

# UCL CERTIFICATE OF HIGHER EDUCATION IN ASTRONOMY

## RELEVANT BASIC CONCEPTS OF PHYSICS (27<sup>th</sup> Feb 2020)

These guidelines give an idea of the basic concepts that potential applicants need to be familiar with, before the course starts in October 2020. Some of this material will be seen in detail during the course.

Rather than printing, we advice to use them to compile your own personal notes on a hand written dedicated notebook. This process helps fixing ideas much better.

The most relevant concepts of mathematics and physics are also illustrated in the boxes called TOOLS OF THE ASTRONOMER'S TRADE throughout your Universe text book.

best regards,

francisco diego

f.diego@ucl.ac.uk

# INTERNATIONAL SYSTEM OF UNITS (SI)

Fundamental units:

length= metre (m)

mass= kilogram (kg)

time = second (s)

temperature = kelvin (K)

frequency = hertz (Hz, cycles per second)

## Derived units:

force = newton (N) defined as the force required to accelerate a body of one kg by one metre per second every second

ENERGY is the capacity to produce change, illustrated as a force (measured in newtons) acting upon a distance (measured in metres)

One newton acting along one metre equals one joule of energy

$$1 \text{ newton-m} = 1 \text{ joule} = 1 \text{ J}$$

POWER is how fast energy is used  
One joule per second = 1 watt = 1W

- force = newton ( $N = \text{kg} \times \text{m}/\text{s}^2$ )
- energy = joule ( $J = N \times \text{m}$ )
- power = watt ( $W = \text{J}/\text{s}$ )
- pressure (force applied to a surface area) pascal ( $\text{Pa} = \text{N}/\text{m}^2$ )

# ATOMIC STRUCTURE

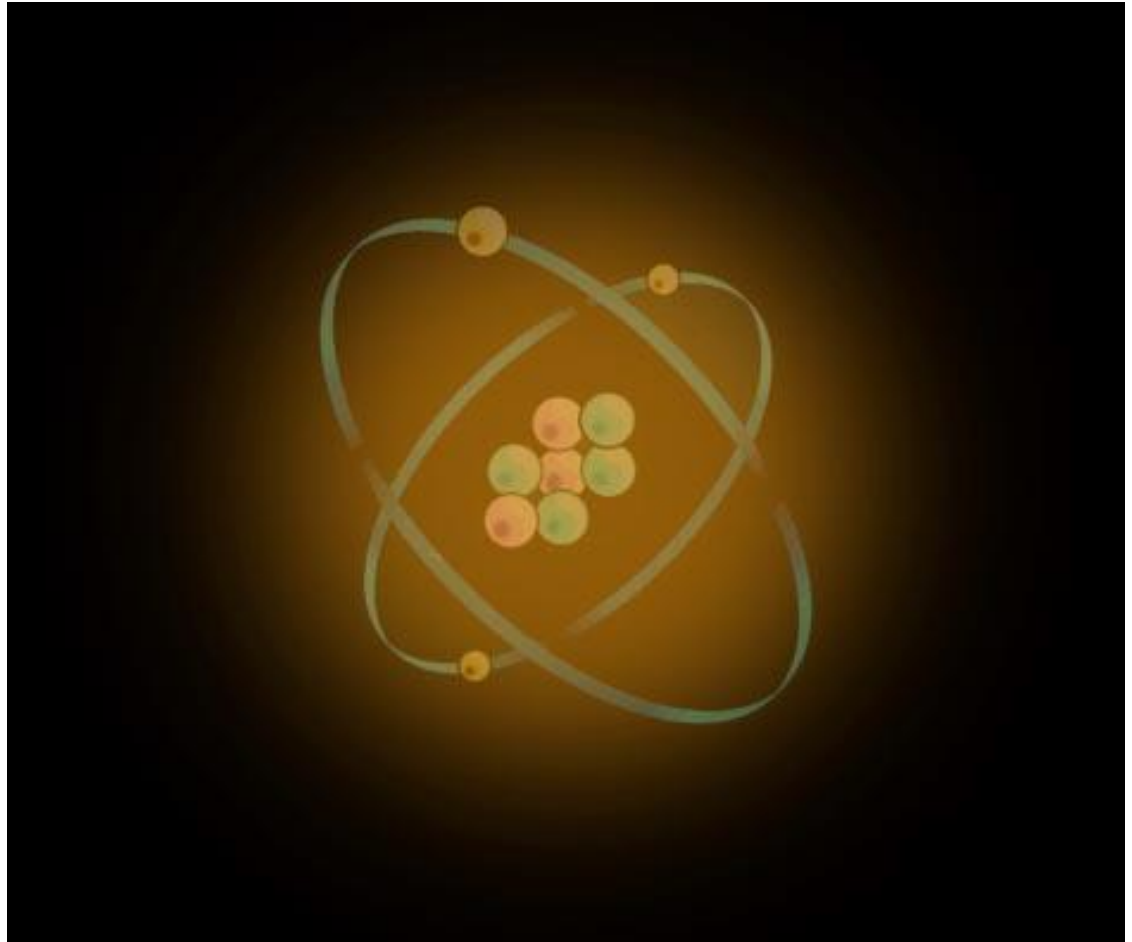
These notes are a summary of the origin and nature of atoms. This topic will be seen in detail at the introduction modules of the certificate.

