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GYAN-VIGYAN SARITA: शिक्षा

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HAPPY BASANT PANCHAMI AND BEST OF LUCK FOR FINAL EXAMINATIONS

या कुन्देन्दुतुषारहारधवला या शुभ्रवस्त्रावृता या वीणावरदण्डमण्डितकरा या श्वेतपद्मासना। या ब्रहमाच्युत शंकरप्रभृतिभिर्देवैः सदा वन्दिता सा मां पात् सरस्वती भगवती निःशेषजाड्यापहा॥१॥

DEVIKA.M

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

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<u> संपादकीय</u>

हमारे शिक्षित युवाओं का स्तर

संदीपन ऋषि का नाम सभी जानते हैं। उनके यहाँ सुदामा और कृष्ण शिक्षा प्राप्त किये। भीष्म ने ऋषि परशुराम से शिक्षा ली। भीष्म क्षत्रिय थे। कालांतर में परशुराम ने क्षत्रिय कुमारों को शिक्षा देने से मना कर दिया क्योंकि क्षत्रियों ने उनके पिता की हत्या कर दी थी। वह केवल ब्राह्मणों को ही शिक्षा देते थे। कर्ण ने ब्राह्मण बनकर परशुराम से शिक्षा ली परंतु परशुराम को जब वास्तविकता का पता चला तो उन्होंने उसे श्राप दे दिया कि जब उसे सीखी विद्या की सबसे अधिक जरुरत होगी तभी वह उनसे सीखी विद्या भूल जायेगा। आचार्य द्रोण ने एकलव्य को शिक्षा देने से मना कर दिया था फिर भी उसने चोरी से उनकी मूर्ति का निर्माण कर, मूर्ति को ही गुरु मानकर, और एकांत में अभ्यास कर, धनुर्विद्या में पारंगत हो गया। चोरी पकड़े जाने पर उसे अपना अंगूठा गुरु को देना पड़ा।

ये कुछ ऐसे उदहारण हैं जहाँ शिक्षा प्राप्त करने के पहले शिक्षार्थी को गुरु के प्रति अनुशासनबद्ध होना पड़ता था। अनुशासनहीनता का शिक्षा प्राप्ति में कोई स्थान नहीं था। यदि शिक्षक की इच्छा हुई तो वह विद्यार्थी बनाता था अन्यथा उसे मना कर दिया करता था।

आज स्थिति बदल चुकी है। शिक्षा में सबसे अधिक भ्रष्ट आचरण समा गया है। कुछ शिक्षक तो नौकरी मिलने के बाद पुस्तकालय भी नहीं जाते हैं। विद्यार्थियों की क्या कहें ? यदि किसी विद्यालय ने अपने विद्यार्थियों पर कोई प्रतिबन्ध लगाया तो वे उसके खिलाफ एकजुट हो जाते हैं । हाल ही में दिल्ली के एक विद्यालय में सुरक्षा की दृष्टि से मोबाइल कैमरे से सेल्फ़ी लेने पर मनाही क्या हुई कि सभी ने इस पर आपत्ति कर दी। ऐसा लगा मानो विद्यालय में पढ़ाई की कम और सेल्फ़ी की ज्यादा जरुरत है। विद्यालय को प्रतिबन्ध वापिस लेना पड़ा।

मनमौजीपन का शिक्षा प्राप्ति में कोई स्थान नहीं होता है। चाहें वह अध्ययन का क्षेत्र हो अथवा अनुशासन का, हर दशा में विद्यार्थी को विद्यालय के नियमों को मानना चाहिए। प्रसिद्ध जवाहर लाल नेहरू विश्व विद्यालय में विगत कई महीनों से वातावरण दूषित बना हुआ है। यहां अन्य कारणों के साथ साथ एक प्रमुख कारण है अनुशासन की कमी।

शिक्षा सरकार की मोहताज हो गयी है। उत्तर प्रदेश में विधान सभा के चुनाव होने हैं। समस्त बोर्ड चाहें वह यू पी बोर्ड हो, सीबीएसई हो अथवा आई एस सी, किसी ने भी अपनी वार्षिक परीक्षाओं के लिए नियमित समय पर परीक्षा तिथियां घोषित नहीं की। सभी बोर्ड इस बात का इंतज़ार करते रहे कि पहले चुनाव की तिथि घोषित हो तब वे अपनी परीक्षा की तिथियां घोषित करेंगे जब कि आई आई टी ने अपनी परीक्षा की तिथियां समय पर घोषित कर दी थीं। क्या विडम्बना है कि स्कूल, कॉलेजों में पढ़ाई बंद कर , शिक्षक और कर्मचारियों की चुनाव में ड्यूटी लगाई जाती है। कक्षा ८ तक के सरकारी विद्यालयों की हालत तो यह है कि यहां के सभी शिक्षक -शिक्षिकाओं का बहुमूल्य समय मतदाता सूची जांचने, मतदान कार्ड बनवाने, और फिर घर घर जाकर सभी को मतदान कार्ड बांटने में ही बीत जाता है।

ज़रा इंजीनियरिंग ग्रेजुएट्स की दशा देखिये। करीब चार हज़ार इंजीनियरिंग और तकनीकी संस्थाओं से लगभग पंद्रह लाख ग्रेजुएट्स प्रतिवर्ष परीक्षा पास करते हैं। पर इनमें से करीब ८० प्रतिशत नौकरी पाने के योग्य नहीं होते हैं। कारण दिया जाता है कि उनमें प्रतिभा (Talent), कौशल (Skill), और मूल संकल्पनाओं की पर्याप्त समझ (Sufficient understanding of basic concepts) की कमी है। इनके बारे में सबसे मज़ेदार बात यह है कि ये सब के सब अपने बारे में न तो हिंदी और न ही अंग्रेजी में ही कुछ बता सकते हैं। एक वास्तविकता और है जो डरावनी है। वे सिद्धान्त (Theory) जानते हैं, पर उनका प्रयोग (Practical) कैसे करें यह उनको उनके कॉलेजों में नहीं बताया जाता है। स्पष्ट है कि सिखाने का तरीका बदलना होगा। भाषा की अज्ञानता (Poor language skill) को दूर करना होगा। हमारी शिक्षा को स्वकेन्द्रित (Selfcentred) से हटाकर समाज प्रेरक (Pro-society) बनाना होगा। उसमें नवपरिवर्तन (Innovation) लाना होगा, सामाजिक मूल्यों (Moral values) की कमी से उसको उबारना होगा और सब जानते हुए भी कुछ न आना (Jack of all and master of none) की सीख से बचना होगा।

हम हाल में जयपुर की प्राचीन स्मारकों को देखने गए। जयगढ़ किले की दीवारें नामों से सजी पड़ी थीं । लिखावट देखकर लिखने वाले अपढ़ नहीं लग रहे थे। कहीं कहीं तो प्लास्टिक के कचरे, पानी की बोतलें, कागज के लिफाफे भी जमीन पर बिखरे पड़े थे। कहां कहीं तो प्लास्टिक के कचरे, पानी की आदमी जब शहर आता है तब वह या तो डर से या अपनी आदत से कोई भी कागज़ या गन्दगी वहां नहीं फेंकता है जहाँ सफाई देखता है लेकिन शहर के लोग ऐसा नहीं करते हैं। शायद शहर के लोग अपने चारों ओर के समाज के प्रति नकारात्मक सोच रखते हैं और विद्यालय में सीखी अच्छी बातों को जल्दी भूल जाते हैं।

चलो, हम ऐसी शिक्षा दें तथा लें जिसमें सर्जनात्मकता (creativity) हो और नकारात्मकता (negativity) न हो।

The secret of genius is to carry the spirit of the child into old age, which means never losing your enthusiasm.

Aldous Huxley

The ultimate value of life depends upon awareness and the power of contemplation rather than upon mere survival

Aristotle

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HONESTY BREAKDOWN

Coordinator's Views

Ours is a country where भी राम disowned माँ सीता to behold his राज-धर्म, poor अवण moved on to carry his blind old parents on a pilgrimage, and there are numerous inspiring stories. Nevertheless, there were villains which lead to great wars which helped to glorify those noblemen. Every individual in his childhood must have heard grandmother's tales from the rich scriptures inherited by our country. Despite beginning of everyday with newspaper filled with sorts of atrocities of inhuman, financial misappropriation, political lineage, etc. is deeply disappointing. It is most unfortunate cases that are initiated based on prima facie charges and evidences, linger on for years and sometimes decades with accused and plaintiff claiming to be innocent and righteous, respectively. At the end of it, culprit is absolved on either lack of evidence or technicalities of law. It is quite intriguing and frustrating and impels to throw away the newspaper, and set on to daily routine and the day ends with a hope to have a better day tomorrow.

All religious scriptures provide for introspection, confession and penance, but all these words are suitable only for discourses, preaching and lectures to others and not for imbibing in one's own life. It is not a breakdown of honesty, an honesty of intentions and purpose. Here, an effort is being made to share introspection of honesty from personal experiences and how does it reversibly influence education.

moral, financial, intellectual, professional, and administrative systems. Home is the first place where his parents and other members of the family interact with him. These members, while carrying on their business of life, tend to ignore presence of child considering him to be innocent and ignorant. But, the child is picking the traits of survival from parents and other members of family. Home is the first school of the child where his values for eat to live or live to eat is shaped. These values find manifestation in earn to live or live to earn, as it grows in age. Survival instinct of human being has prompted developments growth of knowledge, inventions to transform it from predator stage into a global village with interdependencies of sorts. This forms the first premise that every individual, howsoever accomplished or otherwise, is a result of impact of the society, in which his home has played an elemental role, and biological constraints, if any.

In my formative period in professional career I had an opportunity to work under an Executive Engineer who was first to have a Master Degree in Engineering and his father was a veteran engineer from US in pre-independence era and migrant from Pakistan. The old man in first meeting gave two advices -a) an officer is one who not only creates work for his subordinates, but also for his boss, and **b**) officer is not a position but an opportunity to do good for the others. Initial feeling of getting an executive position was to eat, drink and be merry in a company of likes. In this mental frame, such sermons sounded quite lousy. But, a mix of values nurtured in childhood and the mould at office, under an officer with whom family level interactions had developed, forced an introspection to evolve necessity to live to work rather than just work to live. These, two propositions are complementary and not the least contradictory. Living requires work and is a necessity, to be able to do work. And when one lives to work, the result is far more than individual requirement. Such a person is never extravagant in spending his work on self but

A child grows in an environment which is influenced by *finds an outlet beyond self. This is an effect which happens* moral, financial, intellectual, professional, and administrative *so unknowingly that it can be better experienced than* systems. Home is the first place where his parents and other *explained*.

Looking back to all the developments of knowledge, science and technology, the pioneer philosophers, mathematicians and scientists had chosen to burn candles in their pursuits and on the contrary they were subjected to ridicule and torture, case of Socrates is the climax of it. Another, important observation is all these contributions are truth of nature which is universal, integrated and complementary to each other. The only one difference among them is that later contributions have tried to replace assumptions of the earlier ones with more substantiated arguments. Had this not been there human civilization would have continued to lives in hamlets of bigger size.

In the contemporary scenario filled with allegations and counter allegations related to honesty, the focus is generally of financial irregularities or use of power to extend favour or disfavour based on whims and fancies or likes or dislikes. It therefore becomes essential to understand the kind of irregularities and their remedy into education.

The first premise into the subject matter is when one grows in position; he tends to become more of society than of his own. Higher position is like a place in pyramid which offers a wider horizon to observe, think and act. In this position any act has its repercussions on a wider cross-section. In middle stage of my career the position called for managing a stage wide transition of certain system automation through in-house human resource of age old human systems all across the state as a part of state policy. Successful transition within the time frame, without disruption demanded a sense of realization of the human problems of a small support team and their prompt resolution, a sense of self-discipline, crediting the teammates for their accomplishments and preparedness to take blame of failures. This was a great learning and experience to lead in an adventure to live beyond. It has prompted how come there is breakdown of honesty, and the way it happens. Work to live, is a real life necessity, because unless one lives he cannot work beyond self for the larger good, essence of

A common man is very sensitive to financial irregularities, knowing well that systems are designed to provide a safeguard it against fraudulent. In such a situation it is a knife edge walk to execute good without getting inflicted with the charge of *Financial Dishonesty*. In such a situation, the biggest safeguard is honesty of purpose and self-discipline. Financial dishonesty is traceable, auditable and cognizable and simplest to sensitize the environment and dethrone any individual. Such a situation leads to complacency, lack of adventure and red-tape regime and thus it dissuades development and reforms. *This necessitated to look beyond how so called financial dishonesty from the perspective of purpose and is it really financial irregularity*.

In project execution, there is a back office engineering, and in-situ engineering. Despite, detailed engineering, during execution, requirements of in-situ moderation crop-up. This calls for on the spot decisions in-line with the letter and spirit the basic design philosophy. This is a pragmatic approach, which is seen to be missing in financial evaluation of a decision. Execution is a real time proposition and it has always a financial fallout which one justifies using on and administrative intellectual, professional, moral competence in command. If such moderations are manipulated to fulfill personal motives is it not an **Executive Dishonesty**?

Intellectual competence is all about justifying an act, happening or a situation using logic. In महाभारत, भगवान कृष्ण had logic to justify every act of पांडव to win over कौरव by differentiating धर्म-अधर्म. It is an unbeatable example of intellectual manouvere. An honest confession, of a lapse, in every system provides regulation of punishment, if it is inevitable. It seems to have become a walk of life where visible accused are exonerated to make a free walk without any kind of penance, and wrong doing perpetuates, *is this not an* **Intellectual Dishonesty?**

Growth of professional excellence is through exercise of professional knowledge, and every such exercise has learning for exercise of the skill in future occasions. Personal experience in professional career, cited above, a selfcorrective system was devised to log problems and their resolutions. The system worked and those contributed to make the automated system error/problem-free were recognized and it gave them a sense of pride by way of participation towards perfection. The laws of Thermodynamics proclaim that 100% efficiency cannot be achieved, and so is the case of man-made systems. Despite need of a continuous endeavor to attain perfection in the inhouse development, successors invested time and energy to highlight un-rectified deficiencies. Is it not a Professional Dishonesty? It leads to merit in other aspects of honesty to understand why no damage could be inflicted by successors.

Work to live, is a real life necessity, because unless one lives he cannot work beyond self for the larger good, essence of this discussion, Moral Honesty. But, it has invoked sense of Personal Social Responsibility, the guiding philosophy of Gyan Vigyan Sarita to work passionately without expectation of any reciprocation. This age and stage of life when one having done justice to the family, profession and position, generally have a healthy and active life. Even after reaching this stage of life if one works endlessly for selfaccomplishment *is it not Moral Dishonesty*? This question is dimensionless and can lead to an endless debate.

There is a commonly prevalent philosophy at work: काम मत कर,

काम का जिक्र कर, जिक्र की फिक्र कर, and **ABCDE** of work (**A**- first Avoid, **B**- if it comes again Bypass, **C**- if it still comes back Confuse, **D**- if the case is still compelling Diffuse its necessity, and **E**- execute it nothing works). This has given rise to belief that 90% people live on work done by 10% people. Are these 90% people not **Administratively Dishonest**?

Human being is the most wonderful creation of GOD, which only can live beyond, while living for itself. Fights between good-evil, honesty-dishonesty persisted ever since सती-युग,

perhaps it is the order of nature. Despite, good and honesty has not vanished on this earth. All that it demands is faith in self, and honesty of purpose. Adaption of this initiative in School of Excellence, Jhabua and prima facie acceptance at Adarsh Bal Niketan School, IITR-Campus signifies that there are good and honest people. These persons are ready to bestow their faith on an endeavor apparently selfless and honest. Such persons are ready to give it a try, and work for it, unless it turns out to be breach of trust. We continue to look forward optimistically with an openness to collectively complement with more of such elite persons or initiatives.

Conclusion: Impersonification of this initiative with its endowment to the almighty is with a sublime quote in Marathi is: तूच करता तूच करविता, शरण तुला भगवंता (you are the doer, you are the one to make me do it, we submit to you GOD). Without going into spiritual discourse, it is confessed that spiritual belief brings in humility; in its absence a sense of supremacy creeps in to fuel human urge of personal glorification and ambitions. This realization has led to keep this initiative a non-organizational; yet a small set of persons passionate to **democratize education** with a sense of **Personal Social Responsibility** (PSR) have selflessly joined in this mission which is **nonremunerative, non-commercial and non-political**.

This e-Bulletin is an effort to invite kind attention, concern and participation of elite to complement in the endeavor to the extent they can, rather than being possessive of their belongings. If this happens, our stay in heavenly abode will be with a satisfaction of leaving behind a legacy for our beloved descendants to live, work and grow in a society which is tending to be more caring and sharing. Page 6 of 44 1st Supplement to 2nd Quarterly e-Bulletin: Gyan- Vigyan Sarita: शिक्षा http://www.gyanvigyansarita.in/

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.

This column in next Supplementary e-Bulletin due on 1st Febroary'17 shall contain **Probability** in Mathematics, **Waves and Motions** in Physics and **Quantum Numbers** in Chemistry.

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**: $\Re and$ 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>20th of this month</u> to enable us to incorporate your contribution in next bulletin, <u>subhashjoshi2107@gmail.com</u>.

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

- 2nd monthly Supplement to Quarterly e-Bulletin <u>Gyan-Vigyan Sarita</u>: 1987 shall be brought out 1st March'17
- And this cycle monthly supplement to Quarterly e-Bulletin Gyan-Vigyan Sarita: 剤細 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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IMPORTANCE OF PHYSICAL EDUCATION

Aarti Sharma

Human life does not exist without physical movement. Physical activity is essential to prevent and reduce risks of many diseases besides adding a sense of purpose and quality to life.

Physical education should, therefore, constitute an integral and important part of the education system as it has an imperative role in developing physical and mental health of the children from kindergarten to high school stage. Many educational objectives are achieved by means of big muscle activities involving games and sports, gymnastics, exercise and other physical activities. Thus, educators should emphasize the importance of a strong program for physical education and place a priority on children being active at school keeping in view of the immense social and mental benefits that flow from physical education.

