RECENT TRENDS IN SUPERHEAVY CHEMICAL ELEMENTS

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ABSTRACT

Transmutation of one element or metal into another is the cause of new Alchemies. The concepts of new alchemies were developed during 1901-1921. Thoughts of alchemy was authenticated through a process with the nuclei of certain light elements such as nitrogen, that could be 'disintegrated' by the impact of energetic alpha particles coming from some radioactive source and fast protons were emitted. Blackett, using cloud chamber proved that actually nitrogen transformed into oxygen isotope, to study the above situation it needed the support of both physics and chemistry since the Superheavy elements [SHEs] are biased with them. The definition of superheavy elements varies among different groups of people: but I use the term SHEs as: "those elements with an atomic number ≥112**.**

The circular diameter of the field of superheavy elements enormously increased with the use of both chemistry and physics. This indeed is a big leap forwarded. There is a strong evidence for the elements upto 118; a homology of radon. Experimenters set out to search for two more elements with atomic number 119 & 120 so that seventh row will be complete. If elements 119 & 120 followed by 121 become the members of eighth period it would be a milestone of the super-actinides. Of course, few difficulties like Nuclear, Optical spectroscopy shell effect may be solved very soon that enables the existence of the superheavy elements, using gas-filled recoil spectrometers, chemistry and its branch metal-organic chemistry presently focusing on element 114.

The chemistry of superheavy elements always focus a one-atom-at-a-time situation while large numbers of atoms and molecules are deeply inherent in the statistical approach to understanding chemical reaction as dynamic, reversible processes. At the same time nuclear aspects: nuclear synthesis of superheavy elements including production, separation and identification with nuclear decay properties of the heaviest elements, also played a key role to leap forward.

Key Words: Cold Fusion Reaction (CFR), Hot Fusion Reaction (HFR), Spatial Periodic Table (SPT), Flerov Laboratory of Nuclear Reactions (FLNR), Superheavy Chemical Elements (SHCEs).

INTRODUCTION

Superheavy elements taken into account for this work are: 112 Cn 277, 113 Unt 284, 114 Fl 289, 115 Unp 288, 116 Lv 292, 117 Uns 292, and 118 Uno 294 with respect to their masses. These elements have very short half life and are produced by synthesizing. The first attempt to synthesize an artificial new element was taken up at RIKEN, Japan. The Joint Institute for Nuclear Research [JINR] Dubna, Russia an International and Intergovernmental Institute comprising eighteen member states and six associated members together producing these elements using eight types of laboratories: High Energy Physics, Nuclear Problems, Theoretical Physics, Neutron Physics, Nuclear Reactions, Information Technologies, Radiation Biology and University Centre. Flerov Laboratory of Nuclear Reactions[FLNR] at Dubna, main activities includes : synthesis of SHEs, fusion-fusion dynamics and multi-nucleon transfer, structure of light nuclei [$^{6,8,10}He$,$^{5,7}H$……..], reaction mechanisms, nuclear theory and applied research and educational activities, help globally to know the new-elements . It is the duty of concerned researcher to develop the field of interest.

SHCEs-its Annals: Right from the creation of the world the process of recording history of only worthy contribution has begun. The unbiased, truthful and effective presentation by the writers of history will only stand the test of the time and attracts readers to get engrossed from the beginning to end.

The entire history of SHCEs circumferences by five stages:

(i) **Prior to the Nuclear atom**: 18^{th} Century, and this was that period in which Dmitrii I Mendeleev and Lothar Meyer worked about the arrangement, number and location of the elements in the form which was later named as 'Periodic Table. This work has taken approximately 35 years from 1880 to 1915 and during this period the atomic number of an element was discussed properly. After Uranium [1801 Martin Heinrich Klaporth-German chemist] and regarding its heaviness many chemists & physicists came forward and the top a Glasgow resident, occupationally a technical chemist, named Edmund Mills adopted numerology and used formula $y=15(P-0.9375^{x})$, if $p\geq17$, x tending towards infinity and for P=16 we get A=240, close to the experiment value 239.70 as for as Uranium concerned. Many people like Mills and Meyer group (Department of Organic chemistry- University of Belgrade 1906), William A Tilden British chemist [1910] worked on 'direction oriented method to explain heaviness of uranium. The Discovery of Radioactivity, X-ray spectroscopy and the like branches of science were witnessed about the existence of 'Superheavy elements'.

