HISTORY & MYSTERY OF CHEMISTRY!

Citizen Science Zoom Webinar
6 PM; 05/07/2020; Sunday
Whatsapp: 9029096196 for registration!
CONSTITUTION OF INDIA
Part IV A (Article 51 A)

Fundamental Duties

Fundamental Duties – It shall be the duty of every citizen of India —
(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
(c) to uphold and protect the sovereignty, unity and integrity of India;
(d) to defend the country and render national service when called upon to do so;
(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
(f) to value and preserve the rich heritage of our composite culture;
(g) to protect and improve the natural environment including forests, lakes, rivers, wildlife and to have compassion for living creatures;
(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
(i) to safeguard public property and to abjure violence;
(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;
(k) who is a parent or guardian, to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

Individual Social Responsibility towards our Fundamental Duties

Purpose of Education is to moralize and socialize the people.
- Dr. B. R. Ambedkar

51 A (h)
To develop the scientific temper, humanism and the spirit of Inquiry and Reform
Chemistry is the "scientific study of matter, its properties, and interactions with other matter and with energy".

So...who were among the first to consider “the world of matter” as “the real world”?
Philosophical origins of materialism: Greece

Nothing exists except atoms and empty space; everything else is opinion. - Democritus

The first principles of the universe are atoms and empty space.... The atoms are unlimited in size and number, and they are borne along in the whole universe in a vortex, and thereby generate all composite things—fire, water, air, earth. For even these are conglomerations of given atoms.

(Democritus)

Epicureans believed that senses also relied on atoms. Every object was continually emitting particles from itself that would then interact with the observer. All sensations, such as sight, smell, or sound, relied on these particles. e.g. red particles were not themselves red but were emitted in a manner that caused the viewer to experience the colour red.
A brief history of chemistry
Philosophical origins of materialism: India

Scientific and Rational Empiricism

The founder of Lokāyata philosophy, Brihaspati, posited that the world itself and all material objects of the world are real.

A human being is built up of the four elements. When they die the earthly in them returns and relapses to the earth, the fluid to the water, the heat to the fire, the wind to the air, and their faculties pass into space.

Fools and wise alike, on the dissolution of the body, are cut off, annihilated, and after death they are not.
- Ajita Kesakambali (~ 6th century BC)

http://www.carvaka4india.com/2011/12/lokayata.html#
Perhaps the most philosophically sophisticated position of Indian Materialism is the assertion that even human consciousness is a material construct.

The same is being tested and asserted by modern neuroscience as a phenomenon of emergence of consciousness due to collective neuro-biochemical activities.
Adherents of the school of philosophy founded by Kanada considered the atom to be indestructible, and hence eternal. They believed atoms to be minute objects invisible to the naked eye. Vaiseshikas further held that atoms of same substance combined with each other to produce dvyanuka (diatomic molecules) and tryanuka (triatomic molecules). Kanada also put forward the idea that atoms could be combined in various ways to produce chemical changes in presence of other factors such as heat. He gave blackening of earthen pot and ripening of fruit as examples of this phenomenon.
The philosopher's stone is a legendary alchemical substance capable of turning base metals such as mercury into gold.

It is also called the elixir of life, useful for rejuvenation and for achieving immortality; for many centuries, it was the most sought goal in alchemy.

The philosophers' stone was the central symbol of the mystical terminology of alchemy, symbolizing perfection at its finest, enlightenment, and heavenly bliss. Efforts to discover the philosophers' stone were known as the Magnum Opus ("Great Work")
The equivalent of the philosophers' stone in Buddhism and Hinduism is the Chintamani. It is also referred to as Paras/Parasmani.

The most commonly mentioned properties are the ability to:

- Transmute base metals into gold or silver
- Heal all forms of illness and prolong the life of any person who consumes a small part of philosopher’s stone diluted in wine
- Creation of perpetually burning lamps
- Transmutation of common crystals into precious stones and diamonds,
- Reviving of dead plants
- Creation of flexible or malleable glass
- The creation of a clone or homunculus

The more general name for the Indian science of alchemy or proto-chemistry is Rasaśāstra, or "The Science of Mercury".

Early Indian alchemical texts discuss the use of prepared forms of mercury or cinnabar.

Many plant extracts were used and tested for medicinal properties. Chyawanprasha is one of the traditional rasayanas. Specific adaptogenic herbs are also included in rasayanas including haritaki, neem, amla, shilajit, ashwaganda, holy basil-Tulsi, guduchi and shatavari.

https://www.vitiligolanka.com/rasayana_ayurveda.htm
Ancient Chemistry of China-
Inventors of Paper and gunpowder

https://en.wikipedia.org/wiki/Science_and_technology_in_China
Bronze metallurgy of Africa & chemistry of Mummification!

