Welcome to 3.091

3.091 Introduction to Solid State Chemistry
Fall Term 2004

Lecturer Professor Donald R. Sadoway

Text ***Chemistry: Structure and Dynamics***, 2nd Edition, J.N. Spencer, G.M. Bodner, and L.H. Rickard, Wiley, New York, 2003 (3 volumes)

Lectures Monday, Wednesday, and Friday, 11:00-12:00, (L01)
Monday, Wednesday, and Friday, 1:00-2:00, (L02)

3.091 Homework No. 1

- assigned September 8

- tested September 14

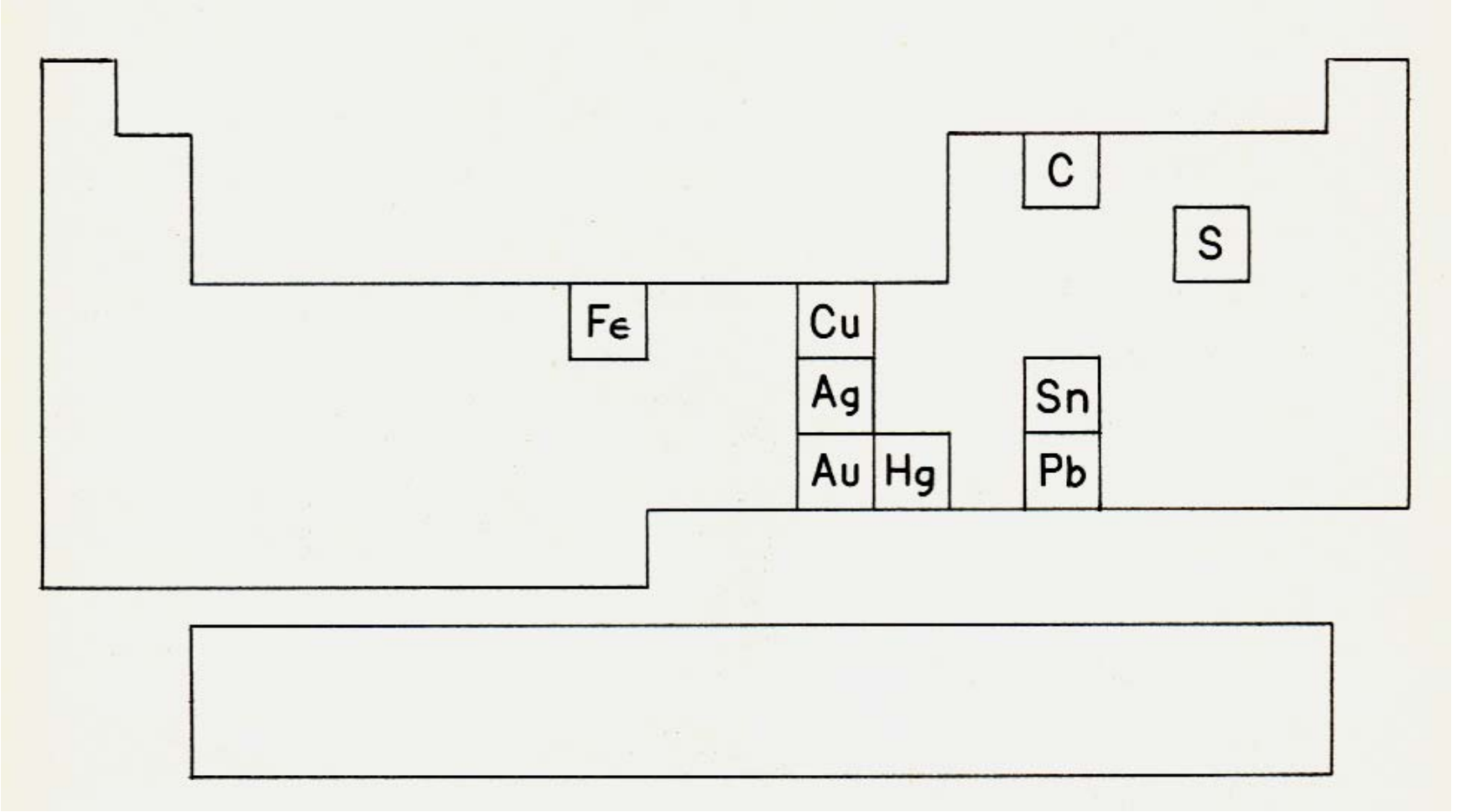
from SBR Core Text:

Ch. 1 # 9, 39, 47-51, 62, 88

Ch. 2 # 83, 102, 123, 129, 173

- issued along with model solutions

~ 2400 years ago



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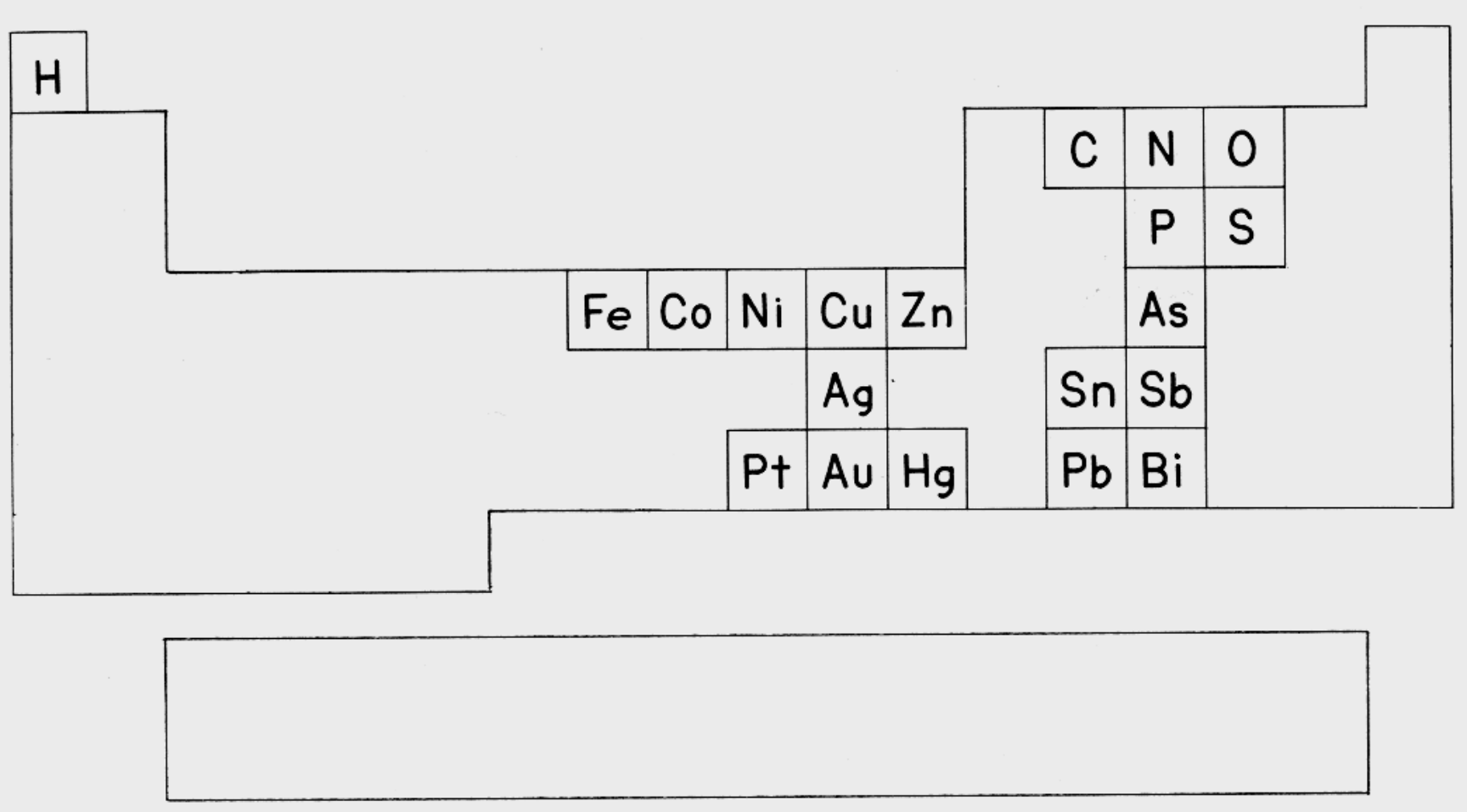

