SOLUTIONS

1. (B)

$\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$

$\vec{\upsilon} = \frac{d\vec{r}}{dt} = (-a\omega\sin\omega t)\hat{i} + (a\omega\cos\omega t)\hat{j}$

$\vec{\upsilon}\cdot\vec{r} = -a^2\omega\sin\omega t\cos\omega t + a^2\omega\sin\omega t\cos\omega t = 0$

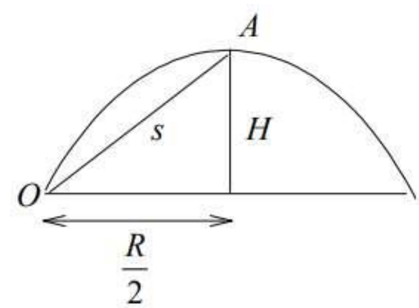
i.e., $\vec{\upsilon}$ is $\perp$ to $\vec{r}$.

2. (B)

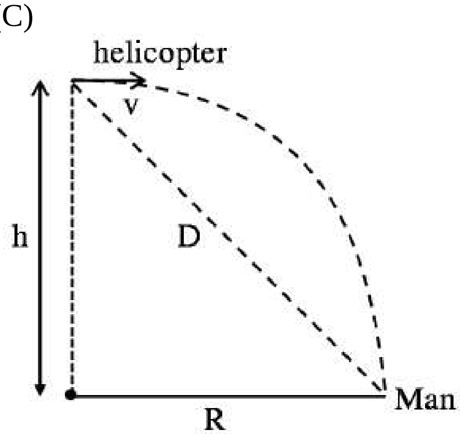
$s = \sqrt{H^2 + \left(\frac{R}{2}\right)^2}$

$H = \frac{u^2\sin^2\theta}{2g}, \frac{R}{2} = \frac{u^2\sin\theta\cos\theta}{g}$, Time of ascent, $T = \frac{u\sin\theta}{g}$

$v_{av.} = \frac{s}{T} = \frac{u}{2}\sqrt{1+3\cos^2\theta}$



3. (C)



$R = \sqrt{\frac{2h}{g}}\cdot v$

$D = \sqrt{R^2 + h^2}$

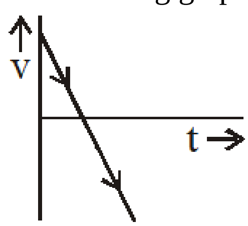
$$= \sqrt{\left(\sqrt{\frac{2h}{g}} \cdot v\right)^2 + h^2}$$

$$D = \sqrt{\frac{2hv^2}{g} + h^2}$$

Option (C) is correct.

4. (B)
Option (B) represent correct graph for particle moving with constant acceleration velocity time graph is straight line with position slope and x-t graph should be an opening upward parabola.

5. (A)
When the body is thrown vertically upwards, the acceleration remains constant and negative. Hence, the following graph correct represents velocity *vs*. time.



6. (B)

$V = \alpha t + \beta t^2$

$$\frac{ds}{dt} = \alpha t + \beta t^2$$

$$\int_{S_1}^{S_2} ds = \int_1^2 \left(\alpha t + \beta t^2\right) dt$$

$$S_2 - S_1 = \left[\frac{\alpha t^2}{2} + \frac{\beta t^3}{3}\right]_1^2$$

As particle is not changing direction
So distance = displacement

$$\text{Distance } = \left[\frac{\alpha[4-1]}{2} + \frac{\beta[8-1]}{3}\right]$$

$$= \frac{3\alpha}{2} + \frac{7\beta}{3}$$

7. (B)

$$V = \frac{dx}{dt} = 3\alpha t^2 + 2\beta t + \gamma$$

At $t = 0$, $v = r$

$$a = \frac{dv}{dt} = 6\alpha t + 2\beta$$

At $t = 0, a = 2\beta$

Ratio $= \frac{a}{V} = \frac{2\beta}{\gamma}$

8. (A)

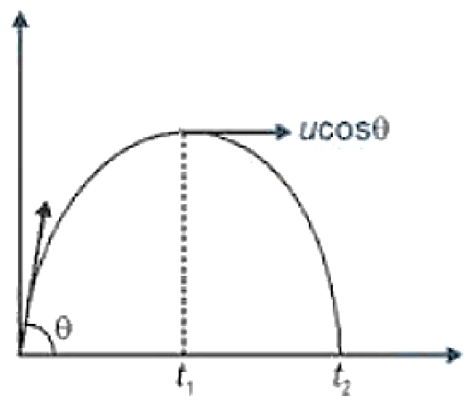
$t = mx^2 + nx$

$\frac{1}{v} = \frac{dt}{dx} = 2mx + n \qquad v = \frac{1}{2mx+n}$

$\frac{dv}{dt} = -\frac{2m}{(2mx+n)^2}\left(\frac{dx}{dt}\right)$

$a = -(2m)v^3$

9. (D)



Time of ascent

$t_1 = \frac{u\sin\theta}{g}$

Time of descent

$t_2 = \sqrt{\frac{2H}{2g}}$

$t_2 = \sqrt{\frac{u^2\sin^2\theta}{2g^2}} = \frac{u\sin\theta}{\sqrt{2}\,g}$

$t = t_1 + t_2 = \frac{u\sin\theta}{g} + \frac{u\sin\theta}{\sqrt{2}\,g}$

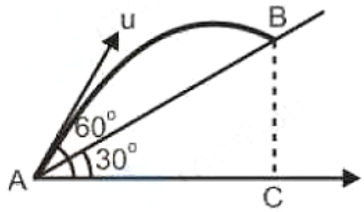
$\Rightarrow \frac{u\sin\theta}{g}\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$