Educationists' View point : According to the USA based Institute, <u>National Association of Sports and Physical</u> <u>Education (NASPE)</u>, kids in elementary school need to spend one hundred fifty minutes per week in physical education. Most of the schools regrettably do not follow this but those who do can expect lifetime benefits for the students. In fact, a majority of the curriculum setters have misconception about the physical education and ignore its role in the healthy growth and development of the child.

Schools have either eliminated or shortened their requirements for physical education to raise the test scores of students by spending less time in the sports field and more time in the classroom. Non realization of benefits of physical education has made it the most neglected component of the modern education system resulting in raising a deskbound slothful young generation which sometimes is not even able to outlive their parents due to inactivity and obesity.

How can a physical education program transform the young generation? :_The development of healthy young bodies is the biggest benefit of a well-developed school program of physical education as it can ensure a slew of benefits for the young generation as enumerated in succeeding points.

Improved physical fitness : Physical fitness is required in leading a healthy lifestyle. Engaging school children in regular physical activities every day helps them to improve overall body composition, develop cardiovascular health as well as muscular flexibility, strength and endurance and maintain fitness. A regular physical activity improves the body's absorption of nutrients, increases physiological processes and improves digestive processes. There is improved hand-eye coordination as well as good movements of the body, which helps in developing a healthy overall posture.

Tackling obesity:__Obesity is a severe health disease and can lead to many problems such as diabetes, heart problems and imbalances in hormones in children. The most common causes of obesity are genetic factors, lack of physical activity, unhealthy eating patterns, or a combination of these factors. This health problem can be greatly contained by encouraging physical education. Students involved in physical activities have a better chance of avoiding health related problems like obesity and control their weight.

Aids in Development of Locomotors and non-loco motor <u>skills</u>: Physical Education helps in the advancement of critical skills required for a child's growth and development namely locomotors and non-loco motor skills. These skills form the foundation of the human movement and include walking running skipping, hopping, bending swaying pushing etc. A good physical education program is necessary for development of these skills with different kinds of physical exercises and games like gymnastics, ball games and various other activities, thereby leading to strengthening of these basic building block of coordination.

Stress reduction : Physical Education is also considered imperative for maintaining mental fitness by enhancing the energy to concentrate and reducing fatigue and stress. Physical activity becomes an outlet for releasing tension and anxiety, and facilitates emotional stability and resilience. Physical activity also improves the ability to sleep, which in turn reduces stress.

Improved self-confidence and self-esteem :_Physical education injects a strong sense of self-worth in children. As they acquire proficiency of skills and concepts in different physical activities they can become more confident and self-reliant.

Enhances peer relationships : Physical education can be a major force for competing with others successfully and provides opportunities to learn socializing skills. Being able to participate in games and sports is an important part of peer culture notably during childhood and adolescence.

Development of life long hobbies :_The period of preadolescence is when kids can build up a leaning towards Sports. Any of these sports introduced such as kabaddi, races tennis and basketball can turn into life-long hobbies. Page 8 of 44 1st Supplement to 2nd Quarterly e-Bulletin: Gyan- Vigyan Sarita: शिक्षा http://www.gyanvigyansarita.in/

Until they are introduced to it, children won't discover how enjoyable specific sports actually are.

Psychological Strength : In cricket there is not a single player who has never gone out, in Tennis there is no single player who has never missed a ball, in hockey there is no single player who was never taken over by opponent team and thus missed to score a goal. In essence every player learns to accept defeat and analyse to gain control over his game as well as recognize strength of others. In addition, most of the sports are played as a team, which inculcates a team spirit. Moreover, in sports judgements are required to made real-time and independently. This enhances sharpness of observation, quick decision making and risk taking

ability.. These three qualities of accepting defeat, team spirit, sharpness and risk taking ability are essential and important attributes of personality.

Given the numerous benefits that accrue to the students' mental and physical and psychological health from physical education apart from enhancing the academic performance and the social assimilation skills, the importance and indispensability of the physical education should no longer be ignored by the educationists and a well developed and implemented physical education program is the need of the hour to bring about much wanted changes in the sedentary lifestyle of the children apart from enhancing cognitive skills.



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ABOUT US

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This is an initiative, not an abrupt eruption, but driven by spirit of returning back to society with a spirit of Personal Social Responsibility (PSR) by a team of co-passionate persons who have survived many decades of rough weather conditions. It is not an organization, and it aims at Democratization of Education, in spiritual sense.

It works on non-remunerative, non-commercial and non-political manner. Its financial model is based on Zero-Fund-&-Zero-Asset, wherein participation is welcome from those who wish to contribute, with तन और मन. As and when the feel need of धन to supplement the initiative ownership of Funds and Assets is theirs, we are just user if it.

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 <u>Mentor's Manual</u> is being developed to support the cause.
- We are implementing this philosophy through <u>Online Mentoring</u>

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GROWING WITH CONCEPTS - Mathematics

BASIC CALCULUS

Prof. SB DHAR

Calculus is the study of how things change. The development of calculus and its applications to physics and engineering is probably the most significant factor in the development of modern science beyond where it was in the days of Archimedes. In this article, we shall restrict ourselves to the knowing of the Basics of the Calculus. We shall elaborate its uses in day to day life in some coming issue.

The present day's calculus has been divided into two parts:

- (a) Differential Calculus, and
- (b) Integral Calculus.

In differential calculus, students are taught Functions, their nature, domain, range, continuity, discontinuity, value of functions, limits, differentiability, uses of derivatives to find the nature of curves etc.

In integral calculus, students learn how to find the antiderivatives, their nature, their applications in evaluating the area, volume etc., of the bounded region.

Let us have a bird's eye view on the facts one by one.

FUNCTION

Definition:

If X and Y are two non-empty sets, we say that f is a function from X to Y if for every element x of X, there exists one and only one element f(x) in Y. The set X is called the domain. The set Y is called the codomain of f. The set of values of f(x) is called the range of f. The Range is always a subset of Codomain. Domain is represented by Df and Range is represented by Rf.

It is represented as $f: X \to Y$ or y=f(x) where $x \in X$ and $y \in Y$. The function *f* is called a real-valued function if for every real $x \in X$, there exists a real $y \in Y$.

TYPES OF FUNCTION

Identity Function

Let R be the set of real numbers. Identity function is defined as f : $R \rightarrow R$ by y = f(x) = x for each $x \in R$.

Domain of this function is R and the Range is also R.



Constant Function

Constant function is defined as $f : R \rightarrow R$ by y = f(x) = c, where *c* is a constant, for each $x \in R$.

Its domain is R and its range is only {c}.



Domain of the function in the graph is R and the Range is $\{3\}$.

Polynomial Function

It is defined as $f : R \to R$ where $y = f(x) = a_0 + a_1 x + a_2 x^2 + ... + a_n x^n$, n is a non-negative integer and $a_0, a_1, a_2, ..., a_n$ are Real Numbers.

Examples:

(a)
$$f(x) = 2 + 3x + 4x^2$$

(b) $f(x) = 5 + \sqrt{6}x + 9x^4$

Linear function

A function *f* defined for all real *x* by a formula of the form f(x) = ax + b, is called a linear function because its graph is *a straight line*.

In other words, we may say that all the polynomial functions whose highest degree is equal to 1 are called the Linear functions.

Rational Function

$$y = h(x) = \frac{f(x)}{g(x)}$$
, where $f(x)$ and $g(x)$ are polynomial

functions. This function is defined only when $g(x) \neq 0$.

Domain for this function is the domain common for both f(x) and g(x) for which y is defined.

Modulus Function

It is defined as $f(x) = |x|, x \in \mathbb{R}$.



Its domain is R and its Range is $[0,\infty)$

Signum Function

It is defined as $f(x) = \frac{|x|}{x}$ or

$$f(x) = \frac{x}{|x|}, x \in \mathbb{R} - \{0\}.$$

It is also defined as $f(x) = \begin{cases} 1, x > 0\\ -1, x < 0\\ 0, x = 0 \end{cases}$



The domain is R and the range is $\{-1,0,1\}$.

Greatest Integer Function

It is defined as $f(x) = \lfloor x \rfloor$



Domain of this function is R and the range is set of all Integers.

Examples:

$$\left[\frac{1}{2}\right] = 0, \left[-\frac{1}{2}\right] = -1, \left[3\frac{1}{2}\right] = 3, \left[-4\frac{1}{2}\right] = -5$$

Composite function

Let *f* and *g* be real valued functions of a real variable. The composite function of *g* and *f* is denoted by *gof* or (gof)(x)=g(f(x)) for all $x \in dom f$ such that $f(x) \in dom g$.

Periodic function: A function f(x) is said to be periodic if there exists such a T>0 for which f(x+T)=f(x-T)=f(x) for all $x \in X$.

Note:

There are infinitely many T satisfying the equality but the least positive is said to be the period.

All six basic trigonometric functions are periodic functions. Period of *sinx*, *cosx*, *cosecx*, *secx* is 2π and the period of *tanx*, *cotx* is π .

Factorial function

This is defined as f(n) = n! = 1.2.3....n. for all positive integers.

The domain of this function is the set of positive integers. The value of the function i.e., the Range increases so rapidly that it is more convenient to display this function in tabular form rather than as a graph. This is listed as the pairs (n, n!).

VALUE OF A FUNCTION

Example:

Let
$$f(x) = \frac{1}{1 + \frac{1}{1 + \frac{1}{x}}}$$
, then find the value of $f\left(\frac{1}{2}\right)$. Find the

domain of *f* also.

Solution:

To find
$$f\left(\frac{1}{2}\right)$$
, put $x = \frac{1}{2}$ in the expression.
 $f\left(x = \frac{1}{2}\right) = \frac{1}{1 + \frac{1}{1 + \frac{1}{x}}} = \frac{1}{1 + \frac{1}{1 + 2}} = \frac{1}{1 + \frac{1}{3}} = \frac{1}{1 + \frac{1}{3}} = \frac{3}{4}$

To find the domain of this function, we must keep in mind the fact that "the domain is the set of values of x for which f(x) has a unique value", and according to this, x cannot be 0 and -1 as these values make f(x) undefined. So the domain will be R- $\{-1,0\}$.

Determinate Form

When a unique value of an expression f(x) at x = a is possible, it is said to be in the

determinate form.

Example:

The expression $f(x) = \frac{x+1}{x+3}$ has unique value for each x when it is 0, 1, 2, 3 etc.

Indeterminate Form

When a unique value of an expression f(x) at x=a is not possible, it is said that it is in Indeterminate form.

Example:

The expression $f(x) = \frac{x-1}{x^2-1}$ becomes $\frac{0}{0}$, and cannot have

any value at x=1. Hence it is called to have indeterminate form at x=1.

Note:

- 1. If $Rf \subseteq Y$, it is called **Into** Function.
- 2. If Rf = Y, it is called **Onto** Function.
- 3. One-one function is called Injective.
- 4. Onto function is called Surjective.
- 5. One-one Onto is called Bijective.
- 6. **Inverse** of a function is defined only when it is one-one onto.
- 7. If f'(x) is possibly negative or positive then it is manyone.
- 8. If f'(x) > 0, for all real x then it is One-one onto.

9. If f(-x)=f(x) for all x, it is called an Even function.

- 10. If f(-x) = -f(x) for all x, it is called an Odd function.
- 11. The product of two even or two odd functions is always even function.
- The product of even and odd is always an odd function.
 Every function can be expressed as the sum of an even
- and an odd function. For example:

 $f(x) = \frac{1}{2} (f(x) + f(-x)) + \frac{1}{2} (f(x) - f(-x))$

14. Two functions f and g are equal if and only if

(i) f and g have the same domain, and

(ii) f(x) = g(x) for every x in the

domain.

LIMITS

Definition

Let f be a function defined in a domain which we take to be an interval (a,b). Let also h be a quantity between a and b.

We say $\lim_{x \to h^-} f(x)$ is the expected value of f at x=h given the

value of f near to the left of h. This value is called the Left hand limit of f at h.

We say $\lim_{x \to h^+} f(x)$ is the expected value of f at x=h given the

value of f near to the right of h. This value is called the Right hand limit of f at h.

When the Left Hand Limit is equal to the Right Hand Limit, we say that the Limit of the function exists at x=h and it is represented by $\lim f(x)$.

Some Properties of Limits

(a)
$$\lim_{x \to a} \{f(x) + g(x)\} = \lim_{x \to a} f(x) + \lim_{x \to a} g(x)$$

(b) $\lim_{x \to a} \{f(x) - g(x)\} = \lim_{x \to a} f(x) - \lim_{x \to a} g(x)$

(c)
$$\lim_{x \to a} \left\{ cf(x) \right\} = c \lim_{x \to a} f(x)$$

(d)
$$\lim_{x \to a} \{f(x).g(x)\} = \lim_{x \to a} f(x).\lim_{x \to a} g(x)$$

(e)
$$\lim_{x \to a} \frac{f(x)}{g(x)} = \frac{\lim_{x \to a} f(x)}{\lim_{x \to a} g(x)}$$
 provided $g(x) \neq 0$

Important methods to evaluate Limits

(a) Factorization: In this method, we factorize the Numerator and the Denominator, cancel the common factors and then put the value of the variable.

Example:

If
$$\lim_{x \to 3} \frac{x^3 - 13x^2 + 51x - 63}{x^3 - 4x^2 - 3x + 18} = \frac{a}{10}$$
, then find the value of *a*.

Solution:

By putting x=3, we get left hand expression to be 0/0.

We shall use method of factorization to eliminate the factor (x-3) from Numerator and Denominator.

$$\lim_{x \to 3} \frac{x^3 - 13x^2 + 51x - 63}{x^3 - 4x^2 - 3x + 18} = \frac{a}{10}$$

$$\Rightarrow \lim_{x \to 3} \frac{(x - 3)(x - 3)(x - 7)}{(x - 3)(x - 3)(x + 2)} = \frac{a}{10}$$

$$\Rightarrow \lim_{x \to 3} \frac{(x - 7)}{(x + 2)} = \frac{a}{10} \Rightarrow \frac{(3 - 7)}{(3 + 2)} = \frac{a}{10} \Rightarrow \frac{-4}{5} = \frac{a}{10}$$

$$\Rightarrow a = -8$$

(b) L'Hospital Rule:

When the expression is of the form 0/0 or ∞/∞ and both the Numerator and the Denominator are differentiable, we differentiate them separately and check whether they are in indeterminate form. When this form eliminates, we put the value of the variable.

Example:

If the derivative of
$$\sqrt{x}$$
 is $\frac{1}{2\sqrt{x}}$ for all x>0, and

$$\lim_{x \to 9} \frac{\sqrt{x} - 3}{x - 9} = \frac{1}{a}$$
 then find the value of a .

Solution:

On putting x=9 in the Left hand expression, it becomes $\frac{0}{0}$. It is

given that function is differentiable. We shall use L'Hospital Rule to evaluate this limit, i.e., differentiate Numerator and Denominator separately w.r.t x,

$$\lim_{x \to 9} \frac{\sqrt{x} - 3}{x - 9} = \frac{1}{a} \Longrightarrow \lim_{x \to 9} \frac{\frac{1}{2\sqrt{x}}}{1} = \frac{1}{a} \Longrightarrow \frac{1}{2\sqrt{9}} = \frac{1}{a} \Longrightarrow a = 6$$

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Example:

Evaluate:
$$\lim_{x \to 0} \left(\frac{1}{\sin x} - \frac{1}{x} \right)$$

Solution:

$$\lim_{x \to 0} \left(\frac{1}{\sin x} - \frac{1}{x} \right) = \lim_{x \to 0} \left(\frac{x - \sin x}{x \sin x} \right)$$

It is of the form 0/0. Let us apply L'Hospital Rule.

Differentiate Numerator and Denominator separately w.r.t x

$$= \lim_{x \to 0} \left(\frac{1 - \cos x}{x \cos x + \sin x} \right)$$
 on putting x=0, again it is of the form

0/0. Let us again differentiate Nr and Dr w.r.t x

$$= \lim_{x \to 0} \left(\frac{0 + \sin x}{-x \sin x + \cos x + \cos x} \right) = \lim_{x \to 0} \left(\frac{0}{1+1} \right) = 0$$

Some Important Limits

(a) Trigonometric Limits

$$\lim_{x \to 0} \frac{\sin mx}{mx} = 1$$
$$\lim_{x \to 0} \frac{\tan mx}{mx} = 1$$

Example:

Find the value of $\lim_{x \to 0} \frac{\sin 2x}{5x^2 + 7x}$

Solution:

On putting x=0, the expression becomes 0/0, an indeterminate form.

Let us use trigonometric limit $\lim_{x \to 0} \frac{\sin mx}{mx} = 1$

$$\lim_{x \to 0} \frac{\sin 2x}{5x^2 + 7x} = \lim_{x \to 0} \frac{2\sin x \cos x}{x(5x + 7)} = \lim_{x \to 0} \left(\frac{\sin x}{x}\right) \frac{2\cos x}{(5x + 7)}$$
$$= 1 \cdot \frac{2}{(7)} = \frac{2}{7}$$

(b)Exponential Limits

$$\lim_{x \to 0} (1 + mx)^{\frac{1}{mx}} = e$$
$$\lim_{x \to \infty} \left(1 + \frac{1}{x}\right)^x = e$$

Example:

Find the value of
$$\lim_{x \to \infty} \left(1 - \frac{5}{2x} \right)^{4x}$$
.

