# GYAN-VIGYAN SARITA: शिक्षा

A non-remunerative, non-commercial and non-political initiative to Democratize Education as a Personal Social Responsibility (PSR) <sup>2nd</sup> Supplementary Bulletin dt 1<sup>st</sup> June'17 of 3<sup>rd</sup> Quarterly e-Bulletin

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... start, without loosing time, with whatever is available.

<u>संपादकीय</u>



## मां की चाह : संतान की सफलता

शिक्षा देती है। सीखने के लिये कहती है। प्यार करना और निडर होना
 सिखाती है। मां का प्यार, वह प्यार है जिसे हासिल नहीं करना पड़ता है।
 इसके लिये उपयुक्त नहीं बनना पड़ता है। यह स्वतः मिलता है। मां का
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 प्यार शांति देता है। मां के हाथों में कोमलता रहती है। हर कोई सुख की
 नींद, मां की गोद में ही पाता है। मां के दिल की गहराई मापना असंभव है,
 पर यदि कभी कोई उसकी तलहटी तक पहुंचेगा तो उसे मिलेगा कि वहां
 केवल क्षमा करना ही संजोकर रखा हुआ है। ईश्वर की कल्पना यदि कभी
 जा सकती है तो वह केवल मां के रूप में ही हो सकती है।

बच्चे का जीवन मां का चेहरा देखकर शुरू होता है और मां का जीवन उसे प्यार करते हुये बीतता है। मां संतान को अपने में विश्वास करना सिखाती है। मां का जान बच्चे के लिये संपूर्ण होता है। बच्चे के जन्म के समय, मां का भी नया जन्म होता है। सौभाग्य, मां की ममता में बसा होता है। मां वह है जो बिना मांगे देती है और बिना भूले लेती है। यह सांसारिक नियम है कि हर जगह कुछ पाने के लिये कुछ देना होता है परंतु मां का सानिध्य पाने के लिये किसी को कुछ भी देने की जरूरत नहीं पड़ती है। मां से सबकुछ, उसे बिना कुछ दिये मिलता है। मां से बढ़कर कोई भी नहीं है। आचार्य शंकर ने अपने अपराधों को क्षमा करने के लिये देवी मां से प्रार्थना करते हुये कहा है कि-

कुपुत्रो जायेत् क्वचिद्पि कुमाता न भवति' अर्थात् पुत्र भले ही कुपुत्र हो जाये पर माता कभी भी कुमाता नहीं होती है।

हम विनम्र भाव से श्रद्धेय डा0 सुभाषकुमार जोशी, कोआर्डीनेटर, ज्ञान विज्ञान सरिता, के माता जी के गो-लोकधाम गमन पर उनकी संवेदनाओं में उनके साथ हैं। ईश्वर से हमारी प्रार्थना है कि वह उनको शक्ति दे कि वह अपनी माता जी के आशीर्वचनों के माध्यम से दुःख के क्षणों से बाहर आकर आगे बढ़ें और अपनी ऊर्जा को बच्चों को उन्नत बनाने में लगायें।

गो-लोकधामवासी मां को शत शत नमन!

कहते हैं-जीवन नश्वर है। यहां की हर वस्तु नश्वर है। सुख नश्वर है। सुविधायें नश्वर हैं। विधि-विधान नश्वर हैं। अपनत्व नश्वर है। पर यादें नष्ट नहीं होती हैं। समय का प्रवाह उन्हें अपने साथ दूर नहीं ले जा पाता है। काल का प्रभाव उस पर नहीं पड़ता है। समय के साथ धुंधली हुयी यादें भी वापिस आ जाती हैं, ठीक उसी प्रकार-जैसे वर्षों से सूखी दूर्वा पानी पाते ही पनप कर हरी हो जाती है।

मां का आशीष भी वह शक्तिशाली वचन है जो कभी समय के साथ कमजोर नहीं पड़ता है। कभी व्यर्थ नहीं जाता है। कभी असफल नहीं होता है। सदा आगे बढ़ने की प्रेरणा देता रहता है। कर्मठ बनाता रहता है। कर्म करने की शक्ति देता रहता है। दूसरों में दोष न देखने की आदत डालता

रहता है, और अपने को पहले से अधिक अच्छा बनाने के लिये कहता है।

मां की गोद में खेलते-खेलते बच्चा कब बड़ा हो जाता है? घुटनों के बल चलने वाला कब दौड़ने लगता है? वह कब युवा हो जाता है? वह कब प्रौढ़ हो जाता है? यह सब मां जान नहीं पाती है। मां के लिये वह हमेशा उसके कलेजे का ट्कड़ा बना रहता है। भला ट्कड़ा बड़ा कैसे हो सकता है?

सत्य तो यह है कि बच्चों को हंसता-खेलता देख, मां को अपनी बढ़ती उम्र का पता ही नहीं चलता है। वह अपनी बढ़ती उम्र भूली रहती है। बच्चों को प्रसन्न देख, अपना कष्ट भूली रहती है। परवरिश में हुयी थकान उसे याद नहीं रहती है। जब बच्चा मां की चरणों में बैठकर उसके चरणों को केवल स्पर्श कर लेता है तब मां के उठते हाथ, उसकी उठती आंखें, उखड़ती सांसें कह उठती हैं-सदा खुश रहो, चिरायु रहो, मेरी उम्र लग जाये, तुम्हारी सब बलायें हमारे हिस्से में आ जायें।

मां वास्तविकता है। प्रेम की प्रतिमूर्ति है। आशीर्वाद की खान है। विकास दिखाने वाली किताब है। अच्छी सीख देने वाली कृति है। इतिहास गवाह है कि शिवाजी महाराज को उनकी माता जीजाबाई ने महान मराठा साम्राज्य की स्थापना के लिये प्रेरित किया।

मां एक महान शिक्षिका होती है। वह संतान को भाषा सिखाती है। विश्व की समस्त भाषायें मातृभाषा कहलाती हैं। मां बैठने, बोलने और सुनने की

## An Appeal: Gyan Vigyan Sarita A non-organizational initiative of a small set of Co-passionate Persons

Philosophy: Personal Social Responsibility (PSR)

**Objective:** Groom competence to Compete among unprivileged children from 9<sup>th</sup>-12<sup>th</sup> in Maths and Physics, leading to IIT-JEE.

**Financial Model:** *Zero-&-Fund-Zero-Asset* (*ZFZA*). It calls for promoters and facilitators to provide infrastructure for use to the extent they feel it is neither abused nor there is a breach of trust. And, reimbursement of operational expenses to the participators

## **Operation:**

- a. **Mode:** Online since July'16, using Google Hangouts, a free we-conferencing S/w, with connectivity upto 15 nodes.
- b. **Participation:** Voluntary and Nonremunerative, Non-Commercial and Non-Political

## **Involvement:**

- a. As Promoter
  - i. Initiate a Learning Center,
  - ii. Sponsor a Mentor who is willing to join on certain terms,
- iii. sponsor cost of operation and up-gradation of infrastructure to voluntary mentors,
- iv. Sponsor Website.
- b. As Facilitator
  - i. Provide space and infrastructure for **Online Mentoring Sessions (OMS)**, which is generally available, with a marginal add-on,
  - ii. Garner support of elite persons to act as coordinators at a Learning Centre.
- c. As Participator -
- i. As a Mentor,
- ii. As Coordinator,
- iii. As Editor and or contributor of thought provoking articles for e-Bulletin, which are relevant to the initiative, and make it more purposeful and reachable to the target audience.
- iv. As author of Chapters for Mentors' Manual, being uploaded as a Free Web Resource,

- v. Anything else that you feel can add value to the mission and make it more purposeful.
- vi. Anything else that you consider to make this initiative to become more effective.

**Background:** The initiative had its offing in May'12, when its coordinator, a power engineer by profession, soonafter submission of Ph.D. Thesis in April'12, at IIT Roorkee, at the age of 61 years, decided to mentor unprivileged students.

SARTHAK PRAYASH, a Ghaziabad based NGO, warmly accepted the proposition and created a facility to mentor students from 8+ to prepare in mathematics and physics and prepare them for engineering entrance tests. They warmly reciprocated and created a class room.

Experience in this selfless social work were used to navigate across without losing focus. He was associated with SUBODH FOUNDATION from Sept'15 to Sept'16 during which he published a monthly e-Bulletin **SUBODH-पत्रिका** to create visibility across persons who could make a difference.

In Sept'16, post transition, the mission has been continued as a non-organizational entity Gyan Vigyan Sarita, with a set of Four persons, including retired Prof. SB Dhar, Alumnus-IIT Kanpur, a middle aged Shri Shailendra Parolkar, Alumnus-IIT Kharagpur, settled at Texas, US and Smt. Kumud Bala, Retired Principal, Govt. School Haryana. Earlier, they were complementing the OMS. While, the initiative survived transition. website: a http://gyanvigyansarita.in has been launched. It contains under its Menu: Publication>e-Bulletins, and >Mentors' Manual. You may like to read them.

Actions Requested: May please like to ponder upon this initiative. Queries, *if any, are heartily welcome*. We would welcome your collective complementing in any of the areas listed at **Involvement**, above, to make the mission more purposeful and reachable to target children.

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## Coordinator's Views Excelling Mathematics and Physics : Vacations

Excelling is a process of enhancing of assimilating a subject or imbibing a skill, where it becomes intuitive. Mathematics and Physics are two subjects in which excellence is a state where one starts realizing and analyzing them in everything around, in a manner as natural as effortless breathing or blinking of eyes. These subjects involve an analytical approach starting with observation, correlation of cause and effect and their extrapolation into a unknown domain called imagination. All the classical discoveries are results of analysis of observations, otherwise remained unnoticed, by those thoughtful and brave people who had courage to think out-of-box and promulgate their imagination in the form of postulates, theories and hypotheses. These discoveries shook the then wise persons and prophets commanding collective faith and conscience of the contemporary society. History of scientific discoveries contains numerous examples of atrocities on scientists who, through their relentless efforts, laid foundation of prevalent world of science and technology, which imparts us all comforts on the tip of fingers.

The human body is an excellent example of world of knowledge, its complexity and interdependency. In human body each organ while performing its discrete role is complemented by other organs, not substituted, in its performance in a perfect synchronism. Any disorder or injury be it nail of foot or hair, pain is felt by the individual. But, in the world of knowledge, performance of a person to perform depends upon his ability to integrate and apply knowledge of different disciplines.

Nevertheless, there are some rules which are at root of the world of knowledge. These basics are evolved with mathematics, and many out of phobia or obsession do undermine it. In this context role of mathematics was elaborated in a separate article. Likewise, physics, which has mathematics as other side of the coin, evolves cause and effect through various processes and phenomenon occurring in nature. These two subjects are so much intertwined that as one advances into journey of study of nature, they cannot be visualized distinctly. This unique nature of these two subjects is seen from the most beautiful equation  $1 + e^{j\pi} = 0$ . Here, each of the terms was devised as a mathematical pursuit independently by different philosophers at different point of time and place. But, they are in perfect union and helpful in exploring natural phenomenon from classical mechanics to modern physics. This is the reason that mathematics is considered to be mother of all sciences. Learning of mathematics and physics is step by step and higher learning integrates all pre-learning like a continuous chain.

