Magnetism & Matter DPP-JEE

11 September 2020 17:00

$q \rightarrow m$ $\quad \frac{1}{\varepsilon_0} \rightarrow \mu_0$

$p \rightarrow M$

$E \rightarrow B$ (intensity of magnetic field or magnetic induction or magnetic flux Density)

MAGNETISM & MATTER **DDS ACADEMY**

1. An iron rod of length L and magnetic moment M is bent in the form of a semicircle. Now its magnetic moment will be

(a) M (b) $\frac{2M}{\pi}$ ✓ (c) $\frac{M}{\pi}$ (d) $M\pi$

$M = m \times L$

$m = \frac{M}{L}$ — (1)

$L = \pi r$

$r = \frac{L}{\pi}$ — (2)

$M' = m \times 2r$

$= \frac{M}{L} \times \frac{2L}{\pi}$

$M' = \frac{2M}{\pi}$

2. A magnet of magnetic moment M and pole strength m is divided in two equal parts, then magnetic moment of each part will be

(a) M (b) $M/2$ ✓ (c) $M/4$ (d) $2M$

$M = m \times L$

$-m/2$, $+m/2$, $\frac{L}{2}$

3. A magnet of magnetic moment 20 C.G.S. units is freely suspended in a uniform magnetic field of intensity 0.3 C.G.S. units. The amount of work done in deflecting it by an angle of 30° in C.G.S. units is

(a) 6 (b) $3\sqrt{3}$ (c) $3(2-\sqrt{3})$ ✓ (d) 3

$(W_{\theta_1 \to \theta_2})_{ext} = -(W)_{Mag\ cons.} = -(-\Delta U) = \Delta U = U_{\theta_2} - U_{\theta_1}$

freely suspended position → Stable Eq.

$\theta_1 = 0°$

$\theta_2 = 30°$

$U_\theta = -\vec{M}\cdot\vec{B} = -MB\cos\theta$

$= -MB\{\cos\theta_2 - \cos\theta_1\}$

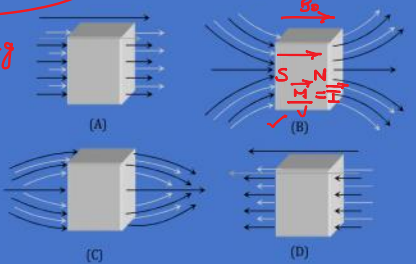
$= -20 \times 0.3\left\{\frac{\sqrt{3}}{2} - 1\right\}$

$= 3\cdot(2-\sqrt{3})J$

4. A uniform magnetic field, parallel to the plane of the paper existed in space initially directed from left to right. When a bar of soft iron is placed in the field parallel to it, the lines of force passing through it will be represented by

ferro. Mag

initially



(a) Figure (A) (b) Figure (B) ✓
(c) Figure (C) (d) Figure (D)

5. A magnetic needle is kept in a non-uniform magnetic field. It experiences

(a) A force and a torque ✓
(b) A force but not a torque
(c) A torque but not a force
(d) Neither a torque nor a force

$F_N = mB_1$ $\quad F = mB_2$

6. A magnetic needle lying parallel to a magnetic field requires W units of work to turn it through 60°. The torque required to maintain the needle in this position will be

(a) $\sqrt{3}W$ ✓ (b) W (c) $\frac{\sqrt{3}}{2}W$ (d) $2W$

$W_{ext} = \Delta U = U_{\theta_2} - U_{\theta_1} = U_{60°} - U_{0°}$

$= -MB(\cos 60° - \cos 0°)$

$W = \frac{MB}{2}$ — (1)

$\tau_{ext} = \tau_{Mag} = (M \times B)\times\sin\theta$

$= 2W \times \sin 60°$

$\Rightarrow \tau = W\sqrt{3}$

7. A magnet of magnetic moment M is rotated through 360° in a magnetic field H, the work done will be

(a) MH (b) $2MH$ (c) $2\pi MH$ (d) Zero ✓

$W_{ext} = -(W_{cons.})_{Mag.} = -(-\Delta U) = \Delta U = U_{\theta_2} - U_{\theta_1}$

