بسم الله الرحمن الرحيم

وقل رب زدني علماً

EDUCATION WITH HAMZA

SUBJECT:
PHYSICS

CLASS:
12TH

PREPARED BY:
RAJA HAMZA KHAN

Education with Hamza

وَقُل رَّبِّ زِدْنِي عِلْمًا

DEDICATED TO

تمام تعریفیں ربِ لاشریک کے لئے جس نے مجھ ناچیز کو پیدا کیا۔ اور لاکھوں کروڑوں درود اس ذات پر جس نے ہماری بخشش کے لئے رو رو کر دعا مانگی۔ ان نوٹس کو امت محمدیہ کی آسانی کے لئے بنایا گیا ہے۔ ان کا ثواب ربِ موسیٰ و ہارون نبی آخر زماں ﷺ کی جملہ آل و اولاد اور امت کو عطا کرے آمین۔

راجہ حمزہ خان

DISCLAIMER

انتباہ

یہ نوٹس مفاد عامہ کے لئے بنائے گئے ہیں۔ ان کی اشاعت باقاعدہ طور پر ڈی سی آفس میں رجسٹرڈ ہے۔ ان کو بیچنا یا کسی بھی طور پر مالی فائدے کے لئے آگے بھیجنا قانوناً جرم ہے۔ ایسا کرنے والوں کے خلاف قانونی کاروائی کی جائے گی۔

Short Questions:

Chapter # 15 Gravitation

(1) Why can gravitational not account for the formation of molecules? Why don't two books on your desk attract each other gravitationally, despite Newton's law of gravitation?

Ans: Gravitational force is too weak to bind atoms into molecules.

Explanation:

* Molecular bonds are formed by Electrostatic forces.

* Gravitational force between atoms is negligible compared to electrostatic forces between charged particles.

$$Fg = \frac{Gm1m2}{r^2}, \quad Fe = \frac{Kq1q2}{r^2}$$

* k >> G ($9\times10^{9} Nm^2Kg^{-2}$ >> $6.67\times10^{11} Nm^2Kg^{-2}$)

* The gravitational force between books is extremely small, so books do attract each other.

Explanation:

* The gravitational force between two objects is directly proportional to product of their masses.

* The masses of two books are relatively small. Gravitational force between them is so small.

* The friction between books and desk is much stronger than this weak gravitational pull.

(2) Why does an apple fall towards the earth due to gravity, while the earth does not move towards apple? Can gravitational field strength be negative? Explain.

Ans: The Earth does move, but its motion is hardly noticeable due to its massive mass.

Explanation:

* Both the apple and earth experience equal gravitational force.

* Since Earth's mass is huge, it means that acceleration due to apple's gravitational pull is practically undetectable.

* Thus for same gravitational force, the apple with its smaller mass will experience a much larger acceleration than Earth.

$$\uparrow a_{apple} = \frac{F}{m_{apple}} \downarrow \qquad \downarrow a_{earth} = \frac{F}{m_{earth}} \uparrow$$

No, Gravitational field strength can not be negative.

Explanation:

* Gravity is fundamentally an attractive force and is always directed towards mass creating field.

* Gravitational field strength is measure of force per unit mass.

* The field strength is a measure of intensity which is always positive or zero.

$$mg = \frac{GMm}{r^2}$$

$$g = \frac{GM}{r^2} \geq 0$$

(3) What factors determine strength of gravitational field around a planet? If two planets have same mass but different radii. How would their gravitational field strengths compare?

Ans: The strength of a planet's gravitational field depends upon mass and distance from its center.

Explanation:

* The gravitational field strength is directly proportional to mass of planet and inversely proportional to square of distance from planet center.

$$g = \frac{GM}{r^2} \qquad g \propto \frac{1}{r^2}$$

Explanation:

* The gravitational field strength is inversely proportional to square of distance from planet center

$$g = \frac{GM}{r^2} \qquad g \propto \frac{1}{r^2}$$

* So if two planets have same mass but different radii, the planet with smaller radii will have stronger gravitational field strength at its surface.

(4) Why satellites in higher orbits have lower orbital velocities? How gravitational potential energy of two point masses is related to concept of gravitational potential?

Ans: Satellites in higher orbits have lower orbital velocities because gravitational force decreases with distance.

Explanation:

* The orbital velocity is derived from balancing gravitational force and centripetal force.

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$V = \sqrt{\frac{GM}{r}}$$

Orbital velocity decreases with distance from central mass because gravitational force weakens with distance.

Gravitational potential energy is product of mass and gravitational potential.

Explanation:

* Gravitational potential is work required to bring a unit mass from infinity to a given point in field.

* Gravitational potential is potential energy per unit mass.

$$V = U/m \text{ , } U = Vm$$

5. How does mass of earth affect the orbital velocity required for a satellite to stay in orbit. Is it possible for an objects gravitational potential energy to become negative? If so, what does this mean for object motions?

Ans. Greater earth mass increases the required orbital velocity for a satellite.

Explanation:

The orbital velocity is derived from balancing gravitational force and centripetal force.

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$V = \sqrt{\frac{GM}{r}}$$

Orbital velocity is proportional to square root of earth mass.

$$V \alpha \sqrt{M}$$

Yes, gravitational potential energy can be negative meaning the object is bound with in the gravitational field.

Explanation:

* Gravity is an attractive force.

* Work is needed to move an object against gravity, which increase its energy.

* When gravitational field does work to pull something closer, it loses energy. This "work done by field" is gives rise to negative potential energy.

$$U = \frac{GMm}{r}$$

(6) What are main features of gravitational force? Distinguish between g and G.

Ans: Following are main features of gravitational force.

(i) It is always an attractive force.

(ii) It is independent of medium between particles.

(iii) It holds good over a wide range of distance (i.e. from inter-planetary distances to inter-atomic distances).

"g" stands for acceleration due to gravity. It is defined as acceleration set up in body while falling freely under effect of gravity alone (The value of g on surface of earth is 9.8 ms^{-2}or 980 cms^{-2}g is vector quantity.

G stands for universal gravitational constant. It is defined as force of attraction acting between two bodies each of unit mass placed unit distance apart. The value of G is $6.673\times10^{-11}Nm^2kg^{-2}$
$6.67\times10^{-8}\ dyne\ cm^2g^{-2}$ G is a scalar quantity.

(7) If person goes to a height equal to radius of earth from its surface. What should be his weight relative to that on earth? When dropped from the same height a body reaches the ground quicker at poles than at equator. Why?

Ans: At surface of Earth, weight W = m g = $\frac{GMm}{R^2}$

At height (h=R) weight

W' = m g' = $\frac{GMm}{(R+h)^2} = \frac{GMm}{(R+R)^2}$

$\frac{W'}{W} = \frac{R^2}{(2R)^2} = \frac{1}{4}$ o, W'= $\frac{w}{4}$

It means weight would reduce to one-fourth of weight on surface of Earth.

The Acceleration due to gravity is more at poles than at equator. When the initial velocities and distances travelled are the same, the time taken by body is smaller if acceleration due to gravity is large

(8) A body is taken center to mean. What will be changes in weight of body? What would happen if force of gravity were to disappear suddenly?

Ans: At center of Earth, the weight of body is zero. g is zero.

(i) As the body is moved from center of Earth to surface, its weight increases (due to increase in g).

(ii) Again the weight increases, becoming $\frac{1}{6}$ on moon's surface.

If force of gravity suddenly disappears, then:

(i) All bodies will lose weight.

(ii) We should be thrown away from earth due to centrifugal force.

(iii) Earth's docking and in fact all operations would become impossible.

(9) Under what conditions, the weight of person can become zero. The earth is acted upon gravitational attraction of sun. Why does not earth fall into sun?

Ans: Under following conditions, the weight of person can become zero.

(i) At center of earth, the value of g is zero. So weight of person (W=m g) is zero.

(ii) At null points in space, the resultant gravitational forces due to different masses cancel out, hence weight of person is zero there.

The Earth does not fall into sun due to its stable orbital around sun. The gravitational pull of sun provides necessary centripetal force onr earth

(10) When satellite is suddenly stopped in its orbit, what will happens to it? What are essentials to call a satellite stationary?

Ans: Suppose that satellite is revolving at height 'h' above surface of Earth. When satellite is suddenly stopped in its orbit, its K.E becomes zero and total energy of satellite became equal to its potential energy.

$$E = \frac{GMm}{R+h}$$

(i) It should revolve in an orbit coplanar and concentric with equatorial plane.

(ii) The sense of its orbital motion should be same as that of rotational motion of Earth i.e. in anti-clockwise direction.

(iii) Its time period should be exactly 24 hours.

Chapter # 16 Statistical Mechanics and Thermodynamics

(1) Mention the different ways of increasing number of molecular collisions per unit time in a gas? By reducing volume of a gas at constant temperature, the pressure of gas increases. Explain it on basis of kinetic theory?

Ans: The number of collision per unit time can be increased by:

* Increasing temperature of gas.

* Increasing Number of molecules.

* Decreasing volume of Gas.

* Increasing pressure on gas.

According to the kinetic theory of the gas, the pressure of the gas is caused by collision of gas molecule with walls of container.

On reducing volume, number of molecule per unit volume increases.

Hence, a large number of molecules collide with walls of vessels per second and a large momentum is transferred to wall per second.

(2) Why is temperature below absolute zero not possible? Estimate the average K.E of helium atom at temperature on surface of sun (6000K).