Recently, during interaction with mother of a student of a leading school, it was learnt that during pre-vacation PTM, the learned parents were advised to utilize vacations to complete the syllabus of their child. These parents were in search of a tutor who could do that, despite paying a hefty fee of the school. Philosophy of having vacations is to break the monotony of life by engaging in something different which helps to acquire skill or excellence needed to be what one wants to be, but is unable to do in routine. It is to be noted that underlying concept of the philosophy is **a**) break of monotony and **b**) maintain focus of life.

It is seen that as craze of modern and international schools is growing, children are heavily burdened with school schedule, curriculum and assignments that they hardly have time to selfstudy and work intuitively. They are reduced to run-of-the-mill with no place for ingenuity. In recent past there was a request to review scientific essays of school students, all them were from reputed high class school. The competition was organized at behest of an initiative from a leading academic institution. Honestly, the excitement of review got butchered seeing all essays simply copypaste from the web. No thought was put by any of them to identify topic or the problem, elaboration of the various dimensions of the problem, possible remedies, and selection of a remedy considered best leading to a conclusion or a future direction. The basic objective of essay competition was dissipated into cosmetic glamour.

Learning of mathematics and physics unlike other subjects and skills is seamless, and has to start from basics. A child who has missed this basic approach in his previous learning finds it extremely difficult to cope with the academic schedule at school, while reworking upon the previous learning. In process, the lag increases and it turns this inability in phobia, aversion and at times hatred for the subjects and even towards the persons advocating for it. Despite, learned parents find it difficult to adventure to expose their child work out of stream.

This is where Gyan Vigyan Sarita dismisses the notion of a famous love song "जो त्मको हो पसंद वही बात कहेंगे , त्म दिन को अगर रात कहो

रात कहेंगे..." of movie सफर of early 70s, being an initiative which is neither a business nor a commercial profiteering oriented. On the contrary, it emphasizes upon utilizing vacations of children so as to build their firm foundation of basics, while leading them to group learning and self-study. This initiative is pursued with a self-conviction by a group of Four individuals, and not an organizational entity. It is totally selfless and is driven in a nonremunerative, non-commercial and non-political manner with a sense of <u>Personal Social Responsibility (PSR)</u>.

It is extremely difficult to sell this concept to elite parents and invite their collective complementary role to mentor their own beloved child. After, pursuing this mission for nearly Five Years, we came across a likeminded very senior engineer-cum-executive, who has invested his child from Class 9<sup>th</sup> since last one year in this initiative. Recently, three more very senior engineers have expressed their faith and commitment by investing their child in 9<sup>th</sup> in it. Our real target, first generation students and their parents, are still out of reach and yet accord a motivational acceptance.

The journey is slow and tough bu,t we are passionately committed to it. While doing so we remember words of **Robert Frost**, with a slight moderation -

#### The Woods are lovely, dark and deep.

But, **-** We have promises to keep,

#### And miles to go before - We sleep,

#### And miles to go before - We sleep.

We request our learned readers to kindly pro-act and collectively complement to give education a place of value and excellence, and not the cost or returns. If we can collectively do that, we shall be preserving democracy, as said by Franklin D. Roosevelt – Democracy cannot succeed unless those who express their choice are prep. The real safeguard of democracy, therefore, is education. That is why call for Democratization of Education

## TACKLING DEPRESSION AND ANXIETY AMONG CHILDREN

There is a rising occurrence of academic stress and anxiety among school going children. Pressure of coping with heavy curriculum comprising several subjects and topics, too many assignments and examinations coupled with inadequate time to understand and prepare for the same, fierce competition at various levels keep the students on edge all the time as they are not able to cope with this unrealistic grueling schedule. Resultantly, they suffer from round the clock intense psychological pressure and are unable to study, concentrate, remember, sleep or eat. They also experience related health problems like headaches and breathlessness.

Curative Action: Constant state of anxiety levels call for timely corrective action on the part of both schools and parents. They should ensure that students do not suffer any health problem due academic pressure. Both schools and parents need to provide thorough motivation and support to help cope with emotional and mental strain that the children may confront during their school going days. In addition to this, stress management incorporating programs below mentioned constituents should be developed and put into practice to deal with stress and depression among students.

**Pranayaam :** Pranayaam refers to practice of controlling the breath, which is the source of our *prana*, or life force. It is an active intervention to release stress as it calms down the brain and rejuvenates other body parts. It helps take the oxygen to right places so that the inner cells are energized to function properly resulting in overall improvement of health as all body parts get more oxygen and energy. The resistance power of the body also gets enhanced as toxins get washed off from the body

**Meditation :** Meditation is an effective tool to drive out anxiety and dispel psychological problems like ill will, self-doubt. Meditation describes a state of consciousness, when the mind is free of scattered thoughts and various patterns by cessation of the thought process i.e., all the activity of the mind is reduced to one .By practicing meditation as a relaxation technique on a daily basis, students can learn to let go of the unhealthy emotional states that lead to the creation of mental tensions.

#### **Other effective tools**

**1. Give a session of relaxed atmosphere to children:** Schools should allow teachers to initiate an informal session with the students once a week where the students are free to discuss their doubts, anxieties , inhibitions without fear of getting questioned and reprimanded. Teachers should be friendly and informal and give a patient hearing to the fears and anxieties of the students.

2. Intermingle with five elements of the nature: Our universe and human body is made with the composition of five elements ( panchbhoot )- Earth(*Prithvi*), Water(*Jal*) , Air(*Vayu*) , fire(*agni*), ether(*aakash*). It is said that even five senses of a human body also correlate with these elements. Urban mechanical lifestyle which involves constant exposure to concrete structures whether at home or outside, maze of metaled roads, pollution disrupts this balance as it distances indivisual from five elements of nature and set drudgery and despair in the life. To remove this, school precincts should develop an environment that enable the experiencing and blending of five elements of nature to soothen their mind and body. Performing of "Agnihotra" or the Daily Havan that incorporates the essence and benefits of these five elements can also positively impact the mental and physical health of the students.

3. Creative corner: There should be a creative zone for the students where they can just unleash their pent up vigor and liveliness suppressed by constant academic pressure. Dance, music, drawing, crafts are some of the creative activities that have a dabbing impact as they absorb all the anxieties and frustrations of the students. It would be even better if the schools are able to provide specialized to the students according to their assistance hobbies and passions.

**4.** Adequate spacing between periods: Generally, academic periods in the school timetables whose duration is around forty minutes are planned back to back without any suitable break. This leaves the students mentally exhausted as they get no time to prepare themselves psychologically for the next session which is a must to understand every bit of

### Aarti Sharma

the topic. Their mind keeps lingering in the contents of the earlier period while the next period rolls over. Resultantly, most of what is taught in the ensuing period cannot capture the attention of the student. Additionally, they get physically and mentally worn out by continuous sitting sessions for hours at a stretch.

This practice of continuous teaching of different academic disciplines as per conventional time tables should be dispensed with. Periods in the time table should be adequately spaced with at-least a five minutes tranquil spell so that the students' brain gets to some time to unwind and freshen up. A refreshed mind can learn and understand the concepts in much shorter time and in a better manner than usual duration of forty minutes.

Conclusion: Stress, anxiety and depression among school going children due to academic and career pressure and fierce competition is a serious phenomenon and needs to be nipped in the bud by parents and schools alike lest they timelv compound into severe physical and mental health problems as is the trend nowadays. Future of children is in the hands of these two institutions. They should ably equip children to prepare for the challenges of the future and simultaneously help them to deftly handle and avert these ailments and make them psychologically and emotionally strong individuals.



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## **INVITATION FOR CONTRIBUTION OF ARTICLES**

Your contribution in the form of an article, story poem or a narration of real life experience is of immense value to our students, the target audience, and elite readers of this Quarterly monthly e-Bulletin **Gyan-Vigyan Sarita:** शिक्षा, and thus create a visibility of the concerns of this initiative. It gives them a feel that you care for them, and they are anxiously awaiting to read your contributions. We request you to please feel free to send your creation, by <u>20<sup>th</sup> of this month</u> to enable us to incorporate your contribution in next bulletin, <u>subhashjoshi2107@qmail.com</u>.

We will be pleased have your association in taking forward path our plans as under-

- 2<sup>nd</sup> Supplementary e- Bulletin of 3<sup>rd</sup> Quarterly e-Bulletin <u>Gyan-Vigyan Sarita: 秋和</u> shall be brought out 1<sup>st</sup> June'17. It shall be dedicated to Indian Statistical Day to commemorate Birth Day of great Indian Statistician Late Shri Prasanta Chandra Mahalanobis; 29<sup>th</sup> June'1893 – 28<sup>th</sup> June'1872).
- And this cycle monthly supplement to Quarterly e-Bulletin Gyan-Vigyan Sarita: 創細 aimed to continue endlessly

We believe that this quarterly periodicity of e-Bulletins shall make it possible for our esteemed contributors to make contribution rich in content, diversity and based on their ground level work.

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## Time – Life's Most Precious Gift

#### Sandhya Tanwar

The clock never stops ticking, every other second is a new second. No one can stop arrival and departure of dawn and dusk. We have only 24 hours to give our best performance in different areas of our lives.

We all, have a habit of putting things to the last minute. By doing that, we face scarcity of enough time for completion of the task effectively and efficiently and in the rush of task completion, the quality of work is often compromised.

Time is the most precious element of human existence. The successful persons know how to put energy into time and how to draw success from it.

Ask the value of few seconds, from the persons who do yoga, it's very difficult to perform asanas for longer than one minute. Imagine the value of every second, when a bomb squad is trying to defuse a time bomb. Imagine the pain of a mother, when she is delivering a baby, every second is like an hour for her. Imagine the value of time, when you are left with one more question in your exam, answer of which you already know and the bell rang.

We all waste our days, weeks, months and years by doing things which we don't really like and sometimes for the happiness of others. Time is precious, waste it wisely.

The major problem of today's world is that, people don't concentrate on themselves, they spend their time and energy in gossiping and focusing on others. Be picky with whom you invest your time in, wasted time is worse than wasted money.

In today's world, everyone is busy, no one has time to spend with their loved ones. The greatest gift you can give to someone is your time. Because when you dedicate your time, you are offering a part of your life that you will never get back.

As students, we postpone preparation of our exams to the last minute. And then we complaint about the lesser number of holidays during exams.

Live every day like it's your last day and you will never run out of time. You never know, what future will bring to you. That's the mantra. Just don't waste time, it's very precious, appreciate its value, as it's priceless and no one can buy it. Once gone, it never comes back. Invest it in the things which makes you happy. Invest it in yourself, to make a better version of yourself by each passing day.

People waste the most precious years of their life by unnecessarily dwelling into their past for several years. Unknowingly, by doing that, they push themselves towards depression. If you love life, don't waste time, for time is what life is made up of.

Remember that life is a one-time offer, use it well. Every second is of infinite value. Appreciate the value of time. So wake up, time is ticking!!!!! Sometimes later becomes never, so DO IT NOW!!!