(ii) **Quantum based concept**: Remarkable presentation of nuclear atomic model by Ernest Rutherford, the recognition of Isotopy, X-ray spectra by Henry Mosley's and Quantum theory is an impulse on the periodic table since the Z and A ruled out older arrangements and definitions. Bohr atomic model explains the Orbit of an electron was characterized by two quantum numbers-speculations are ruled out and would help upper limit to the periodic table for addition. Quantum numbers help to explain the ground realities of an atom. Bohr delivered a lecture in Gottingen, June 1922 that "We might proceed further and construct hundreds or thousands of elements". This is nothing but a reflection on the existence of heavy and 'Superheavy Elements'.

(iii) **The minimum time hypothesis:** During this period Superheavy elements were considered but with 'smallest' value, A fixed minimum duration Δt below which the time measuring have no meaning this is called **"**Choron"- very useful to represent the period and velocity of an electron. This phase mainly reflects the time mean -minimum-time principle and had demonstrated a definite limit to the number of existing elements. This principle was used by Gordon (1928), Walter Glaser and Kurt Sitte[German] calculated Z values and for uranium they declared Z_{MAX}=90.5±0.5. Off-main stream theory, is another attempt to calculate the maximum atomic number by the **Indian** Mathematician '**Vishnu Narlikar** the father of the Cosmologist **Jayanth Narlikar** and as per calculation" there can be no element beyond uranium- but, we are at 'Superheavy elements.

(iv) Cosmic crapshoot: Arthur Erich Haas, physicist at the University of Vienna, says in his lecture that "a mother substance of uranium in the form of another and possibly unknown element" indicates Superheavy elements or Superheavy radioactive elements. According to Walther Nernst thought that " Superheavy radioactive elements had existed.He also thought " they were still being formed in the deposit of space". I also feel "there may be a group of superheavy elements with different span life time in space."

(v) Jean's Superheavy Elements: Presence of Heavy and Superheavy elements in the star and nebulae- supported universe evolves from 'Complex to Simple. Satisfied by James Jeans a renowned physicist and astronomer and also by the Nobel laureate Nernst, Explanation of James Jeans was that the Star younger and more massive than the Sun would consist mainly of the 'superheavy elements', as that nebulae would be particularly rich in elements of the highest atomic weights, indicates presence of 'superheavy elements'.

DISCOVERY OF SUPERHEAVY ELEMENTS: Superheavy elements are discovered through Cold Fusion Reaction (CFR) and Hot Fusion Reaction (HFR)

Cold Fusion Reactions (CFR): Cold Fusion reactionuse beam and target nuclei that are closer to each other in order to produce compound nucleus. The complete fusion of one target nucleus with one beam nucleus-with generally lower excitation energy that typically requires evaporation of one or no neutron generates fewer neutron-rich isotopes of element that have higher survival probabilities w.r.t. fission, but have lower fusion Probabilities. e.g: $^{70}Zn + ^{208}Pb \rightarrow ^{277}112 + 1n$; Scattering area of cross-section is σ=~1 PICOBARN

Hot Fusion Reaction (HFR): Hot Fusion Reactions use more asymmetric beam and target nuclei that produce a compound nucleus with generally higher excitation energy that typically requires evaporation of 3 to 5 neutrons. This generates more neutron–rich isotopes of elements, have lower survival probabilities with respect to fission, but have higher fusion probabilities. e.g. $^{48}Ca + ^{244}Pu \rightarrow ^{288}114 + 4n$; cross-sections just above 1pborn due to the neutron-richness of this isotope of element 114, it never subsequently decays to any known isotopes, and thus its identification is more problematic.

Production of Superheavy Elements: Before I proceed, a bank of questions needs answers.

How many chemical elements are there?
How many can there be?
Is there any limit to the atomic weight?
Is there any exact 'stability limit' for SHEs?
Do SHEs more or above Z≥118 exist?
Are there any hyperheavy or other elements beyond SHEs?
Is there any ending of chemical elements if no, how many periods would that be?
Is there any relation or index by which we can predict similarities in between SHEs?
Where the chemical element system should be ended?
How many periods and columns does the final form contain?

