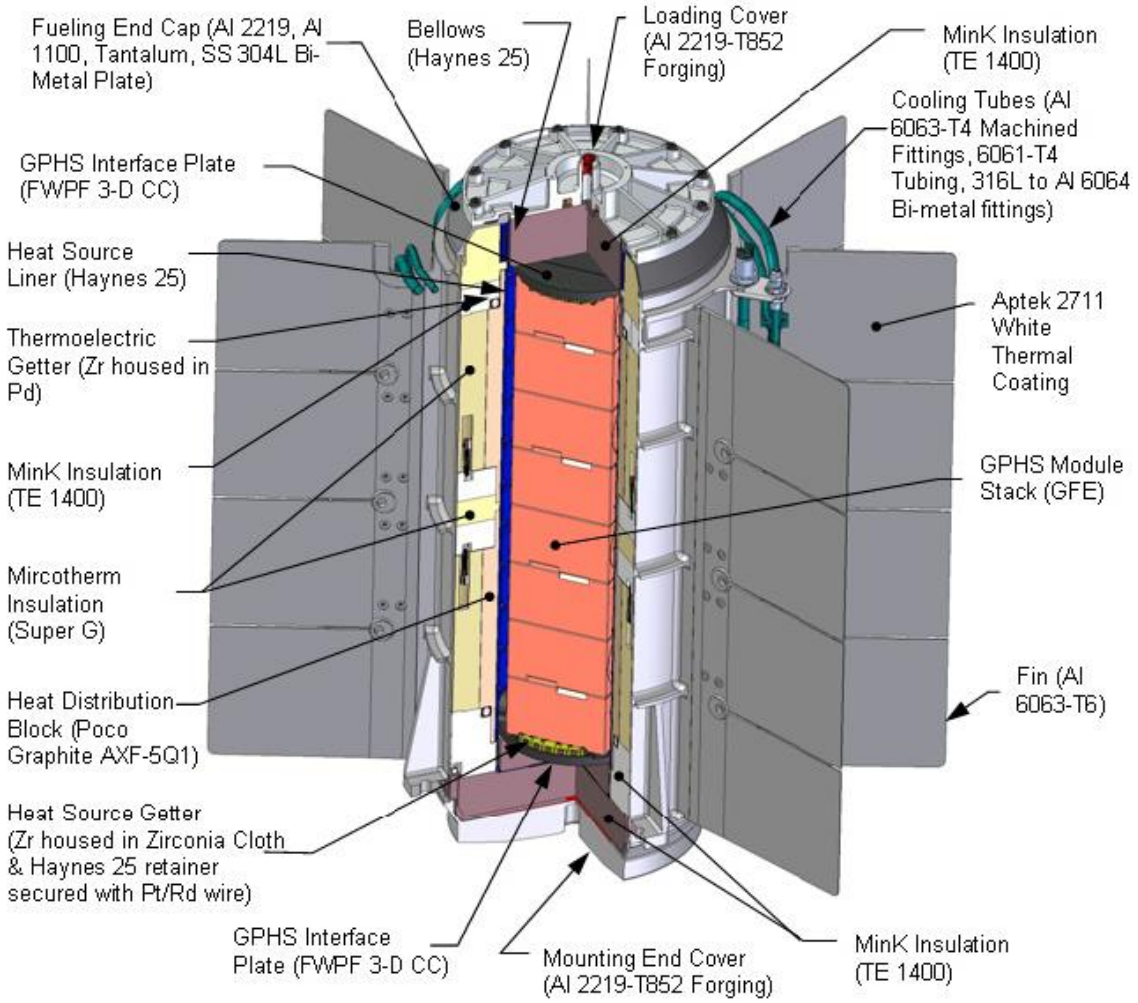
$PuO_2(OH)^{+} + H_2O \rightarrow PuO_2(OH)_2 + H^{+}$

$PuO_2(OH)_2 + H_2O \rightarrow PuO_2(OH)_3^{-} + H^{+}$

III $Pu^{3+} + H_2O \rightarrow Pu(OH)^{2+} + H^{+}$

V $PuO_2^{2+} + H_2O \rightarrow PuO_2OH + H^{+}$

Radionuklidové zdroje energie

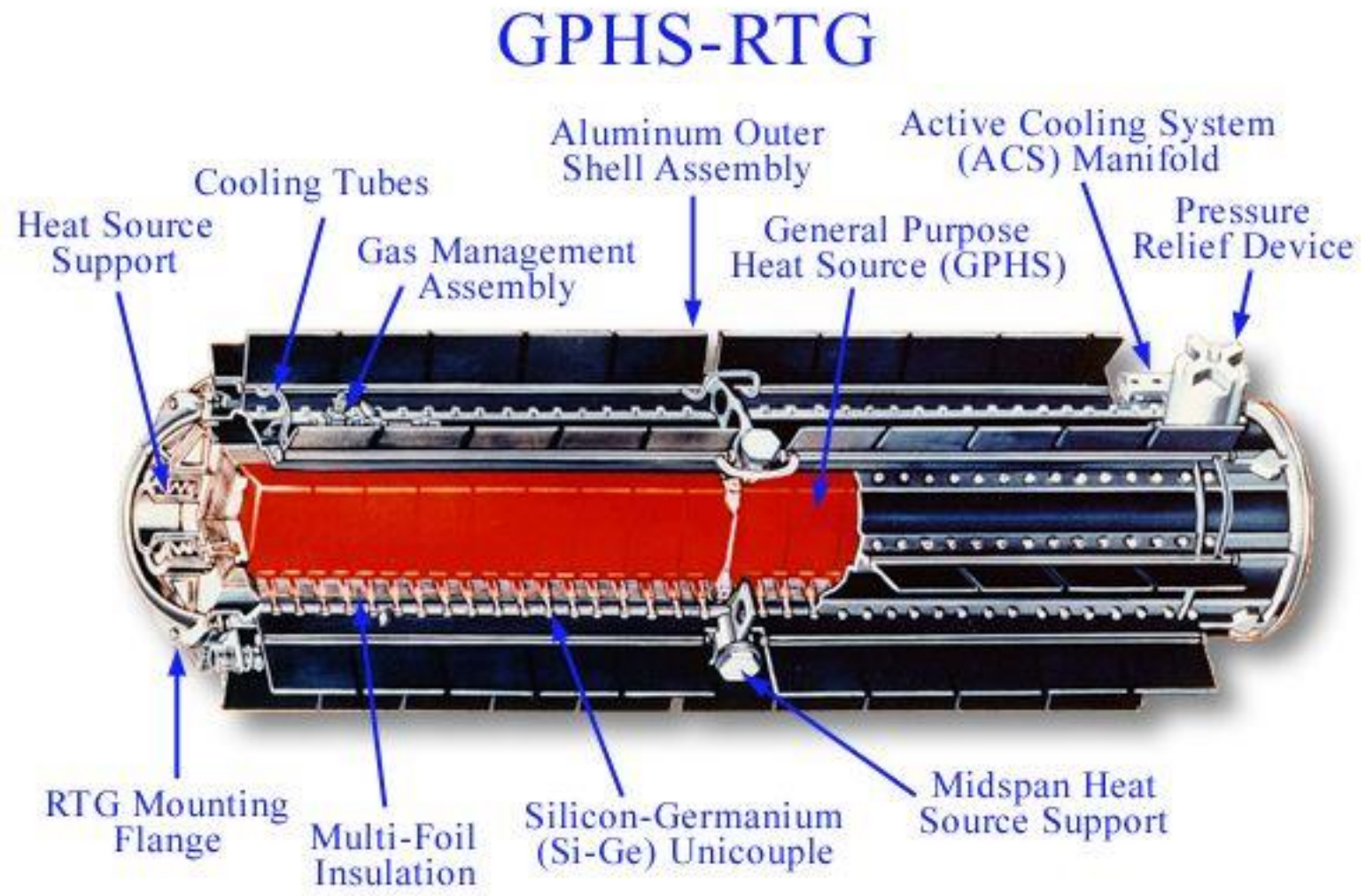


Multi-Mission Radioisotope Thermoelectric Generator

Powered by Pu-238 dioxide GPHS modules (8 modules, 4 PuO_2 tablets per module, iridium casing). Generate about 2 kW thermal power.

Use PbTe/TAGS thermocouples. Designed to produce 125W electrical power (100W after 14 years. Mass 43 kg – about 2.8 We/kg

Radionuklidové zdroje energie



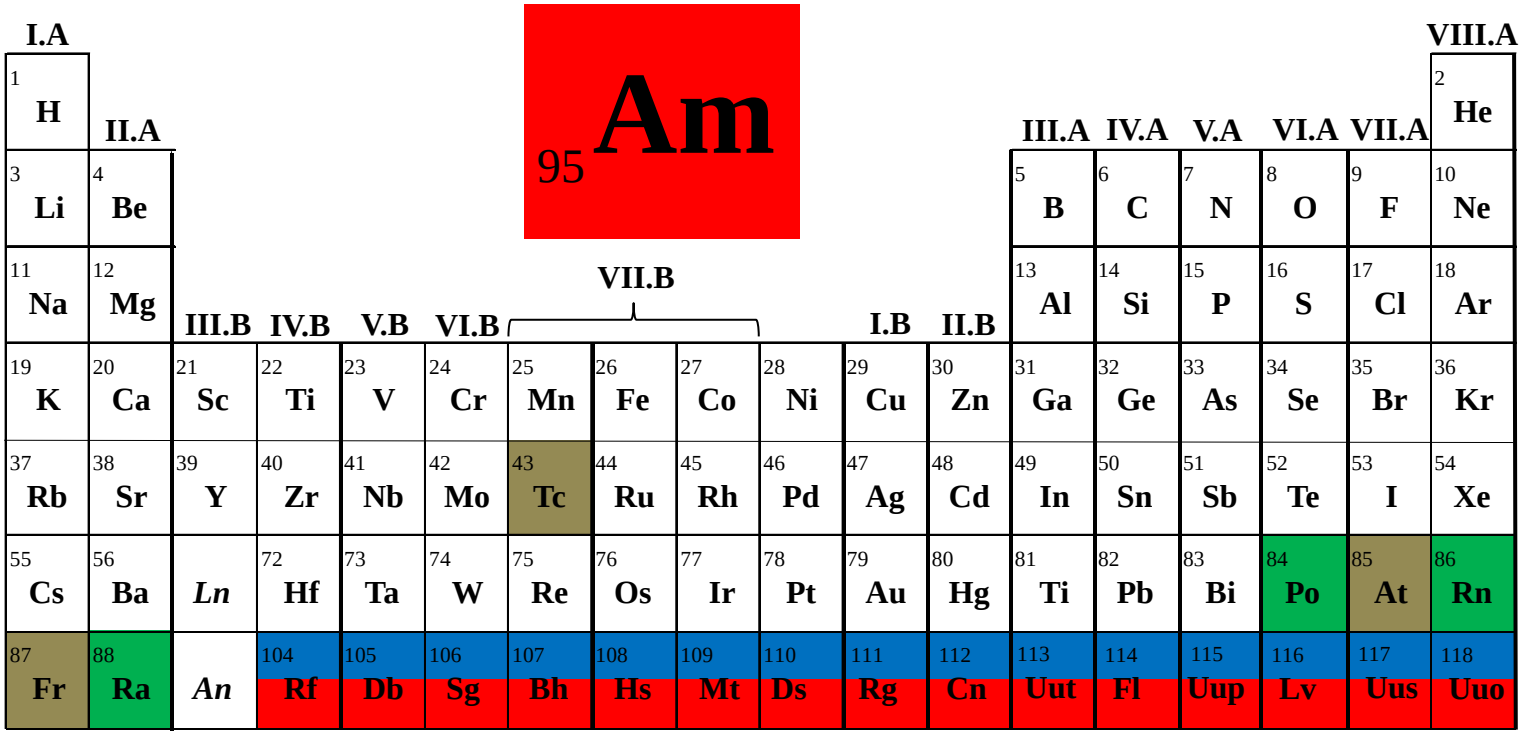
GPHS = General Purpose heating Source. Výkon až 285 W_e. Velké laboratoře pro průzkum vnějšího vesmíru (sonda Galileo, Ulysses, Cassini, New Horizons). Si/Ge termočlánky.