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## **GROWING WITH CONCEPTS**

## Concepts of an expert are not like a static foundation of a huge structure; rather it is like blood flowing in a vibrant mind.

During growing into an expert, each one must have used best of the books available on subject and received guidance of best of the teachers. Authors might have had limitations to take every concept thread bare from first principle and so also must be the constraint of teacher while mentoring a class with a diversity of inquisitiveness and focus. As a result, there are instances when on a certain concept a discomfort remains. The only remedy is to live with the conceptual problem and continue to visualize it thread bare till it goes to bottom of heart and that is an **ingenious illustration**.

In this column an effort is being made to take one topic on Mathematics, Physics and Chemistry in each e-Bulletin and provide its illustration from First Principle. We invite all experts in these subjects to please mail us their ingenious illustrations and it would be our pleasure to include it in the column.

We hope this repository of ingenious illustrations, built over a period of time, would be helpful to ignite minds of children, particularly to aspiring unprivileged students, that we target in this initiative, and in general to all, as a free educational web resource.

*This e-Bulletin covers – a)* <u>Mathematics</u>, b) <u>Physics</u>, and c) <u>Chemistry</u>. This is just a beginning in this direction. These articles are not replacement of text books and reference books. These books provide a large number of solved examples, problems and objective questions, necessary to make the concepts intuitive, a journey of educational enlightenment.

Looking forward, these articles are being integrated into Mentors' Manual. After completion of series of such articles on Physics, representative problems from contemporary text books and Question papers from various competitive examinations, it is contemplated to come up with solutions of different type of questions as a dynamic exercise to catalyse the conceptual thought process.

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**OUR MENTORING PHILOSOPHY:** Mentoring is not teaching, neither tuition nor coaching. It is an activity driven by passion, and commerce has no place in it. In this effort is to caution students that -

- This place is not where they will be taught how to score marks and get higher ranks, but to conceptualize and visualize subject matter in their real life so that it becomes intuitive.
- This place is not to aim at solutions but inculcate competence to analyze a problem and evolve solution.
- This place does not extend selective and personalized attention, rather an opportunity to become a part of which is focused on learning and problem solving ability collectively.
- This place provides an opportunity to find students above and below one's own level of learning. Thus students develop not in isolation but learn from better ones and associate in problem solving to those who need help. This group dynamics while create a team spirit, an essential attribute of personality, while one learns more by teaching others.
- This place has strategically chosen Online Mentoring, so that those who are unprivileged can gather at one point and those who can facilitate learning of such students by creating, necessary IT setup. Aseperate **Mentor's Manual** is being developed to support the cause.

We are implementing this philosophy through **Online Mentoring** 

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**Prof. SB DHAR** 

*GROWING WITH CONCEPTS – Mathematic* 

## **THEORY OF EQUATIONS**

A polynomial when equated to zero makes an equation. The solution of the equation is called the root of the equation.

The graph of a quadratic function  $f(x) = ax^2 + bx + c$ changes as a, b, c change. It looks like



**Note**: The values of the variable that makes a polynomial zero are called Zeros and not roots.

#### **Example**:

- (a) A polynomial of one degree x+5=0 is called monomial equation. It has one solution.
- (b) A polynomial of degree 2,  $x^2+3x+2=0$  is called a quadratic equation. It has 2 solutions.
- (c) A polynomial of degree 3, x<sup>3</sup>-6x<sup>2</sup>+11x-6=0 is called a cubic equation. It has 3 solutions.

#### Way to write the equation when roots are known

- (a) If α and β are the roots of a quadratic equation, then the quadratic equation is written as x<sup>2</sup> + (sum of the roots)x + (product of roots) = 0, or x<sup>2</sup> + (α+β)x + (αβ) = 0
- (b) If  $\alpha$ ,  $\beta$ , and  $\gamma$  are the roots of a cubic equation, then the quadratic equation is written as  $x^3 + (sum of the roots)x^2 + (sum of the products of two$ roots at a time)x + (product of all the three roots) = 0

 $x^{3} + (\alpha + \beta + \gamma)x^{2} + (\alpha\beta + \beta\gamma + \gamma\alpha)x + (\alpha\beta\gamma) = 0$ 

#### Facts relating to the equation

- 1. A polynomial equation has at least one solution, i.e., it has at least one root.
- 2. A polynomial equation of degree *n* has *n* roots.
- 3.  $ax^2 + bx + c = 0$  is called a quadratic equation if *a* is not zero.
- 4. If *a*, *b*, *c* are real then the equation is called with real coefficients.

- 5. The expression  $(b^2 4ac)$  is called the discriminant of the quadratic equation and is generally represented by D. It shows the nature of the roots of the equation.
- 6. If D > o, the roots are real and distinct, if D=o, the roots are real and equal, if D<o, the roots are imaginary, if D = a perfect square, then the roots are rational provided *a*, *b*, *c* are rational otherwise, irrational.

b + c = o), then the roots are 1 and  $\frac{c}{a}$  and in the case of  $ax^2-bx+c=o$ , the roots are -1 and  $\frac{c}{a}$  if a - b + c = o.

- 8. If a *quadratic equation* is satisfied by *more than two roots* (real or complex), then it is called the *Identity* and then a = b = c = o.
- If α, β be the roots of the equation (x-a)(x-b)=c, c ≠ 0, then the roots of the equation (x-α)(x-β)+c=0 are a and b.
- 10. If  $D_1$  and  $D_2$  are the Discriminant of two quadratic equations  $a_1x^2+b_1x+c_1=0$  and  $a_2x^2+b_2x+c_2=0$  respectively and  $D_1+D_2 \ge 0$  then at-least one of the  $D_1$  and  $D_2$  is  $\ge 0$  i.e. at least one of the equations has real roots.
- 11. If  $D_1+D_2<0$ , then at-least one of  $D_1$  and  $D_2<0$ , i.e. at least one of the given equations has imaginary roots.
- 12. If  $D_1, D_2 < 0$ , then the equation  $(a_1x^2+b_1x+c_1)(a_2x^2+b_2x+c_2)=0$  will have two real roots.
- If D<sub>1</sub>.D<sub>2</sub>>0, then in the case (i) D<sub>1</sub>>0 and D<sub>2</sub>>0 i.e., the equation (a<sub>1</sub>x<sup>2</sup>+b<sub>1</sub>x+c<sub>1</sub>)(a<sub>2</sub>x<sup>2</sup>+b<sub>2</sub>x+c<sub>2</sub>)=0 will have four real roots and in the case (ii) D<sub>1</sub><0 and D<sub>2</sub><0 the equation (a<sub>1</sub>x<sup>2</sup>+b<sub>1</sub>x+c<sub>1</sub>)(a<sub>2</sub>x<sup>2</sup>+b<sub>2</sub>x+c<sub>2</sub>)=0 will have four complex roots.
- 14. If D<sub>1</sub>.D<sub>2</sub>=0, then in the case (i) D<sub>1</sub>>0 and D<sub>2</sub>=0 and (ii) D<sub>2</sub>>0 and D<sub>1</sub>=0 i.e., the equation (a<sub>1</sub>x<sup>2</sup>+b<sub>1</sub>x+c<sub>1</sub>)(a<sub>2</sub>x<sup>2</sup>+b<sub>2</sub>x+c<sub>2</sub>)=0 will have two equal and two distinct real roots and in the case of (i) D<sub>1</sub><0 and D<sub>2</sub>=0 and (ii) D<sub>2</sub><0 and D<sub>1</sub>=0 i.e., the equation (a<sub>1</sub>x<sup>2</sup>+b<sub>1</sub>x+c<sub>1</sub>)(a<sub>2</sub>x<sup>2</sup>+b<sub>2</sub>x+c<sub>2</sub>)=0 will have two equal real roots and two imaginary roots.

- 15. A polynomial equation f(x)=o has exactly one real root equal to  $\alpha$  if  $f(\alpha)=o$  and  $f'(\alpha)\neq o$  and f(x)=o has exactly two real roots  $\alpha$ ,  $\beta$  if  $f(\alpha)=f'(\alpha)=o$  and  $f''(\alpha)\neq o$ .
- 16. If *a*=1, *b* and *c* are integers, and roots are rational, then roots will be integers.
- 17. If *a,b,c* are rational and D is a perfect square then roots are rational.
- 18. To obtain the equation whose roots are reciprocal of the roots of a given equation: replace *x* by  $\frac{1}{x}$ .
- 19. To obtain the equation whose roots are negative of the roots of a given equation: replace x by -x.
- 20. To obtain the equation whose roots are square of the roots of a given equation: replace x by  $\sqrt{x}$ .
- 21. To obtain the equation whose roots are the n<sup>th</sup> power of the roots of a given equation: replace x by  $x^{\frac{1}{n}}$ .
- 22. If equations  $a_1x^2 + b_1x + c_1 = 0$  and  $a_2x^2 + b_2x + c_2 = 0$  are such that  $a_1, a_2 \neq 0$ ,  $a_1b_2 \neq b_1a_2$  and they are to have a common root, then  $(b_1c_2 b_2c_1)(a_1b_2 a_2b_1) = (c_1a_2 c_2a_1)^2$ .
- 23. Quadratic

expression

 $ax^2 + 2hxy + by^2 + 2gx + 2fy + c$  can be resolved into two linear factors if  $abc+2fgh-af^2-bg^2-ch^2=o$ . It can be expressed in the determinant form as below:

- $\begin{vmatrix} a & h & g \\ h & b & f \\ g & f & c \end{vmatrix} = 0$
- 24. Between any two roots of a polynomial f(x)=o, there is always a root of its first derivative f'(x) = 0.
- 25. If *x*<sup>2</sup>+*ax*+*b* is an integer for every integer *x*, then (*a*+*b*) is always an integer.
- 26. Every equation has a root real or imaginary.
- 27. The root is the value of the equation's variable which satisfies it.
- 28. The number of roots of an equation is equal to its degree and not more than in any case.
- 29. Equations with real coefficients may have imaginary roots but they occur in pair i.e. a+ib and a-ib are present together.

- 30. Equations with rational coefficients may have surds roots but they occur in pair i.e.  $(a + \sqrt{b})$  and  $(a \sqrt{b})$  are always together.
- 31. Equations with all positive coefficients has no positive root i.e.,  $x^3 + ax^2 + x + b = 0$  will have no positive root.
- 32. Equations having coefficients of all even powers of x as (-) and of all odd powers (+) will have no negative root i.e.  $x^5 a x^4 + b x^3 c x^2 + dx 1 = 0$  will have no negative root.
- 33. Equations containing only even powers and all coefficients having same sign will have no real root i.e.,  $x^6 + a x^4 + b x^2 + c = o$  will have no real root.
- 34. Equations containing only odd powers and all coefficients having same sign will have no real root except x = 0, i.e.  $x^5 + a x^3 + b x = o$  will have no real root except x = o.
- 35. An equation of odd degree has at least one real root whose sign is opposite to its last term.
- 36. An equation of even degree will have at least two real roots one negative and one positive whose last term is negative.
- 37. The maximum number of positive roots in an equation is equal to the change of sign of the coefficients of f(x) and the maximum number of negative roots is equal to the change of sign in f(-x). This is called the Descarte's Rule of sign.
- 38. Descarte's Rule of sign gives the maximum number of positive or negative real roots. It does not give the exact number of positive or negative real roots of f(x)=0.
- 39. In an equation f(x) if for values a and b, f(a) and f(b) have different signs, then a root must exist between a and b.
- 40. f(a) and f(b) containing same signs has either no root or an even number of roots of f(x) between a and b.
- 41. f(a) and f(b) containing different signs has an odd number of roots of f(x) between a and b.
- 42. If an equation has r equal roots, its first derivative f(x) will have (r-1) equal roots.
- 43. To find an equation whose roots are enhanced by *m*, replace *x* by *x*-*m*.
- 44. To find an equation whose roots are diminished by m, replace x by x + m.
- 45.  $ax^2 + bx + c = 0$  is positive or greater than o for all values of x ∈ R iff a>0, D<0.

