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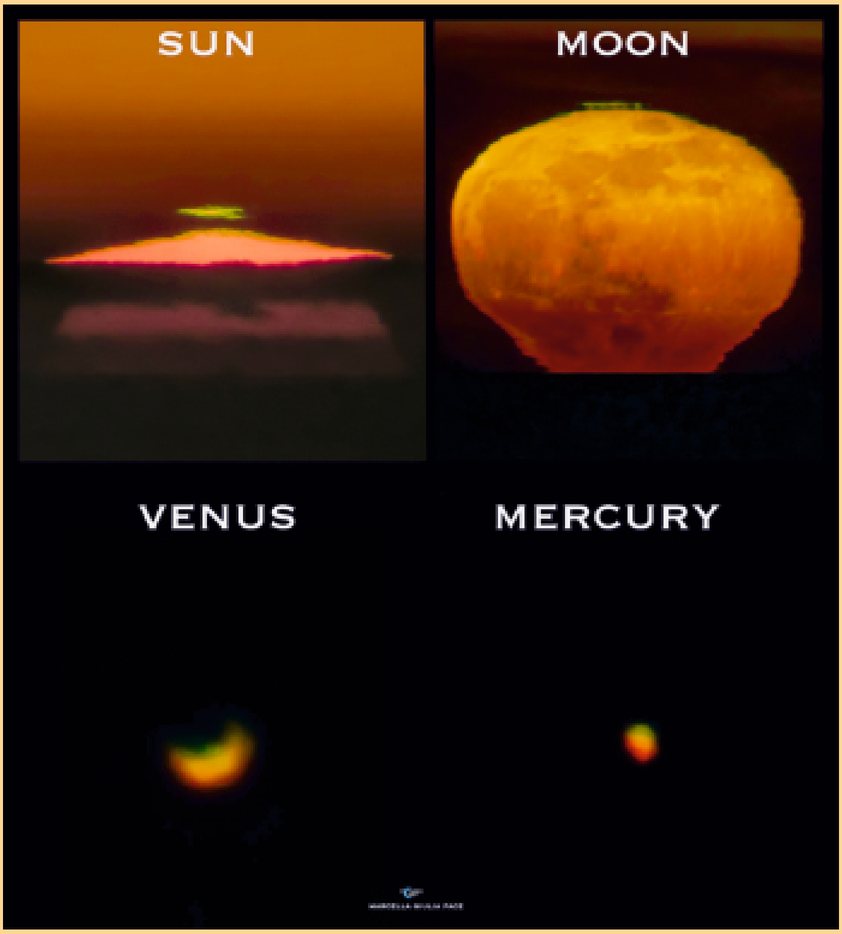

Follow a sunset on a clear day against a distant horizon and you might glimpse green just as the Sun disappears from view. The green flash is caused by refraction of light rays traveling to the eye over a long path through the atmosphere. Shorter wavelengths refract more strongly than longer redder wavelengths and the separation of colors lends a green hue to the last visible vestige of the solar disk. It's harder to see a green flash from the Moon, not to mention the diminutive disks of Venus and Mercury. But a telescope or telephoto lens and camera can help catch this tantalizing result of atmospheric refraction when the celestial bodies are near the horizon. From Sicily, the top panels were recorded on March 18, 2019 for the Sun and May 8, 2020 for the Moon. Also from the Mediterranean island, the bottom panels were shot during the twilight apparition of Venus and Mercury near the western horizon on May 24. https://apod.nasa.gov/apod/ap200530.html

PHYSICS NEWS

Capturing the coordinated dance between electrons and nuclei in a light-excited molecules

Using a high-speed "electron camera" at the Department of Energy's SLAC National Accelerator Laboratory, scientists have simultaneously captured the movements of electrons and nuclei in a molecule after it was excited with light. This marks the first time this has been done with ultrafast electron diffraction, which scatters a powerful beam of electrons off materials to pick up tiny molecular motions. "In this research, we show that with ultrafast electron diffraction, it's possible to follow electronic and nuclear changes while naturally disentangling the two components," says Todd Martinez, a Stanford chemistry professor and Stanford PULSE Institute researcher involved in the experiment. "This is the first time that we've been able to directly see both the detailed positions of the atoms and the electronic information at the same time."The technique could allow researchers to get a more accurate picture of how molecules behave while measuring aspects of electronic behaviors that are at the heart of quantum chemistry simulations, providing a new foundation for future theoretical and computational methods.

Read more at :https://phys.org/news/2020-05-capturing-electrons-nuclei-light-excited-molecule.html

Original paper : *Science (2020).* science.sciencemag.org/cgi/doi … 1126/science.abb2235

A single proton can make a world of difference

Scientists from the RIKEN Nishina Center for Accelerator-Based Science and collaborators have shown that knocking out a single proton from a fluorine nucleus, transforming it into a neutron-rich isotope of oxygen, can have a major effect on the state of the nucleus. This work could help to explain a phenomenon known as the oxygen neutron dripline anomaly. The neutron dripline is a point where adding a single neutron to a nucleus will lead to it immediately drip a neutron, and this sets a limit on how neutron rich a nucleus can be. This is important for understanding neutron rich environments such as supernovae and neutron stars, since nuclei at the dripline will often undergo beta-decay, where a proton is converted into a neutron, driving it up the periodic table. What was poorly understood is why the dripline for oxygen, with 8 protons, is 16 neutrons, while that of fluorine, with just one extra proton, is 22 neutrons, a much larger number. To try to understand why, the research group used the RI Beam Factory, operated by RIKEN and the University of Tokyo, to create an exotic nucleus, fluorine 25, which has 9 protons and 16 neutrons. The 16 neutrons and 8 of the protons form a complete shell, making it a 'doubly magic' nucleus that is especially stable, and the one extra proton—known as a "valence proton"—exists outside that core. The beam was then collided with a target to knock out the proton, leaving oxygen 24, and the SHARAQ spectrometer was used to analyze the resulting nucleus. The researchers analyzed what is known as the 'spectroscopic factor,' which is used to gauge the effects of interactions among nucleons in a nucleus on individual particles. According to Tsz Leung Tang, the main author of the study, "This is quite an exciting result, and it tells us that the addition of a single valence proton to a nucleus core - a doubly magic one in this case - can have a significant effect on the state of the core."

Read more at : https://phys.org/news/2020-05-proton-world-difference.html**.**

Original paper:*Physical Review Letters (2020).* DOI: 10.1103/PhysRevLett.124.212502

Researchers demonstrate high-efficiency emission of dispersive wave in gas-filled hollow-core photonic crystal fibers

In the past decade, anti-resonant, hollow-core photonic crystal fibers (HC-PCFs) have become excellent platforms for studying ultrafast nonlinear optics such as ultrashort pulse compression to the single-cycle regime, efficient generation of tunable dispersive wave (DW) at deep and vacuum ultraviolet wavelengths and soliton-plasma interactions. Although the transmission window of anti-resonant HC-PCF is disrupted by the presence of several sharp resonances, the appearance of these resonance bands gives rise to a new approach to high-efficiency emission of narrow-band DW. However, the high-efficiency DW generation can be achieved only when the wavelengths of the pump pulses are close to the resonance bands of the anti-resonant fibers.Recently, the research group from Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences has made new study on high-efficiency emission of dispersive wave.They demonstrated that photoionization effect of the pump pulse could greatly enhance the phase-matched DW emission within the resonance band of a gas-filled HC-PCF.

Read more at: https://phys.org/news/2020-05-high-efficiency-emission-dispersive-gas-filled-hollow-core.html

Sandeep Kaur
Department of Physics, PU Chd.

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- Letters and comments on matter published in the Bulletin.
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- Research papers in specialised fields of mainstream physics may not be sent. Research journals catering to specific areas of physics already exist. However, reviews of recent developments in various fields are welcome.
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- The length of the write-up should not, ordinarily, exceed 6 pages of the Bulletin, including diagrams, photographs, tables, etc.
- All matter received for publication is subject to refereeing. The editors reserve the right to abridge/alter the write-up for the sake of clarity and brevity.

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- Venue of the activity
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- Sponsors, if any (IAPT, RC or any other funding agency)
- Summary of the activity
- Name of the coordinator/convener/organiser along with address, email and mobile number

Maximum two photographs, if available, may be sent separately via email, preferably of the activity or audience.

Please send the report soon after the activity is over, not later than, say, three months.

If you are sending reports of more than one activities for publication in one issue of the Bulletin, kindly send a consolidated report of all the activities in a single communication.

Equation of State (EoS) of Solid Matter

N. V. Chandra Shekar and Balmukund Shukla

"What we have learned is like a HANDFUL OF EARTH, What we have yet to learn is like the WHOLE WORLD"- Avaiyaar-Medieval Tamil poetess-12th century AD

The 5% matter

Homo sapiens are endowed with the power of enquiry which they use for their quest for the truth about the universe. The advancement of science has led to mind-boggling progress in technology and ultimately great comfort of homo-sapiens. It is a great irony that although with all the tremendous control over various aspects of nature, homo-sapiens are a lonely species on the planet! And, the ultimate realization that what we know about the Universe is minuscule compared to the unknown and must be a reason for much-needed humility. As is shown in the **figure 1** all matter in the entire universe is only 27 % and out of which the baryonic matter (which is protons, neutrons atoms and molecules) is less than 5%. This less than 5% of matter is what we call plasma, gas-liquid and solid encountered in the scientific and technological processes of importance and relevance to humans. Most of the quantum mechanics developed during the first half of the 20th century has been worrying about explain mechanisms about the small fraction of the Universe! However, the great bulk of matter 90-95 % (of the 5% of Universe!!) of the visible universe is the mass of baryonic matter- stellar –interstellar objects, planets and exoplanets. The conditions prevailing in these are so exotic and extreme as compared to the terrestrial conditions that it has attracted enormous attention and has led to advances in astrophysics. States of matter under extreme conditions of pressure and temperatures are of high importance and relevance because of applications in the area of nuclear, thermonuclear, welding, synthesis of super hard materials, impact protection of space vehicles, high voltage and high power electro-physics and defence applications.

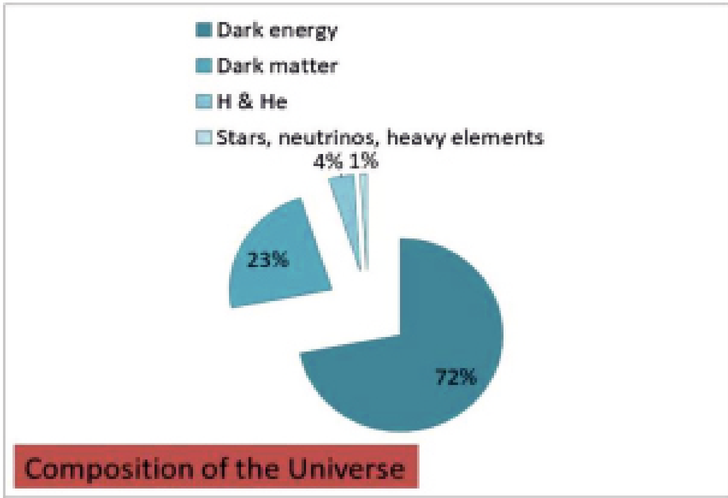

Figure 1.*Composition of Universe*

Equation of State

The very important problem in condensed matter physics or geophysics or astrophysics is to reliably predict the structural, electronic and physical properties under high pressure and temperatures. Equation of state of a system is the relationship between its thermodynamic quantities such as pressure,volume, temperature, energy, density, entropy, specific heat etc. It is of importance to both fundamental science and applied science.

Historically speaking

Historically, J. D. van der Waals can be called Father of Classical Equation of State when he introduced, in 1873, the first equation of state derived by the assumption of a finite volume occupied by the constituent molecules. His formula modernized the study of equations of state [**see box item 1**].

Box item 1

VAN DER WAALS, JOHANNES DIDERIK (1837 - 1923).
In 1873, van der Waals obtained his doctor's degree for a thesis entitled Over de Continuiteit van den Gas- en Vloeistoftoestand (on the continuity of the gas and liquid state). This equation of state was a dramatic improvement over the ideal gas law. It was van der Waals' genius that made him see the necessity of taking into account the volumes of molecules and the intermolecular forces ("van der Waals forces", as they are now generally called) in establishing the relationship between the pressure, volume, and temperature of gases and liquids. This copy of Over de Continuiteit is open to the chapter where van der Waal's equation of state, (P + a/V2)(V - b) = RT, is first derived. Van der Waals won the Nobel Prize for this work in 1910.
Partington IV, pp638-640; Nobel Lectures, Physics, 1901-1921.

Laws of Boyle's, Charles and Gay Lussac were discovered much before his contributions. In 1834, Émile Clapeyron had combined Boyle's Law and Charles' law into the *first statement of the ideal gas law:* $pV_m = R(T_C$ (in°C) + 267), where R is the gas constant. Later it was found to be 273.2, and then the Celsius scale was defined with 0 °C = 273.15 K, giving:

$p V_m = R (T_C + 273.15)$.

The Modern age of Equation of State started with P. W. Bridgman (1882-1961) who studies equation of state with laboratory static and dynamic techniques and got a great fillip with Walter Kohn (1923-2016) who developed the density functional theory for the equation of state of many-electron systems [**see box item 2**].

Box item 2

Bridgman entered Harvard University in 1900, and studied physics through to his Ph.D. From 1910 until his retirement, he taught at Harvard, becoming a full professor in 1919. In 1905, he began investigating the properties of matter under high pressure. A machinery malfunction led him to modify his pressure apparatus; the result was a new device enabling him to create pressures eventually exceeding 100,000 kgf/cm2 (10 GPa; 100,000 atmospheres). This was a huge improvement over previous machinery, which could achieve pressures of only 3,000 kgf/cm2 (0.3 GPa). This new apparatus led to an abundance of new findings, including a study of the compressibility, electric and thermal conductivity, tensile strength and viscosity of more than 100 different compounds. Bridgman is also known for his studies of electrical conduction in metals and properties of crystals.
https://en.wikipedia.org/wiki/Percy_Williams_Bridgman

Kohn made significant contributions to semiconductor physics, which led to his award of the Oliver E. Buckley Prize by the American Physical Society. He was also awarded the Feenburg medal for his contributions to the many-body problem. His work on density functional theory was initiated during a visit to the École Normale Supérieure in Paris, with Pierre Hohenberg, and was prompted by a consideration of alloy theory. The Hohenberg–Kohn theorem was further developed, in collaboration with Lu Jeu Sham, to produce the Kohn-Sham equations. The latter is the standard work horse of modern materials science, and even used in quantum theories of plasmas. In 2004, a study of all citations to the Physical Review journals from 1893 until 2003, found Kohn to be an author of five of the 100 papers with the "highest citation impact", including the first two.
https://en.wikipedia.org/wiki/Walter_Kohn

Matter Phase diagram

Figure 2 gives the matter phase diagram. At lower end of the density–temperature diagram we have condensed matter (P=1 Mbar and T=0.01eV). At lower pressures and temperatures matter exhibits exceptionally diverse properties and variety. The physical, chemical and biological properties of substances are sharp non-monotonic functions of composition. They are mostly defined by the electronic structure of their condensed state (which is made up of atoms and molecules). As we go to higher pressure matter becomes more uniform in its structures and properties.