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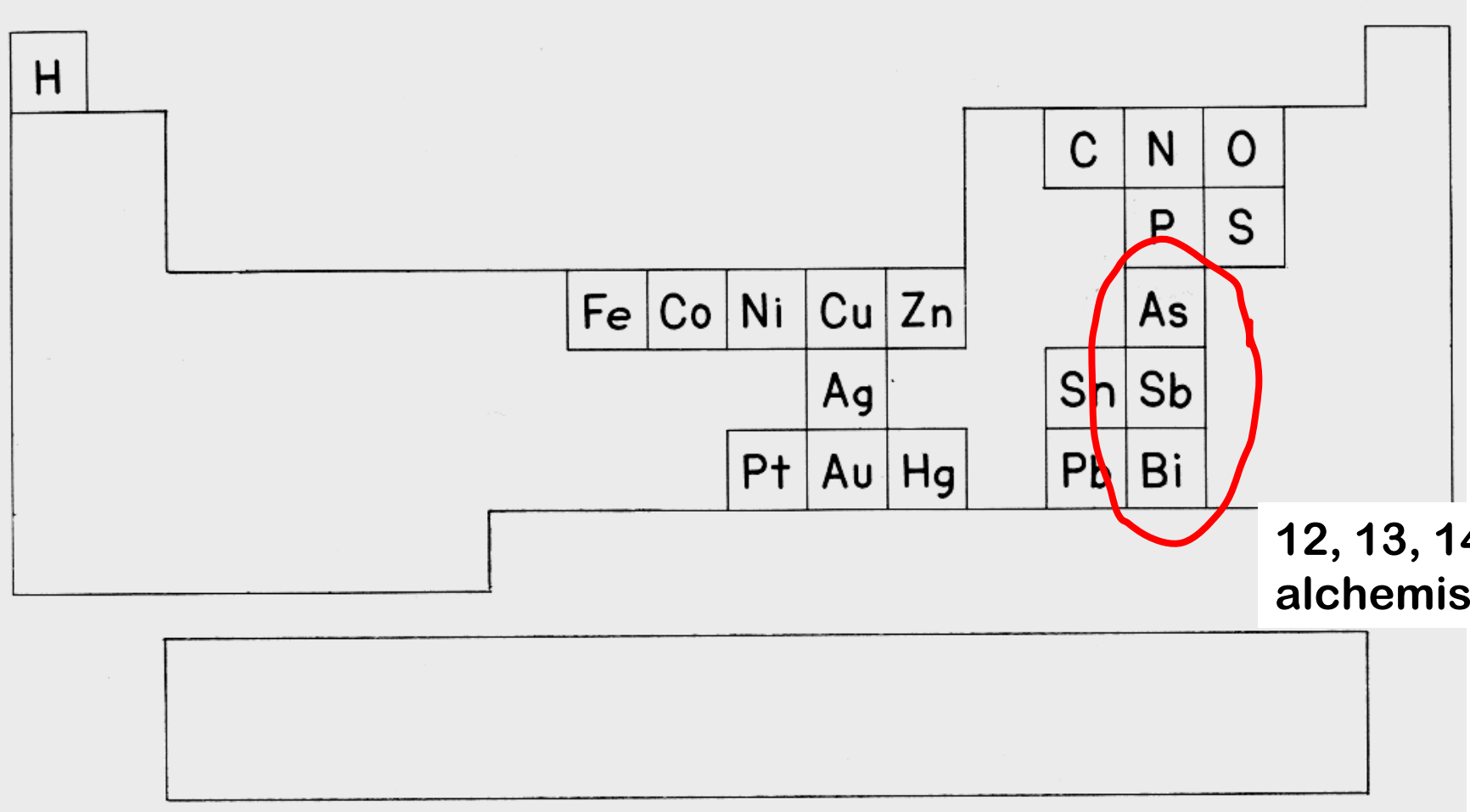
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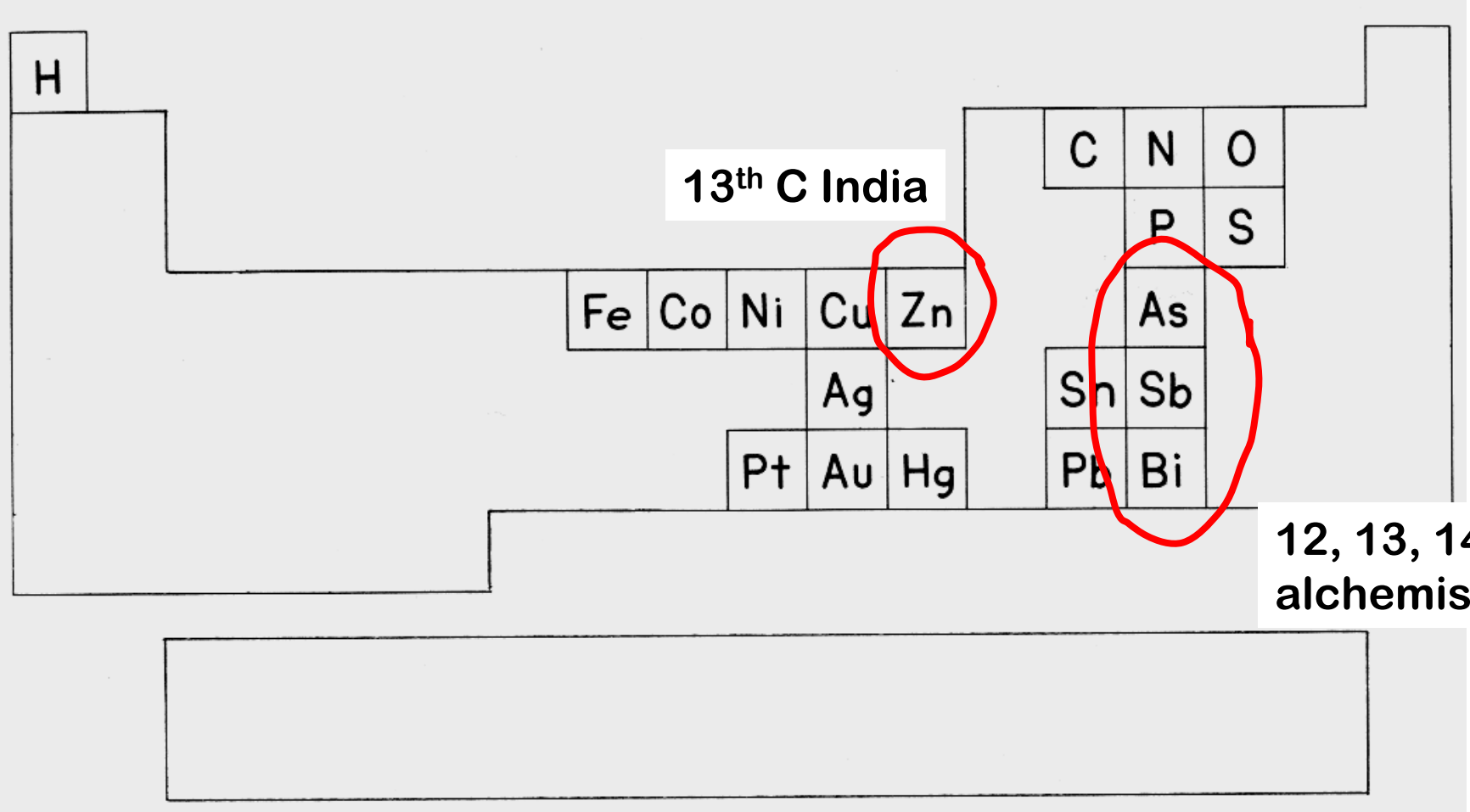
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