Raman Effect : When a strong beam of visible or ultraviolet line-spectral light illuminates a gas, a liquid or a transparent solid, then a small fraction of the light is scattered in all directions. The spectrum of the scattered light is found to have the lines of the same frequencies as the incident beam (called Rayliegh lines) and also certain weak lines of the changed frequencies. This production of additional new lines is called Raman effect, and lines are called Raman lines. The Raman lines corresponding to each exciting (Rayliegh) line occur symmetrically on both sides of the exciting line. The lines on the low-frequency side of the exciting line are called stokes lines, while those on the high-frequency side are called anti-stokes lines. The anti-stokes Raman lines are much weaker than stokes Raman lines.

The displacement (in cm^{-1}) of the lines are independent of the frequencies of the later. If an another light source with a different line-spectrum is used, then another Raman lines are obtained for the same scattering substance. However, the displacements from the exciting lines are the same. For different scattering substances, the displacements have different magnitudes. Thus, the Raman displacements are the characteristic of the scattering substance.

Pauli's exclusion principle : The electrons in an atom are distributed in a definite way among various shells and sub-shells. This distribution is governed by a principle given by Pauli in 1925. This is called *Pauli's exclusion principle*. This states that no two electrons in an atom can exist in the same quantum state. This concludes that no two electrons can have the same set of the four quantum numbers. There are certain numbers whose specification actually explains in detail configuration of the electrons in the shell and sub-shell which are called quantum numbers. There are four quantum numbers - principal quantum number (n). Orbital or azimuthal quantum number (l), spin quantum number (s) and magnetic quantum number (m_l).

Radioactivity : Radioactivity is in fact a chance discovery by Henry Becquerel, a French scientist. In 1896 he found that a photographic plate wrapped around three folds in the black paper was affected by a piece of mineral uranium kept over it for some time. Some rays were thought to be emitted by the uranium piece which could pass through the black paper and subsequently affected the plate. Intensive research work were carried out by Becquerel, Madam Curie and Pierre Curie which confirmed that this type of radiation was not only limited to uranium but a number of other elements like thorium, radium, polonium etc. and their salts also emit similar penetrating radiations. Such elements are said to be radioactive and the spontaneous emission of the radiation is called radioactivity (natural). Such spontaneous invisible radiations also penetrate through the opaque substances which ionise the gases and affects the photographic plates.

The property associated with the emission of this types of penetrating radiations are called radioactive rays or Becquerel rays (α, β and γ-rays). Soddy was the first to suggest that this type of radiation is a result of the transformation of a unstable nucleus to a more stable nucleus. Rutherford studied the effect of electric and magnetic fields on the radiation emitted by different radioactive substances. He observed that the radiation has three

(ii) The emission occurs spontaneously and cannot be speeded up or slowed down by the physical means such as change of pressure, temperature etc.

(iii) The disintegration occurs at random and which atom would disintegrate first is simply just a matter of chance.

(iv) The rate of disintegration of a particular substance (i.e. number of atoms disintegrating per second) at any instant is proportional to the number of atoms present at that instant.

If N be the number of atoms present in a radioactive substance at any instant t, and dN be the number that disintegrates in a short interval dt. Then the rate of disintegration is $-\frac{dN}{dt}$ which is proportional to N i.e.

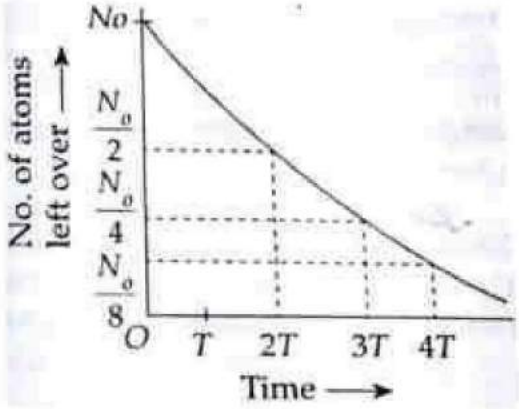
$-\frac{dN}{dt} = \lambda N$. where; λ is called decay constant. (–ve sign indicates that atoms decay with time).

$\Rightarrow \frac{dN}{N} = -\lambda\, dt.$

On integration and simplification, $N = N_0 e^{-\lambda t}$

where, N_0 = number of atoms in the begining.

N = number of atoms at the time t.



This equation shows that the number of atoms of a given radioactive substance decreases exponentially with time (i.e. more rapidly at first and slowly afterwards). This is called Rutherford-Soddy law of the radioactive decay.

Half life period : The atoms of a radioactive substance undergo continuous decay so that their number goes on decreasing. The time-interval T in which the mass of a radioactive substance or the number of its atoms is reduced to half its initial value is called the half-life period of that substance.

The half life period of a radioactive substance is constant, but it is different for different substances.

As by Rutherford-Soddy law;

$N = N_0 e^{-\lambda t}$

where, λ is the decay constant.

Now, let T be the half life period of any substance then $N = \frac{N_0}{2}$

Thus $\frac{N_0}{2} = N_0 e^{-\lambda t}$

$\Rightarrow \quad \lambda T = \log_e 2 \quad (\because t = T)$

$\Rightarrow \quad T = \frac{\log_e 2}{\lambda} = \frac{0.693}{\lambda}$

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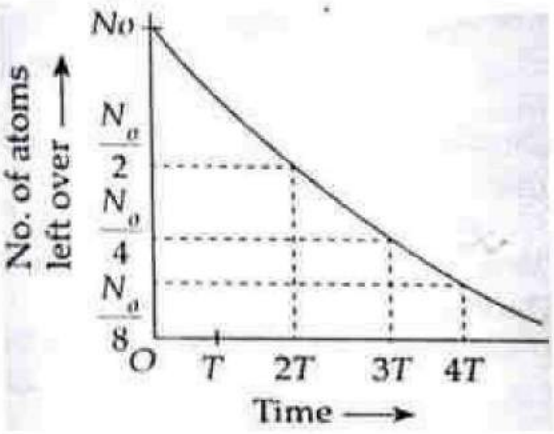

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$$_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + \beta + \bar{\upsilon}.$$

Thus, (parent nucles) (daughter nucleus)

Similarly, $_{6}C^{14} \rightarrow {}_{7}N^{14} + \beta + \bar{\upsilon}.$

$_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + \beta + \bar{\upsilon}.$

Nuclei having excess neutrons (high value of n/p ratio) are found to decay by β-emission.

(iii) γ-decay : When a parent atom emits gamma rays, no charge is involved as these are neutral rays, so no change in mass number and atomic number during γ-decay takes place. In fact γ-rays are electromagnetic waves having energy in the form of photon and its emission changes the nucleus from an excited state (high energy state) to a less excited (lower energy state) state.

The above mechanism of radioactive transformations (α, β and γ-decays) are called *Soddy-Fajan's group displacement laws.*

Radioactive series : Practically all the natural radioactive elements lie in the range of atomic numbers from Z = 83 to Z = 92. The nuclei of these elements are unstable and disintegrate by ejecting either an α-particle or a β-particle. By ejection of α, β-particles new atoms are formed and if these atoms have also unstable nuclei then further emission also takes place, until a stable nuclei is not to be found and a series of radioactive elements are obtained called radioactive series.

There are four radioactive series (UTAN)—

(i) Uranium Series : In this series the parent element is uranium- $_{92}U^{238}$ and the end product of this series after the the emission of six α-particles and five β-particles is obtained as radium lead ($_{82}Pb^{206}$) which is indistinguishable chemically from the ordinary lead and it is a stable isotope of the lead.

(ii) Thorium Series : The parent element of this series is Thorium - $_{90}Th^{232}$. It goes through a series of transformations in many respects similar to the uranium series and ends with a stable isotope of lead ($_{82}Pb^{208}$).

(iii) Actinium Series : The parent element of this series is an isotope of Uranium called Actino-Uranium- $_{92}U^{235}$ and its end product is again a stable isotope of lead ($_{82}Pb^{207}$).

(iv) Neptunium Series : With the discovery of the unstable transuranic elements (the elements of atomic number greater than 92 are called transurenic elements), another radioactive series was traced out. This is called Neptunium series after its longest-lived member Neptunium. Its origin is traced back to plutonium and it doesn't end in a stable isotope of lead but in the stable isotope of Bismuth ($_{83}Bi^{209}$).

Activity of radioactive substance and its units : The activity of a sample of any radioactive material is the rate at which its constituent atoms disintegrate. Thus if dN be the number of atoms which disintegrate during a time-interval dt, the activity of the sample will be given by

$$\text{activity} = -\frac{dN}{}$$

The negative sign indicates that the number of atoms is decreasing with time.

The traditional unit of the activity is curie and 1 curie (Ci) = 3.7×10^{10} disintegrations/second.

An another unit of the activity is Rutherford and 1 Rutherford = 10^6 disintegrations/second.

SI unit of the activity is the becquerel (Bq) and 1 becquerel (Bq) = 1 disintegration/second.

Thus 1 Ci = 3.7×10^{10} Bq.

Artificial radioactivity : The idea of artificial radioactivity was firstly conceived by I. Curie and F. Juliot. Hence I. Curi & F. Juliot were assumed to be the real inventor of artificial radioactivity. The radioactive elements in which natural disintegration of nucleus occurs are heavier elements. Rutherford took the attempt and became successful in making a stable nucleus of ordinary nitrogen by the bombardment of fast moving α-particles. This phenomenon of making a stable nucleus into an unstable nucleus by the artificial means is called artificial radioactivity or induced radioactivity or man-made radioactivity.

Thus, when a nitrogen nucleus ($_7N^{14}$) is struck by an α-particle ($_2He^4$), a proton ($_1H^1$) is ejected leaving the recoiling oxygen nucleus ($_8O^{17}$).

$$_7N^{14} + {}_2He^4 \rightarrow {}_8O^{17} + {}_1H^1$$

Nitrogen α-particle Oxygen isotope proton

Rutherford thereby transformed ordinary nitrogen into a rare isotope of oxygen. This was the first artificial nuclear transformation.

Carbon dating : The idea of the carbon dating was suggested by Prof. Libby, an Atomic scientist of Chicago. Our atmosphere contains a large number of stable isotopes. When cosmic rays strike these isotopes, a number of radio isotopes are produced. One of these radio isotopes is carbon-14 ($_6C^{14}$) which is produced by the bombardment of atmospheric nitrogen with high energy neutrons.

$$_7N^{14} + {}_0n^1 \rightarrow {}_6C^{14} + {}_1H^1.$$

Radio carbon is unstable and decays (by emitting β-particle) to nitrogen with half life of 5600 years. The carbon-14 is incorporated into the atmospheric carbon dioxide molecules which are taken inside by the plants when they breathe CO_2. Animals which eat the plants also take carbon–14 inside theirself. Ultimately the concentration of $_6C^{14}$ in all living organisms reaches at an equilibrium value of nearly 15 decays/minute. When an organism dies, it stops taking $_6C^{14}$ from the atmosphere and the concentration of $_6C^{14}$ present in organism decreases with the time. By measuring the ratio of the concentration of $_6C^{14}$ to $_6C^{12}$ in any ancient organism, say tree one can estimate the real date and time when the organism was died ?

Nuclear sizes and shapes : The Rutherford α-particle scattering experiment established that the mass of an atom is concentrated within a small positively-charged region at the centre which is called *nucleus* of the atom. Since during Rutherford's time many scattering experiments, using highly energetic electrons and neutrons as the scattering particles, have been

performed to determine the size of the nucleus. An electron interacts with a nucleus only through the electrical forces, while a neutron interacts only through the nuclear forces. Thus, the electron scattering tells us about the distribution of the charge in a nucleus and neutron scattering tells us about the distribution of the nuclear mass. These experiments have shown that the volume of a nucleus is directly proportional to the number of nucleons present in it, which is its mass number A.

If the nuclear radius of any nucleus be R then the volume will be $4/3\pi R^3$ and so R^3 will be proportional to A.

Thus, $R = R_0 A^{\frac{1}{3}}$.

The value of the constant R_0 is experimentally found which is given by $R_0 = 1.2 \times 10^{-15}$ m

Here, the length 10^{-15} m is described as 1 femtometer (fm) or 1 fermi.

So $R = R_0 A^{\frac{1}{3}} = 1.2 A^{\frac{1}{3}}$ *fm*, for the all nuclear radii. The radius varies from nucleus to nucleus but their order is of 10^{-15} meter or 1 fm. For most purposes atomic nuclei are assumed to be spherical.

Packing fraction : The masses of the all atomic isotopes are very close to the whole numbers, but not exactly the whole numbers. The difference between the actual atomic mass M of an isotope and its mass number is defined as the packing fraction P of the isotope.

Thus, $P = \dfrac{M - A}{A}$

The packing fraction is positive for the isotopes of very low and very high mass numbers and negative for the rest. It is zero for ${}_6C^{12}$.

Mass defect and Binding energy : The masses of all the stable nuclei are less than the sum of the masses of their constituent particles (protons and neutrons) in the free state. This means that when the protons and neutrons combine to form a nucleus, a loss of mass results. The missing mass is released in the form of energy when the nucleus is formed.

If Δm be the missing mass in the formation of a nucleus, the energy released ΔE will be given by Einstein's mass energy equivalent relation;

$$\Delta E = \Delta m c^2.$$

where, c is the speed of light.

The missing mass (Δm) is called the mass defect and its energy equivalent (ΔE) is called binding energy of the nucleus. Here ΔE would is the actual energy that must be supplied to the nucleus to break into its constituent particles. More binding energy means the energy required to break the nucleus is larger. Thus binding energy is a measuring parameter of the stability of the nucleus.

Practical units for mass energy equivalence : In nuclear physics, the mass of the fundamental (elementary) particles is generally expressed in terms of unified mass unit (u), defined as one twelfth (1/12th) of the mass of the normal carbon atom (${}_6C^{12}$).

Also $1\ u = 1.67 \times 10^{-27}$ kg.

The energy of a particle ... which is the energy acquired by an electron in falling through a potential difference of one volt.

Also, $1\ eV = 1.6 \times 10^{-19}$ joule.

The equivalent energy for 1 unified mass unit is expressed as

$$1\ u = 931\ MeV = 931.5\ MeV.\ (exactly)$$

Nuclear fission : In 1939 two German scientists Otto Hahn and Fritz Strassman discovered a new type of nuclear reaction. They found that when any uranium nucleus ($_{92}U^{235}$) is bombarded with a neutron then, the nucleus splits up into almost equal fragments with the release of some free neutrons and tremendous amount of energy (about 200 MeV) per $_{92}U^{235}$ nuclei. Such a nuclear reaction is called nuclear fission.

Thus, the process in which a heavy nucleus splits up into the two nuclei of nearly comparable masses with a tremendous release of energy and some free neutrons is called nuclear fission.

One of the typical fission reaction is—

$$_{92}U^{235} + {}_{0}n^{1} \rightarrow (_{92}U^{236}) \rightarrow {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3{}_{0}n^{1} + \Delta E\ (200\ MeV)$$

In the fission process of $_{92}U^{235}$ slow neutrons take part and their products are not always barium and krypton, so many possible pairs of the fragments occur. The average number of neutrons which are released in the uranium fission is 2.5.

Nuclear chain reaction : As 2.5 neutrons are produced per fission through each uranium atom and these neutrons produced in the nuclear fission under the favourable condition cause further atoms of uranium to undergo fission and in turn emit more neutrons which will cause further fission explosion. Thus, a chain reaction is established in a short span of time releasing an enormous amount of energy. One gram of $_{92}U^{235}$ on fission releases nearly 2×10^{7} kilo calorie of energy.

The ratio of the rate of production of neutrons to the rate of their disappearance is called the reproduction factor (k). If k is less than 1, the chain reaction will not be sustained, at $k = 1$, the reaction will just be sustained and if k is greater than 1, the reaction will sustain.