Ans: According to kinetic interpretation of temperature

$$T = \frac{2}{3K} < \frac{1}{2} mv^2$$

$$T \alpha K.E$$

* Absolute temperature is directly proportional to average K.E of gas molecules.

* As heat is removed the temperature falls and velocity of molecules decreases.

* At Absolute zero molecular motion ceases i.e. the K.E becomes zero.

* As K.E cannot be negative, so no further decrease in K.E is possible. Hence temperature cannot be decreased below 0 K (zero kelvin).

Given data:

T = 6000 K

$k = 1.8 \times 10^{-23}$

Using formula:

$K.E = \frac{3KT}{2}$

$$= \frac{3 \times 1.8 \times 〚10〛 \hat{} 23 \times 6000/2}{2}$$

$K.E = 1.24 \times 10^{-19}$

(3) Show that the ratio of root mean square speeds of molecules of two different gases at a certain temperature is equal to square root of inverse ratio of their masses. Show that temperature of ideal gas is directly proportional to average transitional kinetic energy?

Ans: If mass of molecule of 1st gas is m_1 then its root mean square speed at certain temperature is

$$V1_{rms} = \sqrt{\frac{3KT}{m1}} \quad \text{\_\_\_\_\_(1}$$

If mass of molecule of 2nd gas is m_2 then its \text{r.m.s} speed at certain temperature is

$$V2_{rms} = \sqrt{\frac{3KT}{m2}} \quad \text{\_\_\_\_ (2}$$

Divide 1 by 2:

$$\frac{V1_{rms}}{V2_{rms}} = \frac{\sqrt{\frac{3KT}{m1}}}{\sqrt{\frac{3KT}{m2}}}$$

$$\frac{V1_{rms}}{V2_{rms}} = \sqrt{\frac{3KT}{m1}} \times \sqrt{\frac{m2}{3KT}}$$

$\frac{V1_{rms}}{V2_{rms}} = \sqrt{\frac{m2}{m1}}$

According to Ideal gas law:

PV = n R T

Where 'n' is no of moles of gas

V is volume T is Absolute temperature and R = 8.314 j$mol^{-1}k^{-1}$ is universal gas constant.

As, number of moles n can be expressed as:

n = $\frac{N}{N_A}$

Where N_A = 6.022 × 10^{23} (Atom per mole) is Avogadro Number.

P V = N ($\frac{R}{N_A}$)T

Putting $\frac{R}{N_A}$ = K called Boltzmann constant and its value is 1.38×10^{-23} J K^{-1}

So,

P V = N k T _____ 2)

As,

P V = $\frac{2N}{3}$ < $\frac{1}{2}$ mv^2>_____(3)

Comparing Eq (2) and (3)

N k T = $\frac{2N}{3}$ < $\frac{1}{2}$ mv^2>

T = $\frac{2}{3k}$ < $\frac{1}{2}$ mv^2>_____(4)

As, $\frac{2}{3k}$ = constant

So, T= constant < $\frac{1}{2}$ mv^2>

Tα < $\frac{1}{2}$ mv^2> or T α K.E

(4) Two different gases have exactly the same temperature. Does this mean their molecules have same rms speed? Helium gas is filled in closed vessel whose coefficient of thermal expansion is negligible. When it is heated from 300 K to 600 K then find average kinetic energy of helium atoms.

Ans: No, when two gases have exactly same temperature, the Average \text{K.E} per molecule for each gas is same.

$$< \frac{1}{2} mv^2 > = \frac{3KT}{2}$$

But as different gases may have molecule of different masses, the rms speed $rms = \sqrt{\frac{3KT}{m}}$ of molecules of different gases shall be different.

$$< \frac{1}{2} mv^2 > = \frac{3KT}{2}$$

* Average k.e per molecules of gas is directly proportional to temperature in kelvin.

* In this case temperature is doubled the k.e become double.

(5) The pressure of given mass of gas is halved at constant temperature. What will be volume of gas in comparison to its initial volume? Explain on basis of kinetic theory? On which of following factors does Average kinetic energy of gas molecules depends?

(i) Nature of Gas (ii) Volume (iii) Absolute temperature

(iv) What will be its value at Absolute zero?

Ans: $p=\frac{2N}{3V} < \frac{1}{2} mv^2>$

When Temperature is constant then $< \frac{1}{2} mv^2>$ remains constant

N →constant

$v\alpha\frac{1}{P}$

Therefore if P becomes P/2 (V) volume becomes double.

(i) The Average kinetic energy of gas molecules is independent of nature of gas.

(ii) Depends upon temperature of gas $< \frac{1}{2} mv^2> = \frac{3KT}{2}$

(ii) The Average k.E of gas molecules is independent of volume of gas.

(iv) At absolute zero, rms velocity of gas molecules become zero. So mean k.e per molecule of gas becomes zero at absolute zero.

Chapter # 17 Simple Harmonic Motion

(1) If we halve length of simple pendulum to its original length, what is the alteration in period of pendulum? What is its new frequency? If amplitude of vibration of a body executing SHM is doubled, what will happen to maximum kinetic energy?

Ans: Time period decreases by a factor of$\sqrt{2}$ and value of new frequency is $\sqrt{2}$ times.

Explanation:

$T = 2\pi \sqrt{\frac{l}{g}}$

$T' = 2\pi \sqrt{\frac{l'}{g}} = 2\pi \sqrt{\frac{\frac{l}{2}}{g}} = \frac{1}{2}[2\pi \sqrt{\frac{l}{g}}]$

$T' = \frac{T}{\sqrt{2}}$

$f' = \frac{1}{T'} = \frac{1}{\frac{1}{\sqrt{2}}} = \sqrt{2}$ Hz.

If amplitude of vibration is doubled, the maximum K.E becomes four times.

$K.Emax = \frac{1}{2}Kxo^2$

$K.Emax = \frac{1}{2}k\ (2xo)^2$

$= \frac{1}{2}k\ 4xo^2$

= 4 [$\frac{1}{2}$Kxo^2] = 4 K.E max

(2) When marching soldiers are about to cross a bridge they break steps. Why? Suppose that a driving force has half frequency as compared to frequency of an oscillator. Will it produce resonance? Similarly, if driving frequency is twice the frequency of oscillator, will it produce resonance?

Ans: Marching soldiers are advised to break their steps to avoid resonance that could damage the bridge.

* Marching in step can create a periodic force.

* If frequency of force is matched the bridge's natural frequency leading to resonance.

* Due to resonance the amplitude grows so high in bridge structure, it may collapse.

* No. Resonance occurs in either case.

Explanation:

* Resonance occurs only when driving frequency matches the natural frequency.

* If driving frequency is half or twice the natural frequency resonance does not occur.

(03) Pendulum clocks are made to run at correct rate by adjusting the pendulum's length. Suppose you move from one city to another where acceleration due to gravity is slightly greater. Will you have to lengthen or shorten pendulum to keep correct time. Other factors are remaining constant? Explain Two mass-spring vibrate with SHM. If spring constant are equal and mass of one system is twice that of other, which system has a greater period?

Ans: The Length of pendulum should be increased in order to keep correct time.

Explanation:

$T = 2\pi \sqrt{\frac{l}{g}}$

* If acceleration due to gravity increases, pendulum's period would decrease.

* The pendulum's length should increase to counteract this effect.

* A longer pendulum takes more time to swing. This will increase the period.

* Hence, the lengthen pendulum will compensate the faster swing due to higher gravity.

The system with twice the mass has a greater period.

Explanation:

$Tm = 2\pi \sqrt{\frac{m}{k}}$

$T_{2m} = 2\pi \sqrt{\frac{2m`}{k}} = \sqrt{2}\ \{2\pi \sqrt{\frac{m}{k}}\}$

$T_{2m} = \sqrt{2}$ Tm.

The system with twice mass has $\sqrt{2}$ times the greater period.

(07) Give some applications in which resonance play an important role. A simple pendulum is set into vibration and left untouched, eventually stops. Why?

Ans: There are some common phenomenen in which resonance play an important role such as:

* In Radio sets Tuning a radio is best example of Resonance when we turn the knob of radio to tune a station we are changing the natural frequency of electric circuit of receiver to make it equal to transmission frequency of radio station. When two frequencies matches it is tuned to the particular radio station.

* Speed of sound at room temperature determined by making the air column of a resonance tube resonate with a vibrating tuning fork of known frequency.

* It eventually stops due to damping.

Explanation:

* As pendulum swings it encounters resistance from air, which act as a drag force opposing its motion.

* The pendulum continuously does work against the resistance of air so its energy of oscillation decreases.

$E = \frac{1}{2}Kxo^2$, $E \alpha xo^2$

(05) Under what conditions the motion of simple pendulum be SHM. At what position is velocity of particle executing SHM

a) maximum b) minimum?

Ans: Small angular displacement is basic condition for simple pendulum to be SHM.

Explanation:

* For SHM the restoring force must be proportional to displacement.

* The restoring force must be in a simple pendulum is component of gravity F = -mgsinθ.

* For small angles sin$\theta \approx \theta$ making restoring force proportional to displacement a requirement for SHM.

* For large angles the restoring force is no longer directly proportional to displacement, and motion deviates from SHM.