- Tutenkhamen’s bronze dagger and mummy
  - In British Museum

- Bagels Bronze statue

- African version of Ayurveda!

[Link to article](https://www.worldatlas.com/articles/the-most-notable-mummies-of-egypt.html)
Lost wax process for Casting of bronze in Tamil Nadu

Agaria-tribal iron smelters and forgers, Jharkhand; the makers of Ashoka Pillar

The production of metallic zinc was described in the *Rasarnava* written around 1200 A.D. The fourteenth century work *Rasaratnasmuchchaya* describes how the “tin-like” metal was made. Calamine was heated indirectly with charcoal to around 1000°C in a covered crucible fitted with a condenser. Zinc vapour was evolved and the vapour was air cooled in the condenser located below the refractory crucible (See Figure).

Schematic representation of the Indian method for producing zinc.

Pictre Courtesy: Var-Pahl Abasri

In the late 8th century, Jābir ibn Hayyān introduced a new approach to alchemy, based on scientific methodology and controlled experimentation in the laboratory, in contrast to the ancient Greek and Egyptian alchemists whose works were often allegorical and unintelligible, with very little concern for laboratory work.

The seeds of the modern classification of elements into metals and non-metals could be seen in his chemical nomenclature.

He proposed three categories:

- "Spirits" which vaporise on heating, like arsenic (realgar, orpiment), camphor, mercury, sulfur, sal ammoniac, and ammonium chloride.

- "Metals", like gold, silver, lead, tin, copper, iron, and khar-sini (Chinese iron)

- Non-malleable substances, that can be converted into powders, such as stones.
From “magical” alchemy to “muggle world” of atoms

Antoine Lavoisier, who is also considered as father of modern chemistry, changed the chemical science from a qualitative to a quantitative one. He discovered that, although matter may change its form or shape, its mass always remains the same. (Conservation of mass)

"Two equal volumes of gas, at the same temperature and pressure, contain the same number of molecules"

-Amedeo Avogadro

STIOCHIOMETRY & MOLE CONCEPT!

https://en.wikipedia.org/wiki/Antoine_Lavoisier


Dalton’s Atomic Theory (1808)

- All matter is composed of extremely small particles called atoms
- Atoms of a given element are identical in size, mass, and other properties; atoms of different elements differ in size, mass, and other properties
- Atoms cannot be subdivided, created, or destroyed
- Atoms of different elements combine in simple whole-number ratios to form chemical compounds
- In chemical reactions, atoms are combined, separated, or rearranged

16 g

16 g + 2*32 g → 44 g + 2*18 g
Unravel the mysterious chemical patterns! - Dobereiner’s Triad

https://en.wikipedia.org/wiki/D%C3%B6bereiner%27s_triads
The turning point in the history of chemistry: Karlsruhe Conference (1860)

- The very first international scientific conference was held in Karlsruhe, Germany on Sept. 3, 1860.
- The actual idea to organize the conference originated with August Kekulé, a young German chemist in his 30s who first proposed that carbon is tetravalent. Kekulé discussed the possibility of the conference with a young French chemist named Adolphe Wurtz. They approached a German chemist in Karlsruhe named Karl Weltzien.
- Karlsruhe was near the Black Forest, a very desirable holiday destination during that era.
- Despite the short notice, some 140 scientists traveled from across Europe—and even from as far away as Mexico—to attend the symposium. Recognizable names such as Robert Bunsen, of the now-famous burner, and Emil Erlenmeyer, who developed the omnipresent flask, Dmitri Mendeleev and Lothar Meyer were in the audience.
- When the 1860 conference began, chemistry was in a total state of disarray!
- There were 17 proposed formulas for the acetic acid. Participants broke into groups to discuss contentious issues, such as stoichiometry or representation of molecular formulas, and then they would return to the plenary hall to share their deliberations.

http://allperiodictables.com/AAEpages/aaeKarlsruheCongress.html
In fact, the conference was mostly dominated by voices from the old guard, the organizers began to fear their efforts were in vain and that the conference was going to be a complete failure.

Another common misconception was promoted by Berzelius, a powerful Swedish chemist of that era, Berzelius had correctly figured out that electrostatic forces were important for ionic bonding in salt, but then he had incorrectly concluded that all molecular bonding was forged by electrostatic attraction. (IONIC BOND)

Using this faulty reasoning, Berzelius argued that diatomic molecules such as H\textsubscript{2} and O\textsubscript{2} were impossible because the atoms would repel each other in the same way that like charges do.

