Unit 8

On completion of the unit you should be able to:

1. state the mass, charge and location of protons, electrons and neutrons.
2. given the atomic number of an element, draw diagrams showing the protons in the nucleus and the electrons in shells (or energy levels) around the nucleus.
3. write the electron dot formulae for the elements in groups 1 to 8 in the periodic table.
4. define isotopes, mass number and atomic mass.
5. given the relative abundance and isotopic masses for an element, calculate the atomic mass of that element.
6. given the atomic number and mass number of an element, calculate the number of electrons.

ATOMS AND THE PERIODIC TABLE

8.1 **Atom**

- **Subatomic particles**

Today's focus.

8.2 **Isotope**

Reading: Hebden – page 144-146

8.3 **Arrangement of electrons**

- **Bohr model of the atom**
  Reading: Hebden – page 142
- **Lewis electron-dot formulas of elements**
  Reading: Hebden – page 167
- **Quantum mechanical model of the atom**

8.4 **Electron configurations of atoms**

8.5 **Atomic mass**

- **Tabulated atomic mass**

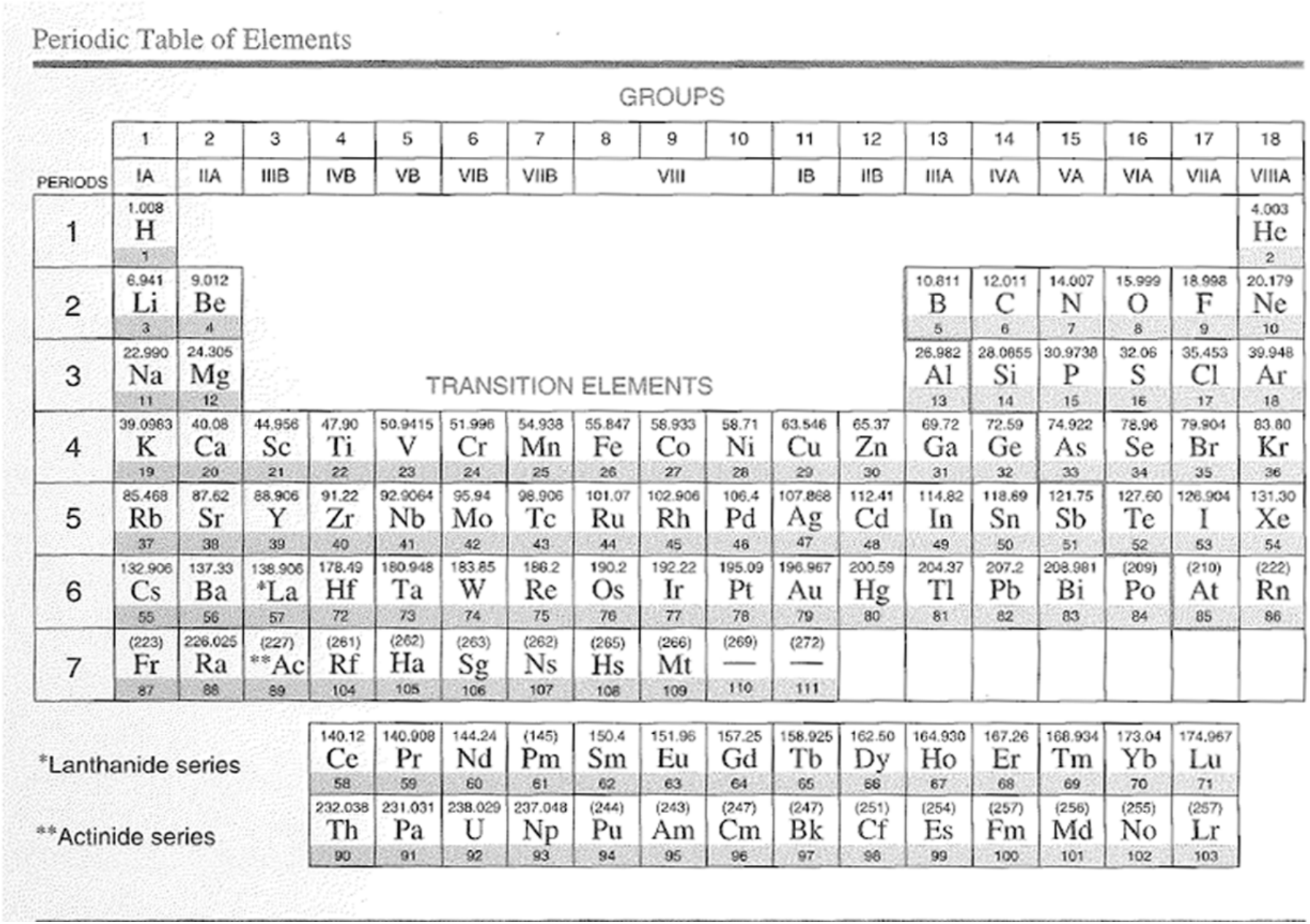
Reading: Hebden – page 150

8.6 **Periodic table of the elements**

Review

- **Metals Nonmetals and Semimetals**
  - **Properties of metals**
  - **Properties of nonmetals**
