WEEKLY TEST MEDICAL PLUS - 01 R
SOLUTION Date 12 -01-2020

[PHYSICS]

1. We have

$$r = \frac{\sqrt{2mqV}}{qB} = \sqrt{\frac{2mV}{aB^2}}$$

$$\frac{r_1}{r_2} = \sqrt{\frac{m_1}{m_2}}$$

$$\frac{m_1}{m_2} = \frac{r_1^2}{r_2^2}$$

Hence, $$\frac{m_1}{m_2} = \frac{(2)^2}{(3)^2} = \frac{4}{9}$$

2.

3. Given $\theta = 23°$, $B = 2.6 \text{ mT} = 2.6 \times 10^{-6}$ T

and $F = 6.5 \times 10^{-17}$ N

We know

$$F = qvB\sin\theta$$

$$6.5 \times 10^{-17} = 1.6 \times 10^{-19} \times v \times 2.6 \times 10^{-6} \times \sin 23°$$

$$v = \frac{6.5 \times 10^{-17}}{2.6 \times 10^{-6} \times 1.6 \times 10^{-19} \times 0.39}$$

$$v = 4 \times 10^5 \text{ ms}^{-1}$$

4. Radius, $$r = \frac{mv}{qB}$$

or $$B = \frac{mv}{qr}$$

$$= \frac{9.1 \times 10^{-31} \times 1.3 \times 10^6}{1.6 \times 10^{-19} \times 0.35}$$

$$= 2.1 \times 10^{-5} \text{ T}$$

5.

6. $$\frac{1}{2}mv^2 = eV$$

$$\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 182$$

$$v^2 = \frac{1.6 \times 10^{-19} \times 182 \times 2}{9.1 \times 10^{-31}}$$

$$= 64 \times 10^{12}$$

$$v = 8 \times 10^6 \text{ ms}^{-1}$$

7. We have, $M = NIA$

$$B = \mu_0 nI$$

Torque, $C = MB$

Here, $C = (n_1 I_1 A)(\mu_0 n_2 I_2)$

$$= \left(10 \times \frac{21}{44} \times 10^{-6}\right)\left(4 \times \frac{22}{7} \times 10^{-7} \times 10^3 \times 2.5\right)$$

$$= 1.5 \times 10^{-8} \text{ N-m}$$

8. Magnetic field

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2i}{R} \quad \text{and} \quad B_2 = \frac{\mu_0}{4\pi} \cdot \frac{4i}{R}$$

$$B_2 - B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2i}{R} = B$$

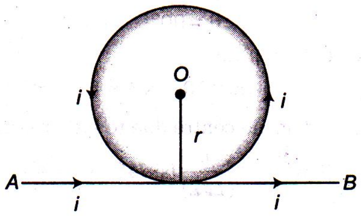
$$B_2 = 2B_1$$

$$2B_1 - B_1 = B$$

$\therefore$ $B_1 = B$

9. The magnitude of the magnetic field at point O due to straight part of wire is

$$B_1 = \frac{\mu_0 i}{2\pi r}$$



B_1 is perpendicular to the plane of the page, directed upwards (right-hand palm rule 1).
The field at the centre O due to the current loop of radius r is

$$B_2 = \frac{\mu_0 i}{2r}$$

B_2 is also perpendicular to the page, directed upward (right hand screw rule).

$\therefore$ Resultant field at O is

$$B_1 + B_2 = \frac{\mu_0 i}{2r}\left(\frac{1}{\pi} + 1\right) = \frac{\mu_0 i}{2\pi r}(\pi + 1)$$

10. If a coil of radius R is carrying current I, then magnetic field on its axis at a distance x from its centre is given by

$$B_{\text{axis}} = \frac{\mu_0}{4\pi} \frac{2\pi I R^2}{(x^2 + R^2)^{3/2}} \quad \ldots\text{(i)}$$