$U_\theta = -MB\cos\theta$

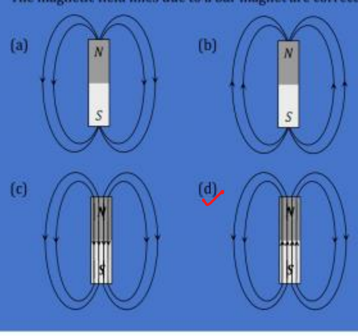
$= -MB\cdot\{\cos\theta_2 - \cos\theta_1\}$

$= -MB\cdot\{\cos 360° - MB\cos 0°\}$

$= -MB\{1-1\}$

$\Rightarrow W_{ext} = -MB \times 0 = 0$

8. The magnetic field lines due to a bar magnet are correctly shown in



(d) ✓

Magnetic field lines

9. The magnetic lines of force inside a bar magnet

(a) Are from south-pole to north-pole of the magnet
(b) Are from north-pole to south-pole of the magnet
(c) Do not exist
(d) Depend upon the area of cross-section of the bar magnet

10. A magnet of magnetic moment $2\ J\,T^{-1}$ is aligned in the direction of magnetic field of 0.1 T. What is the net work done to bring the magnet normal to the magnetic field

$\theta_1 = 0^\circ$; $\theta_2 = 90^\circ$

(a) 0.1 J (b) 0.2 J
(c) 1 J (d) 2 J

$(W_{\theta_1 \to \theta_2})_{ext} = U_{\theta_2} - U_{\theta_1} = -MB\cdot\{\cos 90^\circ - \cos 0^\circ\}$
$= -MB\{0-1\} = MB$
$= 0.2 J$

11. Which of the following statements are true about the magnetic susceptibility χ_m of paramagnetic substance

(a) Value of χ_m is inversely proportional to the absolute temperature of the sample
(b) χ_m is positive at all temperature
(c) χ_m is negative at all temperature
(d) χ_m does not depend on the temperature of the sample

$\chi_{para} = \frac{\mu_0 \cdot C}{T}$; $\chi_{para} \propto \frac{1}{T}$; $0 < \chi_{para} < 1$

12. The relative permeability is represented by μ_r and the susceptibility is denoted by χ for a magnetic substance. Then for a paramagnetic substance

$\because 0 < \chi_{para} < 1$
& $\mu_r = (1+\chi)$ $\Rightarrow$ $\mu_{para} > 1$

(a) $\mu_r < 1, \chi < 0$ (b) $\mu_r < 1, \chi > 0$
(c) $\mu_r > 1, \chi < 0$ (d) $\mu_r > 1, \chi > 0$

13. If a magnetic substance is kept in a magnetic field, then which of the following is thrown out
(a) Paramagnetic (b) Ferromagnetic
(c) Diamagnetic (d) Antiferromagnetic

14. The magnetic susceptibility is negative for
(a) Paramagnetic materials
(b) Diamagnetic materials
(c) Ferromagnetic materials
(d) Paramagnetic and ferromagnetic materials

$-1 \leq \chi < 0$
dia

15. Which of the following statements is incorrect about hysteresis ★ heat loss
(a) This effect is common to all ferromagnetic substances
(b) The hysteresis loop area is proportional to the thermal energy developed per unit volume of the material
(c) The hysteresis loop area is independent of the thermal energy developed per unit volume of the material
(d) The shape of the hysteresis loop is characteristic of the material

16. Curie temperature is the temperature above which
(a) A paramagnetic material becomes ferromagnetic
(b) A ferromagnetic material becomes paramagnetic
(c) A paramagnetic material becomes diamagnetic
(d) A ferromagnetic material becomes diamagnetic