Atoms are made of tiny fundamental particles that formed just after the origin of the Universe and then came together to form all the atoms that make the Universe we see today. Whatever is visible in the Universe is mainly made of atoms and sometimes of those particles when they are loose.

All atoms are formed by a nucleus and an envelope. The nuclei of all atoms are clusters of two kinds of particles: protons and neutrons. The number of protons in the nucleus of an atom determines the chemical element of that atom. One for hydrogen, two for helium, three for lithium, eight for oxygen, twenty for calcium, etc. This is called atomic number.

The envelope is formed by tiny electrons distributed in a kind of concentric layers. As many electrons as protons.

The image shows an atom of lithium with 3 protons, 4 neutrons and 3 electrons,



# **THE BIG BANG**

**Origin of the  
Universe**

**Pure energy**

**Time = 0**





**Electrons**

**quarks**

**Formation of fundamental particles**

**Time =  $10E-43$  sec**





**Protons**

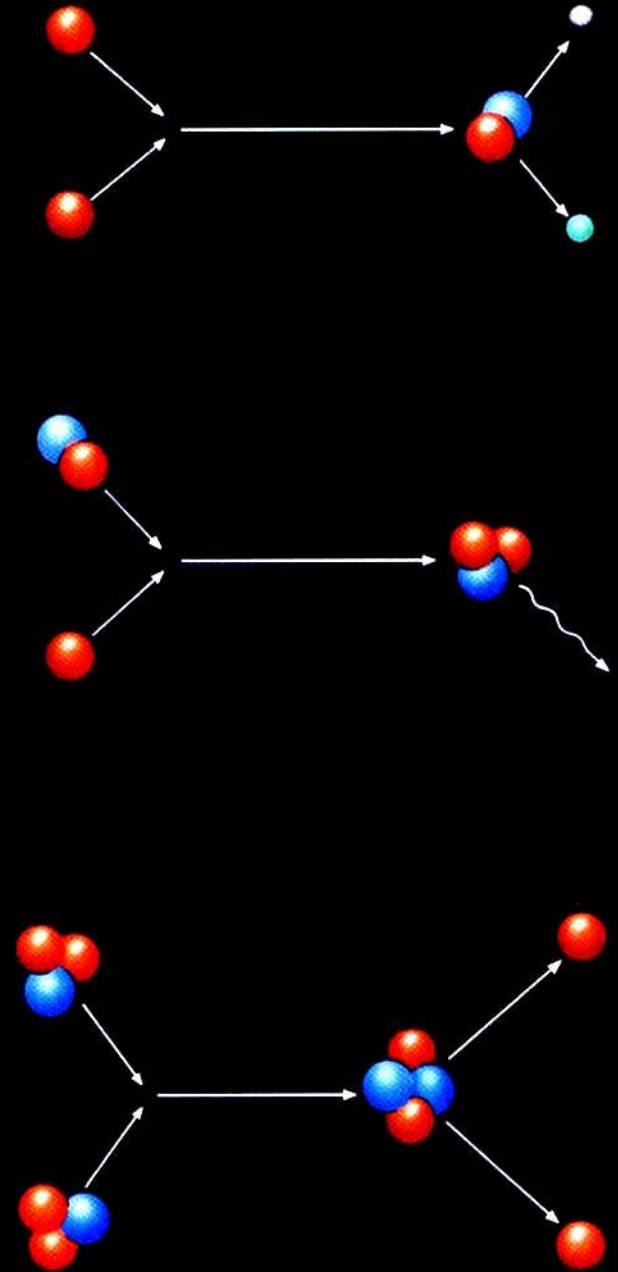
**Neutrons**

**Electrons**

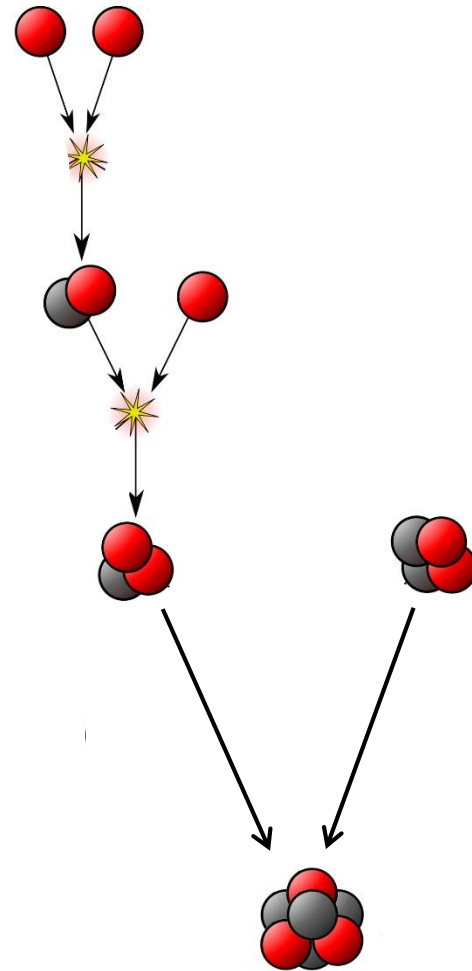
**Quarks assemble into protons and neutrons**

**Time =  $10E-9$  sec**

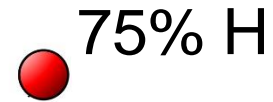
Protons (red) and neutrons (blue) assemble, FUSE together into clusters while the Universe is still hot enough for that to happen. These will be nuclei of atoms, so the process is called nuclear fusion.



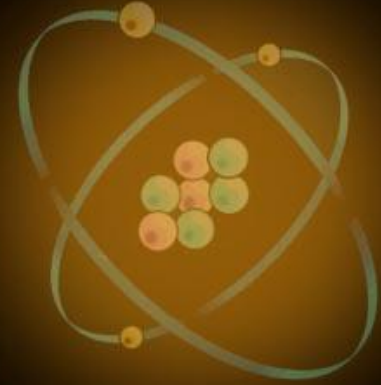
But the Universe  
keeps expanding,  
hence cooling  
down..... so after 15  
minutes this process  
comes to an end.



At that point, there were 75% of hydrogen nuclei, 25% of helium nuclei and only traces of lithium nuclei.

