Q. 13. Two identical loops, one of copper and the other of aluminium, are rotated with the same angular speed in the same magnetic field. Compare (I) the induced emf and (II) the current produced in the two coils. Justify your answer.

Answer:

We know that induced emf (e) and induced current (i) in a rotating coil is given by

$e = NAB\omega Sin\omega t$, $e = e_p Sin\omega t$, Hence peak value of emf = $e_p = NAB\omega$.

Similarly peak value of current= $i_p = e_p/R$

Where

N=number of turns

A = Area of the coil

B= Magnetic Field

ω = Angular velocity

Since all are same for both cupper and aluminium, and does not depend on nature of material hence

(i) The ratio of induced emf = 1 : 1
(ii) The ratio of induced current = 1 : 1

Q. 14. An $\alpha -$ particle and a proton are accelerated from rest by the same potential. Find the ratio of their de Broglie wavelengths.

Answer: We know that de Broglie wavelength (λ) is given by $\lambda = \frac{h}{mv}$

We know that charge x potential = kinetic energy therefore $eV = \frac{1}{2}mv^2$

or $2meV = m^2v^2$ or $\sqrt{2meV} = mv$

Therefore $\lambda = \frac{h}{\sqrt{2meV}}$ $\therefore \lambda \propto \frac{1}{\sqrt{m}}$ [For same potential $= V =$ constant]

We know that alpha particle $= {}_2^4He$

Proton is ${}_1^1H$

$\therefore$ Mass of alpha particle $= 4$ times mass of proton

$\therefore \lambda_{proton} \propto \frac{1}{\sqrt{m}}$ and $\lambda_{alpha} \propto \frac{1}{\sqrt{4m}}$

$\therefore \frac{\lambda_{proton}}{\lambda_{alpha}} = \frac{1}{\sqrt{m}} \times \frac{\sqrt{4m}}{1} = \frac{2}{1}$

$\therefore \lambda_{proton} : \lambda_{alpha} = 2 : 1$

Q. 15. Write two factors justifying the need of modulating a signal.

A carrier wave of peak voltage 12 V is used to transmit a message signal. What should be the peak voltage of the modulating signal in order to have a modulation index of 75%?

Answer:

1. To decrease the antenna size

   Explanation: We know that for transmitting a signal of wavelength λ the antenna height required is λ/4.
   Therefore to transmit υ =1 Hz frequency
   $c = \lambda \times \upsilon$
   $c=3\times10^8$ m/s
   $3\times10^8 = \lambda \times 1$
   $\lambda= 3\times10^8$ m
   Height of antenna required (h)= $\lambda/4=3\times10^8/4$ = 300x1000x1000/4=75000,000 m =75000 KM, Thus it is difficult to construct such huge antenna. Now let us modulate this signal to high frequency say 100 MHZ then

   $3\times10^8 = \lambda \times 100\times10^6$
   $\lambda = 3$ m
   Therefore required antenna height = $\lambda/4=3/4$=0.75 m, which is easy to construct.

2. To simultaneously send data and to multiplex data.
   Explanation: without multiplexing Signal, it will interfere with the normal voice in the air

Problem: We know that modulation index $\mu_a = \frac{A_m}{A_c}$

Given $\mu_a = 72\% = 0.75$

$\mu_a = 72\% = 0.75$

$0.75 = \frac{A_m}{12}$

$\therefore\ A_m = 0.75 \times 12 = 9.00 = 9\ V$

Q. 16. Write Einstein's photoelectric equation. State clearly the three salient features observe in photoelectric effect, which can be explained on the basis of the above equation.

Answer: Einstein's photoelectric equation: Supplied energy to photo electron is used up to come out (work functionϕ_0), remaining is used as kinetic energy.

I.e. $h\nu = \phi_0 + \frac{1}{2} mv^2{}_{max}$

$K_{max} = \frac{1}{2} mv^2{}_{max} = h\nu - \phi_0 = h\nu - h\nu_0$

I. A part of the energy of the photon is used in liberating the electron from the metal surface which is equal to the work function ϕ_0 of the metal.

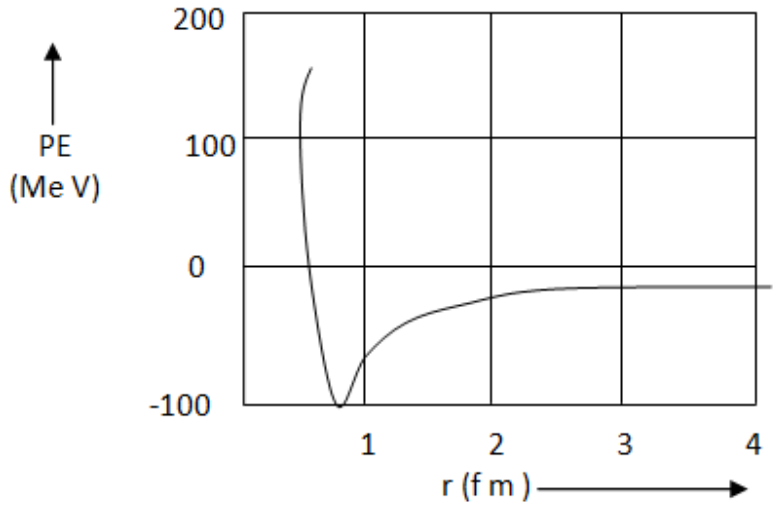
II. The rest of the energy of the photon is used to get the maximum kinetic energy K_{max} to the emitted photo electron.