$T > T_C$ para
$T = T_C$
$T < T_C$ ferro

v. Good Quest. 17. The materials suitable for making electromagnets should have
(a) High retentivity and high coercivity
(b) Low retentivity and low coercivity
(c) High retentivity and low coercivity
(d) Low retentivity and high coercivity

Solenoid & toroid

18. If a ferromagnetic material is inserted in a current carrying solenoid, the magnetic field of solenoid
(a) Largely increases (b) Slightly increases

(c) Largely decreases (d) Slightly decreases

19. In the hysteresis cycle, the value of H needed to make the intensity of magnetisation zero is called

(a) Retentivity ✓(b) Coercive force or coercivity

(c) Lorentz force (d) None of the above

20. When a ferromagnetic material is heated to temperature above its Curie temperature, the material

(a) Is permanently magnetized

(b) Remains ferromagnetic

(c) Behaves like a diamagnetic material

✓(d) Behaves like a paramagnetic material

21. Two identical magnetic dipoles of magnetic moments 1.0 $A\text{-}m^2$ each, placed at a separation of $2m$ with their axis perpendicular to each other. The resultant magnetic field at a point midway between the dipoles is

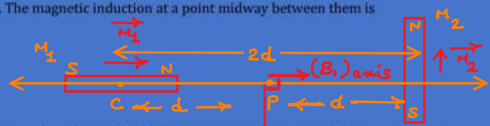
(a) $5 \times 10^{-7}\,T$ (b) $\sqrt{5} \times 10^{-7}\,T$

(c) $10^{-7}\,T$ (d) None of these

22. Two identical short bar magnets, each having magnetic moment M, are placed a distance of $2d$ apart with axes perpendicular to each other in a horizontal plane. The magnetic induction at a point midway between them is

(a) $\frac{\mu_0}{4\pi}(\sqrt{2})\frac{M}{d^3}$ (b) $\frac{\mu_0}{4\pi}(\sqrt{3})\frac{M}{d^3}$

(c) $\left(\frac{2\mu_0}{\pi}\right)\frac{M}{d^3}$ ✓(d) $\frac{\mu_0}{4\pi}(\sqrt{5})\frac{M}{d^3}$



$B_P = \sqrt{B_1^2 + B_2^2}$

$= \sqrt{\left\{\frac{\mu_0}{4\pi}\cdot\frac{2M}{d^3}\right\}^2 + \left\{\frac{\mu_0}{4\pi}\cdot\frac{M}{d^3}\right\}^2}$

$\Rightarrow B_P = \frac{\mu_0}{4\pi}\cdot\frac{M}{d^3}\cdot\sqrt{5}\ T$

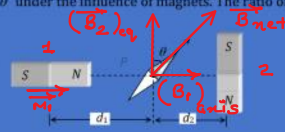
23. Two magnets A and B are identical and these are arranged as shown in the figure. Their length is negligible in comparison to the separation between them. A magnetic needle is placed between the magnets at point P which gets deflected through an angle θ under the influence of magnets. The ratio of distance d_1 and d_2 will be

(a) $(2\tan\theta)^{1/3}$

(b) $(2\tan\theta)^{-1/3}$

✓(c) $(2\cot\theta)^{1/3}$

(d) $(2\cot\theta)^{-1/3}$



$(B_2)_{eq}$

$\theta = \tan^{-1}\left\{\frac{B_{1axis}}{B_{2eq}}\right\} \Rightarrow \tan\theta = \frac{\frac{\mu_0}{4\pi}\cdot\frac{2M}{d_1^3}}{\frac{\mu_0}{4\pi}\cdot\frac{M}{d_2^3}} = \frac{2d_2^3}{d_1^3}$

