WEEKLY TEST MEDICAL PLUS - 01 TEST - 23 R & B SOLUTION Date 10-11-2019

[PHYSICS]

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

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

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

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

2. **(d)** Velocity is the time derivative of displacement.

Writing the given equation of a point performing SHM

$$x = a\sin\left(\omega t + \frac{\pi}{6}\right) \quad \ldots(i)$$

Differentiating Eq. (i), w.r.t. time, we obtain

$$v = \frac{dx}{dt} = a\,\omega\cos\left(\omega t + \frac{\pi}{6}\right)$$

It is given that $v = \frac{a\omega}{2}$, so that

$$\frac{a\omega}{2} = a\,\omega\cos\left(\omega t + \frac{\pi}{6}\right)$$

or $$\frac{1}{2} = \cos\left(\omega t + \frac{\pi}{6}\right)$$

or $$\cos\frac{\pi}{3} = \cos\left(\omega t + \frac{\pi}{6}\right)$$

or $$\omega t + \frac{\pi}{6} = \frac{\pi}{3} \Rightarrow \omega t + \frac{\pi}{6}$$

or $$t = \frac{\pi}{6\omega} = \frac{\pi \times T}{6 \times 2\pi} = \frac{T}{12}$$

Thus, at $T/12$ velocity of the point will be equal to half of its maximum velocity.

3. **(d)** $v = \frac{dy}{dt} = A\omega \cos \omega t = A\omega\sqrt{1 - \sin^2 \omega t}$

$= \omega\sqrt{A^2 - y^2}$

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

$\therefore \quad v = \omega\sqrt{a^2 - \frac{a^2}{4}} = \omega\sqrt{\frac{3a^2}{4}} = \frac{2\pi}{T}\frac{a\sqrt{3}}{2} = \frac{\pi a\sqrt{3}}{T}$

4. **(b)** Acceleration $\propto$ – (displacement).

$A \propto -y$

$A = -\omega^2 y$

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

$A = -ky$

Here, $y = x + a$

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

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

Applying conservation of energy

$$mgx - \frac{1}{2}kx^2 = 0 - 0 \Rightarrow x = \frac{2mg}{k}$$

6. **(c)** For a particle executing SHM

acceleration $a \propto -\omega^2$ displacement (x) ...(i)

Given $x = a\sin^2 \omega t$ ...(ii)

Differentiating the above equation, we get

$$\frac{dx}{dt} = 2a\omega(\sin \omega t)(\cos \omega t)$$

Again differentiating, we get

$$\frac{d^2x}{dt^2} = a = 2a\omega^2\left[\cos^2 \omega t - \sin^2 \omega t\right]$$

$$= 2a\omega^2 \cos 2\omega t$$

The given equation does not satisfy the condition for SHM [Eq. (i)]. Therefore, motion is not simple harmonic.

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

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

8. **(d)** The given velocity-position graph depicts that the motion of the particle is SHM.

In SHM, at $t = 0$, $v = 0$ and $x = x_{max}$.

So, option (d) is correct.

9. **(b)** For a simple harmonic motion $\frac{d^2y}{dt^2} \propto -y$

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

$y = 5 \cos\left(\frac{3\pi}{4} - 3\omega t\right)$ satisfy 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.

Option (c) is correct.

10. **(b)** Equation of SHM is given by

$$x = A \sin(\omega t + \delta)$$

$(\omega t = \delta)$ is called phase.

when $x = \frac{A}{2}$, then

$$\sin(\omega t + \delta) = \frac{1}{2} \Rightarrow \omega t + \delta = \frac{\pi}{6}$$

or $\phi_1 = \frac{\pi}{6}$

For second particle, $\phi_2 = \pi - \frac{\pi}{6} = \frac{5\pi}{6}$

$\therefore \quad \phi = \phi_2 - \phi_1$

$$= \frac{4\pi}{6} = \frac{2\pi}{3}$$

11. **(a)** Given, damping force $\propto$ velocity

$$F = kv \Rightarrow k = \frac{F}{v}$$

Unit of $k = \frac{\text{unit of } F}{\text{unit of } v} = \frac{\text{kg-ms}^{-2}}{\text{ms}^{-1}} = \text{kgs}^{-1}$

12. **(b)** We now that $v_{max} = a\omega$ and $v = n\lambda$

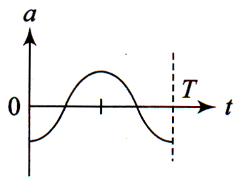
$$\therefore \quad \frac{v_{max}}{v} = \frac{a\omega}{n\lambda} = \frac{a(2\pi n)}{n\pi} = \frac{2\pi a}{\lambda}$$

$$= \frac{2\pi a}{2\pi / k} = ka = \frac{\pi}{2} \times 3 = \frac{3\pi}{2}$$

13. **(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.