As a physicist the above mentioned galaxy of questions reflect on the mind screen. This work aims at answering a few of these in an unbiased manner. To answer all the questions there is a need for extensive, large-scale research that might take decades.. The large-scale research program aims at synthesizing of SHEs with an atomic number larger than Z=107. The Joint Institute of Nuclear Research near Moscow reported the element Z=118 and provisionally named by IUPAC as 'ununoctium' or eka-radon and at the same time a team of physicists observed that there is controversy regarding the element Z=117 named as 'ununseptium' or eka-astatine which was announced in 2010. On the other hand, discovery report of Z=112, called unbibium or eka-thorium, remain confirmed.

Flag year: Modern research field-heavy ion collision is nothing but the first step to produce chemical element using collision in the year 1940-41.

The research by Glenn Seaborg and his team (Lawrence Livermore National laboratory) dominated till 1960 had been produced transuranic metals neptunium (Z=93), plutonium (Z=96) including the last of the actinides Z=103 . As a matter fact these two elements are by Fermi and his group in Rome named as "ausinium" and "hespernium" and Fermi himself explored this fact in his Nobel Lecture in Stockholm. This is seen as the beginning of experimental research in transuranic or superheavy elements, before Quantum theory and Nuclear atom, actually may be less known.

Modern Method: Proton-21 Laboratory: Fourteen (14) new long –living superheavy elements found by Proton-21 laboratory and one long-living superheavy element found by A.Marinov were identified. Due to the introduction of superheavy elements the Periodic Table structure is changed and proposed 'spatial periodic table' developed based on classic electron shell structure model.

The main branch of experimental research of superheavy nuclei isotopes and exotic isotopes of light nuclei is a new elements synthesis by different accelerator with latter investigation of nuclei collision results. However this method has two important and unsolved problems.

The first one is the excess energy of the synthesized nucleus. The energy required to overcome the coulomb barrier during the nuclei collision transforms into internal energy of the newly formed nucleus and it is usually enough for instant nuclei fission, because the internal cluster of the nuclei have energy over Coulomb barrier. This leads to a very complex experimental task of "discharge" of excess energy by the high-energy particle radiation-gamma-quanta, neutron, positron, proton, alpha-particle. As a result of excess energy the synthesized nuclei lifetime may be 10^{-22}s and less. This is the one assumption that: why the lifetime of SHEs is less or is it to produce in 'high energy accelerator!

The second problem is a neutron deficiency of the synthesized elements. The stability curve of isotopes manifests non-linear increase of required neutrons for nucleus stabilization by proton quantity increase. Therefore it is almost impossible to obtain a stable superheavy nucleus isotope (so-called islands of stability) from usual combination nuclei because all the heavy nuclei synthesized by collision of lighter nuclei will have neutron deficiency. The experiments on nuclei collision are usually made on neutron excess nuclei, such as several lead isotopes. Though this doesn't guarantee the synthesized nucleus stability because its stable isotope requires a specific neutron-proton ratio (usually having a few possible variants) and while pursing heavier nuclei synthesis this neutron excess becomes insufficient.

Maximal Atomic Number(MAN): During the investigation of superheavy nuclei-'the maximum possible quasi-stable elements in the nature which relates to 'nucleons collective states, strong force peculiarities and many-body problem etc come into focus. It is easy to go with only atoms in their classical understanding i.e. a relatively small quasi-spherical homogeneous nucleus with multi-electron shells. The calculated value for the final closed shell element in the periodic table is assume Z_{max}=2310.

Spatial Periodic Table (SPT): Due to 14 long-living superheavy elements the existing periodic table is effected mainly due to the application of 'advanced model of SO (4, 2) group in graph table form. This model exhibited limits and the structure of the periodic table which consists 22 periods and 2310 elements.

Ending of the Periodic Table: Nobody can be sure about the ending of the chemical periodic system, since after the SHEs with shorter half life period, is there any existence of SHEs in Stars and Nebulae with the

Higher life time? Is there any 'HYPERHEAVY ELEMENTS [HHES]. ARE SHES & HHES cent percent radioactive? We may get answer for such questions in 'future'.

CONCLUSION

Based on nearest and distant experiments:

- Elements 119 and 120 may by synthesized in Ti and Cr fusion reactions with smallest cross-sections about 0.02-0.04pb and perhaps they are the last SH Elements with life time $T_{1/2}$ greater than 1 µsec.
- May be narrow path way to the island of stability is found
- Uranium-like beam may be used to get closeness to the β-stability line
- New kind separators and detectors are needed to know the reaction products
- No one is sure whether all future Nuclei [SHE & HHE] will be with short-life period or high life period as particular answer is not yet found about the presence of SHEs in stars and etc

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