Let v= w $\sqrt{xo^2 - x^2}$

* At mean position x=0, the velocity is greatest

v= w $\sqrt{xo^2 - x^2}$ = w $\sqrt{xo^2 - 0}$ = w $\sqrt{xo^2}$ = w. x_0

* At extreme position x=x_0 velocity is zero

v = w $\sqrt{xo^2 - x^2}$ = w $\sqrt{xo^2 - xo^2}$ = w $\sqrt{0}$= 0

(06) Justify importance of critical damping in car suspension system? Differentiate between free and forced oscillation.

Ans: It prevents oscillations while returning to equilibrium quickly.

Explanation:

* A car's suspension system prevents oscillations after a shock, bringing car back to the equilibrium position as quickly as possible.

* Critical damping ensures comfort and smooth ride.

Free Oscillations	Forced Oscillations
A body is said to be execute free oscillation if It oscillates with its natural frequency without the interference of external force.	when a freely oscillating system is under action of the certain force then it is said to execute forced oscillations.

Example: A simple pendulum vibrates freely with its natural frequency when there is no external force	Example: The vibrations of a factory floor caused by running of heavy machinery.

Chapter # 18: Diffraction & Interference

(01) How is an interference pattern formed by a diffraction grating different from a double slit? A beam of light always spreads and why can a beam not be produced with parallel rays to prevent spreading?

Ans: Fringes pattern of diffraction grating are narrower and much brighter while fringes pattern of double slit are wider and less intense.

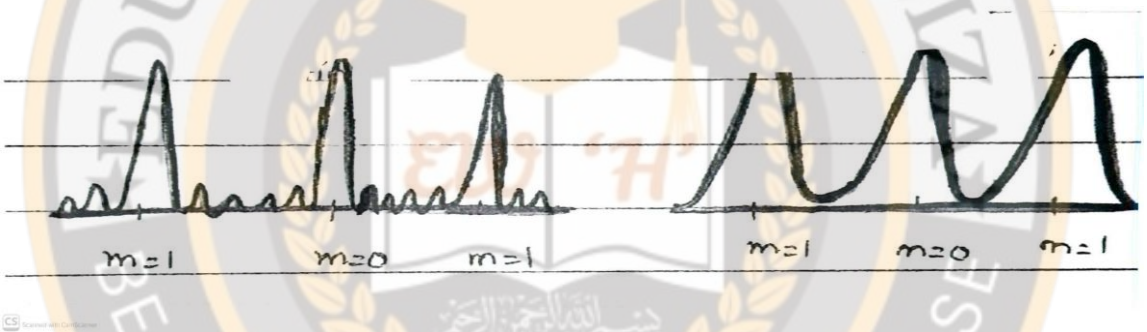
Explanation:

* A diffraction grating has many slits, leading to constructive interference at specific angles for multiple orders (m=0, 1, 2...) creating a series of bright, narrow lines.

$$d \sin\theta = m\lambda$$

* A double slit has only two slits, resulting in broader bright fringes with destructive interference minima

$$d \sin\theta = m\lambda$$



A perfectly parallel beam is impossible due to wave nature of light.

Explanation:

* Wave nature of light causes diffraction which makes light beams spread out.

* Diffraction causes light to spread out due interaction of light waves with each other and limited diameter of light source

(02) In sunlight, shadow of building has fuzzy edges even if building does not is this a refraction effect? Explain. A laser pointer emits a coherent beam of parallel light rays. Does light from such a source spread out at all. Explain.

Ans: No, it is due to diffraction and finite size of light source.

Explanation:

* The fuzziness arises because sun is an extended light source.

* Every point on edge of building's shadow acts as origin of new wave front.

* Diffraction involves bending of light waves around obstacles.

Yes, Laser beam will spread slightly out over distance due to diffraction.

Explanation:

* A laser source emits coherent, nearly parallel light.

* The finite width of a laser beam results in diffraction at aperture causing the beam to diffract.

(03) A beam of light passes through single slit to create diffraction pattern. How will spacing of bands in pattern change if width of slits is increased? Describe a diffraction grating and interference pattern it produces?

Ans: The spacing of bands decreases as the slit width increases.

Explanation:

The width of slit is increased, the angle of diffraction is smaller.

$$\theta = \lambda/d$$

Hence, spacing of bands decreases.

A diffraction grating is a surface with many closely spaced slits, producing sharp, bright maxima at specific angles.

Explanation:

* Light passing through different slits interferes constructively at angles where path differences are integer multiples of wavelength.

* The condition for constructive interference is d\sin\theta = m\lambda.

* The pattern consists of sharp & bright lines (maxima) separated by dark regions

(04) Suppose a monochromatic light falls on diffraction grating. What happens to interference pattern if same light falls on grating that has more lines widely per centimeter?

What is the significance of equation d sinθ = mλ in context of a) diffraction gratings b) Young's double slit experiment?

Ans: The pattern become sharper and more widely spaced.

Explanation:

* Increasing number of lines per centimeter decreases grating spacing.

$$d = \frac{L}{N}$$

* The angle of diffraction is inversely proportional to line spacing or distance between the lines.

$$\theta = \lambda/d$$

* A smaller d results in larger θ, spreading maxima further apart.

* The increased number of slits also sharpens peaks.

(a) In diffraction grating's multiple slits cause light waves to interfere constructively at angles satisfying d sinθ = mλ where d is grating spacing, $\lambda$is wavelength and m is order of maximum.

The pattern shows sharp, well defined maxima due to large number of slits.

(b) For Young's Double Slit Experiment, constructive interference gives positions of bright fringes on screen where d is distance between slits. The pattern consists of equally spaced bright and dark fringes due to coherent wave superposition.

(5) What is effect of following aspects of diffraction grating on the resulting interference pattern? a) number of slits, b) width of slits. Describe conditions necessary for sustained interference patterns to be observed in Young's double-slit experiment?

Ans: (a) Increasing number of slits sharpens and intensifies the principal maxima.

Explanation: More slits result in narrower and brighter principal maxima with darker minima between them because interference becomes more pronounced.

(b) Increasing slit width reduces diffraction and can broaden or blur maxima.

Explanation: Wider slits reduce individual diffraction effects which can cause the overall diffraction envelope to shrink affecting the sharpness and contrast of interference pattern.

The two sources must be coherent and monochromatic to produce a sustained interference pattern.

Explanation: For stable interference:

* Light sources must have constant phase difference (coherent).

* They must emit light of same wavelength (monochromatic).

* The slit width should be narrow to ensure diffraction.

* The distance between slits and screen must be large enough for clear fringe visibility.

(6) How can you increase fringe width in Young's double slit experiment? The Young's double slit experiment apparatus is taken from air to water. What will happen to interference pattern?

Ans: The fringe width is

$$\Delta y = \frac{\lambda L}{d}$$

The fringe width can be increased by increasing:

(i) by increasing wavelength ƛ

(ii) by increasing distance between coherent source L

(iii) By decreasing distance between coherent sources d

The fringe width is $\Delta y = \frac{\lambda L}{d}$

When Young's double slit apparatus is brought from air into water, then wavelength \lambda of light decreases and fringe width Δy decreases.

(07) Why does a diamond sparkle more than a glass of same shape and size? In Young's experiment, if distance between slits 'd' is halved and distance between slits and screen 'L' is doubled then find the change in fringe width Δy.

Ans: The refractive index of diamond is very high and its critical angle is small i.e 24°. When a beam of light enters it, it totally reflected number of times inside it and it emerges in various directions causing the sparkling of diamond. But in case of glass, refractive index is less and critical angle greater than diamond, so it does not sparkle like a diamond.so, it does not sparkle like a diamond.

By increasing slit separation d fringe spacing \Delta x is decrease and vice versa.

Explanation: The fringe spacing is given by:

$$\Delta y = \frac{\lambda L}{d} \text{\_\_\_\_\_ (1}$$

where ƛ is wavelength of light.

If distance between 2 slits is halved:

$$d' = \frac{d}{2}$$

Distance between slit and screen is doubled:

L' = 2L

$$\Delta y` = \frac{\lambda L`}{d`}$$

Putting value of L' and d'

$$\Delta y` = \frac{\lambda(2L)}{d/2}$$

$$\Delta y` = 4(\frac{\lambda L}{d}) \_\_\_(2$$

Putting value from Eq (1) and (2)

$$\Delta y` = 4\Delta y$$

The fringe width will become four times.

Chapter # 19: Electric Potential and Capacitor

(01) What is the relationship between electric potential and electric potential energy? If you wish to store a large amount of energy in capacitor bank, would you connect capacitors in series or parallel? Explain?

Electric Potential Energy	Electric Potential Difference
Electric potential energy is energy stored due to the position of charge in an electric field U = qV.	Electric potential is measure of work done per unit charge to move charge in an electric field keeping in electrostatic equilibrium. $\Delta V = w/q$ = Ed

Capacitors should be connected in parallel to store a large amount of energy.

Explanation:

The total capacitance in parallel increases Ceq = C1 + C2 + C3 + …..

Energy stored in capacitor U = $\frac{1}{2}$CeqV^2

Hence, parallel connection increases capacitance, allowing more energy storage at same voltage.

(02) What are units of (a) electric potential difference (b) electric potential energy (c) Capacitance. What is net amount of charge on charged capacitor?

Ans: (a) Electric Potential Difference: Volts (V)

$$\Delta V = w/q_{\circ} \quad 1\text{volt} = \frac{1joule}{1columb}$$

(b) Electric Potential Energy: Joules (J)

$$U = qV = 1J = \frac{1joule}{1columb} \times 1 \text{ columb}$$

(c) Capacitance: Farads (F)

$$C = \frac{Q}{V} \qquad 1\text{farad} = \frac{1columb}{1volt}$$

The net charge on charged capacitor is zero.