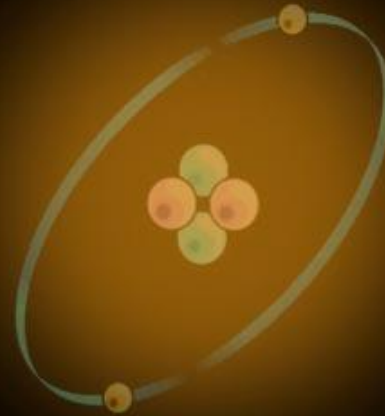


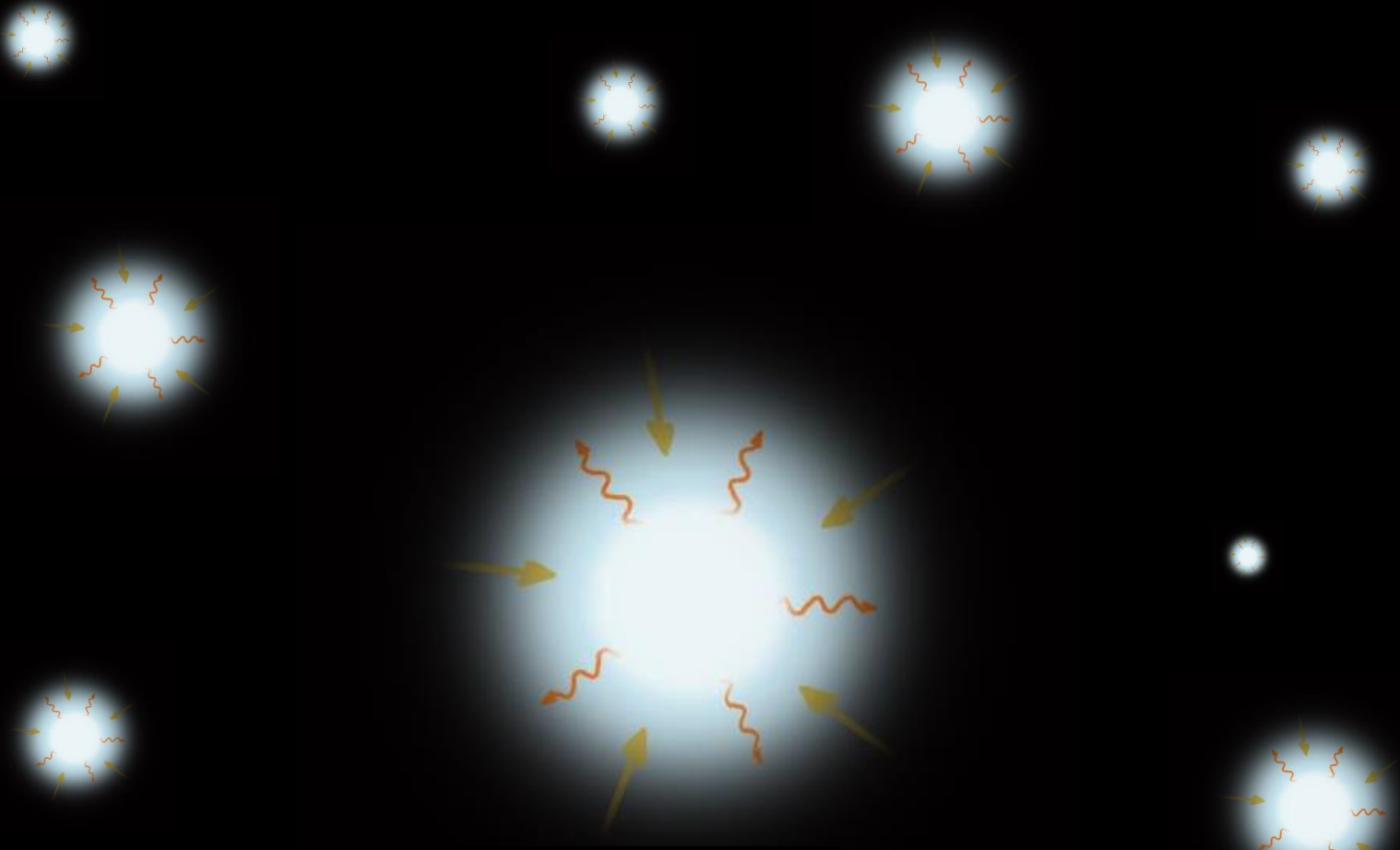
Traces Li



Time = 380,000 years

The nuclei capture their  
clouds of electrons to  
become proper atoms of  
hydrogen, helium and  
lithium

