CBSE CLASS XII PHYSICS
Magnetism

One mark questions with answers

Q1. What are the units of pole strength and magnetising force?

Ans1. Ampere-metre and Ampere-turns/metre respectively.

Q2. What do you mean by 10° E as angle of declination?

Ans2. The angle between geographic meridian and magnetic meridian is 10° E at a place.

Q3. What is Bohr's magneton?

Ans3. Orbital magnetic moment = n ***x*** Bohr's magneton.
Bohr's magneton = 9.27×10^{-24} ampere-m^2.

Q4. If an electron is revolving around the nucleus of a hydrogen atom with velocity 'v' in an orbit of radius 'r', write the expression for equivalent current.

Ans4. Equivalent current = $ev/2\pi r$

Q5. Write an expression for the magnetic dipole moment contributed by electron to the atom revolving in an orbit of radius 'r' with velocity 'v'.

Ans5. Magnetic dipole moment = evr/2.

Two mark questions with answers

Q1. If the torque acting on a bar magnet placed at 30° angle with the uniform magnetic field of strength 0.4 T is 0.08 Nm, what is the magnetic moment of the bar magnet?

Ans1. Torque, τ = MB sin θ .... (*i*), where 'θ' is the angle between the magnetic axis and the magnetic field.
Given, torque τ = 0.08 Nm,
angle $\theta = 30^\circ$ and
magnetic field B = 0.4 T
Then from (*i*)
$M = \tau/B \sin\theta = 0.08/\{0.4 \times (1/2)\} = 0.4\ Am^2$

Q2. If instead of electrons revolving around the nucleus of an atom protons are taken then what will be the value of Bohr's magneton?

Ans2. Bohr's magneton = $eh/4\pi m$
Using all the values of planck's constant , mass 'm' of the proton in S.I system we have
Bohr's magneton = $(1.6 \times 10^{-19} \times 6.634 \times 10^{-34})/(4 \times 3.14 \times 1.67 \times 10^{-27})$
= 5.05×10^{-27} A-m^2.

Q3. An electron is moving in second orbit of a hydrogen atom, making 10^{15} rps. Calculate magnetic moment associated with the orbital motion of electron. If the orbit of electron is in X-Y plane then what will be the direction of the magnetic moment?

Ans3. Equivalent current , I = Frequency *x* charge
Charge on electron, e = 1.6 *x* 10^{-19}C (standard value)
frequency,f = 10^{15} rps
I = 1.6 *x* 10^{-19} *x* 10^{15} A = 1.6 *x* 10^{-4} A
Radius of second orbit = 0.5 *x* 4 Å
Magnetic dipole moment of the atom, M = current *x* area = I *x*
A = 1.6 *x* 10^{-4} *x* π *x* (2 *x* 10^{-10} m)^2 = 2.0 *x* 10^{-23} A-m^2.

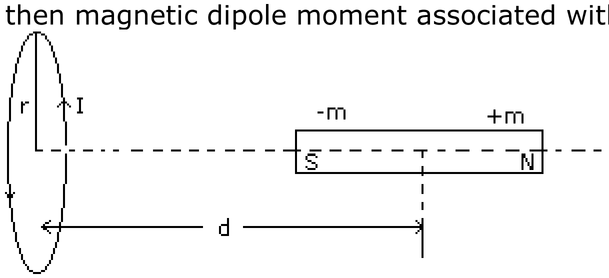
Q4. Find the magnitude of the force between two magnetic poles of strength 1.4 amp-m and 1.8 amp-m in a medium of relative permeability 1500 at a distance of 0.06 m from each other. Give the nature of force also.

Ans4. Magnetic pole strength, m_1 = 1.4 amp-m
Magnetic pole strength, m_2 = 1.8 amp-m
Distance between poles, r = 0.06 m
Absolute permeability of air, μ_o = 4π *x* 10^{-7} Wb/amp-m
Relative permeability of medium,μ_r = 1500 then
F = ($\mu_o\mu_r$ *x* $m_1m_2/4\pi r^2$)
= (4π *x* 10^{-7} *x* 1500 *x* 1.4 *x* 1.8)/(4π *x* 0.06 *x* 0.06)
= 1.05 *x* 10^{-3} N.
This force is repulsive in nature because both the poles are north poles.