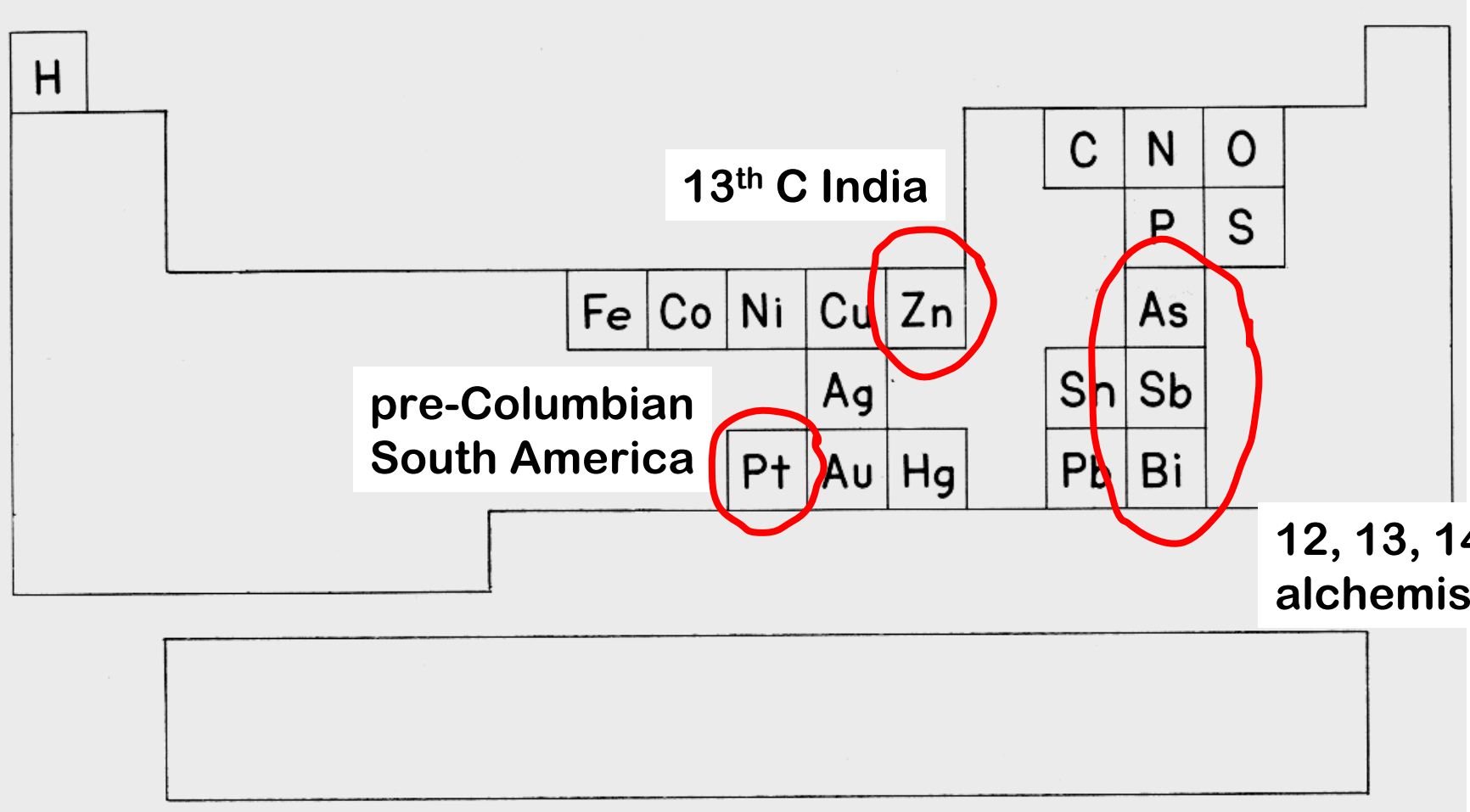
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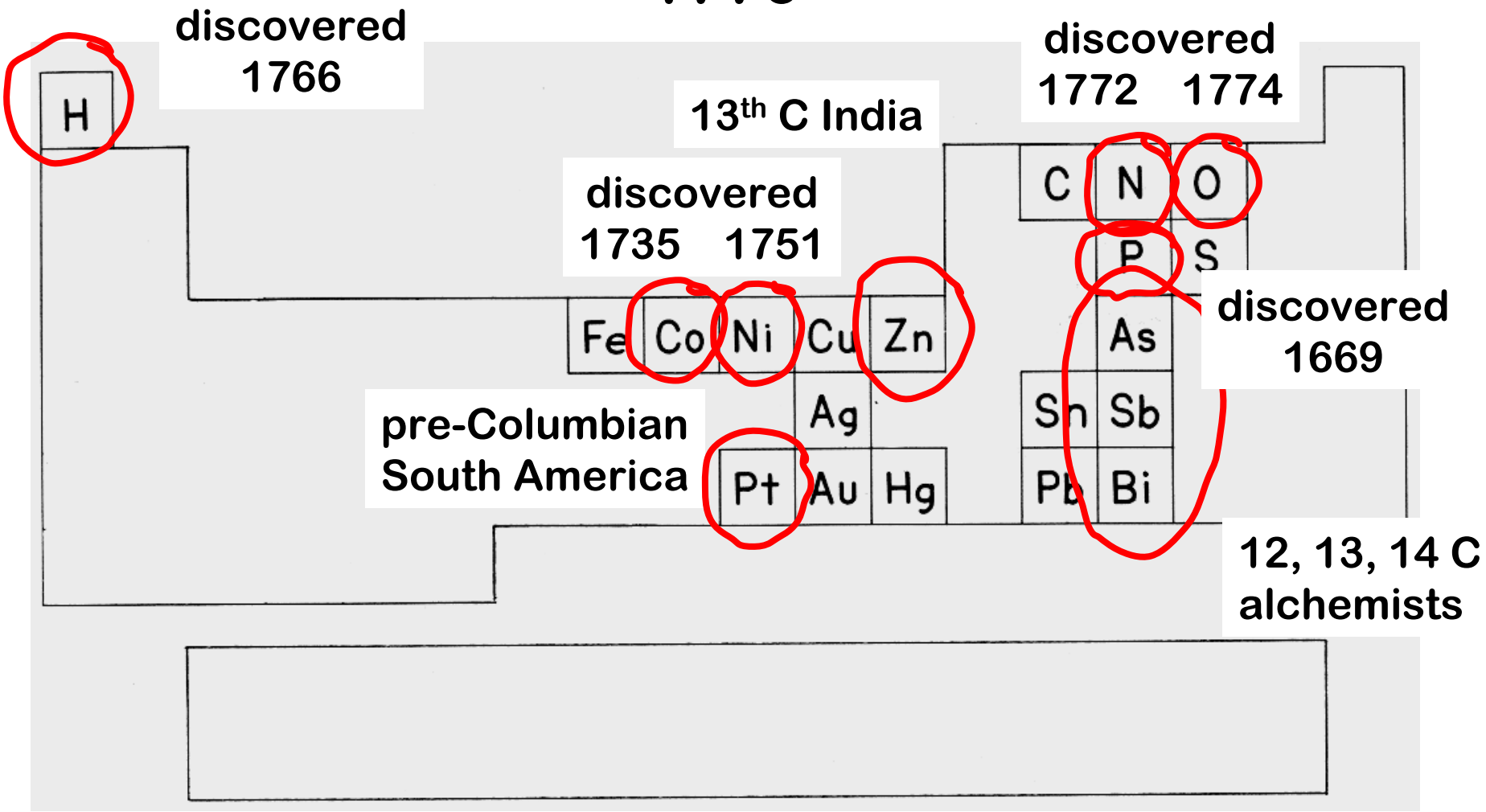
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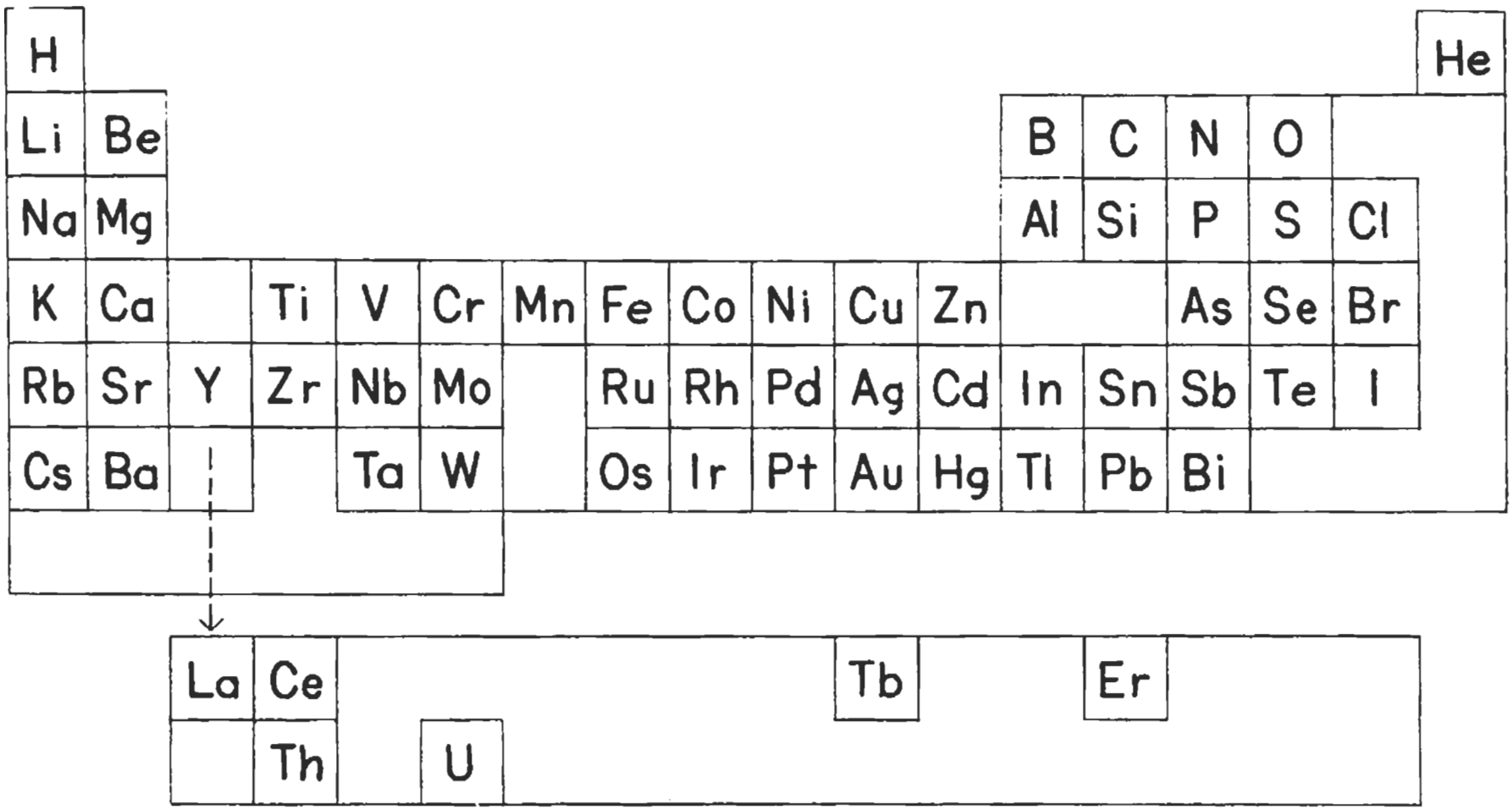
John Dalton
1803

