Welcome to 3.091
### 3.091 Periodic Table Quiz
September 18, 2003

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Name ____________________________

Grade _______/10

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This quiz covers various elements and their positions on the periodic table. Each numbered box represents a different element. Participants are required to identify the elements, their symbols, and possibly their properties based on the periodic table's layout.
La Lazy
Ce college
Pr professors
Nd never
Pm produce
Sm sufficiently
Eu educated
Gd graduates
Tb to
Dy dramatically
Ho help
Er executives
Tm trim
Yb yearly
Lu losses.
La Loony
Ce chemistry
Pr professor
Nd needs
Pm partner:
Sm seeking
Eu educated
Gd graduate
Tb to
Dy develop
Ho hazardous
Er experiments
Tm testing
Yb young
Lu lab assistants.
La Learned
Ce cool
Pr people
Nd never
Pm punt
Sm Sadoway:
Eu even
Gd geniuses
Tb think
Dy Donald
Ho has
Er engineering
Tm theory
Yb you’ll
Lu love.
CEase not I to slave, back breaking to tend;
PRideless and bootless stoking hearth and fire.
No Dream of mine own precious time to spend
Pour'ed More to sate your glutt'nous desire.
SMelting anew my ten-thousandth hour
EUtopia forever I eschew.
Growing Dimmer is my fleeing power
To Bid these curs'ed problem sets adieu.
DYing away whilst thy hosts are fought
HOpeless I come should in lecture I doze.
ERgo, like a sad slave, stay and rest nought.
Then Must I tool and toil while fatigue grows.
Yet, Bloody though I must be, and quite ill
Light the Universal abyss I will.

- Blake Stacey
CEase not I to slave, back breaking to tend; 
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Pour'ed More to sate your glutt'rous desire. 
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The Structure of the Atom

status report *ca. end of the 19th century*

* atom is electrically neutral
* -ve charge carried by electrons
* e- has very small mass
  - bulk of the atom is +ve,
  - most mass resides in +ve charge

Question:
what is the spatial distribution of charge inside an atom?
Thin piece of metal foil

$\alpha$-particles

$7.68 \text{ MeV}$

$0.6 \mu\text{m}$

ZnS screen (Geiger Counter)

Rutherford (1911)

Figure by MIT OCW.
Marsden's Analysis

Scattering of an $\alpha$-particle which approaches a heavy nucleus with an impact parameter $b$. 

Figure by MIT OCW.
I. On the Constitution of Atoms and Molecules.
By N. Bohr, Dr. phil. Copenhagen.

Introduction.

In order to explain the results of experiments on scattering of α rays by matter Prof. Rutherford† has given a theory of the structure of atoms. According to this theory, the atoms consist of a positively charged nucleus surrounded by a system of electrons kept together by attractive forces from the nucleus; the total negative charge of the electrons is equal to the positive charge of the nucleus. Further, the nucleus is assumed to be the seat of the essential part of the mass of the atom, and to have linear dimensions exceedingly small compared with the linear dimensions of the whole atom. The number of electrons in an atom is deduced to be approximately equal to half the atomic weight. Great interest is to be attributed to this atom-model; for, as Rutherford has shown, the assumption of the existence of nuclei, as those in question, seems to be necessary in order to account for the results of the experiments on large angle scattering of the α rays.

In an attempt to explain some of the properties of matter on the basis of this atom-model we meet, however, with difficulties of a serious nature arising from the apparent

† Communicated by Prof. E. Rutherford, F.R.S.
‡ E. Rutherford, Phil. Mag. xxi. p. 661 (1911).
§ See Max Geiger and Marsden, Phil. Mag. April 1913.
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† E. Rutherford, Phil. Mag. xxi. p. 869 (1911).
‡ See also Geiger and Marsden, Phil. Mag. April 1913.

instability of the system of electrons: difficulties purposely avoided in atom-models previously considered, for instance, in the one proposed by Sir J. J. Thomson*. According to the theory of the latter the atom consists of a sphere of uniform positive electrification, inside which the electrons move in circular orbits.

The principal difference between the atom-models proposed by Thomson and Rutherford consists in the circumstance that the forces acting on the electrons in the atom-model of Thomson allow of certain configurations and motions of the electrons for which the system is in a stable equilibrium; such configurations, however, apparently do not exist for the second atom-model. The nature of the difference in question will perhaps be most clearly seen by noticing that among the quantities characterizing the first atom a quantity appears—the radius of the positive sphere—of dimensions of a length and of the same order of magnitude as the linear extension of the atom, while such a length does not appear among the quantities characterizing the second atom, viz. the charges and masses of the electrons and the positive nucleus; nor can it be determined solely by help of the latter quantities.

The way of considering a problem of this kind has, however, undergone essential alterations in recent years owing to the development of the theory of the energy radiation, and the direct affirmation of the new assumptions introduced in this theory, found by experiments on very different phenomena such as specific heats, photoelectric effect, Röntgen-rays, &c. Whatever the alteration in the
Bohr Postulates for the Hydrogen Atom

1. Rutherford atom is correct
2. Classical EM theory not applicable to orbiting e⁻
3. Newtonian mechanics applicable to orbiting e⁻
4. $E_{\text{electron}} = E_{\text{kinetic}} + E_{\text{potential}}$
5. e⁻ energy quantized through its angular momentum:
   $L = mvr = nh/2\pi, \quad n = 1, 2, 3,...$
6. Planck-Einstein relation applies to e⁻ transitions:
   $\Delta E = E_f - E_i = h\nu = hc/\lambda$
   $c = \nu\lambda$
Isotopes of Hydrogen

$^{1}H$ hydrogen
1766 Henry Cavendish, London

$^{2}H$ deuterium $^{2}D$
1931 Harold Urey, Columbia U.

$^{3}H$ tritium $^{3}T$
1934 Ernest Rutherford, Cambridge U.
hydrogen: environmentally friendly fuel?

- Cavendish observed that combustion of hydrogen produced water vapor by the reaction

\[
H_2 + \frac{1}{2} O_2 \rightleftharpoons H_2O
\]

- but, in an internal combustion engine

\[
H_2 + \text{air (80\% N}_2 / 20\% O_2) \rightleftharpoons H_2O + NO_{x}
\]

- other issues:
  * safety (H\(_2\) on board)
  * environmental impact of H\(_2\) production
  * cost