Explanation: A charged capacitor has equal and opposite charges on its two plates (+q on one and -q on other), so net charge

q_{net} = +q + (-q) = 0

(03) Write some applications of capacitors in real life. Would you place the plates of parallel-plate capacitor closer together or farther apart to increase their capacitance?

Ans: (i) Capacitors store energy and release it in devices like camera's flash.

(ii) Smoothing voltage fluctuations in power supplies and electronics.

(iii) Signal filtering in electronic circuits and audio systems.

(iv) Motor start and run applications.

The plates should place closer together to increase capacitance.

Explanation:

Capacitance of a parallel-plate capacitor is

$$C = \frac{A\epsilon_\circ}{d}$$

Hence, bringing plates closer together (decreasing d) will increase the capacitance.

(04) What is meant by electroreception? If capacitor is fully charged and then left for discharging. How much charge will be left on plate of capacitor after time equal to one time constant.

Ans: Electroreception is the ability of some animals to detect electric fields.

Explanation:

- Certain species use specialized organs to sense electric fields generated by prey or environment.
- This ability is used by sharks, electric fish, and some amphibians to sense prey, navigation or communication.

After one time constant the charge left is approximately 37% of initial charge.

$q = q_\circ e^{\frac{r}{RC}}$

$q = q_\circ e^{\frac{RC}{RC}}$

$q = q_\circ e^{-1}$

$q = o.37\ q_\circ$

This means about 63% of charge has dissipated after one time constant and 37% left on plate of capacitor.

(05) Prove that time constant of a series RC circuit \tau = RC. Verify that ohm times farad is equivalent to second.

Given data: The time constant of a series RC circuit =t = RC.

To prove: 1 ohm × 1 Farad = 1 second

Proof:

According to Ohm's law:

V = IR

Putting I = $\frac{q}{t}$

V = $\frac{q}{t}$R

Or R = $\frac{Vt}{q}$_____(1

According to equation q = CV:

C =$\frac{q}{v}$ ____(2

Multiplying eq (1) and (2) we get

RC = $\frac{Vt}{q} \times \frac{q}{V}$

RC = t

(06) Do electrons tend to go to region of higher potential to lower potential? How can you identify that which plate of a capacitor is positively charged?

Ans: Electrons tend to go to the region of higher potential.

Reason: As electrons are released in an electric field, they move from negative end (low potential) to positive end (high potential) because negative plate repels electron and positive plate attracts it.

To identify that which plate of a capacitor is positively charged, a gold leaf Electroscope is used.

Explanation: To check the polarity of capacitor plate, it is brought near the disc of positively charged electroscope. If the divergence of gold leaves increases, the plate is positively charged and vice versa.

(07) Find the potential at a point lying at a distance of 1 meter from a charge of 10 μc. A capacitor is connected across battery. (i) Why does each plate receive a charge of exactly the same magnitude? (ii) Is this true even if plates are of different size?

Ans: as, V = k $\frac{q}{r}$

q = 10 μm

q = 10 $\times 10^{-6}$ C = 1$\times$ 10^{5} C

A diode allows current to flow in one direction only.

r = 1 meter

thus, v = 9 $\times$ 10^{9} $\times$ 10^{-5}

= 9$\times$ 10^{4} volts

(i). this is because of conservation of charge. If q1 and q2 are charges taken by two plates, then q1 + q2 must be zero because charge on battery is simply redistributed and not created or destroyed.

(ii). Yes, the charges will be equal; magnitude even if two plates have different sizes.

(8). The electric potential is constant through a given region of space is electric field zero or non zero in this region explain if point charge q of mass m is released in non uniform electric field with field lines pointing in same directions will it make a rectilinear motion?

Ans. As electric field strength can be defined as negative of potential gradient.

E = $-\frac{\Delta V}{\Delta r}$_____ (1

Since the potential is constant in given region for example inside hollow charged sphere.

V = Constant

So potential difference is zero.

$\Delta V = 0$

So eq 1 becomes

$E = \frac{\Delta V}{\Delta r} = \frac{o}{\Delta r} = 0$

So E = 0

Yes, charged particle will make a rectilinear motion.

Reason:

A non-uniform electric field means that either its magnitude varies or its direction varies or both vary.

We also know that direction of electric field is represented by electric field lines. Now, in the question, it is made clear that field lines are in same direction. They are not changing.

F = qE

(09) Water has large dielectric constant but it is rarely used in capacitor why? How we can increase the capacitance of capacitor?

Ans: Reason: Water has very high value of dielectric constant 78.5. It is rarely used in capacitors as dielectric.

* This is because of following reasons.

* Water molecules have dipole moments, so it can be easily polarized under a given electric field. This is decreases effect of electric field between capacitors plates.

* Water can conduct electricity because it contains H^+ and OH^- ions.

Capacitance of parallel plate capacitor with dielectric of permittivity ∈ as medium between two plates is given by

$C_{med} = \frac{A\in}{d} = \frac{A\in_{\circ}\in r}{d}$ $\qquad \in = \in_{\circ} \in r$

Capacitance of parallel plate capacitor can be increased:

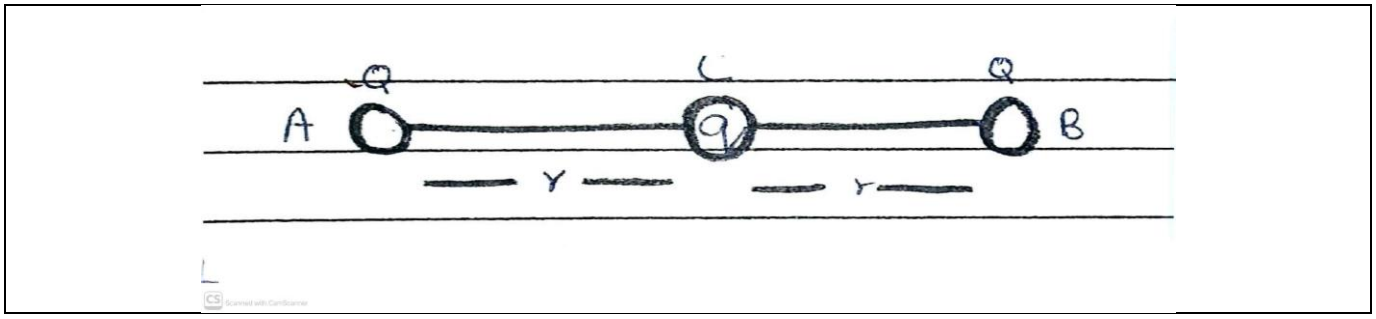
* By increasing area of plates of capacitor.

* By decreasing distance between two plates of capacitor.

* By using dielectric of greater permittivity between two plates of capacitors.

(10) How can electric potential be high when electric potential energy relatively low? Will energy stored in three capacitors be greater when they are connected in series or in parallel?

Ans: At mid-point between two equal and like charges electric potential is high but electric potential of charge placed at that point will be



Net potential at point C due to two equal and similar charges Q (located at A and B) is given by

Vnet= k $\frac{Q}{r}$+ K $\frac{Q}{r}$ (maximum valve)

Potential difference at point C due to two equal and similar charges Q (located at A and B) is given by

$$\Delta U = q\Delta V$$

$$\Delta U = q(0) = 0 \quad \text{(minimum valve)}$$

The energy storing formula of a capacitor is

U = $\frac{1}{2}$ CV^2

C = capacitance

V = Applied voltage across capacitor

Electrical energy stored in capacitor depends upon capacitance of capacitor and square of applied voltage.

* When a number of capacitors are connected in parallel, all of them will get the same voltage so each one will store energy as per as their capacitance value and net energy storage will be sum of all individual energy storage.

Chapter # 20 Alternating Current

(01) Define a) mutual induction b) self induction. Does SI unit for mutual induction and self-induction are same? Explain.

Ans: a) The phenomenon in which a changing current in one coil induces an emf in another coil.

$$E_s = -M\frac{\Delta Ip}{\Delta t}$$

b) The phenomenon in which a changing current in a coil induces an emf in itself.

$$E_L = -L\frac{\Delta I}{\Delta t}$$

Yes, SI unit for mutual and self induction is same.

