[PHYSICS]

1.
. The effective acceleration of a bob in water $= g' = g\left[1 - \dfrac{\sigma}{\rho}\right]$

where σ and ρ are the densities of water and the bob respectively. Since, the periods of oscillation of the bob in air and water are given as

$$T = 2\pi\sqrt{\dfrac{l}{g}} \text{ and } T' = 2\pi\sqrt{\dfrac{l}{g'}}$$

$\therefore$ $\qquad \dfrac{T}{T'} = \sqrt{\dfrac{g'}{g}} = \sqrt{\dfrac{g\left(1 - \dfrac{\sigma}{\rho}\right)}{g}}$

$$= \sqrt{1 - \dfrac{\sigma}{\rho}} = \sqrt{1 - \dfrac{1}{\rho}} \qquad [\because \sigma = 1]$$

Putting $\qquad \dfrac{T}{T'} = \dfrac{1}{\sqrt{2}}$

We obtain, $\qquad \dfrac{1}{2} = 1 - \dfrac{1}{\rho} \Rightarrow \rho = 2$

2. When the elevator is at rest, its time period is given by

$$T = 2\pi\sqrt{\dfrac{l}{g}} = 2\pi\sqrt{\dfrac{l}{10}}$$

When the elevator accelerates upwards, its time period becomes

$$T' = 2\pi\sqrt{\dfrac{l}{g + a}} = 2\pi\sqrt{\dfrac{l}{10 + 10}}$$

$$= 2\pi\sqrt{\dfrac{l}{20}}$$

$$= 2\pi\sqrt{\dfrac{l}{10}} \times \dfrac{1}{\sqrt{2}}$$

$$= \dfrac{T}{\sqrt{2}}$$

3. Velocity of bob $v = \sqrt{2gl(1 - \cos\theta)}$

$$= \sqrt{2 \times 9.8 \times 2 \times (1 - \cos 60°)}$$

$$v = \sqrt{2 \times 9.8} \text{ m/s}$$

4.

5.

6. Let displacement equation of particle executing SHM is

$$y = a \sin \omega t$$

As particle travels half of the amplitude from the equilibrium position, so

$$y = \frac{a}{2}$$

Therefore, $$\frac{a}{2} = a \sin \omega t$$

or $$\sin \omega t = \frac{1}{2} = \sin \frac{\pi}{6}$$

or $$\omega t = \frac{\pi}{6}$$

or $$t = \frac{\pi}{6\omega}$$

or $$t = \frac{\pi}{6\left(\frac{2\pi}{T}\right)}$$ $$\left(\text{as } \omega = \frac{2\pi}{T}\right)$$

or $$t = \frac{T}{12}$$

Hence, the particle travels half of the amplitude from equilibrium in $\frac{T}{12}$ s.

or

60. Given,

and

7.

8.

9.

10.

11. Time period of a simple pendulum

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

It is independant of the mass of the bob. Therefore time period of the pendulum will remain T.

12.

13. Time period of simple pendulum,

$$T = 2\pi \sqrt{\frac{l}{g}} \Rightarrow \frac{\Delta T}{T} = \frac{1}{2} \frac{\Delta l}{l}$$

But at temperature $\theta°$ C, increase in length of pendulum,

$$\frac{\Delta l}{l} = \alpha \Delta \theta$$

∴ $$\frac{\Delta T}{T} = \frac{1}{2} \alpha \Delta \theta$$

or $$\frac{\Delta T}{T} = \frac{1}{2} \times 9 \times 10^{-7} \times (30 - 20)$$

$$= \frac{1}{2} \times 9 \times 10^{-7} \times 10$$

$$= 4.5 \times 10^{-6}$$

or $\qquad \Delta T = 4.5 \times 10^{-6} \times 0.5$

$\qquad\qquad\qquad = 2.25 \times 10^{-6}$ s

14.

15.