Dalton's Model of the Atom (1803)

1. Matter is composed of atoms that are **indivisible** and **indestructible**.
2. All atoms of an element are **identical**.
3. Atoms of **different elements** have **different weights** and **different chemical properties**.
4. Atoms of different elements **combine in simple whole number ratios** to form **compounds**.
5. Atoms **cannot be created or destroyed**. When a compound is decomposed, the atoms are recovered unchanged.

other classifications:

* “triads” 1829, Döbereiner (Jena)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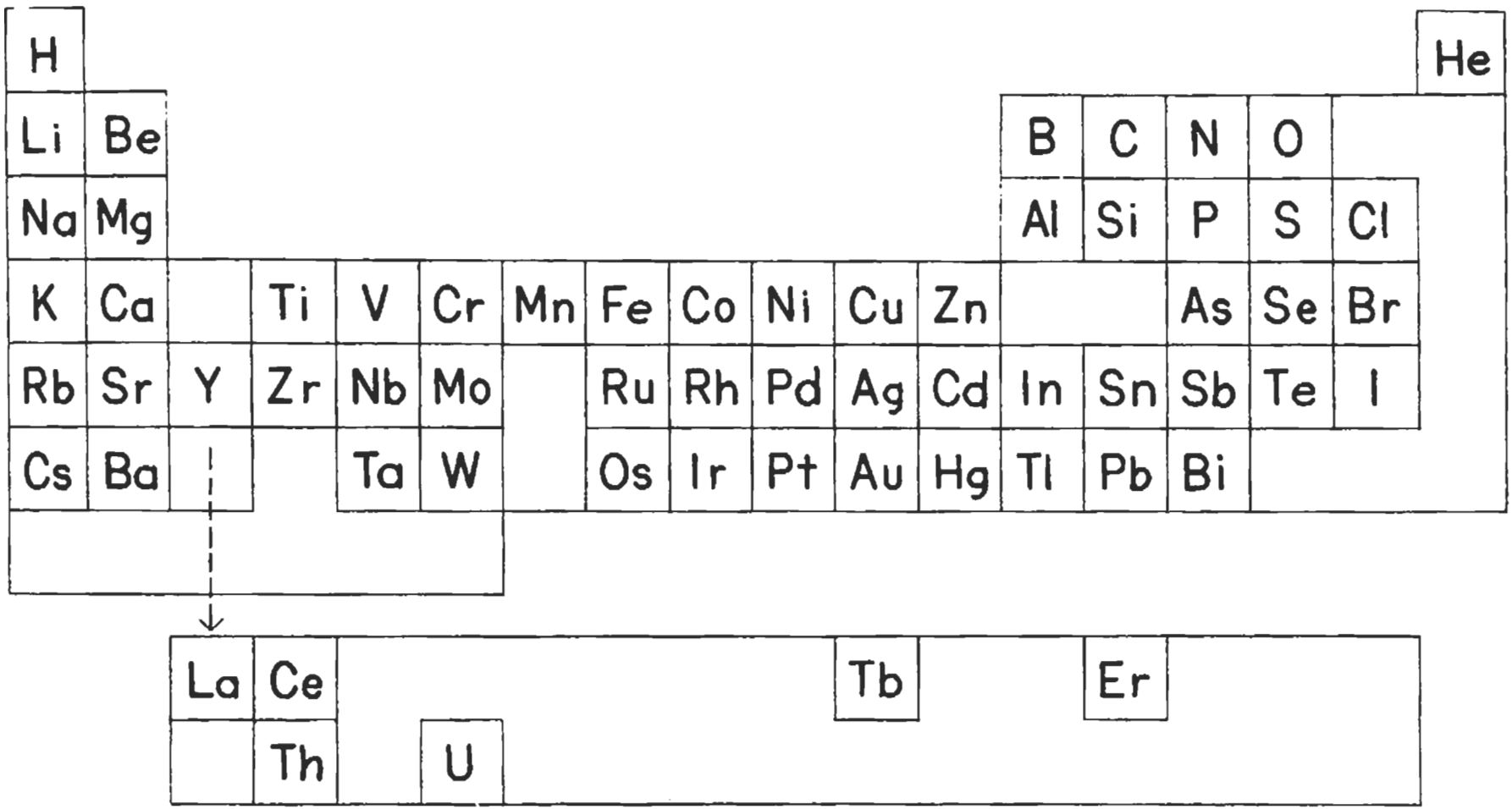
other classifications:

* “triads” 1829, Döbereiner (Jena)

* “octaves” 1864, Newlands (London)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other classifications:

* “triads” 1829, Döbereiner (Jena)

* “octaves” 1864, Newlands (London)

* “periodic table”
    1869, Mendeléef (St. Petersburg)
    1870, Meyer (Tübingen)

Д. И. Менделеев (60-е годы).