Three mark questions with answers

Q1. A current carrying coil of radius 0.004 m is placed on the axis of a magnet of magnetic moment 2 *x* 10^5 Joules/Tesla and length 0.2 m at a distance of 0.30 m from the centre of magnet. The plane of the coil is perpendicular to the axis of the magnet. Find the force on the coil when a current of 2.0 amp is passed through it. [($\mu_0/4\pi$) = 10^{-7} N/A^2]

Ans1. If 'A' is the area of cross-section of the current-carrying coil and a the radius of the coil, then magnetic dipole moment associated with the coil is



Magnetic moment,M = IA = I(πr^2) = 2.0[3.14 *x* (0.004)^2] = 1.0 *x* 10^{-4} amp *x* m^2
Now magnetic field on the axis of a current-carrying coil at a distance of 'd' from its centre is given by
B = ($\mu_o/4\pi$) *x* ($2M/d^3$) [$\because$ r < < d]
Due to this field, the force on the north pole of the magnet.
F_N = + m B_1 =
and the force on the south pole of the magnet : F_s = - m B_2 =($\mu_o/4\pi$) *x* (2mM/(d + l)^3)
$\therefore$ Net force on the magnet due to current-carrying coil is given by, F' = F_N + F_s = mB_1 - mB_2
So the net force on the coil due to magnet, is F = - F' = mB_2 - mB_1

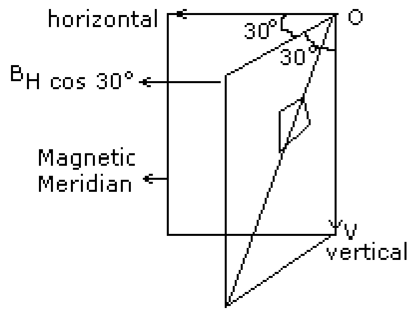
$$= \frac{\mu_0}{4\pi} 2mM\left[\frac{1}{(d-l)^3} - \frac{1}{(d+l)^3}\right]$$

$$= \frac{\mu_0}{4\pi} \frac{2M \times m \times 2l\,(3d^2 + l^2)}{(d^2 - l^2)^3}$$

Putting the values, we get
= 2 ***x*** 10^{-3} Newton.

Q2. A vertical plane at an angle of 30° with magnetic meridian is used for an experiment.The axis of the magnet is inclined at an angle of 60° with horizontal direction. Find the true dip at that place.

Ans2.



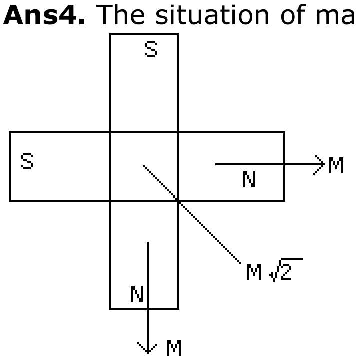
Let B_v and B_H be the vertical and horizontal components of earth's magnetic field respectively, then true dip, tan θ =B_v/B_H
In the given situation the horizontal component of the earth's magnetic field will be B_HCos30°.
So, tan60° =B_v/B_HCos30° = tanθ/cos30°
tanθ = cos30° ***x*** tan 60° = (√3/2) ***x*** √3 = 3/2
So, true dip, θ = $\tan^{-1}(3/2)$.

Q3. A magnet is suspended in the magnetic meridian. Now if it is rotated through an angle θ in the horizontal plane, show that the ratio of the tangent of the apparent dip to the true dip is 1/cos θ.

Ans3. If ϕ represents the actual angle of dip when the magnet is in the magnetic meridian, then tan ϕ =B_v/B_H ----(*i*)
where B_v and B_H are the horizontal and vertical components of the earth's magnetic field respectively.
In a plane at an angle 'θ' with the magnetic meridian the horizontal component becomes B_HCosθ.
Hence, the apparent dip tanϕ' = B_v/B_HCosθ.----(*ii*)
From (*i*) and (*ii*)
tanϕ'/tan ϕ = 1/Cosθ.