16. **(b)** Acceleration of simple harmonic motion is

$$a_{\max} = -\omega^2 A$$

or $\quad \dfrac{(a_{\max})_1}{(a_{\max})_2} = \dfrac{\omega_1^2}{\omega_2^2}$ (as A remains the same)

or $\quad \dfrac{(a_{\max})_1}{(a_{\max})_2} = \dfrac{(100)^2}{(1000)^2} = \left(\dfrac{1}{10}\right)^2 = 1:10^2$

17. **(d)** Time period of spring pendulum, $T = 2\pi\sqrt{\dfrac{M}{k}}$.

If now mass in doubled $T' = 2\pi\sqrt{\dfrac{2M}{k}} = \sqrt{2}T$

18. **(b)** Acceleration $\propto -$ (displacement).

$$A \propto -y$$
$$A = -\omega^2 y$$

$$A = -\dfrac{k}{m}y$$

$$A = -ky$$

Here, $y = x + a$

$\therefore$ acceleration $= -k(x + a)$

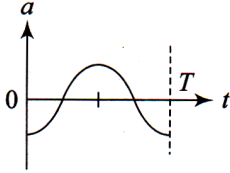19. **(b)** Use the law of conservation of energy. Let x be the extension in the spring.

Applying conservation of energy

$$mgx - \dfrac{1}{2}kx^2 = 0 - 0 \implies x = \dfrac{2mg}{k}$$

20. **(c)** Displacement, $x = A \cos(\omega t)$ (given)

Velocity, $v = \dfrac{dx}{dt} = -A\omega \sin(\omega t)$

Acceleration, $a = \dfrac{dv}{dt} = -A\omega^2 \cos(\omega t)$

Hence graph (c) correctly depicts the variation of a with t.

21. **(c)** The two displacement equations are $y_1 = a \sin(\omega t)$

and $y_2 = b \cos(\omega t) = b \sin\left(\omega t + \dfrac{\pi}{2}\right)$

$y_{eq} = y_1 + y_2$

$= a \sin \omega t + b \cos \omega t$

$= a \sin \omega t + b \sin\left(\omega t + \dfrac{\pi}{2}\right)$

Since the frequencies for both SHMs are same, resultant motion will be SHM.

Now $A_{eq} = \sqrt{a^2 + b^2 + 2ab \cos\dfrac{\pi}{2}}$

$\Rightarrow \quad A_{eq} = \sqrt{a^2 + b^2}$

22. **(a)** Maximum velocity $V_{max} = A\omega = \beta$ **(i)**

maximum acceleration $\alpha_{max} = A\omega^2 = \alpha$ **(ii)**

Equation (ii) divided by (i) $\omega = \dfrac{\omega}{\beta} \Rightarrow \dfrac{2\pi}{T} = \dfrac{\omega}{\beta}$

$T = \dfrac{2\pi\beta}{\alpha}$

AVIRAL CLASSES
CREATING SCHOLARS

23. **(a)** If initial length $l_1 = 100$ then $l_2 = 121$

By using $T = 2\pi\sqrt{\dfrac{l}{g}} \Rightarrow \dfrac{T_1}{T_2} = \sqrt{\dfrac{l_1}{l_2}}$

Hence, $\dfrac{T_1}{T_2} = \sqrt{\dfrac{100}{121}} \Rightarrow T_2 = 1.1T_1$

% increase $= \dfrac{T_2 - T_1}{T_1} \times 100 = 10\%$

Alternative: Time period of simple pendulum

$$T = 2\pi\sqrt{\dfrac{l}{g}} \Rightarrow T \propto \sqrt{l}$$

$\therefore \quad \dfrac{\Delta T}{T} = \dfrac{1}{2}\dfrac{\Delta l}{l}$

Since, $\dfrac{\Delta l}{l} = 21\%$

$\therefore \quad \dfrac{\Delta T}{T} = \dfrac{1}{2} \times 21\% \approx 10\%$

24. **(d)** As springs are connected in series, effective **force** constant

$$\dfrac{1}{k} = \dfrac{1}{k_1} + \dfrac{1}{k_2} \Rightarrow k = \dfrac{k_1 k_2}{k_1 + k_2}$$