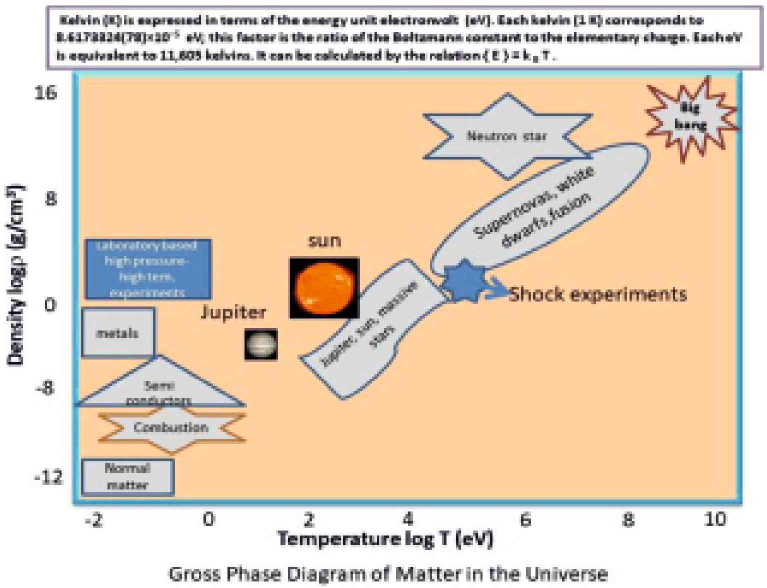

Figure 2: *The matter phase diagram*

Figure 3 shows the Pressure-Temperature diagram of the matter. Region-1 represents a normal state of matter where the equation of state is controlled by ordinary chemical forces. This region includes phase transitions such as solid-liquid-gas transitions, structural phase transitions and second-order transitions like paramagnetic to Ferromagnetic transitions. If we increase temperature corresponding to region-1 keeping the pressure fixed, we will enter to region-2 where the matter dissociates into atoms and molecules. The equation of state in this region is described by the equation of state for an ideal gas up to a good approximation.

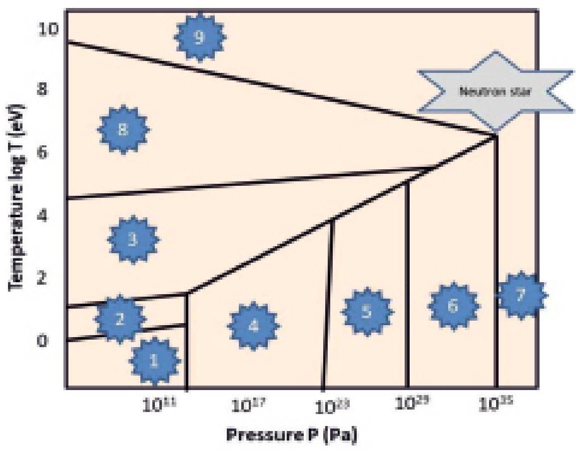

Figure 3 *Represents Pressure vs Temperature diagram over various order of magnitudes of pressure and temperature. The above figure represents the Pressure vs Temperature diagram over various order of magnitudes of pressure and temperature.*

In region-3, electron dissociation of matter occurs and one may use Saha equation to describe the equation of state. In this region, the matter is in a plasma state where the electrons from nondegenerate gas. If the thermal energy (K_BT) of electrons is much larger than the Fermi energy at 0 K, the electron gas is said to be non-degenerate and the electron behaves as a classical gas. However, in region-4 Fermi energy is much greater than the thermal energy, so quantum effects start to dominate. In this region, the equation of state is described by Thomas-Fermi and other related models. The difference between region-4 and region-5 is that, due to high pressure, we cannot ignore the relativistic effects. Therefore, in region-5, proper relativistic corrections must be incorporated. Region-5 is extensively studied in many astrophysical problems. Region-6 and 7 are the full-fledge relativistic case of electrons, protons and neutrons. In region-8, the thermal energy is almost twice the rest mass energy of the electrons. So pair production of electrons and positrons occur in this region. Neutrons also undergo beta decay in this region. In region-9, the thermal energy is twice the nuclear rest mass-energy. In this region protons and anti-protons are created and are in equilibrium with radiation.

Pressure-Volume-Temperature relations of fluids

With the approximation that molecules are very small as compared to the volume of the gas and there is no attraction or repulsion between the molecules, the so-called ideal gas equation is given as

$pV=RT$

However, none of these ideal gas equations gave useful results until J. D. van der Waals in 1873, in what Clausius called "very interesting paper", deduced the equation of state of imperfect gas as,

$(p+a/V^2)\ (V-b)=RT$

Where a and b are constants taking account of attraction and the finite size of molecules, respectively.

Based on approximations there are several modified van der Waal characteristic equation of state derived for gases for various temperature and pressure ranges. The most important feature of van der Waals equation is that it applies to a liquid state with the same constants and the equation describes critical point. We can now look at very practical applications of this equation of state for reservoir fluids. Presently, petroleum and its products are of foremost importance in the world economic scenario. In petroleum technology and science, understanding the phase diagram of reservoir fluids is very crucial. They are the fluids mixture in the deep earth within the rocks. They include liquid hydrocarbon (mainly crude oil), aqueous solutions with dissolved salt, and hydrocarbon and non-hydrocarbon gases such as methane and hydrogen sulphide, respectively. Hydrocarbons range from methane containing one atom of carbon to substances that contain 100 carbon atoms. In spite of the complexity of hydrocarbon fluids found in an underground reservoir, equations of state have shown the surprising performance of phase-behaviour calculations of these completed fluids. As explained earlier, an Equation of State (EOS) is an analytical expression relating pressure to the volume and temperature. Presently, several equations of states are used to describe the behaviour of reservoir fluids and they appear to be reliable in respective regimes of pressure and temperature. For example, a plot of pressure vs total volume of a pure substance is shown in figure 4. It is expected that the equation of state represents the volumetric behaviour of pure substance in the entire range of volume both in the liquid and the gaseous state. Subsequently, the EoS which was developed for pure fluids was extended to mixtures by using mixing rules. The mixing rules are simply a means of calculating mixture parameters equivalent to those of pure substance. In the literature, many equations of state are compared and used for describing the reservoir fluids at various depths of the earth. The findings have shown that there is no universal equation of state that will give the best prediction of all the thermodynamic properties of different types of reservoir fluids.

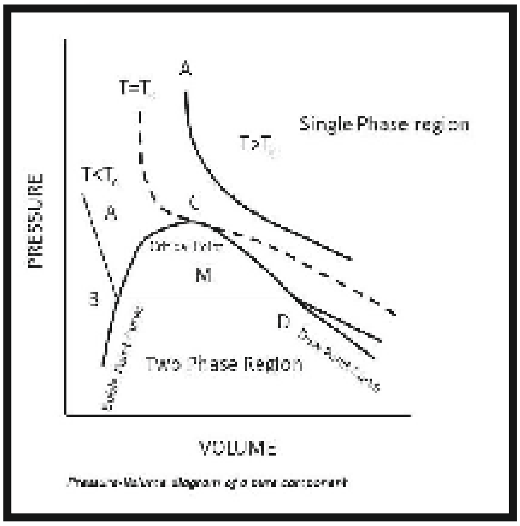

Figure 4 *Plot of pressure vs total volume of a pure substance*

Here, typical reservoir oil has been considered for Vapour/liquid equilibrium analysis and figure 4 describes the phase envelope of the oil sample. In this case, the sample has been analysed to identify various components using the liquid gas chromatograph and a compositional simulator is utilised for stimulating the PVT phase envelope. The software is used to find the phase envelope of the reservoir sample in the estimation of different characteristics of the oil sample.

Pressure-Volume-Temperature relations of solids

Matter in solid form is different from the gaseous and liquid states due to the long-range order of its atoms. A solid has a crystal structure and associated symmetry. Moreover, the inter-atomic/inter-planar distances in a solid are of the order of the few angstroms. A solid can have several types of forces acting between its atoms-which could be van der Wall, covalent, ionic or metallic. At the very short inter-atomic distances found in solids, we must take into account not only the interaction of the nucleus and electrons within each atom but also the interaction between the nuclei and electrons of different atoms. The knowledge of the equation of state of solids (EoS of solids) is of immense importance to basic as well as applied researchers. For basic researchers, the EoS provide a test to the theoretical models of cohesion and predict the structural stability and phase transition behaviour. They are used for pressure calibration in static as well as dynamic high-pressure experiments. In geophysics EoS studies help to understand the structure of the earth and in astrophysics to solve the mysteries of the evolution of stellar bodies. In applied sciences, their importance arises from their inputs for hydro-dynamical calculations in fission-fusion research.

There are various approaches in arriving at an expression for the equation of state of a solid. Here the following methods are described in a very brief manner

(i). Method using inter-atomic potentials

(ii). Method using finite deformation of solids

(iii). A method involving lattice vibrational energy (Gruneisen parameter)

In all the approaches the objective will be to arrive at a relationship **f(P, V, T)=0;** it represents a surface in PVT space. The PV isotherm (T=constant), isoentrope (S=constant) and shock Hugoniot (the locus of all possible states that be reached by using a single shock from a given initial state) are particular curves on this surface.

Box item 3

Francis Birch (1903-1992) is a famous case electrical engineer turned into a world class experimetal physicist. He was a graduate student under Prof. P. W Bridgman. Birch published over 100 papers. He developed what is now known as the Birch-Murnaghan equation of state in 1947.

Eduard Gruneisen (1877-1949) was a German physicist; co-eponym of Mie–Gruneisen equation of state Grüneisen was born in Giebichenstein. The Grüneisen Parameter was named after him. Since 1929 he was together with Max Planck editor of Annalen der Physik.

(i). Method using interatomic potentials

The cohesive forces in solid materials are basically electrostatic. However, their actual nature depends on the valence charge distribution around the atoms forming the solid. ***The Coulombic forces*** between charged structures elements like positive ions, negative ions, and free electrons. For example, when **r** is some characteristic dimension of the crystal lattice, the dependence of the Coulomb energy on **r** is **c/r;** where **c** is a constant independent of **r**. ***Repulsive Forces:*** When atoms or ions approach one another closely, their electron shells overlap and this gives rise to special quantum repulsive forces which are generally of the form**a exp (-r/ρ)**; where **a** and **ρ** are ideally constants. ***The van der Waals*** forces act between atoms and ions with filled electron shells as well as between saturated molecules. They are due to the polarization of atoms and can be represented approximately in the form: $-\xi(r)\frac{c}{r6}$; where ξ(r) is an approximation factor. The forces arising due to **sharing of electrons, a feature of the covalent bonds,** is directional in nature, i.e., atoms tend to join along with definite directions.A detailed theory of the covalent bonds is very complex because of its valence charge distribution.

Based on the above definitions bonding forces in crystalline solids can be divided roughly into four types. These four types are ionic solids, van del Wall solids, covalent solids, and metallic solids.Ionic crystals are those substances in which the main structural elements are positive and negative ions. The electrostatic energy of ionic crystals is expressed as: $-\frac{\alpha q^2}{r}$, where q is the smallest ionic change; r is the shortest distance between ions of opposite sign; α is the Madelung constant, which depends only on the lattice structure.

The potential (potential energy) for ionic crystals (*refer "cohesive energy" in any standard text on solid-state physics*)

$$E_p = \frac{3A}{b\rho_o} \exp\left[b\left(1 - x^{-1/3}\right)\right] - \frac{3K}{\rho_0} x^{-1/3}$$

Where ρ_o is the density under normal conditions (room temperature and atmospheric pressure); and $x = V/V_0$ is the dimensionless volume; $V_0 = 1/\rho_0$ is the volume of a unit mass of matter under normal conditions; V αr^3; A, b, and K are constants.

Using the well-known equation

$$P = -\left(\frac{\partial F}{\partial V}\right)_T = -\rho_0\left(\frac{\partial F}{\partial x}\right)_T,$$

relating P to F(free energy), an expression for the potential pressure $-P_p$ due to the potential energy of an ionic crystal can be obtained:

$P_p = Ax^{-2/3}\exp\left[b\left(1-x^{1/3}\right)\right] - Kx^{4/3}$, which is derived on the assumption that, at T = 0, the free energy and the potential energy are equal. By the addition of a term representing the zero-point vibrations, we obtain the isotherm of an ionic crystal at T = 0.

This the bulk modulus is derived as

$K_T = -V\left(\frac{\partial P}{\partial V}\right)_T = -x\left(\frac{\partial P}{\partial x}\right)_T$

whose potential component is

$K_P = -V\frac{Ax^{-2/3}}{3}\left(bx^{1/3} + 2\right)\exp\left[b\left(1-x^{1/3}\right)\right] - \frac{4}{3}Kx^{-4/3}$.

(ii). Method using finite deformation of solids

Francis Birch (see Box item 3) used the phenomenological theory of finite deformations put forward by F. D. Murnaghan. Here, free energy F is expanded as a power series of ε: (strain tensor)

$F = a_o + a_1\varepsilon + a_2\varepsilon^2 + a_3\varepsilon^3 + \ldots$,

Where the coefficients a_l depends only on temperature.

And pressure is given by

$P = -\left(\frac{\partial F}{\partial V}\right)_T = -(a_1 + 2a_2\varepsilon + a_2\varepsilon + 3a_3\varepsilon^2 + \ldots)\frac{d\varepsilon}{dV}$

$$\frac{d\varepsilon}{dV} = \rho_\eta(1-2\varepsilon)^{\frac{5}{2}}$$

which yields (ρ_η is density before deformation and ρ_ξ is density after deformation)the isothermal bulk modulus to be,

$K_T = -V\left(\frac{\partial P}{\partial V}\right)_T = V\left(\frac{\partial P}{\partial \varepsilon}\right)_T\frac{d\varepsilon}{dV}$

$$K_T = \frac{\rho_\eta^2}{9\rho_\xi} = (1-2e)[(2a_2 - 5a_1) + 2(3a_3 - 7a_2)\varepsilon + \cdots]$$

In the absence of deformation ($\varepsilon = 0$), the bulk modulus is

$K_{To} = \frac{\rho_\eta}{9}(2a_2 - 5a_1)$.