By not accepting the existence of diatomic molecules, it was impossible to get the correct formula for water formation, and water itself (H\textsubscript{2} + 1/2 O\textsubscript{2} → H\textsubscript{2}O).

“The trouble with famous scientists then and now is that it can be very difficult for others to successfully attack their theories,” Laing says.

But just before the meeting’s close, a relatively unknown Italian chemist named Stanislao Cannizzaro gave a long, impassioned, and eloquent lecture that argued for Avogadro’s perspective on molecules and his experiments using gases like N\textsubscript{2}, O\textsubscript{2}, CO\textsubscript{2} & H\textsubscript{2} (COVALENT BOND).

After Cannizzaro’s lecture, one of his friends handed out a paper that effectively reiterated his speech and that several important delegates read on their trips home.

“It was as though the scales fell from my eyes; doubt vanished, and it was replaced by a feeling of peaceful certainty,“ wrote Meyer, who would later go on to construct a correct periodic table around the same time as Mendeleev put his together.

Mendeleev wrote that the meeting “produced such a remarkable effect on the history of our science that I consider it a duty ... to describe all the sessions ... and the results.”
Alexandre-Emile Beguyer de Chancourtois – Spiral Staircase Pattern (1862)

Newland’s theory of Octaves (1865)

<table>
<thead>
<tr>
<th>Note of musical scale</th>
<th>1/8</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8/1</th>
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<tbody>
<tr>
<td><strong>Indian</strong></td>
<td>sa</td>
<td>re</td>
<td>ga</td>
<td>ma</td>
<td>pa</td>
<td>dha</td>
<td>ni</td>
<td>sa</td>
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<td><strong>Western</strong></td>
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<td>mi</td>
<td>fa</td>
<td>so</td>
<td>la</td>
<td>ti</td>
<td>do</td>
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<tr>
<td>H(1st)</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>O</td>
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<tr>
<td>F(8th)</td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
<td>S</td>
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<td>K</td>
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<td>Cr</td>
<td>Ti</td>
<td>Mn</td>
<td>Fe</td>
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<tr>
<td>Co &amp; Ni</td>
<td>Cu</td>
<td>Zn</td>
<td>Y</td>
<td>In</td>
<td>As</td>
<td>Se</td>
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<tr>
<td>Br</td>
<td>Rb</td>
<td>Sr</td>
<td>Ce &amp; La</td>
<td>Zr</td>
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<td></td>
</tr>
</tbody>
</table>

Increasing order of atomic mass
Lothar Meyer’s Periodic Table (1869)

https://www.sciencehistory.org/distillations/magazine/an-element-of-order
Mendeleev’s Periodic Table (1869)

https://www.chemistryviews.org/details/ezine/11149411/The_Periodic_System_between_Chemistry_and_Physics.html
More elements join the party, the noble ones!

WILLIAM RAMSAY
In 1894, William Ramsay discovered the noble gases and realised that they represented a new group in the periodic table.
Enter the radioactive elements! Scientists now getting “Curie”ous!

Antoine Henri Becquerel

- In 1896, while investigating uranium salts, Becquerel accidentally discovered radioactivity. Becquerel found that the photographic plates were fully exposed when in contact with radioactive salt.

Marie and Pierre Curie discovered element Radium, named the phenomena as Radioactivity! They also discovered another new element Polonium and showed that atoms might also be divisible! (1898)

Indivisible “Atoms” were broken by the power of Physics!

JJ Thomson, who discovered electron, was mentor of E Rutherford who discovered Proton, who then mentored J Chadwick, who discovered neutron! All three won a nobel prize.
Atomic Spectra

- Each element on the periodic table has a unique spectral “fingerprint.”

These are emission spectra. Absorption spectra look like the “negative” of these.

Electrons jump from one level to another and emit only certain specific kinds of light!
So you all are telling me that electrons are just tiny particles?

- De Broglie

(Probably wanted to say this, but didn’t)

Electron has a Wave Nature too!