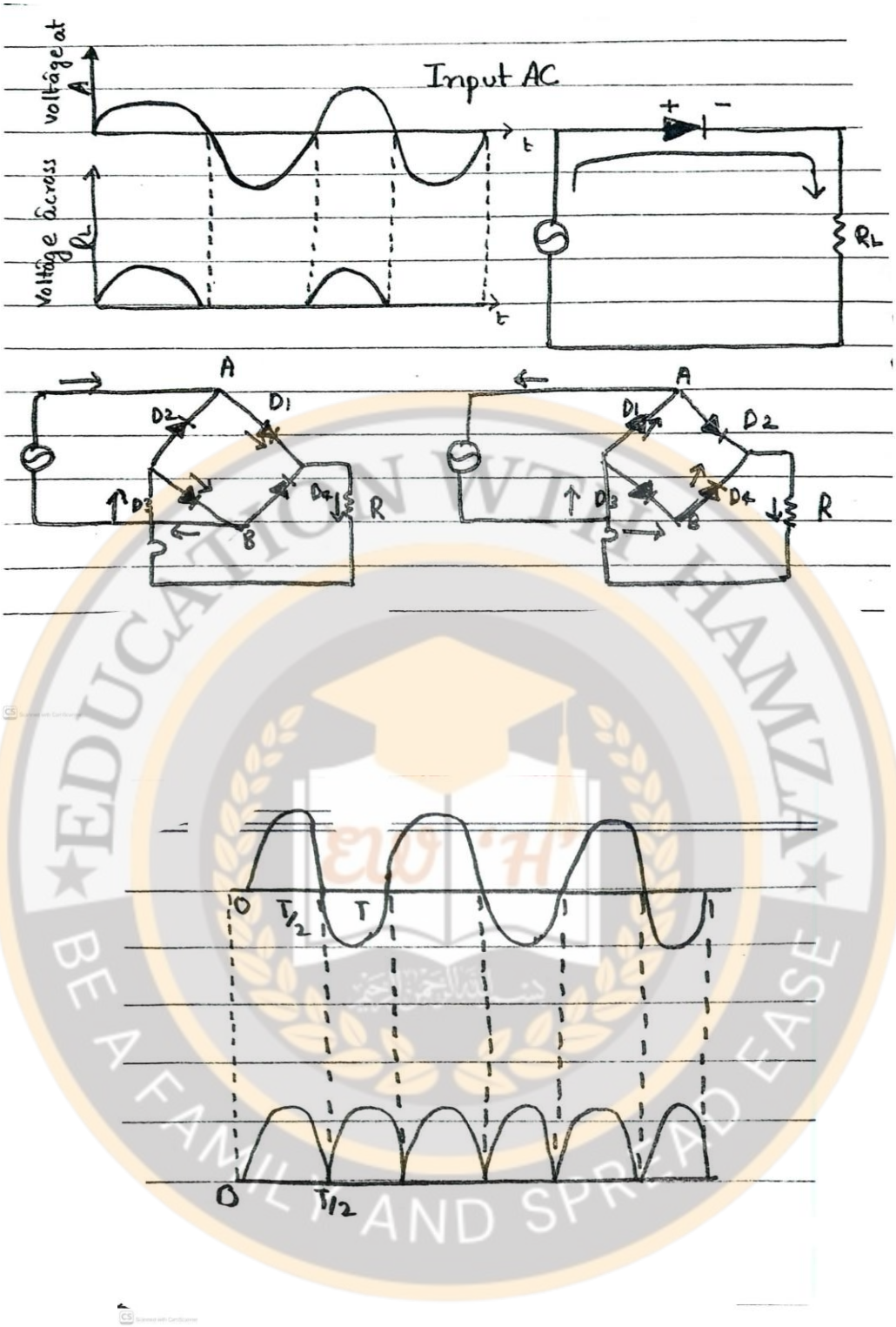
Explanation:

Since, both mutual inductance (M) and self inductance (L) describes the ability to induce emf due to changing current. They share same SI unit Henry (H)

H = V s A^{-1}

(02) Draw circuit for half wave rectifier and full wave rectifier. What is use of single diode for half-wave rectification of an alternating current?

Ans: Half-wave Rectifier:



A diode allows current to flow in one direction only.

Explanation: In half-wave rectification the diode conducts during one half of AC cycle (positive or negative) and blocks the current during other half. This results in a pulsating DC output.

(3) Is the frequency content of output of a half wave rectifier and full wave rectifier the same? Explain briefly. In half wave rectifier the negative side of signal is blocked after rectification. Why?

Ans: No, the frequency of full wave rectifier output is twice that of half wave rectifier.

Explanation:

* The half-wave rectifier's output frequency is same as input frequency.

* The full-wave rectifier's output frequency is twice the input frequency.

Yes, negative side of signal is blocked in a half wave rectifier.

Explanation: The diode conducts only during positive half cycle and blocks the negative half cycle, resulting in an output with only positive pulses.

(04) Distinguish between root mean square and peak values for sinusoidal alternating current? Define Impedance. How it is related to resistance, reactance, and frequency? Also find SI units?

Ans: Root Mean Square Value:

* The RMS value represents equivalent DC value that would generate same amount of heat in a resistor as AC current with that RMS value.

* The RMS value is approximately 70.7% of peak value.

Irms = $\frac{I_{peak}}{\sqrt{2}}$

Peak Value:

* This is maximum amplitude of sinusoidal alternating current.

* It represents highest current reached during one complete cycle of waveform.

Impedance is total opposition offered by an AC circuit to flow of current and is denoted by Z.

Explanation:

Impedance combine both resistance and reactance into a single quantity.

Resistance is frequency-independent while reactance depends on frequency.

Xc= $\frac{1}{2\pi fc}$, $X_l = 2\pi fl$

Impedance is calculated as:

Z= $\sqrt{R^2 + (X_l - X_c)^2}$

= $\sqrt{R^2 + (2\pi fl - \frac{1}{2\pi fc})^2}$

(05) Differentiate between Reactance and Impedance? Why does a capacitor block DC but allow AC to pass through.

Reactance	Impedance
It is opposition to AC due to inductance or capacitance. Xc= $\frac{1}{2\pi fc}$, $X_l = 2\pi fl$	| It is total opposition to AC flow by combined effect of resistance and reactance in a circuit. Z= $\sqrt{R^2 + (X_l - X_c)^2}$

A capacitor blocks DC because it cannot pass steady currents but it allows AC due to continuous charging and discharging.

Explanation:

In a DC circuit, after capacitor is fully charged, no more current

flows because the voltage across it became constant.

In DC f=0.

Xc= $\frac{1}{2\pi fc}$ = $\frac{1}{2\pi(0)C}$ α (reactance is infinite)

In AC voltage changes continuously causing capacitor to charge and discharge repeatedly allowing Alternating current to pass.

(06) How does reactance of a capacitor change with an increase in frequency? How does capacitance of capacitor effect the current through it in an AC circuit?

Ans: The reactance of capacitor decreases as frequency increases.

Explanation: Capacitive reactance is inversely proportional to frequency.

Xc= $\frac{1}{(2\pi f\uparrow)c}$

This means capacitor offers less opposition to current flow at higher frequencies, allowing more AC to pass through.

Example: Doubling the frequency halves the reactance (assuming capacitance remains constant).

In an AC circuit the current through the capacitor increases as the capacitance increases.

$$I = \frac{V}{X_c} \quad , \qquad \frac{V}{\frac{1}{2\pi fc}} = V\,(2\pi fc)$$

$$I\uparrow = V\,[2\pi fc\uparrow]$$

Thus, higher capacitance allows more current to flow for a given AC voltage and frequency.

(7). What is phase difference between voltage and current in a:

(a). capacitor (b). inductor

Ans. Capacitor: in capacitor, the current leads the voltage by 90 degrees.

Explanation: in a capacitor voltage across it is proportional t6o accumulated charge.

- When an AC voltage is applied the current flows to charge capacitor.first, and only then does voltage across capacitor start to increase.
- Therefore, current reaches its peak valve before voltage does resulting in a 90 degree phase lead of current over voltage.

$$U = \frac{1}{2}CV^2$$

In a inductor, voltage leads current by 90^\\circ.

Explanation: In an inductor, the voltage across it is proportional to rate of change of current.

When an AC current flows through an inductor, the inductor opposes changes in current by generating a voltage. The voltage reaches its peak value before the current does, meaning voltage leads current by 90 degree.

Q.8 Name the device that will (a) permit flow of direct current but oppose the flow of alternating current (b) permit flow of alternating current but not direct current. Discuss comparison between direct current and alternating current.

Ans: a) An inductor is a device which will perform flow of direct current but oppose the flow of alternating current.

b) A capacitor is a device which will permit flow of alternating current but oppose the flow of direct current.

Direct Current	Alternating Current
1. DC flows in one direction in circuit.	1. AC reverses its direction while flowing in circuit.
2. The frequency of DC is zero.	2. The frequency of AC is 50 Hz.
3. E.g: Current from cell or battery	3. E.g: Current from AC generator or main supply.
4. The voltage of DC cannot travel very far and it begins to lose energy.	4. safe to transfer over longer city distances.

Q.9 Why is AC more dangerous than DC? What are the advantages and disadvantages of AC over DC?

Ans. AC or alternating current is current which changes its magnitude and direction periodically with time. Direct current or DC current has constant magnitude and flow in one direction only.

* AC current has 50 or 60 frequency and it changes its direction 50 times per second. Also, the AC current can have a direct impact on our heart and brain.

* Our heart is driven by Electric pulses. Electric frequency of AC current can effect the frequency of heart and can lead to heart attack. When person come in contact with AC current, it can cause muscles to contract and causing sweating due to which resistance of skin reduces.

Following are Advantages of AC over DC:

* AC is easy to generate than DC.

* AC is less expensive than DC.

* The AC can be transmitted over long distance while DC cannot be transmitted over long distance.

* The power loss during transmission in AC is less than DC.

Disadvantages:

* Alternating voltages cannot be used for charging of batteries.

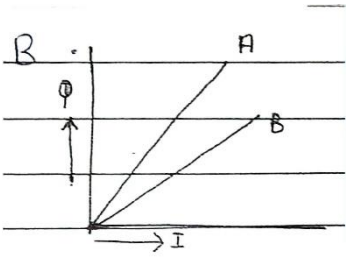
* Alternating voltages cannot used for certain applications e.g: Electroplating, Electro refining or electrolysis.

* At high voltages, it is more dangerous to work with AC than DC.