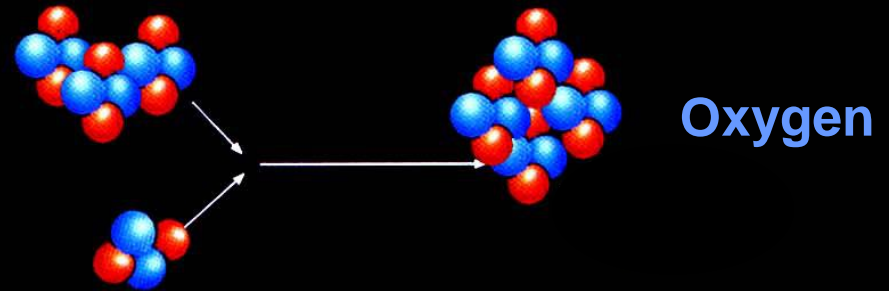
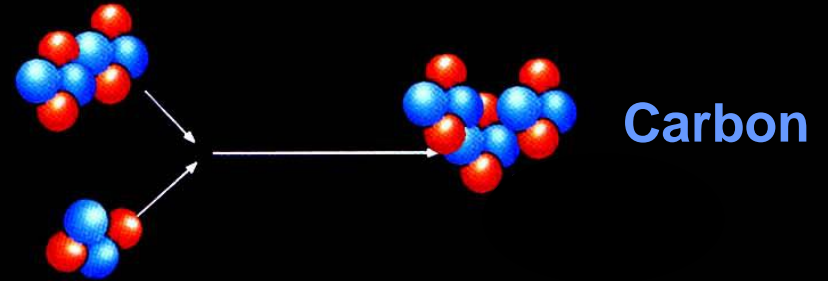
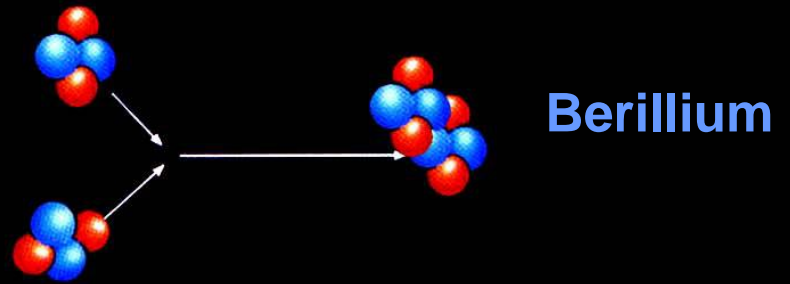