  - **Properties of semimetals**

REVIEW: Periodic Table of Elements



Periodic Table of Elements

GROUPS

PERIODS	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1.008 H 1																	4.003 He 2
2	6.941 Li 3	9.012 Be 4											10.811 B 5	12.011 C 6	14.007 N 7	15.999 O 8	18.998 F 9	20.179 Ne 10
3	22.990 Na 11	24.305 Mg 12											26.982 Al 13	28.0855 Si 14	30.9738 P 15	32.06 S 16	35.453 Cl 17	39.948 Ar 18
4	39.0983 K 19	40.08 Ca 20	44.956 Sc 21	47.90 Ti 22	50.9415 V 23	51.996 Cr 24	54.938 Mn 25	55.847 Fe 26	58.933 Co 27	58.71 Ni 28	63.546 Cu 29	65.37 Zn 30	69.72 Ga 31	72.59 Ge 32	74.922 As 33	78.96 Se 34	79.904 Br 35	83.80 Kr 36
5	85.468 Rb 37	87.62 Sr 38	88.906 Y 39	91.22 Zr 40	92.9064 Nb 41	95.94 Mo 42	98.906 Tc 43	101.07 Ru 44	102.906 Rh 45	106.4 Pd 46	107.868 Ag 47	112.41 Cd 48	114.82 In 49	118.69 Sn 50	121.75 Sb 51	127.60 Te 52	126.904 I 53	131.30 Xe 54
6	132.906 Cs 55	137.33 Ba 56	138.906 *La 57	178.49 Hf 72	180.948 Ta 73	183.85 W 74	186.2 Re 75	190.2 Os 76	192.22 Ir 77	195.09 Pt 78	196.967 Au 79	200.59 Hg 80	204.37 Tl 81	207.2 Pb 82	208.981 Bi 83	(209) Po 84	(210) At 85	(222) Rn 86
7	(223) Fr 87	226.025 Ra 88	(227) **Ac 89	(261) Rf 104	(262) Ha 105	(263) Sg 106	(262) Ns 107	(265) Hs 108	(266) Mt 109	(269) — 110	(272) — 111							