Q.10 A plot of magnetic flux versus current I is shown for two inductors A and B. Which of two has larger value of self-inductance? A small resistor R^+ is usually put in parallel with current carrying coil of an electromagnet. What purpose does it serve?

Ans: As $\emptyset = LI$, L = $\frac{\emptyset}{I}$ = slope of $\emptyset - I$ *graph.*

Since slope of $\emptyset - I$ graph for inductor A is greater than slope of $\emptyset - I$ graph for inductor B, therefore inductor A has larger value of self inductance than B.



When current in coil of a large electromagnet is switched off, the magnetic flux changes at very high rate, therefore, induced emf is very high and may cause sparking which would damage the insulation.

Q.11 What is physical significance of self inductance? An ideal inductor when connected in AC circuit does not produce heating effect through it reduces current in circuit? Explain why?

Ans: The self-inductance is called electrical inertia of coil which is measure of inertia in mechanical motion. If inductance is large, the induced emf is high and greater to opposition to change in current. To overcome this inertia this coil should be connected to an external voltage source.

An ideal inductor is coil having some inductance (L) but no ohmic resistance (R). Amount of heat produced in some t = I^2 Rt. As R=0, therefore heat produced = 0. However, the inductor offers inductive reactance X_L = ω, L= 2πf L to the AC. Therefore current is reduced.

Chapter # 21.Quantum physics

Q.1 Prove that energy and momentum of photon are directly proportional to each other. Convert 800 MeV into Joules?

Ans: Photon energy and momentum are directly proportional.

E = PC

E = mc^2 E= hf= $\frac{hc}{\lambda}$, p = h/λ, E= pc

E =(mc)c

E = Pc

800 MeV = 800 $\times 10^6$ 1.6 $\times 10^{-19}$ J = 1.28 $\times 10^{-10}$ J

Q.2 Write two phenomena to describe photon-electron interaction. In the interpretation of photoelectric effect, how it is known that an electron does not absorb more than one photon?

Ans: Photoelectric effect and Compton scattering.

* In photoelectric effect, a photon transfers all the energy to an electron, ejecting it.

* In Compton scattering, a photon scatters off an electron, transferring part of its energy.

Experimental results from photoelectric experiments support single photon process.

Explanation: A single photon can eject only one electron, as its energy can be absorbed by only one electron at a time. Experimental evidence shows:

* Instant emission of electrons upon exposure to light.

* Kinetic energy of emitted electrons depends only on frequency of incident light and not on its intensity.

Q.3 Which aspects of photoelectric effect cannot be explained by classical physics? Discuss daily life example for Compton's experiment.

Ans: Photoelectric effect has three aspects that cannot be explained by classical physics:

* Instantaneous ejection of Electrons.

* The existence of a threshold frequency for electrons emission.

* The dependence of k.e of emitted electron on light frequency not on intensity.

Compton scattering is observed in X-ray imaging in medical diagnostics.

Explanation:

* Compton scattering occurs when an incoming X-ray photon collides with electrons, transferring some of its energy to electron and scattering at lower energy.

* This scattering process helps create the contrast in an X-ray image.

* Denser tissues like bones scatter more photons, appearing brighter.

* Soft tissue allow more photons to pass through, appearing darker.

Q4. Differentiate between Compton's shift and Compton's wavelength? How can you say that scattering angle of photon plays effective role in measurement of Compton's shift?

Compton's Shift	Compton's Wavelength
The change in wavelength $\Delta\lambda$ between a scattered X-rays and an incident X- $\Delta\lambda = \frac{h}{m_\circ c}$ (L-cosθ) It depends on scattering angle and is independent of incident photon's wavelength or scattering material.	| The wavelength of a photon whose energy is equal to rest energy of an electron. $\lambda c = \frac{h}{m_\circ c} = 2.43 \times 10^{-12}$ m It is a fundamental constant in physics.

Compton's shift $\Delta\lambda$ depends upon scattering angle θ

$$\Delta\lambda = \frac{h}{m_\circ c}(\text{L-cos}\theta)$$

* If scattering angle of X-rays photon is θ =0 then $\Delta\lambda = 0$

* If scattering angle of X-rays photon is θ = 90 then $\Delta\lambda = \frac{h}{m_\circ c}$

* If scattering angle of X-rays photon is θ =180 then

$\Delta\lambda = 2(\frac{h}{m_\circ c})$

Q.5 What are conditions required for pair production to occur? What is meant by de Broglie wavelength?

Ans: The pair production requires at least 1.02 MeV energy photon.

* The pair production can happen only in presence of electric field of a heavy nucleus.

* Presence of nucleus facilitates the conservation of both energy and momentum.

The de Broglie wavelength refers to wavelength associated with moving particle.

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

* De Broglie suggested that particles might have both wave properties and particle properties. De Broglie wavelengths are quite visible in case of subatomic particles like electrons.

* For everyday objects, the de Broglie wavelength is extremely small, making wave like properties negligible.

(06) If photoelectric effect is observed for one metal, can you conclude that the effect will also be observed for another metal under same conditions? A beam of red light and beam of blue light have exactly same energy. Which light contains greater number of photon?

Ans. No. It is not conditional.

Explanation:

* Work function of metal is given by $\emptyset = hf_\circ = \frac{hc}{\lambda_\circ}$

As we know that ejection of electron from metal surface depends upon work function of metal.

* The different metals have different work functions.

* It is not necessary that a photon of light emitting electron from one metal will always emit electron from other metal.

Beam of red light contains greater number of photons.

Reason: As energy of photon is E = hf = $\frac{hc}{\lambda}$

So, Energy of a photon is En = n $\frac{hc}{\lambda}$

As En is same, h and c are constant.

So, n$\alpha\lambda$

As, $\lambda_{red} > \lambda_{blue}$ and $n_{red} > n_{blue}$

So, red beam will have greater number of photons than blue beam.

(07) Why don't we observe Compton's effect with visible light? If an electron and a proton have same de-Broglie wavelength, which particle has greater speed?

Ans. First we don't observe Compton's effect with visible light because visible light has smaller energy and low frequency.

Explanation: We do not observe Compton's effect with visible light because visible light photon is very low energy photon. It can be absorbed by a single electron of an atom so no scattering occurs.

- Compton's effect occurs with high energy and high frequency photons like X-rays.
- X-rays photon can transfer a part of energy to electron and scatter.

Speed of electron is greater than speed of proton.

Reason: According to de-Broglie's hypothesis, the wavelength of wave associated with a moving particle is

$$\lambda = \frac{h}{mv} \text{ or } v = \frac{h}{m\lambda}$$

* As λ is same for both electron and proton and h is Planck's constant.

$$V \alpha \frac{1}{n}$$

me<mp

Therefore, Ve > Vp

* As mass of electron is less than proton, therefore electron will have greater speed.

(08)a If frequency of incident light on cathode is doubled, how will the following changes: (i) k.e. of ejected electrons (ii) Photoelectric current (iii) Stopping potential. (b) When light shines on a surface, is momentum transferred to metal surface?

Ans. (b) Yes, the momentum is transferred to metal surface.

Reason: According to Einstein, light photon behaves like a particle, so when it is incident on metal surface, it transfers both its momentum and energy. Eg: We have observed in photoelectric effect that when a metal surface is exposed to light of suitable frequency, electrons are emitted out of surface. It is possible only when photons of light transfer their energy and momentum to surface electrons.

(a) If frequency of incident light is doubled, then:

(i) k.e. of ejected electron will be greater than twice.

(ii) The current will not change.

(iii) The stopping potential will also be greater than twice because it depends on k.e.

(09)a Can pair production take place in vacuum? Explain (b) Which photon red, green, or blue carries the most energy and momentum?

Ans. (b) Blue light has most energy and momentum.

Reason: As energy and momentum of a photon are given by

$$E=\frac{hc}{\lambda} \text{ and } p=\frac{h}{\lambda}$$

Since blue photon has shortest wavelength ƛ (according to above equations) it carries most E and p.

(a) No, pair production cannot take place in vacuum.

Reason: For pair production gamma-rays interact with heavy nucleus which gains recoil momentum to conserve momentum. Heavy nucleus is not available in vacuum.

If pair production takes place in vacuum, it will be a violation of law of conservation of momentum. So, to conserve momentum a heavy nucleus is needed.

(10) When a metal surface is exposed with monochromatic light, then all the photoelectrons are not emitted from metal surface with same k.e. why? An increase in frequency of incident light increase velocity with which photo electron is ejected. Explain how?

Ans. In photoelectric emission, the maximum k.E. is acquired by that electron which is most loosely bound To the metal surface electrons acquire different energies for their emission, hence the different photoelectrons are emitted with different k.E.

In photo electric emission, $\frac{1}{2}mv^2 = hv = \emptyset_\circ$

The increase in frequency of incident light increase the energy of incident photon. Since work function $\emptyset_\circ$ of given photosensitive surface being fixed, therefore the kinetic energy of photoelectrons increases with increase in frequency of incident light due to it, the velocity v of photoelectrons increases.

Chapter # 22 Nuclear Physics

(01) What are some of potential benefits and drawbacks of using nuclear energy as a source of electricity compared to other forms of energy? What happens to atomic number and mass number of nucleus that: (a) Emit electron (b) Undergoes electron capture (c) Emits α particle?