$\therefore \frac{d_1}{d_2} = \left\{\frac{2}{\tan\theta}\right\}^{\frac{1}{3}}$

$\Rightarrow \frac{d_1}{d_2} = \{2\cot\theta\}^{\frac{1}{3}}$

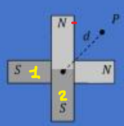
24. Two short magnets of equal dipole moments M are fastened perpendicularly at their centre (figure). The magnitude of the magnetic field at a distance d from the centre on the bisector of the right angle is

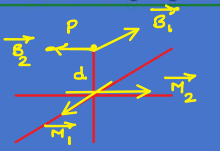
(a) $\frac{\mu_0}{4\pi}\frac{M}{d^3}$

(b) $\frac{\mu_0}{4\pi}\frac{M\sqrt{2}}{d^3}$

✓(c) $\frac{\mu_0}{4\pi}\frac{2\sqrt{2}M}{d^3}$

(d) $\frac{\mu_0}{4\pi}\frac{2M}{d^3}$

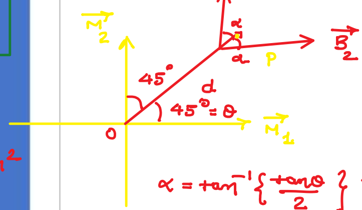




$B_P = \sqrt{B_1^2 + B_2^2}$

$= \sqrt{\left(\frac{\mu_0}{4\pi}\cdot\frac{M}{d^3}\right)^2 \times 2}$

$= \frac{\mu_0}{4\pi}\cdot\frac{M\sqrt{2}}{d^3}$



$\alpha = \tan^{-1}\left\{\frac{\tan\theta}{2}\right\} \Rightarrow \tan\alpha = \frac{1}{2}$

$\cos\alpha = \frac{2}{\sqrt{5}}$

$B_{net} = 2B\cdot\cos\left(\frac{2\alpha}{2}\right)$

$= 2\cdot\frac{\mu_0}{4\pi}\cdot\frac{M}{d^3}\cdot\sqrt{1+3\cos^2 45^\circ} \times \frac{2}{\sqrt{5}}$

$= \frac{\mu_0 M}{\pi d^3}\cdot\sqrt{1+\frac{3}{2}} \times \frac{1}{\sqrt{5}}$

$= \frac{\mu_0 \cdot M}{\pi d^3}\cdot\frac{1}{\sqrt{2}}$

$= \frac{\mu_0}{4\pi}\cdot\frac{M\,2\sqrt{2}}{d^3}$

25. An iron rod of volume $10^{-4}\,m^3$ and relative permeability 1000 is placed inside a long solenoid wound with 5 *turns/cm*. If a current of 0.5 A is passed through the solenoid, then the magnetic moment of the rod is

$n = \frac{5}{cm} = 500\,m^{-1}$

(a) 10 Am^2 (b) 15 Am^2

(c) 20 Am^2 ✓(d) 25 Am^2

$M = N\cdot i\cdot A$

$= n \times L \times i \times A$

$= n\cdot i\cdot V = 500 \times 0.5 \times 10^{-4} = 25\,A\cdot m^2$

26. A bar magnet has coercivity $4 \times 10^3\ Am^{-1}$. It is desired to demagnetise it by inserting it inside a solenoid 12 *cm* long and having 60 turns. The current that should be sent through the solenoid is

(a) 2 A (b) 4 A

(c) 6 A ✓(d) 8 A

$(H)_c = 4 \times 10^3\ Am^{-1}$; $B_c = \mu_0\cdot H_c = \mu_0\cdot n\cdot i$

$H_c = ni$

27. For substances hysteresis $(B - H)$ curves are given as shown in figure. For making temporary magnet which of the following is best.

