NSTF
National Science & Technology Forum

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Chemical elements for South Africa's future: 'Rare elements for new technologies' & 'Managing elements for nutrition and safety' (#IYPT_ZA)

The International Year of the Periodic Table of Chemical Elements 2019 (#IYPT)

Discussion Forum Concept Paper

Background

The General Assembly of the United Nations (UN) proclaimed 2019 the International Year of the Periodic Table of Chemical Elements (IYPT) in December 2017, during its 72nd session. Thereby the UN has recognised the importance of raising global awareness of chemistry and how it can promote solutions to global challenges in energy, agriculture, health and other critical sectors.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) announced the IYPT in March 2018. The announcement said: "The Periodic Table of Chemical Elements is more than just a guide or catalogue of the entire known atoms in the universe; it is essentially a window on the universe, helping to expand our understanding of the world around us."

The periodic table is regarded as one of the most important achievements of modern science, conceptually uniting various scientific disciplines.

Leading scientific centres across the world supported the proclamation of 2019 as the Year of the Periodic Table. They include:

- the International Union of Pure and Applied Chemistry (IUPAC)
- International Union of Pure and Applied Physics (IUPAP)
- the European Association for Chemical and Molecular Sciences
- the International Council for Science (ICSU)
- the International Astronomical Union (IAU)
- Joint Institute for Nuclear Research (JINR)
- the International Union of History and Philosophy of Science and Technology (IUHPST)

Other stakeholders are expected to be brought together "including scientific societies and unions, educational and research institutions, technology platforms, non-profit organizations and private sector partners to promote and celebrate the significance of the Periodic Table of Elements and its applications to society during 2019."

Fairly recently four super heavy elements have been discovered namely: with atomic numbers 113 (Nihonium), 115 (Moskovi), 117 (Tennesin) and 118 (Oganesson).

The year 2019 is significant because it marks various significant anniversaries, e.g.

- the discovery of phosphorus 350 years ago by the alchemist Hennig Brand
- The grouping of 33 elements into gases, metals, non-metals and earths, in 1789, by Antione Lavoisier
- Next year is the 190th anniversary of Johann Wolfgang Döbereiner's work on "triads"
- The discovery of francium in 1939 by Marguerite Perey
- The 100th anniversary of the founding of IUPAC – which along with IUPAP confirms the discovery of new elements and gives them their official names

The IYPT will be used by UNESCO's International Basic Sciences Programme to promote international co-operation in the basic sciences for sustainable development. A UNESCO Global Microscience Experiments Project will also be dedicated to the periodic table. Microscience is an educational initiative that provides low-cost experimental equipment to primary and secondary school pupils – and university students in some countries.

Focus of the NSTF discussion forum

Among the critical problems that South Africa is faced with are the demise of mining as a reliable economic sector, in the context of the 4th Industrial Revolution. Further job losses are inevitable and there is a scramble to catch up with the technologies and opportunities offered by this new era. At the same time, South Africa is a country blessed with substantial mineral resources. It is generally recognised that these resources have to be beneficiated and not just exported to other countries. Creating products and industrialisation are the key to our economic future.

Electronic hardware contains small amounts of a variety of metals as essential components. As the industry continues to grow at an exponential pace, and 4IR technologies all rely on electronics, it is anticipated that these metals will become increasingly hard to access.

There are other urgent issues that lie at the foundation of creating a better future. Prominent, and urgent, among them are education, health and food security. According to the Food and Agriculture Organization (FAO) food security is not only about the quantity of food available, but about whether people are getting the nutrition required for good health.

It appears that much is known about the essential minerals required by the human body, and the exact quantities of these that ensure good health. Much research has been done on the food sources that can supply us with these minerals, and the effects of deficiencies and over-supply of various minerals in our bodies. However, there is much public confusion about these matters, and supplements are readily sold from the shelves of pharmacies and health shops. Some products are believed to be superior to others in the health benefit they are supposed to provide, for example Himalayan salt has become popular and is often believed to be superior to ordinary salt. While the moneyed classes debate the merits of such products, the poor eat whatever food they can get and are more likely to suffer major nutritional deficiencies.

Scope and structure of the NSTF discussion forum

To narrow down the wealth of possible topics and information related to the periodic table, a selection of topics that are relevant to society and the economy must be made. Therefore, the NSTF is providing a platform to discuss the following topics over two days:

1. **Rare elements for new technologies.** What elements might be in demand now and in the future for use in 4IR technologies? Does South Africa have significant deposits of such minerals? Might it be feasible to extract these minerals, now or in the future? What challenges have to be overcome to make it feasible?
2. **Managing elements for nutrition and safety**. What are the issues related to essential minerals in human nutrition? Where and how do people in South Africa suffer nutritional deficiency in terms of minerals in their diets? What has to be done to remedy these problems? What are the issues related to the safety of substances

people inadvertently come into contact with? Some elements are now known to be fatally harmful. For example: lead contained in old paint in houses where people still live or buildings that are being demolished. Another example is asbestos – in old ceilings etc. What potential harm should the public and workers in high risk environments be aware of, in these cases as well as others? What should be done to prevent such harm?