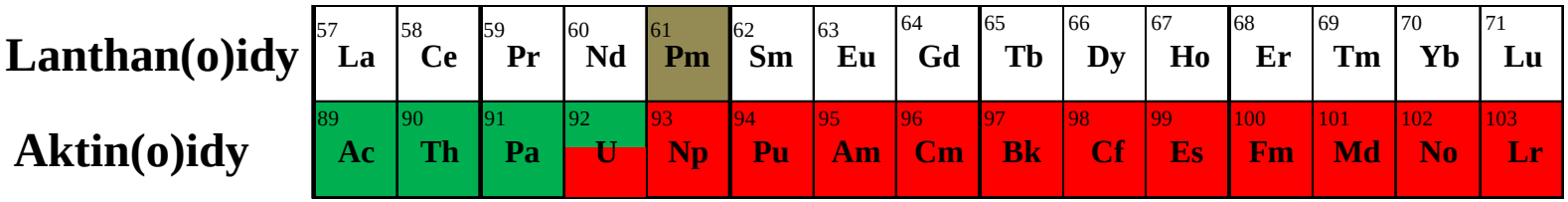
Radionuklidové zdroje energie

Plutonium Powered Pacemaker (1974)

Powered by thermoelectric batteries containing 2 to 4 curies of plutonium-238 (88 year half-life). In 2003, there have between still 50 and 100 people in the US with nuclear powered pacemakers.
Titanium case, electronics embedded in epoxy.
Designed to withstand any credible event including gunshots and cremation.
Dose rates at the surface of the pacemaker are approximately 5 to 15 mrem per hour from the emitted gamma rays and neutrons. The whole body exposure is estimated to be approximately 0.1 rem per year to the patient and approximately 7.5 mrem per year to the patient's spouse.

Americium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Americium (1)

A	T	druh záření	příprava
237	1,3 h	EZ, α $5 \cdot 10^{-3}$ %	^{239}Pu(d,4n)
238	1,86 h	EZ, α < $5 \cdot 10^{-4}$ %	^{239}U(p,2n); ^{237}Np(α,3n)
239	12,1 h	EZ, α $5 \cdot 10^{-3}$ %	^{239}Cm$\xrightarrow{EZ}$
240	2,12 d	EZ, α $2 \cdot 10^{-4}$ %	^{239}Pu(d,n)
241	433a	α	^{241}Pu$\xrightarrow{\beta^-}$
242	16,0 h	EZ 17 %, β^- 83 %	^{241}Am(n,γ)
242m$_1$	144 a	IP, α 0,5 %	^{241}Am(n,γ)
243	7370 a	α	^{242}Am(n,γ); ^{243}Pu$\xrightarrow{\beta^-}$
244	10,1 h	β^-	^{243}Am(n,γ)
244m$_1$	26 m	β^-	^{243}Am(n,γ)
245	2,08 h	β^-	^{245}Pu$\xrightarrow{\beta^-}$
246	40 m	β^-	^{244}Pu(^{3}He,p)
246m	25 m	β^-	^{246}Pu$\xrightarrow{\beta^-}$
247	24 m	β^-	^{244}Pu(α,p)

Americium (2)

T_T = 1176 ºC T_V = ~2067 ºC ρ = 11,7 g/cm^3

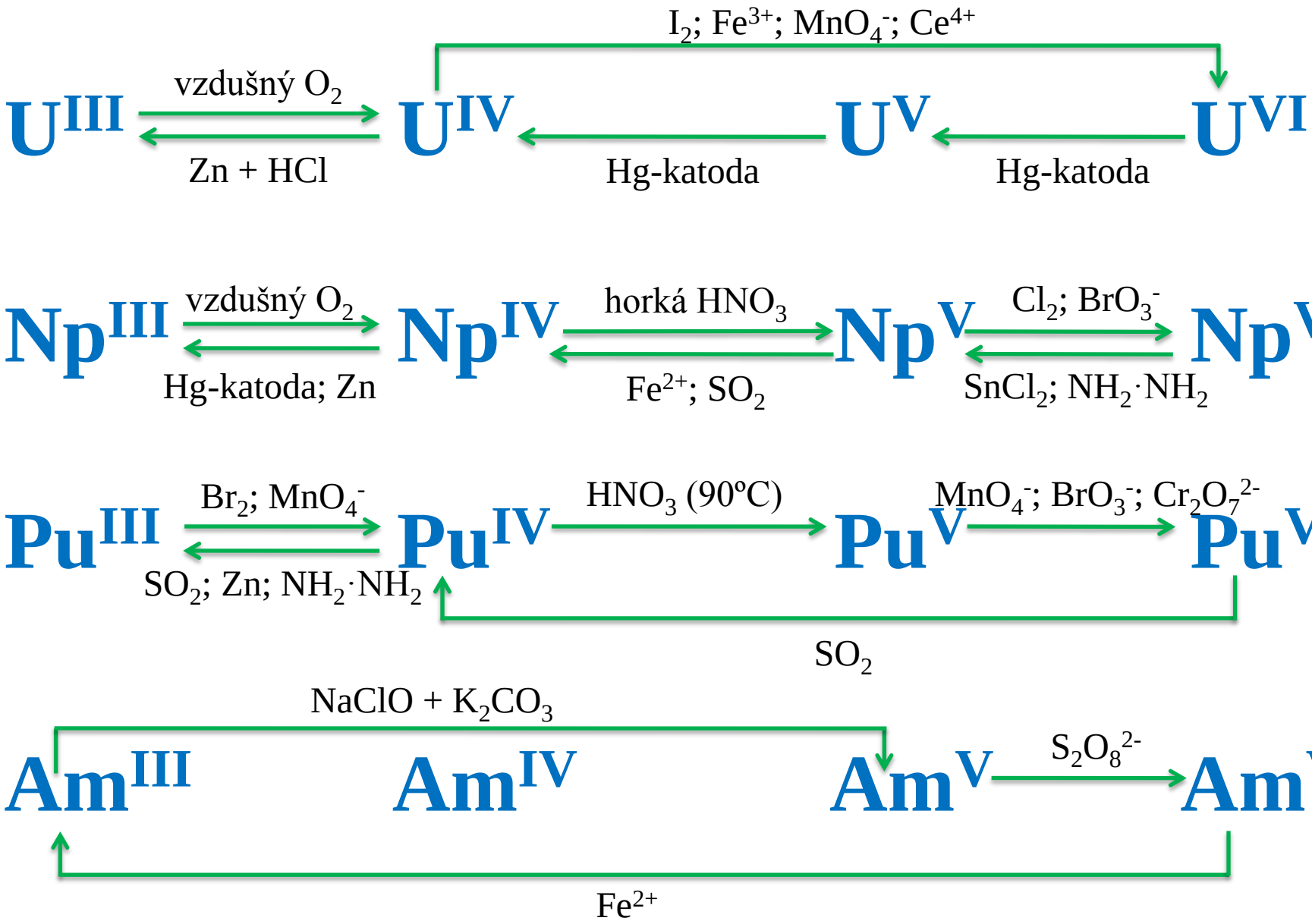
1944 SEABORG, JAMES, MORGAN

$$^{238}U(\alpha,n)^{241}Pu \xrightarrow[14,1r]{\beta^-} {}^{241}Am \xrightarrow[458\ a]{\alpha}$$

$$^{241}Am(n,\gamma)^{242}Am \xrightarrow[16,1\ h]{EZ} {}^{242}Pu(n,\gamma)^{243}Pu \xrightarrow[5,0\ h]{\beta^-} {}^{243}Am \xrightarrow[7600\ a]{\alpha}$$

AmO_2	AmF_3	$Am_2(C_2O_4)_3$	AmH_2
Am_2O_3	AmF_4	$AmPO_4$	Am_4H_{15}
$Am(OH)_3$	$AmCl_3$	$KAm(SO_4)_2 \cdot 2H_2O$	Am_2S_3
$Am(OH)_4$	$AmBr_3$	$KAmO_2F_2$	
	AmI_3	$KAmO_2CO_3$	
$AmOCl$		$NaAmO_2(CH_3COO)_3$	

Redox vlastnosti U-Am



Disproporcionace Pu, Np, Am

Pu(V) $2Pu_2O^{4+} + 4H^+ \leftrightarrow Pu^{4+} + PuO_2^{2+} + 2H_2O$

$PuO_2^{+} + Pu^{4+} \leftrightarrow PuO_2^{2+} + Pu^{3+}$ K = 8,5 (0,5mol/L HCl)

$PuO_2^{+} + Pu^{3+} + 4H^+ \leftrightarrow 2Pu^{4+} + 2H_2O$

Pu(IV) $3Pu^{4+} + 2H_2O \leftrightarrow 2Pu^{3+} + PuO_2^{2+} + 4H^+$

Np(V) - viz Pu(V), pouze v H_2SO_4

Am(V) $3AmO_2^{+} + 4H^+ \leftrightarrow Am^{3+} + 2AmO_2^{2+} + 2H_2O$

Př.: Pu^{IV} v 0,5mol/L HCl:
27,2% Pu^{III}; 58,4 % Pu^{IV}; 13,6 % Pu^{VI}; 0,75 % Pu^{V}