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

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

$$y_{eq} = y_1 + y_2$$
$$= a\sin\omega t + b\cos\omega t$$
$$= a\sin\omega t + b\sin\left(\omega t + \frac{\pi}{2}\right)$$

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

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

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

15. **(b)** As we know, for particle undergoing SHM,

$$V = \omega\sqrt{A^2 - X^2}$$

$$V_1^2 = \omega^2\left(A^2 - x_1^2\right) \text{ and } V_2^2 = \omega^2\left(A^2 - x_2^2\right)$$

On subtracting the relations

$$V_1^2 - V_2^2 = \omega^2\left(x_2^2 - x_1^2\right)$$

$$\omega = \sqrt{\frac{V_1^2 - V_2^2}{x_2^2 - x_1^2}}$$

$$T = 2\pi\sqrt{\frac{x_2^2 - x_1^2}{V_1^2 - V_2^2}}$$

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

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

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

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

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

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

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

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

Alternative: Time period of simple pendulum

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

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

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

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

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

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

Hence, frequency of oscillation is

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

19. **(b)** Time taken by particle to move from $x = 0$ (mean position) to $x = 4$ (extreme position) $= \frac{T}{4} = \frac{1.2}{4} = 0.3$ sec

Let t be the time taken by the particle to move from $x = 0$ to $x = 2$ cm

$$y = a\sin\omega t \Rightarrow 2 = 4\sin\frac{2\pi}{T}t \Rightarrow \frac{1}{2} = \sin\frac{2\pi}{1.2}t$$

$$\Rightarrow \frac{\pi}{6} = \frac{2\pi}{1.2}t \Rightarrow t = 0.1\text{ sec}$$

Hence time to move from $x = 2$ to $x = 4$ will be equal to $0.3 - 0.1 = 0.2$ sec

Hence total time to move from $x = 2$ to $x = 4$ and back again $= 2 \times 0.2 = 0.4$ sec

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

Springs are connected in parallel

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

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

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

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

Hence, frequency of oscillation is

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

22. **(a)** Let $y = \sin\omega t - \cos\omega t$

$$\frac{dy}{dt} = \omega\cos\omega t + \omega\sin\omega t$$

$$\frac{d^2y}{dt^2} = -\omega^2\sin\omega t + \omega^2\cos\omega t$$

or $\quad a = -\omega^2(\sin\omega t - \cos\omega t)$

$\quad a = -\omega^2 y$

$\Rightarrow \quad a \propto -y$

This satisfies the condition of SHM. Other equations do not. Hence, $\sin\omega t - \cos\omega t$. represents SHM

23. **(d)** $T \propto \sqrt{m} \Rightarrow \frac{T_2}{T_1} = \sqrt{\frac{m_2}{m_1}} \Rightarrow \frac{5}{3} = \sqrt{\frac{M+m}{M}}$

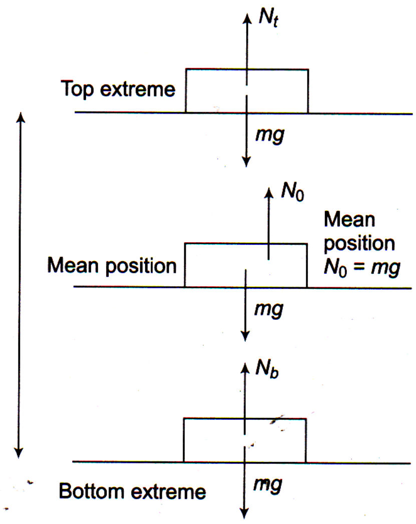
$\Rightarrow \quad \frac{25}{9} = \frac{M+m}{M} \Rightarrow \frac{m}{M} = \frac{16}{9}$

24. **(a)** In this case frequency of oscillation is given by $n = \frac{1}{2\pi}\sqrt{\frac{\sqrt{g^2+a^2}}{l}}$, where a is the acceleration of car. If a increases then n also increases.