Types of nuclear fission : The fission chain reaction is of two types namely;

(a) Controlled chain reaction : A fission chain reaction which proceeds slowly and in balanced manner without any explosion and in which the energy released can be controlled is called controlled chain reaction.

Nuclear reactors operate on this principle, which are the main sources of the nuclear power and in which controlled nuclear chain reaction takes place. In a nuclear reactor the energy released through the fission is used to generate electricity. Several nuclear power plants for the generation of electricity are operating in India and in various countries of the world.

Basic components of the nuclear reactor :

(i) Nuclear fuel : The elements undergoing fission in a reactor are called nuclear fuel. Some common fuels are uranium isotopes U^{233}, U^{235}, thorium isotope Th^{232} and plutonium isotope Pu^{239}.

(ii) Moderator : Moderators are used to slow down the emitted neutrons which have a high velocity range. Some common moderators are graphite, heavy water, beryllium, beryllium oxide and some organic liquids. Slowing down of neutrons is also called thermalisation of the neutrons. Heavy water (D_2O) is one of the best moderator.

(iii) Coolant : A coolant removes the tremendous amount of heat developed inside the reactor core. Through a heat exchanger, the coolant transfers heat to the secondary thermal system of the reactor. Water, steam, helium, CO_2, air, molten metals etc. are used as coolants.

(iv) Control rods : The control rods are used in initiating and stopping the nuclear fission reactions of the nuclear reactor. Due to large absorption cross-section area, cadmium and boron rods are used as control rods. When control rods are inserted in the reactor unit, they absorb the fast moving neutrons and the chain reaction ceases.

(v) Radiation protective arrangement : In a nuclear reactor large amount of penetrating radiations like γ-rays in addition to the neutrons are also generated. These radiations pose a danger to the technicians working around the reactor. Hence a reactor is always surrounded by a thick shield in the form of concrete wall many meters thick (lined with lead) to absorb these radiations and prevent them from the leakage to the adjacent areas.

Types of fission reactors :

(i) Homogenous and Heterogeneous reactors : Basically both are fission reactors but in homogeneous type, fuel and moderator are mixed to form a mixture, while in heterogeneous type fuel and moderator are separately carried out in the steel tubes.

(ii) Fast breeder reactors : A nuclear reactor that breeds (produces) more fissile material than it consumes is called breeder reactor. These reactors are much more economical than other type of reactors as they consume raw fuel like Th^{232} and U^{238}. $_{90}Th^{232}$ is not fissionable but through a fast breeder reactor it is converted to U^{233} which is a very good nuclear fuel. Similarly U^{238} is converted to Pu^{239} (Plutonium) which is very useful fissionable material. Owing to a very high temperature about 9000°C in the core, a molten metal is used as coolant.

(b) Uncontrolled or Explosive chain reaction : A nuclear chain reaction in which fission neutrons keep on increasing until the whole of the fissionable material is consumed is known as explosive or uncontrolled chain reaction.

Such a reaction proceeds very quickly with the liberation of huge amount of energy in a short time. An atom bomb works on this principle and it is a practical example of the uncontrolled / explosive fission.

Nuclear Fusion : When two or more light nuclei moving with high speeds are fused together to form a single nucleus, then this process is called nuclear fusion. The mass of the product nucleus is less than the sum of the masses of the nuclei which are fused. The lost mass is converted into energy which is released in the form of fusion energy.

The energy output in a fusion reaction is 24.6 MeV which is too much less than energy released in the fission of a U^{235} nucleus which is about 200 MeV. But this doesn't mean that the fusion is a weaker energy source than the fission. The number of deutrons (reactants of the fusion reaction) in 1 gm of heavy hydrogen is much larger than the number of U^{235} nuclei in 1 gm of uranium. Thus, the energy output per unit mass of the material consumed is much more in the case of fusion of the light nuclei than in the case of the fission of heavy nuclei.

The process responsible for the solar energy is the fusion of light nuclei and here four hydrogen nuclei fuse together directly to form a helium nucleus.

$$4_1H^1 \rightarrow {}_2He^4 + 2\ {}_{+1}\beta^0 + 2\nu + \Delta E\ (24.6\ MeV)$$

The fusion process is very difficult to carry out, as the nuclei to be fused are positively charged, so they will repel one another strongly. Hence they must be brought very close together not only by the high pressure but also with high kinetic energies of about 0.1 MeV and for it a temperature of the order of 10^8 kelvin is required. Such high temperatures are available on the sun and stars. On earth fusion may be produced by exploding a nuclear fission bomb. Thus, a very high temperature is needed for the fusion of nuclei, the process is called a thermo nuclear reaction and the corresponding energy as *thermo nuclear energy*. Also at the temperature of 10^8K fusion materials (hydrogen, deutron, tritum etc) become ionised and the electrons are stripped and alongwith the nuclei, these materials behave like an ionised gas which is called *plasma* (fourth state of matter).

Plasma confinement and control fusion : There is no material container which can accumulate plasma within itself, but if an alternating magnetic field of a very large magnitude generated by mega ampere current and if a torus-shaped machine is used, then plasma can be confined. The torus-shaped machine, developed firstly by former USSR is called tokamak. Such alternating magnetic field repels the plasma from the side and compels it to remain confined to the centre of the container (vessel).

By such methodology and some other alternative ways, the path of development towards the formation of nuclear fusion reactors was searched. The nuclear fuel of the fusion reactors is heavy water (D_2O) which is found abundantly in the oceans or seas. Thus, the acute power crisis could be easily sorted out if the fusion reactors become operative. The research and development activities are going on in this regard and a prototype of nuclear fusion reactor has perhaps been designed and fabricated by France but it is yet to be confirmed.

Uncontrolled/Explosive fusion : Hydrogen bomb works on the principle of nuclear fusion and it is approximately 1000 times more powerful than

atom bomb (fission bomb). The essential conditions for the operation of a hydrogen bomb or the start of nuclear fusion, an extremely high temperature and pressure is required. Thus for the achievement of the essential conditions the functioning of a hydrogen bomb, an atom bomb (fission bomb) is used as a primer. The hydrogen bomb has no limitation like atom bomb and it will never explode unless it is ignited as uncontrolled nuclear fission.

Fusion is the source of stellar energy (i.e. the energy released by the sun and stars). The temperature of the sun's core is very high and fusion occurs by fusing the four hydrogen nuclei into helium. Although there are two different processes by which reactions occur in the stellar condition-a proton-proton cycle and a carbon-nitrogen cycle. But the energy released in both the cases comes out to be the same (about 24.6 MeV).

The sun is radiating energy at the rate of 10^{26} J sec.$^{-1}$. Thus, the loss of the matter occurrence from the sun is 4×10^6 tonnes per second. But the sun has a very large mass (10^{30} kg) which will continue for several billion years.

Fluorescence : There are various types of substances occurring in our nature and on a few of them if a ultraviolet light of smaller wavelength but larger frequency incidents, then it is absorbed by them and emit a light of longer wavelength (shorter frequency) this incident or phenomenon is called fluorescence and the corresponding substances are called fluorescent substances.

The examples of fluorescent substances are fluorspar, petrol, quinine sulphate, uranium oxide etc. To detect X-rays we use barium platino cyanide which is a sensitive fluorescent substance on passing X-rays, through which it absorbs the X-rays and emits green light. Today in tube-light, the inner coating of fluorescent substances are laminated to get a fascinating and decorative flavour of the light.

Phosphorescence : As from the basic characteristic of fluorescence, substances which emit light until they are in absorbing position of suitable light of lower wavelength. But there are also some substances which not only emit the incident light at glance but is also remain emitting for some more longer time, even while its incidence is stopped. This is called phosphorescence and the corresponding substances are called phosphorescent substances. On heating, the ability and quality of the phosphorescent substance is completely destroyed.

The examples of the phosphorescent substances are zinc sulphide, calcium sulphide, barium sulphide etc. Today in the needle of watches and in various hoarding boards employed for the advertising and marketing purposes the lamination of the phosphorescent substances are used. These needles and hoarding boards absorb sunlight in the day and shine in very glazy and fascinating way in the night.

Superconductivity : The phenomenon of superconductivity was firstly invented in 1911 by a Dutch physicist K. Onnes. He experimentally observed that the electrical resistance of some metals, alloys and compounds drops suddenly to zero when the specimen is cooled down below a certain

temperature called transition temperature (T_C). This phenomenon is called superconductivity and the specimen cooled down is called Superconductor. He also observed that resistance of the mercury vanishes completely at 4.2K. The critical (transition) temperature (T_C) below which a material undergoes a transition from a state of normal conductivity to a superconductivity is different for different materials. The normal good conductors like Cu, Ag, Au, Li, Na, K etc. do not exhibit the phenomenon of superconductivity even at more and more lower temperature. Thus, these are called normal metals. This implies that in general not all materials are superconducting.

Since the superconducting state of a material is characterised by the zero electrical resistance even in the absence of an applied voltage and the current can persist for years without any detectable decay. A bulk superconductor in a weak magnetic field acts like a perfect diamagnet with zero magnetic field into the interior. If a super conducting material is kept in a magnetic field and then cooled down below its critical (transition) temperature (T_C), it expels all the originally present magnetic flux from its interior and it is called *Meissner effect*. In fact this phenomenon was observed by W. Meissner and R. Ochsenfeld in 1933.

Also scientists from all over the world have been trying to develop the new materials that are superconducting at high temperatures. A break through in this regard come into existence when a hot superconductor was obtained in 1986. When Karl Alex Muller of *IBM'S* Zurich Lab made a substance of metallic oxide of lanthanum-barium-copper called ceramics that lost its electrical resistance at 30 K and it was called a hot superconductor. In 1987 the value of transition temperature (T_C) raised up to about 90 K when Paul Chu and his team discovered a ceramic copper-oxide superconductor, called cuprate consisting of Yttrium, barium and copper oxide.

Applications

(i) Large scale application of superconductor are in the transmission of power. The cables made from superconductors can save 30 to 40 percent power which is lost the conventional system of transmission. The solenoid of a superconductor can trap a large amount of electrical energy endlessly within itself.

(ii) Extremely sophisticated electronic devices such as Magnetic Resonance Imaging (*MRI*) scanners, superconducting Quantum Interference Devices (*SQUIDs*) etc. are today utilised frequently.

Theory of relativity

Michelson-Morley Experiment : According to the wave theory of light a light source sets up a disturbance transporting in all directions through a hypothetical medium called *ether* which fills up all the space and penetrates inside all the matter. But the assumption of ether created a problem. Does ether remain stationary in space when material bodies (including earth) move in it or is it dragged alongwith the moving bodies? But the observation of the aberration of light from the stars had indicated that the ether must be stationary in space, there is a relative motion between the body and the ether. A number of experiments were performed to detect a relative motion between the earth and the ether, Michelson-Morely experiment is one of

them. Michelson-Morely by their experiment observed that the motion of the earth through ether is meaningless and it (ether) could not be experimentally detected.

Einstein's Special theory of relativity : In 1905 Einstein propounded his special theory of relativity which is explained as below—

(i) The laws of Physics have the same form in all the inertial frames moving with a constant velocity relative to one another. This is called principle of relativity. This postulate also confirms the absence of any concept of the universal reference frame.

(ii) The speed of light in free space is the same in all the inertial frames of reference. This is called principle of constancy of the speed of light. This postulate follows directly from the result of Michelson-Morely experiment.

An Inertial frame of reference : Any space-time rectangular co-ordinate system in which a body totally finds itself in rest anywhere is called an inertial frame of reference. The Newton's laws of motion are defined in this frame.

But if a body is not to be found to remain in the rest position or be in motion, then the frame of reference is called non-inertial. In non-inertial frame Newton's laws of motion are not defined and applicable.

VII. Electronics

The area of electronics has become very extensive in which broad and various electronic devices are frequently operative and through it agriculture, communication, medical sciences, defence, industry, space research, engineering, education etc are extensively studied. During the early time under the electronics vacuum tube diodes and triodes were used and that's why the equipments earlier than the nineteenth century like larger radiogrames etc. were noisy and inconvenient. Afterwards these vacuum tubes were replaced and discarded by the semi conductors and transistors and now solid state electronic devices have been fabricated and designed which are compact, cheapest, convenient and efficient. Now apart from these solid state electronic devices, Integrated circuits are utilised as microchips in the microprocessors and computers and are studied in the digital electronics segment.

Thermionic emission : Whenever a metallic wire or filament is heated strongly in vacuum then electrons start to emit and these electrons are called thermions, while the phenomenon of electron emission is called thermionic emission. The phenomenon of thermionic emission was firstly invented by Thomas Alva Edison in 1884. The vacuum tube diodes, triodes, pentode etc. had been fabricated on the principle of thermionic emission. The electrons are also obtained by thermionic emission in the x-rays tube and cathode rays tube.

Diode valve : In 1904 Fleming fabricated a device in which two electrodes–a cathode and an anode were inserted in a cylindrical glass valve which was fully evacuated. Here anode acts like a plate, while cathode acts like a filament and both are kept separate and attached through a pin. In this valve filament is made from metallic wire and on heating the plate (made

which encloses cathode (filament). If a positive potential is supplied to the plate, the emitted electrons from the filament start to attract and accumulate around the cathode. The space around which electrons accumulate is called space charge region. Thus, when a +ve potential is supplied to the plate then electrons move towards the plate and a circuit is completed between the plate and filament and a current flows from the plate to filament. This is called plate current.

Diode valves are used as rectifier through which an alternating current (a.c.) is converted into a direct current (d.c.).

Triode valve : In 1907 Dr. Lee De Forest a USA based scientist fabricated a device which was similar to the diode valve alongwith which another element called control grid was attached. In other words, if in a diode valve an additional electrode is attached to control the thermionic emission in an evacuated (vacuum tube) tube it is called a triode valve. Thus there are three electrodes (plate, filament, grid) in a triode valve and this valve is utilised in the form of amplifier, oscillator, modulator, transmitter and detector.

Semi-conductor : A semi-conductor is a solid material whose electrical resistivity is higher than that of a conductor and lower than that of an insulator. Typical values of the resistivity of a semi-conductor lie between 10^{-12} to 1 ohm - meter at room temperature. The electrical resistance of a semi-conductor decreases with increase in temperature over a particular temperature - range which is the specific characteristic of a semi-conductor. The relation between the resistance R and absolute temperature T for a semi-conductor is given by

$$R = Ae^{\frac{B}{T}},$$ where the A, B are constants

Thus a semi-conductor has a negative temperature coefficient and this behaviour is contrary to that of a metallic conductor for which resistance increases with the rise of temperature. At ordinary temperature the pure semi-conductor has very small conductivity and this semi-conductor is called intrinsic semi-conductor. At 0 K all the semi-conductors are in pure form and behave like insulators. But the electrical conductivity of a semiconductor can be increased by a large value by addition of a small amount of suitable impurity called doping. Usually if 1 atom of an impurity is dopped to a pure (intrinsic) semi-conductor of 10^6 atoms, its conductivity increases 16 times and this semi-conductor is called impure or extrinsic semi-conductor.

Broadly there are three elements, silicon (Si) Germenium (Ge) and grey tin (Sn) in their crystalline form which are extensively used as semi-conductors. But Ge and Si are the most widely used semi-conductors in the fabrication of the solid state electronic devices. There are also numerous semi-conductor compounds like $GaAs$, $PhSe$, ternary alloys etc.

Extrinsic semi-conductor : As from earlier discussion a pure semi-conductor is a poor conductor of electricity and that's why it is made impure to increase the electrical conductivity by doping impurity. This impure semi-conductor is called an extrinsic semi-conductor. But the doping of the impurity also depends on the types of impurity.

Thus there are two types of extrinsic semi-conductors depending upon the nature of the impurity mixed up.