Solution:

Let us use the special limit $\lim_{x\to 0} (1+mx)^{\frac{1}{mx}} = e^{-\frac{1}{mx}}$

$$\lim_{x \to \infty} \left(1 - \frac{5}{2x} \right)^{4x} = \lim_{x \to \infty} \left\{ \left(1 - \frac{5}{2x} \right)^{\left(-\frac{2x}{5} \right)} \right\}^{-\frac{5(4x)}{2x}}$$
$$= e^{\lim_{x \to \infty} -\frac{5(4x)}{2x}} = e^{-10}$$

(c)The limits when x tends to infinity

Example:
$$\lim_{x \to \infty} \frac{1}{x} = 0$$

Example:

Evaluate
$$\lim_{x \to \infty} \frac{x^3 - 13x^2 + 51x - 63}{x^3 - 4x^2 - 3x + 18}$$

Solution:

The expression becomes of the form $\frac{\infty}{\infty}$ after replacing x by infinity. In this case we divide the Numerator and the denominator by the highest power of x i.e., x^3 .

$$\lim_{x \to \infty} \frac{x^3 - 13x^2 + 51x - 63}{x^3 - 4x^2 - 3x + 18} = \lim_{x \to \infty} \frac{1 - \frac{13}{x} + \frac{51}{x^2} - \frac{63}{x^3}}{1 - \frac{4}{x} - \frac{3}{x^2} + \frac{18}{x^3}}$$
$$= \frac{1 - 0 + 0 - 0}{1 - 0 - 0 + 0} = 1$$

CONTINUITY

A function *f* is said to be a continuous function at x=c if the left hand limit, the right hand limit and its value at *c*, coincide i.e.,

Limit = *value*,

Or,

Right hand limit= Left hand limit= Value at the point

A function f is said to be continuous in an open interval (a,b) if it is continuous at every point in this interval.

A function f is said to be continuous in the closed interval [a,b] if

(a) f is continuous in (a,b)

(b)
$$\lim_{x \to a^+} f(x) = f(a)$$

(c)
$$\lim_{x \to b^-} f(x) = f(b)$$

DISCONTINUITY

A function *f* is said to be discontinuous at x = a if

(a) $\lim_{x \to a_{-}} f(x)$ and $\lim_{x \to a_{+}} f(x)$ exist but are not equal.

(b) $\lim_{x \to a^{-}} f(x)$ and $\lim_{x \to a^{+}} f(x)$ exist and are equal but are not equal to f(a).

(c)f(a) is not defined.

Example:

If $f(x) = \frac{x^3 - 2x^2 - 2x - 3}{x^3 - 4x^2 + 4x - 3}$ for all $x \neq 3$. Explain how the

function f should be defined at x = 3 so that the function becomes a continuous function on all of R.

Solution:

$$\lim_{x \to 3} \frac{x^3 - 2x^2 - 2x - 3}{x^3 - 4x^2 + 4x - 3} = \lim_{x \to 3} \frac{(x - 3)(x^2 + x + 1)}{(x - 3)(x^2 - x + 1)}$$
$$= \lim_{x \to 3} \frac{(x^2 + x + 1)}{(x^2 - x + 1)} = \frac{13}{7}$$

So, if the value of the function is defined to be 13/7, equal to the limit, the function will become continuous.

DERIVATIVE AND DIFFERENTIATION

Definition of derivative

A function f(x) is said to have a derivative at x=h if the Right hand derivative is equal to the Left hand derivative. It is denoted

by
$$\frac{d}{dx}f(x)$$
 or $f'(x)$

Right hand derivative

$$\frac{d}{dx}f(x) = f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

Left hand derivative

$$\frac{d}{dx}f(x) = f'(x) = \lim_{h \to 0} \frac{f(x-h) - f(x)}{-h}$$

When

Right Hand Derivative = Left Hand Derivative = a finite value,

The function is said to have a derivative. The finite value is called the derivative of f(x) at x=h.

The process to evaluate the derivative is called **Differentiation**.

DERIVATIVE OF

A COMPOSITE FUNCTION

Example:

Suppose g is a differentiable function and that f(x)=g(x+5) for all x. If g'(1)=3, and f'(a)=3, then find the value of a.

Solution:

$$f(x) = g(x+5)$$

$$\Rightarrow f'(x) = g'(x+5) \text{ on differentiating both sides w.r.t x}$$

$$\Rightarrow f'(-4) = g'(1) \text{, putting } x+5=1 \text{ i.e., } x = -4$$

$$\Rightarrow f'(-4) = g'(1) = 3$$

$$\Rightarrow a = 3$$

Some Important Derivatives

(a) Power Rule

$$\frac{d}{dx}(x^n) = nx^{n-1}$$

(b) Exponential Rule

$$\frac{d}{dx}(a^{x}) = a^{x} \log_{e} a;$$
$$\frac{d}{dx}(e^{x}) = e^{x}$$

(c) Logarithmic Rule

$$\frac{d}{dx}(\log_a x) = \frac{1}{x\log_e a}; \quad \frac{d}{dx}(\log_e x) = \frac{1}{x}$$

Example:

Let $y = \log_3(x^2 + 1)^{\frac{1}{3}}$, and $\frac{dy}{dx} = \frac{2x}{a(x^2 + 1)}$, then find the value of a.

Solution:

$$y = \log_3 \left(x^2 + 1\right)^{\frac{1}{3}} \Rightarrow y = \frac{1}{3}\log_3 \left(x^2 + 1\right)$$
$$\Rightarrow \frac{dy}{dx} = \frac{1}{3} \cdot \frac{2x}{(x^2 + 1)\log_a 3}$$

On comparing the given expression with this expression,

 $a = 3\log_e 3$

(d) Derivative of the product of a constant and a function

$$\frac{d}{dx}(cf(x)) = c\frac{d}{dx}f(x)$$

(e) Sum and difference rule

$$\frac{d}{dx}(f(x)\pm g(x)) = \frac{d}{dx}f(x)\pm \frac{d}{dx}g(x)$$

(f) Product Rule

$$\frac{d}{dx}(f(x)g(x)) = f(x)\frac{d}{dx}g(x) + g(x)\frac{d}{dx}f(x)$$

(g) Quotient Rule

$$\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) = \frac{g(x)\frac{d}{dx}f(x) - f(x)\frac{d}{dx}g(x)}{\left(g(x)\right)^2}$$

if $g(x) \neq 0$

(h) Chain Rule

$$\frac{d}{dx}(f(g(x)) = f'(g(x))\frac{d}{dx}g(x))$$

(i) Implicit Differentiation

Example:

Differentiate *sin(xy)*=*xy* w.r.t *x*

Solution:

$$\sin(xy) = xy \Rightarrow \cos(xy) \left(x \frac{dy}{dx} + y \right) = \left(x \frac{dy}{dx} + y \right)$$
$$\Rightarrow \left(\cos xy - 1 \right) \left(x \frac{dy}{dx} + y \right) = 0 \Rightarrow \frac{dy}{dx} = -\frac{y}{x}$$

(j) Trigonometric functions derivatives

$$\frac{d}{dx}\sin x = \cos x$$
$$\frac{d}{dx}\cos x = -\sin x$$
$$\frac{d}{dx}\tan x = \sec^2 x$$

$$\frac{d}{dx}\cos ecx = -\cos ecx \cot x$$
$$\frac{d}{dx}\sec x = \sec x \tan x$$
$$\frac{d}{dx}\cot x = -\cos ec^2 x$$
$$\frac{d}{dx}\sin^{-1}x = \frac{1}{\sqrt{1-x^2}}$$
$$\frac{d}{dx}\cos^{-1}x = -\frac{1}{\sqrt{1-x^2}}$$
$$\frac{d}{dx}\tan^{-1}x = \frac{1}{1+x^2}$$
$$\frac{d}{dx}\cot^{-1}x = -\frac{1}{1+x^2}$$
$$\frac{d}{dx}\sec^{-1}x = \frac{1}{x\sqrt{x^2-1}}$$
$$\frac{d}{dx}\sec^{-1}x = \frac{1}{x\sqrt{x^2-1}}$$

Application of derivative

(a) Stationary point

A point *a* in the domain of a function *f* is called a stationary point of f if f'(a)=0. It is called a critical point of *f* if it is either a stationary point of *f* or if it is a point where the derivative of *f* does not exist.

(b) Slope of the tangent lines

$$\frac{dy}{dx}$$
 or $\frac{d}{dx}f(x)$ is called the slope.

Example:

Let
$$f(x) = \frac{x - \frac{3}{2}}{x^2 + 2}$$
 and $g(x) = \frac{x^2 + 1}{x^2 + 2}$. At what values of x do the curves $y = f(x)$ and $y = g(x)$ have parallel tangent lines?

Solution:

The point or points at which the curves will have parallel tangents is/are the solution points of the equation formed by equating f'(x)=g'(x).

and

$$f'(x) = \frac{x^2 + 2 - 2x\left(x - \frac{3}{2}\right)}{\left(x^2 + 2\right)^2}$$
$$g'(x) = \frac{2x\left(x^2 + 2\right) - 2x\left(x^2 + 1\right)}{\left(x^2 + 2\right)^2}$$

On solving

$$\frac{x^{2}+2-2x\left(x-\frac{3}{2}\right)}{\left(x^{2}+2\right)^{2}} = \frac{2x\left(x^{2}+2\right)-2x\left(x^{2}+1\right)}{\left(x^{2}+2\right)^{2}}$$

We get x=-1, x=2

(c) Point of Inflexion

The point at which $\frac{d^2 y}{dx^2} = 0$ is called the point of inflexion.

(d) Monotonicity: Increasing and decreasing functions,

A function y=f(x) is said to be strictly increasing if $\frac{dy}{dx} > 0$ and

strictly decreasing if $\frac{dy}{dx} < 0$.

A function
$$y=f(x)$$
 is said to be increasing if $\frac{dy}{dx} \ge 0$ and

decreasing if $\frac{dy}{dx} \le 0$.

Example:

Suppose that the derivative of a function *f* is given by $f'(x) = (x-2)^2(x+4)$, then find the interval on which *f* is increasing.

Solution:

A function f(x) is said to be increasing if and only if $f'(x) \ge 0$.

Hence, $f'(x) = (x-2)^2(x+4) \ge 0$

 \Rightarrow (x+4) ≥ 0 as (x-2)² is positive for all values of x.

 $\Rightarrow x \ge -4 \text{ or } x \in [-4, \infty).$

(e)Maxima and Minima: Local maxima and local minima, Absolute maxima and absolute minima, First derivative test, Second derivative test

FIRST DERIVATIVE TEST

If f'(x) changes sign from + to – as x increases through c, then c is a point of local maxima and f(c) is called the local maximum value of f(x).

If f'(x) changes sign from - to + as x increases through c, then c is a point of local minima and f(c) is called the local minimum value of f(x).

If f'(x) does not change the sign as x increases through c, then c is neither a point of local maxima nor a point of local minima. Such point is called a point of inflexion.

SECOND DERIVATIVE TEST

If the function y=f(x) is twice differentiable, then

- (a) x=c is a point of local maxima if f'(c)=0 and f''(c)<0;
 f(c) is the local maximum value of the function.
- (b) x=c is a point of local minima if f'(c)=0 and f''(c)>0; f(c) is the local minimum value of the function.

If f'(c)=0 and f''(c)=0, then the test fails and we should go through the first derivative test.

RATE OF CHANGE

Let a function be y=f(x).

$$\frac{d}{dx}f(x)$$
 is called the rate of change of y with respect to x.

Thus, if *s* represents the distance and *t* represents the time, then ds

 $\frac{ds}{dt}$ represents the change of distance with respect to time i.e., the speed.

TANGENT AND NORMAL

A line that touches a curve f(x) at a point (x_I, y_I) is named as the tangent to the curve at that point. Its equation is given by

$$y - y_1 = \left(\frac{dy}{dx}\right)_{(x_1, y_1)} (x - x_1)$$

The normal to the curve is defined as the line that is perpendicular to the tangent and passes through the point of contact. Its equation is given by

$$y - y_1 = -\frac{1}{\left(\frac{dy}{dx}\right)_{(x_1, y_1)}} (x - x_1)$$

APPROXIMATION

We know from the definition of derivative that

$$f'(x) = \lim_{\delta x \to 0} \frac{f(x + \delta x) - f(x)}{\delta x}.$$
 It means that the approximate value of $f'(x)$ is $\frac{f(x + \delta x) - f(x)}{\delta x}$

Or,
$$f(x + \delta x) = f(x) + f'(x)\delta x$$

 δx is taken with proper sign. If the function is increasing, it is positive (+). If the function is decreasing, it is negative (-).

ROLLE'S THEOREM

Let *f* be a continuous function defined on closed interval [a,b], differentiable on open interval (a,b) and f(a)=f(b), where *a* and *b*

are some real numbers, then there exists at least one point c in (a,b) such that f'(c)=0.

Example:

Verify the Rolle's Theorem for $f(x)=x(x-1)^2$ in [0,1].

Solution:

Given function is

- (a) Continuous in the interval [0,1].
- (b) It is differentiable in (0,1).
- (c) f(0)=f(1)=0

hence

$$f'(x) = (x-1)^2 + 2(x-1)x = (x-1)(x-1+2x)$$

= (x-1)(3x-1)

On solving (x-1)(3x-1) = 0 we get x=1 and 1/3. Since x=1 does not lie between 0 and 1 hence it is neglected and x=1/3 is the required value.

LAGRANGE' MEAN VALUE THEOREM

Let *f* be a continuous function defined on closed interval [a,b], differentiable on open interval (a,b), where a and b are some real numbers, then there exists at least one point c in (a,b) such that

$$f'(c) = \frac{f(b) - f(a)}{b - a}.$$

Example:

Let $f(x) = x^4 + x + 3$ for $0 \le x \le 2$. Find a point c whose existence is guaranteed by the mean value theorem.

Solution:

We shall search for the completion of Lagrange's Mean Value Theorem.

- (i) $f(x) = x^4 + x + 3$ is continuous being a polynomial between [0,2]
- (ii) $f(x) = x^4 + x + 3$ is differentiable between (0,2)

(iii)
$$f'(c) = 4c^3 + 1 = \frac{f(2) - f(0)}{2 - 0} = \frac{21 - 3}{2} = 9$$

 $\Rightarrow 4c^3 = 8 \Rightarrow c^3 = 2 \Rightarrow c = (2)^{\frac{1}{3}}$

(iv) Since $(2)^{\frac{1}{3}} \in (0,2)$, hence the conditions of Mean Value Theorem are satisfied.

INDEFINITE INTEGRATION

Integrals represent a family of curves. Integrals are also called as antiderivatives or primitives.

If two functions differ by a constant, then they have the same derivative. The process of finding integrals is called Integration.

If
$$\frac{d}{dx}f(x) = F(x)$$
, then we write $\int F(x)dx = f(x) + C$.

C is called the constant of integration and symbol \int is called the integration sign.

F(x) is called the derivative of f(x).

f(x) is called the integral of F(x).

Some Properties of Integral

$$\int (F(x) + G(x))dx = \int F(x)dx + \int G(x)dx$$
$$\int (F(x) - G(x))dx = \int F(x)dx - \int G(x)dx$$
$$\int (aF(x))dx = a \int F(x)dx$$

Some standard integrals

$$\int x^{n} dx = \frac{x^{n+1}}{n+1}, n \neq -1$$
$$\int \frac{1}{x} dx = \log_{e} x$$
$$\int e^{x} dx = e^{x}$$
$$\int \sin x dx = -\cos x$$
$$\int \cos x dx = \sin x$$
$$\int \tan x dx = \log \sec x$$
$$\int \cos e c x dx = \log(\cos e c - \cot x)$$
$$\int \sec x dx = \log(\sec + \tan x)$$

 $\int \cot x dx = \log \sin x$

METHODS TO EVALUATE INTEGRALS

(a) Using direct anti-derivatives

Example:

Integrate $\tan^2 x \text{ w.r.t.} x$

Solution:

$$\int \tan^2 x dx = \int (\sec^2 x - 1) dx = \int \sec^2 x dx - \int dx$$

 $= \tan x - x + C$, C is a constant of Integration

(b) Integration by substitutions or Change of variables

Example:

Integrate
$$\frac{2x}{x^2 - 1}$$
 w.r.t.x.

Solution:

$$\int \frac{2x}{x^2 - 1} dx = \int \frac{dt}{t} \text{ where } t = x^2 - 1$$
$$= \log t + C$$
$$= \log (x^2 - 1) + C$$

(c) Trigonometric integrals

Example:

Integrate $\sin^2 x$ w.r.t. x

Solution:

We know that sin²x is not a derivative of any known function. Let us change it to some known terms.

$$\cos 2x = 1 - 2\sin^2 x$$

Or,

$$\sin^{2} x = \frac{1}{2}(1 - \cos 2x)$$

$$\int \sin^{2} x dx = \frac{1}{2} \int (1 - \cos 2x) dx$$

$$= \frac{1}{2} \left(\int dx - \int \cos 2x dx \right)$$

$$= \frac{1}{2} \left(x - \frac{1}{2} \sin 2x \right) + C$$

Trigonometric substitutions

(**d**)

$$\int \frac{1}{\sqrt{4x-x^2}} dx$$

Solution:

$$\int \frac{1}{\sqrt{4x - x^2}} \, dx = \int \frac{1}{\sqrt{4 - (x - 2)^2}} \, dx$$

Put $x - 2 = 2\sin t \Rightarrow dx = 2\cos t dt$

Therefore,

$$= \int \frac{1}{\sqrt{4 - (x - 2)^2}} dx = \int \frac{2\cos t dt}{\sqrt{4 - 4\sin^2 t}}$$
$$= \int \frac{2\cos t dt}{2\cos t} = \int dt = t + C$$

$$=\sin^{-1}\frac{x-2}{2}+C$$

(e) Integration by parts

Rule: *II function must have integral*. ILATE Rule (I-Inverse, L-Lograrithmic, A-Algebraic, T-Trigonometric, E-Exponential function) is followed in selecting the first function.

$$\int (I.II) dx = I \int II dx - \int \left(\left(\frac{d}{dx} I \right) \int II \right) dx$$

Example:

Integrate x sinx w.r.t.x

Solution:

$$\int x \sin x dx = x \int \sin x dx - \int \left(\frac{d}{dx}x\right)(-\cos x) dx$$
$$= -x \cos x + \int \cos x dx$$
$$= -x \cos x + \sin x + C$$

(f) Partial fractions

When a fraction is decomposed into two or more fractions in such a way that their sums or differences together make the original fraction, then they are called the partial fractions of the original fraction.

For example:

$$\frac{3}{4} = \frac{1}{2} + \frac{1}{4}.$$

$$\frac{1}{2} \text{ and } \frac{1}{4} \text{ are called the partial fractions of } \frac{3}{4}.$$

WAYS TO FIND PARTIAL FRACTIONS

(a)
$$\frac{1}{(x-a)(x-b)} = \frac{A}{(x-a)} + \frac{B}{(x-b)}$$
, the values of A and B

can be calculated by equating both sides.