Expressing ε in terms of ρ_ξ / ρ_η, we obtain

$$\varepsilon = \frac{1}{2}\left(\left(1 - \left(\frac{\rho_\xi}{\rho_\eta}\right)^2/_3\right)\right)$$

And then the expression for the pressure becomes

$$P= -\frac{3K_{To}}{2a_2 - 5a_1}\left[a_1 + a_2\left(1-\left(\frac{\rho_\xi}{\rho_\eta}\right)^{\frac{2}{3}}\right) + \frac{3}{4}a_3\left(1-\left(\frac{\rho_\xi}{\rho_\eta}\right)^{\frac{2}{3}}\right)^2 + \cdots\right]\left(\frac{\rho_\xi}{\rho_\eta}\right)^{\frac{6}{3}}$$

If we assume that the initial undeformed state $\eta$is the state at P=0, we can show that $a_1=0$; then, the final expression for the pressure becomes

$$P = \frac{3}{2} K_{To}\left(x^{-1/2} - x^{-8/2}\right)\left[1 - \frac{3}{4}\frac{a_3}{a_2}\left(x^{-2/3}\right)\ \ldots\right]$$

Where, as before we have used $x=\rho_0/\rho = \left(\frac{\rho_\xi}{\rho_\eta}\right)$.

The expression is a **Birch equation**. The parameters K_{To} and a_3/a_2 are found experimentally using static high-pressure methods (with the help of diamond anvil cells).Equation of state of solids could be determined up to several hundreds of giga-pascals (figure 5). Table 1 lists various experimental methods used generally for the measuring parameters used for an equation of state determination. For example, Holzapfel (1998) can be consulted for the description of equations of state of solids under very high pressures.

(iii). A method involving lattice vibrational energy (Gruneisen parameter)

Gustav Mie derived the equation of state for a solid using classical statistical mechanics. Gruneisen (see box item 3) gave a different derivation of the Mie equation of state.

When a solid is heated at constant volume, all the thermal energy supplied to it is transformed into the lattice vibration energy, so that

$$2E_K = \int_0^T C_V\, dT,$$

where C_V is the specific heat at constant volume. It follows that

$$\left(\frac{\partial P}{\partial T}\right)_V = \frac{\gamma}{V}\frac{\partial(2E_k)}{\partial T} = \frac{\gamma}{V}C_V.$$

Table 1: Determination of Equation of State using various experimental methods

Using static compression techniques employing Diamond Anvil Cell, multi anvil cell X-ray diffraction- both angle and energy dispersive, neutron scattering, electron microscopy (TEM), X-ray nano-imaging, Raman spectroscopy, Brillouin scattering, resonant ultrasound spectroscopy, ultrasonic interferometry, photoacoustic spectroscopy
Using dynamic compression (Hugoniot) obtained using in-contact explosives or high-speed impacts like guns etc.
Using deformation-DIA, Rotational Drickamer apparatus Radial XRD, Rotational DAC, X-ray computed micro-tomography, X-ray coherent imaging

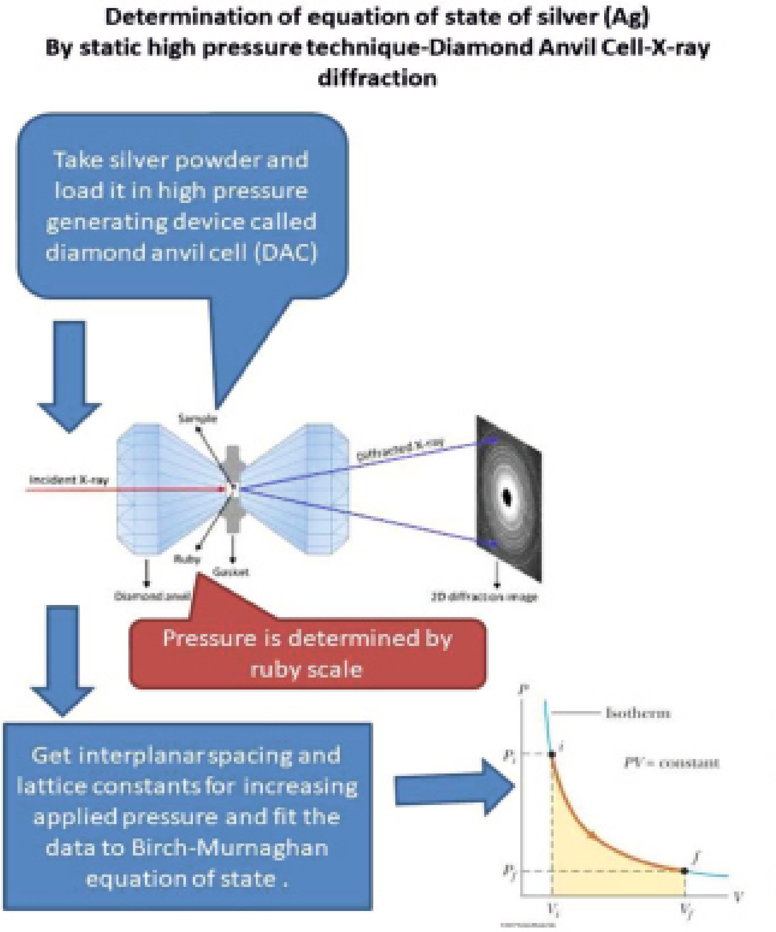

Figure 5: *Scheme for determination of EOS of Ag in the laboratory*

Since,

$$(\partial P/\partial T)_V = -\frac{(\partial V/\partial T)_P}{(\partial V/\partial P)_T} = -\left(\frac{\partial V}{\partial P}\right)_P \left(\frac{\partial V}{\partial P}\right)_T$$

We obtain the well-known expression for the ***Gruneisen parameter***:

$$\gamma = \frac{\alpha V K_T}{C_V}$$

Where $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P$ is the thermal expansion coefficient;

and $K_T = -V\left(\frac{\partial V}{\partial P}\right)_T$ is the isothermal bulk modulus.

Mie and Gruneisen were successful in explaining the qualitative properties of crystals from formal assumptions about the nature of the forces acting between particles. Anderson (1995) can be consulted for the importance of this parameter for geophysicists, and its micro and macro definitions.

In conclusion, the study of the equation of state of matter is a very important field both for basic as well as applied researchers. The quest for determination of equations that are universal to larger regimes of PVT is continuously being explored by geophysicists and astrophysicists.

Suggested further reading material:

- ✓ Anderson, O.L. (1995) Equations of State of Solids for Geophysics and Ceramic Science. Oxford University Press, Oxford, 405 pp.
- ✓ Angel, R.J. (2000) Equations of state. In: R.M. Hazen and R.T. Downs (Eds.) High-temperature and high-pressure crystal chemistry, Reviews in Mineralogy and Geochemistry, 41, 35-60.
- ✓ Birch, F. (1947), Finite elastic strain of cubic crystals, Physical Review, 71, 809-824
- ✓ Godwal B K, Sikka S K, Chidambaram, equation of state theories of condensed matter up to 10TPa, Phys. Rep 102 (1983) 121
- ✓ Holzapfel W. B. Equations of state for solids under strong compression 16 (1998) 81-126
- ✓ Jeanloz, R. (1988) Universal Equation of State. Physical Review B, 38, 805-807.
- ✓ Murnaghan, F.D. (1937) Finite deformations of an elastic solid. American Journal of Mathematics, 59, 235–260.
- ✓ Sahu, P. Ch, Chandra Shekar N V, High-pressure research on materials –II, Resonance 12 (2007) 49
- ✓ Sahu P. Ch, Chandra Shekar N V, High-pressure research on materials –I, Resonance 12 (2007) 10
- ✓ Shalom E, Ajoy G, Heinrich H, Fundamentals of equations of state (World Scientific, New Jersey, 2002)
- ✓ Zharkov V N, Kalinin V A, Equation of state for solids at high pressure and temperature (Springer Science+Business Media LLC, 1971)

Prof. N.V. Chandra Shekar (right) is Head, Condensed Matter Physics Division of the Materials Science Group of Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu. He is also Scientist–in-Charge UGC-DAE CSR, Kalpakkam Node. His primary research interests are in the area of high pressure phase transitions and synthesis and study of novel materials under extreme pressure and temperature conditions. He is also a Professor, Homi Bhabha National Institute, a deemed to be University under Department of Atomic Energy.

Dr. Balmukund Shukla (left) is Scientist in Condensed Matter Physics Division of the Materials Science Group of Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu. His research interests are in high pressure phase transitions of intermetallics and oxides ; specifically in uranium based compounds.

Report (RC-09)

Online National Awareness Program on COVID-19

Program Coordinator: Kamal Kumar Kushwah, Jabalpur Engineering College (JEC)
Co-ordinators: Saurabh Singh(JEC), Hameed Khan(GRKIST) and S.K. Mahobia (JEC)
Control Center: Jabalpur, M.P.
Date: May 12-13, 2020

The program was an initiative of Indian Association of Physics Teachers (IAPT, RC-09) during lockdown period of COVID-19 Pandemic. The aim of program was to make our students, teachers and public aware of protocols of COVID-19 pandemic proposed by world health organization (WHO). An online quiz with certification was organized containing questions based on the awareness of COVID-19. A minimum score of 80 % was set as a qualifying mark for issuance of a certificate. In total, **4637** candidates participated in the program from all over the country, of which **2171** successfully qualified for a certificate which were issued online.

In the quiz, some information was also sought about the background of participants. An analysis showed 71% participants were from urban area and 29% from rural area. There was almost equal participation from male and female respondents. Regarding educational background, as many as 51% were from UG level, 36% were from PG level and above and 13 % from schools.

It was a team work to the core. As many as 34 resource persons belonging to various institutions from 7 cities, working from their homes, took part in this exercise. The team included some doctors from medical profession.

The study material and tutorials were provided to participants before the quiz. Dr. Gireesh Soni and Dr. Vijay Bhat played key role in preparing that material. Questions were prepared by Dr Kanchan Khare and Dr. Swati Mahobia.

As a coordinator I thank all the resource persons for the successful execution of the program.

Kamal Kumar Kushwah
Program Coordinator

To our readers

For change of address and non-receipt of the Bulletin, please write (only) to:
our New Address :
The Managing Editor
Flat No. 206, Adarsh Complex,
Awas Vikas-1 Keshavpuram, \
Kalyanpur, Kanpur-208017
Email : iaptknp@rediffmail.com
Mob. : 09935432990

INDIAN ASSOCIATION OF PHYSICS TEACHERS

National Graduate Physics Examination 2020

Day and Date of Examination : Sunday, January 19, 2020

Time : 10 AM to 1 PM

<u>Instructions to Candidates</u>

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24	○	●	○	●

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Part B- Maximum Marks: 150 Time for Part B : 120 minutes

Part A

25 x 6 = 150

Mark the correct option/options (Any number of options may be correct).
Marks will be awarded only if all the correct options are marked. No negative marking.

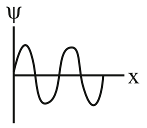
1. The position vector of a particle of mass m is expressed as $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. The value of $\vec{\nabla}.\hat{\vec{r}}$ is
   a) 0
   b) $\frac{1}{r}$
   c) $\frac{2}{r}$
   d) $\frac{3}{r^2}$

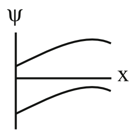
2. An infinitesimal volume element in cylindrical coordinate system is
   a) $d\tau = s^2\, ds d\varphi dz$
   b) $d\tau = \varphi ds d\varphi dz$
   c) $d\tau = z ds d\varphi dz$
   d) $d\tau = s ds d\varphi dz$

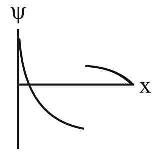
3. An electric field defined in a certain region is given by $\vec{E}(x,y,z) = ax\hat{i} + cz\hat{j} + 6by\hat{k}$. The set of values of parameters a, b and c that permits $\vec{E}(x,y,z)$ to be a valid electric field is / are
   a) 13, 1, 12
   b) 17, 6, 1
   c) 13, 1, 6
   d) 45,6,1

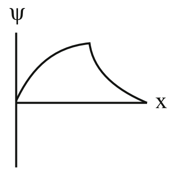
4. In a Newton's ring experiment, the plano-convex lens of radius R is kept on to a plane glass plate to obtain a central dark spot surrounded by concentric bright and dark rings. When the lens is raised vertically up by a distance 'h' without disturbing the set up, one thousand fringes emerge out of the centre and the central spot is still dark. The wavelength (λ) of the light used is
   a) $\lambda = h$
   b) $\lambda = h/5$
   c) $\lambda = h / 500$
   d) λ cannot be determined by the given data

5. Acceptable wave function (s) to represent the quantum state of a physical system is/are

   a) 

   b) 

   c) 

   d) 

6. If $\vec{A}$ is the magnetic vector potential, the value of $\oint \vec{A}.\vec{dl}$ is equal to
   a) 0 (Zero)
   b) Electric flux (ϕ_E)
   c) Magnetic flux (ϕ_B)
   d) Magnetic induction ($\vec{B}$)

7. An electron propagating along the x-axis passes through a silt of width Δy = 1nm. The uncertainty in the y-components after passing through the slit is
   a) $(\Delta p_y)(\Delta y) \sim \hbar$; 1.06×10^{-25}kgm/sec
   b) $(\Delta p_x)(\Delta x) \sim \hbar$. 7; 32×10^{-25}kgm/sec
   c) $(\Delta v_y)(\Delta y) \sim \hbar /m$; 1.16 10^5m/sec
   d) $(\Delta v_x)(\Delta x) \sim \hbar /m$; 7.32 10^5m/sec

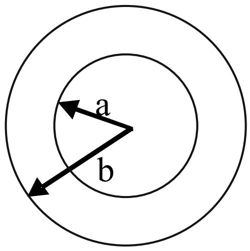
8. A hollow spherical shell as shown carries charge density $\rho = \frac{k}{r^2}$ in the region. $a \le r \le b$ The electric field in the region ($r \ge b$) is

a) $\vec{E} = \frac{k(r - a)}{\varepsilon_0 r^2}\hat{r}$

b) $\vec{E} = \frac{k(b - a)}{\varepsilon_0 r^2}\hat{r}$

c) $\vec{E} = \frac{k(b - a)}{\varepsilon_0 r^2}\hat{\theta}$

d) $\vec{E} = \frac{k(r - a)}{\varepsilon_0 r^2}\hat{\theta}$



9. A square plate of uniform thickness and side 'a' has its centre O at the point of intersection of the two diagonals AC and BD. A quarter of the plate is cut and removed so that the remainder looks like the shape in the Fig. 2

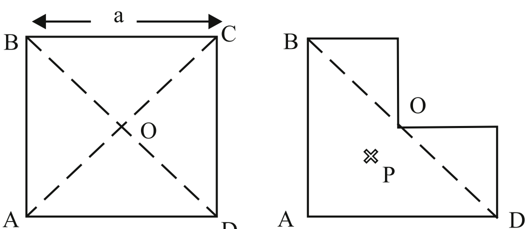


Fig. 1 Fig. 2

The centre of mass of this shape moves to P along the diagonal OA. The distance OP is

a) $\frac{a}{6\sqrt{2}}$

b) $\frac{a}{3\sqrt{2}}$

c) $\frac{a}{\sqrt{3}}$

d) $\frac{a}{\sqrt{2}}$

10. In an experiment with plane transmission diffraction grating with N parallel slits using monochromatic light, a number of principal maxima is observed. The intensity at the principal maximum

a) increases with the order of diffraction
b) decreases with the order of diffraction
c) is the same for all orders of diffraction
d) is proportional to N^2 in a particular order

11. A particle is released from $x = 1$ in a force field $F(x) = \left(\frac{1}{x^2} - \frac{x^2}{2}\right)\hat{i}$, for $x \ge 0$ which of the following statement(s) is/ are true?

a) $\vec{F}(x)$ is conservative.
b) $\vec{F}(x)$ is non-conservative.
c) The particle moves towards $x = \sqrt{2}$
d) The particle moves towards the origin.