(i) *n*-type semi-conductor : If a pentavalent element (impurity) like phosphorous, arsenic, antimony etc. is dopped or mixed in *Ge* and *Si*, then five valance electrons of the pentavalent impurity form a covalent bond and one electron becomes mobile due to which it (electron) acquires a certain energy in excitation form. Thus electron becomes free and it goes to the conduction band from the valance band. Such semi-conductors are called *n*-type and electrons are called majority charge carriers and since surplus electrons are supplied by the impurity (pentavalent) so impurity is called donor impurity. Also due to the release of electrons from the valance band a vacancy is created and it is filled by the another electrons and thus a hole (positive charge carrier) is created which is also respondent for the conductivity. These holes are called minority charge carriers for *n*-type semi-conductor. But over all, *n*-type semi-conductor is a neutral crystal.

(ii) *p*-type semi-conductor : If a trivalent element (impurity) like indium boron, gallium or aluminium etc, is dopped or mixed in *Ge* and *Si*, then three valance electrons of the trivalent impurity form a covalent bond and from anywhere of *Ge* and *Si* an electron becomes available for the trivalent atom and thus four covalent bonds form. But due to an electron availability for the trivalent atom any covalent bond of *Ge* or *Si* breaks and a vacancy is created as a hole (positive ion). Due to large holes creation and its conduction these conductors are called *p*-type semi-conductor. Since electrons are accepted by the trivalent impurity and mainly conductivity is done by the holes, that's why such impurity is called acceptor impurity and holes are majority charge carriers for *p*-type semi-conductors. Also some electrons become available and are respondent for a few conduction is called minority charge carrier but over all *p*-type crystal (semi-conductor) is also neutral.

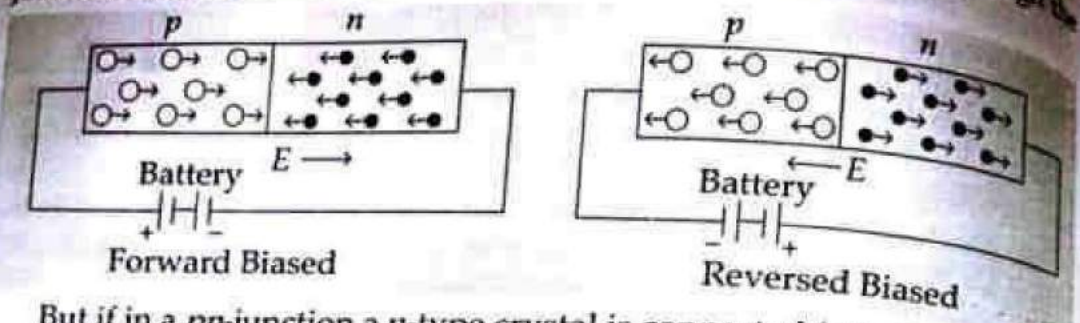
***pn*-junction or semi-conductor diode :** Pure or impure semi-conductors are bilateral electronic equipment through which the current flows in either direction with equal magnitude. Although if in a semi-conductor there exists a *p*-type region on one side and a *n*-type region on the another side then the semi-conductor becomes unilateral and the current flows easily in only one direction. The specific location in the semiconductor where the region changes from *p*-type to *n*-type (the lattice structure remaining continuous) is called a *pn*-junction. The semi-conductor containing a *pn*-junction is called semiconductor diode.

A *pn*-junction is not the interface between the two pieces of the semi-conductor of the opposite types pressed together. It is a single piece of semi-conductor crystal having an excess of donor impurities into one side, and of acceptor impurities into the other. By four methods, *pn*-junctions are fabricated and designed which are growing, alloying, diffusing an ion implantation. The thickness of the *pn*-junction is of the order of 10^{-6} meter.

Forward biased and Reversed biased *pn*-junction :

If in a *pn*-junction, a *p*-type crystal is connected with the positive terminal of the battery and a *n*-type crystal is connected with the negative terminal of the battery, then it is said to be in forward biased position and

junction due to the creation of an external field E.



But if in a *pn*-junction a *p*-type crystal is connected (attached) with the negative terminal of the battery and a *n*-type crystal is connected (attached) with the positive terminal of the battery, then it is said to be in the reversed biased position and at this position only very small amount of current flows due to the minority charge carriers through the junction.

Applications of *pn*-junction :

(i) As a rectifier : In the absence of any external voltage applied across a *pn*-junction, there is no current in the diode. Under this condition a few majority charge-carriers (holes in *p*-region and electrons in *n*-region) have sufficient energy to move across the junction despite the opposing internal field and form a forward current. This current is however exactly balanced by the reverse current formed by the flow of minority carriers (electron in *p*-region and holes in *n*-region) across the junction which is supported by the internal field. The net current is thus zero, this is the action of a rectification. Thereby *pn*-junction acts like a rectifier in which an alternating current (a.c.) is converted into a direct current (d.c.).

(ii) As a Zener diode : When *pn*-juction is in a reverse biased condition then it acts like a zener diode for a long voltage range and it is used as a voltage stabliser.

(iii) As a Tunnel diode : A tunnel diode is a semi-conductor device (*pn*-junction diode) which makes use of the a quantum mechanical phenomenon of the potential barrier penetration. It is a *pn*-junction which is made from a heavily dopped semi-conductor.

(iv) As a Photo conductor : A photo conductor is a device that detects optical signals. A commercial photo conductor is called a photo conductive cell and has a layer of cadmium sulphide (CdS) containing a small amount of bismuth or indium impurity on its sensitive surface. When a light falls on the surface of the photo conductor, the current in the circuit increases depending upon the intensity of the incident light.

Photo conductive devices or cells are used in industry, photography and light-intensity measurement. The most commonly used cell is the cadmium sulphide (CdS) photo conductive cell which is excellently sensitive in the visible range. A lead sulphide (PbS) or indium antimony ($In\ Sb$) cell is used for the infrared detection. A selenium cell is particularly sensitive in the blue region. *PN*-photo diode is a junction type photo conductor having several advantages over an ordinary bulk-type photo conductive cell.

(v) As a Solar cell : A solar cell is a semi-conductor device (*pn*-junction) which converts the solar energy directly into the electrical energy and it is based upon the phenomenon of photo voltaic effect. The commercial solar

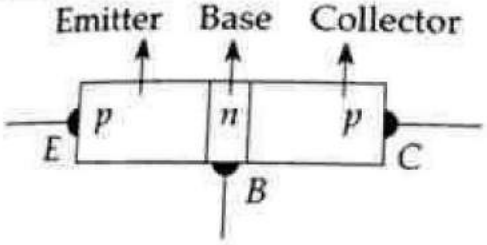
...cells are ... and it is used in space vehicles when a small mass of the solar batteries is needed or inaccessible places on the earth where automatic equipments/devices are kept non-stopped operating.

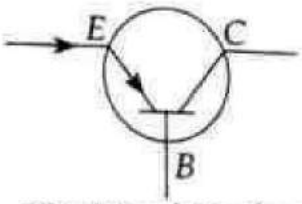
Junction Transistor or Bipolar Transistor : A junction transistor is a semi-conductor device consisting of two *pn*-junctions placed back to back, one under a forward bias and another under a reverse bias. A forward-biased *pn*-junction offers a low resistance, while a reverse-biased offers a high resistance. Also in junction transistor both majority and minority carriers play a significant role and that's why it is also called bipolar transistor and it is a solid state electronic control device.

Such point contact transistor was firstly invented by John Bardeen and Walter Brattain in 1948. But these transistors were found to have the problem in their fabrication. Also these were found to be electrically noisy and lacked a larger power gain. Thus, a modified and comprehensive approach was taken for its commercial fabrication and design by William Shockely in 1951. Thus, on the commercial level the real inventor of the bipolar junction transistor was William Shockely. At present some more modified techniques of its fabrication and designing have been developed and these techniques are zone refining, diffusion, epitaxial, planar, beam-lead, ion implantation etc.

The junction transistor is of two types—*pnp* transistor and *npn* transistor.

***pnp* transistor :** It consists of a very thin slice of *n*-type semi-conductor sandwiched between small block of *p*-type semi-conductor. The central slice is called base, while the left and right blocks are called emitter and collector.

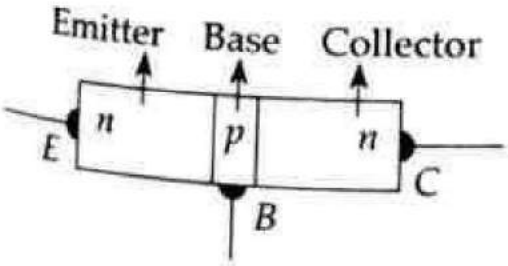


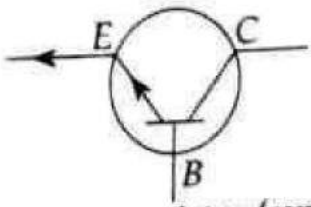


pnp transistor (symbol)

The emitter is given a positive potential, while the collector is given a negative potential with respect to base. Thus the emitter-base (p–n) junction is under forward-bias (low resistance), while the base-collector (n–p) junction is under reverse-bias (high resistance).

***npn* transistor :** It consists of a thin slice of *p*-type semi-conductor sandwiched between two small blocks of *n*-type. In this transistor the emitter is given a negative potential, while the collector is given a positive potential with respect to the base. Again the emitter-base (n-p) junction is under forward bias, while the base-collector (p-n) junction is under reverse-bias.





npn transistor (symbol)

In working position for every bipolar junction transistor *pnp* or *npn*

Emitter current (I_e) = Base current (I_b) + collector current (I_c).

There are three modes of configuration for the working of a junction transistor as given below :

(a) Common base configuration.

(b) Common emitter configuration.

(c) Common collector configuration.

Unipolar transistor or Field Effect Transistor (*FET*) : A Field Effect Transistor (*FET*) is a semi-conductor electronic device in which the current is controlled by the variation of an electric field and is carried out by the majority charge carriers only. Like a vacuum tube, the *FET* is a unipolar (one type of carrier) device. There are two types of field effect transistors—Junction Field Effect transistor (*JFET*) and Metal-Oxide-Semi-conductor Field Effect Transistor (*MOSFET*). There are two classes of *JFETs*—*n*-channel *JFET* like a thermionic tube (triode valve), *FET* is a voltage-controlled device, while the conventional transistor uses a base current to control the large collector-current. That's why bipolar junction transistor is a current-controlled device. Also *FET* is less noisy than a bipolar transistor so it is frequently used in *FM* (Frequency Modulated) radio. *FETs* have smaller size and longer life. Hence, a large number of them are incorporated today in the Integrated Circuits (*IC*), while bipolars are cheaper and offer a larger range of choice which are used in the discrete circuits (digital electronics).

Application of transistors : Almost all the solid state electronic control devices are made from the bipolar or unipolar junction transistors. Some electronic devices which use junction transistors directly are power amplifiers, voltage amplifiers, oscillators, modulators etc.

Also some *FETs* are specially used as switches in the digital circuits, as a phase-shifter in the oscillator circuit and as a Voltage Variable Resistor (*VVR*) which is used in an attenuator circuit, an automatic gain control circuit etc.

Modern electronic devices

(i) Cathode Ray Oscilloscope (CRO) : Cathode Ray Oscilloscope (*CRO*) is one of the most widely used device having a large number of applications. A cathode ray oscilloscope consists of the following main components—cathode ray tube, horizontal and vertical voltage amplifiers, power supply circuits etc.

Both the a.c. and d.c. voltage can be measured through a *CRO* and it is used in the television receiver and Radar. It is also used for radio servicing and to locate the falts in various electronic equipments. It is used also in the construction of electro cardiograph and in the industries to study the mechanical pressure and to get the indicator diagrams of the internal combustion engines. *CRO* is also used in measuring an extremely short interval of time even less than a micro second.

(ii) Television : Television was firstly invented in 1923 by John L. Baird through which both sound and light were are transmitted in the form of an electromagnetic wave by the means of resonance from any suitable place. In other words pictures, scenes and photographs of moving objects

vehicles etc are transmitted in the form of an electromagnetic wave through the picture tube and by the means of an amplified modulation these are picturised on the television screen.

Broadly there are two parts in the television :—

(i) Iconoscope : Iconoscope transforms the scattered light wave of the picture of any object into an electromagnetic wave which is transmitted to the far flung distances and places by an amplified modulation mechanism.

(ii) Kineoscope : It is a type of Cathode Ray Oscilloscope (*CRO*) through which cathode ray adjusts the tuning similar to the iconoscope and produces a resonance with an amplified, modulated electromagnetic wave. Consequently fascinating, fluorescent pictures and scenes due to the persistence of the vision appear.

(iii) RADAR (Radio Detection and Ranging) : The Radar was firstly invented by Robert Watson but its first prototype was designed by the two American scientists Taylor and Young. It is a device through which the actual location (position) and the configuration of the unwanted bodies are detected and measured by the electromagnetic wave of the flying aircraft at higher altitudes.

The radars are also used to detect and measure the position (or location) and distance (or height) of the cloud, to explore the evidence of any metal or oil reserve, to detect the outer layer of the atmosphere and to obtain the height of ionosphere etc.

(iv) LASER (Light Amplification by Stimulated Emission of Radiation) : Laser is a device that produces an intense, coherent and highly directional beam of the single frequency. It can be transmitted over a great distance without being spread. The light beam can be intense enough to vaporise the hardest and the most heat resistant materials. The first ruby laser was demonstrated by Theodore H. Miaman in 1960. Any laser device consists of three main components— an active medium, a pumping source and an optical resonator. All lasers work on a basic principle that whenever electricity, heat, light or chemical reaction excites an atom it accommodates the extra energy by rearranging its electrons, shifting some of them from the ground energy level to higher energy levels. This excited state of electron is unstable and to become stable the electron falls back to its ground state emitting extra energy in the form of light. This kind of emission is called stimulated emission. The important kinds of lasers include optically pumped lasers, liquid lasers, gas discharge lasers, semi-conductor lasers etc. Laser works up to femto (10^{-15}) second, while super fast computer works only up to nano (10^{-9}) second.

Applications of Laser :

(i) In Information Technology (*IT*) : Laser is frequently used in the fabrication and composition of *CD* (Compact Disc), *DVD* (Digital Versatile Disc) and in the collection of datas and its storage in *CD*.

(ii) To measure time and distance : By the help of laser both distance and time can be measured most accurately and precisely. Also through it not only the longest distance is to be measured accurately but also the smallest distances, even interatomic distances, are measured in the most

excellent and accurate form. That's why by the laser interatomic distances and so internal structure of the atoms are authentically studied.

(iii) To construct hologram : With the help of laser a special type of three dimensional photograph is drawn in the hologram form.

Holography : Dennis Gobar firstly invented a three dimensional photograph (complete view of an object) which is not possible through any camera lens system by the means of a highly coherent light. Thus, the complete resemblance of an object in a very distinct manner is sketched and in which the originality of the object appears is called holography. In holography we do not record the object (being photographed) but record the light waves reflected from the object. This photographic record is called a *hologram*. The hologram has no resemblance with the object, although it contains all the informations about it in the form of an optical code. When this hologram is illuminated by a source of coherent light a three dimensional photograph of the object is formed. Thus, in holography we do not use any lens (or camera) and obtain a perfect (excellent) and original touch of the object in its photograph. This photography technique was firstly utlised in 1962 by Y.N. Denisluk after the invention of laser in 1960.

(iv) To sketch the path (trajectory) of flight : For the security point of view the accurate path of the aircrafts and aeroplanes are sketched through a powerful laser which is very convenient for the air traffic control and comfortable journey. Also rockets and satellites follow this technique for their smooth and perfect destinations in the space.

(v) In Industry : In the industrial sector lasers are mainly used in surveying, to facilitate data network, the processing of objects or commodities, to examine non-decomposed substances etc. Today lasers are also utilised frequently in cutting an extremely hard object, cloth, in the construction of buildings, metallic pipes, in the exploration of mines, in the furnishing of diamonds and gems jewellery. By the means of a special laser cutting technique the diamond's look has been made more fascinating and stylish.