At centre,

$$B_{\text{centre}} = \frac{\mu_0 I}{2R} \quad \ldots\text{(ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{B_{\text{axis}}}{B_{\text{centre}}} = \frac{\mu_0 I R^2}{2(x^2 + R^2)^{3/2}} \times \frac{2R}{\mu_0 I}$$

$$= \frac{R^3}{(x^2 + R^2)^{3/2}} = \frac{1}{8}$$

or $$\frac{R}{(x^2 + R^2)^{1/2}} = \frac{1}{2}$$

$\Rightarrow$ $x = \sqrt{3}R$

11. . In case of straight conductor of infinite length, the magnetic field is given by

$$B = \frac{\mu_0}{4\pi} \times \frac{2i}{a}$$

$$\Rightarrow \quad 10^{-6} = \frac{10^{-7} \times 2 \times i}{0.02}$$

$$\Rightarrow \quad i = 0.1 \text{ A}$$

12. The magnetic field at a distance r from the straight wire

$$B = \frac{\mu_0 i}{2\pi r} \text{ or } B \propto \frac{1}{2}$$

or $$\frac{B_2}{B_1} = \frac{r_1}{r_2}$$

$\therefore$ $$\frac{B_2}{B} = \frac{5}{20} = \frac{1}{4} \text{ or } B_2 = \frac{B}{4}$$

13. The magnetic field due to small element conductor of length is given by

$$dB = \frac{\mu_0}{4\pi} \frac{idl \sin\theta}{r^2}$$

This value will be maximum when

$$\sin\theta = 1 = \sin 90°$$

$$\theta = 90°$$

14. Magnetic field $B = \mu_0 ni$

$$= 4\pi \times 10^{-7} \times 5 \times 1000 = 2\pi \times 10^{-3} \text{T}$$

15. Magnetic field at the centre due to either arm

$$B_1 = \frac{\mu_0}{4\pi} \times \frac{i}{(L/2)}[\sin 45° + \sin 45°]$$

$$= \frac{\mu_0}{4\pi} \times \frac{2\sqrt{2}i}{L}$$

Field at centre due to the four arms of the square

$$B = 4B_1 = \frac{\mu_0}{\pi} \times \frac{2\sqrt{2}i}{L}$$

i.e., $$B \propto \frac{1}{L}$$

16. The magnetic field is given by

$$B = \mu_0 ni$$

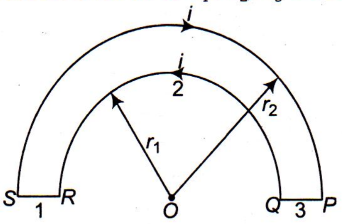
where $\mu_0 = 4\pi \times 10^{-7} \text{T mA}^{-1}$,

$$n = \frac{1000}{50 \times 10^{-2}}, \; i = 5 \text{ A}$$

$\therefore$ $$B = 4\pi \times 10^{-7} \times \frac{1000}{50 \times 10^{-2}} \times 5$$

$$B = 1.26 \times 10^{-2} \text{T}$$

17. In the following figure, magnetic field at O due to sections 1, 2, 3 and 4 are considered as B_1, B_2, B_3 and B_4 respectively.



$$B_1 = B_3 = 0$$

$$B_2 = \frac{\mu_0}{4} \cdot \frac{i}{r_1}$$

$$B_4 = \frac{\mu_0}{4} \cdot \frac{i}{r_2}$$

So, $$B_{net} = B_2 - B_4 = \frac{\mu_0 i}{4}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

18. In general, Newton's third law is not valid for electromagnetic phenomena but for long parallel conductors and steady current, we can porve that Biot-Savart law and Lorentz force give the results in accordance with Newton's third law.

19. The magnetic field at the centre of a circle is given by

$$B = \frac{\mu_0 i}{2r}$$

where, i is current and r the radius of circle.

Also, $$i = \frac{q}{t}$$

For helium nucleus, $q = 2e$

$\therefore$ $$i = \frac{2e}{t}$$

So, $$B = \frac{\mu_0 \cdot 2e}{2rt}$$

$$= \frac{\mu_0 \times 2 \times 1.6 \times 10^{-19}}{2 \times 0.8 \times 2} = 10^{-19}\mu_0$$

20. $B = \frac{\mu_0 N i}{l}$; where N = total number of turns, l = length of the solenoid.