Technologické schéma „PUREXu“

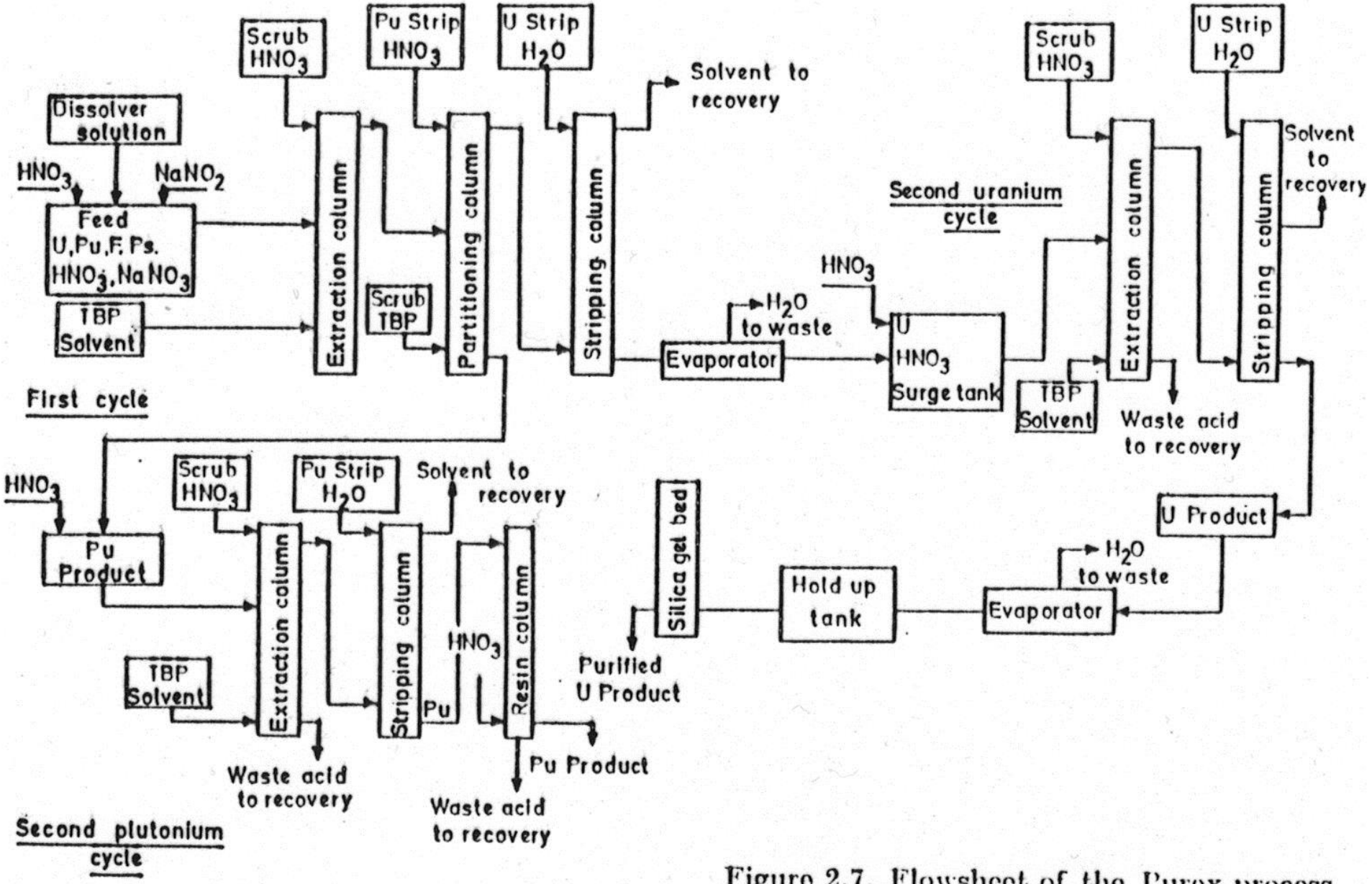
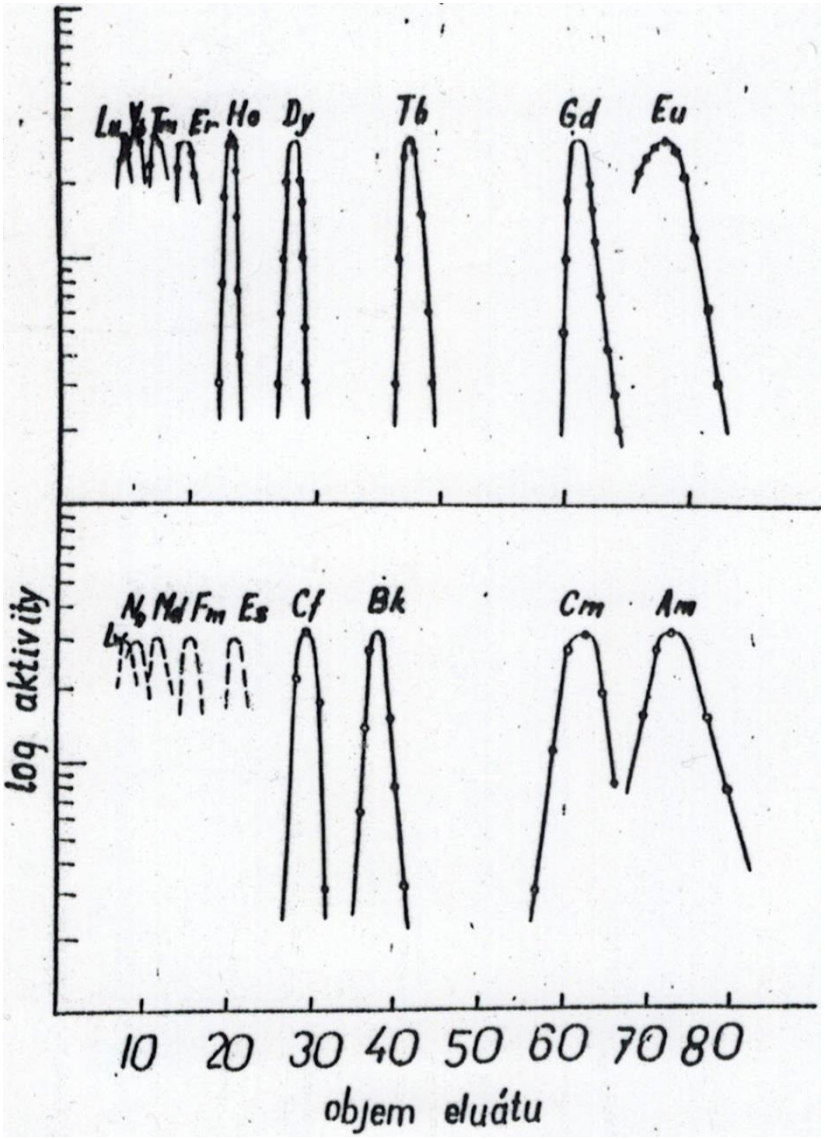
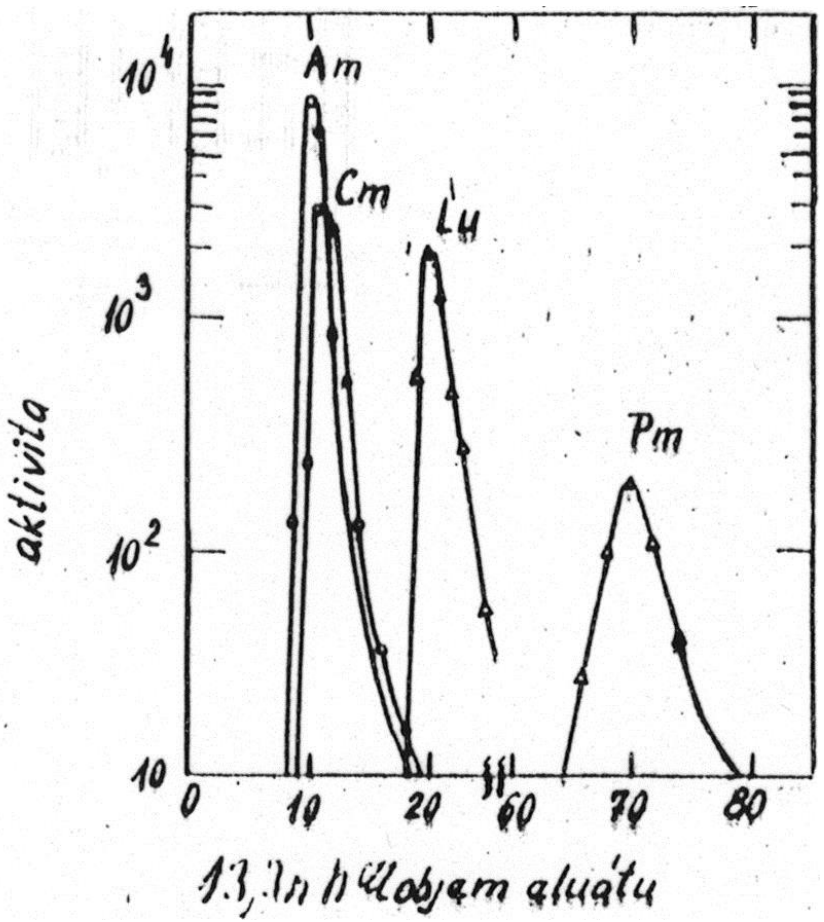


Figure 2.7. Flowsheet of the Purex process.