(vi) In defence : The lasers are used to measure the accurate position and distance of the missiles and other sophisticated weapons. Under the *star war programmes*, the destructive power of the laser is being utilised to destroy missiles in the sky.

(vii) In chemistry : In chemistry lasers are used as remedial equipment and in the chemical reactions lasers are used as a catalyst or an autolyst.

(viii) In health and medical science : Today lasers are playing a significant and relevant role specially in the incurable and undiagonised diseases. Through the laser today cancer has become curable, the barrier produced in the blood clotting in the veins of heart is being sorted out, and many surgical operations in human eye are being completed without any complicacy and problem in perfect way. Specially in the treatment of eye a modern technique which is called *Eximer Lassic Laser*, through it the human eye glass can be permanently discarded (abandoned). Argon or krypton ion lasers are also frequently used in the treatment of the retina of the eye and some other problems of the human eyes. The *laser radial keratotomy techniques* are used to adjust the abnormal shape of the eye

lens. Through the laser and *optical fibre endoscope* the blood clotted ulcers have easily become curable in a very convenient and simple way. By laproscopic treatment the stones of gall bladder and kidney are removed without any rigorous surgical work in a very short interval of time.

MASER (Microwave Amplification by Stimulated Emission of Radiation : The maser was invented by three American scientists Gordon, Gieger and H. Townes in 1952 and it is similar to the laser upto maximum extent. In fact maser is an optical device which uses microwave in apmlified form of longer wavelength of the light, while ordinary laser uses light rays simply.

Through masers the actual position of the artificial satellites, fighter planes, unwanted missiles etc are detected by the help of the radar. In ocean water masers are today utilised to communicate some important messages and details needed. Also through the masers remedial measures are performed similar to the lasers.

Laser technology in India : In 1964 the first laser as Gallium Arsenide (GaA) semi-conductor laser was designed and fabricated by Bhabha Atomic Research Centre (BARC). The BARC is the largest centre for developing laser technology in a very exclusive way in India. The lasers developed so far are *He-Ne* laser, *He-Cd* laser, copper vapour laser, ruby laser etc. Some other centres where lasers are designed and fabricated are Centre for Advanced Technology (CAT), Defence Research and Development Organisation (DRDO), Indian Insititutue of science (*I I Sc.*) Banglore, and Indian Institute of Technology (*IIT*) Kanpur. An exclusive centre for the laser research is *IIT*- Kanpur whose laboratories are too m ch enriched and where research works on the laser plasmas, quantum opt cs, ultrafast process, nonlinear optics etc are going on with the American Collaboration.

Miscellaneous

1. Important Physical quantities and their units

Physical quantity	Unit (S.I.)	Physical quantity	Unit (S.I.)
Length	Metre	Sp. heat capacity	Joule/kg-K.
Time	Second	Electric power	kilo Watt hour (kWh)
Volume	Cubic metre	Electric resistance	Ohm
Velocity	Metre/sec.	Electric potential	Volt
Force	Newton	Latent heat	Joule/K
Pressure	Pascal	Surface tension	Newton/metre
Energy	Joule	Moment of inertia	kg. m^2
Temperature	Kelvin	Electric charge	Coulomb
Mass	Kilogram	Electric capacity	Farad
Density	kg/m^3.	Power	Joule/sec or watt
Heat	Joule	Viscosity	Newton-sec. $metre^{-2}$
Electric current	Ampere	Work	Newton-metre or Joule
Area	Sq. metre	Luminous Intensity	Lumen

Physical quantity	Unit (S.I.)
Frequency	Hertz
Wavelength	Metre
Speed	metre/sec.
Acceleration	metre/sec^2.
Plane angle	radian
Intensity (in sound)	decibel
Absolute temperature	Kelvin
Potential difference	Volt
Electric field intensity	Newton/Coulomb
Magnetic dipole moment	Ampere-metre
Magnetic field or magnetic induction	Tesla, weber-per metre^2

Physical quantity	Unit (S.I.)
Linear momentum	Newton-sec.
Magnetic flux	Weber, Maxwell
Power of the lens	diopter
Angular velocity	rad/sec.
Solid angle	Steradian
Luminous Intensity	Candela
Atmospheric pressure	Bar
Astronomical distance	Light year
Supersonic motion	mach
Acceleration due to gravity	metre/sec^2.

2. Conversion Units

One inch	2.54 cm	one foot	0.30 meter
One yard	0.91 meter	one mile	1.60 km
One fadam	1.8 meter	one chain	20.11 meter
One nautical mile	1.85 km	one angustrum	10^{-10} meter
Square inch	6.45 square cm	Square foot	0.09 square meter
Square yard	0.83 square meter	one acre	$10^4 m^2$
Square mile	2.58 square km	one cube inch	16.38 cm^3
Cube foot	0.028 cube meter	one yard	0.76 m^3
One liter	1000 cm^3	one pint	0.56 liter
One grain	64.8 mili gram	one drum	1.77 g
One ounce	28 gm	one pound	0.45 kg
One erg	10^7 Joule	one poundal	0.13 Newton
One calorie	4.2 Joule	one horse power	746 watt
One Newton	10^5 dyne	one fadam	6 feet
One nautical mile	6080 feet	one mile	5280 feet
One mile	8 farlang	one yard	3 feet
One foot	12 inch	50°C	122°F
37°C	98.6°F	32°F	0°C
-40°C	-40°F		

3. Scientific devices/equipments

Devices/Equipments	Use
Ammeter	Electrical devices employed to measure current in ampere.
Altimeter	The device that measures the altitudes of aircraft.
Audiometer	The device that measures the intensity of sound.
Audiophone	The device or equipment employed in the ears by which the process of listening becomes easy and appreciable.
Animometer	The device through which the power and speed of wind are measured.
Avrometer	The device used to detect any fault in radio.
Airometer	The device used to measure the weight and density of air and gases.
Accumulator	The device used to restore electrical energy.
Ascalator	Moving mechanical ladders.
Apicoiscope	The device/equipment used to display the opaque (in transparent) photo on the screen.
Aviontiometer	The device used to detect and measure the intensity of sunrays.
Adiometer	The equipment through which the distances travelled by the wheels of vehicles are measured.
Barometer	The device used to measure atmospheric pressure.
Barograph	The device used to measure atmospheric pressure and used to focus on autographics.
Bolometer	The device used to measure thermal radiations.
Binoculars	The device used for the magnification of objects.
Crescograph	The device through which the growth in plants is detected and measured.
Calorimeter	The device used to measure the amount of heat.
Cardiogram	The device used to measure the heart beats of human body.
Carburator	The equipment used in internal combustion heat engine, vehicle's engine etc.
Compass-box	The equipment used to detect the North-South direction of any place.
Cyclotron	The device used to accelerate positively charged particles, ions etc.
Cytotron	The device by which artificial climate is produced.
Callipers	The device through which the external and the internal diameters of the cylindrical objects are measured.
Cathode ray tube	The equipment through which electrons are emitted or ejected.
Coolidge tube	Modern *X*-ray tube (device) used for various purposes.

Devices/Equipments	Use
Chronometer	The equipment employed in ships/steamers to measure the right time.
Cardiograph	The equipment through which human's heart beats are recorded and detected through graphics.
Denial cell	The device used to flow direct current (dc) through the circuit.
Density meter	The device used for density measurement.
Dynamometer	The device through which the power generated by an engine is measured.
Dictaphone	The device used to record own statement to listen another.
Dynamo	The device used to convert mechanical energy into electrical energy.
Dip circle	The device used to measure the angle of dip.
Dialysis Machine	The device used in blood purification for the person suffering through cardio related problems.
Dialetometer	The device used to measure the change in volume.
Electroscope	The device that confirms the presence of electric charge.
Electro meter	The device used to measure the potential difference (pd).
Electric motor	The device used to convert electrical energy into mechanical energy.
Electron microscope	The equipment used to analyse the micro substance.
Epidayscope	The equipment employed to project or expose pictures on the screen.
Electroinsifle graph	The mechanical device used to measure the potential of the human mind.
Endoscope	The device through which inner parts of the human body is diagnosed.
Fethometer	The device used to measure the depth of seas and oceans.
Geiger Mullar counter	The device used to measure the radiation of a radio active substance.
Gravometer	The device used to detect the presence of oil on water surface.
Gyroscope	The device used to obtain the speed and orientation of a moving object.
Galvanometer	The device used to measure the sharpness of electric current.
Gramophone	The device used to reproduce sound by sound wave.
Ganong respiratory	The device used to measure the respiration coefficient.
Hydrophone	The device used to measure the sound waves inside water.

Devices/Equipments	Use
Heart lungs machine	The device used in surgical operations of heart and lungs.
Hygrometer	The device used to measure atmospheric humidity.
Comograph	The equipment to used depict the motion of the heart beat in graphics way.
Calidoscope	The equipment used to detect various type of geometrical figures.
Lactometer	The device used to detect and measure the purification of milk.
Loudspeaker	The device used to enhance sharply the slow voice and loud voice is listened.
Lightening Conductor	The equipment employed and installed in multistoried buildings to protect the building from thundering lightening.
Megaphone	The device used to throw sound or voice remotely.
Microphone	The device used to transform sound energy into electrical energy.
Micrometer	The device used to obtain the $\frac{1}{1000}$th part of a milimeter.
Microtom	The equipment through which any substance is cut into the very smaller pieces.
Manometer	The device used to measure the pressure of gases.
Machmeter	The device through which the speed of air is expressed as in the form of the speed of sound.
Oscilliograph	The device through which electro mechanical vibrations are depicted graphically.
Ondometer	The device through which the frequency of an electromagnetic wave is measured.
Phonograph	The equipment through which sound writing is composed.
Photometer	The device through which the illumination and intensity of two light sources are compared.
Phototelegraphic	The equipment through which any photograph is brought from one place to another.
Pyrometer	The device used to measure extremely high temperature (temperature of the sun, star)
Periscope	The device used for those objects which are beyond the purview of looking range but through it objects are made easily to be seen.
Phonometer	The device used to know the power of brightness of light.
Pipate	The thin tube shaped equipment which measures the fixed volume of liquids.
Parasuit	The equipment used to fall on the earth's surface from higher altitudes from aircrafts during an emergency.

Devices/Equipments	Use
Photometer	The device through which the rate of evaporation of water is measured.
Polygraph	The device through which the truth of a human being is examined.
Paicnometer	The device used to measure the density of liquids and coeff. of linear expansion.
Quadrant	The device used to measure the altitudes and angles in navigation and astronomical science.
Radiator	The device used to cool the engine of vehicles.
Radiometer	The device used to measure thermal radiations.
Rain Gauge	The device used to measure the amount of rain of a certain place in a specific time.
Radar	The device used to measure the speed and direction of far coming aircrafts and fighter planes.
Refractometer	The device used to obtain the refractive indices of the transparent media.
Radio Micrometer	The device used to measure the thermal radiations.
Safety lamp	The device used in mines to avoid mines related mishaps.
Sextant	The device used to measure altitude
Stroboscope	The device with which the speed of a body is measured which executes the periodic motion.
Submarine	The equipment (water ship) which detects marine activities inside the ocean or sea water.
Sifgmoscope	The device through which human pulse vibration is measured.
Sphygmomanometer	The device used to measure the blood pressure of the human body.
Secrometer	The device used to measure the concentration of sugar.
Speedometer	The device used to measure the speed of motor vehicles.
Scrue Gauge	The device used to measure the diameters of thin wires.
Stop-watch	The device used to record true and accurate time.
Seismograph	The device used to measure the intensity of the earthquake.
Stethoscope	The device used to listen to the vibrations of the heart and lungs.
Spectroscope	The device used to analyse the spectrum.
Sterioscope	The device used to sketch two dimensional photographs.
Spherometer	The device used to measure the curvature.
Sphygmophone	The device used to listen the fast pulse vibrations.
Tokometer	The device used to measure the speed of the aircraft.

Devices/Equipments	Use
Transformer	The device used to regulate (high or low) AC voltage.
Telemeter	The device used to record flung physical incidents.
Teleprinter	The device used for receiving telegraphic massages and auto print technique with itself.
Thermostat	The equipment used to regulate the static temperature.
Telex	The device used to do direct conversation between two countries.
Theodolight	The device used to measure the cross-sectional and rectangular angles.
Taximeter	The equipment that displays directly the fare of the passengers.
Thermopile	The device used to measure the intensity of the radiation.
Turbine	The device used to transform the kinetic energy of the fluid into rotational energy and then the mechanical work is done.
Tokiometer	The device used to measure distance, latitude specially during survey and this device is like Thiodolight.
Ultrasonoscope	The device used to detect tumour, and some problems of the heart.
Udometer	The device used to measure the amount of rainfall.
Viscometer	The equipment used to measure the viscosity of the liquids.
Vacuum-cleaner	The equipment used to remove the dust particles.
Videophone	The device used in which alongwith voice (sound) of telephone photo also appears.
Van-de-graph generator	The device through which high potential difference is produced.
Venturimeter	The device through which the speeds of flow of liquid are measured.
Wattmeter	The device used to measure electric power.
Wavemeter	The device through which the wavelength of the radiowave is measured.
Xylophone	The device of a new musical instrument.

4. Inventors related to devices/equipments

Device/Equipment	Inventors	Device/Equipment	Inventors
Television	J.L. Beared	Radio	Marconi
Barometer	Torricelle	Telegraph	Morse
Lens camera	Jeans	Aeroplane	Wright brothers
Tyre	Dunlop	Seftipin	Walter Hunt
Telescope	Hans Lippershey	Thermionic triode	Leco Duo Forest
Revolver	Colt	Thormas Flask	Dewar

Device/Equipment	Inventors	Device/Equipment	Inventors
Military Tank	Swington	Rail engine	George Stefans
Dialysis Machine	Colf	Steam boat	Frank Wheetal
Electric Bulb	Edison	Arc lamp	Devi
Spectroscope	Bunsen	Lift	F.G. Otis
Transistor	Shaklay	Dynamo	Micheal Faraday
Fountain Pen	Waterman	Radar	Robert Watson
Gyroscope	Foucalt	Submarine	Bushwel
Transformer	Faraday	Bi-cycle	Macmillan
Tape Recorder	Poulsan	Seftirezor	Gillette
Crascograph	J.C. Bose	Parasuit	A.G. Gagreen
Steam Engine	James Watt	Sextant	Compel
Motor Vehicle	Asteen	Ball pen	John J. Bond
Gramophone	Edison	Electric fan	Wheelar
Vapour turbine	Parsons	Machine gun	James Puckle
Telephone	Graham Bell	Printing Machine	Kaekstan
Calculator	Pascal	Refrigerator	Harison & Kaitlin
Holography	Denish Gobar	Petrol car	Karl Benz
Helicopter	Bracket	Wireless Telegraphy	Marconi
Gas Engine	Daymlar	Sismometer	Robert Mallet
Cyclotron	Lawrance	Micrometer	William Gas Cogin
Power loom	Carl Wright	Lightening conductor	Franklin
Diesel Engine	Rudolf Diesel	Thermionic diode	J.A. Fleming
Type Machine	Soldz	E-Mail	ReTomlinshon
Scooter	G. Brousa	Chronometer	John Harisson
Glider	Sir George Faily	Microscope	Janson & Janson
Jet engine	Frank Wheetal	Printing technique	Gu tenberg
Nuclear furnace	Aneriko Fermi	Heart Lung machine	Denish Mailrose
Thermometer	Fahrenheight	Air conditioner	Wills Hevyl & Carriare
Air break	George Wasting house	Gieger Mullar Counter	Gieger
Photometer	Adberd Charles Pikring		

5. Inventions in Physics/Inventors

Inventions	Inventors	Inventions	Inventors
Speed of light	Fizeou	Diode valve	J.A. Fleming
Mica sheet	C.R.T. Wilson	Triode valve	L.D. Forest
Electronic charge	Millikan	Dynamite	Alfred Nobel
Neutrino	Pauli	Laser rays	T.H. Memon
Safety lamp	H. Devi	Photon	Einstein

Inventions	Inventors
Radioactivity	H. Becquarel
Law of pressure	Pascal
Superconductivity	K. Onnes
Corpuscular theory of light	Newton
Law of refraction of light	Snell
Principle of relativity	Einstein
Thermal effect of electric current	Joule
Speed of light in liquid	Foucalt
Current electricity, Electric battery	Alexander Volta
Static electricity	Thels
Modern X-ray tube	Coolidge
Law of electric resistance	Ohm
Electromagnetic wave	Henric Hertz
Thermionic emission	Thomas Alva Edison

Inventions	Inventors
Induction coil	Roamcorf
Law of Gravitation	Newton
Law of cooling	Newton
Newtons' laws of motion	Newton
Artificial disintegration of atom	Fermi
Principle of Floatation	Archemedes
Nuclear fission	Ottohaan and Strassman
Interference of light	Thomas Young
Electric charge	Benzamine Franklin
Maser rays	Gorden, Geeger
Wave theory of light	Hygens
Law of electric attraction	Coulomb
Logrithm	Briggs, J. Nappier
Mechanical equivalent of heat	Joule

6. Eminent Physicist and their outstanding contributions

Physicists	Countries	Outstanding Contributions
A. Fermi	Italy	Identification of artificial radioactive elements, Atomic furnace construction etc.
A. Salam	Pakistan	Gave intercorelation between electro-magnetic forces and weak forces.
Archemedes	Greece	Propounded concept of upthrust (boyancy) in liquids, provided principle of lever, discovery of sp. gravity etc.
Aryabhatt	India	An eminent mathematician and astronomer of 5th century, some more special contribution in mathematics.
Bhaskar-I	India	A famous astronomer and mathematician of 7th century.
Bhaskar-II	India	A famous astronomer and mathematician of 12th century.
B. T. Nag Choudhary	India	The colleague of Dr. Lawrence who was the inventor of Cyclotron has special contribution in the nuclear physics etc.