$\Rightarrow$ $$0.2 = \frac{4\pi \times 10^{-7} \times N \times 10}{0.8} \Rightarrow N = \frac{4 \times 10^4}{\pi}$$

Since N turns are made from the winding wire, so length of the wire $(L) = 2\pi r \times N$ [$2\pi r$ = length of each turns]

$\Rightarrow$ $$L = 2\pi \times 3 \times 10^{-2} \times \frac{4 \times 10^4}{\pi}$$

$$= 2.4 \times 10^3 \text{ m}$$

21. In this case magnetic force provides necessary centripetal force *i.e.*, $qvB = \frac{mv^2}{r}$

Radius of path $r = \frac{mv}{Bq} = \frac{\sqrt{2mE}}{qB}$

$$r = \frac{\sqrt{2mE}}{Bq} = \frac{\sqrt{2m_1E_1}}{Bq}$$

or $E_1 = \frac{mE}{m_1} = \frac{(2m_1)}{m_1} \times 50 \text{ keV}$ $[\because m = 2m_1]$

$= 100 \text{ keV}$

22. The component of velocity perpendicular to H will make the motion circular while that parallel to H will make it move along a straight line. The two together will make the motion helical.

23.

24. In a perpendicular magnetic field,

Magnetic force = centripetal force

i.e., $Bqv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Bq}$

$\therefore$ $\frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{B_2}{B_1}$

$$\frac{r_1}{r_2} = \frac{1}{2} \times \frac{1}{2}$$

$$r_2 = 4r_1 \Rightarrow r_2 = 4r$$

25. A charged particle moves in a straight line under the action of an electric field whereas it moves in a circular path under the action of a magnetic field. Thus, for the particle moving in a circular path, $E = 0$, $B \neq 0$.

26. When particle describes circular path in a magnetic field, its velocity is always perpendicular to the magnetic force.

Power, $P = \mathbf{F} \cdot \mathbf{v} = Fv\cos\theta$

Here, $\theta = 90°$

$\therefore$ $P = 0$

But $P = \frac{W}{t} \Rightarrow W = P \times t$

Hence, work done

$W = 0$ (everywhere)

27. When electron moves in both electric and magnetic fields then,

$$qE = qvB$$

$$v = \frac{E}{B} = \frac{1500}{0.40} = 3750 \text{ ms}^{-1}$$

$$v = 3.75 \times 10^3 \text{ ms}^{-1}$$

28. Radius of circular path $r_a = \frac{m_a v_a}{qB}$ and $r_b = \frac{m_b v_b}{qB}$

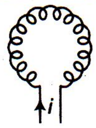
According to questions

$$r_a > r_b$$

$\therefore$ $\frac{m_a v_a}{qB} > \frac{m_b v_b}{qB}$

or $m_a v_a > m_b v_b$

29. Toroid is ring shaped closed solenoid.



30. According to Fleming's right-hand rule, the force on the charge will be towards west.

31. If magnet is cut along the axis of megnet of length l, then new pole strength becomes half *i.e.*, $m' = \frac{m}{2}$ and new length remains same *i.e.*, $l' = l$.

$\therefore$ New magnetic moment

$$M' = \frac{m}{2} \times l = \frac{ml}{2} = \frac{M}{2}$$

If non magnet is cut perpendicular to the axis of magnet, then new pole strength $m' = m$ and new length $l' = l/2$

$\therefore$ New magnetic moment

$$M' = m \times \frac{l}{2} = \frac{ml}{2} = \frac{M}{2}$$

32. For longitudinal positions

$$B_1 \propto \frac{2M}{d^3}$$

For transverse positions

$$B_2 \propto \frac{M}{d^3}$$

$$\therefore \quad \frac{B_1}{B_2} = 2:1$$

33. Work done in rotating the magnet through an angle θ from initial position (*i.e.*, $\theta_1 = 0°$) is given by

$$W = MB(\cos\theta_1 - \cos\theta)$$
$$= MB(\cos 0° - \cos\theta)$$
$$= MB(1 - \cos\theta)$$

34. In non uniform magnetic field a magnetic needle experiences a force and a torque.

35. Torque is a vector quantity and it is given by

$$\boldsymbol{\tau} = \mathbf{M} \times \mathbf{B}$$
$$= (50\hat{i}) \times [0.5\,\hat{i} + 3.0\hat{j}]$$
$$= 150\,(\hat{i} \times \hat{j})$$
$$= 150\,\hat{k}\ \text{N-m}$$

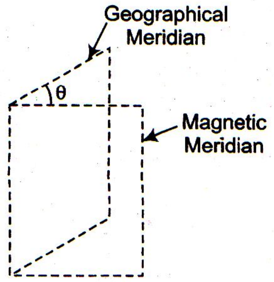
36. A freely hanged magnet stays with its magnetic axis parallel to magnetic meridian.