Q4. In an experiment, two identical magnets are kept one over the other such that they bisect each other and are mutually perpendicular. If the time period of oscillations of this combined system of magnets is 6 seconds, find the time period of oscillations of one magnet if the other is taken away.

Ans4. The situation of magnets is as shown in the figure:

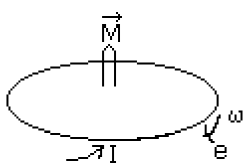


Resultant moment of inertia of both the magnets about the axis of rotation will be 2I, where 'I' is the moment of inertia of each magnet.
The time period of this combination in the horizontal magnetic field of earth, H is given by
$T = 2\pi\sqrt{(2I/M\sqrt{2}B_H)}$
or $6 = 2\pi\sqrt{(2I/M\sqrt{2}B_H)}$................ (1)
When one magnet is removed, then
$T' = 2\pi\sqrt{I/MB_H})$.............. (2)
Dividing eq. (2) by eq. (1), we get
$T'/6 = 1/(2)^{1/4}$
or, $T' = 6 \times 2^{1/4}$.
$= 6 \times 1.189 = 7.13$ sec.

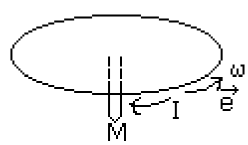
Five mark questions with answers

Q1. What are diamagnetics? Give electron theory of diamagnetism. Discuss the effect of temperature on diamagnetism.

Ans1. Diamagnetics are those substances, which are weakly magnetised in a comparatively stronger magnetic field. The magnetisation is in a direction opposite to that of the applied magnetic field. They have paired electrons. They are repelled in magnetic field. Net magnetic moment of each atom is zero and so that of the specimen is also zero. Hence, diamagnetics can be considered as equivalent to a two electron system revolving in opposite direction such that they cancel each other's magnetic moment.



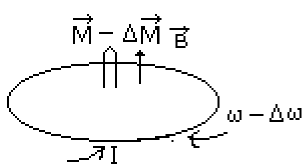
(*i*)



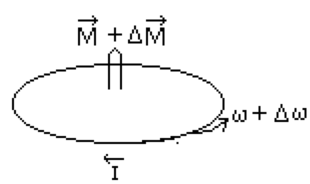
(*ii*)

In figure(i), magnetic moment is towards the reader and in figure(ii), magnetic moment is away from the reader. Net $\vec{M}$ is zero.

Now, let a magnetic field be applied to the system of electrons normal to the plane of loops and towards the reader.



(*iii*)



(*iv*)

Due to magnetic field a Lorentz force $\vec{F} = -e(\vec{v} \times \vec{B})$ acts on each electron. Using Right hand rule, electron in figure (i) is retarded whereas electron in fig(ii) is accelerated.
As M = IA and

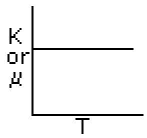
I = frequency $\times$ charge

So,I increases, M increases for electron in fig(ii) and M decreases for electron in fig (i).

Now, net magnetic moment is $\vec{M} + \Delta\vec{M} - (\vec{M} - \Delta\vec{M}) = 2\Delta\vec{M}$.

This net magnetic moment is opposite to **B** in direction and the diamagnetic specimen is said to be magnitised. On removing $\vec{B}$,again net magnetic moment of electrons becomes zero as before i.e. net M = 0 and specimen is demagnetised.

Effect of temperature on diamagnetism : Since there is no dipole moment associated with atom of diamagnetics so question of alignment of dipole does not arise. When a diamagnetic material is placed in external magnetic field there is always induced dipole moment and this magnetic moment is due to force of magnetic field on the revolving electrons and temperature change has no role to play for magnetisation.



Q2. What happens when a magnet is kept in a uniform magnetic field? Derive an expression for the torque acting on the magnet and frequency of angular SHM of the magnet.

Ans. (Try yourself).

Q3. Define the terms relative permeability and magnetic susceptibility. Establish a relation between the two. Plot graphs between magnetic susceptibility and temperature for paramagnetics and ferromagnetics.

Ans. (Try yourself).

Q4. Give principle, theory and working of vibration magnetometer. How will the expression of time period of the magnet be modified if another magnet is brought near the oscillating magnet?

Ans. (Try yourself).