12. A plane polarised light is passed through a quarter wave plate $\left(\frac{\lambda}{4}\text{ plate}\right)$. The emergent light

a) is elliptically polarised light
b) may be elliptically polarised light
c) may be circularly polarised light
d) may be plane polarised light

13. A sample of magnetic material is kept in the region of a magnetic field. The magnetic field is suddenly withdrawn under adiabatic conditions. The change in temperature is observed due to

a) Magnetic component of entropy
b) Lattice component of entropy
c) Phononic component of entropy
d) Vibrations of atoms about their mean position

14. Meissner effect can be used to distinguish between

a) metal and insulator
b) metal and semiconductor
c) superconductor and perfect metal
d) superconductor and insulator

15. The density of state changes with energy in nano rods as

a) E^0
b) $E^{\frac{1}{2}}$
c) $E^{-\frac{1}{2}}$
d) $E^{\frac{3}{2}}$

16. Two systems with heat capacities and entropies c_1, S_1 and c_2, S_2 respectively, interact thermally and come to a common temperature T_f. If the initial temperature of the system one was T_1, what were the initial temperature of system two (T_2) and net change in entropy (Δs) of combined system? You may assume that the total energy of the combined system remains constant.

a) $T_2 = \frac{C_1}{C_2}(T_f - T_1) + T_f$

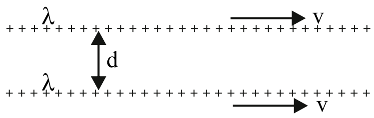
b) $T_2 = \frac{C_1}{C_2}(T_f - T_1) - T_f$

c) $S = In\left[\frac{T_2^{C_2}}{T_1^{C_1}} \cdot T_f^{C_1 - C_2}\right]$

d) $S = In\left[\frac{T_2^{C_2}}{T_1^{C_1}} \cdot T_f^{C_1 + C_2}\right]$

17. Two linear simple harmonic motions of equal amplitude, and frequency ω and 2ω along perpendicular directions of axes of X and Y respectively are impressed on a particle. If the initial phase difference between them is $\frac{\pi}{2}$, the resultant path followed by the Particle is
a) straight line
b) circle
c) parabola
d) ellipse

18. Two identical line of charge (charge per unit length λ) are moving parallel to each other at a separation d with velocity v. The value of v for which the electrostatic force of repulsion is completely compensated by magnetic attraction between them is



a) $v = \frac{c}{2}$

b) $v = \frac{c\sqrt{3}}{2}$

c) $v = \frac{1}{\sqrt{2}} c$

d) $v = c$

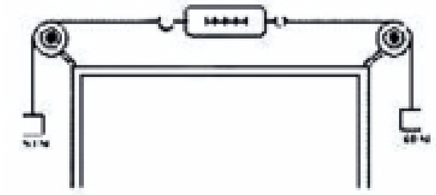
19. In the Kronig-Penney model, electrons are assumed to be moving in
a) one-dimensional square well potential
b) one-dimensional square well periodic potential
c) three-dimensional coulomb potential
d) a periodic harmonic potential

20. The ground state energy of a particle in an one-dimensional quantum well is 4.4 eV. If the width of the well is doubled, then the new ground state energy is
a) 1.1eV
b) 2.2eV
c) 8.8eV
d) 17.6Ev

21. Property (ies) of first order transition is /are
a) discontinuity in entropy
b) discontinuity in volume
c) discontinuity in derivative of Gibb's free energy
d) involvement of Latent heat

22. The distinction between Fermi-Dirac (FD) and Bose- Einstein (BE) distribution arises due to
a) Spin
b) Pauli exclusion principle
c) Indistinguishability
d) Wave function

23. A spring balance is stretched horizontally over a table by strings going over pulleys attached to table edges, and hanging 50 N weights. The reading on the balance in equilibrium is



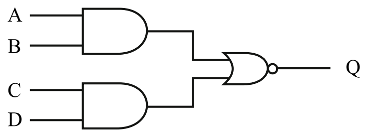
a) 100 N
b) 50 N
c) 25 N
d) 0

24. Fourier series of a given function f(x) in interval 0 to L is given

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos\frac{n\pi x}{L} + \sum_{n=1}^{\infty} b_n \sin\frac{n\pi x}{L}$$

then find the value of b_2 for f(x) = x, in the region (0,L)
a) L/2π
b) L/π
c) 2L/π
d) 4L/π

25. The Boolean equation of the circuit diagram shown below is



a) $Q = \overline{A.B + C.D}$
b) $Q = \overline{(\overline{A + B}).(\overline{C + D})}$
c) $Q = (\overline{A + B}).(\overline{C + D})$
d) $Q = A.B + C.D$

Part B_1 — 10x5 = 50

Answer all the following in brief (not more than 10 lines) with appropriate reasoning

B1. Imagine that by some grand feat of technology it becomes possible to create a perfectly uniform magnetic field (in z-direction) in a perfectly cubical region (with edges parallel to the x, y, z, axes). Is it possible to shoot a charged particle from outside this region into this magnetic field such that upon entry the particle remains confined to the region? If yes, how can this be done, and if no, why not?

B2 Electromagnets are used by cranes to hold, pickup, and move heavy metallic loads. This implies that magnetic forces can be used to do work. Defend or Refute.

B3 The radius vector of a planet sweeps out equal area in equal intervals of time. This is consistent with the conservation of angular momentum of the planet. Defend or Refute.

B4. Steel is more elastic than rubber, Defend/Refute

B5. A zone plate exhibits focusing action like a convergent lens but has multiple foci unlike the convex lens. Defend or refute.

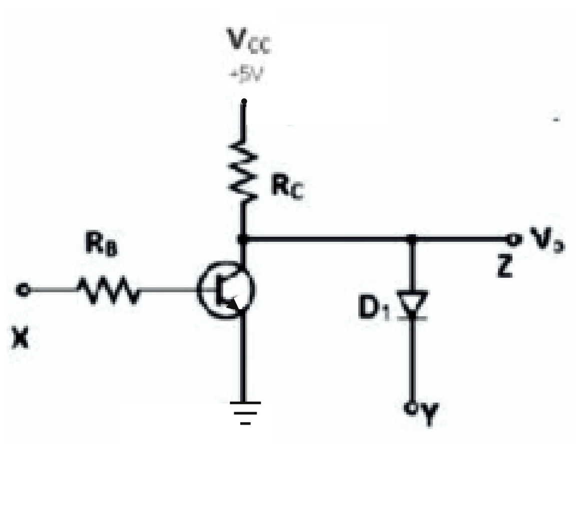
B6. A beam of plane polarised light is made incident normally on a quartz plate wtih faces cut parallel to the optic axis. If the plane of vibration of the incident beam is inclined at 30^0 with the optic axis, the ratio of intensities of ordinary and extraordinary rays, is found to be 1:3. Defend or refute.

B7. The minimum uncertainty in the energy of a hydrogen atom, if an electron remains in the exited state for 10^{-8} sec, is 3.3 ev. Defend or refute.

B8. The total energy of a moving particle is found to be much larger than its rest energy. Its de-Broglie wave length is equal to the wavelength of a photon of identical energy. Defend or refute.

B9. Neutrons can be slowed down, even by ordinary water which have Hydrogen-nuclei (^1_1H) having mass almost equal to that of neutrons. Still heavy water is used for this purpose in a reactor. Explain why?

B10. In the given circuit, the transistor has negligible collector – to – emitter saturation voltage and diode drops negligible voltage across it under forward bias. If V_{cc} is +5 volt, X & Y are digital signals with 0V and V_{cc} as logic 1, then the Boolean expression for Z as output is.......... Write the expression by filling up the gap.



Part B_2 10x10 = 100

Solve all the 10 problems. Each carries 10 marks.

P1. (a) The half-life of a sample of Ra^{226} is 1620 years, how many number of atoms decay in one second in 1gm sample of Ra?

(b) The amount of drug dissolved in the body is proportional to the amount present in the capsule, If 30% of 500 mg is dissolved in 1 hour, calculate the time taken to dissolve 450 mg.

P2. Knowing that $\int_A^B \vec{F}.\vec{dl}$ is regarded as the work done in moving a particle from A to B, evaluate the work done by the force $\vec{F} = 2xy\hat{i} + (x^2 - z^2)\hat{j} - 3xz^2\hat{k}$ N in moving a particle of mass m = 2kg from A (0,0,0) to B (2m,1m,3m) when the motion is restricted along a straight line.

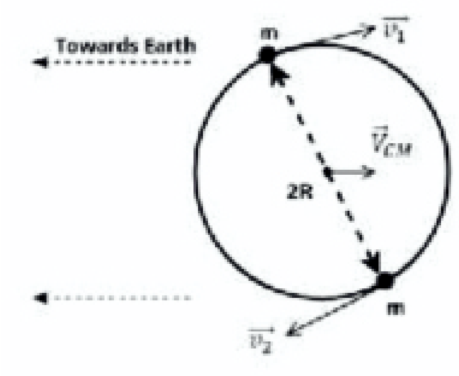
P3. When a surface is irradiated with light of wavelength $\lambda = 4950\ A^0$, a photo-current appears which vanishes if a retarding potential greater than 0.6V is applied across the photo-tube. When a different source of light is used, it is found that the critical retarding potential is changed to 1.1V. Find the work function of the emitting surface and the wavelength of the second source. If the photo-electrons (after emission from the surface) are subjected to a perpendicular magnetic field of 10 tesla, what changes will be observed in the above two retarding potentials?
($h = 6.63 \times 10^{-34}$ J-s, $c = 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C)

P4. A current distribution gives rise to a vector potential $\vec{A} = x^2yi + y^2xj - 4xyzk\ \frac{Wb}{m}$ calculate

a) the magnetic induction $\vec{B}$ at a point P(−1,2,5)

b) the magnetic flux-through the surface defined by $(0 \le x \le 1, -1 \le y \le 4, z = 1)$

P5. The figure shows a binary star system with its orbital plane containing the line of view from the Earth.



The system is a spectroscopic binary and light from it received on the Earth shows measurable Doppler shift. A hydrogen line corresponding to 4.568110×10^{14} Hz frequency in the laboratory, shows Doppler shifted frequency ranging from $f_{min} = 4.567710 \times 10^{14}$ Hz to $f_{max} = 4.568910 \times 10^{14}$ Hz in the light received from the binary. The time between two successive observations in which f_{max} is recorded is 11 days. Find

a) Velocity $\vec{V}_{CM}$ of centre of mass of the binary,

b) Speed v of either star on the circular orbit,

c) Radius R of the common circular orbit and

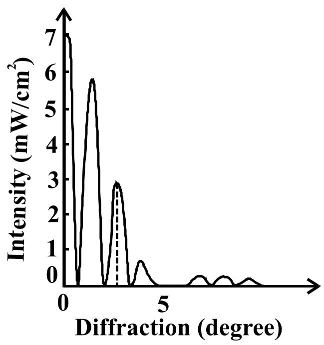
d) The common mass of the stars.

($G = 6.674 \times 10^{-11}$). The Doppler shift for electromagnetic waves is given by $f = f_0\left(1 - \frac{u}{c}\right)$ where u is the speed of the source away from a stationary observer.

P6. Explain the terms 'line-width' and 'frequency spread' for a spectral line obtained from a LASER. One of the most prominent line of Krypton (orange) is $\lambda = 6058\ A^0$ with the coherence length L = 20 cm. Calculate the line-with and the coherence time.

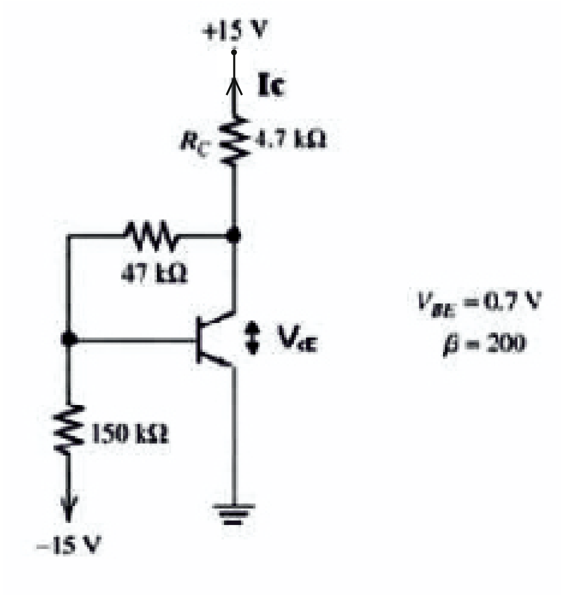
P7. Explain the terms self and mutual inductance. Write expressions for self and mutual inductance. A short solenoid (length l and radius a, with n_1 turns per unit length) lies on the axis of a very long solenoid (radius b, n_2 turns per unit length) as shown in figure. Current i flow in the short solenoid. Calculate the flux through the long solenoid. Also find mutual inductance between the two coils.

P8. Write down expression for the intensity for double slit diffraction. What do you mean by missing order in double slit diffraction pattern? Light of wavelength 440 nm passes through a double slit, yielding the diffraction pattern of intensity I verses diffraction angle as shown in the figure. Calculate width of each slit and slit separation.