Dělení a izolace transplutoniových prvků

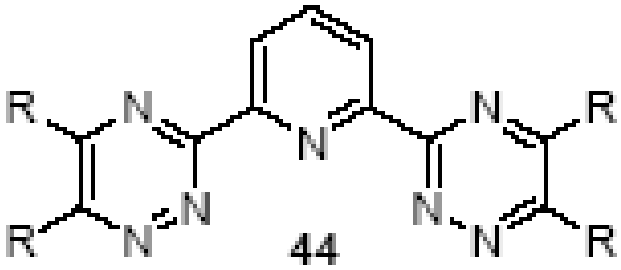


Eluční křivky An a Ln z katexu pomocí α-HIM

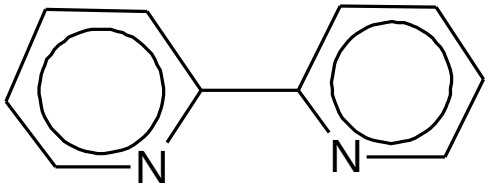


Vzájemná separace An od Ln na měniči aniontů

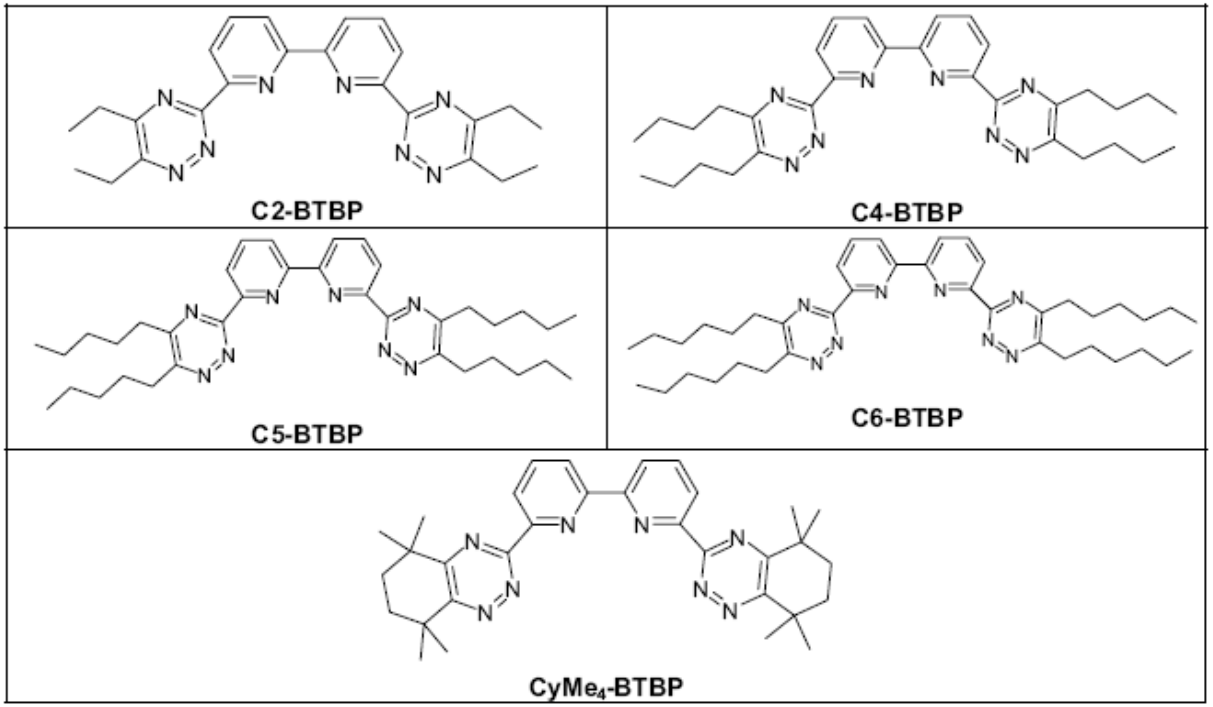
Nová extrakční činidla



**General structure of bis-triazinyl-pyridines –
the so-called BTPs (R=alkyl, aryl)**

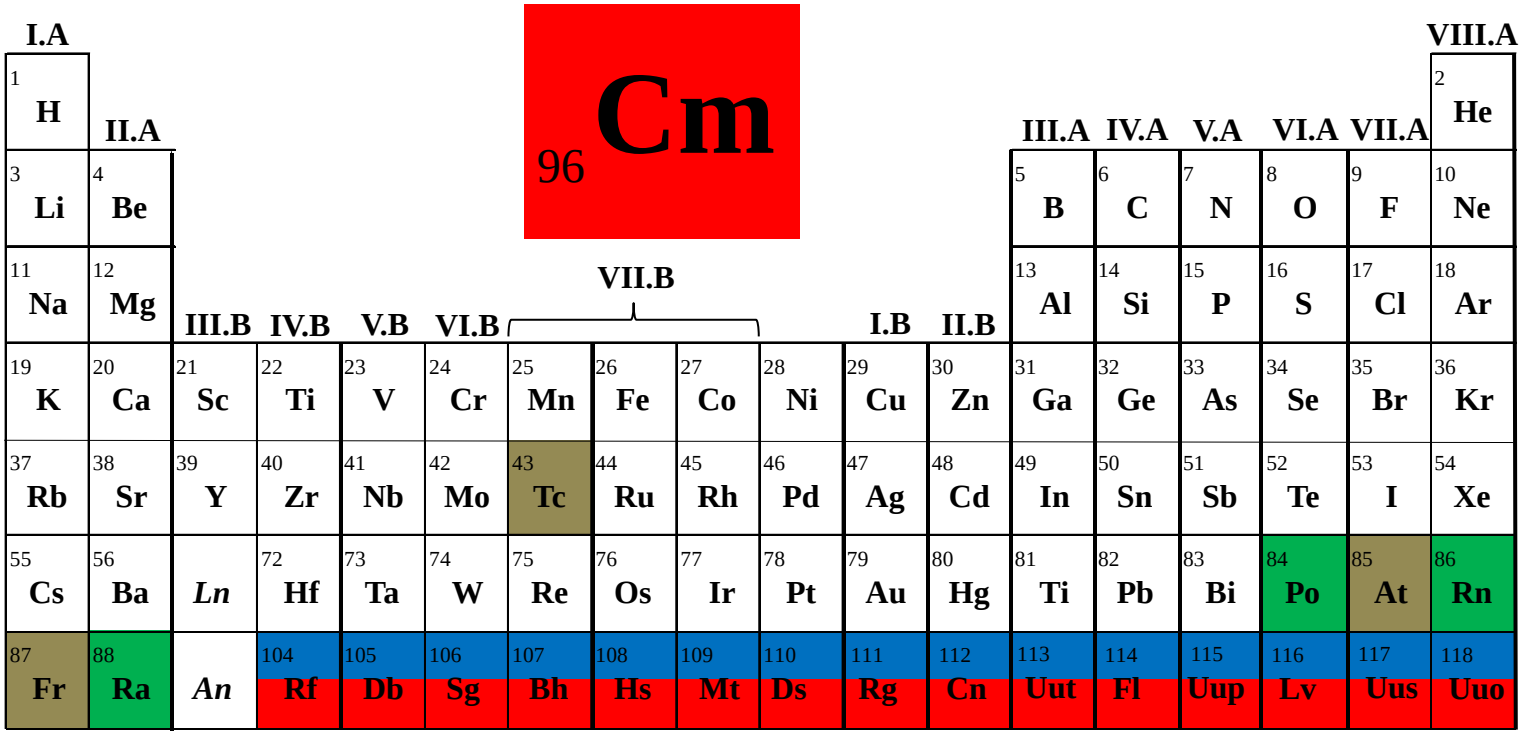


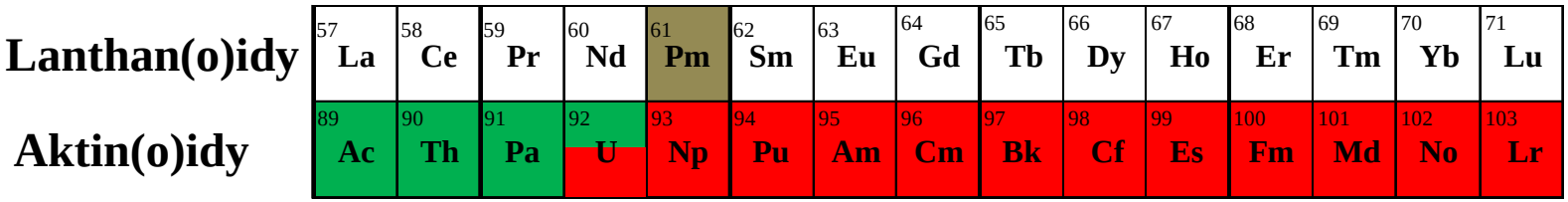
General structure of 2, 2'-bipyridine



The molecular structures of bis-triazinyl-bipyridine – BTBP ligands

Curium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Curium

A	T	druh záření	příprava
243	35 a	α	^{239}Pu(d,4n)
244	19 a	α	viz níže
245	8265 a	α	^{239}Pu(n,γ)^{6}
246	$5\cdot10^{3}$ a	α	^{239}Pu(n,γ)^{7}; ^{238}U(n,γ)^{8}
247	$1{,}6\cdot10^{7}$ a	α	^{238}U(n,γ)^{9}
248	$3{,}84\cdot10^{5}$ a	α	^{238}U(n,γ)^{9}; ^{252}Cf $\xrightarrow{\alpha}$

A = 238 – 251 , β^- = 249, 251

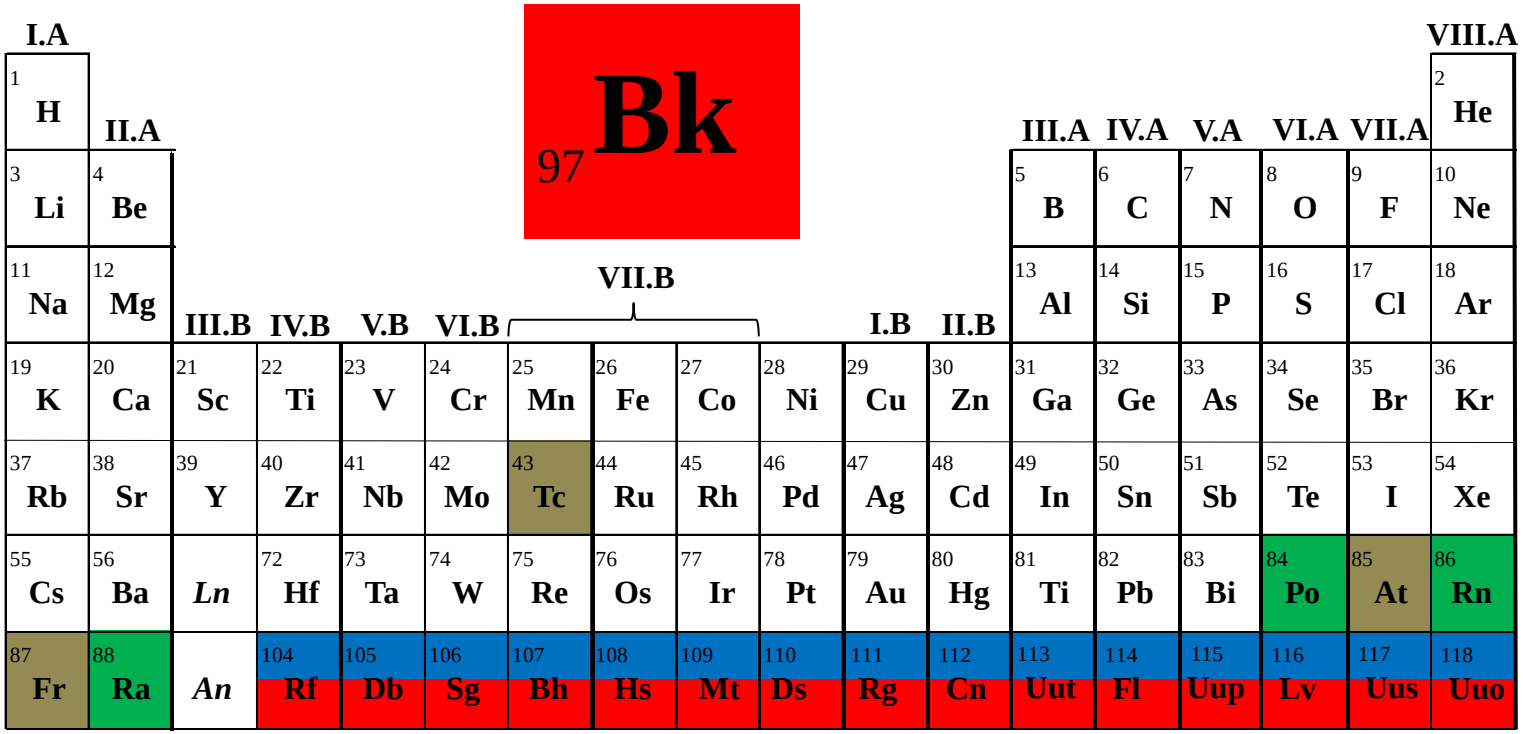
^{239}Pu(α,n)^{242}Cm $\xrightarrow[162{,}5\ \mathrm{d}]{\alpha}$ E_n = 32-44 MeV

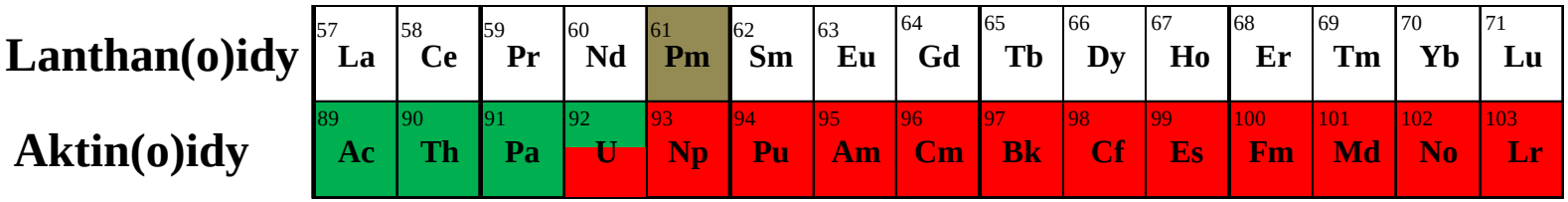
1944 SEABORG, JAMES, MORGAN

^{241}Am(n,γ)^{242}Am $\xrightarrow[16\ \mathrm{h}]{\beta^-}$ ^{242}Cm ($\xrightarrow[162{,}5\ \mathrm{d}]{\alpha}$) $2\cdot10^{11}$ Bq·mg^{-1} !

^{239}Pu(n,γ)^{4} ^{243}Pu $\xrightarrow[5{,}0\ \mathrm{h}]{\beta^-}$ ^{243}Am(n,γ)^{244}Am $\xrightarrow[26\ \mathrm{m}]{\beta^-}$ ^{244}Cm ($T_{1/2}$ = 19 a)

Berkelium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Berkelium

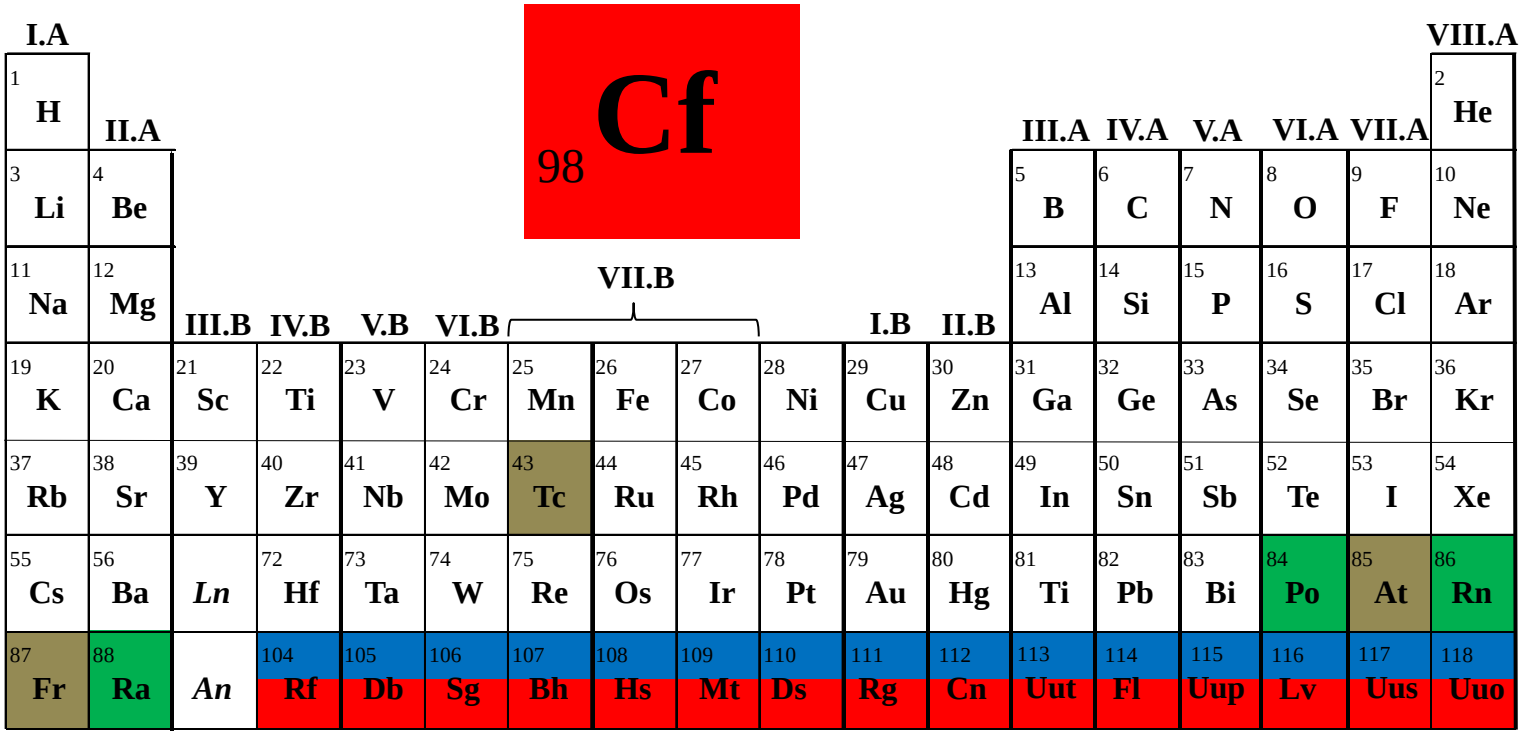
A	T	druh záření	příprava
247	$1{,}38 \cdot 10^3$ a	α	$^{244}Cm(\alpha,p)$; $^{247}Cf \xrightarrow{\beta^-}$
248	9 a	α	$^{246}Cm(\alpha,pn)$
248m	23,7 h	β^- 70 %, EZ 30 %	$^{248}Cm(d,2n)$
249	320 d	β^- > 99 %	$^{239}Pu(n,\gamma)^{10}$