Hence, frequency of oscillation is

$$n = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}} = \dfrac{1}{2\pi}\sqrt{\dfrac{k_1 k_2}{(k_1 + k_2)m}}$$

25. **(c)** $n = \dfrac{1}{2\pi}\sqrt{\dfrac{K_{\text{effective}}}{m}}$

Springs are connected in parallel

$$K_{\text{eff}} = K_1 + K_2 = K + 2K = 3K$$

$\Rightarrow \quad n = \dfrac{1}{2\pi}\sqrt{\dfrac{(K + 2K)}{m}} = \dfrac{1}{2\pi}\sqrt{\dfrac{3K}{m}}$

26. **(a)** As springs are connected in series, effective force constant

$$\dfrac{1}{k_{\text{eff}}} = \dfrac{1}{k} + \dfrac{1}{k} = \dfrac{2}{k} \Rightarrow k_{\text{eff}} = \dfrac{k}{2}$$

Hence, frequency of oscillation is

$$n = \dfrac{1}{2\pi}\sqrt{\dfrac{k_{\text{eff}}}{m}} = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{2M}}$$

AVIRAL CLASSES
CREATING SCHOLARS

27. For a simple harmonic motion

$$\frac{d^2y}{dt^2} \propto -y$$

Hence, equation $y = \sin \omega t - \cos \omega t$

and $y = 5\cos\left(\frac{3\pi}{4} - 3\omega t\right)$ are satisfying this

condition and equation $y = 1 + \omega t + \omega^2 t^2$ is not periodic and $y = \sin^3 \omega t$ is periodic but not SHM.

28. The motion of planets around the sun is periodic but not simple harmonic motion.

29. For freely falling case the effective g is zero, so that frequency of oscillation will be zero.

As $f = \frac{1}{2\pi}\sqrt{\frac{g_{eff}}{\lambda}}$

$f = \frac{1}{2\pi}\sqrt{\frac{0}{\lambda}}$

$f = 0$

30. $x(t) = A\cos(\omega t + \phi)$

where, ϕ is the phase constant.

31. $y_1 = 5[\sin 2\pi t + \sqrt{3}\cos 2\pi t]$

$= 10\left[\frac{1}{2}\sin 2\pi t + \frac{\sqrt{3}}{2}\cos 2\pi t\right]$

$= 10\left[\cos\frac{\pi}{3}\sin 2\pi t + \sin\frac{\pi}{3}\cos 2\pi t\right]$

$= 10\left[\sin\left(2\pi t + \frac{\pi}{2}\right)\right] \Rightarrow A_1 = 10$

Similarly, $y_2 = 5\sin\left(2\pi t + \frac{\pi}{4}\right)$

$\Rightarrow A_2 = 5$

Hence, $\frac{A_1}{A_2} = \frac{10}{5} = \frac{2}{1}$

32. The potential energy, $U = \frac{1}{2}kx^2$

$2U = kx^2$

$2U = -Fx$ $(\because F = -kx)$

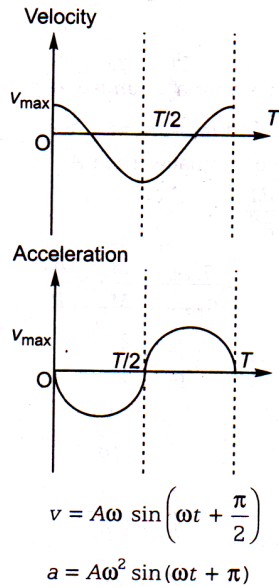or $\frac{2U}{F} = -x$

or $\frac{2U}{F} + x = 0$

33. Phase difference $\Delta\phi = \phi_1 - \phi_2$

$= \frac{3\pi}{6} - \frac{\pi}{6}$

$= \frac{2\pi}{6} = \frac{\pi}{3}$

34. In SHM, the acceleration is ahead of velocity by a phase angle $\dfrac{\pi}{2}$.

$$v = A\omega \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$a = A\omega^2 \sin(\omega t + \pi)$$