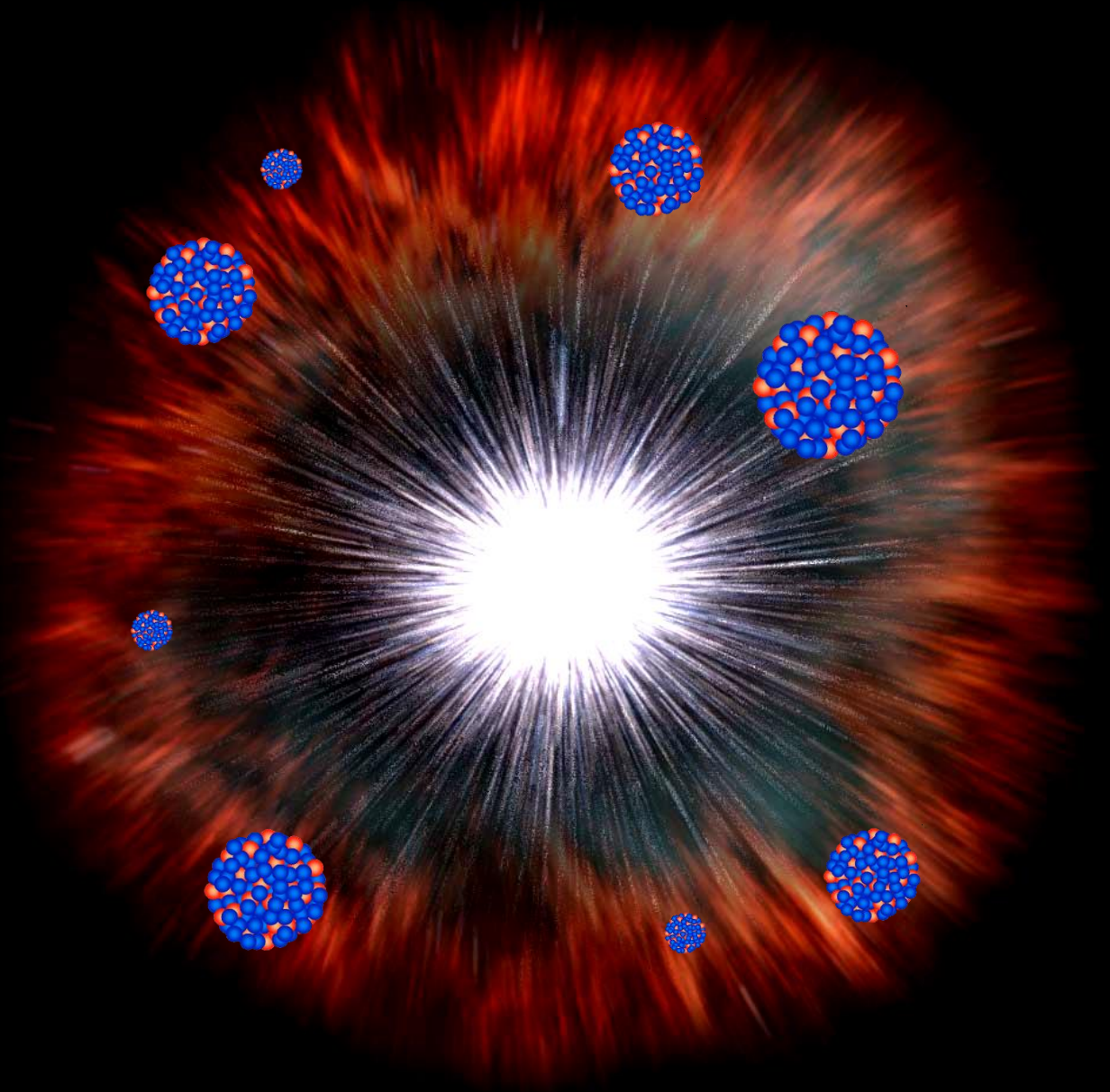
Time = 500 million years

Formation of the first stars from  
clouds of hydrogen and helium

The cores of stars reach millions of degrees, enough to fuse together larger numbers of protons and neutrons



During the violent deaths of the first massive stars, the material reaches thousands of millions of degrees, enough to fuse together hundreds of protons and neutrons







Time = 1,000 million years

All the possible atoms have been formed by the stars

Periodic table of the elements complete

Sequential numbers refer to numbers of protons (atomic numbers)

1 <b>H</b>																	2 <b>He</b>																
3 <b>Li</b>	4 <b>Be</b>											5 <b>B</b>	6 <b>C</b>	7 <b>N</b>	8 <b>O</b>	9 <b>F</b>	10 <b>Ne</b>																
11 <b>Na</b>	12 <b>Mg</b>											13 <b>Al</b>	14 <b>Si</b>	15 <b>P</b>	16 <b>S</b>	17 <b>Cl</b>	18 <b>Ar</b>																