37. At magnetic poles, angle of dip is 90°, so horizontal component of earth

$$B_H = B\cos\theta = B\cos 90° = 0°$$

38. A dip needle in a plane perpendicular to magnetic moridian will remain always vertical.

39. Angle between magnetic meridian and geographical meridian is called angle of declination.



40. Total strength of magnetic field

$$B^2 = B_H^2 + B_V^2$$

$\therefore$ $$B_V = \sqrt{B^2 - B_H^2}$$

$$= \sqrt{(0.5)^2 - (0.3)^2} = 0.4$$

$$\tan\phi = \frac{B_V}{B_H} = \frac{0.4}{0.3} = \frac{4}{3}$$

$\therefore$ $$\phi = \tan^{-1}\left(\frac{4}{3}\right)$$

41. Vibration magnetometer is simple instrument which is used to find out the magnetic moment of a magnet or to compare the magnetic moments of two bar magnets. Here the magnet is made to oscillate and its time period is calculated, hence the instrument is called vibration magneitormeter. It's time period is given by

$$T = 2\pi\sqrt{\left(\frac{I}{MH}\right)}$$

42. Time period of vibrating magnet is given by

$$T = 2\pi\sqrt{\left(\frac{I}{MH}\right)}$$

$\therefore$ $$\frac{T_1}{T_2} = \sqrt{\left(\frac{M_2}{M_1}\right)}$$

$\therefore$ $$\frac{M_1}{M_2} = \frac{T_2^2}{T_1^2}$$

$$= \frac{(60/15)^2}{(60/10)^2} = \frac{4}{9}$$

43. For a tangent galvanometer if I amp are current flows through coil then this current is proportional to angle of deflection (of the needle).

$$I \propto \tan\theta$$

$\therefore$ $$\frac{I_1}{I_2} = \frac{\tan\theta_1}{\tan\theta_2}$$

$\Rightarrow$ $$\frac{2}{I_2} = \frac{\tan 30°}{\tan 60°}$$

$\therefore$ $$I_2 = 6\text{ A}$$

44. Time period, $T \propto \frac{1}{\sqrt{B_H}} = \frac{1}{\sqrt{B\cos\theta}}$

$\therefore \quad \frac{T_1}{T_2} = \sqrt{\frac{B_2\cos\theta_2}{B_1\cos\theta_1}}$

$\therefore \quad \frac{B_1}{B_2} = \frac{T_2^2}{T_1^2} \times \frac{\cos\theta_2}{\cos\theta_1}$

$= \left(\frac{3}{2}\right)^2 \times \frac{\cos 60°}{\cos 30°}$

$\therefore \quad \frac{B_1}{B_2} = \frac{9}{4\sqrt{3}}$

45. $L = \pi R \therefore R = \frac{L}{\pi}$

New effective length will become, $L' = 2R = \frac{2L}{\pi}$

[CHEMISTRY]

46. The order of acid strength is RCOOH > HOH > ROH > HC≡CH
Electron-releasing alkyl group R in ROH makes it lesser acidic than H_2O.

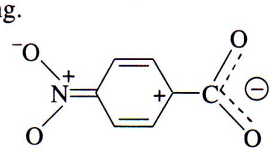
47. Nearer the chlorine to the —COOH group, stronger the acidity. Hence, the correct order is
$CH_3CH_2CHClCOOH > CH_3CHClCH_2COOH > CH_2ClCH_2CH_2COOH$

48. Larger the electronegativity of halogen, stronger the acidity. Hence, the correct order is
$FCH_2COOH > BrCH_2COOH > ICH_2COOH$

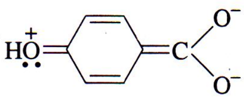
49. Tollens reagent gives white precipitate with methanoic acid and not with ethanoic acid.

50. Electron-releasing group makes benzoic acid a weaker acid while electron-attracting group makes it a stronger acid. Stronger the acid, lesser the value of pK_a°. Hence, the correct order is
$pK_a^\circ(p\text{-}O_2NC_6H_4COOH) < pK_a^\circ(C_6H_5COOH) < pK_a^\circ(p\text{-}HOC_6H_4COOH)$

51. The nitro group interacts with the phenyl ring and thereby induces some positive charge on the ring bearing the COO^- causing a strong electron-withdrawing inductive effects on COO^- group. This effect is base-stabilizing and thus acid strengthening.