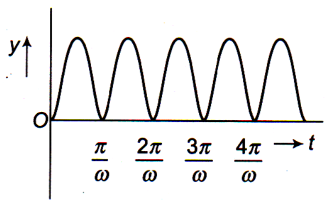
25. **(c)** The net effect of these two forces must be towards mean position.

At the mean position, there is no net force and hence normal reaction equals mg. Above mean position, normal reaction is less than mg and below mean position, normal reaction is greater than mg.

At the top extreme:



26. **(d)** Here, $y = \sin^2 \omega t$



$$\frac{dy}{dt} = 2\omega \sin\omega t \cos\omega t = \omega \sin 2\omega t$$

$$\frac{d^2y}{dt^2} = 2\omega^2 \cos 2\omega t$$

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

Hence, function is not SHM, but periodic.

From the y–t graph, time period is $t = \frac{\pi}{\omega}$

27. **(d)** Potential energy $U = k|x|^3$

Hence force, $F = -\frac{dU}{dx} = -3k|x|^2$ ...(i)

Also, for SHM, $x = a \sin \omega t$

and $\frac{d^2x}{dt^2} + \omega^2 x = 0$

$\Rightarrow$ Acceleration, $a = \frac{d^2x}{dt^2} = -\omega^2 x$

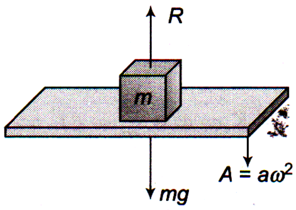
$\Rightarrow$ $F = ma = m\frac{d^2x}{dt^2} = -m\omega^2 x$ ...(ii)

From Eqs. (i) and (ii), we get $\omega = \sqrt{\frac{3kx}{m}}$

$\Rightarrow$ $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{3kx}} = 2\pi\sqrt{\frac{m}{3k(a\sin\omega t)}}$

$\Rightarrow$ $T \propto \frac{1}{\sqrt{a}}$

28. **(a)** By drawing free body diagram of object during the downward motion at extreme position, for equilibrium of mass



$mg - R = mA$ (A = Acceleration)

For critical condition $R = 0$

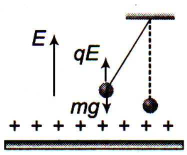
so $mg = mA \Rightarrow mg = ma\omega^2$

$$\Rightarrow \omega = \sqrt{\frac{g}{a}} = \sqrt{\frac{9.8}{3.92 \times 10^{-3}}} = 50$$

$$\Rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi}{50} = 0.1256 \text{ sec}$$

29. **(a)** In this case time period of pendulum becomes

$$T' = 2\pi\sqrt{\frac{l}{\left(g + \frac{qE}{m}\right)}}$$



$\Rightarrow \quad T' < T$

30. **(a)** $T = 2\pi\sqrt{\frac{m}{K}} \Rightarrow m \propto T^2 \Rightarrow \frac{m_2}{m_1} = \frac{T_2^2}{T_1^2}$

$$\Rightarrow \frac{M+m}{M} = \left(\frac{\frac{5}{4}T}{T}\right)^2 \Rightarrow \frac{m}{M} = \frac{9}{16}$$

30. **(c)** $\frac{mv^2}{r} > mg$

At highest point $mg = \frac{mv^2}{r} - N$

31. (d) Using acceleration $A = -\omega^2 x$

At $-x_{max}$ A will be maximum and positive.

32. (d) Acceleration $= -\omega^2 y$. So $F = -m\omega^2 y$

y is sinusoidal function.

So F will be also sinusoidal function with phase difference π

33. (d) At time $\frac{T}{2}; v = 0$ $\therefore$ Total energy = Potential energy.

34. (b) PE varies from zero to maximum. It is always positive sinusoidal function.

35. (d) Potential energy of particle performing SHM is given by: $PE = \frac{1}{2}m\omega^2 y^2$ *i.e.* it varies parabolically such that at mean position it becomes zero and maximum at extreme position.

36. (a) Potential energy is minimum (in this case zero) at mean position ($x = 0$) and maximum at extreme position ($x = \pm A$).

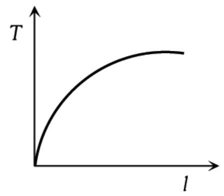
At time $t = 0$, $x = A$, hence potential should be maximum. Therefore graph I is correct. Further in graph III. Potential energy is minimum at $x = 0$, hence this is also correct.