Physicists	Countries	Outstanding Contributions
Copernicus	Poland	Discovery of the solar system, firstly to explain that all celestial bodies are revolving around the sun.
C. V. Raman	India	Raman effect, related to scattering of light, special research on crystallography of solids.
Dr. Raja Ramanna	India	Contribution in 1st nuclear explosion (Atom bomb) of India at Pokharan in 1974.
Dr. V. Sarabhai	India	Space research, cosmic rays research etc.
de-Broglie	France	Dual nature of matter (matter as a particle and matter as a wave).
Denish Gobar	U. K.	Discovery of three dimensional photography (holography)
Dr. Adberd Taylor	U. S. A.	Construction of hydrogen bomb (Fussion bomb)
Einstein	Germany	Comprehensive and special theory of relativity, explanation of photo electric effect, gave mass energy equivalence relation ($E = mc^2$), discovery of photon etc.
Galelio	Italy	Law of inertia, Kinematical equations, discovery of telescope etc.
G. Marconi	Italy	Wireless telegraphy, radio and wireless message.
H. Devi	U. K.	Discovery of safety lamp.
H. Cauvendish	U. K.	Determination of the density of the earth.
Heisenberg	Germany	Principle of uncertainly, propounded theory of Quantum mechanics.
H. A. Baithe	U. S. A.	Explanation of stellar energy (energy confined within stars).
H. Yukawa	Japan	Discovery of elementary particle meson.
H. J. Bhabha	India	The father of Indian Atomic energy, special contribution in space and cosmic-rays showers.
J. J. Thomson	U. K.	Discovery of electron
James Chadwick	U. K.	Discovery of Atomic neutron
John Dalton	U. K.	Proposed Atomic model
J. Kepler	Germany	Planatory motion, motion of satellites etc around the sun
J. B. Narlikar	India	Propounded new theory of relativity.
J. C. Bose	India	Discovery of crescograph, wireless messages, discovery of intrinsic sensation of plants.

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Physicists	Countries	Outstanding Contributions
K. M. Krishnan	India	The colleague (associate) of Dr. C. V. Raman in the invention of Raman effect.
Max Planck	Germany	Propounded Quantum theory.
Millikan	U. S. A.	Determine electronic charge, analysis of cosmic rays.
M. N. Saha	India	Principle of thermal ionisation.
Maxwell	Scotland	Electromagnetic theory of light, the law of molecular speed distribution.
Niels Bohr	Denmark	Propounded hydrogen line spectrum, first success in atomic model, quantum theory of radiation etc.
Newton	U. K.	Universal gravitational law, laws of motion, reflecting telescope, discovery of calculus, Binomial theorem etc.
Otto Haan	Germany	Construction of atom bomb (Fission bomb)
Robert Watson	U. K.	Discovery of radar.
Roentgen	Germany	Discovery of X-rays.
R. P. Finmen	U. S. A.	Research activities in Quantum electrodynamics.
S. Chandrashekhar	India	Astronomy (Chandrashekhar's limit), floatation physics, general relativity theory etc.
Satish Dhavan	India	Research activities in nuclear physics, special contribution in space research, has special role in Indian artificial satellites Aryabhat and Rohini.
S. Ramanujan	India	A special contribution in the theory of number system and algebraic inequalities.
S. N. Bose	India	Discovery of boson (an elementary particle).
T. Alva Edison	U. S. A.	Phonograph, electric bulb, picture telegraph (discovery), discovery of thermionic emission etc.

Objective Questions

1. The S.I. Unit of entropy is :
   (a) Joule/sec (b) Joule/kelvin
   (c) J-kelvin (d) Joule-sec
2. The unit of work is :
   (a) Joule (b) Newton (c) Watt (d) Dyne
   [RRB T. C. 2005]
3. Parsec is the unit of :
   (a) distance (b) magnetic force
   (c) shining of light (d) time *[UPPCS (Pre) 1997]*

4. Light year is the unit of :
(a) distance (b) time
(c) intensity of light (d) mass [RRB ASM/C.C. 2005]

5. Which of the following is not the unit of time ?
(a) leap year (b) lunar month (c) light year (d) None of these [RRB C.C. 2003]

6. Which of the following is not matched ?
(a) Decibel—unit of sound (b) Horse power—unit of power
(c) Nautical mile—unit of distance
(d) Celsius—unit of heat [UPPCS (Pre) 2001]

7. The unit of magnetic flux is :
(a) weber (b) weber/meter
(c) weber-ampere (d) weber-sec

8. The S.I. unit of the Young's modulus of elasticity is :
(a) dyne/cm. (b) newton/meter
(c) newton/meter^2 (d) newton-sec [RRB TC 2005]

9. Which of the following is a vector quantity ?
(a) energy (b) momentum
(c) moment of inertia (d) all of these

10. An artificial satellite orbiting around the earth does not fall down. This is so because the attraction of the earth :
(a) does not exist at such distance
(b) is neutralized by the attraction of the moon
(c) provides the necessary speed for its steady motion
(d) provides the necessary acceleration for its motion [CSAT 2011]

11. The electric current density is :
(a) a vector quantity (b) a scalar quantity
(c) both (d) None

12. The surface of a lake is frozen in severe winter, but the water at its bottom is still liquid. What is the reason ?
(a) ice is a bad conductor of heat
(b) since the surface of the lake is at the same temperature as the air, no heat is lost
(c) the density of water is maximum at 4°C.
(d) none of the statements (a), (b) and (c) given above are correct. [CSAT (Pre) 2011]

13. Lumen is the unit of :
(a) Luminous intensity (b) Luminous flux
(c) Both (d) None [RRB ASM/GG 2004]

14. Candela is the unit of :
(a) Luminous flux (b) Luminous effect
(c) Luminous pressure (d) Luminous intensity [RRB ASM/CC 2004]

15. Which one of the following pair doesn't have the same dimension ?
(a) force and pressure (b) work and energy
(c) impulse and momentum (d) pressure and stress [RRB TC 2002]

16. The physical quantity obtained by the division of linear momentum of a body to its velocity is :
(a) velocity (b) acceleration (c) mass (d) force
[BPSC (Pre) 2002]

17. The bodies executing free falling motion have :
(a) equal momentum (b) equal velocity
(c) equal acceleration (d) equal force *[RRB TC/CC, 2002]*

18. The increasing amount of carbon dioxide in the air is slowly raising the temperature of the atmosphere because it absorbs?
(a) the water vapour or the air and retains its heat
(b) the ultraviolet part of the solar radiation
(c) all the solar radiation
(d) the infrared part of the solar radiation *[CSAT, 2012]*

19. Rocket operates (works) on the principle of :
(a) Energy conservation (b) Bernoulli's theorem
(c) Avogadro's concept (d) Momentum conservation
[RRB Assitt. Driver 2003]

20. The blackboard seems black because it :
(a) reflects every colour (b) does not reflect any colour
(c) absorbs black colour (d) reflects black colour *[CDS, 2011]*

21. A cricket player catches a fast coming ball by pulling his hands back because :
(a) the ball can come to a position of rest
(b) the ball can be accelerated (c) the ball can exert a larger force
(d) the ball can exert a lesser force *[RRB Metro Rail 2002]*

22. Force is the product of :
(a) mass and velocity (b) mass and acceleration
(c) weight and velocity (d) weight and acceleration
[BPSC (Pre) 2002]

23. The weight of a human body is :
(a) same at every places on the earth's surface
(b) maximum at the poles (c) maximum at the equator
(d) more on the mountains than the plains *[RRB 2006]*

24. If the weight of a man is 600 N on the earth, then his weight on the moon will be :
(a) 6000 N (b) 60 N (c) 1000 N (d) 100 N
[RRB Metro Rail 2002]

25. If the weight of an object on the earth's surface is 29.4 N then the mass of the object would be :
(a) 2 kg (b) 3 kg (c) 4 kg (d) 29.4 kg
[RRB TC 2004]

26. A man (astronaut) can apply a more longer jump on the moon's surface than the earth's surface, because :
(a) he is weightless on the moon
(b) there exists no atmosphere on the moon
(c) the gravitational pull on the moon is lesser than that of the earth's surface
(d) the moon is smaller than the sun *[RRB CC 2003]*

27. The weight of an object of mass 1 kg can be expressed as :
(a) 1 N (b) 10 N (c) 9.8 N (d) 9 N [RRB TC/CC 2010]

28. The product of the moment of inertia and the angular acceleration is :
(a) force (b) torque
(c) work (d) angular momentum [RRB 2010]

29. A body is charged negatively. It implies that :
(a) it has lost some of its protons
(b) it has acquired some electrons from outside
(c) it has lost some of its electrons (d) none of the above [CDS, 2011]

30. A piece of ice is floating on the surface of the water kept in a beaker and when this piece melts then the level of the water in the beaker :
(a) will increase (b) will decrease
(c) will be same
(d) will firstly increase then it would decrease [RRB ASM/GG 2004]

31. Due to contraction of eyeball, a long sighted eye can see only :
(a) farther objects which is corrected by using convex lens
(b) farther objects which is corrected by using concave lens
(c) nearer objects which is corrected by using convex lens
(d) nearer objects which is corrected by using concave lens [CDS, 2011]

32. Why do you feel cool under a tree but not so under a tin shed on a sunny day?
(a) The greenness of the tree gives the cool feeling
(b) Photosynthesis absorbs heat
(c) The leaves convert water vapours into water which is a heat-absorbing process
(d) The leaves give out water which vaporizes absorbing some heat as latent heat [CDS, 2011]

33. Why an iron nail floats on mercury but sinks in water ?
(a) less chemical affinity of iron than mercury with water
(b) the weight of iron nail is more than water but less than mercury
(c) the density of iron is more than water but less than mercury.
(d) None of these

34. Water has its maximum density at : [UPSC (Pre) 1994]
(a) 100°C (b) 4°C (c) 0°C (d) –4°C

35. Which one among the following would expand the most on being heated ? [BPSC (Pre) 1998]
(a) Water (b) Alcohol (c) Glass (d) Air

36. If two pieces of ice are mutually pressed to each other then these pieces stick because : [CDS 2011]
(a) at higher pressure the melting point of ice decreases
(b) at higher pressure the melting point of ice increases
(c) at higher pressure the melting point of ice firstly decreases and then increases
(d) there exists no relation between the pressure and melting point of the ice [RRB ASM/GG 2004]

37. At higher altitudes water boils at the temperature lower than 100°C because :
(a) due to lesser atmospheric pressure boiling point of water lowers
(b) the gravitational pull is lesser here
(c) the winds on the mountains are stormy
(d) None of these *[UPPCS (Pre) 1994]*

38. The inside pressure of a soap bubble is :
(a) more than the atmospheric pressure
(b) less than the atmospheric pressure
(c) equal to the atmospheric pressure
(d) half of the atmospheric pressure *[UPPCS (Pre) 1995]*

39. The sudden downfall of the reading of barometer indicates that the weather :
(a) will be stable and calm (b) will be rainy
(c) will be stormy (d) will be cyclonic *[UPPCS 1996]*

40. In which of the following kinetic energy does not exist :
(a) fired bullet (b) flowing water
(c) imparted hammer (d) stretched bow
[RRB TC/CC 2002]

41. If a moving body doubles its velocity then the kinetic energy of the body will be :
(a) double (b) four times (c) same (d) three times
[RRB TC/CC 2001]

42. The cyclist (man) leans or bends himself around a turning because :
(a) speed of man and cycle should be the same, otherwise the cycle will skid
(b) he bends to locate the centre of gravity inside the base which prevents him from falling down
(c) he bends to exert pressure on the cycle's wheels to move on the curved track (path)
(d) he bends to cross the curved path speedily *[RRB ASM/GG 2004]*

43. Which of the following force is exerted by a cream separator machine of the milk :
(a) centrifugal force (b) centripetal force
(c) non-central force (d) external force *[RRB TC/CC 2005]*

44. When a stone piece is brought from the moon's surface to the earth then :
(a) its mass will change
(b) its weight will change but its mass would remain constant
(c) the weight and mass both will change
(d) neither mass nor weight will change *[BPSC (Pre) 2004]*

45. The person sitting in a lift or elevator will experience more :
(a) when the lift is accelerated downwards
(b) when the lift is accelerated upwards
(c) when it is coming downwards with equal velocity
(d) when it is going upwards with equal velocity *[UPPCS (Pre) 1990]*

46. The apparent weight of a person sitting in a lift is less than its real weight when the lift moves

(a) upwards with an acceleration
(b) downwards with an acceleration
(c) upwards with equal velocity
(d) downwards with equal velocity

47. The time period of a pendulum watch : *[RRB TC 2004]*
(a) depends on the mass (b) depends on the length
(c) depends on the time (d) depends on the temperature

48. The pendulum watches become slowed down in summer because : *[BPSC (Pre) 2005]*
(a) of longer summer day
(b) the weight of the pendulum is increased in the summer
(c) pendulum becomes elongated and correspondingly time is elongated at per unit oscillation
(d) of appearance of friction in the coils *[UPPCS (Pre) 1994]*

49. If the length of a simple pendulum is increased by 4% then its time period will be :
(a) increased by 3% (b) increased by 2%
(c) increased by 4% (d) None of these *[RRB ASM/GG 2004]*

50. The ratio of the transverse deformation and the longitudinal deformation is called :
(a) Poisson ratio (b) Bulk modulus of elasticity
(c) Rigidity modulus of elasticity (d) Young's modulus of elasticity *[RRB Assist. driver 2003]*

51. The raindrops are spherical due to :
(a) surface tension
(b) atmospheric friction of air molecules
(c) gravity of the spherical earth
(d) viscosity of the raindrops *[RRB GG 2003, UPPCS (Pre) 2005]*

52. If a ship moves from fresh water into seawater, it will —
(a) sink completely (b) sink a little bit
(c) rise a little higher (d) remain unaffected *[CDS, 2011]*

53. The unit of viscosity is :
(a) poise (b) pascal (c) poiseuille (d) none of these *[RRB ASM 2003]*

54. The scientist associated with floatation is :
(a) Archemedes (b) Newton (c) Louis Pasteur (d) All of these *[RRB CC 2005]*

55. Satellites used for tele-communication relay are kept in a geostationary orbit. A satellite is said to be in such an orbit when :
1. The orbit is geosynchronous
2. The orbit is circular
3. The orbit lies in the plane of the earth's equator
4. The orbit is at an altitude of 22,236 km

Select the correct answer using the codes given below :
(a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 2 and 4 only (d) 1, 2, 3 and 4 all *[CSAT (Pre) 2011]*

56. If a coin is to
then it rises
(a) 9.8 m

57. The freque
(a) 20 Hz
(c) 1 Hz –

58. The angul
(a) decre
(c) remai

59.