P9. A piece of N-type Silicon of length L=10 μm has a cross sectional area A=0.001cm^2. A voltage 10V is applied across the sample yielding a current I = 100 mA. Calculate the resistance, conductivity & electron density of sample if the electron mobility μ_n = 1400 cm^2/V-sec.

P10. Analyse the circuit given in figure and determine I_c and V_{CE}. Given that V_{BE} = 0.7 V and β = 200.



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Q.No.	a	b	c	d
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Part A

25 x 6 = 150

Mark the correct option/options (Any number of options may be correct).
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1. Unit Vector $\hat{r} = \frac{1}{|\vec{r}|}(\hat{i}x + \hat{j}y + \hat{k}z)$

$$\vec{\nabla} \cdot \hat{r} = \vec{\nabla} \cdot \frac{1}{|\vec{r}|}(\hat{i}x + \hat{j}y + \hat{k}z)$$

$$= \left(\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}\right) \cdot \frac{1}{\sqrt{x^2+y^2+z^2}}(\hat{i}x + \hat{j}y + \hat{k}z)$$

$$+\frac{\partial}{\partial x}\left(\frac{x}{\sqrt{x^2+y^2+z^2}}\right) + \frac{\partial}{\partial y}\left(\frac{y}{\sqrt{x^2+y^2+z^2}}\right) + \frac{\partial}{\partial z}\left(\frac{z}{\sqrt{x^2+y^2+z^2}}\right)$$

$$= \frac{3}{\left(\sqrt{x^2+y^2+z^2}\right)} - \frac{x^2+y^2+z^2}{\left(x^2+y^2+z^2\right)^{3/2}} = \frac{3}{r} - \frac{1}{r} = \frac{2}{r}$$

Ans: c

2. In the system of cylindrical coordinates the volume element is $d\tau = s\,ds\,d\phi\,dz$

Ans: d

3. The electric field is $E = ax\hat{i} + cz\hat{j} + 6by\hat{k}$ the electric field must be conservative hence $\vec{\nabla} \times \vec{E}$ must vanish so

$$\vec{\nabla} \times E = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ ax & cz & 6by \end{vmatrix} = 0$$

$$\hat{i}\left\{\frac{\partial}{\partial y}6by - \frac{\partial}{\partial z}cz\right\} - \hat{j}\left\{\frac{\partial}{\partial z}ax - \frac{\partial}{\partial x}6by\right\} + \hat{z}\left\{\frac{\partial}{\partial x}cz - \frac{\partial}{\partial y}ax\right\} = 0 \text{ Or}$$

$i(6b-c) + 0 + 0 = 0$ (must be) so the answer is c.

Ans: c

4. In Newton's ring experiment with lens of large radius of curvature R, one can write $2\mu t = n\lambda$ when lens is raised by h $2\mu(t+h) = (n+1000)\lambda$ Using $\mu = 1$ for air, one obtains $\lambda = \frac{h}{500}$

Ans. c

5. The wave function f(x) must be
   a) Continuous
   b) Single valued and
   c) Differentiable

All these properties are exhibited by the function in figure (a)

Ans: a

6. Knowing that magnetic induction $\vec{B} = \vec{\nabla} \times \vec{A}$ Using stokes' theorem

$$\oint \vec{A} \cdot d\vec{l} = \oiint (\vec{\nabla} \times \vec{A}) \cdot d\vec{S} = \oiint \vec{B} \cdot d\vec{S} = \phi_B$$

Ans. c

7. According to uncertainty principle $\Delta p_y \Delta y = \hbar$

$$\therefore \Delta p_y = \frac{\hbar}{\Delta y} = \frac{6.63 \times 10^{-34}}{2\pi \times 1 \times 10^{-9}}$$

$$\therefore \Delta p_y = 1.055 \times 10^{-25} = 1.06 \times 10^{-25} \frac{kgm}{sec}$$

Also $\Delta v_y \Delta y = \frac{\hbar}{m}$ or

$$\Delta v_y = \frac{h}{2\pi m \Delta y} = \frac{6.63 \times 10^{34}}{2\pi \times 9.1 \times 10^{-31} \times 1 \times 10^{-9}}$$

$$\therefore \Delta V_y = 1.16 \times 10^5 \frac{m}{sec}$$

Ans: a, c

8. Total charge in the thick spherical shell between is r = a and r = b is

$$q = \int_a^b \frac{k}{r^2} 4\pi r^2 \, dr = 4\pi k \int_a^b dr$$

$\therefore q = 4\pi k\,(b - a)$ Then

$$\therefore \vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{4\pi k\,(b\text{-}a)}{r^2} \hat{r} \Rightarrow \vec{E} = \frac{k\,(b\text{-}a)}{\varepsilon_0 r^2} \hat{r}$$

Ans: b

9. If the fourth quadrant in added, the centre of mass should go back to O. So if OP = z then

$$\frac{\frac{3M}{4} z - \frac{M}{4} \times \frac{a}{2\sqrt{2}}}{M} = 0 \Rightarrow z = \frac{a}{6\sqrt{2}}$$

Ans: a

10. The intensity at a principal maximum is

$$I = \left(\frac{A \sin \alpha}{\alpha}\right)^2 (N \tan N\beta)^2$$

with all the standard symbols. Further

Lt $\beta \rightarrow \pm n\pi (N \tan N\beta)^2 = N^2$ Therefore

$$I = \left(\frac{A \sin \alpha}{\alpha}\right)^2 (N)^2$$ the first factor decreases in higher orders of diffraction

Ans: b, d

11. The force F is conservative if $\vec{\nabla} \times \vec{F} = 0$ or

$\vec{F}(x) = \left(\frac{1}{x^2} - \frac{x^2}{2}\right) i$; $\vec{\nabla} \times \vec{F} = 0$ Hence $\vec{F}(x)$ is conservative. The particle is in equilibrium when $F(x) = 0 \Rightarrow x^4 = 2 \Rightarrow x = 2^{\frac{1}{4}} \approx 1.18$

At x = 1, F (x) is positive, so particle moves towards $x = \sqrt{2}$

Ans: a, c

12. When a beam of plane polarised light passes through quarter $\left(\frac{\lambda}{4}\right)$ wave plate. The emergent light may be plane polarised, circularly or even elliptically polarised depending upon how the optic axis is inclined with respect to the direction of $\vec{E}$ vector of the incident light.

Ans: b, c, d

13. Sudden withdrawal of magnetic material from magnetic field under adiabatic conditions causes a change of temperature due to increase in magnetic component of entropy.

Ans. a

14. Miessner effect can be used to distinguish between supper conductor and perfect metal

Ans: c

15. Nano rods are one-dimensional objects hence considering one dimensional motion of the conduction electrons in these rods; we can apply the same concepts to calculate the density of states as for a 1 - D free electron gas:

Using periodic boundary conditions, one may have $\psi(x + L) = \psi(x)$ 1

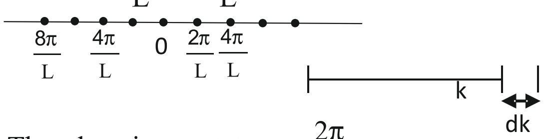
Where L= length of the Nano rod. Now using

$\psi(x) = A e^{ikx}$ .... 1 (for a free electron)

One gets using (1) & (2)

The allowed values of k are

$k = 0, \pm\frac{2\pi}{L}, \pm\frac{4\pi}{L}$, And so on



Thus there is one state per $\frac{2\pi}{L}$

Therefore the number of states between k and k + dk is $= \frac{2dk}{\frac{2\pi}{L}} = \frac{L}{\pi} dk$

Taking D (k) as the density of states (DOS) by definition one can write $D(k)\, dk = \frac{L}{\pi} dk$

Now using $E = \frac{\hbar^2 k^2}{2m}$ & $dE = \frac{\hbar^2}{m} k\, dk$

or $dk = \frac{m}{\hbar^2} \frac{1}{k} dE$ and further writing

D (k) dk - D (E) dE

= number of states between k and (k + dk)

= number of states between E and (E + dE)

We get;

$$D(E)\, dE = \frac{L}{\pi} dk = \frac{L}{\pi} \frac{m}{\hbar^2} \frac{1}{\sqrt{\frac{2mE}{\hbar^2}}} dE \text{ or}$$

$$D(E)\, dE = \frac{L}{\pi} \frac{\sqrt{m}}{\hbar\sqrt{2}} \cdot \frac{1}{\sqrt{E}} dE \Rightarrow D(E) \propto \frac{1}{\sqrt{E}} \text{ or}$$

$$D(E) \propto E^{-\frac{1}{2}}$$

Ans: c

16. Heat given = Heat taken so

$$c_1(T_f - T_1) = c_2(T_2 - T_f)$$

Or $T_2 = \frac{c_1}{c_2}(T_f - T_1) + T_f$

And the net change in entropy is

$$s + c_1\int_{T_1}^{T_f}\frac{dT}{T} = c_2\int_{T_f}^{T_2}\frac{dT}{T} + c_1 \ln\frac{T_f}{T_1} = c_2 \ln\frac{T_2}{T_f}$$

$$s = \ln\left(\frac{T_f}{T_1}\right)^{c_1} + \ln\left(\frac{T_2}{T_f}\right)^{c_2} = \ln\left(\frac{T_f^{c_1}}{T_1^{c_1}} \times \frac{T_2^{c_2}}{T_f^{c_2}}\right)$$

$$s = \ln\left(\frac{T_2^{c_2}}{T_1^{c_1}} \cdot T_f^{(c_1 - c_2)}\right)$$

Ans: a, c

17. Two SHM are x = a and sin ωt and

$y + a \sin\left(2\omega t = \frac{\pi}{2}\right)$ Thereby

$y = a\cos 2\omega t$

$= a\left[1\text{-}2\sin^2\omega t\right] = a\left[1 - 2\frac{x^2}{a^2}\right]$ Or

$y = a - \frac{2x^2}{a}$ Or $x^2 - \frac{a}{2}(y = a)$

This is the equation of parabola.

Ans: c

18. (Magnetic force = Electric force)

$F_{mag} = F_{el}$

$\frac{F_{mag}}{l} = \frac{\mu_0}{4\pi}\frac{2i_1i_2}{d}$ Where $i_1 = \lambda v$ and $i_2 = \lambda v$

$$\frac{F_{mag}}{l} = \frac{\mu_0}{4\pi}\frac{i_1i_2}{d} = \frac{\mu_0}{2\pi}\frac{\lambda^2 v^2}{d} \quad \text{...... (1)}$$

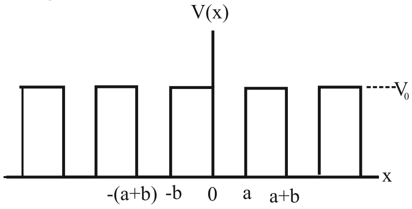
$$\frac{F_e}{l} = \frac{\lambda}{2\pi\varepsilon_0 d}\times\lambda = \frac{\lambda^2}{2\pi\varepsilon_0 d} \quad \text{...... (2)}$$

$$= \frac{\mu_0}{4\pi}\frac{2\times\lambda^2\times v^2}{d} \therefore \frac{\lambda^2}{2\pi\varepsilon_0 d}$$

$$v^2 = \frac{1}{\mu_0\varepsilon_0} \Rightarrow v = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = c = v \therefore c$$

Ans: d

19. Kronig and Penney model is a simplified model for an electron being in a one dimensional periodic potential. In this model, the potential V(x) is a periodic square wave where the electron experiences an infinite one dimensional array of finite potential wells as shown in figure. Each potential well models attraction to an atom in the lattice. The width of the wells must correspond roughly to the lattice spacing.



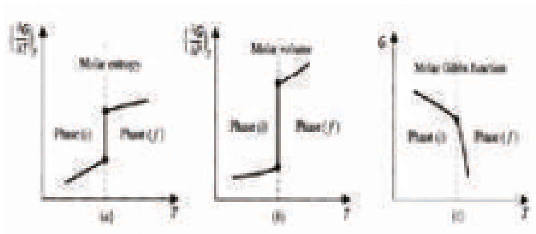
Ans : b

20. The energy states of a particle in a one-dimensional quantum well are

$E_n = \frac{n^2\hbar^2}{2\,ma^2} = 4.4\ eV$ when the width of well is doubled a is replaced by 2a, the energy is decreased four times and becomes equal to 1.1 eV.

Ans: a

21. Characteristics of a first-order phase transition are the discontinuous changes in (a) molar entropy and (b) molar volume where as the (c) Gibbs function is single valued with a discontinuous slope as shown below. Latent Heat is essentially involved in the first-order transition.

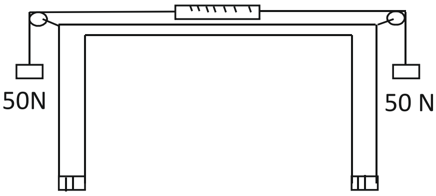


Ans: a, b, c & d

22. Fermions are indistinguishable, have half odd integral spin $\approx (2n+1)\frac{\hbar}{2}$ and obey Pauli Exclusion Principle. The wave function is anti-symmetrical. Boson, are indistinguishable, have integral spin $\approx n\hbar$ and do not obey Pauli Exclusion Principle. The boson wave function is always symmetrical.

Ans: a, b, d

23. The tension in the spring shall be 50 N



Ans: b

24. $$b_n = \frac{2}{L}\int_O^L f)x(\sin\frac{n\pi x}{L}\,dx = \frac{2}{L}\int_O^L x\ \sin\frac{n\pi x}{L}\,dx$$

$$b_n = \frac{2}{L}\frac{L}{n\pi}\left\{-x\cos\frac{n\pi x}{L}\Big|_0^L - \int_0^L \cos\frac{n\pi x}{L}dx\right\}$$

$$b_n - \frac{2}{n\pi} +]L\cos n\pi \quad 0[= \frac{2}{n\pi}\frac{L}{n\pi}\left[\sin\frac{n\pi x}{L}\Big|_0^L\right]$$

$$= \ b_2 \quad \frac{2L}{2\pi} = \cos 2\pi \quad \frac{L}{\pi} \ \neq for\ n \therefore 2$$

The value of the coefficient $b_2 = \frac{L}{\pi}$

Ans: b

25. The Boolean expression for the output of the circuit is $Q = \overline{A\cdot B + C\cdot D}$

Ans: a

Part B1 (Short Answer Question)

B1. If at all, a uniform magnetic field is produced, in a cubical region, along Z-axis then any charged particle projected from outside cannot remain inside forever. Ultimately it has to come out. There may be a number of ways for the charge particle to entre. We discuss a few of them here.

i. If a charged particle enters parallel to Z-axis, it experiences no force hence no acceleration/ retardation hence will go straight and pass out.

ii. If the initial velocity of charge particle is in x-y plane, the particle will experience a force, inside the field region; perpendicular to its velocity as a result it will traverse a circular arc and will come out in any case.

iii. If the initial velocity is perpendicular to a surface, the particle will traverse a semicircle and will come out perpendicular to the surface.