Advantages:

Nuclear Power	Fuel Generated Power
It has higher energy output.	It is not of large amount.
It is permanent for a given period of time	It is not permanent and not for long period.
It is cheaper for electricity.	It is not cheaper.
It does not produce smoke.	It produces smoke.
Waste products can be reprocessed.	Waste product cannot be reprocessed.

Disadvantages:

* It has Radioactive waste.

* It has risk of accidents.

(a) Emits Electron (beta$^-$ decay):

$$^A_ZX \rightarrow {}^A_ZY + {}^\circ_{-1}e + \text{Ue}^-$$

Atomic number increased by 1; mass number remains same.

(b) Electron capture:

$$^{A}_{Z}X + {}^{\circ}_{-1}e \rightarrow {}^{\circ}_{-1}Y + \text{Ue}$$

Atomic number decreases by 1; mass number remains same.

(c) Emits α particle:

$$^{A}_{Z}X \rightarrow {}^{A-2}_{Z-2}Y + {}^{+}_{1}He$$

Atomic number decreases by 2; mass number decreases by 4.

(02) Why does α particle not make physical contact with nucleus when an α particle is headed directly towards nucleus of an atom? An α particle has twice charge of beta particle. Why does former deflect less than latter when passing between electrically charged plates, assuming they both have same speed?

Ans. The strong electrostatic repulsion prevents direct contact.

Explanation:

* Both α particle and nucleus have opposite positive charge.

* The αparticle is deflected before contact due to electrostatic repulsion from nucleus.

* Coulomb force causing alpha particle to scatter instead of colliding.

The alpha particle deflects less due to its greater mass.

Explanation:

* Alpha particle ma = 4u and qa = +2e.

* Beta particle m_B = 0.0005 u and q_B = -1e.

* Since alpha particle has much larger mass than beta particle,

$$m_a \gg m_B$$

(03) Why uranium fuel needs to be enriched before use? If U-238 undergoes alpha decay, what is resulting nucleus?

Ans. Uranium fuel needs to be enriched to increase the proportion of U-235 which is fissile and suitable for nuclear fission.

Explanation:

* Natural uranium contains 0.7% U-235 and 99.3% U-238.

* The enrichment process increases the proportion of U-235 content. It must be increased to 3-5% for use in nuclear reactors.

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Explanation:

* Alpha decay involves emission of an alpha particle.

* This means parent nucleus loses 2 protons and 2 neutrons.

* The atomic number decreases by 2 (from 92 to 90) and mass number decrease by 4 (from 238 to 234).

(04) How do chain reactions occur in nuclear fission? How does molecular weight difference between U-235 and U-238 hexafluoride molecules enables enrichment? What role do porous barriers play in gaseous diffusion process?

Ans. Chain reactions occur when released neutrons from one fission event trigger further fissions.

Explanation:

* When U-235 absorbs a neutron, it undergoes fission.

* U-235 splits into two smaller nuclei and releases energy and 2-3 neutrons.

* If at least one of these neutrons causes another fission, the process sustains itself, forming a chain reaction.

The slight mass difference between U-235 F_6 and U-238 F_6 allows separation via gaseous diffusion where lighter molecules move faster and diffuse more through porous barriers.

Explanation:

* In gaseous diffusion process, uranium is converted into uranium hexafluoride (UF_6) which is gas.

* (UF_6) containing {U-235} is slightly lighter than (UF_6) containing {U-238} due to mass difference between isotopes.

* (UF_6) containing {U-235} molecules move faster.

(05) During alpha decay of a nucleus how does the neutron to proton ratio change? During beta decay of a nucleus how does neutron to proton change ratio?

Ans: Let us consider alpha-decay for $^{238}_{92}U$

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Neutron to proton ratio before alpha decay

$= \frac{238-92}{92} = \frac{146}{92} = 1.5869$ ____ (1

Neutron to proton ratio after decay

$= \frac{238-90}{90} = \frac{144}{90} = 1.6$ ____ (2

From eq (1) and (2) (1.6 > 1.5869)

therefore ratio of neutron to proton increases after alpha decrease.

Let us consider beta-decay of $^{210}_{83}B$

$$^{210}_{83}B \rightarrow {}^{210}_{84}po + {}^{0}_{-1}e + \nu^-$$

Neutron to proton ratio before beta decay:

$= \frac{210-83}{83} = \frac{127}{83} = 1.53$ ____ (1

Neutron to proton after beta decay =

$= \frac{210-84}{84} = \frac{126}{84} = 1.50$ _____ (2

From eq (1) and (2) (1.50 < 1.53) therefore neutron to proton ratio decreases after beta decay.

(06) What is difference between a photon and a neutrino? What percentage of a given mass of a radioactive substance will be left undecayed after five half life periods?

Ans: A photon is one quantum of electromagnetic radiation. It has zero rest mass, zero charge, zero spin and no antiparticle. Its energy E = h f depends on its frequency.

* A neutrino is elementary particle that accompanies \beta-decay. It has zero rest mass, zero charge and spin $= \frac{1}{2}(\frac{h}{2\pi})$.

It has an antiparticle called Antineutrino. It can have any energy from zero to a value permitted by nuclear reaction. Its nature is non-electro magnetic.

As number of half-lives, n=5

$$\frac{N}{N_\circ} = (\frac{1}{2})^n \quad = 1/2^5 \quad = 1/32 \quad = 3.125$$

(07) Why do stable nuclei never have more protons than neutrons? What fraction of a radioactive sample decays after two half lives have elapsed?

Ans: As a known, protons are positively charged and repel each other electrically in nucleus with more than 82 protons or so, the force of repulsion become too large, therefore, excess of neutrons is required for stability. This is because neutrons produce only attractive (nuclear) force amongst them.

If $N_\circ$ = number of original atoms then after 2 half lives, number of un-decayed atoms = $\frac{N_\circ}{4}$

therefore, number of decayed atoms

$$N_\circ = \frac{N_\circ}{4} = \frac{3N_\circ}{4}$$

So radioactive sample will not be completely decayed after 2 half lives only $\frac{3N_\circ}{4}$ will have decayed.

(08) A particle which produces more ionization is less penetrating why? If you say swallowed an alpha-source and a beta-particle which should be more dangerous to you. Explain why?

Ans:- When a particle moves through a medium, it looses energy by ionizing atoms of that medium.

* If ionizes more atoms per unit distance, it looses energy more rapidly.

* As a result it slows down and stop sooner, so it cannot penetrate deeply.

If some one swallowed an alpha-source and a beta-particle which should be more dangerous because it has 100 times more ionization power than beta-particle. It will ionize body cells. So alpha-particle can cause more damage to our body.

(09) Why do heavier nuclei have neutrons than protons? Why are neutrons such good projectiles for producing nuclear reactions?

Ans:- If the heavy elements when number of protons increases the coulombs force of repulsion increases.

* In order to have stability of nucleus there exist strong nuclear attractive force.

* For stability of nucleus in heavy elements when coulomb force increases strong nuclear force must increase by nucleus or electrons increasing number of neutrons in nucleus.

* Hence for stability of nucleus the heavy element must contain greater number of neutrons than protons.

* Neutrons are particles that carry no charge (neutral).

* So, electric and magnetic fields cannot deflect neutrons.

* Neutrons can hit target nucleus without being repelled by nucleus or electron.

* Neutrons have a strong energy of penetration and are considered as best projectiles for producing nuclear reactions.

(10) Why neutron activated nuclides tend to decay beta-decay (either beta$^-$ or beta$^+$)? Why are small and large nuclei unstable?

Ans:- In nucleus when neutron convert into proton an electron is emitted in form of beta$^-$ decay.

* But when proton converts into neutron a positron is emitted in form of the beta$^+$ decay.

* Therefore the nuclei which contains large number of neutrons will decay beta$^-$ particle and nuclei which contain small number of neutron decay beta$^+$ particle.

Heavy nuclei are unstable

Explanation:- The binding energy per nucleon of small nucleus is less than binding energy per nucleus of intermediate nuclei

Therefore, it is easy to break small nuclei.

* The low binding energy per nucleon of heavy nuclei is due to coulomb's repulsive force between the protons in nuclei.

* The binding energy per nucleon of heavy nuclei is less than binding energy of intermediate nuclei.

(11) Why does fusion of light nuclei into heavier nuclei release energy? What factors make a fusion reaction difficult to achieve?

Ans:- In fusion reactions two light nuclei merge to form single

heavier nucleus

$$^2_1H + ^2_1H \rightarrow ^4_2He + 24\text{MeV}$$

* The process releases energy because the total number of resulting single nucleus is less than mass of two original nuclei.

* The difference of mass Δm of the two original nuclei and the resulting single nucleus converts into energy according to Einstein energy mass-equation

$$\Delta m = \Delta\, mc^2$$

* For the fusion of two light nuclei work has to be done against the electrostatic force of repulsion between two positively charged light nuclei.

* For this purpose, the nuclei are moved towards each other with high velocity and high K.E.

* The fusion reaction can take place at temperature about 50 million degrees celsius. At this temperature, the nuclei get sufficient thermal K.E to overcome electrostatic force of repulsion.

Chapter # 23 Cosmology

(01) What is meant by black body radiation? What is relationship between luminosity and radiant flux intensity?

Ans: Black body radiation is electromagnetic radiation emitted by an idealized object that absorb all incident radiation.

Explanation:

A blackbody is a theoretical concept where an object perfectly absorbs all light and re-emits energy based solely on its temperature. This radiation follows a specific spectral distribution described by Planck's law.