- 46.  $ax^2 + bx + c = 0$  is negative or less than o for all values of  $x \in R$  iff a < 0, D < 0.
- 47. Curve represented by the Quadratic expression cuts xaxis at two points iff D>0.
- 48. Curve represented by the Quadratic expression touches x-axis if D=0.
- 49. Curve represented by the Quadratic expression will not intersect x-axis if D<0.
- 50. Curve represented by the Quadratic expression will be completely above x-axis if a > 0.
- 51. Curve represented by the Quadratic expression will be completely below the x-axis if a<0.
- 52. If the roots of the equation represented by  $ax^2 + bx + c = 0$  are real  $\alpha$  and  $\beta$ , and for a real k they are such that  $\alpha < k < \beta$ , then D>0, *a.f(k)<0*.
- 53. If  $k_1$ ,  $k_2$  are such that  $k_1 < \alpha$ ,  $\beta < k_2$ , then  $D \ge 0$ ,  $a.f(k_1)$ > 0,  $a.f(k_2)$  > 0,  $k_1 < -(b/2a) < k_2$ .
- 54. If  $k < \alpha$ ,  $\beta$  or  $k > \alpha$ ,  $\beta$ ; then  $D \ge 0$ , a.f(k) > 0.
- 55. If one of the roots lies in the interval  $(k_1, k_2)$  then  $f(k_1)f(k_2) < 0.$
- 56. If a-b+c=o then one root is -1 and the other root is (c/a).
- 57. If  $ax^2 + bx + c = 0$  and a+b+c = o then one root is always 1 and the other is (c / a).
- 58. If all the terms are with positive coefficients and no odd powers are there, it will have complex roots.
- 59. Every odd degree equation has at-least one real root.
- 60.  $\alpha$  is a repeated root iff  $f(\alpha)=0$  and  $f'(\alpha)=0$ .
- 61. If  $(x-\alpha)^k$  divides f(x) then  $(x-\alpha)^{k-1}$  divides f'(x).
- 62. If both roots are positive, then  $\alpha+\beta>0$  and  $\alpha\beta>0$ .
- 63. If both roots are negative, then  $\alpha+\beta<0$  and  $\alpha\beta>0$ .
- 64. If both roots are greater than k, then  $D \ge 0$ , (-b/2a) > k, a f(k) > 0.
- 65. If both roots are less than k then  $D \ge 0$ , (-b/2a) < k, a f(k)>0.
- 66.  $a^{f(x)} > b$  where a > 0

(a) if b>0, then  $f(x)> \log_a b$  if a>1 and  $f(x)< \log_a b$ *if o<a<1.* 

(b) 
$$x \in D_f$$
 if  $b \le 0$   
67.  $a^{f(x)=1}, a < 0, a \ne 1 \Longrightarrow f(x) = 0$ .  
Example:  
 $5^{x^2+5x+6} = 1$ .

a

 $\Rightarrow$ x<sup>2</sup>+5x+6=0 and may be evaluated.

- 68.  $f(a^x)=0 \Rightarrow f(t)=0$  where  $t=a^x$ .  $2^{2x}-6.2^{x}+8=0$  assume  $2^{x}=t$  and proceed.
- 69.  $a^{f(x)}+b^{f(x)}=c$  where  $a,b,c \in \mathbb{R}$  and  $a^2+b^2=c$ . obviously f(x)=2 gives the solution. Example:

$$3^{x-4}+5^{x-4}=34 \Rightarrow 3^2+5^2=34 \Rightarrow x-4=2$$
 is a solution.

70. If the equation is of the form  $(x-a)^4+(x-b)^4=A$  then the substitution  $t = \frac{(x-a) + (x-b)}{2}$  makes it solvable.

#### **Some Important Questions**

Solve  $x^2+2=0$ 1. Solution:

$$x^2 = -2 \Rightarrow x^2 = 2i^2 \Rightarrow x = i\sqrt{2}, -i\sqrt{2}$$

2. If, for a positive integer n, the quadratic equation  $x(x+1) + (x+1)(x+2) + \dots$ +(x+n-1)(x+n)=10n has two consecutive integral solutions, then find the value of n.

#### Solution:

$$x(x+1) + (x+1)(x+2) + \dots + (x+\overline{n-1})(x+n) = 10n$$

$$\Rightarrow \sum_{r=1}^{n} (x+r-1)(x+r) = 10n$$
$$\Rightarrow \sum_{r=1}^{n} \{x^{2} + (2r-1)x + (r^{2}-r)\} = 10n$$

On solving, 
$$x^{2} + nx + \left(\frac{n^{2} - 31}{3}\right) = 0$$

Let the roots be  $\alpha$  and  $\alpha$ +1, then

$$2\alpha + 1 = -n \Longrightarrow \alpha = -\frac{n+1}{2} \dots (i)$$
$$\alpha(\alpha + 1) = \frac{n^2 - 31}{3} \dots (ii)$$

From equations (i) and (ii), eliminate  $\alpha$ ,  $n^2=121 \Rightarrow n=11$ 

- 3. Let p, q be integers and let α, β be the roots of the equation x²-x-1=0, where α≠β. For n=0,1,2,3,..., let a<sub>n</sub>=pα<sup>n</sup>+qβ<sup>n</sup>. If a and b are rational numbers and a+b √5, then a=0=b.
  (i) If a = 0.2 then show that the value of p + 0 g is 10.
  - (i) If  $a_4 = 28$  then show that the value of p+2q is 12.

#### Solution:

 $a_4 = p\alpha^4 + q\beta^4 \tag{i}$ 

If  $\alpha$  is a root of the given equation then

$$\alpha + \beta = 1$$
(ii)  

$$\alpha^{2} = \alpha + 1 \Rightarrow \alpha^{4} = (\alpha + 1)^{2}$$

$$= \alpha^{2} + 2\alpha + 1 = 3\alpha + 2$$
(iii)  
Similarly,  

$$\beta^{4} = 3\beta + 2$$
(iv)  
From equations (i),(ii), (iii), and (iv)  

$$a_{4} = p\alpha^{4} + q\beta^{4} = p(3\alpha + 2) + q(3\beta + 2)$$

$$= p(3\alpha + 2) + q(3 - 3\alpha + 2)$$

$$= p(3\alpha + 2) + q(5 - 3\alpha)$$

$$= \alpha(3p - 3q) + 2p + 5q$$
Given that  $a_{4} = 28$   
But  $\alpha = \frac{1 + \sqrt{5}}{2}$ 

$$\frac{1+\sqrt{5}}{2}(3p-3q)+2p+5q=28$$
  

$$\Rightarrow \frac{1+\sqrt{5}}{2}(3p-3q)+2p+5q-28=0$$
  

$$\Rightarrow p=q \text{ and } 2p+5q-28=0$$
  

$$\Rightarrow p=q=4$$
  
Therefore,  $p+2q=12$ 

(ii) Prove that the value of  $a_{12}=a_{11}+a_{10}$ . Solution:

Given that  $a_n = p\alpha^n + q\beta^n$ 

Also, 
$$\alpha^2 = \alpha + 1$$
  
 $\Rightarrow \alpha^n = \alpha^{n-1} + \alpha^{n-2}$ 

Similarly,

$$\beta^n = \beta^{n-1} + \beta^{n-2}$$

Hence,

$$a_{n} = p\alpha^{n} + q\beta^{n}$$
  
=  $p(\alpha^{n-1} + \alpha^{n-2}) + q(\beta^{n-1} + \beta^{n-2})$   
=  $(p\alpha^{n-1} + q\beta^{n-1}) + (p\alpha^{n-2} + q\beta^{n-2})$   
=  $a_{n-1} + a_{n-2}$ 

On putting, n=12, we get  $a_{12} = a_{11} + a_{10}$ 



Hence,

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## **CROSSWORD PUZZLE June'17: MOTHER**

Prof. SB. Dhar



#### ACROSS

DOWN

- 1 Mother in Hindi
- 2 Mother in Arabic
- 4 Mother in Telegu
- 8 Mother in Marathi
- 9 Mother in Greek
- 10 Mother in German
- 11 Mother in Bulgarian

- 1 Mother in Ukrainian
- 2 Mother in Urdu
- 3 Mother in Swedish
- 5 Mother in Afrikaans
- 6 Mother in Belarusian
- 7 Mother in Persian
- 10 Mother in French

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(Answer to this Crossword Puzzle shall be provided in Supplementary e-Bulletin Dt. 1<sup>st</sup> July'17) **GROWING WITH CONCEPTS- Physics** 

## **ELECTROMAGNETISM – Part I: Current Electricity**

Study of Electrostatics has led to an understanding that -a) every matter in nature, in its normal state has zero charge, i.e. quantity of (+)ve and (-ve) charges present in it are equal, **b**) when charges in a substance are separated an electric field is established between the separated charges, **c**)when an electric charge is held in an electric field is experiences a force such that that (-ve) charge is accelerated in the (+)ve direction of the electric field, and **d**) the acceleration can be determined with in accordance with the Newton's Second Law of Motion. This creates a scientific curiosity to know -i) Rate of movement of charges in an electric field, **ii**) Relationship between potential difference and rate of movement of charges, **iii**) Is it that the movement of only (-) charges constitute current, or there is possibility of movement of (+) charges, **iv**) Patterns of electric current fixed, periodic or any other, **v**) Are there any effects of movement of charges viz. thermal and magnetic and if so are they dependent on direction of current, **vi**) What are the types of electrical elements, **vii**) If magnetic field is created by flow of charges, is there any effect of movement of electric field or change of magnetic field, is there a way to unify them?

Lightning, a natural disaster in the pre-recorded history, was related to electricity in 1752 by Benjamin Franklin through his famous experiment in 1752. Nevertheless, the answers to the above questions were explored by different scientists independently. It is no exaggeration to admit that we are enjoying a legacy of their pains taking efforts in the form of technological developments.

In this section. a beginning is being made to elaborate concepts relating to each of the question which will lead to an integrated understanding of electromagnetism.