37. (a) $f = \frac{1}{T} = \frac{1}{0.04} = 25\ Hz$

38. (d) From graph, slope $K = \frac{F}{x} = \frac{8}{2} = 4$

$$T = 2\pi\sqrt{\frac{m}{K}} \Rightarrow T = 2\pi\sqrt{\frac{0.01}{4}} = 0.3\sec$$

39. (b) $T \propto \sqrt{l} \Rightarrow T^2 \propto l$



40. C

41. (b) Total potential energy = $0.04\ J$

Resting potential energy $= 0.01\ J$

Maximum kinetic energy $= (0.04 - 0.01)$

$$= 0.03J = \frac{1}{2}m\,\omega^2 a^2 = \frac{1}{2}ka^2$$

$$0.03 = \frac{1}{2} \times k \times \left(\frac{20}{1000}\right)^2$$

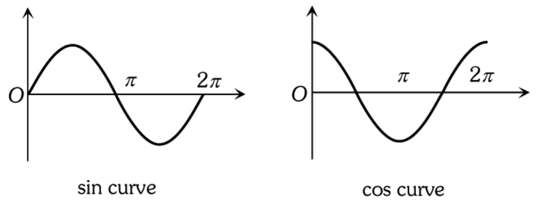
$$k = 0.06 \times 2500\ N/m = 150\ N/m.$$

42. (a) Kinetic energy varies with time but is never negative.

43. (b) Both assertion and reason are correct but reason is not the correct explanation of assertion.

44. (a) In SHM, the acceleration is always in a direction opposite to that of the displacement *i.e.*, proportional to $(-y)$.

45. (a) A periodic function is one whose value repeats after a definite interval of time. $\sin\theta$ and $\cos\theta$ are periodic functions because they repeat itself after 2π interval of time.



It is also true that moon is smaller than the earth, but this statement is not explaining the assertion.

[CHEMISTRY]

46. **(b)** $K = \kappa R = (6.67 \times 10^{-3}\ \Omega^{-1}\ cm^{-1})\ (243\ \Omega) = 1.62\ cm^{-1}$.

47. **(c)** $\lambda^{\infty}BaCl_2 = \frac{1}{2}\lambda^{\infty}Ba^{2+} + \lambda^{\infty}Cl^{-}$

$= \frac{127}{2} + 76 = 139.5\ ohm^{-1}cm^{-1}\ eq^{-1}$

48. **(d)** Molar conductivity $\propto$ no. of ions per mole of electrolyte.

49. **(a)** $CuSO_4 + 2e^- \longrightarrow Cu + SO_4^-$

$Bi_2(SO_4)_3 + 6e^- \longrightarrow 2Bi + 3SO_4^-$

$AlCl_3 + 3e^- \longrightarrow Al + 3Cl^-$

$AgNO_3 + e^- \longrightarrow Ag + NO_3^-$

50. **(c)** $\kappa = \Lambda_c = (200\ S\ cm^2\ mol^{-1})\ (0.05 \times 10^{-3}\ mol\ cm^{-1})$

$= 0.01\ S\ cm^{-1}$

$$R = \frac{1}{\kappa}\left(\frac{\ell}{A}\right) = \frac{1}{(0.01\ S\ cm^{-1})}\left(\frac{1}{3}cm^{-1}\right) = 33.33\ \Omega$$

51. **(b)** At anode $2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$

At cathode $Ag^+ + e^- \longrightarrow Ag$

52. **(d)** Since $Ag^+ + e^- \to Ag$, $Cu^{2+} + 2e^- \to Cu$, $Au^{3+} + 3e^- \to Au$, 3 F of electricity will deposit 3 moles of Ag, 1.5 moles of copper, and 1 mole of gold. Therefore, the molar ratio is 3 : 1.5 : 1 or 6 : 3 : 2.

53. **(c)** $\frac{\text{Weight of Cu}}{\text{Weight of } H_2} = \frac{\text{Eq. weight of Cu}}{\text{Eq. weight. of H}}$

$\frac{\text{Weight of Cu}}{0.50} = \frac{63.6/2}{1}$

Weight of Cu = 15.9 g

54. **(c)** $2O^{2-} \longrightarrow O_2 + 4e$

$$\text{Mole of } e = \frac{0.75 \times 10 \times 60}{96500}$$

$$\text{Mole of } O_2 = \frac{4.66 \times 10^{-3}}{4} = 0.0261 \text{ L}$$

55. **(a)** In galvanic cell/electrochemical cell electrical energy is produced due to some chemical reaction.