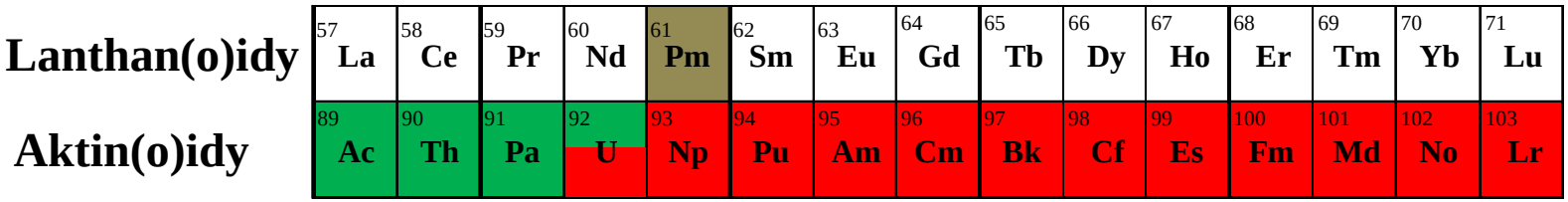
$A = 240 - 251$, $\beta^- = 248 - 251$

1949 THOMPSON, GHORSO, SEABORG

$^{241}Am(\alpha,2n)^{243}Bk$ ($\xrightarrow[4{,}5\ h]{EZ}$ $\xrightarrow[162{,}5\ d]{\alpha}$)

Kalifornium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Kalifornium (1)

A	T	druh záření	T_{SF}	příprava
245	44 m	EZ 66 %, α 34 %		$^{248}Cm(\alpha,n)$
249	470 a	α	$1{,}5 \cdot 10^{9}$ a	$^{239}Pu(n,\gamma)^{10}$
250	9,3 a	α	$1{,}5 \cdot 10^{4}$ a	$^{239}Pu(n,\gamma)^{11}$
251	900 a	α		$^{239}Pu(n,\gamma)^{12}$
252	2,6 a	α, SF 3,2 % *	85,5 a	$^{239}Pu(n,\gamma)^{13}$
253	18,1 d	β^-, α 8 %		$^{239}Pu(n,\gamma)^{14}$
254	60,5 d	SF, α 0,3%	55 d	$^{239}Pu(n,\gamma)^{15}$; exploze

* $2{,}3 \cdot 10^{9}$ $n \cdot s^{-1} mg^{-1}$ ($8{,}7 \cdot 10^{6}$ tepelných, 10^{8} rychlých. $8{,}4 \cdot 10^{4}$ rezonančních)

A = 239 – 256 , β^- = 253 – 255

1950 THOMPSON, STREET, GHIORSO, SEABORG

$^{242}Cm(\alpha,n)^{245}Cf \xrightarrow[44\ m]{\alpha} (^{241}Cm) \xrightarrow[162{,}5\ d]{\alpha}$

Kalifornium (2)

Cf_2O_3 – žlutý

$Cf_{(s)}$ – těkavé

CfF_3

$CfBr_3$

CfI_3

CfOF

CfOBr

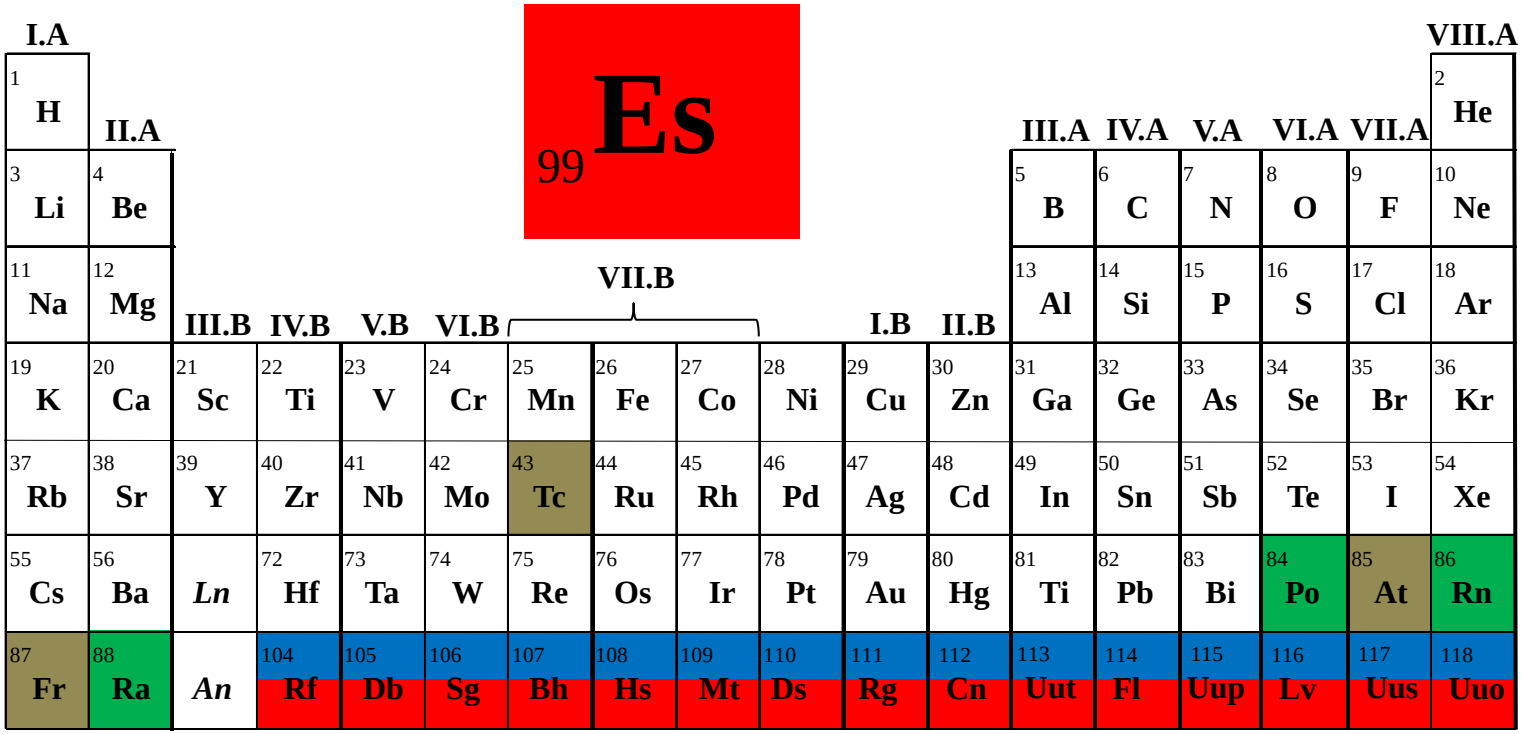
CfO_3

Cf_2S_3

CfO_2 $1/2(Cf_2O_3+O_2)$

CfF_4

Einsteinium



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

Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Einsteinium

A	T	druh záření	T_{SF}
253	20,47 d	α	$6 \cdot 10^{15}$ a
254	275,7 d	α	$> 2{,}5 \cdot 10^{7}$ a
255	39,8 d	β^- 91 %, α 9 %	2440 a

A = 243 – 256 , β^- = 255, 256, 254m

1952 termojaderná exploze – ATOL BIKINI – „MIKE“
v produktech – ^{253}Es; ^{255}Fm $^{238}U(xn) \xrightarrow{x\beta^-}$
„odtajněno“ až 1965

1954 GHIORSO, ROSSI, HARVEY, CHOPPIN
$^{239}Pu(n,\gamma)^{14}\ ^{253}Es$

1954 GHIORSO, ROSSI, HARVEY, THOMPSON
$^{238}U(^{14}N^{6+}, xn\ yp)\ \ ^{246}Es$

$T_T = 860 \pm 50$ °C $EsCl_3$ EsOCl

Metody přípravy TAn (1)

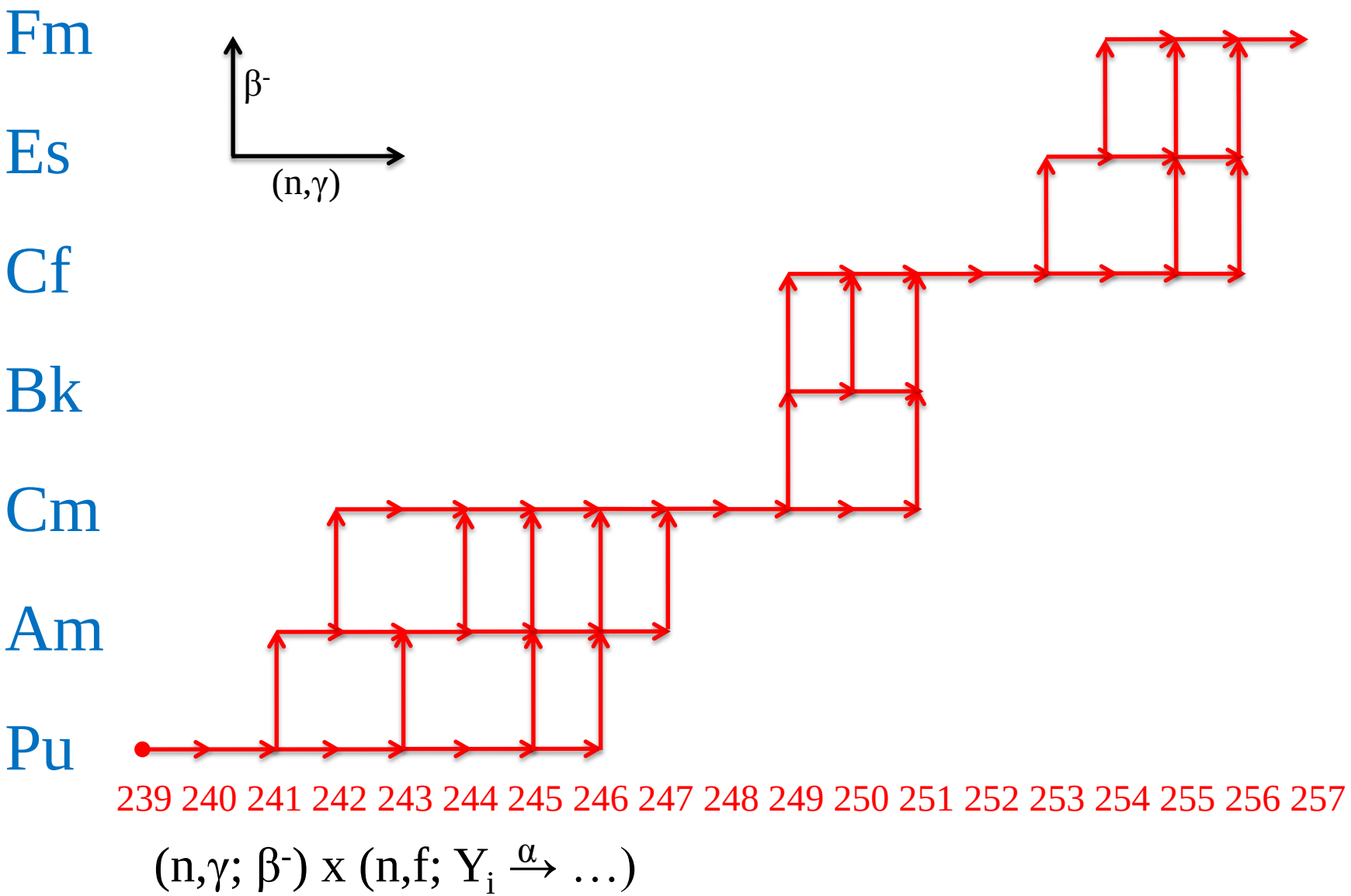
1. $X(č_1,č_2)Y$ $č_1$ = p, d, α, t, … $č_2$ = n – BERKLEY