19 <b>K</b>	20 <b>Ca</b>	21 <b>Sc</b>	22 <b>Ti</b>	23 <b>V</b>	24 <b>Cr</b>	25 <b>Mn</b>	26 <b>Fe</b>	27 <b>Co</b>	28 <b>Ni</b>	29 <b>Cu</b>	30 <b>Zn</b>	31 <b>Ga</b>	32 <b>Ge</b>	33 <b>As</b>	34 <b>Se</b>	35 <b>Br</b>	36 <b>Kr</b>																
37 <b>Rb</b>	38 <b>Sr</b>	39 <b>Y</b>	40 <b>Zr</b>	41 <b>Nb</b>	42 <b>Mo</b>	43 <b>Tc</b>	44 <b>Ru</b>	45 <b>Rh</b>	46 <b>Pd</b>	47 <b>Ag</b>	48 <b>Cd</b>	49 <b>In</b>	50 <b>Sn</b>	51 <b>Sb</b>	52 <b>Te</b>	53 <b>I</b>	54 <b>Xe</b>																
55 <b>Cs</b>	56 <b>Ba</b>											72 <b>Hf</b>	73 <b>Ta</b>	74 <b>W</b>	75 <b>Re</b>	76 <b>Os</b>	77 <b>Ir</b>	78 <b>Pt</b>	79 <b>Au</b>	80 <b>Hg</b>	81 <b>Tl</b>	82 <b>Pb</b>	83 <b>Bi</b>	84 <b>Po</b>	85 <b>At</b>	86 <b>Rn</b>							
87 <b>Fr</b>	88 <b>Ra</b>																																
																		57 <b>La</b>	58 <b>Ce</b>	59 <b>Pr</b>	60 <b>Nd</b>	61 <b>Pm</b>	62 <b>Sm</b>	63 <b>Eu</b>	64 <b>Gd</b>	65 <b>Tb</b>	66 <b>Dy</b>	67 <b>Ho</b>	68 <b>Er</b>	69 <b>Tm</b>	70 <b>Yb</b>	71 <b>Lu</b>	
																		89 <b>Ac</b>	90 <b>Th</b>	91 <b>Pa</b>	92 <b>U</b>	93 <b>Np</b>	94 <b>Pu</b>										