52. At *para* position, —OH places negative charge on the carboxylate group and thus making it



weaker than bezoic acid. This effect predominates over its electron-withdrawing acid strengthening inductive effect. However, at *meta* position, there is no such resonance effect and only inductive effect operates and because of its nearness to the COOH group, *meta* isomer is stronger acid than its *para* isomer.

53. *Meta* hydroxy is stronger than *para* isomer (see Q.52). Because of the *ortho effect*, *ortho* isomer is the strongest acid.

54. Increasing crowdiness near the site of esterification decreases the rate of esterification. Hence, the correct order is 1° > 2° > 3°.

55. Same as Q 54 The correct order is $RCH_2COOH > R_2CHCOOH > R_3CCOOH$

56. α-Hydrogen is replaced by chlorine. The product is $CH_3CH(Cl)COOH$.

57. Heating calcium formate along with calcium benzoate produces benzaldehyde.

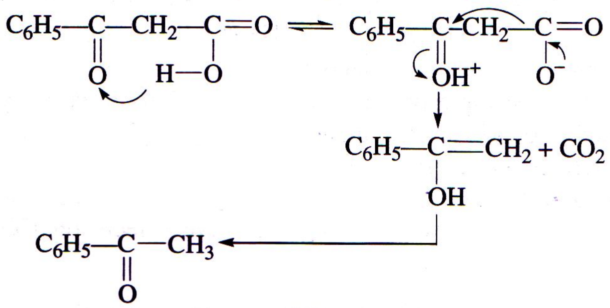
58. The products are CO and H_2O. $HCOOH \xrightarrow{\text{Conc. } H_2SO_4} CO + H_2O$.

59. The Hell-Volhard-Zelinsky reaction is used in the synthesis of α-haloacids.

60. In p-$CH_3COC_6H_4COOH$, the CO group is also reduced by $LiAlH_4$.

61. Succinic acid ($HOOCCH_2CH_2COOH$) gives cyclic anhydride on heating.

62. β-Ketoacids are unstable acids. These readily undergo decarboxylation through a cyclic transition state



63.

64. Bromine is lesser electronegative than fluorine. Bromine attached to β-carbon will cause least enhancement in the dissociation of halo substituted propanoic acid.

65. Carboxylic acids have relatively high boiling points because of hydrogen bonds. Their boiling points are somewhat higher than those of alcohols of comparable molar masses. Since there exists no hydrogen bondings in aldehydes, their boiling points are lower than those of corresponding alcohols.

66. BH_3/THF followed by H_3O^+ reduces only —COOH group without affecting —CO— group. $LiAlH_4$ reduces only —COOH group without affecting C=C group.

67. The order of reactivity is acid chloride > anhydride > ester.

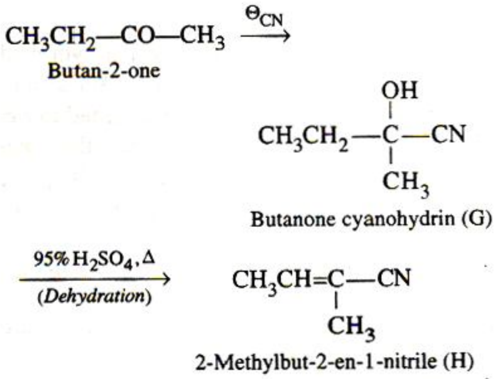
68. The correct order is $Cl^- < RCOO^- < RO^-$.

69. The correct order is $Cl^- < RO^- < NH_2^-$.

70. Electron-withdrawal group increasing reactivity of hydrolysis while the electron-releasing group decreases reactivity. The correct order is p-$O_2NC_6H_4COCl$ > $PhCOCl$ > p-$CH_3OC_6H_4COCl$.

71. (a)
72. (a)
73. (b)
74. (b)
75. (a)

76.



Please note that hydrolysis of cyanides to carboxylic acids requires addition of a molecule of H_2O. *Since 95% H_2SO_4 cannot supply H_2O, therefore, dehydration of (G) occurs to give (H).*

77.

Due to ortho-effect, *o*-nitrobenzoic acid is the strongest acid. Further since electron-withdrawing groups such as NO_2 increase while electron-donating groups such as OH decrease the acid strength *w.r.t.* parent acid, therefore, the overall acidity increases in the order : $C < D < B < A$, *i.e.*, option (*d*) is correct.