TRANSITION ELEMENTS

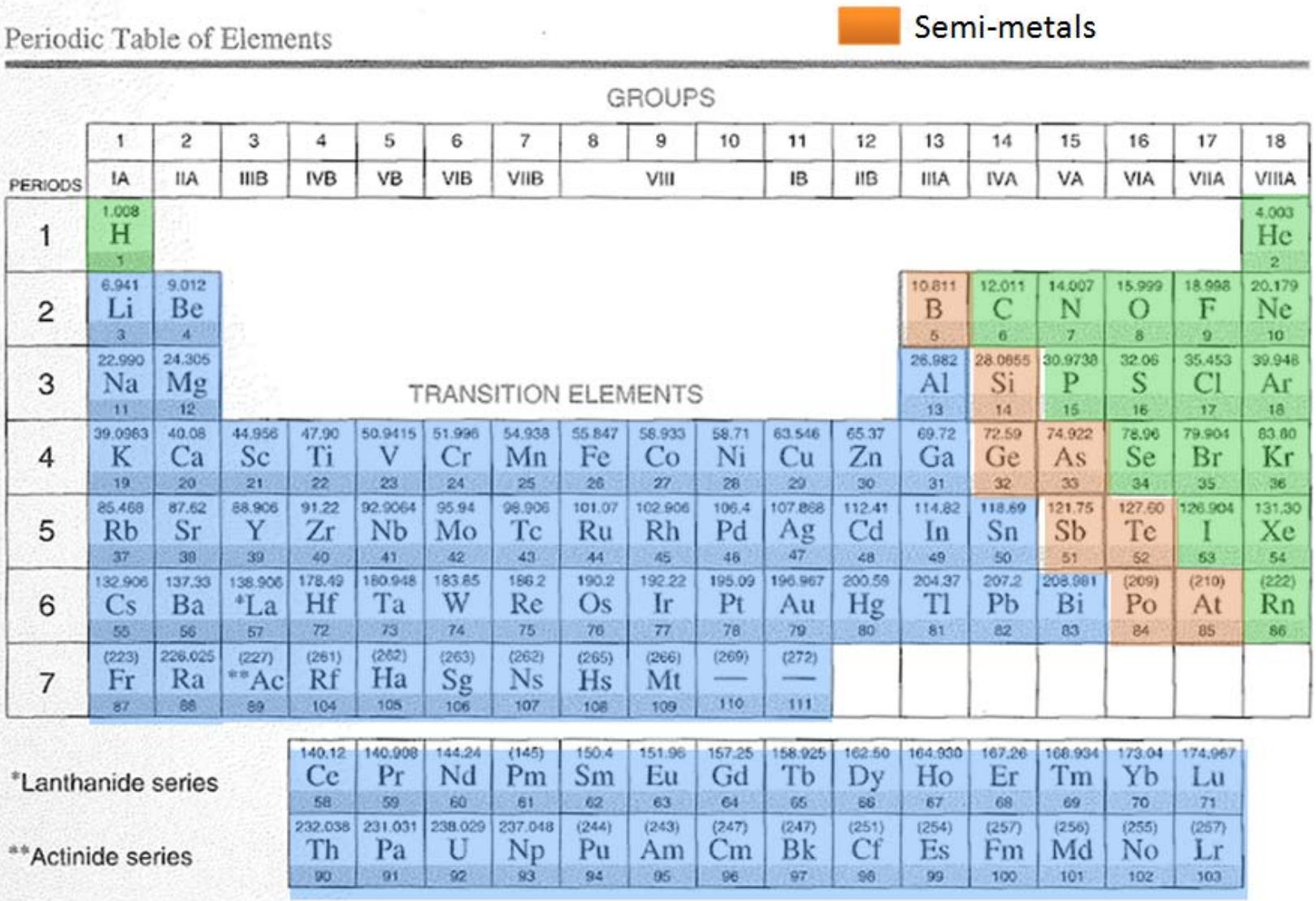
*Lanthanide series	140.12 Ce 58	140.908 Pr 59	144.24 Nd 60	(145) Pm 61	150.4 Sm 62	151.96 Eu 63	157.25 Gd 64	158.925 Tb 65	162.50 Dy 66	164.930 Ho 67	167.26 Er 68	168.934 Tm 69	173.04 Yb 70	174.967 Lu 71
**Actinide series	232.038 Th 90	231.031 Pa 91	238.029 U 92	237.048 Np 93	(244) Pu 94	(243) Am 95	(247) Cm 96	(247) Bk 97	(251) Cf 98	(254) Es 99	(257) Fm 100	(256) Md 101	(255) No 102	(257) Lr 103