2. $X(j,\sum č_i)Y$ j — lehká (Be, C, N, O, Ne) – DUBNA
   střední (Ca, Cr, Fe)
   těžká (Pb, U)
   } DARMSTADT

3. $X(n,\gamma)Y_1(n,\gamma)Y_2(n,\gamma)Y_3$ … X = Pu, … $\varphi \cdot t \approx 10^{21} – 10^{22}$

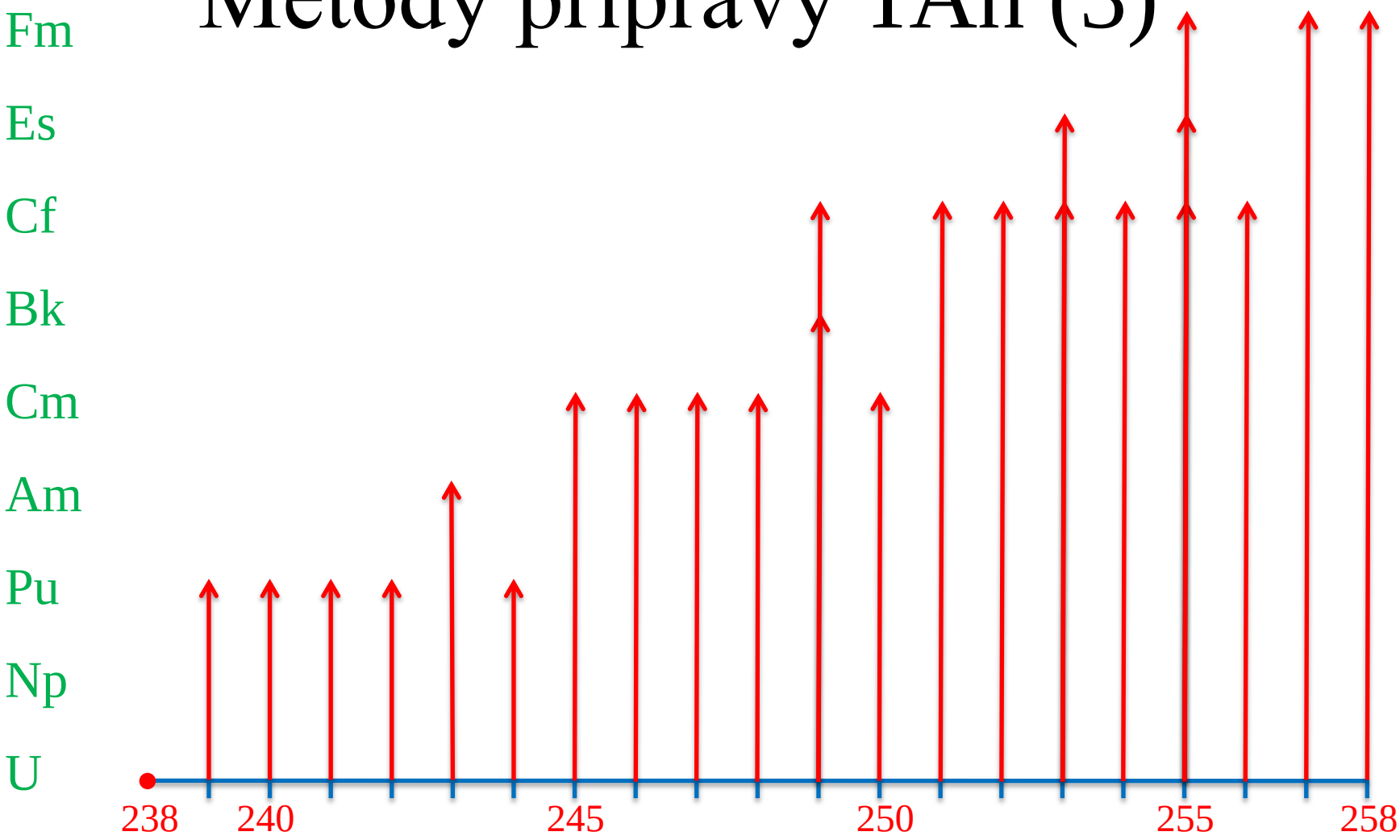
4. $X(xn,\gamma)$ $x \in \langle 1,17 \rangle$

Metody přípravy TAn (2)



$(n,\gamma;\ \beta^-)\ x\ (n,f;\ Y_i \xrightarrow{\alpha} \ldots)$

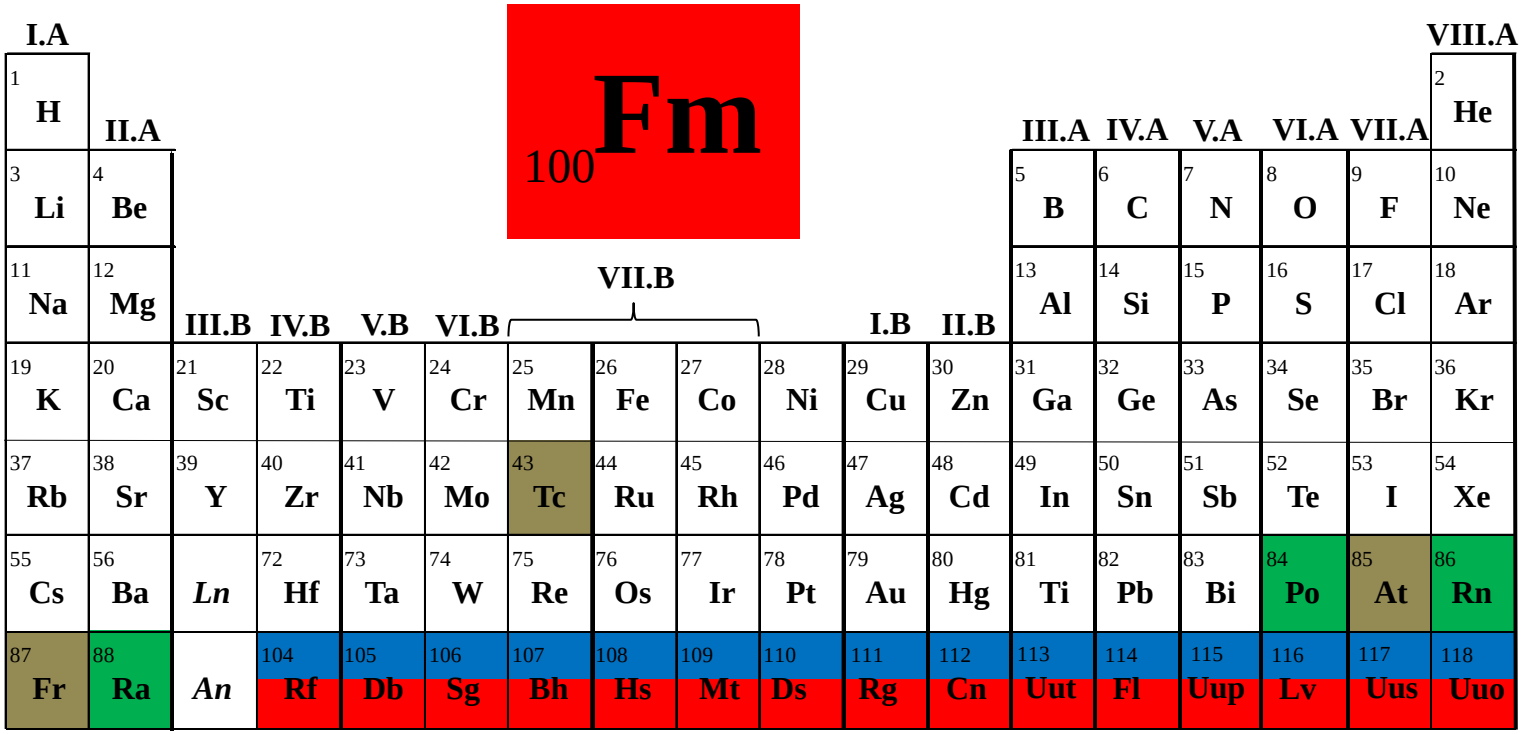
Metody přípravy TAn (3)



Př.: $^{238}U + 15n \rightarrow {}^{253}U \xrightarrow[kr.]{\beta^-} {}^{253}Np \xrightarrow[kr.]{\beta^-} \dots \xrightarrow[kr.]{\beta^-} {}^{253}Cf \xrightarrow[kr.]{\beta^-} {}^{253}Es$

$^{238}U + 17n \rightarrow {}^{255}U \xrightarrow[kr.]{\beta^-} {}^{255}Np \xrightarrow[kr.]{\beta^-} \dots \xrightarrow[kr.]{\beta^-} {}^{255}Es \xrightarrow[kr.]{\beta^-} {}^{255}Fm$

Fermium



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

- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

Fermium

A	T	druh záření	T_{SF}	příprava
255	20,1 h	α		n
257	100,5 d	α, SF	100 a	n

A = 242 – 259 β^- = žádné !!!

1952 „MIKE“ ^{255}Fm

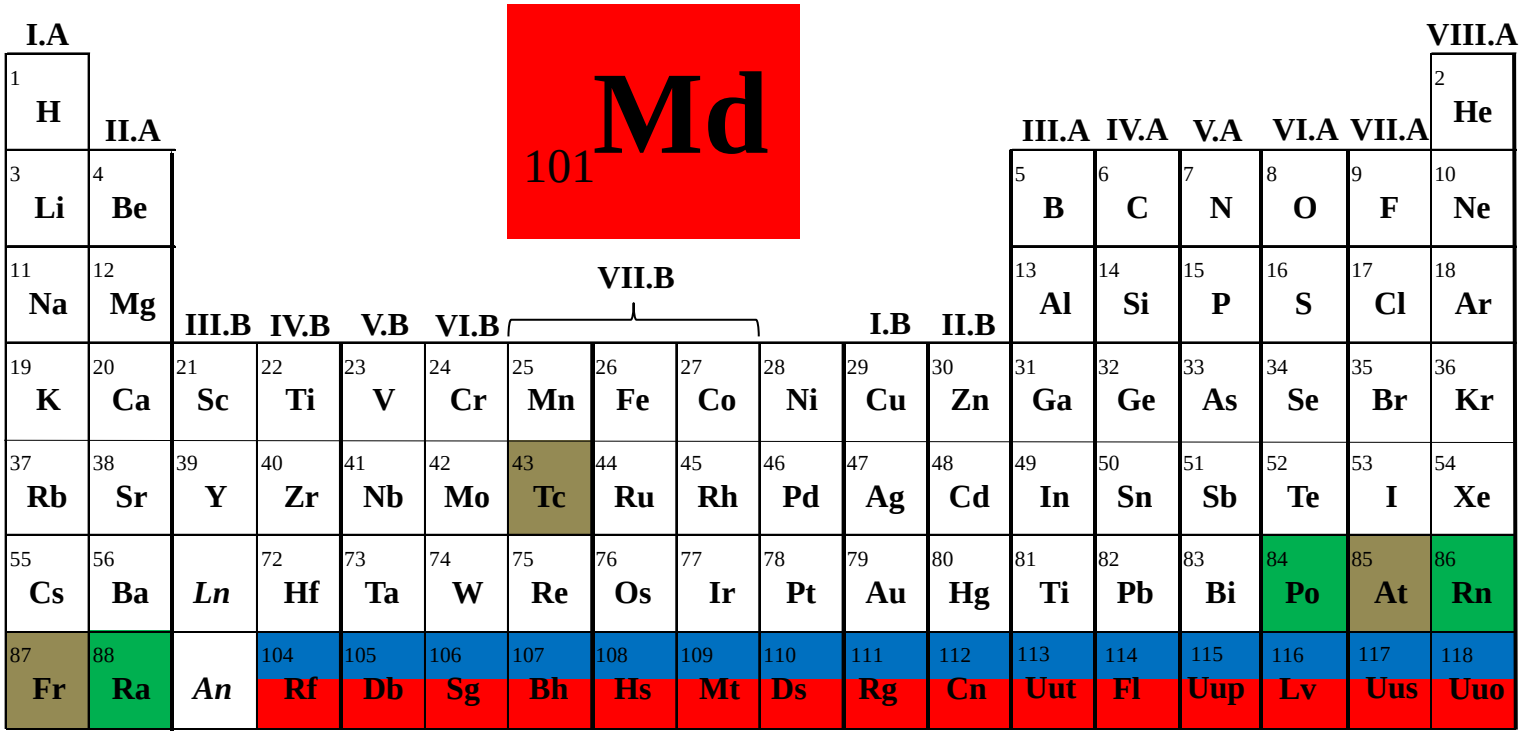
1954 a) THOMPSON, GHIORSO, HARVEY, CHOPPIN