Luminosity	Radiant flux intensity
Luminosity is a measure of total power output of radiation emitted by a star.	The Luminosity per unit area measured on surface of earth.
SI unit of Luminosity is watt (W).	SI unit of radiant flux intensity is wm^{-2}
It depends upon surface area of stars and its temperature.	A greater radiant flux intensity indicates that star is closer to earth.
$L= (4\pi r)^2 rT^4$	$F= \frac{L}{4\pi d^2}$

(02) What is Inverse square law for radiant flux intensity? What is meant by standard candles? Give any two examples?

Ans: The inverse square law states that radiant flux intensity decreases with square of distance from source.

As light spreads out spherically, the intensity (E) at distance r is

given by:

$F= \frac{L}{4\pi d^2}$, $F\alpha \frac{1}{d^2}$

This means if distance doubles intensity becomes \frac{1}{4} of its original value.

Standard candles are astronomical objects with known luminosity used to measure cosmic distances.

Example:

* Cepheid variable stars

* Type 1A supernovae

(03) What is Wien's displacement law? Define Stefan-Boltzman law?

Ans: Wien's displacement law stated that wavelength at which a blackbody emits maximum radiation is inversely proportional to its temperature.

$\lambda_{max} T= 2.898 \times 10^{-3}$ mK

Explanation:

This law describes how peak wavelength of emission from black body shifts with temperature. As temperature increases, the peak wavelength decreases, moving towards ultra violet end of spectrum.

the total energy radiated per unit surface area of blackbody is proportional to fourth power of its temperature.

$$P= \frac{L}{A}= \sigma T^4$$

σ is Stefan-Boltzman constant with a value of 5.67×10^{-8} $Wm^2 K^{-4}$

This law quantifies energy output of a blackbody, indicating hotter objects emit significantly more energy.

(04) How we can estimate radius of star by applying Wien's displacement law and Stefan Boltzman Law? How red shift leads to idea that universe is Expanding?

Ans: Wien's law relates the peak wavelength of star's emitted radiation (λ_{max}) to its temperature (T)

$$T = \frac{2.898 \times 10-3\ m}{\lambda_{max}}$$

The total energy output (Luminosity, L) of star is related to its temperature and radius (R) by the Stefan Boltzman Law.

$$L = (4\pi r^2)\,\sigma T^4$$

$$r = \sqrt{\frac{l}{4\pi\sigma T4}}$$

Red shift is the phenomenon where light from distant galaxies is stretched to longer wavelengths, indicating universe is expanding.

$Z = \frac{\lambda_{observed} - \lambda_{emitted}}{\lambda_{emitted}}$ -

This relationship between redshift and expansion of universe is described by Hubble's law, $V=H_{\circ}d$

* The relationship implies that the farther a galaxy is, the faster it moves away, providing evidence that universe is expanding in all directions.

(05) How does the expansion of universe supports big bang theory? How do different types of spectra (emission, absorption, continuous) provide insights into composition and properties of celestial objects?

Ans: The observed expansion of universe supports the big bang theory by indicating that the universe originated from a hot, dense state and has been expanding ever since.

- Edwin Hubble discovered that galaxies are moving away from us with velocity proportional to their distance, known as Hubble's law

$$V = H_o d$$

This expansion suggests that the universe was compressed into a singular point. This is consistent with Big Bang model of cosmic origin.

Different spectra reveal the compositions, temperature, and physical conditions of celestial objects by analyzing their light.

Explanation:

- A continuous spectrum, produced by hot, dense objects like stars, shows all wavelengths and indicates temperature.
- An emission spectrum, with bright lines at specific wavelengths, arises from excited gases and reveals elements present, e.g. (hydrogen, helium) in nebulae.

Chapter # 24 Earth's Climate

(1) where in atmosphere is water vapour most concentrated and why? what is difference between weather and climate.

Ans. water vapour is most concentrated in atmosphere.

Explanation:

- water vapour is sourced from evaporation and transpiration, which occur mainly at earth's surface.
- The Troposphere is lowest layer of atmosphere which is closest to earth's surface & contains about 99% of atmosphere's water vapour.
- The concentration decreases with altitude because colder air holds less water vapour.

Weather refers to short-term atmospheric conditions; it refers to daily changes in temperature, precipitation, humidity & wind.

Climate is long-term average of weather patterns over decades.

(02) Warm air has greater capacity to hold water vapour. Why? How does atmosphere retain itself?

Ans: Warm air has greater capacity to hold water vapours because when air is heated, its molecules move faster, creating more space for water vapour molecules to occupy, allowing it to hold more moisture compared to cold air. Therefore, warm air has a higher capacity for water vapour, which is why humidity is often higher in warmer climates.

The atmosphere retains itself through gravity and thermal equilibrium.

Explanation:

- Gravity prevents atmospheric gases from escaping into space.
- As Altitude increases, both pressure and temperature decrease. This gradient helps to keep atmosphere intact, as gases are more densely packed at lower altitudes.
- The balance between gravity and thermal motion of gas molecules determines thickness of atmosphere.

(03) What should be the consequences of all the polar ice melts? Is the lithosphere a part of mantle ? Justify your answer.

Ans: Melting polar ice would raise sea levels, and ecosystem disruptions would occur.

Explanation:

- Sea level rise could submerge coastal cities.
- Altered ocean currents would disrupt weather patterns.
- Loss of habitat for polar species.
- Reduced albedo effect (reflectivity) would accelerate global warming.

No, the lithosphere is not part of mantle.

Explanation:

- The Lithosphere is outermost shell on earth.
- The Lithosphere composed of crust and uppermost solid mantle, which constitute the hard and rigid outer layer of earth.
- The mantle extends deeper and is semi-fluid.

(04) What are four components of biosphere ? Why stratosphere is called calm and stable layer ?

Ans: The four components are atmosphere, lithosphere, hydrosphere, biosphere.

Explanation

- The atmosphere provides air and gases for life.
- The lithosphere forms earth's solid surface where organisms live.
- The hydrosphere contains water bodies essential for life.
- The biosphere encompasses all living organisms and ecosystems.

The stratosphere is calm and stable due to its temperature inversion.

Explanation:

- Ozone absorption of UV radiation warms the upper stratosphere.
- The increased temperature prevents convections, meaning it prevents vertical air movement.

- There are no significant weather systems in stratosphere that's why stratosphere is calm and stable layer.

Chapter # 25 Medical Imaging

(01) Differentiate between piezoelectric effect and inverse piezoelectric effect? what is the distinction between a continuous X-ray and a characteristic X-ray?

Piezoelectric Effect	Inverse Piezoelectric Effect
It generates the electric charge from mechanical stress.	It producesmechanical deformation from an applied electric field.
When a piezoelectric material (e.g.: quartz) is mechanically stressed, it produces an electric charge. This is used in sensors & microphones.	When an electric field is applied to piezoelectric material, it undergoes mechanical deformation. This is used in actuators and ultrasound devices.

Continuous X-ray	Characteristic X-ray
When high energy electrons are slowly down in target, lose their energy upon electrostatic interaction they emit a continuous spectrum of X-rays. (bremsstrahlung radiations) $\lambda_{min} = \frac{hc}{K.E} = \frac{hc}{ev}$	When inner shell electrons are ejected and outer shell electron transition to fill the vacancy, they emit X-rays at specific wavelength unique to Target nmaterial $\lambda = \frac{hc}{En - Ep}$

Q2) What is the main purpose of an X-rays can emit electrons from metal surface and X-rays can be diffracted? comment.

Ans: X-rays are the form of electromagnetic radiations that can pass through most materials including body tissues, but are absorbed by denser material like bones or metal, creating contrast in images.

This property make useful in:

→ Medical imaging (e.g detecting fractures, infections, tumors)

→ Dental exams (e.g checking cavities or root issues)

→ Security scanning (e.g airports to inspect luggage)

X-rays exhibit dual nature, which means they possess both wave like and particle like properties.

Explanation:

- When x-rays strikes a metal surface, they can transfer energy to electrons with the metal. If energy of x-ray photon is greater than work function of metal, the electron can be ejected from surface. The ability of x-ray to eject electrons confirms that they carry quantized energy photons behaving like particle.

(03) X-rays have different properties from light even through both originate from orbital transition of electrons in excited atoms. Why is meant by brealcing radiations?

Ans. X-rays have different properties from visible light due to their higher energy and shorter wavelengths.

Explanation:

- X-rays are produced by transitions involving inner-shell electrons which emit high energy, this giving them the ability of greater penetration and ionization ability.
- Visible light is produced by electrons transitions from outer-shells and because it has lower energy, it tends to be absorbed or reflected by matter.

Braking radiations is X-ray radiation produced when high-speed electrons are deaccelerated by electric fields of atomic nuclei.

Explanation:

As electrons are rapidly deaccelerated upon striking a metal target, their K.E is converted into X-ray photon, forming a continuous spectrum.

$$\lambda_{min} = \frac{hc}{K.E} = \frac{hc}{ev}$$

(04) What are K_B characteristic of X-ray?

Ans: K_B X-rays are produced when an electron from (M-shell) (n=3) fills a vacancy in (K shell) (n=1) of an atom.

Explanation:

When an inner shell electron in K shell is removed, electrons from higher energy levels fall to fill the vacancy. If electrons come from M-shell, the energy difference between M and K levels is released as a K_B X-ray photon.

$$E_{KB} = E_m - E_K$$