35. The total energy a particle executing SHM

$$= \frac{1}{2} m\omega^2 A^2$$

The PE of the particle at a distance x from the equilibrium position

$$= \frac{1}{2} m\omega^2 x^2$$

From the question, $\dfrac{1}{2} m\omega^2 x^2 = \dfrac{1}{2}\left(\dfrac{1}{2} m\omega^2 A^2\right)$

$$\Rightarrow \qquad x^2 = \frac{A^2}{2} \Rightarrow x = \frac{A}{\sqrt{2}}$$

36. The average acceleration of a particle performing SHM over one complete oscillation is zero.

37. Let x be the point where KE = PE

Hence

$$\frac{1}{2} m\omega^2 (a^2 - x^2) = \frac{1}{2} m\omega^2 x^2$$

$$2x^2 = a^2, \ x = \frac{a}{\sqrt{2}}$$

$$x = \frac{4}{\sqrt{2}} = 2\sqrt{2} \ \text{cm}$$

38. By using $k \propto \dfrac{1}{l}$

Since, one-fourth length is cut away so remaining length is $\dfrac{3}{4}$ th, hence k becomes $\dfrac{4}{3}$ times ie, $k' = \dfrac{4}{3} k$.

39. Maximum velocity $v_{max} = A\omega$

$$\omega = \frac{2\pi}{T}$$

$\therefore$

$$v_{max} = \frac{2\pi A}{T}$$

$$v \propto \frac{A}{T}$$

$\therefore$

$$\frac{v_1}{v_2} = \frac{A_1}{A_2} \times \frac{T_2}{T_1} = \frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$$

$$v_2 = 6\, v_1 = 6\, v$$

40. For the given figure,

$$f = \frac{1}{2\pi} \sqrt{\frac{k_{eq}}{m}} \qquad\qquad \dots(i)$$

$$= \frac{1}{2\pi} \sqrt{\frac{2k}{m}}$$

If one spring is removed, then $k_{eq} = k$ and

$$f' = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \qquad\qquad \dots(ii)$$

From Eqs. (i) and (ii), we get

$$\frac{f}{f'} = \sqrt{2}$$

$$f' = \frac{1}{\sqrt{2}}\, f$$

41. $\dfrac{d^2 x}{dt^2} + 16x = 0$

$\therefore$

$$\omega^2 = 16 \Rightarrow \omega = 4$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{4} = \frac{\pi}{2}$$

42.

In a complete cycle of SHM, potential energy varies for half the cycle and kinetic energy varies for the other half of the cycle. Thus, for a time period T, the potential energy varies for $\dfrac{T}{2}$ time.
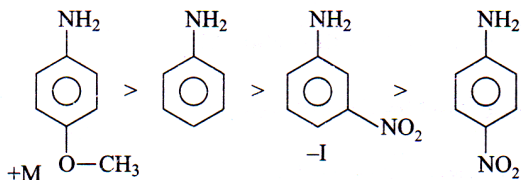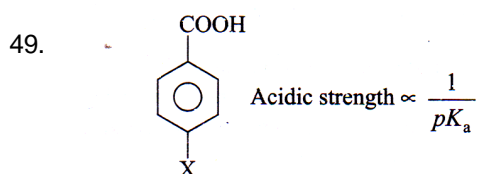
43.
44.
45.

[CHEMISTRY]

46. EDG (+M increases stability)

47. EWG decreases basic strength
EDG increases basic strength

48. More is number of EWG

49.

Acidic strength $\propto \dfrac{1}{pK_a}$

EWG increases acidic strength

50. Due to –I effect and ortho effect.

51. $-NO_2 > -CN > -F > -NH_2$.