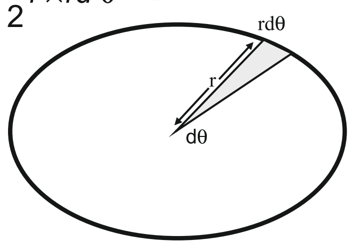
iv. If the initial velocity is not in x-y plane the trajectory will be helical and the particle will ultimately come out.

Over all this is **not possible**

B2. Static magnetic field cannot do work, however, time dependent magnetic fields have associated electric fields and these latter fields do work. The magnetic fields in the vicinity of cranes are non-static and time dependent. Hence it is possible to do work with them. This does not contradict the statement made provided the magnetic field in the statement are required to be to non-static. Hence the statement is defended.

B3 Let the radius vector sweeps an angle $d\theta$ in time dt. Then $\omega)t(= \frac{d\theta}{dt}$ and the area of shaded region is

$dA = \frac{1}{2} r \times rd\,\theta$ and



$\frac{dA}{dt} = \frac{1}{2} r \times r\frac{d\theta}{dt} = \frac{1}{2} r^2 \times \omega$ is areal velocity.

The angular momentum $L = I\omega = mr^2\omega$ or $L = m\left(2\frac{dA}{dt}\right) = 2m\frac{dA}{dt}$

Since m is constant, L is conserved when $\frac{dA}{dt} = constant.$ Hence statement is true.

Defended.

B4. The problem with this statement is that the colloquial meaning of the word elastic is opposite to its scientific meaning. In the colloquial sense, elastic means easily stretchable, Thus colloquially speaking rubber seems more elastic. Scientifically however, the word elastic has the following meanings:

1. High value of Young's modulus
2. Ability to return to original shape once the forces causing deformation are removed
3. Stress and Strain are related through a single valued function. There is no hysteresis.
4. The departure from single-valuedness viz the onset of plasticity occurs for a very high value of stress.

With respect to all these properties, steel is indeed more elastic than rubber. Hence statement interpreted scientifically stands defended.

B5. The working of a zone plate is based on the theory of Fresnel's half period zones and exhibit focusing action like a convex lens $\frac{1}{a} = \frac{1}{b} + \frac{n\lambda}{r_n^2}$. Where a and b are the conjugate distances of object and image from zone of plate. However it has multiple foci.

The respective focal lengths being $f_1 = \frac{r_n^2}{n\lambda}, f_2 = \frac{r_n^2}{3n\lambda}, f_3 = \frac{r_n^2}{5n\lambda}$ and soon where r_n is the radius of os n^{th} half period zone on the zone plate. The statement is defended.

B6. The vibrations of $\vec{E}$ vector of incident light are at 30^0 with optic axis so the amplitude of the E-ray is A cos 30^0 and that of O-ray is A sin 30^0

$$= \frac{\text{The intensity of O-ray}}{\text{The intensity of E-ray}} = \frac{(A\sin 30)^2}{(A\cos 30)^2} \therefore \frac{1}{3}$$

The statement is defended.

B7. Uncertainty principle is expressed

$$\Delta E \times \Delta t = \frac{\hbar}{2}$$

Given that $\Delta t = 10^{-8}$ sec

$$\therefore \Delta E = \frac{6.63\times10^{-34}}{4\pi\times10^{-8}\times1.6\times10^{-19}} = 3.29\times10^{-8}\,eV$$

$\Delta E = 3.3 \times 10^{-8}$ eV and not 3.3eV

Hence refuted

B8. Given that the energy of photon is equal to that of an electron means the electron energy $E = \sqrt{p^2c^2 + m_0^2c^4} = h\nu$ further since m_0c^2 is negligible, much less than E. Therefore E = pc or $\frac{E}{c} = p$ where as the momentum of photon is $\frac{h\nu}{c} = \frac{E}{c}$ thus the momentum of photon equals that of the electron and so must be the wave length i,e $\lambda_{electron} = \lambda_{photon}$ hence the statement is defended.

B9. Hydrogen nuclei have a greater probability of capturing the colliding neutron through the reaction ${}_1^1H + {}_0^1n \rightarrow {}_1H^2 + \zeta\,(energy)$ rather than reducing their energy. The heavy water has negligible cross-section for neutron capture. It only slows down the neutrons. This is why heavy water is a suitable moderator for a nuclear reactor.

B10. Basically without diode, the transistor circuit is a NOT-gate circuit, then the output will be always $\bar{x}$ for input x.

Now diode modified the output. It will allow the current only when diode will be forward bias. If Y input is high then it will be reverse bias and no current will flow through it. Thus output will be high only when both transistor T_1 & diode D_1 do not conduct otherwise it will be low.

Truth Table

x	y	z
0	0	0
0	1	1
1	0	0
1	1	0

Thus the Boolean expression is as $Z = \bar{x}y$

Part B2 (Numerical Problems)

P1 (a) $N = N_0 e^{-\lambda t}$ Thereby $\frac{dN}{dt} = -\lambda N_0 e^{-\lambda t}$

this gives the number of atoms disintegrated in one second. Thus $-\left.\frac{dN}{dt}\right|_{t=1} = \lambda N_0 e^{-\lambda} = \frac{\ln 2}{T}\frac{N_A}{A} \times 1$

$$= \frac{\ln 2}{1620 \times 365 \times 24 \times 3600} \times \frac{6.023 \times 10^{23}}{226} \times 1$$

The number of atoms disintegrated per second is $= 3.62 \times 10^{10}$

(b) Given that $-\frac{dm}{dt} \propto m \Rightarrow -\frac{dm}{dt} = k\,m$

$\frac{dm}{m} = -kdt$ Integrating In $m\big|_{m_0}^{m} = -\,k\,t\big|_0^t$ or $m = m_0 e^{-kt}$ *or* $kt = \ln\frac{m_0}{m}$ where m is the mass left after time t. Now after t = 1 hour, m = (1-0.30) m_0 = 0.7m_0 and after After time t, $m = (1 - 0.90)\,m_0 = 0.1\,m_0$ Then

$$t = \frac{\ln 10}{\ln\frac{10}{7}} = \frac{2.30258}{0.3567} = 6.5\,hr$$ Ans.

P2 $\vec{F}.\vec{dl} = (2xy\hat{i} + (x^2 - z^2)\hat{j} - 3xz^2\hat{k}).(\hat{i}dx + \hat{j}dy + \hat{k}dz)$

$= 2xydx + x^2dy - z^2dy - 3xz^2dz$ Now introducing a new variable t such that

x = 0, y = 0 and z = 0 when t = 0 and

x = 2, y = 1 and z = 3 when t = 1

so that x = 2t ⇒ dx = 2dt y = t ⇒ dy = dt

z = 3t ⇒ dz = 3dt Thereby

$$\int_A^B F.dl = 8\int_0^t t^2 dt - \int_0^t (4t^2 + 9t^2)dt = 162\int_0^t t^3 dt$$

$$\int_A^B F.dl = 3\int_0^1 t^2 dt - 162\int_0^1 t^3 dt = \left(3\frac{t^3}{3} - 162\frac{t^4}{4}\right)\Bigg|_0^1$$

$$\int_A^B Fdl = (1 - 40.5) = -39.5\ J$$

or

$\vec{F}.\vec{dx} = (2xyi + (x^2 + z^2)j - 3xz^2k).(idx - jdy + kdz)$

= 2xydx + x^2dy - z^2dy - 3xz^2dz Now

$$\int_A^B \vec{F}.\vec{dl} = 2x\left(\frac{x}{2}\right)dx - (2y^2)dy - (3y^2)dy = 3\left(\frac{2}{3}z\right)z^2dz$$

$$= \int_0^2 x^2dx - 4\int_0^1 y^2dy - 9\int_0^1 y^2dy = 2\int_0^3 z^3dz$$

$$-\left\{\frac{x^3}{3}\Big|_0^2 - 5\left\{\frac{y^3}{3}\Big|_0^1 = 2\left\{\frac{z^4}{4}\Big|_0^3\right.\right.\right.$$

$$= \frac{1}{3}\times 8 - \frac{5}{3}\times 1 - \frac{2}{4}81 = 1 - \frac{81}{2} = -39.5\,J$$

P3. According to Einstein equation, the energy (hv_1) of the light-photon incident on the surface is equal to the work-function W of the surface plus the kinetic energy E_k of the emitted photo-electron. Thereby

$hv_1 = W + E_k$

If the retarding potential is v_1 then

$E_k = eV_1$ also $v_1 = c / 1\lambda$

$$\therefore \frac{hc}{\lambda_1} = W + eV_1 \Rightarrow W = \frac{hc}{\lambda_1} - eV_1$$

$$= \frac{(6.6\times 10^{-34})\times(3\times 10^8)}{4950 \times 10^{-10}} = (1.6\times 10^{-19})\times 0.6$$

$$= 4.0\times 10^{-19} - 0.96\times 10^{-19} = 3.04\times 10^{-19}\,J$$

$$or\quad W = \frac{3.04 \times 10^{-19}}{1.6\times 10^{-19}} = 1.9\,eV$$

Using the light of another wavelength, (λ_2), we shall have

$$\frac{hc}{\lambda_2} + W = eV_2 = 3.04 \times 10^{-19} + (1.6\times 10^{-19}) \times 1.1$$

$$= 4.80\times 10^{-19}\,J$$

$$\therefore \lambda_2 = \frac{hc}{4.80\times 10^{-19}} = \frac{(6.6\times 10^{-34})\times(3\times 10^8)}{4.80\times 10^{-19}}$$

$$\lambda_2 = 4125\times 10^{-10}\,m = 4125\,\text{A}^0$$

Since the magnetic field does not change the speed of the ejected electrons, there will be no change in the stopping potential in both the cases.

P4 (a) Magnetic induction $\vec{B} = \vec{\nabla} \times \vec{A}$

$$\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x^2y & y^2x & -4xyz \end{vmatrix}$$

$$or\ \vec{B} = \hat{i}\left[\frac{\partial}{\partial y}(-4xyz) - \frac{\partial}{\partial z}(y^2x)\right]$$

$$-\hat{j}\left[\frac{\partial}{\partial z})x^2y(\quad \frac{\partial}{\partial x})+4xyz(\right]$$

$$-\hat{k}\left[\frac{\partial}{\partial x})y^2x(+\frac{\partial}{\partial y})x^2y(\right]$$

$$\vec{B} = -4xz\hat{i} - 0 + \hat{j}\times)0 + 4yz(+\hat{k})y^2 - x^2($$

$$\vec{B} - \ 4xz\hat{i} \quad 4yz\hat{j} \quad)y^2 = x^2(\hat{k}$$

$$\vec{B})-1,2,5(+ \ 20\hat{i} + \ 40j = 3\hat{k} \quad Weber / \text{m}^2$$

b) Magnetic flux

$$\phi = \iint \vec{B}.\vec{ds}$$

Further $\vec{B}.\vec{ds} = \vec{B}.dxdy\,\hat{k}$

$$= \left[-4xz\,\hat{i} + 4yz\,\hat{j} + \left(y^2 - x^2\right)\hat{k}\right].dx\,dy\,\hat{k}$$

$$\phi = \int_0^1\int_{-1}^4 \left(y^2 - x^2\right) dx\,dy$$

$$= \int_0^1\int_{-1}^4 y^2dxdy - \int_0^1\int_{-1}^4 x^2dxdy = \left(\frac{xy^3}{3} - \frac{x^3y}{3}\right)\Bigg|_0^1\Bigg|_{-1}^4$$

$$\phi = \frac{(1-0)\left[(4)^3 - (-1)^3\right]}{3} - \frac{(1^3 - 0)\left[4 - (-1)\right]}{3}$$

$$= \frac{60}{3} = 20\ Web$$

P5 The maximum frequency is observed when the star is moving directly toward the Earth where as the minimum while moving directly away. For the first case we have

$u = v - V_{CM}$ and the second $u = v + V_{CM}$

Thus

$$f_{max} = 4.568910 \times 10^{14} = 4.56811 \times 10^{14}\left(1 - \frac{V_{CM} - v}{c}\right) \text{ and}$$

$$f_{min} = 4.567710 \times 10^{14} = 4.56811 \times 10^{14}\left(1 - \frac{v + V_{CM}}{c}\right)$$

Solving for v and V_{CM}, we get

v = 3.9403 × 10 (m/s) and

$V_{CM} = -1.3135 \times 10^4$ (m/s)

this means that the binary system is approaching the Earth. The radius R can be found

by $\frac{2\pi R}{v} = T, where\, T = 11\, days$

$$R = \frac{vT}{2\pi} = 5.96\times10^9 m \ = 5.96\times10^6 km$$

Now for the circular motion of radius R for any one of the binary stars

$$\frac{Gm^2}{4R^2} = \frac{mv^2}{R} \Rightarrow m = 5.546\times10^{29} kg$$

P6. In Michelson's interferometer the interference pattern produced by two close wavelengths λ_1 and λ_2 disappears if $\frac{2d}{\lambda_2} - \frac{2d}{\lambda_1} = \frac{1}{2}$ where 2d is the path difference between the two beams producing interference. Thus

$$2d = \frac{\lambda_1\lambda_2}{2(\lambda_1 - \lambda_2)} = \frac{\lambda^2}{2(\lambda_1 - \lambda_2)} \quad \text{where } \lambda \text{ is the}$$

mean wavelength of λ_1 and λ_2. If instead of two discrete wavelengths, a beam of light having wavelengths lying between λ and $(\lambda + \delta\lambda)$ is used then the fringes will disappear if $2d \le \frac{\lambda^2}{\delta\lambda}$. This $\delta\lambda$ is known as the line width.

The temporal coherence of the beam, thus is directly associated with the width of the spectral line. Since the fringes are not observed if the path difference exceeds the coherence length L, we may assume that beam contains all the wavelengths lying between λ and $(\lambda + \delta\lambda)$.

Then line width $\delta\lambda = \frac{\lambda^2}{L}$ further using

$\upsilon = \frac{c}{\lambda}$, the frequency spread $\delta\upsilon$ of the line would be $\delta\upsilon = -\frac{c}{\lambda^2}\delta\lambda = \frac{c}{\lambda^2}\times\frac{\lambda^2}{L} = \frac{c}{L}$ Further since conference time $\tau_2 = \frac{L}{c}$ $\therefore \delta\upsilon = \frac{1}{\tau_2}$ thus the frequency-spread of line is of the order of the reciprocal of coherence time. It is clear that if frequency-spread is known, the coherence-time can be calculated.