56. **(a)** $Zn + MgCl_2 \rightarrow ZnCl_2 + Mg$

$$\therefore E^{\circ}_{cell} = E^{\circ}_{Zn/Zn^{+2}} + E^{\circ}_{Mg^{+2}/Mg} = +0.762 - 2.37$$

$$= -1.608 \text{ V}$$

Here, E°_{cell} is negative so no reaction will take place.

57. **(c)** Salt bridge completes the electrical circuit and minimises the liquid–liquid junction potential.

58. **(b)** $Ag|Ag^+||AgI|Ag$

$$E_{cell} = E^{o}_{Ag/Ag^+} + E^{o}_{I^-/AgI(s)/Ag}$$

$$= -0.799 - 0.151 = -0.950 \text{ V}$$

59. **(a)** E° is intensive property and it does not depend on mass of F_2 taking part.

60. **(d)** More is E°_{RP}, more is the tendency to get reduced or lesser is tendency to get oxidised. $E^{o}_{RPCr^{3+}/Cr^{2+}}$ is maximum among all.

61. **(a)** More is E°_{RP}, more is oxidizing power or lesser is reducing power.

62. **(d)** For the cell: $Zn \mid ZnSO_4\,(aq) \parallel H_2SO_4\,(aq) \mid H_2\,(g) \mid Pt$

LHE reaction: $Zn \longrightarrow Zn^{2+} + 2e$

RHE reaction: $2H^+ + 2e \longrightarrow H_2$

Net reaction: $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$

or $Zn\,(s) + H_2SO_4\,(aq) \longrightarrow ZnSO_4\,(aq) + H_2\,(g)$

63. **(a)**

$Cu^{2+} + 1e^- \longrightarrow Cu^+$	$E_1 = 0.15$	...(i)
$Cu^+ + 1e^- \longrightarrow Cu$	$E_2 = 0.50$	...(ii)
$Cu^{2+} + 2e^- \longrightarrow Cu$	$E_3 = ?$	...(iii)

Clearly (iii) = (i) + (ii)

$$-\Delta G^0_3 = -\Delta G^0_1 + (-\Delta G^0_2)$$

$$2 \times F \times E_3 = 1 \times F \times E_1 + 1 \times F \times E_2$$

$$E_3 = \frac{0.65}{2} = 0.325 \text{ V}$$

64. **(c)** Lower SRP containing ion can displace higher SRP containing ion.

65. **(b)** Negative electrode potential (reduction potential) indicates lesser tendency for the reduction. Hence A is readily oxidized.

66. **(a)** The more negative the electrode potential, the lesser the tendency of the metal to undergo reduction and therefore metal would act as stronger reducing agent.

67. **(a)** More negative the standard potential, least the reduction tendency of the ion. The corresponding atom has largest oxidation tendency and thus is a strong reducing agent. Zn is the strongest reducing agent.

68. **(b)** $\Delta G^\circ = -nFE^\circ$ cell if E°_{cell} is positive, then ΔG° will be –ve showing that cell reaction is spontaneous.

69. **(b)** More the negative E° value, larger the reducing power of the metal.

70. **(c)** $Fe^{+2} + Zn \rightarrow Zn^{2+} + Fe$ (Oxidation: $Zn \rightarrow Zn^{2+}$; Reduction: $Fe^{+2} \rightarrow Fe$)

EMF = $E_{cathode} - E_{anode} = 0.44 - (0.76) = +0.32$ V

71. **(d)** The tendency to gain electron is in the order

$Z > Y > X$

Thus $Y + e \rightarrow Y^-$; $X \rightarrow X^+ + e$

72. **(a)** $E = E^\circ - \dfrac{0.0591}{n}\log\dfrac{[\text{Product}]}{[\text{Reactant}]}$

if $\dfrac{[\text{Product}]}{[\text{Reactant}]} = 1$, then $E = E^\circ$.

73. **(c)** $\frac{2}{3}Al_2O_3 \longrightarrow \frac{4}{3}Al + O_2$

Thus, $\frac{2}{3} \times 3\,(O^{2-})$

i.e., $2O^{2-} \longrightarrow O_2 + 4e^-$ $[\because n = 4]$

$\Delta G = +966$ kJ mol^{-1} = 966×10^3 J mol^{-1}

$G = -nFE_{cell}$

$966 \times 10^3 = -4 \times 96500 \times E_{cell}$

$E_{cell} = 2.5$ V