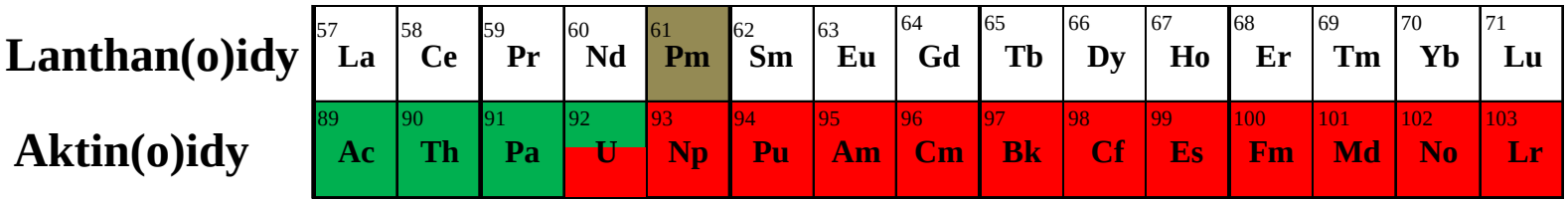
$$^{252+\ldots}Cf(n,\gamma)^{253}Cf \xrightarrow{\beta^-} {}^{253}Es(n,\gamma)^{254}Es \xrightarrow{\beta^-} {}^{254}Fm$$

b) ATTERLING, FORSLING, HOLM, MELANDER, ÅSTRØM

$$^{238}U + {}^{16}O^{6+} \rightarrow {}^{250}Fm + 4n$$

Mendelevium





Umělé cisuranové (mimo řady)

Cisuranové / „Přírodní“

Transuranové

Transaktin(o)idy

Mendelevium

A	T	druh záření	příprava
258	56 d	α	$^{255}Es(\alpha,n)$

A = 247 – 259 α, EZ (259 = SF)

Nelze připravit pomocí $(n,\gamma)^x$!!! (neboť Fm nemá β^-)

1955 GHIORSO, HARVEY, CHOPPIN, THOMPSON, SEABORG

$^{253}Es(\alpha,n)^{256}Md \xrightarrow[75\ m]{EZ} {}^{256}Fm \xrightarrow[160\ m]{SF}$

$N' = 10^9$ atomů $N = N' \cdot \sigma \cdot I \cdot t$ $\sigma = 1$ mb

$t = 10^4$ s (~ 3k)

$\rightarrow N = 1$!!! $I = 10^{14}\ \alpha \cdot cm^{-2} \cdot s^{-1}$

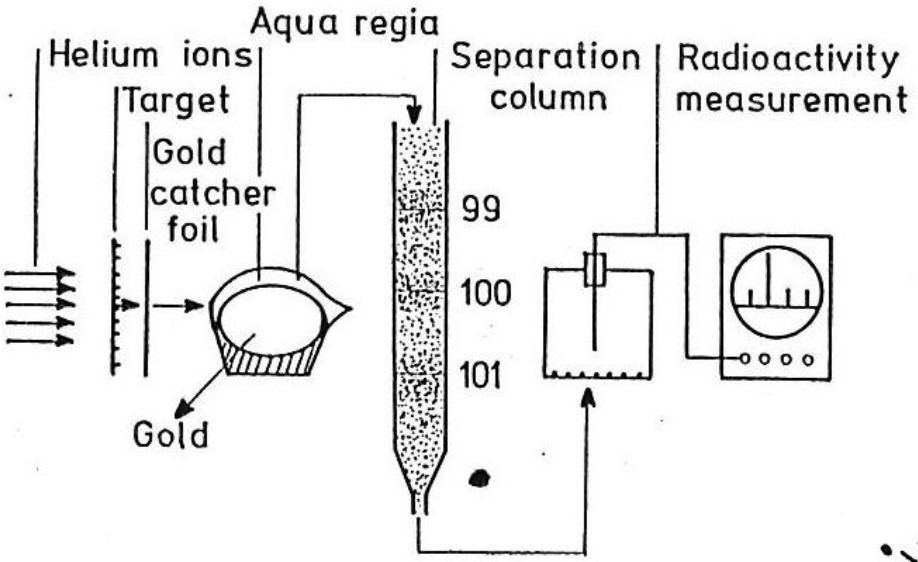
…v praxi 3 experimenty → 5 atomů…

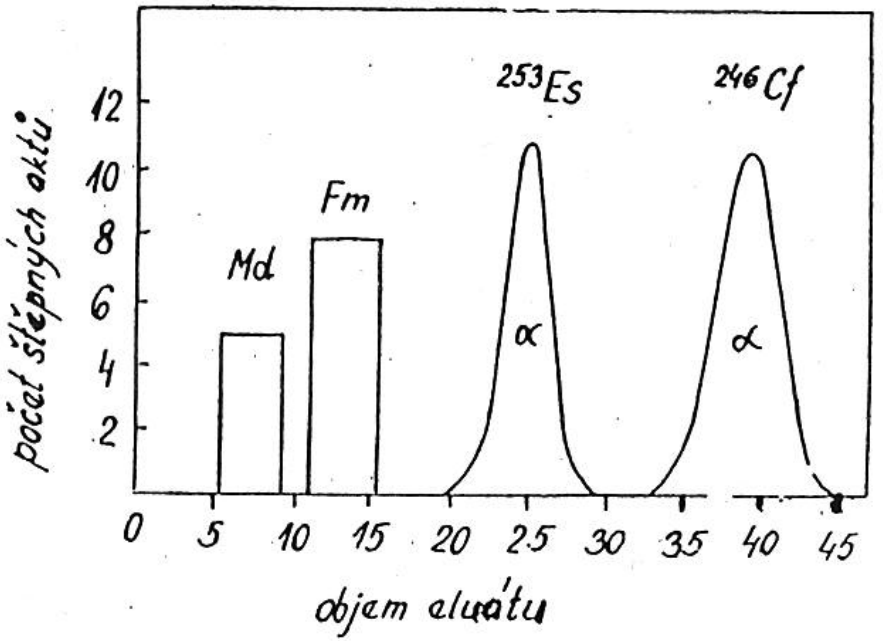
II stálejší než Eu^{II} $BaSO_4$ → separace

JONESŮV REDUKTOR (Zn(Hg) v HCl) III ex. HDEHP v TBP

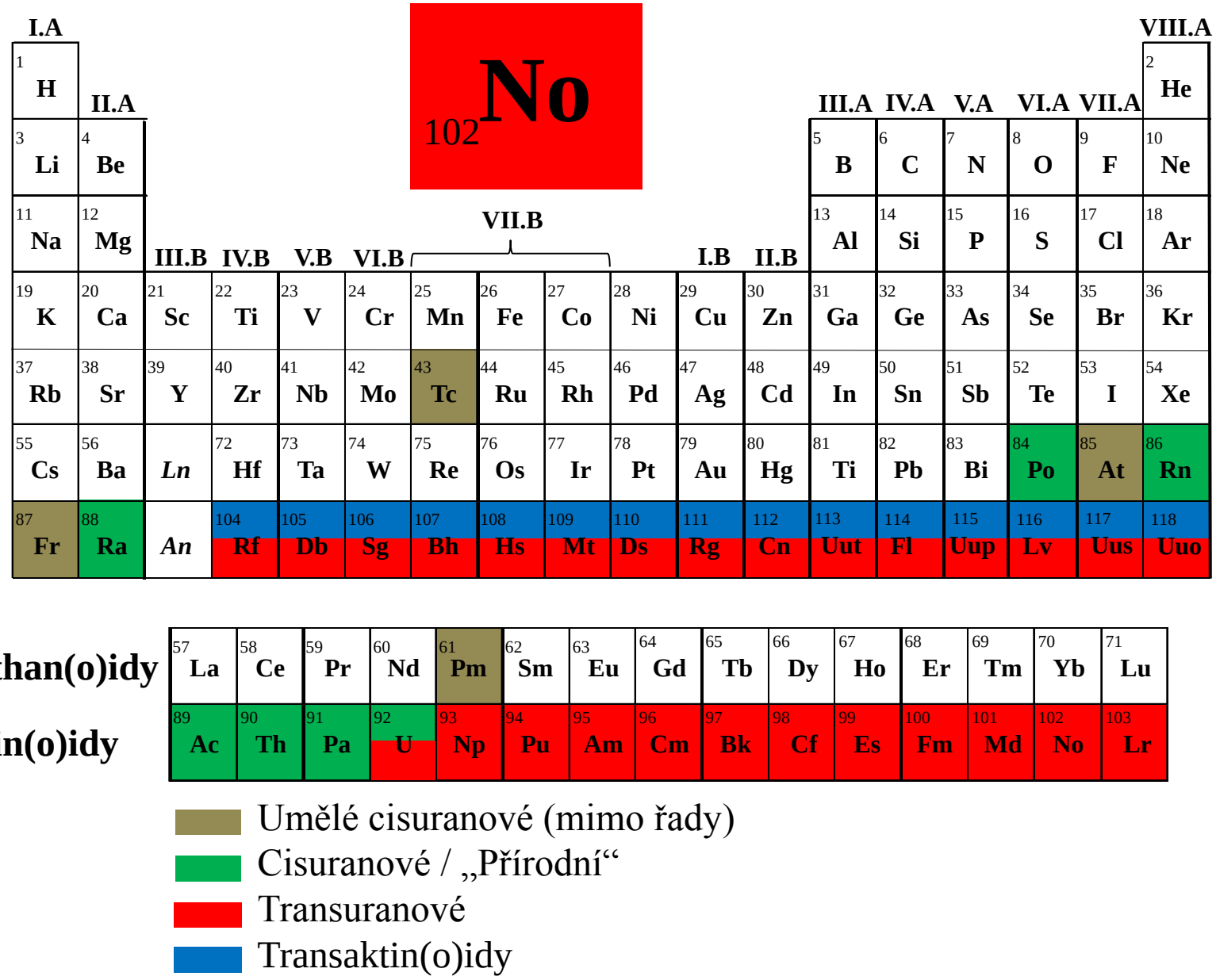
II neex.