Here $\lambda = 6058 A^0 = 6.058 \times 10^{-7}$ m, L = 20 cm

and c = $3\text{x}10^8 \frac{\text{m}}{\text{sec}}$ Then Line width

$$\delta\lambda = \frac{\lambda^2}{L} = \frac{)6.058\times10^{-7}(^2}{0.20}$$

$\delta\lambda = 0.01835\ 10^{-10}$ m $= 0.01835 A^0$

Frequency-spread

$$\delta\upsilon = \frac{c}{L} = \frac{3\times10^8}{0.20} = 1.5 \times 10^9 H_Z$$

$$\tau_c = \frac{1}{\delta\upsilon} \quad \frac{1}{1.5\times10^9} = 0.67\times10^{-9} \text{ sec.}$$

P7 Self-inductance: Whenever a current is passed through a coil, a magnetic flux is found to be linked with the coil. The flux so linked is proportional to the current

i,e $\phi \propto i$ or $\phi = Li$ --------- (1)

This phenomenon is known as self-induction and the constant L is known as the coefficient of self-induction or simply the self - inductance of the coil. L is expressed in units of Weber/ampere = Henry. One may also express the induced emf in the coil as $\varepsilon = -\frac{d\phi}{dt} = -L\frac{di}{dt}$

For a current carrying circular coil of radius r magnetic field produced at its centre is

$B = \frac{\mu_0 ni}{2r}$ If r is small, the flux

$\phi = B.A = \frac{\mu_0 ni}{2r} \cdot \pi r^2$

Thereby the flux linked to n turns is

$n\phi = \frac{\mu_0 \pi n^2 r}{2} i = Li$ therefore the Self Inductance $L = \frac{\mu_0 \pi n^2 r}{2}$

Mutual Inductance: Whenever current is passed through a coil, a magnetic flux is found to be linked with the neighbouring coil such that

$\phi_2 \propto i_1$ or $\phi_2 = M_{21} i_1$ .... (2)

This phenomenon of linkage of flux with the second coil when current is passed through the first coil is known as mutual induction and the constant M_{21} is the coefficient of mutual induction or simply the mutual inductance between the two coils. Unit of M is 'Henry'. Also if the current is passed in second coil, the flux is found to be linked with the first coil i,e $\phi_1 = M_{12} i_2$

It is observed that $M_{12} = M_{12} = M$ and M is known as mutual inductance between the two coils under the given condition.

In case the two coils are in perfect coupling,

$M = \sqrt{L_1 L_2}$ If we consider a long solenoid with n turns per unit length and carrying a current i, the magnetic field at a point on its axis near the middle is $B = \mu_0 ni$ If a coil of small radius rand having N turns is just kept coaxial with the solenoid at its centre, the flux linked with the coil is $\phi_{coil} = NB\pi r^2 = N)\mu_0 ni(\pi r^2$ or

$\phi_{coil} = \mu_0 Nn \pi r^2 i \Rightarrow \phi_{coil} = M i_{solenoid}$

so the mutual inductance between the coil and the solenoid is $M = \mu_0 Nn \pi r^2$ In the present problem a short solenoid is kept coaxial with a long solenoid. If a current I be passed through the long solenoid, flux through the short solenoid is then $\phi_{short} = n_1 l)\mu_0 ni_{long}(\pi a^2$ or

$\phi_{short} = \mu_0 n_1 \ln \pi a^2 i_{long} = M i_{long}$

At the same time $\phi_{long} = Mi_{short}$

$= \phi \therefore \mu_0 n_1 n_2 l \pi a^2 i$ there by the mutualinductance is $M = \mu_0 n_1 n_2 l \pi a^2$

P8 The intensity in the diffraction pattern of double slit is expressed as

$$I = 4R_0^2 \left(\frac{\sin\alpha}{\alpha}\right)^2 \cos^2\beta \text{ .... (1)}$$

Where $\alpha = \frac{\pi}{\lambda} e \sin\theta$ and $\beta = \frac{\pi (e+d) \sin\theta}{\lambda}$

where e and d are the width of each slit and the separation between the two consecutive slits respectively.

Missing order of diffraction: It is seen from equation (1) that the intensity is the product of two terms namely $\left(\frac{\sin\alpha}{\alpha}\right)^2$ which represents the resultant intensity due to single slit and $\cos^2\beta$ which denotes the effect of two slits.

Intensity is maximum when $\cos^2\beta = 1$ showing a maximum. If however the intensity due to single slit vanishes at this position of maximum then this order of maximum is said to be absent hence for absent order

$\sin\alpha = 0$ (Must be) $\Rightarrow e\sin\theta = m\lambda$ and

$\cos^2\beta = 1 \Rightarrow (e+d)\sin\theta = n\lambda$ In the present problem at $\theta\, 5^0$ m = 1, and N = 4

$$\therefore \frac{(e+d)\sin 5}{e \sin 5} = \frac{4}{1} \Rightarrow \frac{e+d}{e} = 4 \Rightarrow d = 3e$$

Also from $e\sin 5^0 = \lambda$ (for first minimum)

$\Rightarrow e = \frac{440\times10^{-9}}{\sin 5^0}\, m = \frac{440\times10^{-9}}{0.08716}$

Thus e = 5.048×10^{-6} m = 0.005 mm and

d = 3×5.04810^{-6} = 0.015mm

P9. According to Ohm's law the resistance of given silicon piece

$R = \frac{V}{I} = \frac{10}{100\times10^{-3}} = 100\Omega$

Also $R = \rho \frac{l}{A} = \frac{l}{\sigma A}$

= the conductivity σ $\frac{1}{RA} \therefore \frac{10\times10^{-6}}{100\times0.001\times10^{-4}} \frac{mho}{m}$

or $\sigma = 1.0 \frac{mho}{meter}$ Further the current is expressed as $i = neAv_d \times neA\mu_e E$ or

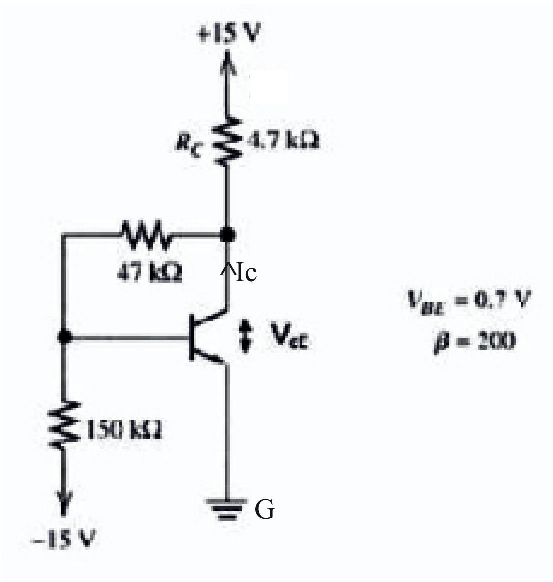
$i = neA\ \mu_e$ or $\frac{V}{l}$

$100 \times 10^{-3} = n \times 1.6 = 10^{-19} \times 0.001 \times 10^{-4} \times 0.14$

$0.1 = n \times 22.4 \times 10^{-28} \Rightarrow n = \frac{100}{22.4}\times10^{25}$ per m^3

Thus the electron density is $n = 4.45 \times 10^{25}$ per m^3

P10. Appling Kirchhoff's voltage law in the input section of the circuit with I_B as the base current, we get



$+15V =)I_C + I_B(R_C + I_B 47k\,\Omega + I_B 150k\Omega - 15V$

Using now $I_C = \beta\ I_B$ in above equation

$30V = [)\beta I_B + I_B(4.7 + I_B \times 47 + 150 \times I_B] \times 1000$

$30V = [)200 + 1(\times 4.7 + 197] \times 1000\ I_B$

or $I_B = \left[\frac{30V}{201\times4.7+197}\right]\times10^{-3} = \frac{30V}{1141.7}\times10^{-3} A$

$I_B = 26.27\times10^{-6} A = 26.27\mu A$

Now the collector current I_c is given as -

$I_C = \beta\ I_B = 200 \times 26.27 \times 10^{-6} = 5.26$ mA

Applying Kirchhoff 's voltage law in the output-section

$15V = I_C R_C + V_{CE}$

$V_{CE} = 15 - 5.26\, mA \times 4.7\, k\Omega$

$V_{CE} = 15 – 24.7 = -9.7$ volt

Note: The transistor is in saturation mode because both emitter junction and collector junction are in forward bias.

National Top 1% of NSEA - 2019 held on 24.11.2019 at 1590 Centres

Sr. No.	Roll No	Name of Student	Gen	Class	Marks	Centre Code	Centre Name	City
1	AP19101119	GANGULA BHUVAN REDDY	M	12	181	APS0020	SRI CHAITANYA JUNIOR KALASALA	VIJAYAWADA RURAL
2	AP19101230	LANDA JITENDRA	M	12	164	APS0020	SRI CHAITANYA JUNIOR KALASALA	VIJAYAWADA RURAL
3	AP19101265	KANDULA YASWANTH	M	12	175	APS0020	SRI CHAITANYA JUNIOR KALASALA	VIJAYAWADA RURAL
4	AP19101286	NANNAPANENI YASASWI	F	12	170	APS0020	SRI CHAITANYA JUNIOR KALASALA	VIJAYAWADA RURAL
5	AP19102127	K. SAI SRIVARDHIN	M	12	173	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
6	AP19102129	A. PRADEEP KUMAR	M	12	178	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
7	AP19102134	M. DIVYA TEJA	M	12	186	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
8	AP19102139	B. VENKATA SOMA SEKHAR	M	12	168	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
9	AP19102140	B. VAMSI KRISHNA	M	12	187	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
10	AP19102141	B. VENKATA SAI KIRAN	M	12	168	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
11	AP19102142	N. ABHILOKESH	M	12	174	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
12	AP19102145	G. RAGHAVENDRA CHOWDARY	M	12	175	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
13	AP19102146	G. MANOJ	M	12	165	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
14	AP19102147	M. S. V SAYI TEJA REDDY	M	12	164	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
15	AP19102148	B. RUTHVIK KUMAR REDDY	M	12	168	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
16	AP19102150	G. VENKATA SRAVAN KUMAR	M	12	170	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
17	AP19102151	B. AARSHA SAI	M	12	162	APS0033	NARAYANA CO SCHOOL	VIJAYAWADA
18	AP19102579	DESAI DIVYESWAR REDDY	M	12	166	APS0047	SRI CHAITANYA GIRLS JR COLLEGE	VIJAYAWADA
19	AP19102634	KAPELLI YASHWANTH SAI	M	12	186	APS0047	SRI CHAITANYA GIRLS JR COLLEGE	VIJAYAWADA
20	AP19103255	CHILUKURI MANI PRANEETH	M	12	173	APS0047	SRI CHAITANYA GIRLS JR COLLEGE	VIJAYAWADA
21	AP19174842	P CHETHAN KRISHNA	M	12	173	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
22	CH19112378	KUNWAR PREET SINGH	M	12	180	CHS0009	KENDRIYA VIDYALAYA SECTOR 31	CHANDIGARH
23	DL19112639	ADITYA SINGH	M	12	165	DLS0002	DELHI PUBLIC SCHOOL SECTOR12 R K PURAM	NEW DELHI
24	DL19112890	ADARSH ROY	M	12	174	DLS0003	REMAL PUBLIC SCHOOL	NEW DELHI
25	DL19113146	SOUMIL AGGARWAL	M	12	179	DLS0006	LAL BAHADUR SHASTRI SENIOR SECONDARY SCHOOL	NEW DELHI
26	DL19113155	GURKIRAT SINGH	M	12	193	DLS0006	LAL BAHADUR SHASTRI SENIOR SECONDARY SCHOOL	NEW DELHI
27	DL19113759	KUMAR SATYAM	M	12	184	DLS0013	KENDRIYA VIDYALAYA DWARKA SEC.5	NEW DELHI
28	DL19114783	RTYA SAWHNEY	F	12	181	DLS0030	DELHI PUBLIC SCHOOL VASANT KUNJ	NEW DELHI
29	DL19114811	PRASENJIT ROY	M	12	158	DLS0030	DELHI PUBLIC SCHOOL VASANT KUNJ	NEW DELHI
30	DL19115154	ARNAV GUPTA	M	12	169	DLS0052	KENDRIYA VIDYALAYA SEC.12 DWARKA	DELHI
31	DL19115270	AMAN BUCHA	M	12	159	DLS0056	KENDRIYA VIDYALAYA AGCR COLONY	DELHI
32	DL19115365	DEV GUPTA	M	11	195	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
33	DL19115386	VAMSHI VANGALA	M	12	166	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
34	DL19115387	SANDEEPAN NASKAR	M	12	177	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
35	DL19115388	TUSHAR GUJRAL	M	12	174	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
36	DL19115389	ABHINAV BARNAWAL	M	12	189	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
37	DL19115390	SOORAJ SRINIVASAN	M	12	179	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
38	DL19115393	ASHUTOSH PANKAJ	M	12	158	DLS0057	PRAGATI PUBLIC SCHOOL	NEW DELHI
39	DL19115638	SAMYAK MAHAJAN	M	12	158	DLS0074	BGS INTERNATIONAL PUBLIC SCHOOL	NEW DELHI
40	DL19115695	NISHANT AGARWAL	M	12	169	DLS0076	KENDRIYA VIDYALAYA PUSHP VIHAR SAKET	DELHI
41	DL19122717	ANIRUDH SHARMA	M	12	190	HRS0044	NARAYANA ETECHNO SCHOOL	GURGAON