(b)
$$\frac{1}{(x-a)^2} = \frac{A}{(x-a)} + \frac{B}{(x-a)^2}$$

(c) $\frac{1}{x-a} = \frac{A}{x-a} + \frac{Bx+C}{a}$

$$=\frac{1}{(x-a)(x^2+b)} = \frac{1}{(x-a)} + \frac{1}{(x^2+b)}$$

Example:

Integrate
$$\frac{x}{1-x^2}$$
 w.r.t.x.

Solution:

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r = h

t = h

$$\frac{x}{1-x^2} = \frac{x}{(1-x)(1+x)} = \frac{A}{(1-x)} + \frac{B}{(1+x)}$$

Or, $x = A(1+x) + B(1-x)$
 $\Rightarrow 1 = A - B$ and $0 = A + B$
 $\Rightarrow A = \frac{1}{2}$ and $B = -\frac{1}{2}$
Hence, $\frac{x}{1-x^2} = \frac{x}{(1-x)(1+x)}$
 $= \frac{A}{(1-x)} + \frac{B}{(1+x)} = \frac{A}{2(1-x)} - \frac{B}{2(1+x)}$
Or,
 $\int \frac{x}{1-x^2} dx = \int \frac{dx}{2(1-x)} - \int \frac{dx}{2(1+x)}$
 $= \frac{1}{2} \log (1-x) - \frac{1}{2} \log (1+x)$

$$= -\frac{1}{2}\log_{e}(1-x) - \frac{1}{2}\log_{e}(1+x)$$
$$= -\frac{1}{2}\log_{e}(1-x^{2}) + C$$

DEFINITE INTEGRALS

It is denoted by $\int_{x=a}^{x=b} F(x) dx$.

a is called the lower limit and b is called the upper limit of the integral. It represents the area between the bounded regions.

It is evaluated by two ways:

- (a) as the limit of the sum, and
- (b) $\int_{x=a}^{x=b} F(x)dx = f(b) f(a) \text{ where } f(x) \text{ is the integral}$ of F(x).

Properties of definite integrals



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$$\int_{x=a}^{x=a} F(x)dx = \int_{t=a}^{x=a} F(t)dt$$

$$\int_{x=a}^{x=b} F(x)dx = -\int_{x=b}^{x=a} F(x)dx$$

$$\int_{x=a}^{x=b} F(x)dx = \int_{x=a}^{x=c} F(x)dx + \int_{x=c}^{x=b} F(x)dx \text{ provided } a < c < b$$

$$\int_{x=a}^{x=b} F(x)dx = \int_{x=a}^{x=b} F(a+b-x)dx$$

$$\int_{x=0}^{x=a} F(x)dx = \int_{x=0}^{x=a} F(a-x)dx \text{ if } F(2a-x) = F(x)$$

$$\int_{x=0}^{x=a} F(x)dx = 0 \text{ if } F(2a-x) = -F(x)$$

$$\int_{x=-a}^{x=a} F(x)dx = 2 \int_{x=0}^{x=a} F(x)dx \text{ if } F(x) \text{ is an even function}$$

$$\int_{x=-a}^{x=a} F(x)dx = 0 \text{ if } F(x) \text{ is an odd function}$$

Second Fundamental Theorem of Calculus

$$\frac{d}{dx}\int_{a}^{x}f(t)dt = f(x)$$

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CROSSWORD PUZZLE Feb'17: CALCULUS

Prof. SB. Dhar



ACROSS

- 3 A theorem whose special case is *Rolle's Theorem*
- 7 A type of discontinuity in which *Limit* \neq *Value*
- 8 Another name for *Absolute Value function*
- 9 A point on a curve at which the *sign of curvature changes*
- 11 Name of a function in which x and y are connected like $x^2-xy-y^2=1$

Down

- 1 The point at which dy/dx=0 and d^2y/dx^2 is not zero
- 2 The function whose *derivative is with negative sign*
- 4 A type of discontinuity whose *limits are unequal*
- 5 Another name for *Integral*
- 6 A point at which *derivative is zero*
- 8 Another name for *Squeeze Theorem*
- 10 Another name for Smallest Integer Function

-00-

(Answer to this Crossword Puzzle shall be provided in 1st Suoolement to Qarterly e-Bulletin No 2, Dt. 1st Feb'17)

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GROWING WITH CONCEPTS- Physics

HEAT & THERMODYNAMICS

Dr. Subhash Kumar Joshi

Subtle manifestation of life is heat. But heat, is something not perceivable while temperature is. Likewise, potential and kinetic energy are not perceivable while height and velocity, respectively, are perceivable. Another, interesting observation is worth experimenting is to keep Two different objects of same size and shape in the sun, together for half-an-hour and feel their temperature; one object is hotter than the other. Perception of heat is temperature while is not directly perceivable. Similar are the observations in the other two forms of energy.

Another, interesting example is when a student is in hurry to go to school and milk gets overheated, mother mixes chilled milk to moderate the temperature so as to make milk drinkable. In another situation of making tea there are two observations, one is initially small bubbles, rising from bottom of the utensil to the top of water, used for making tea, and then bursting, while the hot utensil is held with a ebonite or wooden handle.

Another situation is encountered when same matter at same temperatures in different phases has different heat content viz burns caused by steam and boiling water. There are many more examples encountered in day-to-day-living which are practiced, without questioning, either by convention or by concepts. Likewise, transfer of heat in solids, liquids and gases through a medium and in absence of a medium, i.e. vacuum, involves different concepts. A journey into understanding these concepts, becomes quite interesting and involves multiple concepts.

ZEROTH LAW OF THERMODYNAMICS: Two different objects A and B when at same temperature are brought into contact, in a closed environment, they remain at the same temperature. Such a state when Two objects are at same temperature, and continue to be so, are called in *thermal equilibrium* and is different from equilibrium encountered in mechanics; reason attributed to this difference is that forces are vectors while, temperature is scalar. Likewise, taking another object C is in *thermal equilibrium* with one of the earlier Two, say B; the latter object C is also in *thermal equilibrium* with the third object, A. Further, *a set of objects from a perspective of heat is called Thermodynamic System*

The observation is promulgated as Zeroth Law of Thermodynamics and stated as : *if two thermodynamic systems are each in thermal equilibrium with a third, then they are in thermal equilibrium with each other. Thus thermal equilibrium between two systems is transitive in nature*. Essence of thermodynamic equilibrium is temperature, a perceivable attribute of a matter. Measurement of temperature involves different properties of matter, each of which in different ways. In view of this it provides an integrated perspective on measurement of temperature, which shall be elaborated at the end of the Chapter on Heat. Nevertheless, to facilitate the journey into concepts of heat Four most commonly used scales of temperature are Kelvin, Centigrade, Fahrenheit, Rankine named along with convertibility from one scale to another.

TEMPERATURE SCALE: Transition of temperature from perception to numerical observation has long history, An ancient Greek scientist was first to measure temperature in170 AD in equal parts between freezing and boiling points of water, and extended to Four parts below and beyond either side of the scale. Later, Galileo around 1592 invented a Manometer type air-bulb thermometer with an open end exposed to atmosphere; changes in atmospheric pressure introduced error in measurement. These primitive efforts to measure temperature were followed by numerous scales of measurement and among them Four Scales are in prominent use.

Daniel Gabriel Fahrenheit in 1724 proposed a scale defining 0°F as temperature of brine (equal parts of ice and salt and 32°F for melting point of ice. This got translated into 212°F for boiling point of water at 212°F *Normal Temperature and Pressure (NTP)*. This scale is known as Fahrenheit after the name of the inventor.

Later, a Swedish scientist **Andres Celsius** in 1742 proposed a temperature scale which identified o as boiling point of water at sea level and 100 as freezing point of water. Division of the two identified temperatures in 100 parts got a name *Centigrade* (°C). Soonafter the invention, he flipped around the scale to a logical o°C for freezing point of water and 100°C for the boiling point. In 1948, International Conference on Weights and Measures named it after the inventor as *Celsius* retaining the notation (°C).

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In 1848 Lord Kelvin of Scotland proposed a **Kelvin Scale** which had graduation of each degree as Celsius scale but with a proposition of *Absolute Zero (o°K)*, a theoretical temperature of thermodynamic equilibrium corresponding to minimum energy. This temperature is 273.15 degrees below the freezing of water. This was correlated to triple point of water at, a temperature at which water can coexist in either of the three phases, solid (ice), liquid (water) and gas (vapour) states. This point is since 0.01° C, therefore this point corresponds to 273.16 K; since 1967 convention of scale as °K has been discontinued. In normal calculations, where accuracy is not important, freezing point of water is taken as 2730K, and it is akin to value of acceleration due to gravity (g) taken as either 9.8 or 10.

Eleven years after Kelvin, in 1859 William John Macquorn Rankine, proposed a scale which had Zero corresponding to absolute Zero as postulated by Kelvin, but chose graduation difference equal to that of Fahrenheit scale. This is called Rankine Scale using notation (°R). This scale is popular in United States.

In these four popular scales, the base is Celsius and Fahrenheit which are related with an equation $\frac{F-32}{9} = \frac{c}{5}$, while conversion of Celsius and Fahrenheit to Kelvin and Rankine is by adding a bias 273.16 and 491.67, respectively. Accordingly, some typical temperatures on these Four scales are as under -

Reference	Kelvin (K)	Celsius (°C)	Fahrenheit (°F)	Rankine (°R)
Absolute Zero	0	-273.15	-459.67	0
Freezing Point of Brine	255.37	-17.78	0	459.67
Freezing Point of Water	273.15	0	32	491.67
Triple Point of Water	273.16	0.01	32.018	491.688
Boiling Point of Water at Sea Level	373.1339	99.9839	211.97102	671.64102

CALORIMETRY: It is a science used in *quantification of heat transfer* based on observation that when two substances A and B at different temperatures T_1 and T_2 such that $T_1 > T_2$ are mixed or brought in contact, with a thermal isolation from environment, transfer of heat from A to B will take place till both A & B reach a common temperature *T* which shall be $T_1 > T > T_2$. As per *principle of conservation of energy* heat imparted by A in heat transfer is equal to heat gained by heat gained by B. Quantification of heat transfer required a **unit of heat energy** defined as **Calorie** by Nicolas Clement in 1824. Unlike other units this is not named after a scientist but, it is derived from a Latin word Calor. *A calorie is defined as amount of heat required to increase temperature of one gram of water from* **14.5** °C to 15.5 °C at One atmospheric pressure.



Basic instrument used in Calorimetry is called Calorimeter as shown in the figure. It has copper vessel surrounded by wool pack, fitted inside a wooden enclosure to insulate heat transfer from its walls of the vessel. The box has wooden cover which has three openings – i) for thermometer, ii) for stirrer to create an equilibrium conditions and iii) turning lid to immerse an external object in liquid contained in the vessel, as per experimental requirement. Liquid in the vessel provides proper contact with the calorimeter, thermometer and any other object used in experiment.

Here a new term **Specific heat** (**s**) is introduced, which defined as amount of heat (in Calorie abbreviated as **Cal**) required to increase temperature of One gram of substance by 1°C. Accordingly, for a substance of mass **m**, heat required to raise temperature from θ_1 to θ_2 °C is **h** Calorie, then according to the definition of specific heat $h = ms(\theta_2 - \theta_1)$, or $s = \frac{h}{m(\theta_2 - \theta_1)}$. This relationship is true for loss of heat, in which case is h –ve, and so also $(\theta_2 - \theta_1)$ becomes –ve, thus *s* has an absolute value. Accordingly, unit of **s** in CGS system is **Cal g⁻¹ oC⁻¹**, while in SI unit is J kg⁻¹ K⁻¹. Conversion of unit of heat from CGS into SI requires to know relationship (**1 Cal = 4.186 J**), between units of energy Calorie (**Cal**) and Joule(**J**) shall be elaborated with Joule's Experiment a little later. Extending this concept of Specific Heat, **Heat**

Capacity (*S*) of a body is the amount of heat required raise its temperature by 1°C or 1 K and is S = ms. Another extension of the concept of **Molar Heat Capacity** (*Ms*) is equal to 1 **gram-mol** of substance (it is equal to Molecular Weight or Molecular Mass (*M gm*), accordingly heat capacity of an object S = nM, where n is the Molar Mass i.e. number of Gram-Mol of substance. *Molar Heat Capacity finds extensive application in chemistry*.

Typical determination of Specific Heat of a ball of metal is elaborated below:

Initially, mass (m_1) of an empty dry vessel of calorimeter having specific heat s_v is determined on weighing balance. Then in the vessel enough water is put which fully immerse the metal ball (assume its specific heat to be s_b , and again mass (m_2) of vessel with a non-volatile liquid having specific heat s_l is determined. Now, mass of the ball (m_b) is determined, and it is placed in a hot air chamber till a steady temperature chamber (θ_1) is attained. Meanwhile, the calorimeter is placed in the container, packed with wool, and stirrer is stirred till temperature of water becomes steady at (θ_2) . Now, by turning the lid, the ball is gently immersed in water so as to avoid splashing of water. Soonafter, the stirrer is vigorously stirred and temperature of water is noted till it reaches maximum (θ_3) , which is constantly kept under observation.

Computation of these observations to arrive at specific heat and heat capacity of the metal ball is as under:

Heat Capacity of Calorimeter vessel:	$S_v = m_1 s_v$ Cal- °C-1
Heat gained by the calorimeter:	$h_{g1} = S_v(\theta_3 - \theta_1)$ Cal
Mass of liquid:	$m_l = m_3 - m_1$
Heat gained by liquid inside the calorimeter:	$h_{g2} = m_l s_l (\theta_3 - \theta_1)$
Total Heat gained:	$h_g = h_{g1} + h_{g2} = (S_v + m_l s_l)(\theta_3 - \theta_1)$
Heat Lost by metal Ball:	$h_l = m_b s_b (\theta_2 - \theta_3)$
As per Law of Conservation of Energy:	$h_l = h_g$
	$=>m_b s_b(\theta_2 - \theta_3) = (S_v + m_l s_l)(\theta_3 - \theta_1)$
Specific Heat of Metal Ball	$=> s_b = \frac{(s_v + m_l s_l)(\theta_3 - \theta_1)}{m_b(\theta_2 - \theta_3)}$
Heat Capacity of metal Ball :	$=> S_b = m_b s_b = \frac{(S_v + m_l s_l)(\theta_3 - \theta_1)}{(\theta_2 - \theta_3)}$

LATENT HEAT: In the beginning of fluid mechanics physical states of matter solid, liquid and gas were stated to be in

relation to their inter-molecular energy. As the matter changes its physical state there are two pertinent observations: i) change of state takes place at constant temperature, which is dependent on pressure on the prevalent ambient pressure, ii) it requires extra energy, much higher than Specific Heat and this extra heat is called Latent Heat of the substance.

Temperature at which a matter changes from solid to liquid state it is called Melting Point and corresponding latent heat is called *Latent Heat of Fusion*. This remains same when state of liquid changes to solid, it is called Freezing point. Likewise, temperature at which liquid changes to gaseous it is called Boiling point, corresponding to ambient pressure, and the extra heat is called *Latent Heat of Evaporation*.



This change of state is since related to inter-molecular energy, therefore Latent

Heat is dependent upon temperature and pressure as well. Change in intermolecular distance during transition from liquid to vapour state is since much larger than that during solid to liquid state, dependence of Latent Heat of Evaporation on pressure is much larger than that of Latent Heat of Fusion. This subject matter is since outside domain the target students, further discussions on this dependence of the Latent Heat is being put to a halt here.

Experimental Determination of the Latent Heat of Evaporation, taking specific heat of water to be 1, typically, is as under:

In an experiment, as above, instead of metal ball dry steam at temperature θ_2 is injected in water. It requires two precautions: a) rate of flow steam is so regulated that it does not bubble out of water, and b) stirrer is continuously and vigorously to facilitate (a). As a result there is increase in temperature of water and calorimeter. Mass of steam m_s is determined after recording maximum temperature θ_3 attained by water and steam mixture.

Accordingly, computation of these observations to arrive at Latent Heat of Evaporation, taken to be L_s , shall be as under :

Heat Capacity of Calorimeter vessel:	$S_v = m_1 s_v$ Cal- °C-1
Heat gained by the calorimeter:	$h_{g1} = S_{\nu}(\theta_3 - \theta_1)$ Cal
Mass of liquid:	$m_l = m_3 - m_1$
Heat gained by liquid inside the calorimeter:	$h_{g2} = m_l s_l (\theta_3 - \theta_1)$
Total Heat gained:	$h_g = h_{g1} + h_{g2} = (S_v + m_l s_l)(\theta_3 - \theta_1)$
Heat Lost by Steam in Condensation:	$h_{l1} = m_s L_s$
Heat Lost condensed steam to reach temperature of Mixture:	$h_{l2} = m_s. 1. (100 - \theta_3)$
TotalLost:	$h_l = h_{l1} + h_{l2} = m_s (L_s - (\theta_2 - \theta_3))$
As per Law of Conservation of Energy:	$h_l = h_g$
Accordingly, Latent Heat of Evaporation	$L_{s} = \frac{(S_{v} + m_{l}s_{l})(\theta_{3} - \theta_{1})}{m_{s}(100 - \theta_{3})} + (\theta_{2} - \theta_{3})$

Latent Heat of Evaporation at normal atmospheric pressure, leading to 100°C boiling point, is 539.3 Calorie per gram in CGS and in SI it is 2675.43/kg. Since boiling point is pressure dependent so also the latent heat. This is precisely the reason that cooking in pressure cooker becomes fast. This would become more explicit as this journey enter into Kinetic Theory of Gases. Effect of latent heat of evaporation is experienced during accidental exposure to steam, nevertheless, it is cautioned not to experience heat of steam ; it may cause severe burns.

Experimental Verification of Latent of Fusion of Ice, taking specific heat of water to be 1, typically, is as under:

In this experiment as above, instead of steam, a piece of dry ice of mass (m_i) at o°C, like that of metal ball, is dropped in the liquid, which is miscible in water due to change of state of ice. Let, Latent Heat of Fusion be L_F . After dropping the ice piece stirrer is stirred vigorously till temperature fall to minimum(θ_3), which is constantly observed. Since, calorimeter is at higher temperature; with the decrease in temperature it will lose heat, while ice would gain heat in its melting and the water to attain final temperature of water-ice mixture.