52. $-\overset{+}{N}(CH_3)_3 > -\overset{+}{N}H_3 > -\overset{+}{S}(CH_3)_2 > -F$.

53. Two Cl from same positions gives greater –I-effect than a single F from the same position hence.
$Cl_2CHCOOH$ is stronger acid than FCH_2COOH.

54. $-\overset{\underset{\parallel}{O}}{C}-$ shows –I effect, $CH_3 \rightarrow \overset{\underset{\parallel}{O}}{C} \leftarrow CH_2 \leftarrow CH_3$

55. Ist structure is aromatic in all there examples and 2nd structure is not aromatic and resonance energy of aromatic compound is higher than non aromatic compound.

56. For resonance conjugation should be present as that conjugate site doesn't have π bond.

57. As positive charge is on electropositive carbon.

58. There are unpaired electrons, others have no unpaired electrons.

59. Rate of electrophilic substitution $\propto$ stability of arenium ion

60. The bond order of C – N bond is 2 in III, shortest, 1 in II, longest bond. There is greater extent of delocalisation of nitrogen lone pair in IV because it brings negative charge on oxygen than in I where negative charge moves on carbon. Hence, C – N bond acquire greater partial double bond character in IV than in I. This results in greater shortening of C – N bond length in IV than in I, although I has more resonating structures.

61. A carboxylic acid is always stronger acid than phenol. However, between III and IV, III is more acidic as –CH$_3$ decreases acidic strength by +I effect. Between I and II, II is stronger acid as –Cl has net electron withdrawing effect.

62. I is least acidic due to the absence of any electron withdrawing group on ring. IV is most acidic due to the electron withdrawing resonance effect of –NO$_2$ from ortho-position, although intramolecular

H-bonding decreases acidic strength to some extent. III is less acidic than II due to the steric inhibition of resonance of –NO$_2$ by two adjacent methyl groups.

63. H$_3$N$^{\oplus}$– (CH$_2$)$_2$ – COOH has strongest acid due to strong –I effect of –$\overset{\oplus}{N}$H$_3$

64. The acidity of phenols increases strongly due to – I, – m group on their ortho and para positions. But para substituted phenol is more acidic than ortho substituted due to intramolecular hydrogen bonding in the ortho substituted phenol.

65.

(Strong –I, –M effect of –NO$_2$ group)

(+M effect of –OCH$_3$ group)
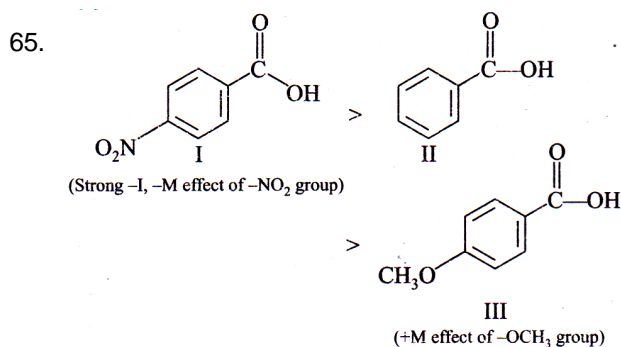
66. In nitromethane, hyperconjugation occurs significantly as
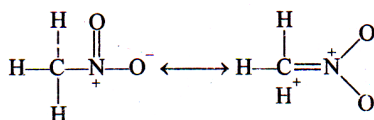
The above hyperconjugation and involved charge separation is responsible for the large dipole moment of nitromethane than calculated theoretically.

67. On the basis of stability of conjugate base due to electronic effects.

68. (c) In the present case, basicity parallels nucleophilicity. R$_3$C$^-$ is the strongest base, hence strongest nucleophile. F$^-$ is weakest base therefore weakest nucleophile. R$_2$N$^-$ is stronger base and stronger nucleophile than RO$^-$.

69. Decreasing order of dipole moment for given compounds:
I > IV > III > III

70.