**George Ohm** in 1827, was first to experimentally define quantitative relationship between electric current and potential difference and is primitive to the understanding of current electricity. It states that "When electric current (I) passes through two points of a conductor, is directly proportional to voltage drop (V) across the two points. The proportionality constant is called resistance (R)." Accordingly,  $\propto V$ , or alternatively,  $V \propto I$ , or V = KI/ Here, constant of proportionality is K = R. Initially, based on value of R electrically materials were classified as **conductor** and **insulator**. Materials having low resistance are called **Conductor**; such materials are conducive for flow of electric current. While, materials which have extremely high resistance such that flow of current through it is negligible are called **Insulators**. Later increased understanding of atomic and crystalline structure materials and their electrical behaviour led to various types of electrical materials viz. Linear resistors, Non-linear resistors, Super Conductors and Semiconductors. Study of Semiconductors shall call a separate section as we take a forward path beyond Electromagnetism, which involves an understanding of atomic structure.

Mathematical derivation of Ohm's Law and quantification of resistance based on the properties of material was done later and is found to be in conformity. Prima facie, structure of solid materials is conglomeration of atoms and molecules, having nucleus embedded into its lattice. Some of the electrons of atoms revolve around nucleus and are called **Bound Electrons**, while a few based on energy state matter move freely in the lattice and are called **Free Electrons**. In conductors. density of free electrons is large enough to constitute electric current, while in Insulators, density of Free Electrons is negligible and thus on application of potential difference across it current is negligible. These free electrons in their continuous motion collide, change direction and continue motion restlessly performing **Brownian Motion**, similar to that of gas molecules, elaborated in **Kinetic Theory of Gases**. Each material in normal state is electrically neutral i.e. it has Zero Charge. Therefore, as per Guass's Law,  $Q = 0 = \oint E. ds$ , and also at any point on the surface of the solid, *E* is also Zero. But, when either the material is placed in an external Electric Field (**E**), or an electric field

is applied across the material a *Potential Difference*  $(V = V_1 - V_2)$  is established such that  $V = \int E. dl$ , here,  $E = \frac{V}{L}$  and **dl** is incremental displacement between two ends of the material across which potential difference exists, as shown in the figure. Each, of the free electrons having (-)ve charge, under influence of external field will experience an acceleration  $(a_e)$  i.e. in a direction opposite to that of the of the Electric Field such that  $m_e a_e = q_e E$ . Here,  $m_e$ - is mass of electron and  $q_e$ - is charge of electron. This is the point where, *Coulomb's* 

Law is being integrated with Newton's Second Law of Motion, and integration of mechanics and electromagnetism starts. Thus acceleration of electron shall be  $a_e = \frac{q_e E}{m_e}$ . The free electrons during motion in the lattice collide, loose energy and come to a state of rest ( $v_e = 0$ ) and are again set to acceleration and the process continues. Distance travelled by an electron between two consecutive collisions is called free path (l) and time taken by an electron to traverse the free path is called relaxation time ( $\tau$ ). Since, it is not possible to determine these two parameters for motion of each electron, these are taken as **Mean Free Path** (l), and **Mean Relaxation Time** ( $\tau$ ) and



analysis is carried out. Using *Galileo's First Equation of Motion*,  $l = 0 + \frac{1}{2}a_e\tau^2$ . Thus cloud of free electrons drift in the direction of Electric Field. Thus average velocity of drift  $(v_d)$  of electrons is  $v_d = \frac{l}{\tau} = \frac{1}{2}a_e\tau = \frac{1}{2}\left(\frac{q_eE}{m_e}\right)\tau$ .

**Current** (I) has been defined as rate of flow of charges  $\left(I = \frac{Q}{t}\right)$  and this requires taking an holistic view of material of length (L), cross sectional area (A), density of free electron (n) per unit volume, drift of electrons cloud through the cross-section PQRS in time  $(\tau)$  shall fill volume between ABCD and PQRS. Thus, current in the instant case shall be  $I = \frac{n \cdot (A \cdot l) \cdot q_e}{\tau} = n \cdot A \cdot q_e \cdot v_d = n \cdot A \cdot q_e \cdot \left(\frac{l}{\tau}\right) = n \cdot A \cdot q_e \cdot \frac{1}{2} \left(\frac{q_e E}{m_e}\right) \tau$ . Accordingly, current (I) in the conductor subjected to potential difference (V) is  $I = \left(\frac{n \cdot q_e^2 \cdot \tau}{2m_e}\right) \cdot \left(\frac{A}{L}\right) \cdot EL = \left(\frac{n \cdot q_e^2 \cdot \tau}{2m_e}\right) \cdot \left(\frac{A}{L}\right) \cdot V = \sigma \cdot \left(\frac{A}{l}\right) \cdot V$ . Here,  $\sigma$  is conductivity of material governed by the properties of material viz. charge density (n) and Mean Free Time ( $\tau$ ) and properties of the conductor. Alternatively, this relationship can be transformed into Ohm's Law where,  $V = \frac{1}{\sigma} \cdot \frac{L}{A} \cdot I = \rho \cdot \frac{L}{A} \cdot I = R \cdot I$ . Here,  $\rho$  is called **Specific Resistance**. It is also called **Resistivity of conductor and mathematically it is reciprocal of Conductivity** ( $\rho = \frac{1}{\sigma}$ ). Thus, while mathematically establishing validity of experimentally determined Ohm's Law, Resistance of a conductor is also defined as  $R = \rho \cdot \frac{L}{A}$ .

**Dependence of Resistance of a Conductor:** Experimentally it has been observed that resistance of conductor increases linearly with the increase in temperature, but over a small range and is expressed as  $\rho_T = \rho_{T_0} (1 + \alpha (T - T_0))$ . Here,  $\alpha$  – is called **Temperature Coefficient of Resistivity.** Typical values of  $\rho$  and  $\alpha$  of commonly used conductors are as under –

Property	Copper	Aluminium	Iron			
Resistivity (Ohm/m)	1.72x10 <sup>-8</sup>	2.63x10 <sup>-8</sup>	9.71x10 <sup>-8</sup>			
Temperature Coefficient of Resistivity (K <sup>-1</sup> )	0.0039	0.0039	0.0050			

A close observation of the above relationship reveals that - **a**) Increase in charge density (n) causes increase in number of charge carriers and thus initially reduces resistivity of the conductor, **b**) Excessive charge density since increases charge carriers reduces mean free path (l) with a consequent reduction in relaxation time ( $\tau$ )

and thus mean drift velocity; this results in increase of Resistivity, c) Keeping the volume of conductor same, x% reduction in cross section increases length of the conductor by a proportion  $\frac{1}{\left(1-\frac{x}{100}\right)} = \left(1-\frac{x}{100}\right)^{-1}$  and in turn resistance of the new geometry by  $\left(1 - \frac{x}{100}\right)^{-2}$  [From Binomial Theorem:  $(1 - x)^{-2} = 1 + 2x + 3x^2 +$ 

 $4x^3 \dots (r+1)x^r \dots$ ]. Accuracy of resistance for the variation in geometry, with this mathematical formulation, depends upon -a) order of variation and b) degree of precision desired. The first Two observations, of the above, substantiate thermal dependence of resistivity of conductor, while the third observation corroborates dependence of resistance of conductor on its geometry.

Summary: It is seen that every conductor by virtue of its composition, experiences collision of free charges during flow current and losses its kinetic energy in each collision. This is similar to the phenomenon in Mechanics and this kind of obstruction to the flow of electrons in electrical circuits is called **Resistance**. Thus resistivity is an intrinsic property of every conductor and may vary with a difference of degree from material, while resistance of an element of circuit, together with the resistivity depends upon its geometry.

Electromotive Force (EMF) and Voltage Difference: Initial study of current electricity started with chemical cell and a combination of such cells is called Battery and arrangement of a Switch circuit is shown in the figure. Battery, with switch open i.e. when current is not [ Closed flowing, it exhibits a potential difference *E* and is called *Electromotive Force*; *it* is the net potential of the battery to supply electric current. But, when switch is closed current is supplied by the battery from its (+)ve terminal and this current returns back to it through (-)ve terminal. In current electricity, unlike Electrostatics, charge does not stay separated, and circuit is completed only when charges supplied in the form of current are returned to the point of supply, and thus, E with battery electric current flows from its (-)ve terminal to (+)ve terminal. At this Battery point, measurements of Voltage and Current are assumed to be available, since knowing about these instruments would require understanding of effects of electric current which are yet to be elaborated.

Here, there are two important concepts are surfaced: a) Potential Difference across battery when current is supplied by it and **b**) Direction of flow electrons within the battery. It is observed that when current is supplied by the battery, a voltage drop occurs in it and it is attributed to *Internal Resistance (R<sub>int</sub>) of the Battery*. The thin connecting wires including switch are , initially, taken to be negligible resistance. Thus, voltage (V) across battery or the resistance (R) is  $V = E - IR_{int}$ . The second question is direction of flow of electrons having (-) charge and as elaborated in Electrostatics, they shall be attracted towards (+)ve potential and notional direction of current is direction of flow of (+)ve charges. Accordingly, direction of flow of Electrons is opposite to the direction of current.

A closer look of the battery circuit, is shown in a separate figure where Internal Resistance of Battery  $(R_{int})$  is shown distinctly and resistances of all conducting connections and switches are lumped into an External Resistance  $(R_{ext})$  while any load or device is shown as Resistance (R). It will be seen that -a) all elements of the circuit are connected in series, **b**) direction of current in the circuit is same, c) Current through resistances is in (+)ve to (-)ve direction while current through battery is from (-) to (+)ve direction which replenishes charges supplied by it through its (+) terminal. Thus at any point of time balance in every element of the circuit (+)ve and (-)ve charges remains. Accordingly, as per Ohm's Law  $E = I(R_{int} + R_{ext} + R)$ , which consumes complete EMF of the battery in resistive elements in a cascaded manner as it encounters during flow of current. Thus, voltage across battery is  $V_b = E - I \cdot R_{int}$  and voltage across



resistance (R) is  $V = E - I(R_{int} + R_{ext}) = I \cdot R$ . This analysis foundation of Series-Parallel Combination of Resistances and Kirchhoff's Laws,

**Combination Of Resistances:** Every electrical circuit is a combination of electrical sources, connecting elements of conducting material, switches and resistances in the form of electrical devices. These element are connected in various formations. Analysis of voltage and currents across different elements of circuits can be carried out by decomposing an integrated and complex circuit into most generic combinations of resistances – a) *Series Combination* and b) Parallel Combination. The basic concepts involved in the analysis are- i) *Ohm's Law – which stipulates relationship between its Resistance (R), current (I) through it and voltage (V) across each resistive element, and ii) at any point of time, despite flow of current, balance of electrical charges remains unaltered. Thus in effect current entering an element at any instant is equal to current leaving the element.* 

A typical Series Combination of Three Resistances is shown in the figure. In this current (I) enters at



**nces** is shown in the figure. In this current (I) enters at point A and leaves at point D. Since, in the circuit there is neither any diversion nor spillage, current leaving the combination (I) remains unaltered; and this true for all cascaded nodes forming the Series Combination. Let, equivalent resistance of the series combination be  $R_s$ . According to Ohms Law voltage across the Series

Combination shall be  $V = IR_s$ . Likewise, for voltage drop across the three elements of the combination  $V_1 = IR_1$ ,  $V_2 = IR_2$  and  $V_3 = IR_3$ . Since, these voltages are cascading and hence  $V = V_1 + V_2 + V_3$ . Using the V,I and R relationships, as per Ohm's Law, it leads to  $V = IR_s = IR_1 + IR_2 + IR_3$ ; alternatively  $IR_s = I(R_1 + R_2 + R_3)$ . It leads to  $R_s = (R_1 + R_2 + R_3)$ , or in its general form the *equivalent resistance of series combination* of **n** resistances is  $R_s = \sum_{i=1}^{n} R_i$ .