Envisaged outcomes:

- Materials on the NSTF website: presentations, videos, proceedings, summary, media release, etc.
- Recommendations, including the mining and beneficiation of rare earth metals, essential minerals and related issues of nutrition, and safety issues.

Target audience:

- Policy makers in mining, industrial development, agriculture and agri-processing, nutrition, etc
- Researchers in geology, mineralogy, information technology, electronic engineering, food security, nutrition, etc
- Electronic engineers, IT hardware professionals, nutritionists, producers of health supplements including traditional medicine products
- All those interested in industrialisation, beneficiation of natural resources, nutrition and dietetics, environmental health and safety in the building industry, etc

Information on the classification of elements relevant to discussions on Day 1 and 2:

Classification of minerals:

One can approach the discussion from the perspective of the classification of minerals. The Nickel–Strunz mineral classes is a system of classification of minerals consisting of ten classes, with further divisions, families and groups. The first class includes many of the elements (as in the periodic table). This class of minerals is also known as the 'Native element minerals', meaning that they occur naturally in un-combined form. The class includes metals, intermetallic elements, and alloys, semi-metals and non-metals.

Elements that occur as native element minerals or alloys:

- Aluminium
- Antimony
- Arsenic
- Bismuth
- Carbon
- Cadmium
- Chromium
- Cobalt
- Copper
- Gold
- Indium
- Iron
- Iridium
- Lead
- Manganese
- Mercury
- Molybdenum
- Nickel
- Niobium
- Osmium
- Palladium
- Platinum
- Rhenium
- Rhodium

- Selenium
- Silver
- Silicon
- Sulfur
- Tantalum
- Tellurium
- Tin
- Titanium
- Tungsten
- Vanadium
- Zinc

Some of these elements are grouped into two groups of metals:

The gold group consists of gold, silver, copper, lead, aluminium, and mercury.

The platinum group (PGMs) consists of platinum, palladium, iridium, osmium, rhodium, and rhuthenium.

"Only gold, silver, copper and the platinum metals occur in nature in large amounts. Over geological time scales, very few metals can resist natural weathering processes like oxidation, which is why generally only the less reactive metals such as gold and platinum are found as native metals."

Non-metallic elements occurring in the native state include carbon and sulphur. Silicon, a semi-metal, has been found in the native state on rare occasions as small inclusions in gold.

Rare-earth elements

"A **rare-earth element** (**REE**) or **rare-earth metal** (**REM**), as defined by IUPAC, is one of a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides, as well as scandium and yttrium.[2] Scandium and yttrium are considered rare-earth elements because they tend to occur in the same ore deposits as the lanthanides and exhibit similar chemical properties. Rarely, a broader definition that includes actinides may be used, since the actinides share some mineralogical, chemical, and physical (especially electron shell configuration) characteristics.[3]

"The 17 rare-earth elements are cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm), samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), and yttrium (Y). "

Sources and further reading

About the Year of the Periodic Table:

- https://en.unesco.org/news/2019-proclaimed-international-year-periodic-table-chemical-elements
- http://www.unesco.org/new/en/unesco-liaison-office-in-new-york/about-this-office/single-view/news/2019_international_year_of_the_periodic_table_of_chemical_el/
- https://physicsworld.com/a/chemists-gear-up-for-2019-international-year-of-the-periodic-table/

Scarce elements and their use in information and communication technologies hardware:

- Metals in computers/e-waste: https://info.mayermetals.com/blog/did-you-know-your-computer-contains-precious-metals
- The top 10 metals powering your mobile: http://www.austmine.com.au/News/category/articles-editorials/the-top-10-metals-and-minerals-powering-your-mobile-phone
- "A **native metal** is any metal that is found pure in its metallic form in nature.[1][2] Metals that can be found as native deposits singly or in alloys" - https://en.wikipedia.org/wiki/Native_metal

- A **rare-earth element** is… https://en.wikipedia.org/wiki/Rare-earth_element
- https://www.gov.za/documents/minerals-and-mining-policy-south-africa-green-paper
- https://www.gov.za/sites/default/files/gcis_document/201409/whitepaperminingmineralspolicy2.pdf

Elements essential for human health and harmful elements

- https://www.netdoctor.co.uk/healthy-eating/a10839/sources-of-minerals/
- https://www.thyroid.org/iodine-deficiency/
- https://www.nda.agric.za/docs/media/NATIONAL%20POLICYon%20food%20and%20nutririon%20security.pdf
- https://www.mining-technology.com/features/featurethe-11-most-dangerous-minerals-4256873/
- https://en.wikipedia.org/wiki/Lead_paint