$i = \frac{H_c}{n} = \frac{H_c}{N}\cdot L$

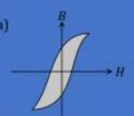
$= \frac{4 \times 10^3 \times 12 \times 10^{-2}}{60}$

$\Rightarrow i = 8A$

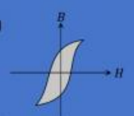
for a temporary magnet

R↓ : C↓

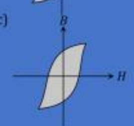
(a)



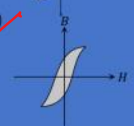
(b)



(c)

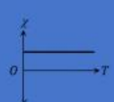


✓(d)

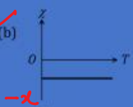


★ **28.** The variation of magnetic susceptibility (χ) with temperature for a diamagnetic substance is best represented by

(a)



✓(b)



$-1 \le \chi_{Dia} < 0$

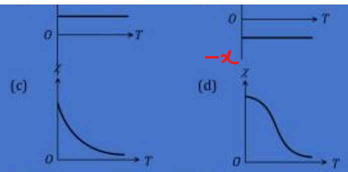
for Diamagnetic substance

χ is independent of T

(c)

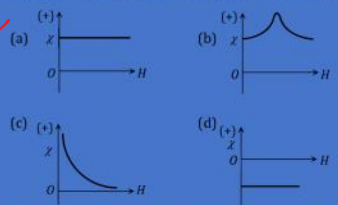
(d)

– Dia



for Diamagnetic substance
χ is independent of T
But at high Temp
$\chi_{Dia} \propto \frac{1}{T}$

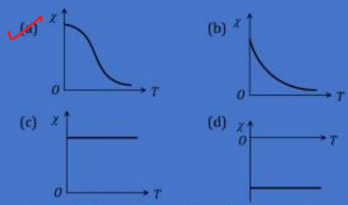
* **29.** The variation of magnetic susceptibility (χ) with magnetising field for a paramagnetic substance is



$\chi = \frac{I}{H}$

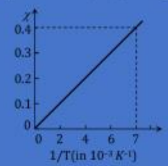
χ depends upon I
not on H

30. The variation of magnetic susceptibility (χ) with absolute temperature T for a ferromagnetic material is *



31. The $\chi - 1/T$ graph for an alloy of paramagnetic nature is shown in Fig. The curie constant is, then

$x \to y$
P



$\frac{1}{T} = x$

$\chi_{para} = \frac{\mu_0 \cdot C}{T}$

$y = m \cdot x$

$\Rightarrow m = \mu_0 \cdot C$

$\Rightarrow \frac{0.4}{7 \times 10^{-3}} = 4\pi \times 10^{-7} \times C$

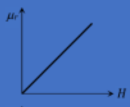
$c = \frac{1000}{7 \times \pi} \approx 45.5$

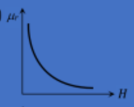
(a) 57 K (b) $2.8 \times 10^{-3} K$

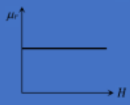
(c) 570 K (d) $17.5 \times 10^{-3} K$

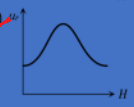
32. For ferromagnetic material, the relative permeability (μ_r), versus magnetic intensity *(H)* has the following shape

*

(a)


(b)


(c)


(d)


$\chi = 1 + \mu_r$
ferro

$\vec{B_0}$ or $\vec{H} \uparrow \longrightarrow \chi \uparrow$

ANSWER KEY

1. B	9. A	17. C	25. D
2. B	10. B	18. A	26. D
3. C	11. A&B	19. B	27. D
4. B	12. D	20. D	28. B
5. A	13. C	21. B	29. A
6. A	14. B	22. D	30. A
7. D	15. C	23. C	31. A
8. D	16. B	24. C	32. D

$B_{net} = \sqrt{B_1^2 + B_2^2 + 2 \cdot B_1 \cdot B_2 \cdot \cos\theta}$

$\because B_1 = B = B$

$= \{ 2B^2 + 2B^2 \cdot \cos\theta \}^{\frac{1}{2}}$

$= \sqrt{2} \cdot B \cdot \{ 1 + 2\cos^2\frac{\theta}{2} - 1 \}^{\frac{1}{2}}$

$B_{net} = 2B \cdot \cos\frac{\theta}{2}$ — (*)