The velc
(a) unif
(b) unif
(c) non
(d) nor

60. The vel
(a) 330

61. Sound
(a) tra
(c) tra
(d) lo

62. Ultras
(a) le
(c) m

63. Infras
(a) l
(c) l

64. The
(a)
(c)
(d)

65. The
(a)
(b)
(c)
(d)

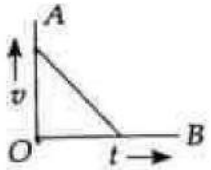
66. If th
wil

56. If a coin is tossed upwards from the ground with a velocity of 9.8 m/sec then it rises to a height :
(a) 9.8 m (b) 10 m (c) 4.9 m (d) 49 m
[BPSC (Pre) 2008]

57. The frequency of sound waves in the audible range is :
(a) 20 Hz — 20,000 Hz (b) 0.5 Hz — 5 Hz
(c) 1 Hz — 10 Hz (d) 20,000 Hz — 40,000 Hz
[RRB ASM/GG 2005]

58. The angular speed of a whirlwind in a tornado towards the centre
(a) decreases rapidly (b) increases
(c) remains constant (d) slowly becomes zero *[CDS 2011]*

59.



The velocity-time (v-t) graph shown above illustrates—
(a) uniform acceleration of an object
(b) uniform retardation of an object
(c) non-uniform acceleration of an object
(d) non-uniform retardation of an object *[CDS, 2011]*

60. The velocity of sound in the air (vacuum) is :
(a) 330 m/sec (b) 220 m/sec (c) 110 m/sec (d) 232 m/sec
[RRB Assistt. Driver 2008]

61. Sound is a :
(a) transverse mechanical wave (b) longitudinal mechanical wave
(c) transverse non-mechanical wave
(d) longitudinal non-mechanical wave

62. Ultrasonic wave has its frequency :
(a) less than 20 Hz (b) more than 20 Hz
(c) more than 20,000 Hz (d) 20 Hz — 20,000 Hz

63. Infrasonic wave has its frequency :
(a) less than 20 Hz (b) more than 20 Hz
(c) less than 20,000 Hz (d) more than 20,000 Hz

64. The noise of 100 db is assumed to be :
(a) a properly listened sound (b) an ordinary conversation
(c) a noise of the street
(d) a noise produced by the machine of a shop and listened at another neighbour's place *[IAS (Pre) 2000]*

65. The focal length of a convex lens is —
(a) the same for all colours
(b) shorter for blue light than for red
(c) shorter for red light than for blue *[CDS, 2011]*
(d) maximum for yellow light

66. If the door of a running refrigerator in a closed room is kept open, what will be the net effect on the room ?

(a) It will cool the room (b) It will heat the room
(c) It will make no difference on the average
(d) It will make the temperature go up and down [CDS, 2011]

67. Decibel is the unit of physical quantity used for :
(a) the speed of light (b) the intensity of heat
(c) the intensity of sound (d) the frequency of radiowaves [SSC Graduate 2005]

68. The echo is produced by the sound waves due to :
(a) the reflection of sound (b) the scattering of sound
(c) the refraction of sound (d) None of these [RRB Driver 2002]

69. SONAR is frequently used by :
(a) Astronauts (b) Doctors (c) Engineers (d) Navigators [UPPCS (Pre) 2004]

70. The pitch or frequency of the siren of a coming train appears to be increasing because of :
(a) Big-bang theory (b) Doppler's effect
(c) Charle's law (d) Archemedes's principle [RRB ASM/GG 2005]

71. The normal temperature of the human body is :
(a) 280 K (b) 290 K (c) 300 K (d) 310 K [IAS (Pre) 1995]

72. When a ball drops onto the floor it bounces. Why does it bounce ?
(a) Newton's third law implies that for every action (drop) there is a reaction (bounce)
(b) The floor exerts a force on the ball during the impact
(c) The floor is perfectly rigid
(d) The floor heats up on impact [CDS, 2011]

73. The lowest possible temperature is :
(a) –273°C (b) 0°C (c) –300°C (d) 1°C [RRB TC 2003]

74. Which one among the following will you put into pure water in order to pass electric current through it ?
(a) Kerosene (b) Mustard oil (c) Lemon juice (d) Sugar [CDS, 2011]

75. The temperature of the body of a healthy man is :
(a) 37°C (b) 37°F (c) 98.4°C (d) 98.4°K [Uttrakhand PCS (Pre) 2005]

76. A refracting telescope consists of :
(a) one concave mirror and one convex lens
(b) two convex lenses of equal focal length
(c) two concave mirrors of different focal lengths
(d) two convex lenses of unequal focal lengths [NDA, 2012]

77. Which of the following is the best conductor of heat :
(a) mercury (b) water (c) leather (d) benzene [UPPCS (Pre) 2005]

78. Garments keep us warm in the winter season because they :
(a) provide heat (b) do not radiate heat
(c) prevent air from coming in the contact of the body
(d) prevent heat of the body from going exterior [SSC Graduate 2004]

79. A glass of water does not turn into ice as it reaches 0°C. It is because —
(a) water does not solidify at 0°C
(b) a certain amount of heat must be supplied to the glass of water so as to solidify
(c) a certain amount of heat must be taken out from the glass of water so as to solidify
(d) water solidifies at 0 K only

80. Cryogenics are used in : [NDA, 2012]
(a) space journey, surgical works and magnetic resonance
(b) surgical works, magnetic resonance and remote sencing
(c) space journey, surgical works and remote sencing
(d) space journey, magnetic resonance and remote sencing [IAS 1999]

81. The dew doesn't form in fast wind blowing during the night because:
(a) the rate of vaporisation is fast
(b) there is a lack of moisture in the wind
(c) the temperature remains high (d) the sky is not clear [BPSC 1995]

82. The main power supply in India is 220V, whereas that in the US is at 110V. Which one among the following statements in this regard is correct
(a) 110 V is safer but more expensive to maintain
(b) 110 V is safer and cheaper to maintain
(c) 110 V leads to lower power loss
(d) 110 V works better at higher latitudes [NDA, 2012]

83. For a steel boat floating on a lake, the weight of the water displaced by the boat is?
(a) less than the weight of the boat
(b) more than the weight of the boat
(c) equal to the weight of the part of the boat which is below the water level of the lake
(d) equal to the weight of the boat [NDA, 2012]

84. The torque on a rectangular coil placed in a uniform magnetic field is large when the —
(a) number of turns is large (b) number of turns is less
(c) plane of the coil is perpendicular to the magnetic field
(d) area of the coil is small [NDA, 2012]

85. Two metallic wires A and B are of same material and have equal length. If the cross-sectional area of B is double that of A, then which one among the following is the electrical resistance of B ?
(a) Twice that of A (b) 4 times that of A
(c) $\frac{1}{4}$ that of A (d) $\frac{1}{2}$ that of A [NDA, 2012]

86. Two thin convex lenses of focal lengths 4 cm and 8 cm are separated by a distance of 4 cm in air. The combination will have the focal length ?
(a) 4 cm (b) 8 cm (c) 12 cm (d) 32 cm [NDA, 2012]

87. In the isothermal process which of the following remains constant :
(a) temperature (b) heat (c) pressure (d) density

88. In the adiabatic process which of the following remains constant :
(a) temperature (b) heat (c) pressure (d) volume

89. For the adiabatic process ideal gas equation is expressed as :
(a) $pV^{\gamma} = \text{constant}$ (b) $pV^{\gamma-1}$
(c) $p^{\gamma}V^{\gamma-1} = \text{constant}$ (d) any of these

90. For the isothermal process ideal gas equation is expressed as :
(a) $PV = RT$ (b) $\frac{p}{V} = RT$ (c) $PV = RT^{\gamma}$ (d) $pV^{\gamma} = RT$

91. A fan produces a feeling of comfort during hot weather, because
(a) our body radiates more heat in air
(b) fan supplies cool air (c) conductivity of air increases
(d) our perspiration evaporates rapidly [NDA, 2010]

92. Which one of the following statements is correct ?
(a) Only electrons reside inside the nucleus of an atom
(b) Both electrons and protons reside inside the nucleus of an atom
(c) Only neutrons reside inside the nucleus of an atom
(d) Both protons and neutrons can reside inside the nucleus of an atom [NDA, 2010]

93. Gases have two specific heat capacities :
(a) one at the constant volume and another at the constant pressure
(b) both at the constant volume
(c) both at the constant pressure (d) none of these

94. The Carnot's engine takes heat :
(a) at constant temperature (b) at constant volume
(c) at constant pressure (d) none of these

95. The Otto engine takes heat :
(a) at constant temperature (b) at constant volume
(c) at constant pressure (d) none of these

96. Entropy is the measurement of :
(a) disorder parameter (b) state of matter
(c) molecular configuration (d) none of these

97. The light is a :
(a) transverse wave (b) longitudinal wave
(c) both (d) none [RRB ASM/GG 2004]

98. The ratio of velocity of X-rays to that of gamma rays
(a) is < 1 (b) is > 1 (c) is 1
(d) depends upon the ratio of their frequencies [NDA, 2010]

99. The velocity of light in vacuum or air is :
(a) 9×10^2 m/sec (b) 3×10^{11} m/sec
(c) 3×10^8 m/sec (d) 2×10^4 m/sec [JPSC (Pre) 2003]

100. On raising the temperature of the medium velocity of light :
(a) increases (b) decreases
(c) remains the same (d) suddenly decreases [SSC 2004]

101. Which one of the following pairs of rays is electromagnetic in nature ?
(a) Beta rays and gamma rays (b) Cathode rays and X-rays
(c) Alpha rays and beta rays (d) X-rays and gamma rays [NDA, 2010]

102. The magnetic lines of force due to a bar magnet
(a) intersect inside the body of the magnet

(b) intersect at neutral points only
(c) intersect only at North and South poles
(d) cannot intersect at all

103. The specific resistance of a conducting wire depends upon — *[NDA, 2010]*
(a) Length of the wire, area of cross-section of the wire and material of the wire
(b) Length of the wire and area of cross-section of the wire but not on the material of the wire
(c) Material of the wire only but neither on the length of the wire nor on the area of cross-section of the wire
(d) Length of the wire only but neither on the area of cross-section of the wire nor on the material of the wire

104. When X-rays are produced — *[NDA, 2010]*
(a) heat is generated at the target (b) heat is absorbed at the target
(c) the temperature of the target remains constant
(d) brilliant light is seen at the target

105. Which one of the statements given below is not correct? *[NDA, 2010]*
(a) A vertical plane passing through the axis of a freely suspended magnet is called the magnetic meridian
(b) A vertical plane passing through the axis of rotation of the Earth is called the geographical meridian
(c) The degree to which the magnetic field can penetrate a medium is known as the relative permeability of the medium
(d) The relative permeability is not a dimensionless quantity

106. If an object is placed at the centre of curvature of a concave mirror, the position of the image is *[NDA, 2010]*
(a) at the principal focus
(b) between the principal focus and the centre of curvature
(c) at the centre of curvature (d) beyond the centre of curvature

107. The radius of curvature of a plane mirror *[NDA, 2010]*
(a) is zero (b) is infinity
(c) can be anywhere between zero and infinity
(d) none of the above

108. The rainbow appears due to : *[RRB CG 2005]*
(a) reflection (b) refraction
(c) scattering (d) both reflection and refraction

109. The sky appears blue : *[RRB 2004]*
(a) due to dispersion (b) due to refraction
(c) due to scattering (d) due to reflection

110. The diffusion of light in the atmosphere is due to : *[IAS (Pre) 2003]*
(a) carbon dioxide (b) dust particle
(c) helium (d) water vapour

111. A coin in a beaker filled with water appears raised. This phenomenon occurs because of the property of *[NDA 2010]*
(a) reflection of light (b) refraction of light
(c) total internal reflection light (d) interference of light

112. A ray of light falls on a transparent glass plate. A part of it is reflected and a part is refracted. The reflected and refracted rays can be perpendicular to each other for
(a) angle of incidence equal to 90°
(b) angle of incidence equal to zero
(c) only one angle of incidence
(d) more than one angle of incidence

113. A man with a dark skin, in comparison with a man with a white skin, will experience [NDA, 2010]
(a) less heat and less cold
(b) less heat and more cold
(c) more heat and less cold
(d) more heat and more cold

114. Which one among the following denotes the smallest temperature? [NDA, 2010]
(a) 1° on the Celsius scale
(b) 1° on the Kelvin scale
(c) 1° on the Fahrenheit scale
(d) 1° on the Reaumur scale

115. For shaving which type of mirror is used : [NDA, 2010]
(a) concave mirror
(b) plane mirror
(c) convex mirror
(d) none of these [BPSC (Pre) 1999]

116. When a body moves with simple harmonic motion, then the phase difference between the velocity and the acceleration is —
(a) 0°
(b) 90°
(c) 180°
(d) 270°

117. An air bubble in water acts like a : [NDA 2010]
(a) convex mirror
(b) convex lens
(c) concave mirror
(d) concave lens [UPPCS (Pre) 2002]

118. A body is thrown vertically upwards and then falls back on the ground. Its potential energy is maximum —
(a) on the ground
(b) at the maximum height
(c) during the return journey
(d) both on the ground and at the maximum height [NDA, 2010]

119. If the power of a convex lens is +2 diopter then the focal length of the lens is :
(a) 200 cm
(b) 100 cm
(c) 50 cm
(d) 2 cm

120. The colour of an opaque object is due to that colour which : [BPSC (Pre) 1996]
(a) is absorbed
(b) is not reflected
(c) is reflected
(d) is scattered

121. Which one of the following pairs does ***not*** have the same dimension [IAS (Pre) 1994]
(a) Potential energy and kinetic energy
(b) Density and specific gravity
(c) Focal length and height
(d) Gravitational force and frictional force

122. The best and the poorest conductors of heat are respectively ? [NDA, 2010]
(a) silver (Ag) and lead (Pb)
(b) copper (Cu) and aluminium (Al)
(c) silver (Ag) and gold (Au)
(d) copper (Cu) and gold (Au)

123. The three fundamental colours are :
(a) blue, yellow and red
(b) blue, green and red
(c) yellow, green and red
(d) blue, yellow and green
[MPPCS (Pre) 2004, RRB TC 2005]

124. A body is at rest on the surface of the earth. Which one among the following statements is correct regarding this ?
(a) No force is acting on the body
(b) Only weight of the body acts on it
(c) Net downward force is equal to the net upward force
(d) None of the above statements is correct *[NDA, 2010]*

125. A pendulum beats faster than a standard pendulum. In order to bring it to the standard beat, the length of the pendulum is to be :
(a) reduced
(b) increased
(c) reduced and the mass of the bob increased
(d) reduced and also the mass of the bob reduced *[NDA, 2010]*

126. Consider the following statements
1. Clear sky appears blue due to poor scattering of blue wavelength of visible light.
2. Red part of light shows more scattering than blue light in the atmosphere.
3. In the absence of atmosphere, there would be no scattering of light and sky will look black.