Computation of these observations to arrive at Latent Heat of Fusion L_F is as under:

Heat Capacity of Calorimeter vessel:	$S_v = m_1 s_v$ Cal- °C ⁻¹
Heat lost by the calorimeter:	$h_{l1} = S_v(\theta_1 - \theta_3)$ Cal
Mass of liquid:	$m_l = m_3 - m_1$
Heat lost by liquid inside the calorimeter:	$h_{l2} = m_l s_l (\theta_1 - \theta_3)$
Total Heat lost:	$h_l = h_{l1} + h_{l2} = (S_v + m_l s_l)(\theta_1 - \theta_3)$
Heat Gained by Ice in meting to water:	$h_{g1} = m_i L_F$
Heat Gained by molten ice to attain temperature of mixture:	$h_{g2} = m_i \cdot 1 \cdot (\theta_3 - 0) = m_i \theta_3$
Total Heat Gained :	$h_g = h_{g1} + h_{g1} = m_i (L_F + \theta_3)$
As per Law of Conservation of Energy:	$h_l = h_g$
	$=> (S_{\nu} + m_l s_l)(\theta_1 - \theta_3) = m_i(L_F + \theta_3)$
Therefore, Latent Heat of Fusion of Ice:	$L_F = \frac{(S_v + m_l s_l)(\theta_1 - \theta_3)}{m_i} - \theta_3$

Latent Heat of Fusion of water is 80 Cal per gram in CGS and in SI it is 334 kJ/kg. Effect of latent heat of fusion of ice is experienced while holding ice which causes intense chillness as compared to dipping hand in ice-cool-water.

MECHANICAL EQUIVALENT OF HEAT: In winter animals shake themselves to warm up, human being rub their palm and face; while sharpening knife it becomes hot and, therefore, dipping knife in water is in practices since immemorial times. This is practiced without knowledge of convertibility of work into heat. Scientific observation of friction generating heat was recorded by Count Rumford who published " An Experimental Enquiry Concerning the Source of the Heat Which is Excited by Friction" in 1978. This inspired many scientists to work in parallel and in 1845 James Prescott Joule a numerical value of 'Mechanical Equivalent of Heat' (in foot-pound force) which equates to 4.1550 J.Cal⁻¹.

A typical apparatus to determine *mechanical equivalent of heat* is shown in the figure. It has two metallic cones of brass. Inner cone, with water of mass m_1 filled in it a little below the brink to avoid spilling, is fitted with an heat insulating disk

cover, circular in shape. The outer cone is fitted to a thermally insulated spindle having a mechanism to rotate it alonhwith a counter to record number of rotations. Let, heat capacity of the two cones is S. The top cover has two holes one is to accommodate a thermometer and other a stirrer. Further, the top disk has a peripheral groove through which a rope, its one end tied in the groove, passing around the disk. The other end of the rope has weight suspended from a pulley. The pulley is fixed such that it remain tangential to the groove at its point of exit from the groove and in the plane of the groove. Let, m is the mass of the pan and M is the weight in the pan. If the spindle is left free, the weight will turn the disk so as to lower the weight. This direction of turning of the cover, under the suspended weight, is noted.

The rope is replaced, in the groove, around the disk disk to have rope

around the pulley. Water inside the inner cone is stirred to bring a uniform temperature of water and cone, initial steady temperature θ_1 is recorded. Now, the, spindle is rotated in a direction reverse to the natural direction of turning of the disk. The speed of rotation of the spindle is so maintained that the suspended weight remains at the same height and stationary. At this state, direction of frictional torque counter balances the torque caused by the suspended weight $(\tau = 2\pi r(M + m)g)$. Let, keeping weight suspended at the same height, the system is made to rotate N revolutions. During this rotation water in the inner cone is constantly stirred and θ_2 is the maximum temperature of the water.

Computation of these observations to arrive at Latent Heat of Fusion L_F is as under:

Work done, during N rotation to overcome frictional force:	$W = \tau N$ N-m
	$=(2\pi r(M+m)g)N$ N-M
Heat gained by water inside the inner cone and the Two metallic cones:	$H = (S + m_1)(\boldsymbol{\theta_2} - \boldsymbol{\theta_1}) \text{ Cal}$
As per principal of conservation of energy:	W = JH
Therefore, Mechanical Equivalent of Heat:	$J = \frac{(2\pi r(M+m)g)N}{(S+m_1)(\theta_2 - \theta_1)}$
This Heat Equivalent was standardized to 4.1860 J.Cal ⁻¹ in 1920.	

THERMAL EXPANSION: In rail tracks spacing is provided at regular spans to avoid bending of tracks. In domestic environment when two conical metal glasses tightly fit into each other, they are separated by putting outer glass into hot water. Likewise, in metal container, having ceramic lagging hot liquid suddenly poured it develops cracks in the lagging. These observations are related to thermal expansion, and find many application in practical life.

Change in volume of solid, liquid and gases, upon heating, depends upon their molecular bonding. Solids since retain their shape, during heating energy imparted to molecules sets in increased molecular vibrations causing their reposition to neutralize the increased stress and thus increase in their dimensions. In *isotropic material*, *having uniform*



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arrangement of molecules in the volume, material change in dimensions is uniformly proportional to its length, width and thickness. While in *anisotropic material*, having distribution of molecules is oriented along crystalline structure, variation in the three dimensions is not uniform. In this elaboration, thermal expansions of isotropic materials is considered. Accordingly, $\alpha \Delta \theta = \frac{\Delta L}{L}$, here, α is **Coefficient of Linear Expansion**. At **o K**, a hypothetical Zero temperature, energy of a matter is minimum, and interpolation of the logic to thermal contraction $\alpha(\theta - 0) = \frac{(L-L_0)}{L_0}$, here, L_0 is the length at **o K**. Thus, length of a material θ_1 **K** is $\alpha(\theta_1 - 0) = \frac{(L_1 - L_0)}{L_0}$.



Taking, θ to be a reference temperature at which length is *L*, and combining these two equations $\alpha(\theta_1 - \theta) = \frac{(L_1 - L)}{L_0} = \frac{\Delta L}{L_0}$. Here, in the denominator $L_0 \rightarrow L$, since variation in length is very small. Accordingly, for all practical purposes, the expression for change in length is generalized to $\Delta \mathbf{L} = \alpha \mathbf{L}(\boldsymbol{\theta}_1 - \boldsymbol{\theta})$.

Relationship between coefficient of linear, with that of coefficient area and volumetric expansions is arrived at by extrapolating linear expansion on surface and volume, as shown below -



Liquids since do not have their own shape, therefore, increase of temperature causes volumetric expansion only, and it is higher than that of solids. Since the liquid occupies space in a container, volumetric expansion of the container is accounted to avoid in determination of the Coefficient of Volumetric Expansion (γ) of liquids.

In gases, larger inter-molecular spacing and that it not only takes shape of the container, it fills the available space energy of molecules associated with temperature, and in turn creates pressure on the walls of the container. This makes volumetric expansion of gases distinct from the liquid and shall be elaborated in section Kinetic Theory of Gases, later in this chapter.

HEAT TRANSFER: Change of temperature is a result of transfer of heat energy as observed in calorimetry. Natural transfer of heat from a body at High Temperature to another body at Low Temperature as seen. Some of the real life experiences of heat transfer are holding cooking tools dipped in hot cooking stuff, heating of water from bottom of the vessel such that hot water is at the top, hot flames rising from gas burner gas, and in winter receiving heat from sunrays. It is the time to understand mechanics of heat transfer. There are basically three Types of Heat transfer: a) Conduction, b) Convection and c) Radiation. And fourth mode of transfer, specific to industrial applications and not in real life environment, is **Advection**. In this hot fluid is transported flown from one point to the other to transfer the heat energy. Each of these are elaborated below.

CONDUCTION: Heat imparted to solids, as per Law of Conservation of Energy induces vibration of molecules about their mean positions retained as vibration energy, Accordingly, a molecule at higher temperature has higher vibration energy as compared to the other at lower temperature. Thus sharing of energy across molecules tend establish a thermal equilibrium in a closed system.

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In a situation a solid having uniform cross sectional area '**A**' has one end or surface '**X**' at higher temperature θ_1 , called source, and other end '**Y**' at lower temperature θ_2 called sink, heat will be continuously transferred. It is observed that rate of heat transfer '**Q**' is: a) proportional to area of cross-section '**A**', b) temperature difference $(\theta_1 - \theta_2)$ between two ends and c) inversely proportional to distance between the two ends points '**l**'. Accordingly, $Q \propto \frac{A(\theta_1 - \theta_2)}{l}$, or $Q = K \frac{A(\theta_1 - \theta_2)}{l}$, here **H** is in Calorie, **A** in m², θ_1 and θ_2 in °C, **l** in Meter, and therefore, *K*- coefficient of thermal conductivity in CGS is Cal.m⁻¹.°C⁻¹, while SI it is

Experimental Determination of K: Experimental set for this is shown in the figure, while the procedure is as under.

A metal rod of uniform cross-section A is fitted with one inside a steam chamber, with steam supplied from top and ejected from bottom, to maintain uniform temperature in the chamber, and in turn of the ends of the metal rod embedded inside the chamber. The rod is provided thermal insulation on its side walls to ensure unidirectional flow of heat. The rod has two mercury pockets at a distance l, thermometers dipped in them measuring temperatures such that $\theta_1 > \theta_2$ indicating direction of flow of heat. A spiral tube on the other end carries water (specific heat s)having inlet in the direction of heat flow, and two thermometers to record temperatures of water at inlet and outlet $\theta_4 > \theta_3$ which is in



accordance with the direction of flow of heat. Steady state temperatures θ_1 , θ_2 , θ_3 and θ_4 are recorded. Mass of water passed through the tube in time *t*, recoded through stopwatch, is measured to be *m*.

Computation of these observations to arrive at Latent Heat of Fusion L_F is as under:

Heat transfer in time <i>t</i> :	$H = m. 1. (\theta_4 - \theta_3)$ Cal
Rate of heat of heat Transfer as per experimental observation :	$Q_1 = \frac{H}{t} = \frac{ms(\theta_4 - \theta_3)}{t}$
Rate of heat transfer as per definition:	$Q_2 = K \frac{A(\theta_1 - \theta_2)}{l}$
As per Law of Conservation of Energy :	$Q = Q_1 = Q_2$ $=> Q = K \frac{A(\theta_1 - \theta_2)}{l} = \frac{ms(\theta_1 - \theta_2)}{l}$
	$=>K=\frac{lms(\theta_4-\theta_3)}{At(\theta_1-\theta_2)}.$

Thermal Resistance (R_h) : This is similar to that shall be encountered in current electricity, which shall be elaborated in separate chapter, and can be used to create a background for that. Temperature difference $(\theta_1 - \theta_2)$ is driving transfer of heat Q Cal.s⁻¹. Therefore thermal resistance to heat flow $R_h = \frac{(\theta_1 - \theta_2)}{Q} = \frac{l}{\kappa A}$, accordingly thermal resistivity $= \frac{1}{\kappa}$.

This concept of thermal resistance is extended to determine temperature difference required to combinations of thermal insulators to transfer certain amount of heat, through Two generic arrangements: **a)** *Series Combination*, and **b)** *Parallel Combination*. In this analysis of Series Combination area of both the materials is taken to be A, while their lengths are l_1 and l_2 , while their Thermal Conductivities are K_1 and K_2 , and temperature. For transfer of heat Q, temperatures across Material A is θ_1 and θ_2 , while that across material B is θ_2 and θ_3 . Likewise for Parallel Combination, Material A and B are taken to be of length l, with temperature difference across their ends at Source Side θ_1 and Sink Side θ_3 , but cross-sectional area as A_1 and A_2 respectively. Let, heat transfer shared by them be Q_1 and Q_2 , respectively such that $Q_1 + Q_2 = Q$. Taking these parameter, Equivalent Thermal Resistance of the Two Combinations is elaborated below.

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It is seen that **thermal resistance is parametric in nature** viz. Resistivity, a characteristic parameter of the material, Geometry, dimensional parameters derived from shape of material.

CONVECTION: A fluid when heated, heat is transferred through conduction to the molecules of fluid in contact with the heating, it can be walls of container or a hot object immersed in it. The fluid molecules undergo volumetric expansion, upon heat gain, and as a consequence due to buoyancy they start getting ascending till they transfer heat to the molecules intercepted during ascend. Likewise, ascending hotter molecules, intercepted by descending cooler molecules also exchange heat. *This intermolecular transfer of heat in fluid is conduction, while the process of ascend/descend of hotter/cooler molecules, respectively, is convection. Thus in totality convection is a hybrid process which involves conduction as started, followed by volumetric expansion/contraction leading movement of molecules due to buoyancy effect.*

Convection is a combination of conduction and convection, in this conduction heating surface transfer heat the fluid molecules through conduction. Likewise, cooler molecules that descend after transfer of heat through convection, gain heat from hotter molecules intercepted by it through conduction. This process continues till liquid attains thermal equilibrium. After this state if heat supply continues, this additional heat is utilized in evaporation so as to retain the thermal equilibrium. Discussions on convections are put to a halt at this point, while readers are welcome to raise their inquisitiveness through *Contact Us*.

RADIATION: Transfer of Heat through radiation has been of interest to human civilization, and source of light and heat were worshiped right since the predator age. Basic understanding of thermal radiation is derived from the fact that when a matter acquires, heat energy it sets molecular vibrations which are responsible for transfer of heat by conduction, convection and radiation.

In state of thermal equilibrium total heat transfer is equal to heat acquired. Transfer of heat by radiation is a process of relaxation of excited atom, molecule and in turn matter which quantized by Plank with equation e = hv, here, e is the quantum of energy, h is the Planck's Constant and v is the frequency of radiation. Understanding the mechanics of heat radiation requires knowledge of atomic, molecular and solid-state physics and hence detailed discussions on this are reserved for inquisitive students who may seek more details through <u>Contact Us</u>.

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A sharp metal needle held with a heat insulating material or a tool on a flame changes colour from its colour at room temperature to bright colour tending to be while, and reverse is the change in colour when cooled down. These observation radiation of rays over a wide spectrum were first documented by Pierre Prevost in 1792. He further propounded a Fluid Theory of heat transfer and at thermal equilibrium heat received by a body, from the surrounding objects is equal heat escaped from it.

Black Body: Two object, one with a highly reflecting surface, and the other with grey surface are kept at room temperature, it is seen in an environment having a constant temperature. It is seen that with passage of time both object attain a thermal equilibrium with the environment. The object having reflecting surface absorbs a smaller faction radiation incipient on it, as compared to the object having a grey surface. But, necessary condition of thermal equilibrium is that amount of heat radiation is equal to radiation emitted by all bodies at all temperature. An ideal Black Body is that which absorbs all the radiation falling on it. An ideal proposition hypothetical black body is a hypothetical proposition, sand in reality it does not exist and so also is an ideal reflecting surface. A closed chamber, with a pin hole and a diverting surface across inside the chamber, as shown in the figure, is an idealized black body, since a radiation once enters it can not leave out, i.e. it is fully absorbed in it.



It is observed that matter exhibits radiation over a wide spectrum and predominant frequency is dependent upon its temperature while intensity of other frequencies is dependent upon molecular and crystalline structure of matter. The matter is composed of charged and neutral particles. Motion of these particles creates a coupled electric and magnetic field known as Electromagnetic Radiation. Heat Radiation is a part of Electromagnetic Radiation Spectrum as much as visible light. It was only in late nineteenth century that it was realized that transfer of heat through radiation is a part of electromagnetic radiation. This shall be discussed in detail in

Chapters on Atomic Structure and other related topics of Modern Physics. Elaboration in this chapter is confined only to Transfer of Heat through Radiation.

Later half of 19th century was quite revealing in respect of thermal radiation. Many scientists worked independently, while their revelation complemented the earlier in furtherance of the knowledge. In this pursuit significant contributions are from Kirchhoff, Wein and Planck are discussed separately.

Newton's Law of Cooling: In 1701 Newton, stated that "rate of cooling of an object is proportional to the difference between temperature of the body and its ambient, i.e. the surrounding". Accordingly, $\frac{dT}{dt} \propto (T - T_a)$. Thus, the relationship comes to $\frac{dT}{dt} = -k(T - T_a)$, or $\int \frac{1}{(T - T_a)} dT = -k \int dt$; or $\ln(T - T_a) = -kt + C$; $T(t) - T_a = (T - T_a)_o e^{-kt}$. Thus, instantaneous temperature of an object is expressed with an equation $T(t) = T_a + (T - T_a)e^{-kt}$. Here, T_o - is initial temperature of an object, T(t)- instantaneous temperature of object at time t, T_a - is ambient temperature. Here, constant of proportionality takes into account other parameters viz. heat loss due to convection, surface area etc.. Growth and understanding of heat, with the evolution of Stefan-Boltzmann Law, has brought limitation of Newton's Law of cooling, and is elaborated here in the following paras.

Kirchhoff's Law of Thermal Radiation: In 1859 Gustav R Kirchhoff discovered universal character of radiation to solve the problem of dependence of of emitted light on nature o, size and shape of body. For an ordinary body transfer of heat of Thermal Radiation incident on a body (taken to be unity) is represented by equation a + r + e = 1, here *a* is the fraction of absorption of radiation, *r* is the fraction of radiation reflected and *e* is the fraction of incident thermal radiation which is transmitted by the body. Under thermal equilibrium Kirchhoff found that: "*ratio of emissive power to absorptive power is same for all bodies* at a given temperature, in thermal equilibrium, is equal to that of a black body and is defined by a function $K(\lambda, T) = \frac{e}{a}$ is independent of body." Here, it is pertinent to know the Two new terms that have been introduced.

Emissive Power: Taking Ω a small surface area ΔA of a body, subtending a solid angle $\Delta \Omega$, emits thermal energy Δu in time Δt , then Emissive Power $E = \frac{\Delta u}{\Delta A \Delta \Omega \Delta t}$.