Periodic Table of Elements

Metals

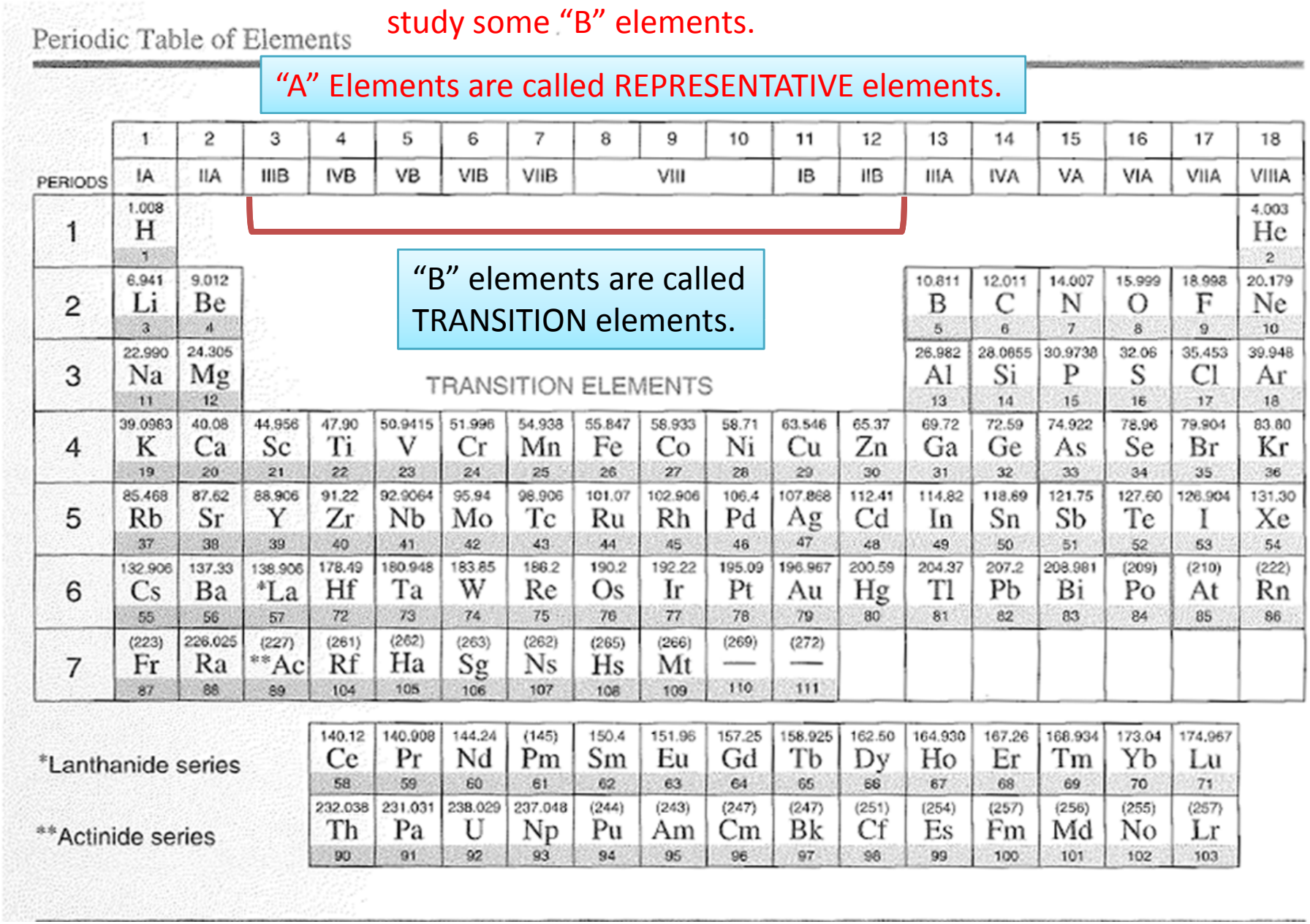
Non-metals

Semi-metals



Periodic Table of Elements

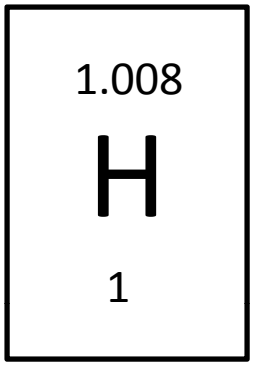
For this course, we will mainly focus on the "A" elements, and we will study some "B" elements.



REVIEW: Periodic Table of Elements

- All the elements on the Periodic Table of Elements are **NEUTRAL**.

The Hydrogen atom



Symbol for Hydrogen

Atomic Number

Atomic Number = # of protons

Hydrogen has **1 proton**!

Since a H atom is NEUTRAL, it must have **1 electron**.