42	GJ19118066	DHRUV MAROO	M	12	164	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
43	GJ19118105	MEHTA NIYATI	F	12	175	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
44	GJ19118148	POOJAN SOJITRA	M	12	171	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
45	GJ19118157	ANANTH KRISHNA KIDAMBI	M	11	162	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
46	GJ19118166	HARSH SHAH	M	12	160	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
47	GJ19118169	DHRUV TARSADIYA	M	12	159	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
48	GJ19118178	RANINGA ANSH	M	12	160	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
49	GJ19118818	MIHIR KOTHARI	M	11	186	GJS0023	VIKRAM A SARABHAI COMMUNITY SCIENCE CENTRE	AHMEDABAD
50	GJ19120210	PARTH URVESH SHAH	M	12	158	GJS0080	KENDRIYA VIDYALAYA CANT. AHMEDABAD	AHMEDABAD
51	GJ19120215	SHAH DHRUV RAJENDRABHAI	M	12	162	GJS0080	KENDRIYA VIDYALAYA CANT. AHMEDABAD	AHMEDABAD
52	HR19112401	KARTIK SHARMA	M	12	173	CHS0009	KENDRIYA VIDYALAYA SECTOR 31	CHANDIGARH
53	HR19113874	DHRUV TYAGI	M	12	183	DLS0015	S M ARYA PUBLIC SCHOOL	NEW DELHI
54	HR19113905	HARSHVARDHAN AGARWAL	M	12	172	DLS0015	S M ARYA PUBLIC SCHOOL	NEW DELHI
55	HR19121525	SUMANT PAREEK	M	12	169	HRS0005	MODERN DELHI PUBLIC SCHOOL	FARIDABAD
56	HR19121728	RISHIT SINGLA	M	11	167	HRS0007	MODERN VIDYA NIKETAN SENIOR SECONDARY SCHOOL	FARIDABAD
57	HR19122320	AMAN BANSAL	M	12	178	HRS0021	RPS PUBLIC SCHOOL SURANA NARNAUL	NARNAUL
58	HR19122537	DIVYANSHU AGARWAL	M	12	162	HRS0039	RPS PUBLIC SCHOOL HANSI	HANSI
59	HR19122712	KESHAV AGARWAL	M	12	188	HRS0044	NARAYANA ETECHNO SCHOOL	GURGAON
60	HR19123671	DHVANIT BENIWAL	M	12	203	HRS0095	KENDRIYA VIDYALAYA NO.II CHANDIMANDIR	PANCHKULA
61	HR19123703	ANUBHAV BHATLA	M	12	165	HRS0095	KENDRIYA VIDYALAYA NO.II CHANDIMANDIR	PANCHKULA
62	JH19125406	SOURADEEP DAS	M	12	159	JHS0010	RAMAKRISHNA MISSION VIDYAPITH	DEOGHAR
63	JH19125870	DAYAL KUMAR	M	12	165	JHS0019	DELHI PUBLIC SCHOOL	RANCHI
64	KA19128654	GOVIND SAJU	M	12	180	KAS0016	ALPINE PUBLIC SCHOOL	BANGALORE
65	KA19128655	UDHAV VARMA	M	11	167	KAS0016	ALPINE PUBLIC SCHOOL	BANGALORE
66	KA19128710	SHUBHAN R	M	12	168	KAS0017	BASE PU COLLEGE	BANGALAORE
67	KA19129536	GAURAV A	M	12	158	KAS0026	NARAYANA OLYMPIAD SCHOOL	BANGALORE
68	KA19129859	KALP VYAS	M	12	169	KAS0039	NATIONAL PUBLIC SCHOOL HSR LAYOUT	BANGALORE
69	KA19129866	PRANAVA SINGHAL	M	12	169	KAS0039	NATIONAL PUBLIC SCHOOL HSR LAYOUT	BANGALORE
70	KA19130449	TAMOJEET ROYCHOWDHURY	M	11	170	KAS0059	JINDAL VIDYA MANDIR	BALLARI
71	KA19131081	ABHIRAM M	M	12	171	KAS0078	RV PU COLLEGE	BENGALURU
72	KL19133180	ADITYA BYJU	M	12	159	KLS0001	KURIAKOSE ELIAS ENGLISH MEDIUM SCHOOL	KOTTAYAM
73	MH19136425	PRERAK SUNIL MESHRAM	M	12	172	MHS0004	RAMAN SCIENCE CENTRE AND PLANETARIUM	NAGPUR
74	MH19136990	KARTIK SREEKUMAR NAIR	M	11	181	MHS0007	THAKUR VIDYA MANDIR HIGH SCHOOL AND	MUMBAI
75	MH19137058	SUBARNO NATH ROY	M	12	187	MHS0007	THAKUR VIDYA MANDIR HIGH SCHOOL AND	MUMBAI
76	MH19137108	AMEYA P DESHMUKH	M	11	176	MHS0007	THAKUR VIDYA MANDIR HIGH SCHOOL AND JUNIOR COLLEGE	MUMBAI
77	MH19137167	ARYAN AJAY VORA	M	12	168	MHS0007	THAKUR VIDYA MANDIR HIGH SCHOOL AND	MUMBAI
78	MH19137321	ADITYA PRASHANT KUDRE	M	12	185	MHS0009	MES ABASAHEB GARWARE COLLEGE	PUNE
79	MH19137426	SHANTANV NENE	M	12	178	MHS0010	PMCS RAJIV GANDHI ACADEMY OF E LEARNING AND JR COLLEGE OF SCIENCE	PUNE

80	MH19137491	ANURAG ABHIJIT PENDSE	M	12	172	MHS0010	PMCS RAJIV GANDHI ACADEMY OF E LEARNING AND JR COLLEGE OF SCIENCE	PUNE
81	MH19137811	AJINKYA VINOD BOBDE	M	12	165	MHS0014	AAICHI SHALA JR.SCIENCE COLLEGE	AKOLA
82	MH19140283	HARSH LULLA	M	12	172	MHS0073	RAMSHETH THAKUR PUBLIC SCHOOL	KHARGHAR
83	MH19141609	DADHICHI DATTATRAYA TELWADKAR	M	12	166	MHS0119	SBES COLLEGE OF SCIENCE	AURANGABAD
84	MH19141614	GULVE VEDANT AVINASH	M	12	163	MHS0119	SBES COLLEGE OF SCIENCE	AURANGABAD
85	MH19143318	THARUN MAHESH	M	12	171	MHS0163	DAV PUBLIC SCHOOL	PUNE
86	MP19148644	SHUBH HARKAWAT	M	12	160	MPS0006	THE SHISHUKUNJ INTERNATIONAL SCHOOL	INDORE
87	MP19150932	SHREEYA MOGHE	F	12	178	MPS0095	I.B.S. GLOBAL ACADEMY	UJJAIN
88	OD19152650	SIBASISH ROUT	M	12	163	ODS0009	SAI INTERNATIONAL SCHOOL	BHUBANESWAR
89	OD19153254	SOURABH SOUMYAKANTA DAS	M	12	161	ODS0020	DAV PUBLIC SCHOOL	BHUBANESWAR
90	PB19155461	AVVAL AMIL	M	12	172	PBS0031	APEEJAY SCHOOL	JALANDHAR
91	PB19156697	GAVISH GARG	M	12	161	PBS0069	GURU NANAK PUBLIC SCHOOL	BATHINDA
92	RJ19158074	VINAMRA MAHAJAN	M	11	161	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
93	RJ19158077	AARYAN KUMAR GUPTA	M	12	169	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
94	RJ19158084	ANANYA DAS	F	12	164	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
95	RJ19158088	ARIN KEDIA	M	12	194	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
96	RJ19158090	HARSH TRIVEDI	M	12	172	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
97	RJ19158103	PRAKHAR BANSAL	M	12	161	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
98	RJ19158115	ABHINAV SINHA	M	12	161	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
99	RJ19158118	ACHINTYA NATH	M	12	191	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
100	RJ19158134	SAHIL GARG	M	12	182	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
101	RJ19158142	SANKALP PARASHAR	M	12	162	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
102	RJ19158146	UTKARSH RANJAN	M	12	191	RJS0004	ST. JOHNS SENIOR SECONDARY SCHOOL	KOTA
103	RJ19158591	VISHAL BULCHANDANI	M	12	165	RJS0005	BHARATIYA VIDYA BHAVAN VIDYASHRAM	JAIPUR
104	RJ19158634	TEJAS KUMAR	M	11	160	RJS0009	JAYSHREE PERIWAL HIGH SCHOOL	JAIPUR
105	RJ19159106	AKHIL AGRAWAL	M	12	159	RJS0009	JAYSHREE PERIWAL HIGH SCHOOL	JAIPUR
106	RJ19159208	VISHWAS KALANI	M	12	175	RJS0009	JAYSHREE PERIWAL HIGH SCHOOL	JAIPUR
107	RJ19159211	VIRENDRA KABRA	M	12	170	RJS0009	JAYSHREE PERIWAL HIGH SCHOOL	JAIPUR
108	RJ19160368	MRIDUL AGARWAL	M	11	196	RJS0012	ST.XAVIERS SR.SEC.SCHOOL	JAIPUR
109	RJ19160502	VAIBHAV SAHA	M	12	162	RJS0016	LORD BUDDHA PUBLIC SCHOOL	KOTA
110	RJ19160715	NEERAJ KAMAL	M	12	161	RJS0016	LORD BUDDHA PUBLIC SCHOOL	KOTA
111	RJ19163581	BARUN PARUA	M	11	177	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
112	RJ19163586	AYAN MINHAM KHAN	M	11	158	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
113	RJ19163591	SHIVAM SOURAV	M	11	174	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
114	RJ19163623	YASHWANTH REDDY CHALLA	M	11	195	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
115	RJ19163628	VAIBHAV RAJ	M	12	194	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
116	RJ19163640	AAKASH OM TRIVEDI	M	12	171	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
117	RJ19163659	ARNAV ADITYA SINGH	M	11	158	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
118	RJ19163660	OMM AGRAWAL	M	11	164	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
119	RJ19163676	MOHIT GUPTA	M	12	170	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
120	RJ19163683	KUNAL SAMANTA	M	12	181	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
121	RJ19163687	AKHIL JAIN	M	12	180	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
122	RJ19163689	SAPTARSHI SEN	M	12	178	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
123	RJ19163695	TANMAY DOKANIA	M	12	174	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
124	RJ19163696	R. MUHENDER RAJ	M	12	161	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
125	RJ19163697	AARYAN TIWARY	M	12	167	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
126	RJ19163700	NAMAN SINGH RANA	M	12	175	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA

127	RJ19163702	OJASWI JAIN	M	12	177	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
128	RJ19163705	PARTH DWIVEDI	M	12	191	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
129	RJ19163706	VIVEK VEER	M	12	176	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
130	RJ19163717	GUTTA SINDHUJA	F	12	171	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
131	RJ19163718	YUVRAJ SINGH SHEKHAWAT	M	12	195	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
132	RJ19163741	LAKSHYA GUPTA	M	12	184	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
133	RJ19163742	AADARSHRAJ SAH	M	12	177	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
134	RJ19163812	KUNAL KUNDWANI	M	12	184	RJS0052	DISHA DELPHI PUBLIC SCHOOL	KOTA
135	RJ19165985	ADITYA TANWAR	M	12	171	RJS0125	YADAV BHARTI SR. SEC SCHOOL	BIKANER
136	TN19167529	PRADEEP S	M	12	171	TNS0006	CHETTINAD VIDYASHRAM	CHENNAI
137	TN19167601	ADITYA S SADHU	M	12	170	TNS0009	CHENNAI PUBLIC SCHOOL	CHENNAI
138	TN19169817	C. ADITYA	M	12	169	TNS0041	MAHARISHI VIDYA MANDIR SENIOR SECONDARY SCHOOL	CHENNAI
139	TN19170082	ANAND NARASIMHAN	M	11	160	TNS0041	MAHARISHI VIDYA MANDIR SENIOR SECONDARY SCHOOL	CHENNAI
140	TS19173160	VISHAL RAVIPATI	M	12	173	TSS0001	FIITJEE WORLD SCHOOL	HYDERABAD
141	TS19173161	PRATHAMESH SACHIN PILKHANE	M	12	173	TSS0001	FIITJEE WORLD SCHOOL	HYDERABAD
142	TS19173244	PADAKANTI AKSHAY KIRAN	M	12	170	TSS0001	FIITJEE WORLD SCHOOL	HYDERABAD
143	TS19173256	GUNDABATHULA SASANK	M	12	165	TSS0001	FIITJEE WORLD SCHOOL	HYDERABAD
144	TS19173260	MAKAM ANISH	M	12	172	TSS0001	FIITJEE WORLD SCHOOL	HYDERABAD
145	TS19174198	SAI ADITYAK	M	10	162	TSS0018	NARAYANA OLYMPIAD SCHOOL	HYDERABAD
146	TS19174222	C V VAMSIDHAR REDDY	M	11	166	TSS0020	SRI CHAITANYA JUNIOR COLLEGE	HYDERABAD
147	TS19174250	K SAI SHREE LAASYA RAAGYNI	F	12	159	TSS0020	SRI CHAITANYA JUNIOR COLLEGE	HYDERABAD
148	TS19174267	SAI ROHAN PALUSA	M	12	160	TSS0020	SRI CHAITANYA JUNIOR COLLEGE	HYDERABAD
149	TS19174699	N SURYA PRAKASH REDDY	M	12	176	TSS0062	NARAYANA JUNIOR COLLEGE C.C. 58333	IBRAHIMPATNAM
150	TS19174823	VIGNESHWAR REDDY	M	12	165	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
151	TS19174829	V V SAI KEERTHANA	F	12	166	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
152	TS19174837	BHAVANA. M	F	12	162	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
153	TS19174841	VIRINCHI MOURYA	M	12	187	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
154	TS19174844	CHUKKA TANUJA	F	12	172	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
155	TS19174861	ADITYA VIRAJ RAO PONUGOTI	M	12	183	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
156	TS19174862	SATHVIK REDDY GARLAPATI	M	12	193	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
157	TS19174868	BANNURU ROHIT KUMAR REDDY	M	11	162	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
158	TS19174872	DEETI YESHASH CHANDRA	M	12	158	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
159	TS19174934	SHASHWAT NAIDU	M	12	162	TSS0066	NARAYANA IIT ACADEMY	HYDERABAD
160	TS19175317	KRUSHNA CHANDRIL.H	M	9	168	TSS0075	SRI GURUDATH HIGH SCHOOL	HANAMKONDA
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162	TS19176899	ANNAM. SAIVARDHAN	M	12	163	TSS0088	SRI CHAITANYA JR KALASALA	HYDERABAD
163	TS19176904	C. VINAY KUMAR	M	12	158	TSS0088	SRI CHAITANYA JR KALASALA	HYDERABAD
164	TS19176914	C. CHANDRABHUSHAN REDDY	M	12	162	TSS0088	SRI CHAITANYA JR KALASALA	HYDERABAD
165	UP19180596	VAIBHAV MISHRA	M	12	159	UPS0009	VANASTHALI PUBLIC SCHOOL	GHAZIABAD
166	UP19182577	L GOKULNATH	M	12	171	UPS0073	KOTHARI INTERNATIONAL SCHOOL	NOIDA
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168	UP19182599	MADHUR AGRAWAL	M	12	161	UPS0073	KOTHARI INTERNATIONAL SCHOOL	NOIDA
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Prof B P Tyagi
Chief Coordinator (Examination)
Ph:9837123716

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Dr. Sanjay Kr. Sharma
Managing Editor
Flat No. 206, Adarsh Complex,
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