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Absorptive Power: It is a fraction α of the incident radiation U_I that is absorbed by the body U_a , accordingly, $\alpha = \frac{U_a}{U_I}$.

Using these two expressions to understand Kirchhoff's Law, $\frac{E}{\alpha} = \frac{\Delta u}{\frac{\Delta A \Delta \Omega \Delta t}{U_I}} = \frac{\Delta u}{\Delta A \Delta \Omega \Delta t} \times \frac{U_I}{U_a} = \left(\frac{U_I}{\Delta A \Delta \Omega \Delta t}\right) \left(\frac{\Delta u}{U_a}\right) = K \frac{\Delta u}{U_a}$. Here, K is a constant term which does not involve property of surface and $\frac{\Delta u}{U_a} = 1$ in case of thermal equilibrium. This proves that the ratio is same for all bodies.

Stephan and Boltzmann Law: Stefan through rough experiments revealed that total amount of power radiated at any temperature increases in fourth power of the absolute temperature and in 1879, he propounded that $\int_9^\infty u(v, T) dv = \sigma T^4$, here v is the frequency of radiation. In 1884, L. Boltzmann deduced this equation theoretically, accordingly, it is known as Stefan and Boldzmann Law of Thermal radiation stating that – "total thermal energy radiated by a body per unit time is proportional to fourth power of temperature in the form $\mathbf{u} = \sigma A T^4$ ", here σ – Stefan-Boltzmann Constant =5.67x10⁻⁸ W.m⁻2.K⁻⁴, A - surface area and T – Absolute Temperature.

Extending this law into the domain of Newton's Law of cooling into a state of thermal equilibrium with the environment, $\Delta u = e\sigma A(T^4 - T_a^4); \quad T = T_a + \Delta T; \quad \Delta u = e\sigma A((T_a + \Delta T)^4 - T_a^4) = e\sigma AT_a^4 \left(\left(1 + \frac{\Delta T}{T_a}\right)^4 - 1\right).$ It leads to simplification using binomial theorem, where in terms containing higher power ΔT of are neglected, $\Delta u = e\sigma AT_a^4 \frac{\Delta T}{T_a} = e\sigma AT_a^3 (T - T_a)|_{\Delta T \text{ is small}}.$ Recalling the concept of heat capacity $\frac{\Delta u}{\Delta t} = ms \frac{\Delta \theta}{\Delta t}$, together with this when temperature of object is comparable the ambient temperature, the factor $\frac{e\sigma AT_a^3}{ms}$ is a close approximation of proportionality constant of Newton's Law of Cooling.

Wien's Displacement Law : W. Wien had studied intensity of radiation from a body at different temperatures and propounded in 1893 that wavelength of the maximum radiation of maximum

intensity is is inversely proportional to the temperature of the body and expressed as $\lambda_{max} \cdot T = b$. Here b is a Wien's Displacement Constant =2.8977685x10⁻³ mK, and this equation is known as Wien's Displacement Law.

Planck's Law: Planck through his series of papers, on quantum postulates, in later part of 19th century postulated radiating power of black body and in 1900 he propounded it in a form known as Plank's Law in infinitesimal form as a equation, as function of frequency (*v*) and temperature (*T*) : $u(v,T)dv = \frac{2hv^3}{c^2} \cdot \frac{1}{\left(e^{\frac{hv}{BT}}\right)^{-1}} \cdot dv$; here, *h*- Planck's constant=6.6260693 x10⁻²⁴ J.s, *v* - Frequency



of radiation, c - velocity of light=2.00392458 ms^-ı, K_B – Boltzmann Constant=1.380650x10-23 JK^-ı, and T -Temperature in Kelvin. Expressing

this equation in terms of wave length $\lambda = \frac{c}{v}$, i.e. $d\lambda = -\frac{c}{v^2}dv$. Introduction of –ve sign represents reflection of graph into second quadrant, and hence it is neglected. Accordingly, substituting this in the above equation leads to, $u(\lambda, T) \cdot d\lambda = \frac{2hc^2}{\lambda^5} \cdot \frac{1}{\left(e^{\frac{2hc^2}{\lambda K_B T}}\right)^{-1}} \cdot d\lambda$. Occurrence of dv and $d\lambda$ on both the sides of the both the Plank's equation, they are generally written

in the forms
$$u(v,T) = \frac{2hv^3}{c^2} \cdot \frac{1}{\left(e^{\frac{hv}{K_BT}}\right) - 1}$$
 and $u(\lambda,T) = \frac{2hc^2}{\lambda^5} \cdot \frac{1}{\left(e^{\frac{hc}{\lambda K_BT}}\right) - 1}$, and is shown in the figure.

Summary of Heat Transfer: It is an important phenomena in understanding of Heat Energy and takes place in Three modes. Salient differences in the three modes of heat transfer are summarized, for comparison, in a table below.

KINETIC THEORY OF GASES: In childhood one must have blown balloons. In this fun it must have been experienced that more force is required as balloon size, so also a careful observation would reveal that as balloon is blown its temperature also increases. This observation can be best explained with the understanding of Kinetic Theory of Gases.

Comparison in Three Modes Heat Transfer												
Particulars	Conduction	Convection	Radiation									
Medium	Solid: required	<i>Fluid:</i> required	<i>Vacuum:</i> Medium not required									
Mechanism of heat transfer	Molecules vibrate about their mean position	It is a process induced due to buoyancy effect and is sandwiched between transfer of heat by conduction at the initiation and termination, till establish thermal equilibrium in fluid	Transfer of energy is through electromagnetic wave energy. Any object which obstruct these waves experiences absorption, reflection and emission.									
Algebraic Expression for rate of heat transfer	$=\frac{ms(\theta_4-\theta_3)}{t}$	Not quantified, since it depends upon ambient conditions also.	$\frac{u = \sigma AT^4; \text{Stepfan and}}{\text{Boltzmann Law}}$									
Loss of Energy	To the extent heat is transferred through the surface of the medium, perpendicular to the direction of heat transfer	To the extent heat is transferred into and through surface of the container of the fluid.	In medium either by reflection or emission.									

KINETIC THEORY OF GASES: In childhood one must have blown balloons. In this fun it must have been experienced that more force is required as balloon size, so also a careful observation would reveal that as balloon is blown its temperature also increases. This observation can be best explained with the understanding of Kinetic Theory of Gases.

Understanding Kinetic Theory of Gas, had its beginning in scientific observations of motion of particles in fluid **Robert Brown** in 1827. Accordingly, it was postulates an *Ideal Gas* having following properties

1) Number of molecules are large.

:

- 2) Molecules of gas keep forming random chaotic motion, which is called Brownian Motion. The adjoining figure shows a few collisions of a single molecule.
- 3) Size of molecules is insignificant to the volume of gas, and hence neglected.
- 4) Intermolecular space in gases is large enough to ignore intermolecular force.
- 5) During motion, collision of molecules interception each other is perfectly elastic and obey Newton's Laws of Motion,
- 6) A volume of gas over a period of time reaches a steady state in respect of density, molecular distribution and velocities of molecules are independent of position, direction and time.

Extending the theory, consider a cubical container placed such that its walls parallel to *i-j*, *j-k*, and *k-*i planes. This



container is filled with an idea gas, whose molecules are performing Brownian Motion. Let, velocity of a typical molecule and its components along three axes are as shown in the figure, such that $v = \sqrt{v_i^2 + v_j^2 + v_k^2}$. Since, all collisions are perfectly elastic therefore change of momentum of a molecule after rebounds from hatched face parallel to plane (L-j-k) shall be $p = 2mv_i$. Let, l be the **mean-free-path** between Two consecutive collisions, then time between two consecutive collisions shall be $t = \frac{2L}{v_i}$. Therefore number of collisions made by the molecule during two consecutive collisions between surfaces (0-j-k) and (L-j-k) shall be $n = \frac{1}{t} = \frac{v_i}{2L}$. Since, force exerted by the molecules is equal to rate of change of momentum, i.e. $f_i = np = \left(\frac{v_i}{2L}\right) \cdot (2mv_i)$, here use of 2L corresponds to distance travelled in completing one cycle of collision. Accordingly, total force exerted on the face shall be summation of forces exerted by all

molecules, thus $F_i = \sum \frac{mv_i^2}{L} = \frac{m}{L} \sum v_i^2$. Considering property (6) of the ideal gas, velocity component of force $\sum v_i^2 = \sum v_j^2 = \sum v_k^2$. This can be normalized as $\sum v_i^2 = \sum v_j^2 = \sum v_k^2 = \frac{1}{3} (\sum v_i^2 + \sum v_j^2 + \sum v_k^2) = \frac{1}{3} \sum v^2$ and that \boldsymbol{m} is characteristic to gas



molecules, while *L* is the length of the edge of the cubical the container. Let, N be the number of molecules of the gas under consideration then $F = \frac{1}{3} \frac{mN}{L} \cdot \frac{\sum v^2}{N} = \frac{1}{3} \frac{mN}{L} v_{rms}^2$. Here, a new term v_{rms} is introduced which is called **rms** value of the velocity, de-abbreviated as **root mean square**, implies that root of the mean of squares of velocities of individual molecule and mathematically expressed as $v_{rms} = \sqrt{\frac{\sum v^2}{N}}$. It leads to $p = \frac{F}{L^2} = \frac{1}{3} \frac{mN}{L^3} v_{rms}^2 = \frac{1}{3} \rho v_{rms}^2$; here $\rho = \frac{mN}{L^3}$, where mN is the mass of gas in volume L^3 . This expression of $p = \frac{1}{3} \rho v_{rms}^2$, leads to $pV = \frac{1}{3} \rho V v_{rms}^2 = \frac{1}{3} mN v_{rms}^2$. Here, total mass of the gas sample = m, while v_{rms} is dependent on kinetic energy of gas $\left(=\frac{1}{2}mNv_{rms}^2\right)$ which is acquired through heat energy (=mNsT), s - is specific heat of the gas and T – temperature in Kelvin. This is a consequence of *Law of Conservation of Energy*.

This Kinetic Theory of Gases (KTG)has been used to substantiate certain **properties of gases**, propounded through experimental verification by different scientist:

Boyle's Law: Since kinetic energy of the gas at constant temperature is constant, and so also v_{rms} , therefore, pV = Constant at a constant temperature known as Boyle's Law. It was published by Robert Boyle's in 1662 from experimental observation.

Charles's Law: Taking a sample of gas, if its pressure is kept constant, and its temperature is raised gradually, then through law of conservation of energy, as discussed above $\frac{1}{2}mNv_{rms}^2 = mNsT$. Accordingly, $v_{rms}^2 \propto T$, and merging constant pressure into this proportionality constant the relationship leads to $V \propto T|_{p=Constant}$, known as **Charles's Law**. In 1780, Jacques Charles formulated this law, but he could not publish it. Later in 1802, Joseph Lious Gay-Lussac confirmed the unpublished discovery naming it after Charles. This can be realized with a balloon filled air, when placed under the sun its volume increases.

Gay-Lussac's Law: In 1809, *Joseph Louis Gay-Lussac* found that for a given mass and constant volume of an ideal gas, the pressure exerted on the sides of its container is directly proportional to its absolute temperature $p \propto T]_{V=Constant}$. In fact, it is another variant of Charles's Law taking volume to be constant, while pressure is proportional to the temperature, extending the logic applied substantiate the Law. In view of this in some references **it is also called Charles's** *Pressure Law*. A sealed container filled with gas when heated, it bursts, and this happens due to pressure built up with increase of temperature.

Dalton's Law of Partial Pressure: John Dalton in 1801, propounded an empirical of partial pressure exerted by non-reacting gases. Pressure on the walls of containers of a gas, as per KTG is due change of momentum of colliding with the walls. Therefore, *total pressure on the walls is equal to pressure exerted by the molecules of the constituent gases*, which mathematically comes to $p = p_1 + p_2 + p_3 + \cdots p_i + \cdots$, here p_i is called partial pressure of ith gas. Let, F_i is the force exerted by ith gas having N_i molecules of the gas. Accordingly, pressure on the wall area A, which is common to all the constituent molecules is $p_i = \frac{F_i}{A}$. Total force on a wall of container of gas $F = F_1 + F_2 + F_3 + \cdots F_i + \cdots$, accordingly, $p = \frac{F}{A} = \frac{F_1}{A} + \frac{F_2}{A} + \frac{F_3}{A} + \cdots \frac{F_i}{A} + \cdots$, this is equivalent to statement of Dalton's Law.

Avogadro's Law: In 1811, Amedeo Avogadro proposed an hypothesis that two samples of different gases of same volume, temperature and pressure contain same number of molecules. According to KTG, $pV = \frac{1}{3}mNv_{rms}^2 = \frac{2}{3}N\left(\frac{1}{2}mv_{rms}^2\right)$. Accordingly, for same volume, pressure and temperature for two different samples o gases, $m_1N_1v_{rems-1}^2 = m_2N_2v_{rms-2}^2$. Since, KE of molecules at same temperature is same i.e. $\frac{1}{2}m_1v_{rms-1}^2 = \frac{1}{2}m_2v_{rms-2}^2$; it implies $N_1 = N_2$.

Graham's Law of Diffusion: A Scottish scientist *Thomas Graham* in 1848 had experimentally established that *rate* of diffusion of gas is inversely proportional to square root of the mass of the particle, it is known as Graham's Law. This is mathematically expressed as $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$, here r_1 and r_2 are the rate of diffusion of two different gases while M_1 and M_2 , respectively are molar masses. It is *logical to believe that rate of diffusion is proportional to velocities of molecules* and therefore, $\frac{r_1}{r_2} = \frac{v_{rms-1}}{v_{rms-2}}$. As per KTE, at constant pressure and temperature it would lead to $m_1 v_{rms-1}^2 = m_2 v_{rms-2}^2$, accordingly, combining KTE with logic of diffusion, it leads to $\frac{v_{rms-1}^2}{v_{rms-2}^2} = \frac{m_2}{m_1} = > \frac{v_{rms-1}}{v_{rms-2}} = \sqrt{\frac{M_2}{M_1}}$. *Graham's Law in its the final form*.

Ideal Gas Equation: Initial elaborations of KTG, for an ideal gas, revealed that $pV = \frac{1}{3}mNv^2$, here *v* is used for v_{rms} at *T* K. Since kinetic energy of molecules is proportional to temperature, as discussed earlier, therefore, at triple point of

water $(T_{tr} = 273.16 \text{ K})$ where velocity of molecules represented by v_{tr} , $\frac{KE_T}{KE_{tr}} = \frac{\frac{1}{2}mNv^2}{\frac{1}{2}mNv^2_{tr}} = \frac{T}{T_{tr}}$, it leads to $v^2 = \frac{v_{tr}^2}{273.16}T$.

Accordingly, Ideal Gas Equation can be written as $pV = N\left(\frac{1}{3} \cdot \frac{mv_{tr}^2}{273.16}\right)T = NkT = nRT$. Here, three new constants are being introduced; firstly : $k = 1.38 \times 10^{-23}$ JK⁻¹, is called **Boltzmann Constant**, Secondly, constant is **Avogadro's Number** $N_A = 6.02 \times 10^{28}$, which represents **number of molecules in One Gram Mol of gas** (Gas of mass in grams equal to molecular weight of gas), and thirdly **Universal Gas Constant** $R = N_A k = 8.314$ JK⁻¹. This definition of N_A leads to $N = nN_A$, here n – represents number of moles of gas, as defined above.

The above two equivalents of pV lead to $\frac{1}{3}mNv^2 = NkT$, or $v = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3kT}{mN_A}} = \sqrt{\frac{3RT}{M_A}}$; here, $M_A = mN_A$ is called molecular

weight of the gas.

These variants of basic equation of KTG find application in different situations while handling either concepts or problems; it is, therefore, essential to know them so as to gain proficiency at it.

Intermolecular Force: One of the premises of KTG is that collisions of molecules are elastic in accordance with Newton's Laws of Motion, and was appropriate in the beginning. But developments into PE

understanding of atomic structure of atom in which there is a nucleus containing positive charges is enveloped by vacuum filled with electrons revolving around it. These molecules retain their structure so long they are away. Collision of molecules is neither like that of Billiard Balls impinging on each other nor like an arrow piercing a vacuum space. As the molecules with kinetic energy approach closer to each other their potential energy reduces and energy of electrons increases as they undergo rearrangement due to electrostatic forces. First graph above in the figure here, indicates Potential Energy (PE) of a molecule at a distance from another molecule, represented on X-axis, while the second graph represents forces between the molecules. As distance decreases, due to force of attraction, PE reduces and there is gain of KE. But, at r_0 , the distance between their center of mass, which is less that the Twice molecular radii, there is a force of repulsion across the Two Nucleus, as also redistribution of electrons, resulting into minimum PE. Further, reduction in distance with increasing force of repulsion there is gain of potential energy till velocity of the molecule reduces to zero. At this point, repulsion of molecules results in rebounding of an elastic collision. Typically, radius of Helium



atom at a separation of 4×10^{-10} m net force is 6×10^{-13} N. This net force comprises of 7×10^{-42} N gravitational force. Thus it is seen that as intermolecular distance net force increases by a factor 10^{29} , making gravitational force negligible. With this quantitative comparison deeper understanding of the phenomenon requires knowledge of electrostatics and structure of atoms, which at this age is not covered. Nevertheless, readers are welcome to raise their inquisitiveness through Contact Us.

Van der Wall's Equation and Correction in Gas Equation: Two of the premises of the KTG, that – a) volume of gas molecules is negligible and **b**) there are no intermolecular forces, were questioned by van der Wall. Regarding first premise, it is nearly true under very low pressure. Whereas, the second premise is invalid since intermolecular repulsion dominates the gravitational attraction as in the range of molecular diameter, as illustrated above. An in 1873, Johannes

Diderik van der Wall proposed a modified equation: $\left(p + \frac{an^2}{v^2}\right)(V - nb) - nRT$, known as van der Wall's Equation. This earned him Nobel Prize in 1910. Here, a and b are constants, known as (known as van der Wall's volume correction and pressure correction constants, respectively. Values of these constants need to be determined experimentally. Taking these constants a and b to be equal to ZERO, it reduces to ideal gas equation.