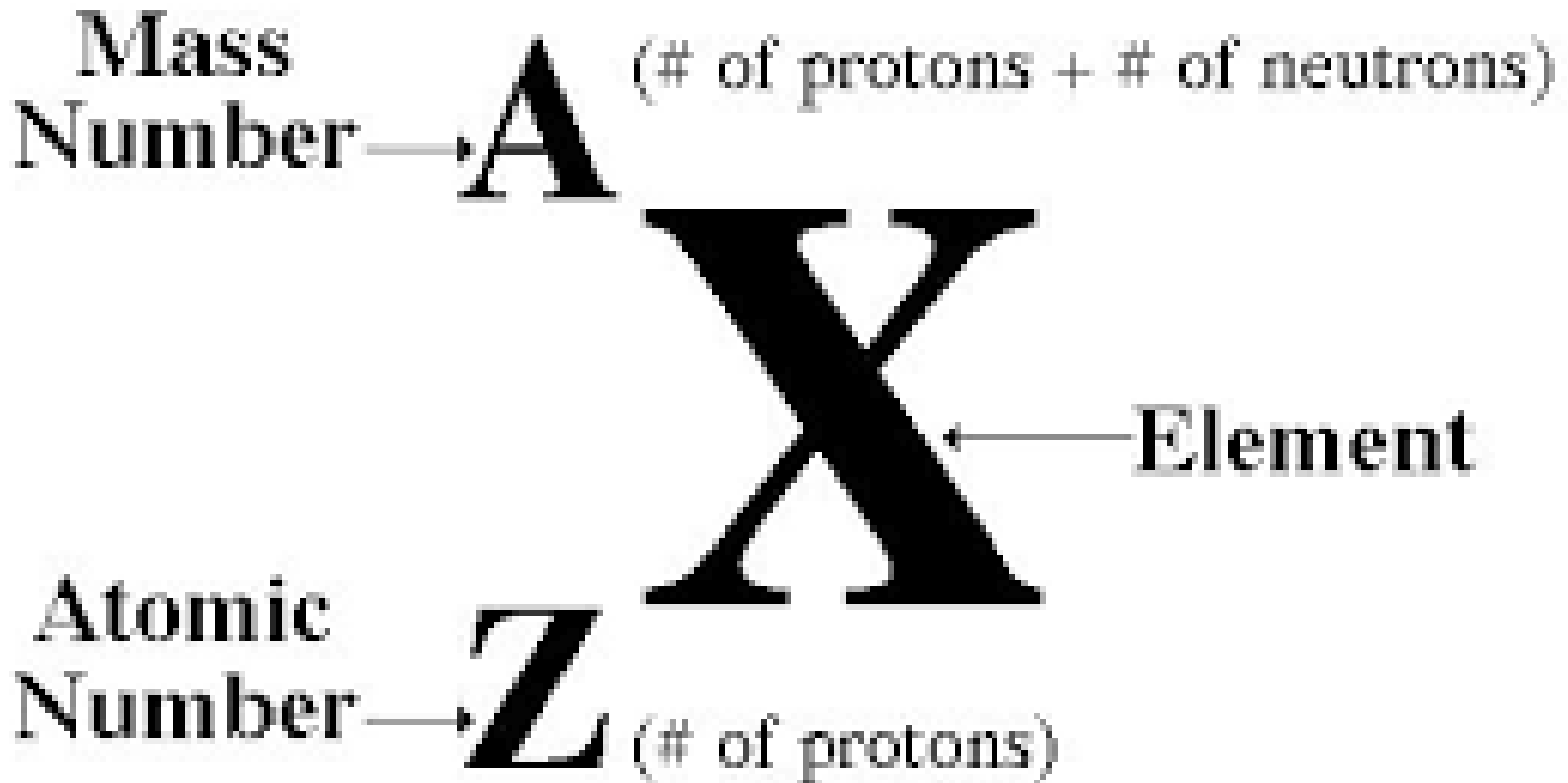
ISOTOPE means same place  
(on the periodic table)

Isotopes of a given element have all the same number of protons but different number of neutrons in their nuclei