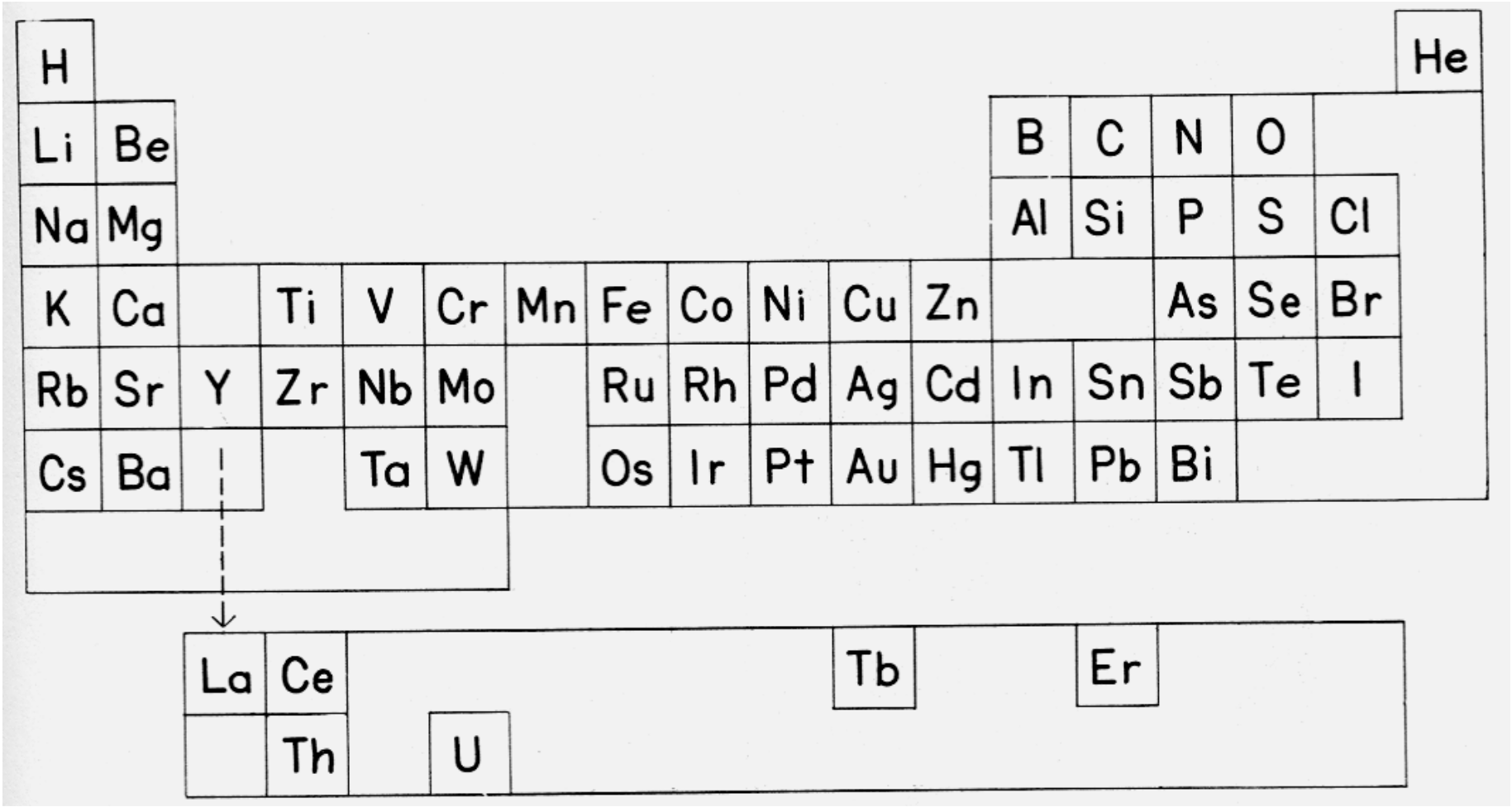
но въ ней, мнѣ кажется, уже ясно выражается примѣнимость выставляемаго мною начала ко всей совокупности элементовъ, изъ которыхъ извѣстенъ съ достовѣрностію. На этотъ разъ я и желалъ преимущественно найдти общую систему элементовъ. Вотъ этотъ опытъ:

			Ti = 50	Zr = 90	? = 180.
			V = 51	Nb = 94	Ta = 182.
			Cr = 52	Mo = 96	W = 186.
			Mn = 55	Rh = 104,4	Pt = 197,4
			Fe = 56	Ru = 104,4	Ir = 198.
			Ni = Co = 59	Pl = 106,6	Os = 199.
H = 1			Cu = 63,4	Ag = 108	Hg = 200.
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210
	O = 16	S = 32	Se = 79,4	Te = 128?	
	F = 19	Cl = 35,5	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207.
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75,6	Th = 118?		

а потому приходится въ разныхъ рядахъ имѣть различное измѣненіе разностей, чего нѣтъ въ главныхъ числахъ предлагаемой таблицы. Или же придется прилагать при составленіи системы очень много недостающихъ членовъ. То и другое мало выгодно. Мнѣ кажется вполнѣ, наиболѣе естественнымъ составить кубическую систему (предлагаемая есть плоскостная), но и попытки для ея образованія не совсѣмъ изъ надлежащимъ результатамъ. Слѣдующія двѣ попытки могутъ показать то разнообразіе сопоставленій, какое возможно при допущеніи основнаго начала, высказаннаго въ этой статьѣ

Li	Na	K	Cu	Rb	Ag	Cs	—	Tl
7	23	39	63,4	85,4	108	133		204
Be	Mg	Ca	Zn	Sr	Cd	Ba	—	Pb
B	Al	—	—	—	Ur	—	—	Bi?
C	Si	Ti	—	Zr	Sn	—	—	—
N	P	V	As	Nb	Sb	—	Ta	—
O	S	—	Se	—	Te	—	W	—
F	Cl	—	Br	—	J	—	—	—
19	35,5	58	80	190	127	160	190	220.