Maxwell's Speed Distribution Law: The equation of an ideal gas recognizes rms velocity of molecules and not

velocity of an individual molecule. In reality velocity of all molecules are different. Boltzmann had come forward with a statistical concept to suggest probability of occurrence different velocities as function of temperature and is known as Maxwell-Boltzmann Distribution of velocities of gas. p(v) = $\frac{N(v)}{N} = 4\pi \left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}}$ A plot of speed distribution of O₂ molecules is shown in the figure. It is seen that as temperature increases peal velocity reduces, but the number of molecules having higher velocities increase and



thus kinetic energy $\left(=\frac{1}{2}mv^2\right)$ of the molecules in the volume increases. This concept is an advanced concept in Statistics, Nevertheless, readers are welcome to raise their inquisitiveness through *Contact Us.*. This concept is extremely useful in explaining evaporation and boiling of liquid.

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Vaporization: This is process during which those molecules of liquid reaching, its surface open to environment, with a kinetic energy greater than the escape potential of the liquid surface get mixed in environment and do not return back to the liquid. Probability of liquid molecules having that kinetic energy is explained by **Maxwell's Speed Distribution**, while the escape energy is explained by **Intermolecular Forces** discussed above. Thus molecules of liquid mixed in air/gas above the liquid surface are called vapour. Vaporization has three manifestations: **a)** Unsaturated Vapour, **b)** Saturated Vapour, and **c)** boiling. Drying of clothes in rainy season is extremely slow and is attributed to high relative humidity.

Take an example of equal volumes volatile liquid in a pan and a bottle. The pan containing liquid, kept open to the environment, dries up after some time; lower the volatility greater is the time and vice-versa. In addition to this rate of evaporation is dependent upon temperature, pressure and wind flow which replaces vapour so generated. Nevertheless,

the liquid in an air tight bottle maintains its level. This must have been observed with scared water like गंगा जल, maintaining it same level if the bottle remains unopened. The reason of the liquid level in bottle remaining unaltered is the saturated vapour inside the bottle at which rate of molecules escaping the surface of liquid is equal to rate of molecules from the ambient air inside bottle returning to the liquid surface. Return of these molecules is explained by *Law Partial Pressure* exerted by vapour on the liquid surface. But, in case of an open pan the vapor is replaced by a fresh air and thus does not allow it to become saturated. <u>Saturated steam pressure</u> at different temperatures finds application in ventilation and air-conditioning applications. Accordingly, *Relative Humidity* (RH) is defined as :

$$RH = \frac{(Amount of water vapour present in a given volume of air at a given temperature)}{(Amount of water vapour required to saturate the same volume of air at the same temperature)} = \frac{(Vapour Pressure of air)}{(Saturated Vapour Pressure (SVP) at the same temperature)} = \frac{(SVP at dew point)}{(SVP at the same temperature)}.$$

This adds *Dew Point* to the vocabulary of Physics; *it is that temperature at which vapour starts condensing, i.e. formation of water droplets (dew) out of vapour starts.*

Boiling is the thermodynamic process where conversion of liquid into steam is in thermal equilibrium and temperature of liquid. Temperature at which boiling starts depends upon ambient pressure; and during this process, saturated vapour pressure is equal to ambient pressure, During change of phase from liquid to vapour or vice-versa system either absorbs or dissipates heat equivalent to Latent Heat for per gram of liquid.

Phase Diagram: Illustration on vapourization brought out that saturated vapour pressure depends upon temperature at which water and vapour co-exist. This happen with every liquid and these liquids upon further

cooling and higher pressure change into solid, the Third Phase. There are some substances which directly transform from solid to vapour phase viz. camphor (कप्र). This temperature dependent

coexistence of liquid-vapour, solid-liquid and liquid-vapour is shown with a curve. At this point a question that occurs is – can there be coexistence of three phases solid, liquid and vapour for any material. Answer is assertive and water, which is most accessible, has it at 4.58 mm Hg pressure and 273.16 K and is called *Triple Point* of Water as shown in the P-T graph; this graph is different for different substance. Triple Point for CO2 it is 216.55 K at 5.11 atmospheric pressure



(760 mm Hg). At atmospheric temperature solid CO2 directly converts into vapour and has extensive application in industry, and is known as dry ice.

Thermodynamics: Basics of heat started with Zeroth Law of Thermodynamics, which defines thermal equilibrium in respect of temperature, and is akin to Newton's First law of Motion, also called Law of Inertia. But, the whole world would have gone static if only the state of equilibrium was to prevail. In mechanics concern of energy conservation was confined to potential and kinetic energy. Nature is dynamic and every object keep interacting with the environment during which its internal energy changes. Introduction to heat adds a third dimension of energy and convertibility of work into heat has been discussed. Understanding of this dynamics is in the domain of Thermodynamics and is defined in Three *Laws as First, Second and Third Law of Thermodynamics* related to the *Conservation of energy*, *efficiency of heat engines* and *Entropy of a system*, respectively. *Entropy* another property of matter shall be introduced in elaborations on Second Law of Thermodynamics. In essence, every work that you see from cooking at home to rocket propulsion is a thermodynamic process and its understanding requires one to know Laws of Thermodynamics.

First Law of Thermodynamics (FLT): It is since related to law of conservation of energy, convertibility of energy is translated into an equation $\Delta Q = \Delta U + \Delta W$, or alternatively $\Delta Q - \Delta U - \Delta W = 0$, here, ΔQ - is amount of heat exchanged by the system with its environment, ΔU – is change in internal energy of the system which depends upon temperature, and ΔW – is the difference in amount of work done by the system and on the system. This equation, as usual is sign sensitive and therefore, the sign convention that is adopted is as under:

Sign	Heat	Internal	Ener	gу	Work	Done				
Convention										
+ve	Heat given to the system	Increase	in	Internal	Work	done	by	the	system	on
		Energy			enviror	iment				
-Ve	Heat taken away or extracted	Decrease	in	internal	Work	done	on	the	system	by
	from the system	energy			enviror	ment				-

Forward journey into thermodynamics require first to determine work done on or by gas and amount of heat required to



change thermodynamic state of gas. *p-v* curve of gas. The *ideal gas equation (IGE)* can be written as y = f(p, v) that pv - nRT. Accordingly, $\Delta \mathbf{v} = \mathbf{v} \cdot \Delta \mathbf{p} + \mathbf{p} \cdot \Delta \mathbf{v} = \mathbf{p} \cdot \Delta \mathbf{v}$; here, $\mathbf{v} \cdot \Delta \mathbf{p} = 0$, in accordance with the definition of work, since despite change of pressure there is no displacement. In view of this in moving from state A to B, work done $w = \int_{v_1}^{v_2} p dv$, i.e. area under the p-v curve. It is to be noted this area would depend upon shape of



the path traversed by the system to change state on p-v

diagram, and accordingly the this work done, which different for each path as shown in the figure.

The FLT can be viewed to define different thermodynamic processes as under –

- a) **Reversible Process** it is that process in which sequence of states are repeated, but in reverse sequence, viz freezing of water, evaporation.
- **b)** *Irreversible Process* in this process sequence can not be traced in reverse order, example age.
- c) Cyclic Process where system return to same thermodynamic state (*P*,*V* and *T*), in this process $\Delta U = 0$, and hence $\Delta Q = \Delta W$. Carnot's cycles, that shall be elaborated a little later, is a reversible cycle and explains Carnot's Engine.
- **d)** Isothermal Process in which temperature remains unchanged i.e. $\Delta T = 0$. In elaborations of KTG is seen that internal energy of gas depends upon its temperature and if $\Delta Q = 0$ and hence $\Delta U = 0$; therefore, $\Delta Q = \Delta W$. Further, using IGE in this process $p\Delta v + \Delta p \cdot v = 0$, thus gradient of p-v curve at any point is $\frac{dp}{dv}\Big|_{Isothermal} = \frac{\Delta p}{\Delta v}\Big|_{\Delta v \to 0} = -\frac{p}{v}$. Thus work done in this process, using IGE $W = \int_{v_1}^{v_2} p dv = \int_{v_1}^{v_2} \frac{nRT}{v} dv = nRT \int_{v_1}^{v_2} \frac{1}{v} dv = nRT \log_e \left(\frac{v_2}{v_1}\right) = nRT \log_e \left(\frac{p_1}{p_2}\right)$. Using Boyle's Law this relationship can be written as $W = nRT \log_e \left(\frac{v_2}{v_1}\right) = nRT \log_e \left(\frac{p_1}{p_2}\right)$, or $\log_e \left(\frac{p_1}{p_2}\right) = \log_e \left(\frac{p_1}{p_2}\right)$.
- e) *Adiabatic Process* in which system does not exchange heat with the environment and hence $\Delta Q = 0$. Accordingly, $\Delta U + \Delta W = 0$, or $\Delta U = -\Delta W$. This process is more complex its understanding requires to relationship between specific heat of gas separately at constant pressure and volume, and shall be discussed after elaboration of this relationship.
- **Isobaric Process** in this process pressure remains unchanged and it is not necessary that change in volume **f**) during process is isothermal. In such a process all finds its full manifestation i.e. $\Delta U = \Delta U + \Delta W$.

Exchange of heat thermodynamic process involve three variables, mass of substance, specific heat of substance and

change of temperature. Compressibility of gases attract two different views at specific heat - a) at constant volume (C_v) , where no work is involved, and b) at constant pressure (C_p) , it involves work $(= \int_{v_1}^{v_2} p dv)$. In the figure, first is the base case where state of the One gram mole of gas is (p, v, T). One Gram Mole gas is taken to rationalize equations. On placing the system with conducting end of the system open to heat source, such that the piston is locked with the pin to keep its



volume fixed at V, *i.e.* Δv , and therefore $p \cdot \Delta v = \Delta w = 0$. Using these inferences FLT leads to: $\Delta Q = \Delta U + 0 = C_v \Delta T$. It is leads to conclusion that at constant volume heat supplied to gas is absorbed in change in internal energy only.

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But, instead if system, in initial condition, is placed on heat source with piston unlocked, heat absorbed by the system to increase temperature of the gas, and in-turn increase in internal energy shall cause increase in internal pressure Δp . Since piston is free to move, this increased internal pressure would effect into expansion of the gas till equilibrium in pressure w.r.t. environment is achieved. This is the case of work done by the system on environment, hence Δw is +ve. This is since a case of transfer of heat under constant pressure heat transferred $\cdot \Delta Q = C_p \Delta T$, is utilized first in change in internal energy $\Delta U = C_v \Delta T$, and doing work as a consequence of change in internal energy such that $\cdot \Delta W = p \Delta v$. Using values of these constituents of FLT, the equation emerges as : $C_p \Delta T = C_v \Delta T + p \Delta v$.

From IGE pv = nRT, and in constant pressure case $p \cdot (V + \Delta v) = nR \cdot (T + \Delta T)$, thus for an incremental change in volume in this case $p\Delta v = nR\Delta T$. Thus $\Delta v = \frac{nR\Delta T}{p}$ and using this value in the above equation arrived at from FLT it leads to $C_p\Delta T = C_v\Delta T + p \cdot \frac{R\Delta T}{p}$, or, $C_p = C_v + R$, here all the constituents are in Cal \cdot Mol⁻¹ \cdot K⁻¹. In case constituents are taken in Jule-equivalent (i.e. Cal \cdot Mol⁻¹ \cdot K⁻¹, then $C_p = C_v + \frac{R}{l}$, since **R** is a **universal gas constant**

Adiabatic Process (Contd.): A man walking fast to reach bus-stop, a student running to reach school in time, pumping air in cycle are close adiabatic process. In this speed of work is so fast that heat generated in the process of work is not having sufficient time to dissipate into the environment and thus ideally Isothermal process is not achievable. Likewise, it is not possible to fully prevent dissipation of heat into environment, and therefore ideal adiabatic process is not achievable. Nevertheless, a typical adiabatic process is visualized in the figure below.

The FLT states, $\Delta Q = \Delta U + \Delta W$, since $\Delta Q = 0$, and hence $\Delta U = -\Delta W = -p\Delta v$. In this equation $\Delta U = nC_v \cdot \Delta T$ in discrete form and $dU = nC_v \cdot dT$, likewise from IGE pdv + vdp = nRdT. This leads to $dT = \frac{pdv + vdp}{nR}$, and using this in equation of FLT-



One and is evident by its basic definition. Integrating both sides of equation in its last form, yields $\gamma \log_e v + \log_e p = \text{Constant}$, or $pv^{\gamma} = \text{Const}$. This equation is known as **Poisson's Law of Adiabatic Process**. This law together with IGE can be written p-T form as $\left(\frac{nRT}{V}\right)v^{\gamma} = nRTv^{\gamma-1} = \text{Const}$. This equation in v-T form turn out to be $p\left(\frac{nRT}{n}\right)^{\gamma} = (nR)^{\gamma} \frac{T^{\gamma}}{n^{\gamma-1}} = \text{Const}$.

Next inference is the gradient of p-v curve in this process, derived Poison's Law, goes : $p\gamma v^{\gamma-1}dv + v^{\gamma}dp = 0$, it leads to $\frac{dp}{dv}\Big|_{Adiabatic} = -\gamma \cdot \frac{p}{v}$. It leads to an interesting finding that ratio of gradient of p-v curve in adiabatic and isothermal process leads to: $\frac{dp}{dv}\Big|_{Adiabatic} = \frac{-\gamma \cdot \frac{p}{v}}{\frac{p}{v}} = \gamma$. Thus, γ is characterizes correlations between isothermal and adiabatic processes.

The third and most important inference is work done in adiabatic process, which again evolves from Poison' Law using basic definition of work, $W = \int_{v_1}^{v_2} p dv = \int_{v_1}^{v_2} \frac{\text{Const.}}{v^{\gamma}} dv = \text{Const.} \int_{v_1}^{v_2} \frac{1}{v^{\gamma}} dv = \frac{1}{1-\gamma} \left[\frac{p_2 v_2^{\gamma}}{v_2^{\gamma-1}} - \frac{\text{Heat Source}}{\text{At Temp. } T_1} \right] = \frac{1}{1-\gamma} [p_2 v_2 - p_1 v_1].$ Together with this form, IGE leads to $W = \frac{1}{1-\gamma} [nRT_2 - nRT_1] = \frac{nR}{1-\gamma} [T_2 - T_1] = \frac{nR}{\gamma-1} [T_1 - T_2].$

Heat Engine: These discussions have laid basic premise for elaboration of Heat Engine which is conceptualized as shown in the figure. It takes heat from a source at high temperature and utilizes it doing work and part of unutilized heat is ejected into a sink at temperature lower than that of the source. Accordingly, efficiency of the Heat Engine $\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1}$. Carnot proposed an



Ideal Heat Engine (IHE) which work in a cycle ABCD as shown on a p-v diagram. The cycle works within Two isothermals at temperature T_1 and T_2 such that $T_1 > T_2$. These two isothermals are coupled by Adiabatic processed represented by BC during expansion and DA during contraction to return to initial state.



 T_1

Accomplishing this cycle through a system of gas filled in an insulated cylinder, in stages, is shown in the figure. Stage-I represents point A on the graph, while after traversing isothermal path AB the system absorbs heat from a source at a temperature T_1 so as to reach a point B represented by Stage-II. Next, the adiabatic path BC is brings system to a lower temperature T_2 corresponding to the point C, represented by Stage-III. Again an isothermal at temperature T_2 ejects heat to heat sink to reach point D, represented by Stage-IV. The last part of the cycle is path DA, which is an adiabatic process to bring back the system to initial state represented by point A. Thus, stage-V is identical to stage-I. Accordingly, work done is equal to area within the curve ABCD comprising of isothermal and adiabatic processes. Thus,

W = (Area under curve AB) +(Area under the BC) +

(Area under the BC) + (Area under curve CD) + (Area under the DA). Thus, mathematically $W = nRT_1 \log_e \left(\frac{v_2}{v_1}\right) + \frac{nR}{\gamma - 1}[T_1 - T_2] + nRT_2 \log_e \left(\frac{v_4}{v_3}\right) + \frac{nR}{\gamma - 1}[T_2 - T_1]$. The, direction of the paths automatically take care of sign convention. It gets simplified in the form of $W = nRT_1 \log_e \left(\frac{v_2}{v_1}\right) - nRT_2 \log_e \left(\frac{v_3}{v_4}\right)$. Accordingly, **efficiency of Carnot cycle** is expressed in the form of $\eta = \frac{nR(T_1 \log_e \left(\frac{v_2}{v_1}\right) - T_2 \log_e \left(\frac{v_3}{v_4}\right)}{nRT_1 \log_e \left(\frac{v_2}{v_1}\right)} = 1 - \frac{T_2}{T_1} \cdot \frac{\log_e \left(\frac{v_3}{v_4}\right)}{\log_e \left(\frac{v_2}{v_1}\right)}$.



Like pressure (P), volume (V), temperature (T) and internal energy (U) another parameter Entropy (S), which simplifies representation of the thermodynamic processes. A system in thermodynamic equilibrium has a definite entropy and if small amount of heat (ΔQ) is given to the system at temperature *T* then change in entropy $\Delta S = \frac{\Delta Q}{T}$. As per LCE, ΔQ has to occur between two discrete systems and, therefore, it is inferred that *entropy of an isolated* system remains constant. The Carnot cycle shown above in p-v diagram is represented in T-S diagram. As per definition of Entropy, path AB of the cycle during involves extraction of heat from source and thus entropy at temperature

 T_1 changes from S_1 to S_2 . And during isothermal path CD heat is ejected to sink at temperature T_2 . During adiabatic processes represented by BC and DA since there is no exchange of heat by the system with the environment, therefore, entropy of the system remains unaltered. Since, path AD returns the system to initial state A, therefore, entropy of the system must be restored to S_1 , and this in accordance with the above inference and is in conformance with the $T_{2} = \begin{bmatrix} T_{2} \\ T_$

Carnot's Theorem propounds that - All reversible engines operating between two temperatures have equal efficiency and no engine operating between the same two temperatures can have an efficiency greater than this.

Second Law of Thermodynamics: It is an evolution of understanding of heat engines which states that - It is not possible to design a heat engine which works on cyclic process and whose only result is to take heat from a body at a single temperature and convert it completely into mechanical work. This also known as Kelvin-Planck statement.