Similarly, a general expression of equivalent resistance of a parallel combination is developed using a typical

connection as shown in the figure. The three resistances are lumped at Points A and B forming a parallel combination of resistances and hence potential difference (V) responsible for diving current in each of the resistances shall be same. Thus, as per Ohm's Law  $V = I_1R_1 = I_2R_2 = I_3R_3$ . Considering, equivalent resistance of the parallel combination to be  $R_p$ , as per Ohm's Law,  $V = IR_p$ . In current electricity, there is no accumulation of charge at any point of time, and therefore, balance of current shall be there at both the nodes A and B. Accordingly,  $I = I_1 + I_2 + I_3$  and using equations evolved for the combination and individual resistances of the combination,  $\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ . It leads to  $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ , or in its general



form the **equivalent resistance of a parallel combination** of *n* resistances is  $\frac{1}{R_n} = \sum_{i=1}^n \frac{1}{R_i}$ 

In 1845 **Gustav Kirchhoff** generalized the analysis of an electrical network which includes resistances and electrical and are known as Kirchhoff's Laws – **a)** *Kirchhoff's Current Law (KCL)* and **b)** *Kirchhoff's Voltage Law (KVL)*. These laws are extremely useful in solving an electrical network.



**KCL** states that **algebraic sum of currents at any node is Zero,** *i.e.* mathematically  $\sum I_j = 0$ . Here, node is a point where various conductors of the network are joined,  $I_j$  is the current in j<sup>th</sup> branch joined at the node. Since, this law invokes algebraic value of current and hence sign convention is extremely important. Accordingly, **sign convention** stipulates that currents entering a node have (+)ve value and currents leaving a node have (-)ve values, and vice-versa. In this sequencing of current viz-a-viz branch with suffix j is not important and is purely for the convenience of the persons making network analysis. Thus

KCL equation of the network comes to  $I_1 + I_2 - I_3 - I_4 - I_5 = 0$ . Similar equations shall be there for each node, and can be solved as simultaneous equations to determine unknown current.

*KVL* states that algebraic sum of voltages in a electrical loop is Zero, i.e. sum of EMF and voltage drops in an electrical loop is Zero and is mathematically expressed as  $\sum V_i = 0$ . Here,  $V_i$ - is the algebraic voltage across **i**<sup>th</sup> element of the loop, also referred to as Mesh. In each loop, a notional current ( $I_j$ ) is considered in a hypothetical direction is considered and is independent of direction in adjoining loops. Here, subscript j represents the **j**<sup>th</sup> loop Accordingly, **sign convention** stipulates that - voltage rise, in case of Voltage sources viz. Battery is taken to be (+)ve, and voltage drop in the direction of current is taken to be (-)ve, which is invariably the case in resistances and voltage sources connected with polarity in a direction reverse to that of current. Thus, in case of an electrical circuit having multiple loops, each loop is assigned



different current and it analysis of the network using KVL involves solving simultaneous equations equal to number of loops . While doing so, consistency of KCL, is node. Elaboration of KVL is presently done with a single loop, and solution of complex networks shall be done taking a forward path and solving problems.

Applying the KVL in the loop shown in figure, it leads to  $E - V_1 - V - V_2 - V - V_3 = 0$ . Here, I - is the notional current in the loop, E- is the EMF of the battery, voltage source, *having its polarities which support the direction of* 

notional current, V - is the absolute value of the voltage of a **voltage source connected** such that *its* polarities are in a direction which oppose the notional current. It leads to a equation of the loop as  $E - V - I(R_1 + R_2 + R_3) = 0$ . Thus it is possible to determine loop current once Values of voltage sources and resistances in loop(s) are known.

Wheatstone Bridge is a device, which is analysed using basic Ohm's Law, KCL and KVL. A typical



Wheatstone bridge is shown in the figure which has four resistances  $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$  are connected across nodes A, B, C and D as shown in the figure. In some references this topology of circuit is also shown in rectangular formation,

as also shown in the figure, which is conceptually and analytically the same. Out of these Four resistances three are fixed, while fourth is a variable resistance. Any of the four resistances can be variable, while in instant case  $R_2$  is taken as variable. Across nodes A and B a voltage source (V) is connected, while across nodes C and D a galvanometer (G) is connected. Galvanometer is a very sensitive



instrument to record small current. It forms base of the Ammeter and Voltmeter and shall be elaborated later. In this values of  $R_2$  is so adjusted that galvanometer (G) shows no deflection, and the *four resistances exhibit a definite relationship*  $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ . This is stated to be balanced condition of the circuit and is being verified analytically.

Let voltages at Four nodes be  $V_A = V$ ,  $V_B$ ,  $V_c$  and  $V_D = 0$ . And current in Three loops ABCA, CBDC and ACBA be  $I, I_1$  and  $I_3$ , respectively. Direction of currents can be taken to be clockwise or anti-clockwise, but it is convenient to have a uniformity in direction-convention. Net, current in each element of the circuit is difference of currents in adjoining loops of which the element forms the branch of the circuit. Accordingly,  $I_{AC} = I_1$ ,  $I_{CB} = I_2$ ,  $I_{AD} = I - I_1$ , and  $I_{DB} = I - I_2$  and  $I_{CD} = I_1 - I_2$ . Current  $I_{CD} = 0$  under balanced condition this eventually leads to  $I_1 = I_2$ . Thus, as per Ohm's Law  $V_{CD} = R_G \cdot [I_1 - I_2] = 0$ , which implies both nodes  $V_c$  and  $V_D$  are it is at same potential (electrical level), this condition bring it a name Bridge and accordingly this circuit configuration is called **Wheatstone Bridge**. At node A validity of KCL is seen;  $-I_1 - (I - I_1) = 0$ , Applying, KVL to loop ACDA,  $V_{AC} - V_{CD} - V_{DA} = 0 = I_1R_1 - 0 - (I - I_1)R_3$ . It leads to  $\frac{R_1}{R_3} = \frac{I - I_1}{I_1}$ . Likewise, in loop CBDC we find that  $\frac{R_2}{R_3} = \frac{I - I_1}{I_1}$ . These two proportions, further, lead to ,  $\frac{R_1}{R_3} = \frac{R_2}{R_4}$ , alternatively, using

invertendo property of ratio-proportions,  $\frac{R_1}{R_2} = \frac{R_3}{R_4}$ . This is beautiful case of integration of basic laws of electrical circuits, and finds extensive application in analysis of electrical and electronic circuits with many variants.

**Electrical Power and Energy:** Electrical Potential Difference between two points is the amount of work done on Jules (N-m) to move unit (+)ve charge from lower potential to higher potential. Likewise, when a unit



(+)ve charge moves from (+)ve potential to (-)ve potential, it imparts that energy to the charge, in accordance with laws of conservation of energy. It is similar to potential energy gained by an object when moved above the ground level, which is get converted into kinetic energy when the object moves towards the ground. In electrostatics, it has been seen that when charge is moved from one point to other against electric field, it increases potential of the point. But, in current electricity, there is only

replenishment of the charge in the form of drift current. but there is no accumulation of charge. Further, electric current  $I = \frac{dQ}{dt}$ , which implies that  $Q = \int Idt$  charge has moved from higher potential to lower potential, as shown in the figure. Thus, **power of a circuit (P)** having potential difference (V) is the rate of doing work in **Joules-s**<sup>-1</sup> in moving charge at a rate  $\frac{dQ}{dt}$ , and is expressed as P = VI. Commonly used unit of electrical power is Watt and One Watt is equal to One Nm-s-1. Applying Ohm's Law to the circuit under consideration,  $P = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$ , alternatively,  $P = (IR)I = I^2R$ . Further, energy consumed by the circuit  $= \int_0^T Pdt = PT$  and **unit of electrical energy is Watt-sec**. In common use the unit of electrical energy is kWH, which implies 1 kW power consumed for one hour.

**Effects of Current Electricity:** Beauty of Current Electricity is that, on it everything happen but nothing can be seen. Realization of the happening is through close examination and correlation of effects with its basic laws. The current electricity does not assume importance by virtue of its existence, rather it is hysterically escalated due to usefulness of its effects which have found an important application through technology be it domestic life or interaction with the outside world. The effects are classified into -a) Thermal Effects, b) Chemical Effect and c) Magnetic Effects. While elaboration of Thermal and Chemical Effects follows in this part, *Magnetic Effects will be elaborated in parts to follow*.

**Thermal Effects of Electric Current:** Thermal effect of current are of two types – a) Heating Effect, it is an irreversible phenomenon and b) Thermo-Electric Effect – a reversible phenomenon and are elaborated here.

Heating Effect: It is seen that when current is passed through a resistance it consumers electrical power.

James Prescott Joule made a careful study of the phenomenon during 1840 and 1843 and demonstrated through an experiment that this electrical power is converted into heat such that  $E = P \cdot t = (I^2 R) \cdot t = W = JH$ . This is known as Joule's Law of Heating. Here, **E** is the energy dissipated by resistance, when current **I** pass through it for time **t** seconds, **P** is the power in watts (rate of energy =  $I^2 R$  consumed per second, **J** is the Joule's constant, and **H** is heat generated by the resistance in Calorie. Equivalence of units of energy to be noted are 1 W-sec=1 Joule= 1 Nm. This is in conformity with the *Law of Conservation of Energy*.



**Thermo-electric Effect of Current:** When electric current is passed through a joint of two dissimilar metals, heating or cooling at the joint takes place. Likewise in closed loop of Two dissimilar metals (Nickel-Copper), with one joint at higher temperature  $T_1$  and the other at  $T_2$ , such that  $T_1 > T_2$ , an electric current is established in the loop. *This current is due to differential concentration of electrons in the Two metals at the Two joints, which produces an emf called* **Thermo EMF** to cause a circulatory current, in accordance with

the Ohm's Law, in the bimetallic loop. This phenomenon is totally a different from the one occurring in



bimetallic strip, as elaborated in Heat and Thermodynamics. This effect is known as **Seebeck Effect**, discovered by **Thomas Johann Seebeck** in 1821. Direction of Thermo EMF is used to sequence metals such that at cold junction current is from metal occurring earlier in the sequence to the metal occurring later in the sequence, which is known as

*Thermoelectric Series.* This series of metals is - Antimony, Nichrome, Iron, Zinc, Copper, Gold, Silver, Lead, Aluminium, Mercury, Platinum-Rhodium, Platinum, Nickel, Bismuth, Constantan and Bismuth.

This Thermo EMF  $E_{AB}$  between two metals is seen to vary with temperature difference  $\theta$ . Let, temperature of cool joint is  $0^{0}C$  and  $\theta^{0}C$  then  $E_{AB} = \alpha_{AB}\theta + \beta_{AB}\theta^{2}$ . If  $E_{AB}$  is Thermo EMF between metal A and B, and  $E_{BC}$  is Thermo EMF between metal B and C, then Thermo EMF between metal A and C is and  $E_{AC} = E_{AB} + E_{BC}$ .