Schrödinger’s Equation

\[
 i\hbar \frac{\partial}{\partial t} \psi(r, t) = -\frac{\hbar^2}{2m} \nabla^2 \psi(r, t) + V(r, t)\psi(r, t)
\]

\(i\) is the imaginary number, \(\sqrt{-1}\).
\(\hbar\) is Planck’s constant divided by 2\(\pi\): \(1.05459 \times 10^{-34}\) joule-second.
\(\psi(r, t)\) is the wave function, defined over space and time.
\(m\) is the mass of the particle.
\(\nabla^2\) is the Laplacian operator, \(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\).
\(V(r, t)\) is the potential energy influencing the particle.
J Dalton's Indivisible sphere Model (1808)

JJ Thompson's Plum Pudding Model (1904)

E Rutherford's Central Nucleus Model (1911)

N Bohr's Planetary Orbit Model (1916)

E Schrodinger's Quantum Mechanical Model (1926)

https://medium.com/@Intlink.edu/a-timeline-of-atomic-models-cb2607b1da85
http://www.mysteryofmatter.net/Periodic_Table.html
The greatest puzzle ever solved by humankind: Modern periodic table and nature chemical bond between elements
### The human civilization and the “Age of the Elements”

<table>
<thead>
<tr>
<th>Age</th>
<th>Techniques and Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stone Age</strong></td>
<td>Mining, chiselling and shaping (Not much chemistry knowledge available)</td>
</tr>
<tr>
<td><strong>Copper Age</strong></td>
<td>Pyro-metallurgy (extracting and purifying metals using fire; Blast Furnace and retort furnace, reduction using coal and coke)</td>
</tr>
<tr>
<td><strong>Bronze Age</strong></td>
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<tr>
<td><strong>Iron Age</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Aluminium Age</strong></td>
<td>Electro-metallurgy (Extracting and purifying metals using electricity; Electric Arc Furnace and Electrolytic Reduction)</td>
</tr>
<tr>
<td><strong>Alloy Steel Age</strong></td>
<td>Organic Chemistry and Chemical Engineering (Fractional Distillation of petroleum, Heterogeneous Catalysis)</td>
</tr>
<tr>
<td><strong>Silicon Age</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Polymer Age</strong></td>
<td>Hydrometallurgy, co-ordination chemistry and Separation Sciences (Extracting metals using acid or base, purification using organic solvent and polymeric resins to ultra high purity)</td>
</tr>
<tr>
<td><strong>Nuclear &amp; Rare Earth Electronics Age</strong></td>
<td></td>
</tr>
</tbody>
</table>
AsanVigyan: A non-zero sum approach
From ‘Me, Myself and I’ to ‘We, Ourself and Us’

Competitive approach between students might bring out some bright students, but at the cost of many who loose out to competition. The winners to do not learn about teamwork. Collaborative approach is for ensuring each and every student attain level of mastery, no one shall be left behind and everyone learns more!
Synergy between science, arts, sports and society

Simultaneous activation of different brain areas to make learning more memorable, effective and enjoyable!

“TO DEVELOP A COMPLETE MIND: STUDY THE SCIENCE OF ART; STUDY THE ART OF SCIENCE. LEARN HOW TO SEE. REALIZE THAT EVERYTHING CONNECTS TO EVERYTHING ELSE.”

LEONARDO DA VINCI
The SOLIDS, LIQUIDS and GASES that we see or feel have a unique property called as MASS and hence known as different states of MATTER. The states are transformed by increasing a certain parameter known as TEMPERATURE which is the measurement of the degree of movement of the basic building blocks of 'MATTER', the 'ATOMS'.

https://asanvigyan.in/jigyasa-map-2-hanging-around-with-all-that-matters/
Formal Curriculum: Synergy of Chemistry and English

Chemical Word Search #1 Identify the first ten elements of the period table in the puzzle given below

www.asanvigyan.in
### Chemistry and Colour-filling

**Periodic table of elements: Fill in the electron blanks**

- Fill in the holes with electrons (-)
- Fill electrons (-) from inner circle to outer circle
- Number of electrons filled = Number of protons (+) in the center

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
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<tbody>
<tr>
<td>-3</td>
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<td>+7</td>
<td>+8</td>
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<td>+9</td>
<td>+10</td>
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</table>

<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
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<td>+11</td>
<td>+12</td>
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<td>+13</td>
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<td>+15</td>
<td>+16</td>
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<tr>
<td>+17</td>
<td>+18</td>
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</tbody>
</table>

Novel methods of Chemistry Education using Card Games

Results and Analysis: A total of 45 students participated in the gaming session, and their results pre and post session is given below.

![Diagram showing improvement in scores](http://www.scienceguru.in/)

**Figure 4.** Points gained by students of Adarsh Vidyalaya arranged in ascending order of pre-session score.
New Games in the Pipeline!
Thank You!