The concept of IHE has found application in actual heat engines used in advanced applications of conversion of heat energy into mechanical energy. These Heat Engines are classified in two broad categories: a) External Combustion Engine and **b**) Internal Combustion Engine.

External Combustion Engine: this type of engines carryout combustion outside the engine to produce heat. This heat is used to evaporate water at high pressure, and thus utilizing latent heat of steam, as shown in the figure below. This pressurized steam is injected into the steam engine cylinder. It is a two stroke engine; in first stroke steam pushes piston forward, and during this, steam/gas behind the piston is exhausted. This forward motion causes half-revolution of the wheel. In send stroke, through movement of valves, steam is injected into the evacuated part of the cylinder. Thus piston

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is pushed back to evacuate to complete remaining half of revolution of the wheel. In this process, earlier filled steam is evacuated. Thus these two strokes make a complete revolution, called cycle of the steam engine and hence it is called **Double Stroke Engine.** The exhaust steam, despite having given away its latent heat for conversion into mechanical energy, itse heat content is considerable. Therefore, in all steam engines exhaust steam is reused in a closed cycle to improve upon thermal efficiency of the heat engine.Regulation of fresh steam and exhaust is done with the help of valves whose movements are coupled through a separate mechanism coupled with the movement of piston.



Internal Combustion Engine: These engines use inflammable gas or liquid like petrol or diesel such that a mixture of inflammable liquid/gas ignites inside the engine. There are broad two types of external combustion engines- a) Petrol Engine, where ignition is caused by an electrical spark and b) Diesel Engine, in this gas is compressed at a pressure

enough to cause self-combustion. In case of liquid fuels, it is mixed with air in an atomizer before being injected into cylinder. While in gas it just a mixture with air to supplement oxygen for combustion. Atomizer is suitably designed and tuned to ensure that exhaust air does not have either unused oxygen or un-burnt fuel. Typical operation of petrol engine, in six stages, comprising of Four Strokes as shown in the figure below.



A Typical Four Stroke Internal Combustion Engine (Source: <u>https://en.wikipedia.org/wiki/Four-stroke_engine</u>)

Summary: This part brings basic concepts of Heat Energy, its transmission, thermodynamics including heat engines. Thermometry, the science of measurement of temperature involves concepts other than that of heat, which have not been touched upon until now. In virew of this Thermometry shall be taken together instrumentation after covering electricity. This is a strategic decision and is in line with the philosophy this manual to make it intrinsic.. Examples drawn from real life experiences help to build visualization and an insight into the phenomenon occurring around. A deeper journey into the problem solving would 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

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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, 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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Author is Coordinator of this initiative Gyan-Vigyan Sarita, a non-organizational entity of co-passionate persons who are dedicated to the selfless mission through **Online Mentoring** Session (OMS) to unprivileged children. He had his career as a power engineer, and after superannuation he did his Ph.D, from IIT Roorkee; soonafter this in 2012, he took a plunge into mentoring unprivileged children with Sarthak Prayash an NGO. The endeavour continued in different forms. Currently the thrust area, at the behest of District Administration, is School of Excellence, in Jhabua, a tribal District in MP.

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The ultimate value of life depends upon awareness and the power of contemplation rather than upon mere survival.

Aristotle

Progress is impossible without change and those who cannot change their mind cannot change anything.

- George Bernard Shaw

Attitude is Little thing that makes a big change.

- Winston Churchill

Don't educate your children to be rich. Educate them to be happy, so when they grow up they will know the value of thing a and not the cost.

-Ratan Tata

GROWING WITH CONCEPTS - Chemistry

MOLE CONCEPT

Kumud Bala

An element is a pure substance that contains only one kind of particles which may be atom or molecule.

ATOMS: An atom is the smallest particle of an element which may or may not be capable of independent existence.

For example: Iron, copper, silver, gold etc. can exist freely. Hydrogen, oxygen, nitrogen etc. cannot exist freely but they exit as H_2 , O_2 , and N_2

MOLECULE: A molecule is the smallest particle of an element or a compound which can exist freely. For example: Molecules of elements N_2 , H_2 , O_2 can exist freely. Molecules of compounds— H_2O , NH_3 , CO_2 etc. exist freely.

Atomic Mass: The atomic masses of all the elements were obtained by comparing with the mass of hydrogen taken as 1 (because it was the lightest element). But by doing so, the atomic masses of most of the elements come out to be fractional. Hence, the reference was changed from hydrogen to oxygen taken as 16. However, a still better reference which now is widely accepted, has been found to be carbon taken as 12. On this basis, the relative mass of hydrogen comes out to 1.008 and that of oxygen as 15.9994 or 16. Hence atomic mass of an element may be defined as follows:

"The atomic mass of an element is the number of times an atom of that element is heavier than an atom of carbon taken as 12".

Atomic masses are expressed as relative masses i.e., with reference to mass of a standard atom. These masses on the atomic mass scale are expressed in terms of "atomic mass unit"(amu).

"One atomic mass unit is equal to 1/12th of the mass of an atom of carbon-12 isotope".

Now-a-days, all atomic masses are expressed on the ${}_{6}^{12}C$ scale, taking mass of this isotope as exactly 12. This scale is called unified scale. Symbol ' μ ' is used instead of 'amu' The atomic masses of the element have been determined accurately during the recent years using an instrument called 'mass spectrometer'. It is found that in a number of cases, atoms of the same element posses different masses (isotopes). In such cases, the atomic mass of the element is taken as the average value. For example—ordinary chlorine is a mixture of two isotopes with atomic masses 35μ and 37μ . They are present in the ratio of 3:1. Hence, average mass of chlorine would be $35x3+37x1+3+1=35.5\mu$

"The atomic mass of an element is the average relative mass of its atoms as compared with an atom of carbon-12 taken as 12".

GRAM ATOMIC MASS: The atomic mass of an element expressed in grams is called gram atomic mass. This amount of the element is also called one gram atom.

For example: Atomic mass of oxygen =16amu, Gram atomic mass of oxygen=16g or one gram atom of oxygen=16g

MOLECULAR MASS: Molecular mass of a substance refers to the relative mass of its molecule.

"The molecular mass of a substance (element or compound) is the number of times of molecules of substance is heavier than $1/12^{\text{th}}$ the mass of an atom of carbon -12 isotope."

OR,

"The molecular mass of a substance is the average relative mass of its molecules as compared with an atom of carbon -12 isotope taken as 12".

For example: Molecular mass of H₂SO₄ is equal to:

2x at. mass of H + at. mass of S + 4x at. mass of O

2x1 +32.0 + 4x 16=98.0µ

GRAM MOLECULAR MASS:The molecular mass of a substance expressed in grams is called it gram molecular mass. This amount of the substance is also called one gram molecule.

For example: Molecular mass of $H_2SO_4=98.0u$, Gram molecular mass of $H_2SO_4 = 98$.og OR one gram molecule of H_2SO_4 .

FORMULA MASS AND GRAM FORMULA MASS: Ionic compounds such as NaCl, KNO₃, Na₂CO₃ etc. do not consist of molecule i.e., single entities but exist as ions closely packed together in three dimensional space. Each ion is surrounded by a number of oppositely charged ions. For example – in NaCl, each Na⁺ ion is surrounded by six Cl⁻ ions and vice versa. Hence in such cases, the formula is used to calculate the formula mass instead of molecular mass.

For example: Formula mass of NaCl = At. Mass of Na + At. Mass of Cl =23.0 +35.5 = 58.5u, mass of one formula unit = 58.5u.

Gram formula mass is expressed in grams e.g. gram formula mass of NaCl = 58.5g

MOLE: Quite commonly, we use different units for counting such as dozen for 12 articles, score for 20 articles and gross for 144 articles, irrespective of their nature. In a similar way, chemists use the unit 'mole' for counting atoms, molecules, ions etc. A mole is a collection of 6.022x10²³particle.

A mole represents 6.022x10²³particles.

The number 6.022×10^{23} is called Avogadro number denoted by 'N'.

For example:

1 mole of hydrogen atoms = 6.022×10^{23} hydrogen atoms

1mole of hydrogen molecules = 6.022×10^{23} hydrogen molecules.

1 mole of sodium ions = 6.022×10^{23} sodium ions.

1 mole of electrons = 6.022×10^{23} electrons

Mole in terms of mass

A mole is defined as the amount of substance that contains the same number of entities (atoms, molecules, ions, or other particles), as the number of atoms present in 12g of the carbon-12 isotope . Number of atoms in 1 mole of C-12 = 12g/mole of C-12 \div 1.992648 x10 ⁻²³g/atoms of C =6.022137x10²³atom/mole for simplicity =6.022x10²³ atoms / mole.

Mass of one carbon atom =1.992648x10⁻²³g

Mass of 6.022x10²³ atoms (or one mole atoms) of any element in grams is equal to its gram atomic mass or one gram atom.

Mass of 6.022x10²³ atoms of oxygen= 16g

Mass of 6.022×10^{23} atoms of sodium= 23g

Mass of 6.022x10²³ atoms of Argon= 40g

One mole of atoms = 6.022×10^{23} atoms = Gram atomic mass of the element

No. of mole = given no. of particles ÷ 6.022x10²³

Mole and Gram molecular Mass: Mass of 6.022x10²³ molecules (or 1 mole molecules) of any substance in gram is equal to its gram molecule mass or one gram molecule.

For example: The mass of 1 mole molecules (6.022x10²³ molecules) of water is equal to 18g.

One gram mole molecules of oxygen = 32g

One gram mole molecules of $CO_2 = 44g$

 6.022×10^{23} molecules of $CO_2 = 44g$

One mole of molecules $\equiv 6.022 \times 10^{23}$ molecules \equiv Gram molecular mass

Mass of 6.022x10²³ formula units (or one mole formula units) of any ionic substance in grams is equal to its gram formula mass.

For example: A mole of NaCl = $58.5 = 6.022 \times 10^{23}$ formula units of NaCl OR 6.022×10^{23} Na⁺ ions and 6.022×10^{23} Clions

1 mole of $CaCl_2$ = 111g = 6.022x10^{23} Ca^{+2} ions and 2x 6.022x10^{23} Cl^- ions

The mass of 1 mole of a substance is called its molar mass.

For example: Molar mass of sodium atoms=mass of 1 mole of sodium atoms = $23g/mole = 6.022 \times 10^{23}$ sodium atoms.

Molar mass of H_2O molecules = mass of 1 mole of H_2O molecules = $18g \text{ mol}^{-1} = 6.022 \times 10^{23} \text{ H}_2O$ molecules

Molar mass of NaCl= mass of 1mole of NaCl formula unit =58.5 mol⁻¹ =6.022x10²³ formula units of NaCl

Mole in terms of volume

Mole is also related to the volume of the gaseous substance. Volume of one mole of any substance is called its molar volume. One mole of an ideal gas occupies 22.4L at N.T.P ($O^{\circ}C$ and 1 atm. Pressure). i.e., $6.022x10^{23}$ molecules.

For example: 1 mole of Hydrogen gas at N.T.P = 22.4 L , 1 mole of CO_2 gas at N.T.P = 22.4 L Molecular mass = Molar Volume x Density



One mole of atoms =
$$\frac{mass of \ an \ element}{atomic \ mass}$$

Mass of one atom =
$$\frac{atomic mass}{6.022x10^{23}}$$

Mole of a compound =
$$\frac{mass of \ compound}{molecular \ mass}$$

Mass of one molecules = $\frac{molecular mass}{6.022x10^{23}}$

One mole of gas at N.T.P = 22.4 L

Calculate the number of moles in each of the following :

(1) 392g of sulphuric acid ($\rm H_2SO_4$) , (2) 44.8L of $\rm CO_2$ at N.T.P,

(3) 6.022×10^{23} molecules of oxygen, (4) 9.0g of aluminium

Solution:

(1) 1 mole of $H_2SO_4 = 98g$ (M. mass = 2x1+32+4x16 = 98g)

Thus, 98g of $H_2SO_4 = 1$ mole of H_2SO_4

 \therefore 392g of H₂SO₄ = 1x392/98 = 4 mole of H₂SO₄

(2) 1 mole of $CO_2 = 22.4L$ at N.T.P 22.4L of CO_2 at N.T.P = 1 mole \therefore 44.8 L of CO₂ at N.T.P = 1x44.8/22.4 = 2 mole of

 CO_2

(3) 6.022x10²³ molecules of $O_2 = 1$ mole of O_2 molecules

Assignment

(1)	One mole of CO ₂ contains									
	(a) 6.022x10 ²³ atoms of C	(b) 6.02x10 ²³ atoms	ns of O							
	(c) 18.1×10^{23} molecules of CO ₂	(d) $3g$ atoms of CO_2	(d) 3g atoms of CO ₂							
(2)	The mass of one molecule of oxygen is									
	(a) 32g (b) 32/6.02x10 ²³ g	(c) 16/6.02x10 ²³ g	(d) 0.32g						
(3)	1 mole of methane (CH ₄) contains									
	(a) 6.02x10 ²³ atoms of H	(b) 4g atoms of hydr	ogen	1						
	(c) 1.81x10 ²³ molecules of methane	(d) 3.0g of carbon								
(4)	Avogadro number is the number of mo	lecules present in:								
	(a) 1L of a gas at N.T.P	(b) 1 ml of a gas at N	I.T.P							
	(c) 22.4 of a gas at N.T.P	(d) 1 ml of a gas at 0)°C ar	nd 1 atm. I	Pressure					
(5)	The mass of an atom of carbon is									
	(a) 1g	(b) 1/12g								
	(c) 1.99x10 ⁻²³ g	(d) 1.99x10 ²³ g								
		(כ) (S)		(ɔ) (ɫ)	(q) (ɛ)	(q) (z)	(ɛ) (፲)			

S19WSnA



Author is M.Sc. (Chem.), M.Ed. and Advanced Diploma in German Language (Gold Medallist). She retired as a Principal, Govt. School Haryana, has 3-1/2 years' experience in teaching Chemistry and distance teaching through lectures on Radio and Videos. She has volunteered to complement mentoring of students for Chemistry through Online Webenabled Classes of this initiative.

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If you see moon..., you see beauty of God...; if you see Sun .. you see power of God..., and if you see mirror, you see creation of God.. so believe in yourself....

Ratan Tata

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Answers to Science Quiz in Supplementary e-Bulletin dt 1st Jan'17 Kumud Bala

1. (d); 2. (d); 3. (b); 4. (a); 5. (b); 6.(a); 7. (c), 8. (d); 9. (b); 10. (b); 11. (a); 12. (a); 13. (b); 14. (d); 15. (a); 16. (c); 17. (a); 18. (d); 19. (d); 20.(a)

Answers to QUIZDOM : Jan'17

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Phanindra Ivachury

1. SURENDRANATH BANERJEE (1848-1925); 2. RABINDRANATH TAGORE; 3. K.M.MUNSHI (KANIYAALAL MANIKLAL MUNSHI); 4. MUNDAKA UPANISHAD (MANTRA 3.1.6) WHICH IS FOUND IN ATHARVA VEDA; 5. INDIRA PRIYADARSHINI GANDHI; 6. MAULANA ABUL KALAM AZAD; 7. RAM PRASAD BISMIL; 8. ISHWAR CHANDRA VIDYASAGAR; 9. "GLIMPSES OF WORLD HISTORY"; 10. CHITTARANJAN DAS; 11. DR.SARVEPALLI RADHAKRISHNAN; 12. RAJA RAM MOHAN ROY; 13. SHYAM PRASAD MUKHERJEE; 14. SAROJINI NAIDU REFERRED TO AS THE NIGHTINGALE OF INDIA

We regret our inability to include QUIZDOM in this e-Bulletin

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SOLUTION TO THE PUZZLE-Jan'17: ON STRAIGHT LINE

Prof. S.B. Dhar

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					Е				I		Е		Т					Ν					
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SCIENCE QUIZ - Feb'2017

Kumud Bala

Amino acid is formed by decomposition of

 (a) carbohydrate
 (b) starch

(c) protein (d) fat

2. An element , which never has a positive oxidation state in any of its compounds , is
(a) boron
(b) oxygen

(c)chlorine (d) fluorine

3. The incorrect statement is

(a) acids have pH more than 7
(b) acids give H⁺ ions in water
(c) acids conduct electricity in aqueous solution
(d) acids turn blue litmus red.

4. Not a half- metal among the following, is(a) silicon(b) boron

(c) arsenic (d) chlorine

- 5. Not correct for isomers of a compound is
 (a) they differ in physical properties
 (b) they differ in chemical properties
 (c) they have same molecular formula
 (d) they have same structural formula.
- 6. Not a correct statement about the trends when going from left to right across the periods of periodic table?(a) the elements become less metallic in nature
 - (b) the number of valence electrons increases
 - (c) the atoms lose their electrons more easily
 - (c) the atoms lose their electrons more easing
 - (d) the oxides become more acidic
- 7. Thermal conduction takes places in(a) solids only(b) liquids only
 - (c) gases only (d) solids, liquids and gases.
- 8. The 'True' for compounds is (a) It shows properties of its constituents (b) It may be homogenous or heterogeneous (c) It can be separated by physical methods (d) It has fixed melting and boiling points 9. The number of moles for 52g of He is (a) 6.022×10^{23} (b) 13 (c) 52 (d) 1 10. The maximum number of electrons that can be accommodated in M-shell is (a) 2 (b) 8 (d) 32 (c) 18 11. Parachutes are made from (a) nylon (b) terylene (c) plastic (d) rayon 12. From its salt solution, Iron can displace (a) zinc (b) sodium (c) potassium (d) copper 13. The resources present in unlimited quantity in nature that can be used over and over are (b) fuels (a) gases (c) renewable resources (d) energy. 14. Restoring of the destroyed forests by planting new trees is known as (a) housekeeping (b) ecosystem (c) afforestation (d) deforestation. 15. The organic substance obtained from dead plants and an animal wastes is
 - (a) manure (b) fertilizer
 - (c) irrigation (d) agriculture.

(Answers to this Science Quiz shall be provided in Second Supplementray Bulletin dt 1st March'17)

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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 नारह 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 the 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 ...