Jean Charles Athanase Peltier in 1834 discovered that, *if an electric current is flown through junction of two conductors heat may be generated or absorbed, which is just reverse of Seebeck Effect. This discovery is known as* **Peltier Effect**.

In 1854, **William Thomson** discovered that if a long metal has non-uniform temperature along its length, and a current is driven through it then heat is produced or absorbed in different sections of the metal in addition to Joule's Effect, and is known as **Thomson's Effect**. In fact Thomson Effect is combining the Seebeck and Peltier Effect.

**Thermo-Chemical Effect of Electric Current:** In liquids molecules break into (+)ve and (-)ve ions due high dielectric constant of the liquid medium, which weakens the electrostatic binding forces between the ions This is known as **electrolytic solution**. This results into deposits of ions as free molecules when an electric current is passed through the electrolytic solution. This phenomenon is known as Electrolysis, which converts a dielectric-solution into a conductor. Michael Faraday in 1834 published quantitative relationship of electrolysis and is known as Faraday's Laws of Electrolysis. In the same year Carlo Matteucci has also discovered Laws of Electrolysis, independently. The Laws of Electrolysis are – a) Mass of a substance deposited or liberated at an electrode is proportional to the electric charge through it, b) Mass of substance deposited or liberated at an electrode is proportional to the chemical equivalent of the substance, and is mathematically represented as  $m = \left(\frac{Q}{F}\right) \left(\frac{M}{z}\right)$ . Here, m is the mass of substance liberated in grams,  $Q = \int I dt$  is the total electric charge passed through the electrode in Coulomb, M is the molar mass of substance in grams per mol, z is the valency of the ions of the substance and F is the Faraday's Constant. This is also written as  $m = \left(\frac{Q}{F}\right) E$ , where

$$E = \frac{M}{r}$$
, is called **chemical equivalent of substance**.

**Summary:** As one advances into journey into Physics, he finds increasing integration of Mathematics into Physics. The advent of current electricity has opened a new era of not only nature but transforming world through technological developments.

*Extending, Electrostatics, this Part on Current Electricity elaborates basics laws of electrical circuits and its Thermal and Chemical effects. In Part-I concepts of waves and in Part- II Sound Waves were elaborated. Understanding current electricity is slightly different from other topics, where one could observe the phenomenon. In this topic everything happen, but nothing is visible. But, verification of phenomenon of current electricity is through observations of its effects. At this point, some of the inter-related topics are referred to but their elaboration has been deferred, till related concepts are covered.<i>Nevertheless, readers are welcome to raise their inquisitiveness, beyond the contents, through <u>Contact Us</u>.* 

Solving of problems, is an integral part of a deeper journey to make integration and application of concepts intuitive. This is absolutely true for any real life situations, which requires multi-disciplinary knowledge, in skill for evolving solution. Thus, problem solving process is more a conditioning of the thought process,

rather than just learning the subject. Practice with wide range of problems is the only pre-requisite to develop proficiency and speed of problem solving, and making formulations more intuitive rather than a burden on memory, as much as overall personality of a person. References cited below provide an excellent repository of problems. Readers are welcome to pose their difficulties to solve any-problem from anywhere, but only after two attempts to solve. It is our endeavour to stand by upcoming student in their journey to become a scientist, engineer and professional, whatever they choose to be.

Looking forward, these articles are being integrated into Mentors' Manual. After completion of series of such articles on Physics, representative problems from contemporary text books and Question papers from various competitive examinations shall be drawn and supported with necessary guidance to evolve solutions as a dynamic exercise which is contemplated to accelerate the conceptual thought process.

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## **SOLUTION TO THE PUZZLE-May'17: ON MATHEMATICS**

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**Kumud Bala** 

**GROWING WITH CONCEPTS - Chemistry** 

## CHEMICAL THERMODYNAMICS

#### First law of thermodynamics

It is simply the law of conservation of energy. It states that "energy can neither be created nor destroyed although it may be converted from one form to another." Or "the total energy of the universe (i.e., the system and surrounding) remains constant, although it may undergo transformation from one form to the other."

#### Justification for first law of thermodynamics

There is no theoretical proof for it. This law is purely based on human experience. Following observation support the validity of this law.

1. Whenever a certain quantity of some form of energy disappears, an exactly equivalent amount of some other form of energy is produced.

**Examples:** 

- In the operation of an electric fan, the electrical energy consumed is converted into mechanical work which moves the blades.
- The electrical energy supplied to a heater is converted into heat.
- The electrical energy passing through the filament of a bulb is converted into light.
- Water can be decomposed by electric current into gaseous hydrogen and oxygen. It is found that 285.8kJ of electrical energy is used to decompose 1 mole of water.

$$H_2O(l) + 286.2KJ \rightarrow H_{2(g)} + \frac{1}{2}O_{2(g)}$$

This energy must have been stored in  $H_2$ and  $O_2$  since same amount of energy in the form of heat is released when 1 mole of water is obtained from gaseous hydrogen and oxygen.

 $\mathrm{H_2}{+}\frac{1}{2}\mathrm{O_2} \rightarrow \mathrm{H_2O}\left(l\right) + 286.2\mathrm{K\,J} \text{ (heat energy)}$ 

Electrical energy supplied = heat energy produced. Thus, energy is conserved in one form or one form of energy may change into the other form.

- 2. It is impossible to construct a perpetual motion machine i.e., a machine which would produce work continuously without consuming energy (Helmholtz 1847).
- There is an exact equivalence between heat and mechanical work i.e., for every 4.184 joules of work done, 1 calorie of heat is produced and vice-versa (James Joule 1840).
   Above observation justify that energy is always conserved though it may change its form.

## Mathematical formulation of the first law of thermodynamics

The internal energy of a system can be increased in two ways:

- (i) by supplying heat to the system, and
- (ii) by doing work on the system.



Suppose the initial internal energy of the system =  $E_1$ . If it absorbs heat q, its internal energy will become =  $E_1$ + q. If further work w is done on the system, the internal energy will further increase and become=  $E_1$ +q+w. This is the final internal energy  $E_2$ .

(P =

Now  $E_2 = E_1 + q + w$   $E_2 - E_1 = q + w$ Or  $\Delta E = q + w$ . If w is work of expansion then,  $w = -P\Delta V$ external pressure,  $\Delta V =$  change in volume) Then  $\Delta E = q - P\Delta V$ 

Or 
$$q = \Delta E + P \Delta V$$

If the process is carried out at constant volume, then  $\Delta V{=}~o$ 

So  $\Delta E = q_v$  i.e, change in internal energy is equal to the heat absorbed or evolved at constant temperature and constant volume.

Neither q nor w is a state function. Yet the quantity q+w is a state function, because  $\Delta E$  is a state function.  $\Delta E = q + w$ . For an ideal gas undergoing an isothermal change  $\Delta E = 0$ , then q = -w i.e heat absorbed by the system is equal to work done by the system.

Internal energy is a state function: (A deduction from the first law of thermodynamics):-

Suppose the internal energy of a system under some conditions of temperature, pressure and volume is  $E_A$  (state A). Now suppose the conditions are changed, so that the internal energy is  $E_B$  (state B). If internal energy is a state function, the difference  $\Delta E = E_B - E_A$  must be same irrespective of the path from A to B. If not, then suppose in going from A to B by path 1, the internal energy increases by  $\Delta E$ , but on returning from B to A by path 2, internal energy decreases by  $\Delta E'$ . If  $\Delta E > \Delta E'$ , some energy has been created and if  $\Delta E < \Delta E'$ , some energy has been destroyed though we have returned to the same condition. This is against the first law of thermodynamics. Hence  $\Delta E$  must be equal to  $\Delta E'$  i.e., internal energy is a state function.

#### Internal energy change

According to first law of thermodynamics, if the process is carried out at constant volume,  $\Delta E = q_v$ , hence internal energy is the heat absorbed or evolved at constant volume.

#### **Enthalpy or Heat content**

If a process is carried out at constant pressure, the work of expansion is given by  $w = -P\Delta V$  where  $\Delta V$  is increase in volume and P is the constant pressure. According to first law of thermodynamics,

 $q=\Delta E-w$ ....(i)  $q_p=\Delta E + P\Delta V$ ....(ii) Suppose when the system absorbs  $q_p$  joules of heat, its internal energy increases from  $E_1$  to  $E_2$  and the volume increases from  $V_1$  to  $V_2$ .

$$\Delta E = E_2 - E_1 \dots (iv)$$
  

$$\Delta V = V_2 - V_1 \dots (v)$$
  
Therefore,  

$$q_p = (E_2 - E_1) + P(V_2 - V_1)$$
  

$$= (E_2 - E_1) + PV_2 - PV_1$$
  

$$= (E_2 + PV_2) - (E_1 + PV_1) \dots (vi)$$

Now, as E, P and V are the functions of state, therefore, the quantity E + PV must also be a state function.

The thermodynamic quantity E + PV is called heat content or enthalpy of the system and is represented by H, thus , if H<sub>2</sub> is the enthalpy of the system in final state and H<sub>1</sub> is the value in the initial state, then H<sub>2</sub>=  $E_2 + PV_2$  and H<sub>1</sub> =  $E_1 + PV_1$ . Putting these values in equation (vi), we get

 $q_p = H_2 - H_1$  or  $q_P = \Delta H_1$  (vii)

where  $\Delta H = H_2$ -  $H_1$  is the enthalpy change of the system.

Hence "enthalpy change of a system is equal to the heat absorbed or evolved by the system at the constant pressure."

It may be remembered that as most of the reactions are carried out at constant pressure (i.e., in the open vessels), the measured value of the heat evolved or absorbed is the enthalpy change.

Further, putting the value of  $q_p$  from equation (vii) in equation (iii), we get  $\Delta H = \Delta E + P \Delta V$ 

Hence, "enthalpy change accompanying a process may also be defined as the sum of the increase in internal energy of the system and the pressurevolume work done, i.e., the work of expansion."

#### Physical concept of enthalpy or heat content

The enthalpy has been defined by the mathematical expression, H=E+PV. Let us try to understand what this quantity really is. Every substance or system has some definite energy stored in it, called the internal energy. This energy may be of many kinds. "The energy stored within the substance or the system that is available for conversion into heat is called heat

content or enthalpy of the substance or the system." Like internal energy, absolute value of the enthalpy of a substance or the system cannot measure and fortunately this is not required also. In thermodynamic process, we are concerned only with change in enthalpy ( $\Delta$ H) which can be measured experimentally. Further, it may be mentioned here that as E and V are extensive properties, therefore, the enthalpy is also an extensive property.

#### Relationship between $\Delta H$ and $\Delta E$

It has already been discussed that  $q_p = \Delta H$  and  $q_v = \Delta E$ . It has also been derived already that at constant pressure,  $\Delta H = \Delta E + P\Delta V$ . The difference between  $\Delta H$  and  $\Delta E$  is not usually significant. When the systems involve gases, the difference becomes significant.