1869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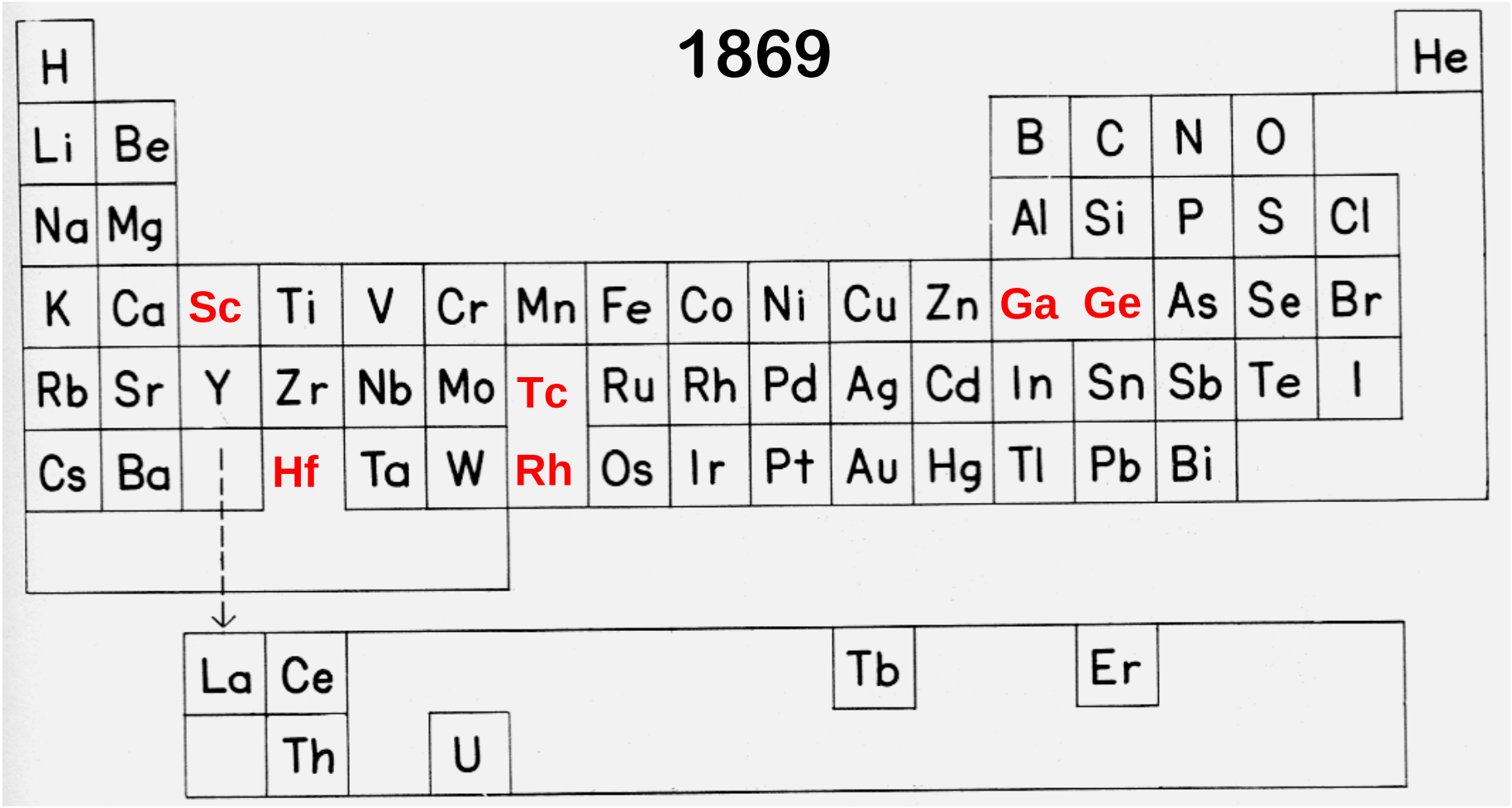


eka-boron	45	Sc	45.0
eka-aluminum	68	Ga	69.7
eka-silicon	72	Ge	72.6
eka-zirconium	180	Hf	178.5

Comparison of eka-silicon with germanium

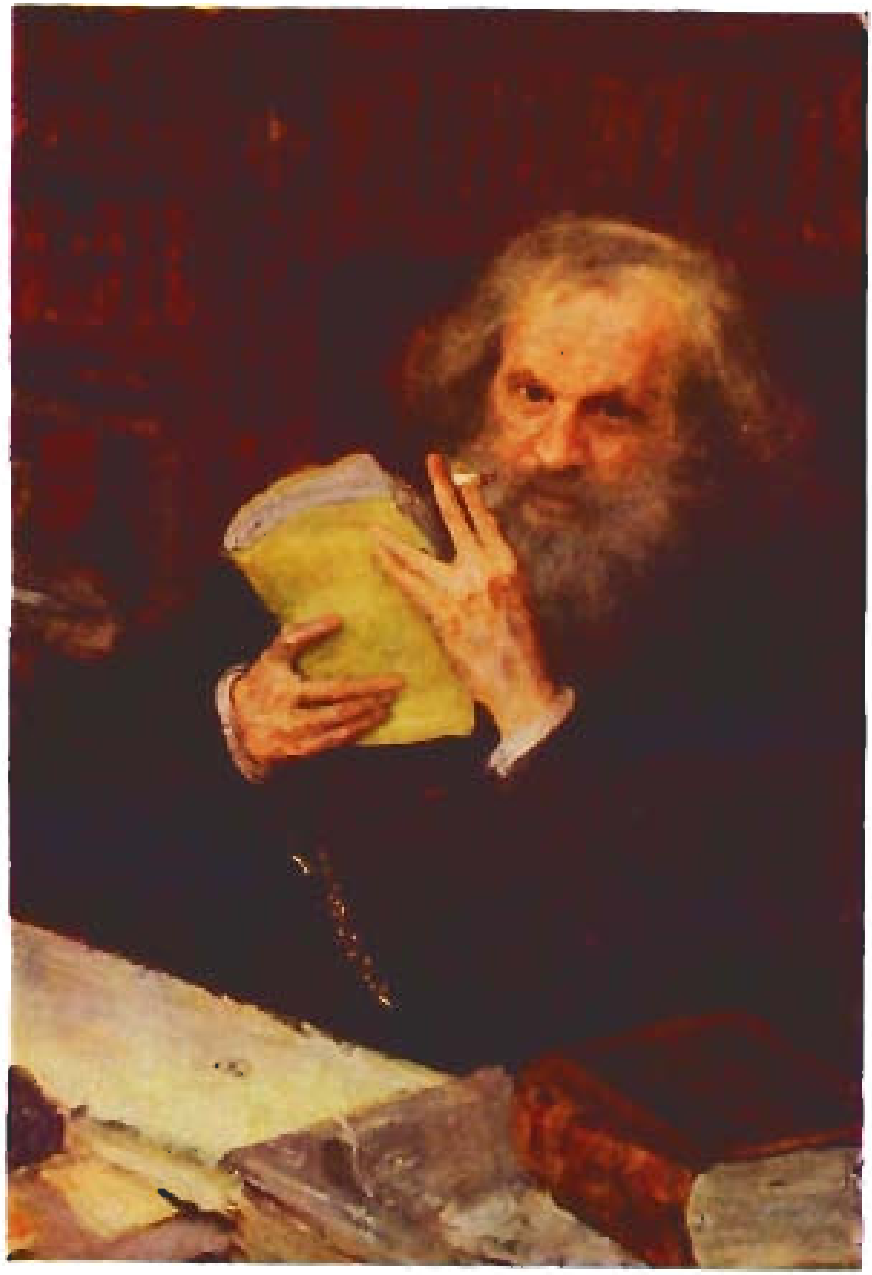
eka-silicon	**germanium**
72 g/mol	72.59 g/mol
5.5 g/cm^3	5.36 g/cm^3
“high” m.p.	m.p. = 958ºC
Es forms EsO_2 which has high m.p. and ρ = 4.7 g/cm^3	Ge forms GeO_2 m.p. = 1100ºC and ρ = 4.70 g/cm^3
$EsCl_4$ volatile liquid with b.p. < 100ºC and ρ = 1.9 g/cm^3	$GeCl_4$ volatile liquid b.p. = 83ºC and ρ = 1.88 g/cm^3

principles of modern chemistry:

***** recognize patterns

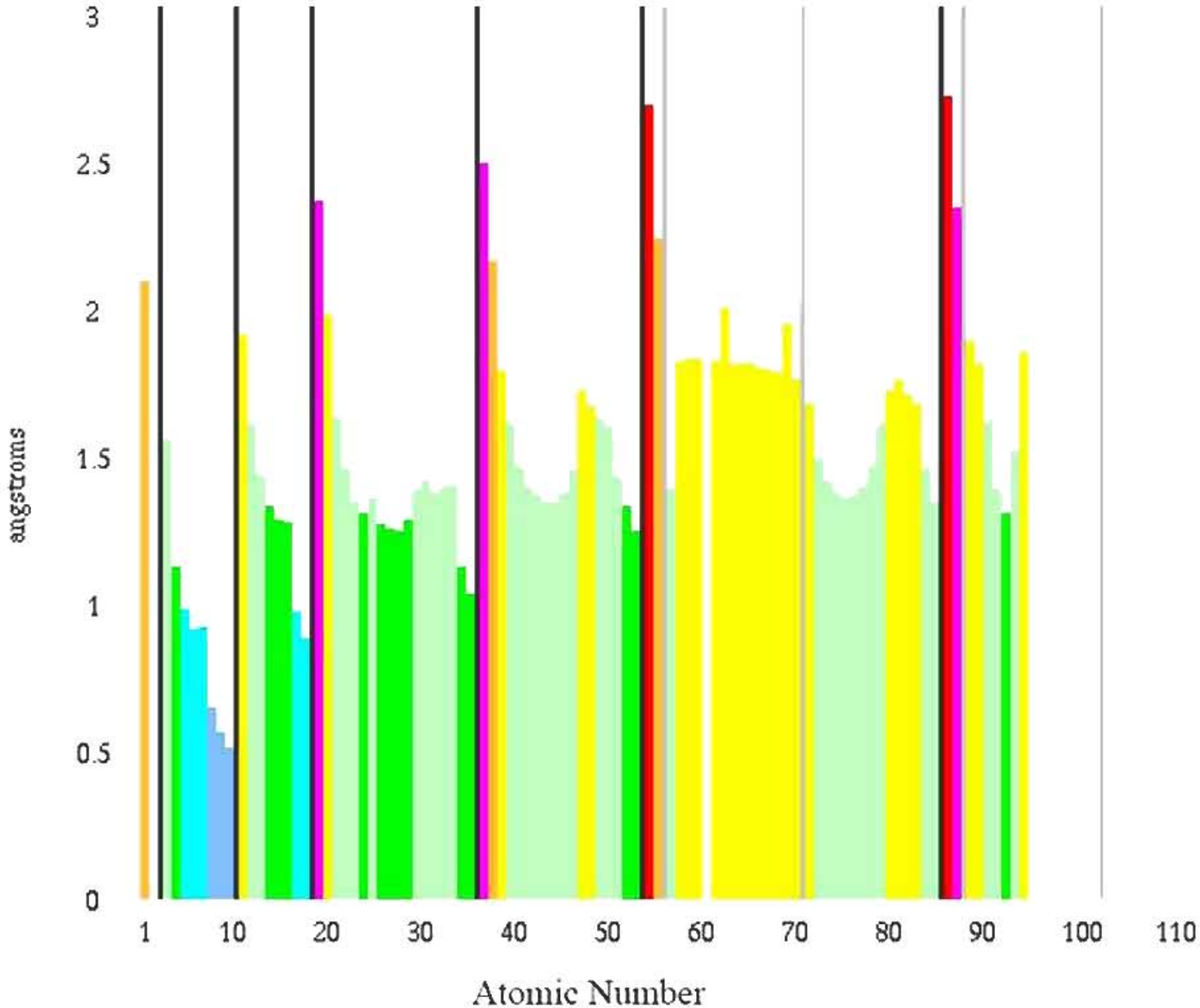
***** develop a quantitative model that

- explains our observations
- makes predictions that can be tested by experiment

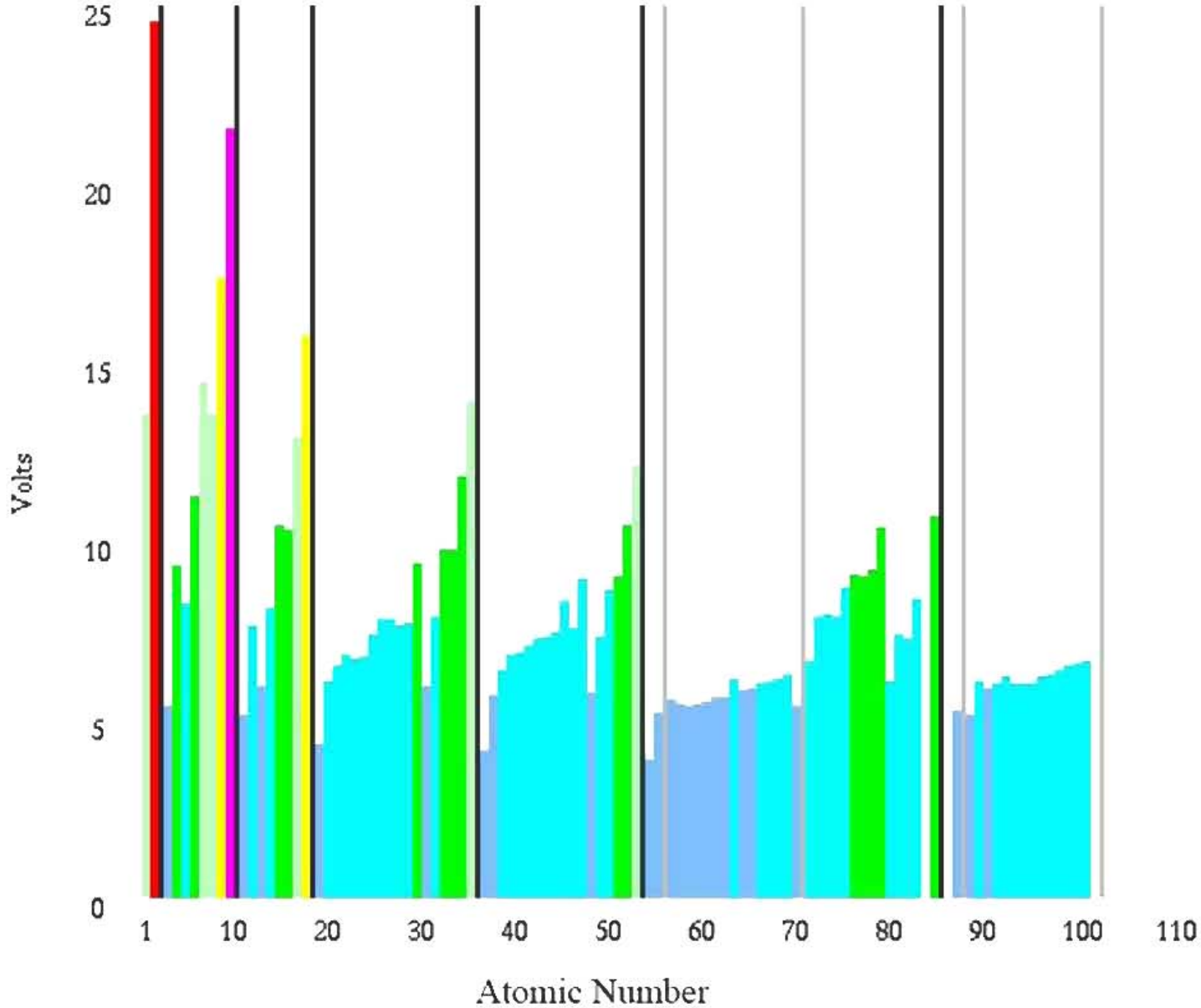


Д. И. Менделеев.
Портрет работы И. Е. Репина.