Elements are atoms.
Atoms are made up of:

Proton
has +1 charge.

Neutron
has no charge.

Electron
has -1 charge.

Question: How many protons and electrons does carbon have?

Answer: 6 protons and 6 electrons

- All the elements on the Periodic Table of Elements can become charged. When they are charged, they are called ions.

REVIEW: Ions

When an atom loses electron(s), they form positive ions.
Positive ions are called CATIONS.

When an atom gains electron(s), they form negative ions.
Negative ions are called ANIONS.

Example:

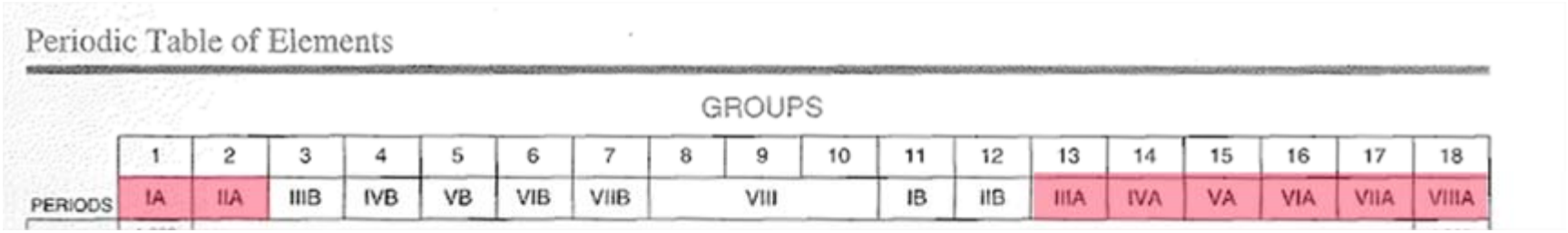
H is a Hydrogen atom (neutral).
H^+ is a Hydrogen ion (+1 charge).

Example:

O is an Oxygen atom (neutral).
O^{2-} is an Oxygen ion (-2 charge).

Valence Electrons & Octet Rule.

REVIEW: Valence Electrons, Ions, Group Names



# of valence electrons	1	2											3	4	5	6	7	8
Charge of Ions formed	+1	+2											+3	$^{+4}/_{-4}$	-3	-2	-1	0

Group Names to remember:

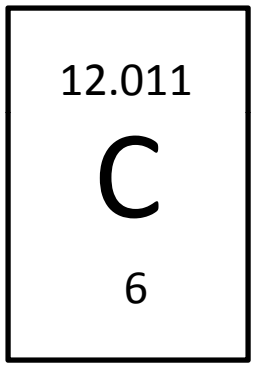
- Group I A elements: Alkali metals
- Group II A elements: Alkaline-earth metals
- Group VI A: Chalcogens
- Group VII A: Halogens
- Group VIII A: Noble Gases

REVIEW: Valence Electrons & Octet Rule

Valence electrons are electrons that are in the *outer shells* of the atom. They are associated with an atom that can participate in the formation of a chemical bond.

# of protons = 6 protons

# of electrons = 6 electrons



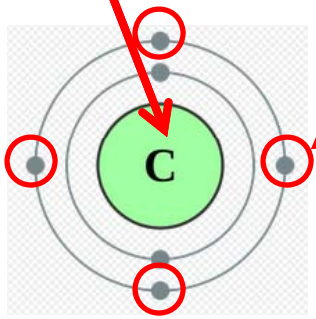
This is the unique identifier of the element.

Atomic Number

Atomic Number = # of protons

The protons are in the nucleus of the atom.

	Mass (amu)
proton	**1.00727647**
neutron	**1.0086654**
electron	**0.000548597**



These are the valence electrons. For carbon, there are FOUR.

Mass Number

Valence electrons are electrons that are in the *outer shells* of the atom. They are associated with an atom that can participate in the formation of a chemical bond.