Consider a chemical reaction taking place at a constant temperature (T) and pressure (P). Let  $V_r$  is the total volume of the gaseous reactants and  $V_p$  is the total volume of the gaseous products,  $n_r$  is the total no. of mole of gaseous reactants,  $n_p$  is the total no. of mole of gaseous products.

According to ideal gas equation PV=nRTAt constant T and P, For reactants =  $PV_r=n_rRT$  .....(i) For products =  $PV_p=n_pRT$  .....(ii) Subtracting equation (i) from (ii) we get  $P(V_p-V_r) = (n_P-n_r)RT$  or  $P\Delta V = \Delta n_gRT$ Now  $\Delta H = \Delta E + P\Delta V$ 

 $\Delta H = \Delta E + \Delta n_g RT$ 

[energy change at constant P]=[energy change at constant V]+[change in no. of gaseous moles]RT.

 $\Delta H$  will be equal to  $\Delta E$  under the following condition:-

- Reactions which do not involve any gaseous components e.g. HCl<sub>(aq)</sub>+NaOH<sub>(aq)</sub>→NaCl<sub>(aq)</sub>+H<sub>2</sub>O<sub>(l)</sub>
- 2. Reaction carried out in closed vessels of fixed volume  $\Delta V=0$ ,  $\Delta H=\Delta E+0xP=\Delta E$
- 3. Reaction which involve gaseous products and reactants but there is no change in the

number of moles of the gaseous components.  $H_{2(g)}+Cl_{2(g)}\rightarrow 2HCl_{(g)}$  Volume change is zero  $\Delta n_g=0, \Delta H=\Delta E+\Delta n_g RT = \Delta E+oxRT=\Delta E$ 

In gaseous reaction,  $\Delta n_g$  is not equal to zero.  $\Delta H$  and  $\Delta E$  will be different.

- 1. Reaction in which there is an increase in the number of moles of the gaseous components.  $\Delta n_g$  is positive. The enthalpy change ( $\Delta H$ ) is greater than internal change (E) i.e.,  $\Delta H > \Delta E$ e.g  $C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta n_g = (1 - \frac{1}{2} = + \frac{1}{2})$  $PCl_{5(g)} \rightarrow PCl_{3(g)} + Cl_{2(g)} \quad \Delta n_{(g)} = (2 - 1 = 1)$
- 2. Reaction in which there is a decrease in the no. of moles of the gaseous components.  $\Delta n_g$ is negative and hence  $\Delta H < \Delta E$  e.g,  $CO_{(g)} + \frac{1}{2}$  $O_2 \rightarrow CO_{2(g)}$   $(\Delta n_g = 1 - 1\frac{1}{2} = -\frac{1}{2})$ ,

$$N_{2(g)}+3H_{2(g)}\rightarrow 2NH_{3(g)}$$
 ( $\Delta n_g=2-4=-2$ )

 $\Delta n_g = 0, \Delta H = \Delta E$   $\Delta n_g = +ive, \Delta H > \Delta E$  $\Delta n_g = -ive, \Delta H < \Delta E$ 

Example:- If water vapour is assumed to be perfect gas, molar enthalpy change at 1 bar and  $100^{\circ}$ C is 41 kJ mol<sup>-1</sup>. Calculate the internal energy change when (i) 1 mol of water is vaporized at 1 bar pressure and  $100^{\circ}$ C. (ii) 1 mol of water is converted into ice.

Solution:- (i) For vaporization of water, the change is:  $H_2O(l) \rightarrow H_2O(g) \Delta n_g = 10 = 1$ 

 $\Delta H = \Delta U + \Delta n_g RT \quad OR \quad \Delta U = \Delta H - \Delta n_g RT = 41.00 kJ \quad mol^{-1} - (1 \quad mol) x(8.314x \quad 10^{-3} kJ \quad K^{-1} \quad mol^{-1}) \quad (373K) = 41.00 - 3.10 kJ mol^{-1} = 37.90 kJ mol^{-1}$ (ii) For conversion of water into ice, the change is  $H_2O$  (l)  $\rightarrow H_2O$  (s), in this case, the volume change is negligible. Hence,  $\Delta H = \Delta U = 41.00 kJ mol^{-1}$ .

Assignment on the above on the next page...

			Assignm	ent								
1.	In an endothermic rea	action:			(A) ∆H<∆E		(B) ΔH>ΔE					
	(A) $\Delta$ H is negative				(C) $\Delta H = \Delta E$	l=0						
	(B) heat is given to the	e surroundings		4.	An adiabatic process is one in which							
	(C) enthalpy of the re	eactants is less that	an that of		(A) ∆E=q							
	the products				(C) q=0		(D) q=	ΡΔV				
	(D) $\Delta E$ is negative			5.	In exothermic reaction ( $H_r$ = enthalpy of re							
2.	$\Delta H$ is related to $\Delta E$ as				and H <sub>p</sub> = entha	alpy of pro	ducts)					
	(A) $\Delta$ H- $\Delta$ E = P $\Delta$ V	(Β) ΔΗ=ΔΕ- ΡΔV			(A) H <sub>r</sub> <h<sub>p</h<sub>		(B) H <sub>r</sub> >	>Hp				
	(C) ΔΗ+ΔΕ =ΡΔV	(D) $\frac{\Delta H}{\Delta E} = p \Delta V$			(C) H <sub>r</sub> = H <sub>p</sub>		(D) H <sub>r</sub> :	=H <sub>p</sub> and $\Delta$	H <sub>p</sub> =0			
3.	For the reaction: $C_{(s)}$ +	$O_{2(g)} \rightarrow CO_{2(g)}$										
			S. (B)	(C) .t	3. (C)	(A)	.2.	ז <sup>.</sup> (כ)	rever			



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## Answers to Science Quiz in May'17

### **Kumud Bala**

1.(c) 2.(b) 3.(d) 4.(d) 5.(c) 6. (a) 7.(b) 8.(a) 9.(d) 10.(a) 11.(b) 12.(c) 13.(b) 14.(d) 15.(c)

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(Answers to this Science Quiz – June'17 shall be provided in Supplementary e-Bulletin dt 1<sup>st</sup> July17)

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**Kumud Bala** 

## **SCIENCE QUIZ- June'17**

# 1. Why a man sitting in a moving bus suddenly moves forward when the bus suddenly stops?

- (A) due to inertia
- (B) due to brakes
- (C) due to negative acceleration
- (D) due to force exerted by the machine
- 2. The person sitting in a moving car has an energy of type
  - (A) kinetic energy
  - (B) potential energy
  - (C) both kinetic and potential energy
  - (D) gravitational potential energy
- 3. Why does mud fly away in hitting carpet with stick?

(A) due to friction(B) due to inertia(C) due to force of stick(D) both (A)and (B)

- 4. Why transition elements are called so?
  - (A) due to variable valency
  - (B) having different colours
  - (C) both (A) and (B)
  - (D) constant valency
- 5. The reason for preparing a super saturated solution, is
  - (A)it can't be prepared at room temperature
  - (B) solute particles can't be homogenized
  - (C) due to presence of oxygen in air
  - (D) none of these
- 6. Enthalpy of products of exothermic reaction is
  - (A) less
  - (B) more

(C) sometimes less and sometimes more (D) equal

7. The person who evolved the concept of relationship between mass and energy, is(A) Einstein (B) Planck

- (C) Dalton (D) Rutherford
- The person associated with the invention of computers, is
   (1) E I

(A) Edison	(B) Babbage
(C) Mac Millen	(D)
Newton	

- 9. The velocity of light was first measured by(A) Einstein(B) Newton(C) Romer(D) Galileo
- 10. The Doctor's thermometer was discovered by(A) Fahrenheit(B) Edison(C) Galileo(D) none of these
- 11. Numismatics is the study of
  - (A) coins(B) number(C) stamps(D) space
- (c) stamps
  (d) space
  (e) stamps
  (f) space
  (f
- (C) numismatics (D) none of these 13. Instrument to measure pressure is:
- (A) saccharimeter (B) ammeter (C) manometer (D) lactometer
- 14. Angstrom measures:
  - (A) quantity of liquid
  - (B) length of light waves(C) length of cables (D) speed of ships.
- 15. The scientist who first discovered that the earth revolves round the sun:
  - (A) Newton (B) Dalton
  - (C) Copernicus (D) Einstein
- 16. The circulation of blood in human body was discovered by:
  - (A) Edward Jenner (B) Joseph Lister
  - (C) William Harvey (D) Jonon Esals
- 17. The credit of developing the polio vaccine goes to:
  - (A) Jonas Salk(B) Alb E. Sabin(C) Selman Waksman(D) none of these
- 18. The wrong combination is:
  - (A) James Watt: steam engine
  - (B) A.G. Bell: telephone
  - (C) J. L. Baird: television
  - (D) J.Perkins: penicillin
- 19. The correct combination is:
  - (A) typewriter: Remington
  - (B) Dynamite: Dunlop
  - (C) evolution: Darwin
  - (D) aeroplane: Harvey

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## **Theme Song :**

<u>PREMISE:</u> We are pleased to adopt a song " इतनी शक्ति हमें देना दाता....." from a old Hindi Movie Do

Aankhen Barah Haath दो आँखें बारह हाथ of year 1957, directed by The Late V. Shantaram. The lyrics are by Shri Bharat Vyas, singer Melody Queen Sushri Lata Mangeshkar, and Music Direction by Vasant Desai. It has become a widely accepted inspirational song and/or prayer in many educational institutions and socially inspired initiatives engaged in mentoring of unprivileged children. This newly formed non-organizational initiative, being selflessly operated by a small set of compassionate persons, finds its philosophy in tune with the song and conveys its gratitude to all he eminent persons who brought out the song in a manner that it has attained an epitome of popularity. While working its mission and passion, the group invites one and all to collectively complement in grooming competence to compete among unprivileged children. The song/prayer goes as under -

इतनी शक्ति हमें देना दाता, मन का विश्वास कमजोर हो ना हम चले नेक रस्ते पे हमसे, भूलकर भी कोई भूल हो ना ॥

दूर अज्ञान के हो अंधेरे, तू हमें ज्ञान की रोशनी दे हर बुराई से बचते रहें हम, जितनी भी दे भली ज़िन्दगी दे बैर हो ना किसी का किसी से, भावना मन में बदले की हो ना ||

इतनी शक्ति हमें देना दाता, मन का विश्वास कमजोर हो ना हम चले नेक रस्ते पे हमसे, भूलकर भी कोई भूल हो ना ॥

हम ना सोचें हमें क्या मिला है, हम ये सोचे किया क्या है अर्पण फूल खुशियों के बाँटे सभी को, सब का जीवन ही बन जाए मधुबन अपनी करुणा का जल तू बहा के, कर दे पावन हर एक मन का कोना ||

इतनी शक्ति हमें देना दाता, मन का विश्वास कमजोर हो ना हम चले नेक रस्ते पे हमसे, भूलकर भी कोई भूल हो ना ॥



Together Each Achieves More (TEAM)

Every end, so also end of this e-Bulletin, is a pause for a review, before re-continuing of a journey far beyond ...