Which of the statement given above is/are correct ?
(a) 1 only
(b) 1 and 2 only
(c) 3 only
(d) 1, 2 and 3 *[CDS, 2010]*

127. Hair of a shaving brush cling together when the brush is removed from water due to
(a) viscosity
(b) surface tension
(c) friction
(d) elasticity *[CDS, 2010]*

128. Which one of the following statements is correct ?
(a) The angle of contact of water with glass is acute, while that of mercury with glass is obtuse
(b) The angle of contact of water with glass is obtuse, while that of mercury with glass is acute
(c) Both the angle of contact of water with glass and that of mercury with glass are acute
(d) None of the above *[CDS, 2010]*

129. Who was the inventor of telescope ?
(a) Galileo (b) Gutenberg (c) Edison (d) Graham Bell
[UPPCS (Pre) 1994]

130. Who was the inventor of radar ?
(a) Robert Watson
(b) Fleming
(c) Bush Wall
(d) Austin *[BPSC (Pre) 2008]*

131. Human eyes are :
(a) converging lenses of variable focal length
(b) converging lenses of fixed focal length
(c) diverging lenses of variable focal length
(d) diverging lenses of fixed focal length

132. The function of heavy water in a nuclear reactor is to :
(a) slow down the speed of neutrons
(b) increase the speed of neutrons (c) cool down the reactor
(d) stop the nuclear reaction [CSAT (Pre) 2011]

133. What is the difference between a CFL and a LED lamp ?
1. To produce light, a CFL uses mercury vapour and phosphor while an LED lamp uses semiconductor material.
2. The average life span of a CFL is much longer than that of an LED lamp.
3. A CFL is less energy-efficient as compared to an LED lamp.
Which of the statements given above is/are correct ?
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3 [CSAT (Pre) 2011]

134. Examine the following statements :
1. Waves of low frequency are actually produced through the flute of lesser length.
2. Sound through the rocks only transmitted in the form of longitudinal elastic waves.
Which one of the following of the above statements is/are true :
(a) Only 1 (b) Only 2
(c) 1 and 2 both (d) Neither 1 nor 2 [IAS (Pre) 2007]

135. Consider the following statements :
1. A person with myopia can see distant objects distinctly but cannot see nearby objects clearly.
2. A person with hypermetropia cannot see distant objects clearly.
3. A person with presbyopia can see nearby objects without corrective glasses.
Which of the statements given above is/are ***not*** correct ?
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 3 only [CDS, 2010]

136. The phenomenon of interference can be obtained by :
(a) two independent sources of light
(b) two virtual and coherent sources of light
(c) any two sources whatever be the wavelength or frequency of the light waves
(d) None of these

137. The visible range of solar radiation is :
(a) 100 – 400 nm (b) 400 - 700 nm
(c) 740 - 10000 nm (d) none of these [BPSC (Pre) 2011]

138. The electrification in a body takes place due to :
(a) electron (b) positron (c) proton (d) neutron

139. The force acting on a particle executing simple harmonic motion is
(a) directly proportional to the displacement and is directed away from the mean position
(b) inversely proportional to the displacement and is directed towards the mean position
(c) directly proportional to the velocity and is directed away from the mean position

(d) inversely proportional to the velocity and is directed towards the mean position [CDS, 2010]

140. As the sunlight passes through the atmosphere, the rays are scattered by tiny particles of dust, pollen, soot and other minute particular matters present there. However, when we look up, the sky appears blue during mid-day, because
(a) blue light is scattered most (b) blue light is absorbed most
(c) blue light is reflected most
(d) ultraviolet and yellow component of sunlight combine [CDS 2010]

141. A passenger in a moving train tosses a five rupee coin. If the coin falls behind him, then the train must be moving with a uniform
(a) acceleration (b) deceleration
(c) speed (d) velocity [CDS, 2010]

142. Non-metals are bad conductors of electricity because :
(a) they lack free or mobile electrons
(b) they have light atoms
(c) they have high melting points (d) All of these

143. An object weights the maximum in :
(a) air (b) water (c) hydrogen (d) vacuum [JPSC (Pre) 2011]

144. The pressure exerted on the ground by a man is greatest
(a) when he lies down on the ground
(b) when he stands on the toes of one foot
(c) when he stands with both feet flat on the ground
(d) all of the above yield the same pressure [CDS, 2010]

145. Which one of the following is not needed in a nuclear fission reactor ?
(a) Moderator (b) Coolant
(c) Accelerator (d) Control device [CDS, 2010]

146. The shortest unit of length is :
(a) micron (b) nanometer
(c) angstrum (d) fermimeter [UPPCS (Pre) 2005]

147. An endoscope, used by doctors for examine the inside of a patient's stomach, works on the principle of :
(a) reflection of light (b) dispersion of light
(c) refraction of light (d) total internal reflection of light [JPSC (Pre) 2011]

148. If two conducting spheres are separately charged and then brought in contact :
(a) the total energy of the two spheres is conserved
(b) the total charge on the spheres is conserved
(c) both the total energy and charge are conserved
(d) the final potential is always the mean of the original potential of the two spheres [NDA, 2010]

149. The electrolyte in a car battery is :
(a) hydrochloric acid (b) sulphuric acid
(c) nitric acid (d) distilled water [BPSC (Pre) 1998]

150. Who was the inventor of voltaic cell :
(a) Benjamin Franklin (b) Thomas Edison
(c) Alizendro Voltas (d) Kirchhoff

151. Two pieces of metallic wire having equal length and equal volume placed in air have different resistances. The two wires must :
(a) have different cross sections (b) have different temperatures
(c) be of different materials (d) be of same density [NDA, 2010]

152. The process of zinc lamination (coating) on the iron is called :
(a) galvanization (b) electroplating (c) ionisation (d) None of these
[Jharkhand PCS (Pre) 2008]

153. The 'absolute zero of temperature' is
(a) the starting point of any scale of temperature
(b) the lowest temperature that is theoretically possible
(c) the temperature at which the vapours of all liquid substances freeze
(d) the temperature at which all substances exist in the vapour phase
[JPSC (Pre) 2011]

154. One astronomical unit is the average distance between :
(a) the Earth and the Sun (b) the Earth and the Moon
(c) the Jupiter and the Sun (d) the Pluto and the Sun
[JPSC (Pre) 2011]

155. Fish can survive inside a frozen lake, because
(a) fish are warm-blooded animals
(b) fish hibernate in ice
(c) water near the bottom does not freeze
(d) ice is a good conductor of heat
[JPSC (Pre) 2011]

156. The S.I. unit of electric flux is :
(a) $Nm^2/coul.$ (b) $N\ coul/m^2$ (c) $Nm^2/coul.^2$ (d) None of these

157. A hollow metal ball carrying an electric charge produces no electric field at points ?
(a) outside the sphere (b) on its surface
(c) inside the sphere (d) only at the centre [NDA, 2010]

158. The filament of an electric bulb is made of :
(a) copper (b) iron (c) lead (d) tungsten
[RRB ASM/GG 2003, 2005, UPPCS (Pre) 2005]

159. The coil in a heater is made of ?
(a) Nichrome (b) Tungsten (c) Copper (d) Iron
[CDS, 2010]

160. Stephen Hawking is a :
(a) Pianist (b) Guitarist
(c) Scientist (d) American politician
[MPPCS (Pre) 2011]

161. The most familiar form of radiant energy in sunlight that causes tanning and sunburning of human skin, is called
(a) ultraviolet radiation (b) visible radiation
(c) infrared radiation (d) microwave radiation
[NDA, 2010]

162. If 10 bulbs each of 100 watt remain switched on for 1 hour daily, then the total electricity consumed everyday would be :
(a) 1 unit (b) 100 kWh (c) 10 unit (d) 10 kWh *[RRB ASM/GG 2004]*

163. Who was the inventor of the lightning conductor ?
(a) Graham Bell (b) Lord Lister
(c) Benjamin Franklin (d) Einstein *[RRB ASM/GG 2004]*

164. A man is sitting on a rotating stool with his arms outstretched. If suddenly he folds his arm the angular velocity of the man would :
(a) increase (b) decrease
(c) become zero (d) remain constant *[NDA, 2010]*

165. Which of the following is a paramagnetic ?
(a) nickel (b) cobalt (c) chromium (d) copper *[UPPCS (Pre) 1990]*

166. Which one of the following is diamagnetic :
(a) iron (b) bismith (c) nickel (d) cobalt *[IAS (Pre) 1998]*

167. The magnetic effect of electric current was firstly observed by :
(a) Henry (b) Oersted (c) Faraday (d) Volt *[RRB ASM/GG 2005]*

168. Who discovered the electric bulb ?
(a) Thomas Edison (b) Alexander Graham Bell
(c) William Cook (d) Terry Edison *[MPPCS (Pre) 2011]*

169. Who invented thermoscope an early form of thermometer ?
(a) Sir Christopher Wren (b) Charles F Richter
(c) Beno Gutenberg (d) Galileo *[MPPCS (Pre) 2011]*

170. Who gave the theory of gravity ?
(a) Charles Newton (b) Charles Babbage
(c) Issac Newton (d) John Adams *[MPPCS (Pre) 2011]*

171. Lenz's law is directly related to :
(a) energy conservation (b) mass conservation
(c) momentum conservation (d) none of these

172. Cloudy nights are warmer than cloud free nights because of ?
(a) green house effect (b) depletion in ozone layer
(c) infrared radiation (d) land surface radiation *[NDA 2010]*

173. Who was the inventor of neutron ?
(a) Rutherford (b) Thomson (c) Chadwick (d) Newton *[UPPCS (Pre) 1995, 1996, Jhrkhand PCS (Pre) 2003]*

174. For a particle revolving in a circular path, the acceleration of the particle is :
(a) along the tangent (b) along the radius
(c) zero *[NDA, 2010]*
(d) along the circumference of the circle

175. The size of the atomic nucleus is in the order of :
(a) 10^{-10} meter (b) 10^{-9} meter (c) 10^{-3} meter (d) 10^{-15} meter *[RRB ASM/GG 2004]*

176. Who was the inventor of positron ?
(a) Rutherford (b) J.J. Thomson (c) Chadwick (d) Anderson [RRB ASM 2004]

177. The antiparticle of the electron is called :
(a) positron (b) neutrino (c) meson (d) antineutrino

178. Who was the inventor of neutrino ?
(a) Pauli (b) Fermi (c) Anderson (d) Yukawa

179. Microwave oven consumes less power due to :
(a) small frequency of radiation (b) short wavelength of radiation
(c) large frequency as well as wavelength of radiation
(d) small frequency as well as wavelength of radiation [NDA, 2010]

180. The sun is constantly radiating energy and yet is surface temperature is nearly constant at 6000°C. The constancy of solar temperature is due to :
(a) fission (b) black hole evaporation
(c) fusion (d) radioactivity [NDA, 2010]

181. Metal pipes used to carry water sometimes burst in the winter. This is because :
(a) water expands when it freezes
(b) metal contracts more than water
(c) outside of the pipe contracts more than inside
(d) metal expands more than water

182. The mesons are : [NDA, 2010]
(a) positively charged particles (b) negatively charged particles
(c) neutral (d) All of these

183. If three identical resistors each of resistance r are connected in parallel, then the equivalent resistance of the three resistors will be :
(a) $3/r$ (b) $r/3$ (c) $3r$ (d) r^3 [NDA 2010]

184. In summer season a fan gives us relaxation because :
(a) our body radiates more heat comparatively in air
(b) fan provides cold air
(c) the conductivity of air is increased
(d) our sweat vapourises very quickly

185. The ratio of the velocities of X-rays and γ-rays is : [NDA 2010]
(a) <1 (b) >1 (c) 1
(d) depends on the ratio of their frequencies

186. The nuclear force exists between : [NDA 2010]
(a) proton – proton (b) proton – neutron
(c) neutron – neutron (d) All of these

187. In the following rays pair which one is found to be naturally electro-magnetic ?
(a) β-rays and γ -rays (b) Cathode rays and X-rays
(c) α-rays and β-rays (d) X-rays and γ-rays [NDA 2010]

188. The nuclear force is :
(a) attractive and spin dependent
(b) attractive but spin independent
(c) repulsive and spin dependent (d) None of these

189. The nuclear force remains influential (effective) only upto :
(a) 10^{-15} m (b) 10^{-10} m (c) 10^{-5} m (d) 10^{-30} m

190. The magnetic lines of force produced through a bar magnet :
(a) cross inside the magnetic body
(b) only cross across the neutral points of the magnet
(c) only cross across the north pole and south pole
(d) do not cross anywhere in the magnet *[NDA 2010]*

191. The nuclear force is a :
(a) conservative force (b) non-conservative force
(c) both of these (d) none of these

192. The phenomenon of natural radioactivity was invented by :
(a) Henry Bacqurel (b) Rutherford
(c) P. Curie (d) None of these

193. The phenomenon of artificial radioactivity was invented by :
(a) Rutherford (b) Madam Curie (c) Newton (d) Dalton

194. The element on which the first artificial radioactive features were experimented :
(a) carbon (b) nitrogen (c) aluminium (d) None of these

195. The end element of every natural radioactive element is :
(a) carbon (b) silicon (c) bismuth (d) sulphur

196. On which of the following specific resistance of a conducting wire depends ?
(a) length of the wire, cross-sectional area of the wire and on the matter of the wire
(b) length of the wire, cross-sectional area of the wire but not on the matter of the wire
(c) only on the matter of the wire but not on the length of the wire and cross-sectional area of the wire
(d) only on the length of the wire and neither on the cross-sectional area of the wire nor on the matter of the wire *[NDA 2010]*

197. The disintegration process of a heavy nucleus into two lighter nuclei is called :
(a) Nuclear fusion (b) Nuclear fission
(c) Radioactive disintegration (d) Mass loss *[RRB 2003]*

198. The formation of a heavy nucleus by the combination of two lighter nuclei is :
(a) nuclear fission (b) nuclear fusion
(c) photoelectric effect (d) chemical reaction

199. Atom bomb is based upon the principle of :
(a) nuclear fusion (b) nuclear fission
(c) both of them (d) None of these *[BPSC (Pre) 1994]*

200. Hydrogen bomb is based upon the principle of :
(a) nuclear fusion (b) nuclear fission
(c) both of them (d) None of these

201. Which types of waves are utilized in the night visionary equipment ?
(a) Radio wave (b) Micro wave
(c) Infra red wave (d) None of these *[IAS (Pre) 2009]*

202. When X-rays are produced, then
(a) heat is produced on the target (b) heat is absorbed by the target
(c) temperature of the target is being constant
(d) a luminous light is to be seen on the target

203. The nuclear reactor is an example of : [NDA 2010]
(a) controlled fission (b) uncontrolled fission
(c) uncontrolled fusion (d) none of these

[RRB ASM/GG 2004]

204. The image of an object kept on the centre of curvature of a concave mirror is formed—
(a) at main focus
(b) between main focus and centre of curvature
(c) between pole and infinity (d) none of these [NDA 2010]

205. Through a beaker containing water a coin kept inside it seems to be upwardly lifted because of—
(a) reflection of light (b) refraction of light
(c) total internal reflection of light (d) interference of light [NDA 2010]

206. Cobalt–60 is usually utilised is radiotherapy because of emission of :
(a) alpha rays (b) beta rays (c) gamma rays (d) X–rays

[IAS (Pre) 1999]

207. The fuel used in the breeder reactor is :
(a) thorium (b) uranium (c) deuterium (d) uranium-235

208. Atomic pile is used in :
(a) the production of nuclear fission
(b) the regulation of nuclear fission
(c) the regulation of thermonuclear fusion
(d) the atomic acceleration

209. Curie is the unit of : [SSC Graduate 2000]
(a) radioactivity (b) temperature (c) heat (d) energy

210. In the nuclear reactor, heavy water (D_2O) is used in the form of :
(a) moderator (b) coolant (c) castodian (d) controller

[RRB TC 2003]

211. The mass-energy relation is the conclusion of :
(a) quantum theory (b) general theory of relativity
(c) arial theory of energy (d) special theory of relativity

[SSC Graduate 2005]

212. The diode is a device which forces the current :
(a) to flow in one direction (b) to flow in both directions
(c) not to flow in any direction (d) None of these