Carbon:

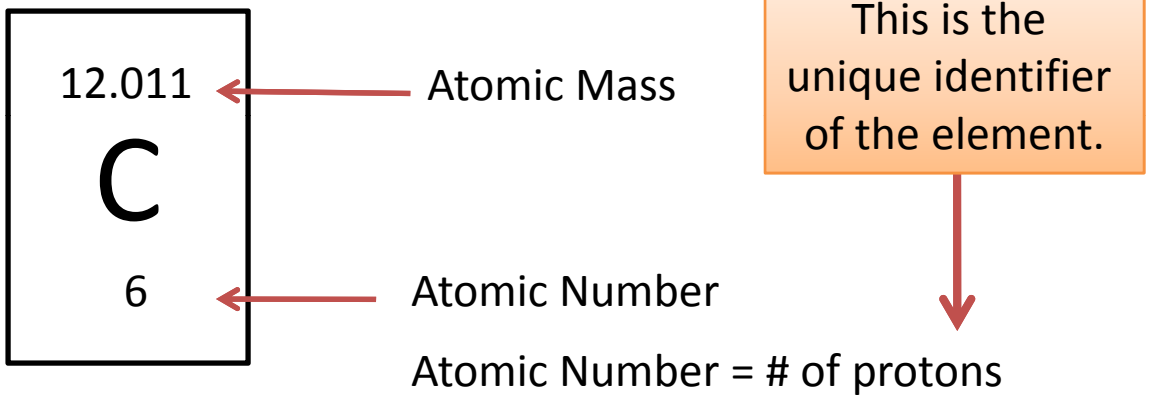
of protons = 6 protons

# of electrons = 6 electrons

Mass Number = 12

# of neutrons = 12 – 6 = 6

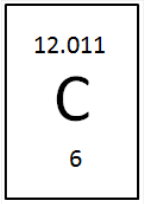
Charge of carbon atom = 0



Atomic Mass rounded to the nearest integer = MASS NUMBER

# of protons + # of neutrons = MASS NUMBER

Isotopes



Atomic Mass rounded to the nearest integer = MASS NUMBER

# of protons + # of neutrons = MASS NUMBER

- Variations of an element; they are neutral
- They have the same number of protons and electrons
- Different number of neutrons, therefore, different mass

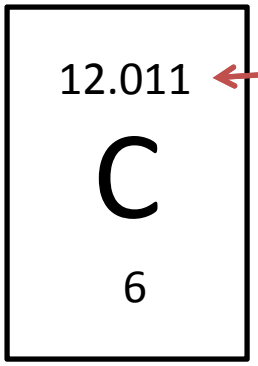
Mass numbers

Example: Carbon has three isotopes

^{12}C, ^{13}C, ^{14}C

	^{12}C Carbon-12	^{13}C Carbon-13	^{14}C Carbon-14
# of protons	6	6	6
# of neutrons	6	7	8
# of electrons	6	6	6
Mass number	12	13	14
Charge	0	0	0

Atomic Mass of Carbon



Can we calculate the atomic mass of carbon from summing up the mass of its protons, neutrons and electrons?

	Carbon
# of protons	6
# of neutrons	6
# of electrons	6
Mass number	12
Charge	0

	Mass (amu)
proton	1.00727647
neutron	1.0086654
electron	0.000548597

6 x (mass of proton) + 6 x (mass of neutrons) + 6 x (mass of electrons) ? = atomic mass of Carbon

6 x (1.00727647) + 6 x (1.0086654) + 6 x (0.000548597) = atomic mass of Carbon

6.04365882 + 6.0519924+ 0.003291582 = atomic mass of Carbon

12.0989428 = atomic mass of Carbon

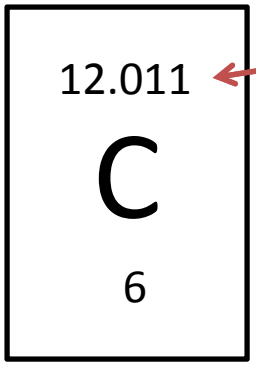
This is NOT 12.011 amu. Not close enough.

1.3×10^{-11} joules per C atom
or
8.13×10^{12} joules per mole C

The difference, 12.0989428 – 12.011 = 0.088 amu

The difference is attributed to BINDING ENERGY!

Atomic Mass of Carbon



Where does this number, ATOMIC MASS, come from?

Atomic mass is defined as the weighted average of the atomic masses of the *naturally* occurring isotopes of an element.