Graph: Atomic Radius vs. Atomic Number



Graph: First Ionization Potential vs. Atomic Number



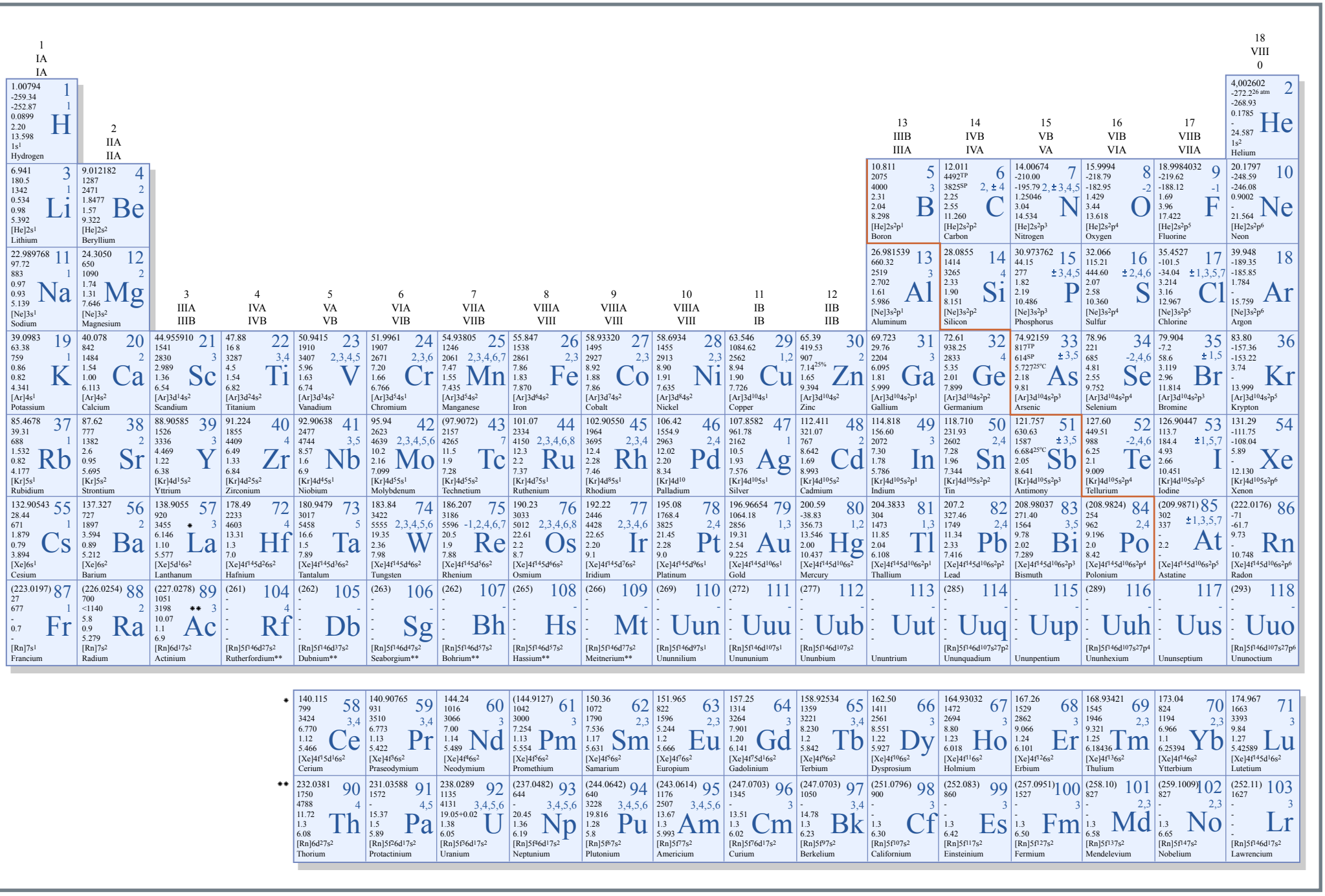


Figure by MIT OCW.

Naming the Superheavy Elements

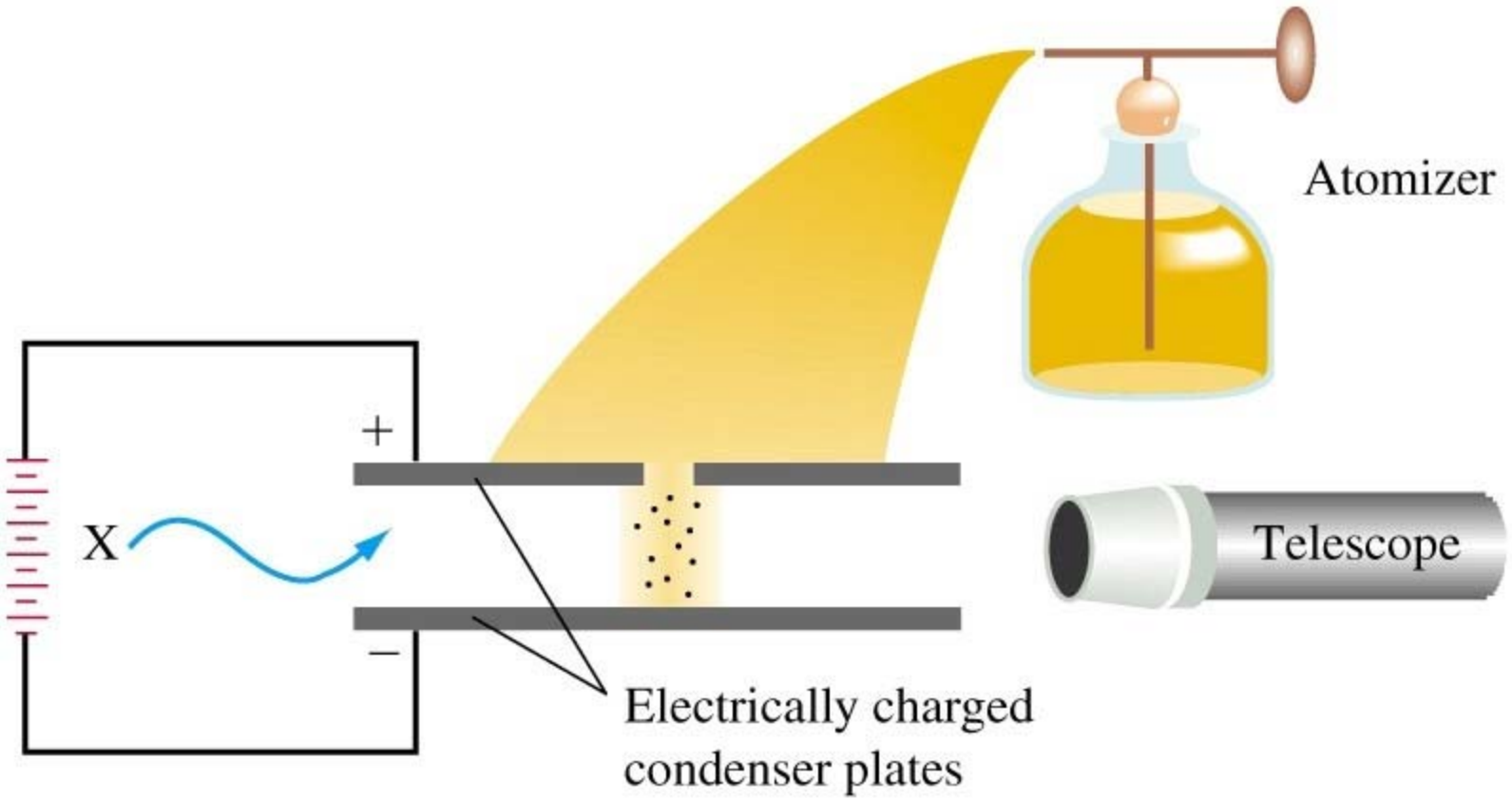
1	un		
2	bi		
3	tri		
4	quad		
5	pent	+	ium
6	hex		
7	sept		
8	oct		
9	enn		
0	nil		

111	**unununium**	**Uuu**
112	**ununbium**	**Uub**
113	**ununtrium**	**Uut**
114	**ununquadium**	**Uuq**
115	**ununpentium**	**Uup**
116	**ununhexium**	**Uuh**
117	**ununseptium**	**Uus**
118	**ununoctium**	**Uuo**
119	**ununenium**	**Uue**
120	**unbinilium**	**Ubn**

Strathern, Paul. *Mendeleyev's Dream: The Quest for the Elements.* Thomas Dunne Books, 21 April 2001. ISBN: 0312262043.

Table 1.3 The Structure of Atoms

particle	symbol	charge (C)	mass (kg)
electron	e^-	-1.6×10^{-19}	9.11×10^{-31}
proton	p^+	$+1.6\times10^{-19}$	1.673×10^{-27}
neutron	n^0	0	1.675×10^{-27}



Robert A. Millikan, University of Chicago (1909)
Nobel Prize in Physics 1923

Aleksandr P. BORODIN

- composer and member of “The Five”:
  Balakirev, Borodin, Cui, Mussorgsky,
  and Rimsky-Korsakov
- professor of chemistry,
  Medico-Surgical Academy, St. Petersburg
- friend of Mendeleyev

today’s selection:
Polovtsian Dance No. 17 from *Prince Igor*