[RRB Assist. Driver 2003]

213. The radar is utilised for :
(a) the detection of solar radiation (b) the observation of planets
(c) the detection of aircrafts, ships etc and for the path indicators
(d) the detection of the intensity of the earthquakes [RRB 2003]

214. A three dimensional photograph is prepared through :
(a) holography (b) photography
(c) photochromatic process (d) radiography

[UPPCS (Pre) 1990, CDS 2003]

215. Who was the inventor of cosmic rays ?
(a) Bruno Rosi (b) Victor Hess (c) Copernicus (d) Edvin Hebel

216. Who designed and fabricated the first prototype of the Radar :
(a) J.H. Van Tassel (b) W.C. Roentgen
(c) P.T. Phonsberth (d) Taylor and Young

217. Who was the inventor of gravitational laws ?
(a) Edison (b) Newton (c) Faraday (d) None of these
[SSC 2000]

218. The Nobel prize started by Alfred Nobel, who had invented :
(a) Aircraft (b) Telephone (c) Safety lamp (d) Dynamite
[RRB Assist. Driver 2003]

219. Who was the inventor of television ?
(a) W. Ramsse (b) Robert Maless (c) J.L. Beyard (d) Johnson
[RRB Gorakhpur GG 2003]

220. The Wright Brothers were the inventors of :
(a) telescope (b) radio (c) aeroplane (d) elevator
[RRB CC 2003]

221. X-rays was invented by :
(a) Hopkins (b) Roentgen (c) Marconi (d) Morse
[RRB GG 2002]

222. Who developed the atom bomb ?
(a) Bearnor Bon Bron (b) J. Robert Opan Heemar
(c) Adberd Taylor (d) Samual Cohen
[RRB GG 2003, UPPCS (Pre) 2005]

223. Who developed the missile ?
(a) Bernor Bon Bron (b) J. Robert Opan Heemar
(c) Adberd Taylor (d) Samual Cohen
[SSC 2002]

224. Who developed the hydrogen bomb ?
(a) Bernor Bon Bron (b) J. Robert Opan Heemar
(c) Adberd Taylor (d) Samual Cohen
[SSC 2002]

225. Who was the inventor of electron microscope ?
(a) Nol & Ruska (b) Robert Koach
(c) Leewan Hock (d) C.P. Swansun
[SSC 2002]

226. Who was the inventor of scooter ?
(a) Brad Shaw (b) Damlar (c) Einstein (d) Formich
[SSC 2004]

227. Relative humidity is measured by :
(a) Hydrometer (b) Hygrometer
(c) Lactometer (d) Potentiometer
[RRB ASM/GG 2005]

228. Which one of the following is used in measuring altitudes ?
(a) Barometer (b) Plane meter (c) Altimeter (d) Hydrometer
[UPPCS (Pre) 1996, CPO SI 2003]

229. The device through which the intensity of the sunrays is measured :
(a) Astrometer (b) Chrescograph
(c) Barometer (d) Actiometer
[RRB TC/CC 2002]

230. Solar radiation is measured by :
(a) Pyrometer (b) Astrometer (c) Barometer (d) Manometer
[RRB GG 2003]

231. The device through which the depth of the sea is measured by the use of sound wave :
(a) Radar (b) Sonar (c) Altimeter (d) Venturimeter
[SSC Grad 2003]

232. The use of thermostat is :
(a) to measure temperature (b) to increase temperature
(c) to keep constant temperature
(d) to convert temperature into electricity
[MPPCS (Pre) 2004]

233. The radiator of vehicles are used for :
(a) to heat the engine (b) to prevent thermal radiation
(c) to keep cool the engine (d) None of these

234. The device to record and to reproduce the detection of the recording is called :
(a) Audiophone (b) Detectophone (c) Gramophone (d) Microphone
[RRB ASM/GG 2004]

235. The law of floatation was invented by :
(a) Newton (b) Wright Brothers (c) Galileo (d) Archemedes
[RRB Disel Assit 2002]

236. In isobaric and isochoric thermodynamical processes :
(a) pressure and volume remain constant
(b) volume and pressure remain constant
(c) pressure and temperature remain constant
(d) None of these

237. In the adiabatic process, which one of the following remains constant :
(a) heat (b) entropy (c) Both of these (d) None of these

238. In the ideal gas which type of energy is absent :
(a) Kinetic energy (b) Potential energy
(c) Both of these (d) None of these

239. The thermodynamical definition of an ideal gas implies that it is only temperature dependent and independent of its volume; it is the statement of :
(a) Joule's law (b) Joule-Kelvin's
(c) Wein's law (d) Stefan's law

240. In the porous plug experiment which one of the following physical quantity remains constant :
(a) enthalpy (b) entropy (c) Both of these (d) None of these

241. Which one of the following has maximum energy ?
(a) Violet light (b) Green light (c) Red light (d) Yellow light
[IAS (Pre) 2009]

242. The external work done is the maximum for the thermodynamical expansion of which one of the following process :
(a) adiabatic (b) isothermal (c) isobaric (d) isochoric

243. The energy radiance is maximum for the lowest wavelength; it is :
(a) Wein's law (b) Stefan's law (c) Planck's law (d) None of these

244. Temperature upto the order of 10^6 K is measured through :
(a) Thermometer (b) Pyrometer
(c) Thermocouple (d) None of these

245. Good absorbers are good emitters. This is the statement of :
(a) Kirchhoff's law
(b) Prevost's theory of heat exchange
(c) Stefan's law
(d) Wein's law

246. On which one of the following thermometric scales only positive temperature is measured :
(a) thermodynamical scale
(b) platinum resistance scale
(c) celsius scale
(d) none of these

247. The Bernoulli's theorem is :
(a) energy conservation
(b) mass conservation
(c) Both of these
(d) None of these

248. In which one of the following is the speed of sound the maximum ?
(a) in the air of 0°C
(b) in the air of 100°C
(c) in the water
(d) in the wood *[IAS (Pre) 2006]*

249. If a tunnel is made along the diameter of the earth and a piece of stone is gently released then :
(a) it will execute SHM
(b) it will execute periodic motion
(c) there is no specific motion
(d) None of these

250. The time period of the revolution of the geostationary satellite around the earth is :
(a) equal to that of the earth
(b) twice that of the earth
(c) equal to that of the moon
(d) None of the above

251. The escape velocity of anybody on the earth's surface is equal to how many times the orbital velocity of the same body on the earth's surface :
(a) 2 times
(b) $\sqrt{2}$ times
(c) $\sqrt{3}$ times
(d) No any relations exists

252. If a body is revolving around the earth's orbit with its usual velocity, then what would be the minimum energy required to let it escape from the orbit :
(a) double of its orbiting energy
(b) $\sqrt{2}$ of its orbiting energy
(c) triple of its orbiting energy
(d) None of these

253. Newton's formula for the velocity of sound is wrong because of his consideration about the propagation of sound as :
(a) an isothermal process
(b) an adiabatic process
(c) Both of these
(d) None of these

254. Laplace made a correction in the basic formula of velocity of sound given by Newton and evaluated the correct value by considering that sound propagation is :
(a) an isothermal process
(b) an adiabatic process
(c) both of these
(d) none of these

255. In the formation of a stationary wave which one of the following process does not occur :
(a) energy transmits from one place to another
(b) energy remains confined within the space
(c) nodes and antinodes form consecutively
(d) None of these

256. Which one of the following is true about the stationary wave :
(a) it is formed by the superposition of two equal and opposite progressive waves
(b) it is formed by the superposition of two equal and of the same direction plane progressive wave propagation
(c) any of the above
(d) None of these

257. Open organ pipes (air columns) are sweater than closed organ pipes because :
(a) all harmonics are present in open organ pipes, while only odd harmonics are present in closed organ pipes
(b) all harmonics are present in closed organ pipes, while only odd harmonics are present in open organ pipes
(c) both of these
(d) Open organ pipes are convenient to blow than closed pipes

258. Which of the following effect is also called Edison effect :
(a) Photoelectric effect (b) Thermionic emission
(c) Both of these (d) None of these

259. Photoelectric effect occurs only in the light of :
(a) any wavelength (b) threshold wavelength
(c) any of these (d) None of these

260. The famous photoelectric effect was fully explained on the basis of :
(a) Quantum theory (b) Wave theory
(c) both of these (d) None of these

261. Which of the following indicates the lowest temperature ?
(a) on 1° C Celcius scale (b) on 1 K scale
(c) on 1° F scale (d) on 1° R scale

262. If a body executes SHM then the phase difference of the velocity and acceleration of the body is—
(a) 0° (b) 90° (c) 180° (d) 270°
[NDA 2011]

263. Which one of the following pairs has not identical dimension ?
(a) potential energy and kinetic energy
(b) density and specific density (c) focal length and height
(d) gravitational force and frictional force
[NDA 2011]

264. At high altitudes, pressure cooker is preferable for cooking, because the boiling point of water
(a) reduces due to higher atmospheric pressure
(b) reduces due to lower atmospheric pressure
(c) increases due to reduced gravitational force
(d) reduced due to increased ozone content in the atmosphere
[CDS 2011]

265. If an object having mass of 1 kg is subjected to a force of 1N it moves with ?
(a) a speed of 1 m/s (b) a speed of 1 km/s
(c) an acceleration of 10 m/s^2 (d) an acceleration of 1 m/s^2
[CDS 2011]

266. An athlete diving off a high springboard can perform a variety of exercises in the air before entering the water below. Which one of the following parameters will remain constant during the fall ?
(a) The athlete's linear momentum
(b) The athlete's moment of inertia
(c) The athlete's kinetic energy
(d) The athlete's angular momentum *[CDS, 2010]*

267. The apparent weight of a steel sphere immersed in various liquids is measured using a spring balance. The greatest reading is obtained for the liquid
(a) having the smallest density (b) having the largest density
(c) in which the sphere was submerged deepest
(d) having the greatest volume *[CDS, 2010]*

268. A semiconductor has :
(a) negative temperature coefficient
(b) positive temperature coefficient
(c) both positive or negative temperature coefficient
(d) None of these

269. Two most popular semiconductors which are frequently used in solid state electronic devices are :
(a) Germenium and Silicon (b) Germenium and Carbon
(c) Silicon and Carbon (d) None of these

270. Which one of the following is the purest form of semiconductor :
(a) intrinsic (b) extrinsic
(c) both of these (d) None of these

271. In *p*-type of semiconductor the current mainly flows due to :
(a) electrons (b) holes
(c) both of these (d) none of these

272. In *n*-type of semiconductor the current mainly flows due to :
(a) electrons (b) holes
(c) both of these (d) none of these

273. A diffraction pattern is obtained using a beam of red light. Which one among the following will be the outcome if the red light is replaced by blue light ?
(a) Bands disappear
(b) Diffraction pattern becomes broader and further apart
(c) Diffraction pattern becomes narrower and crowded together
(d) No change *[CDS, 2010]*

274. The transistor acts like :
(a) an amplifier (b) an oscillator
(c) both of these (d) None of these

275. Which one of the following statements is true ?
(a) Temperatures differing by 25° on the Fahrenheit (F) scale must differ by 45° on the Celsius (C) scale
(b) 0°F corresponds to -32°C
(c) Temperatures which differ by 10° on the Celsius scale must differ by 18° on the Fahrenheit scale
(d) Water at 90°C is warmer than water at 202°F *[CDS, 2010]*

276. To operate through any laser it is common to achieve :
(a) population inversion (b) a meta excited state
(c) a super excited state (d) None of these

277. Which one of the following is marked on the common use fluorescent tubelight ?
(a) 220 K (b) 273 K (c) 6500 K (d) 9000 K

278. Which of the following is the mathematical statement of second law of thermodynamics :
(a) $dQ = Tds$ (b) $dS = TdQ$ (c) $TdU = dQ$ (d) None of these

279. The ratio of the specific heat capacities of a diatomic gas is :
(a) 1.33 (b) 1.44 (c) 1.66 (d) None of these

ANSWERS

1. (b)	2. (a)	3. (a)	4. (a)	5. (c)	6. (d)	7. (a)	8.	
9. (b)	10. (d)	11. (a)	12. (c)	13. (b)	14. (d)	15. (a)	16.	
17. (c)	18. (d)	19. (d)	20. (b)	21. (c)	22. (b)	23. (b)	24.	
25. (b)	26. (c)	27. (c)	28. (b)	29. (b)	30. (c)	31. (c)	32.	
33. (c)	34. (b)	35. (a)	36. (c)	37. (a)	38. (a)	39. (c)	40.	
41. (b)	42. (b)	43. (a)	44. (b)	45. (b)	46. (b)	47. (b)	48.	
49. (b)	50. (a)	51. (a)	52. (c)	53. (c)	54. (a)	55. (a)	56.	
57. (a)	58. (b)	59. (b)	60. (a)	61. (b)	62. (c)	63. (a)	64.	
65. (b)	66. (b)	67. (c)	68. (a)	69. (d)	70. (b)	71. (d)	72.	
73. (a)	74. (d)	75. (a)	76. (d)	77. (a)	78. (c)	79. (c)	80.	
81. (a)	82. (d)	83. (c)	84. (a)	85. (d)	86. (a)	87. (a)	88.	
89. (a)	90. (a)	91. (d)	92. (d)	93. (a)	94. (a)	95. (b)	96.	
97. (a)	98. (c)	99. (c)	100. (a)	101. (d)	102. (d)	103. (b)	104.	
105. (c)	106. (b)	107. (b)	108. (d)	109. (c)	110. (b)	111. (b)	112.	
113. (c)	114. (b)	115. (a)	116. (b)	117. (d)	118. (b)	119. (c)	120.	
121. (b)	122. (a)	123. (b)	124. (b)	125. (a)	126. (c)	127. (b)	128.	
129. (a)	130. (a)	131. (a)	132. (a)	133. (d)	134. (b)	135. (d)	136.	
137. (b)	138. (a)	139. (b)	140. (a)	141. (d)	142. (a)	143. (d)	144.	
145. (c)	146. (b)	147. (d)	148. (d)	149. (b)	150. (c)	151. (c)	152.	
153. (b)	154. (a)	155. (c)	156. (a)	157. (c)	158. (d)	159. (a)	160.	
161. (a)	162. (a)	163. (c)	164. (a)	165. (c)	166. (b)	167. (b)	168.	
169. (b)	170. (c)	171. (a)	172. (d)	173. (c)	174. (b)	175. (d)	176.	
177. (a)	178. (a)	179. (a)	180. (c)	181. (a)	182. (d)	183. (b)	184.	
185. (c)	186. (d)	187. (d)	188. (a)	189. (a)	190. (d)	191. (a)	192.	
193. (a)	194. (b)	195. (a)	196. (b)	197. (b)	198. (b)	199. (b)	200.	
201. (c)	202. (a)	203. (a)	204. (c)	205. (b)	206. (d)	207. (a)	208.	
209. (a)	210. (a)	211. (d)	212. (a)	213. (c)	214. (a)	215. (b)	216.	
217. (b)	218. (d)	219. (c)	220. (c)	221. (b)	222. (d)	223. (a)	224.	
225. (a)	226. (d)	227. (b)	228. (c)	229. (d)	230. (a)	231. (b)	232.	
233. (c)	234. (c)	235. (d)	236. (a)	237. (c)	238. (b)	239. (a)	240.	
241. (a)	242. (c)	243. (a)	244. (b)	245. (a)	246. (a)	247. (a)	248.	
249. (a)	250. (a)	251. (b)	252. (a)	253. (a)	254. (b)	255. (a)	256.	
257. (a)	258. (b)	259. (b)	260. (a)	261. (b)	262. (b)	263. (b)	264.	
265. (d)	266. (d)	267. (c)	268. (a)	269. (a)	270. (a)	271. (b)	272.	
273. (b)	274. (c)	275. (c)	276. (a)	277. (c)	278. (a)	279. (b)		

★★★