71.
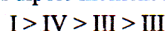
72.   contain 10π electrons. Azulene is a dipolar ion and has both rings aromatic in its ionic form.
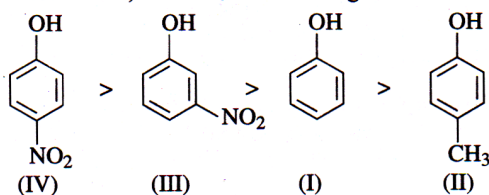
73. As it doesn't obey Huckel's rule.

74. Dipole moment, boiling point and water solubility are greater for II (cis) but melting point is greater for I (trans) isomer.

75. Mesomeric effect is applicable at ortho and para position

76. Vacant d orbital resonance

77. +M, + I stabilize carbocation

78. More stable carbocation due to delocalisation and hyperconjugation.

79. It is an aromatic carbocation, highly stable.

80. (E) 3° and resonance stabilized carbocation

    (D) 2° and resonance stabilized carbocation

    (B) 3° carbocation

    (A) 2° carbocation

    (C) 1° carbocation

81. Although NH_4^+ has positive charge, all its atoms have complete noble gas configuration, does not require electrons, hence not an electrophile.

82. $-NO_2$ has greater electron withdrawing power than $-CN$ by resonance effect, hence IV is most stable followed by III. II is least stable as delocalisation of negative charge is opposed by electron donating resonance effect of methoxy group.

83.

84. Carboxylic acids are stronger acid than $\overset{\oplus}{N}H_3$ in amino acid and $-\overset{\oplus}{N}H_3$ (Y). (Z) is more acidic than (Y) due to $-I$ effect of ($-COOH$) group which is nearer to (Z) than (Y). Hence, the acidic order: $X > Z > Y$.

85. Any factor which stabilizes phenoxide ion makes the corresponding phenol more acidic.

    $-NO_2$ is an electron-attracting group whereas $-CH_3$ is an electron-releasing group.

    An electron-attracting substituent tends to disperse the negative charge of the phenoxide ion and thus, makes it more stable, which, in turn, increases the acid strength of phenol. The substituent in para position is more effective than in the meta-position, as the former involves a resonating structure bearing negative charge on the carbon attached to the electron-withdrawing substituent.

    An electron-releasing substituent tends to intensify the negative charge of the phenoxide ion and thus makes it more unstable. which, in turn, decreases the acid strength of phenol. Hence, the order of acid strength is

86. $\underset{sp^2}{\overset{1}{C}H_2}=\underset{sp^2}{\overset{2}{C}H}-\underset{sp^3}{\overset{3}{C}H_2}-\overset{4}{C}H_2-\overset{5}{C}\equiv\overset{6}{C}H$

87. $-CH_3$ is the best nucleophile because carbon is least electronegative among the given options. The order is

    $H_3\bar{C} > \bar{N}H_2 > \bar{O}H > F^-$

88.
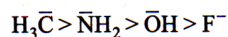
    $\begin{pmatrix} 5,6\text{-Diethyl-3-methyl} \\ dec\text{-}4\text{-ene} \end{pmatrix}$

89. Dipole moment of *p*-dichlorobenzene is zero because of symmetrical structure. *o*-and *m*-dichlorobenzene have higher dipole moments than toluene due to high electronegativity of chlorine than $-CH_3$ group. Further, the *o*-dichlorobenzene has higher dipole moment due to lower bond angle of the *m*-isomer. Hence, the order of increasing dipole moment is: *p*-dichlorobenzene (IV) < toluene (I) < *m*-dichlorobenzene (II) < *o*-dichlorobenzene (III)

90. Alkyl groups with at least one hydrogen atom on the α-carbon atom, attached to an unsaturated carbon atom, are able to release electrons in the following way.

    Note that the delocalization involves σ and π bond orbitals (or *p* orbitals in case of free radicals); thus it is also known

    as σ–π *conjugation*. This type of electron release due to the presence of the system $H - C - C = C$ is known as *hyperconjugation*. This is also known as no bond resonance.