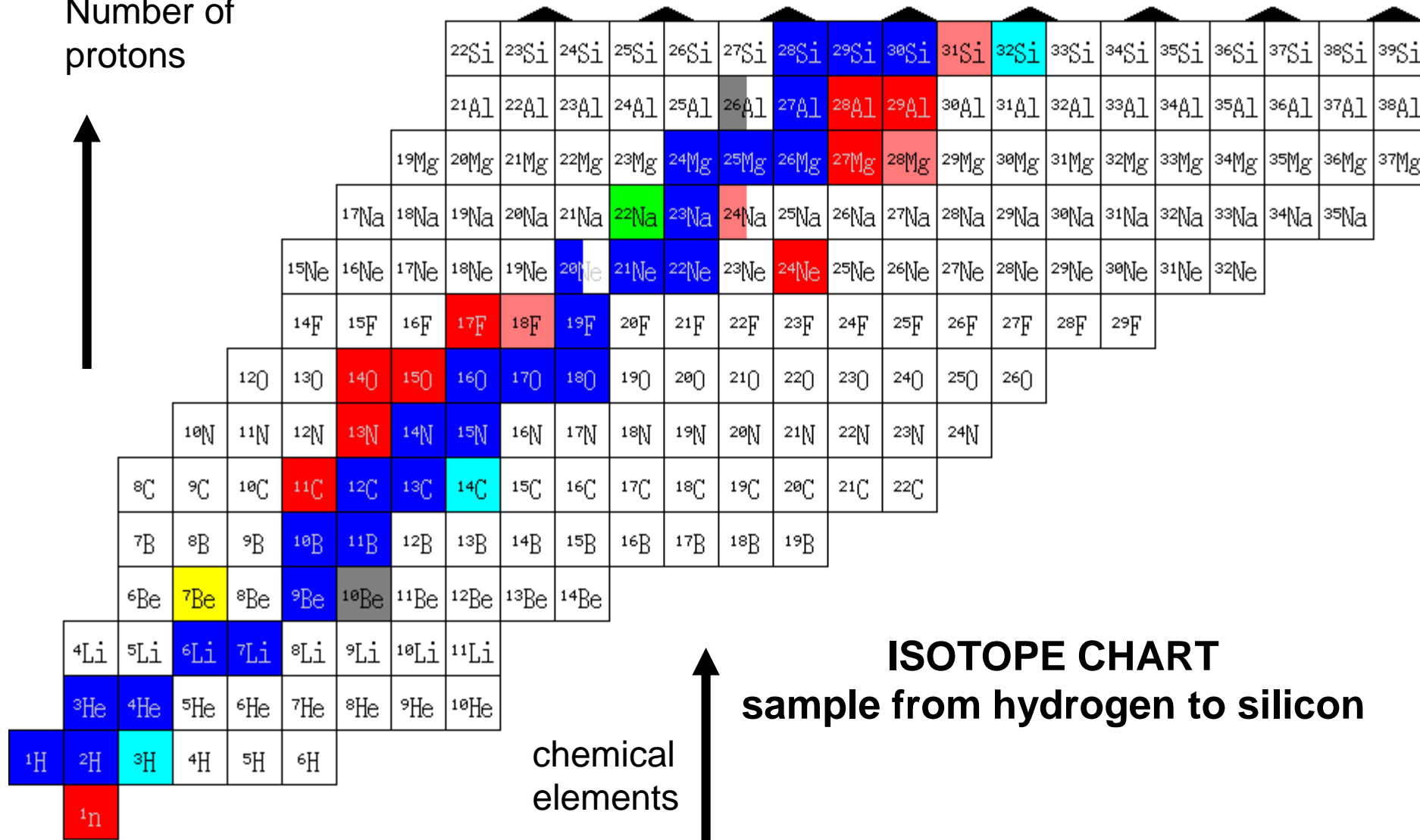
For example carbon has usually 6 protons and 6 neutrons (carbon 12) but can also have 6 protons and 8 neutrons (carbon 14)

Carbon 12 and carbon 14 are isotopes of carbon

# Isotope Symbols



Number of protons



**ISOTOPE CHART**  
sample from hydrogen to silicon

chemical elements



Number of neutrons



isotopes

TO BE CONTINUED.....