Naturally occurring Isotopes of carbon	Mass (amu)	Percent Abundance
^{12}C	12.00000	98.89
^{13}C	13.00335	1.110

$$\left(12.00000 \cdot \frac{98.89}{100}\right) + \left(13.00335 \cdot \frac{1.110}{100}\right) = 12.011 \text{ amu}$$

^{12}C ^{13}C

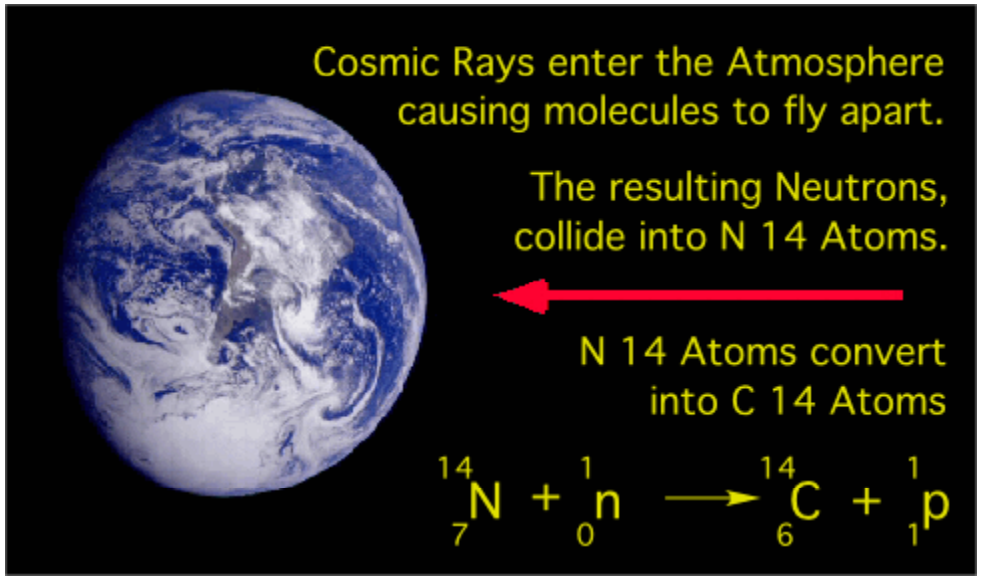
As seen on the Periodic Table.

Atomic Mass of Carbon

12.011
C
6

Atomic mass is defined as the weighted average of the atomic masses of the *naturally* occurring isotopes of an element.

What about ^{14}C?



Produced in the upper atmosphere. It is not naturally occurring like ^{12}C and ^{13}C.

Image credit: http://www.detectingdesign.com/carbon14.html#What

Counting Table

Symbol						
# of protons	9	27			13	
# of neutrons				29		
# of electrons			18			46
Mass number		59		50		108
Charge	0	0	+2	0	+3	+1

Counting Table Answers

Try Hebden Page 149
(answers in the back of the book)

Symbol	F	Co	Ca^{+2}	^{50}Sc	Al^{+3}	Ag^{+1}
# of protons	9	27	20	21	13	47
# of neutrons	10	32	20	29	14	61
# of electrons	9	27	18	21	10	46
Mass number	19	59	40	50	27	108
Charge	0	0	+2	0	+3	+1

Unit 8

On completion of the unit you should be able to:

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2. given the atomic number of an element, draw diagrams showing the protons in the nucleus and the electrons in shells (or energy levels) around the nucleus.
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ATOMS AND THE PERIODIC TABLE

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- **Subatomic particles**

8.2 **Isotope**

Reading: Hebden – page 144-146

8.3 **Arrangement of electrons**

- **Bohr model of the atom**
  Reading: Hebden – page 142
- **Lewis electron-dot formulas of elements**
  Reading: Hebden – page 167
- **Quantum mechanical model of the atom**

8.4 **Electron configurations of atoms**

8.5 **Atomic mass**

- **Tabulated atomic mass**

Reading: Hebden – page 150

8.6 **Periodic table of the elements**

- **Metals Nonmetals and Semimetals**
  - **Properties of metals**
  - **Properties of nonmetals**
  - **Properties of semimetals**

Next lecture we will focus on the electrons!!