III. The negative potential on the collector at which the photoelectric current becomes zero is called the stopping potential. Stopping voltage varies linearly with frequency of light, but depends on the type of material. $K_{max} = h(v - v_0)$

Q. 17. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.

Answer:

Along Y-axis Plot of potential energy in MeV is taken and along X-axis distance of separation for the pair of nucleons in femtometer(fm) taken



Nature of Nuclear Force:

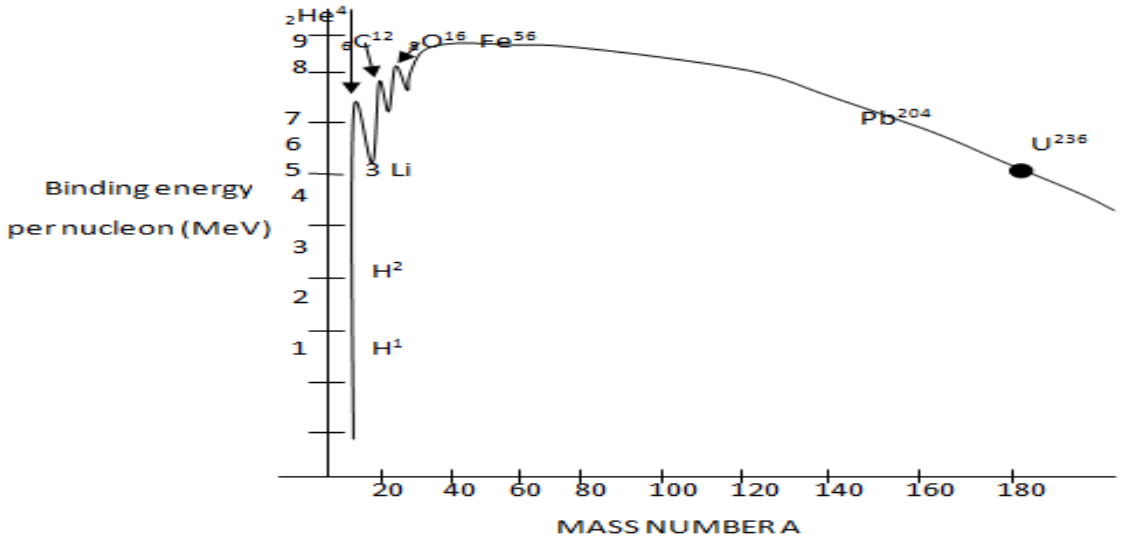
I. The nuclear force between two nucleons falls rapidly to zero as their distance is more than a few femtometres (approx. = 0.8 femtometers)

II. For a separation greater than (0.8 fm approx)r_0, the force is attractive and for separations less than r_0, the force is strongly repulsive.

Or,

Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei, $2 \leq A \leq 240$. How do you explain the constancy of binding energy per nucleon in the range $30 < A < 170$ using the property that nuclear force is short – ranged?

Answer: Binding energy per nucleon is taken along Y-axis and mass number A is taken along X-axis , nuclei having mass number between 2 and 240 ($2 \leq A \leq 240$) considered, the required graphical representation is as shown.



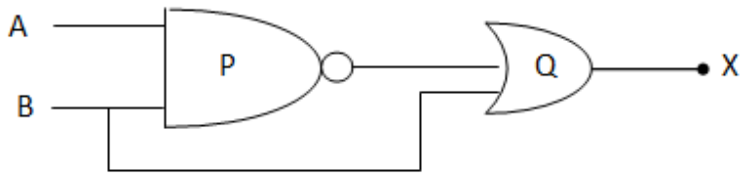
The nucleus in the consistent Binding energy region is large enough so that nuclear forces no longer completely extend efficiently across its width. Attractive nuclear forces in this region, as atomic mass increases, are nearly balanced by repellent electromagnetic forces between protons, as the atomic number increases.

The constancy of the binding energy in the range $30 < A < 170$ is due to fact that the nuclear force is short – ranged.

In elements heavier than xenon, there is a decrease in binding energy per nucleon as atomic number increases. In this region of nuclear size, electromagnetic repulsive forces are beginning to overcome the strong nuclear force attraction.

Q. 18.

I. Identify the logic gates marked P and Q in the given logic circuit.



II. Write down the output at X for the inputs A = 0, B = 0 and A = 1, B = 1.

Answer:

I. The logic gate symbol denoted by P is NAND gate and the logic gate symbol denoted by Q is OR gate.

A $\overline{A}$

P

B **Q**

Finally output from Q gate is $X = \overline{A} + B$.

II. Truth Table :-

Input		$\overline{A}$	Output
A	B		$X = \overline{A} + B$
0	0	1	1
1	1	0	1

Finally output from Q is always 1 (TRUTH) as indicated from the above Truth Table.