Mendelevium





Nobelium



Lanthan(o)idy

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu

Aktin(o)idy

89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

Nobelium (Joliotium)

A	T	druh záření	příprava	produkční rychlost
255	3,1 m	α 61,4 %, EZ 38,6 %	$^{249}Cf(^{12}C;\alpha 2n)^{255}No$	100 atomů/h
259	1,00 h	α 78 %, EZ 22 %	$^{248}Cm(^{18}O;\alpha 3n)^{259}No$	$n \cdot 10^2$ atomů/m

A = 250 – 259

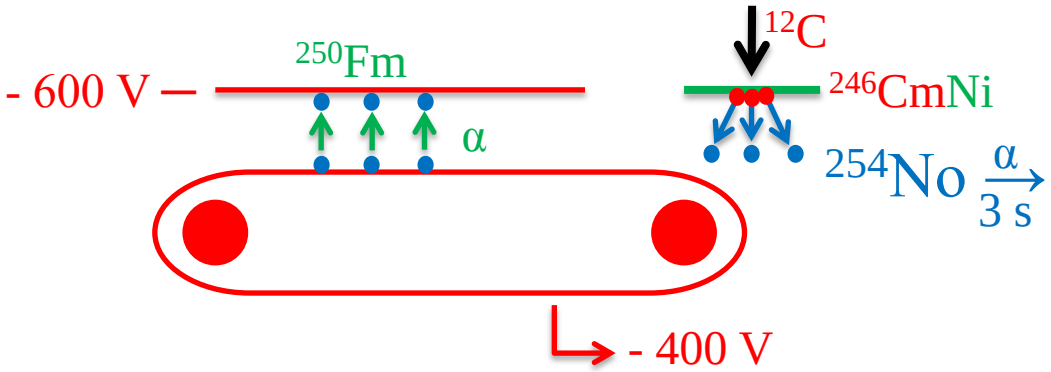
1957 $^{244}Cm + {}^{13}C^{4+} \xrightarrow{?} {}^{251,253}No$ $(T_{1/2} \approx 10\ m)$

1958 Berkeley (GHIORSO et al.) $^{244,246}Cm + {}^{12}C^{n+} \rightarrow {}^{254}No(?)$

Dubna (FLEROV et al.) $^{241}Pu + {}^{16}O^{5+} \rightarrow {}^{253,254}No(?)$

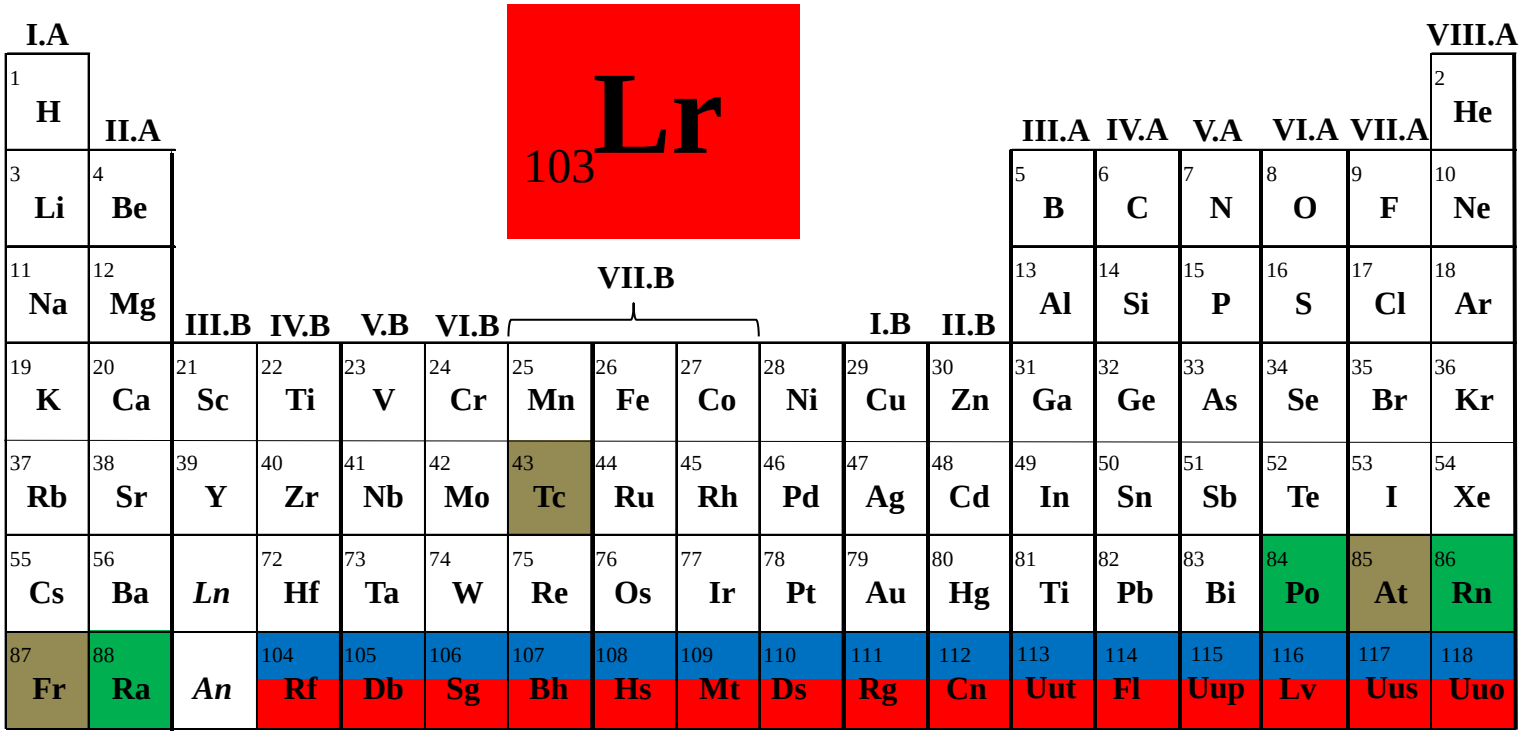
1967 → GHIORSO et al.

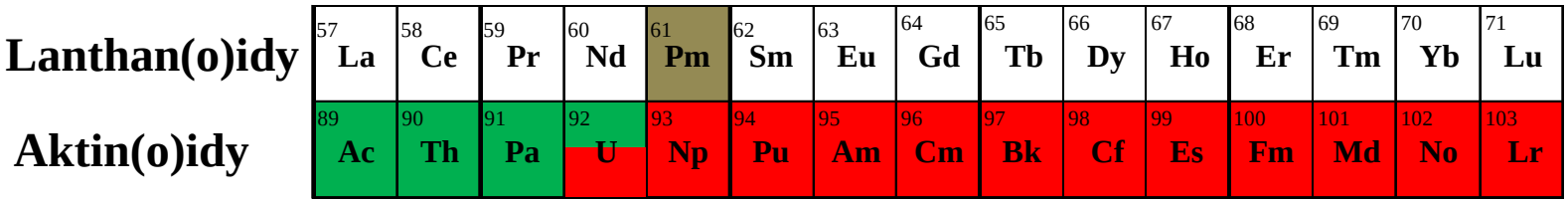
1971 identifikace… K – x-ray ^{251}Fm v koincidenci s α ^{255}No



^{250}Fm - αHiB

Lawrentium





- Umělé cisuranové (mimo řady)
- Cisuranové / „Přírodní“
- Transuranové
- Transaktin(o)idy

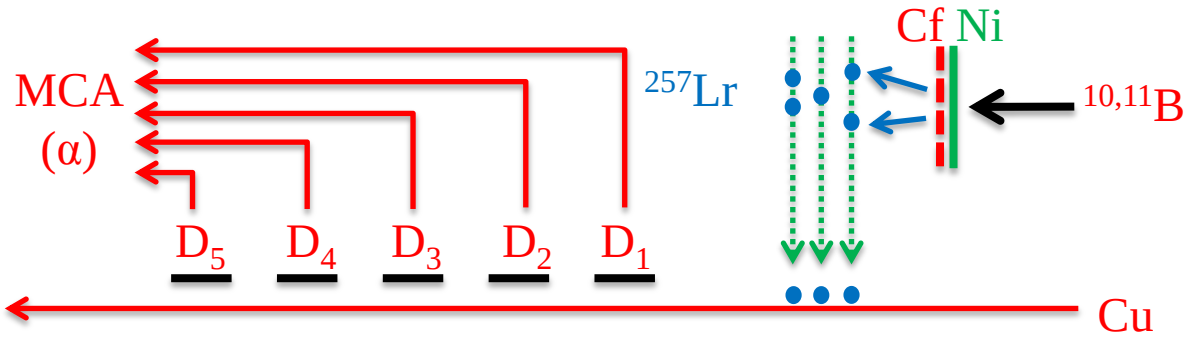
Lawrentium (E.O.LAWRENCE)

A	T	druh záření	příprava	produkční rychlost
256	28 s	α	$^{249}Cf(^{11}B;4n)^{256}Lr$	10 atomů / 3 m
260	3 m	α	$^{248}Cm(^{15}O;3n)^{260}Lr$	1 atom / 10 m

A = 253 – 260

1961 GHIORSO, SIKKELAND, LARSH, LATIMER (Berkeley)

$Cf + {}^{10,11}B \rightarrow {}^{257}Lr$ Lw → Lr (IUPAC)



$T_{1/2} = 8 \pm 2$ s (?!)

$E_\alpha = 8{,}6$ MeV

1965-1967 Dubna $^{255\text{-}257}Lr$ ($T_{1/2}$?!)

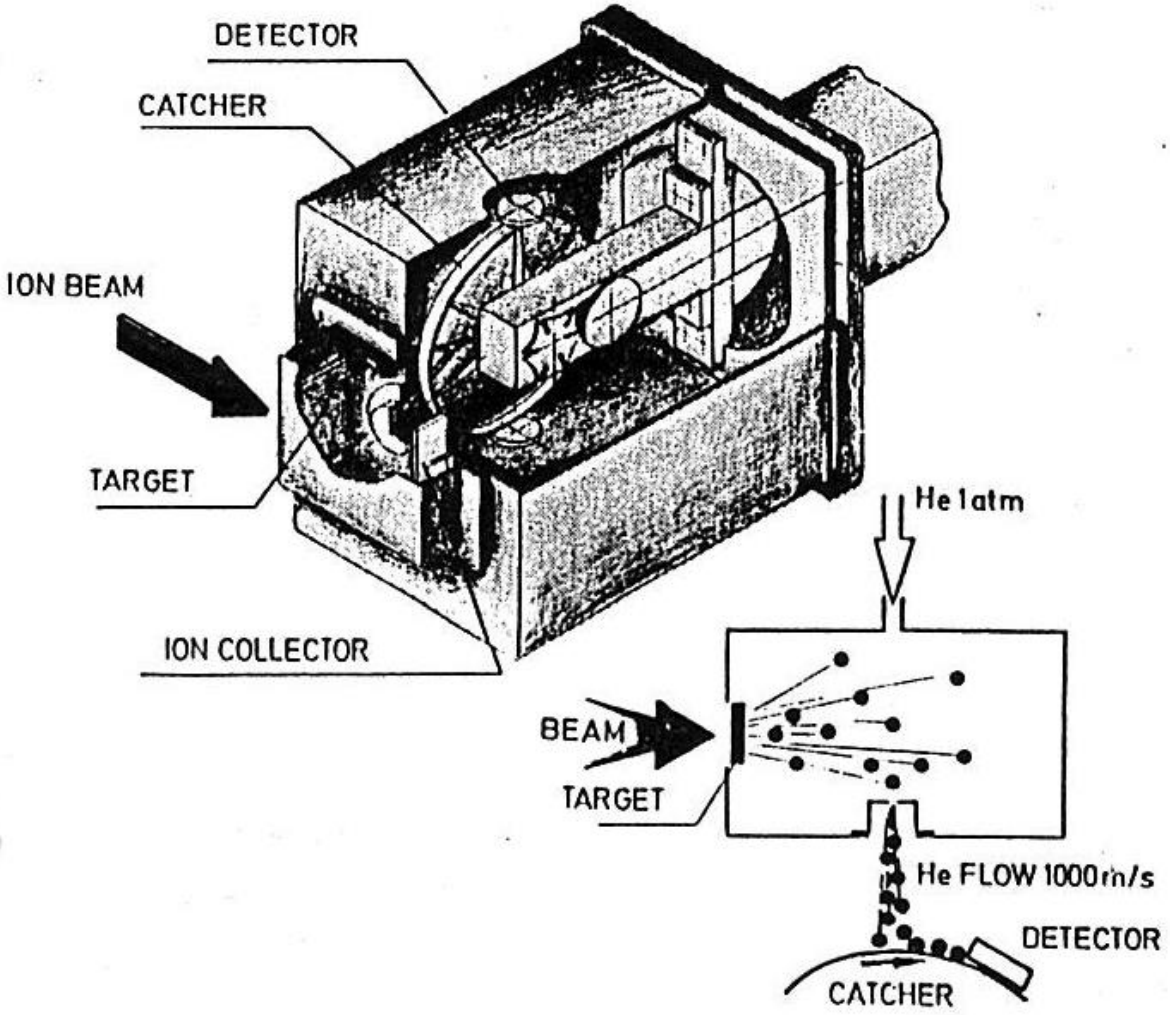
1971 Berkeley $^{255\text{-}260}Lr$

$^{248}Cm + {}^{14}N$ $^{249}Cf + {}^{10}B \rightarrow {}^{257}Lr$ ($T_{1/2} = 0{,}6$ s)

$^{248}Cm + {}^{15}N$ $^{249}Cf + {}^{11}C \rightarrow {}^{258}Lr$ ($T_{1/2} = 4{,}3$ s)

1961 – špatně A (=258)

Lawrentium


DETECTOR
CATCHER
ION BEAM
TARGET
ION COLLECTOR
He 1atm
BEAM
TARGET
He FLOW 1000m/s
DETECTOR
CATCHER