10. (A)

Horizontal component of velocity

$u_H = u\cos 60^\circ = \frac{u}{2}$

$\therefore \quad AC = (u_H)t = \frac{ut}{2}$



and $AB = AC\sec 30°$

$$= \left(\frac{ut}{2}\right)\left(\frac{2}{\sqrt{3}}\right) = \frac{ut}{\sqrt{3}}$$

11. (D)

$R = \frac{u^2}{g}$ and $H = \frac{u^2 \sin^2 \theta}{2g}$

For the maximum range, $\theta = 45°$

$\therefore \quad H = \frac{u^2 \sin^2 45°}{2g} = \frac{u^2}{4g} = \frac{R}{4}$

12. (A)

$t = t_1 + t_2 = \frac{2u}{g}$

$h = ut_1 - \frac{1}{2}gt_1^2$

$= \frac{g}{2}(t_1 + t_2)t_1 - \frac{1}{2}gt_1^2 = \frac{1}{2}gt_1t_2$

$\therefore \; t_1t_2 = \frac{2h}{g}$.

13. (B)

$H = \frac{u^2 \sin^2 \theta}{2g}$ and $T = \frac{2u\sin\theta}{g}$ or $t^2 = \frac{4u^2\sin^2\theta}{g^2}$

$\therefore \quad \frac{T^2}{H} = \left(\frac{2u\sin\theta}{g}\right)^2 \times \frac{2g}{u^2\sin^2\theta} = \frac{8}{g}$

or $\quad T^2 = \frac{8H}{g}$

or $\quad T = 2\sqrt{\frac{2H}{g}}$.

14. (D)

Let $\vec{V}_R = a\hat{i} + b\hat{j}$

Case I $\vec{V}_M = 3\hat{i}$

$\vec{V}_{RM} = \vec{V}_R - \vec{V}_M = (a-3)\hat{i} + b\hat{j}$

Now, $a - 3 = 0$ as $\vec{V}_{RM}$ is vertical

Also $\left|\vec{V}_R\right|^2 = a^2 + b^2$

$\left(3\sqrt{2}\right)^2 = 3^2 + b^2$

$b = 3$

Case II $\vec{V}_M = k\hat{i}$

$\vec{V}_{MR} = (a-k)\hat{i} + 3j66 = (3-k)\hat{i} + 3\hat{j}$

For angle to be $45°, \vec{V}_{RM} = -3\hat{i} + 3\hat{j}$

$k = 6$

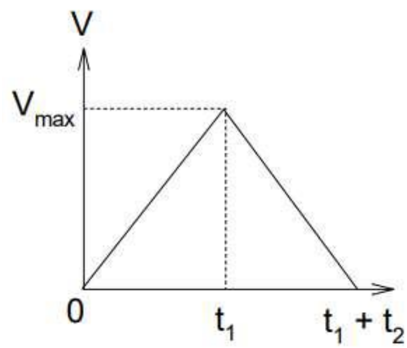
15. (A)

$V_{max} = \alpha t_1 = \beta t_2$

$t_2 = \frac{\alpha}{\beta} \times t_1$

$t_1 + t_2 = t$

$t_1 = \frac{\beta}{(\alpha+\beta)} t$



Distance = Area under Vt graph

$= \frac{1}{2} \times \alpha t_1 \times t$

$D = \frac{1}{2} \frac{\alpha\beta}{(\alpha+\beta)} t^2$

16. (BCD)

$v = \frac{dx}{dt} = 0 - 9 + \frac{3t^2}{3}$

$v = t^2 - 9$

$v = 0$ at $t = 3$

Also, $a = 2t$

The particle's velocity will be zero at $t = 3\text{sec}$. Where it changes its direction of motion.

For $0 < t < 3$ sec. v is –ve and a is +ve so particle is slowing down.

17. (ABC)

At $t = \frac{T}{4}$ and $t = \frac{3T}{4}$, the stone is at same height,

Hence average velocity in this time interval is zero.

Change in velocity in same time interval is same for a particle moving with constant acceleration.

Let H be maximum height attained by stone, then distance travelled from $t = 0$ to $t = \frac{T}{4}$ is $\frac{3}{4}H$ and from $t = \frac{T}{4}$ to $t = \frac{3T}{4}$ distance travelled is $\frac{H}{2}$.

From $t = \frac{T}{2}$ to $t = T$ sec distance travelled is H and from $t = \frac{T}{2}$ to $t = \frac{3T}{4}$ distance travelled is $\frac{H}{4}$.

18. (ABD)

When particle makes angle 45° with the horizontal.

$v_y = \pm v_x$

$u\sin 53° - gt = \pm u\cos 53°$

$\Rightarrow \; t = \frac{u}{g}\left(\frac{4}{5} \mp \frac{3}{5}\right)$

$\therefore \; t = \frac{u}{5g} = 1\text{ s}$ and $t = \frac{7u}{5g} = 7\text{ s}$

19. (ABD)

Equation of straight line can be written as

$a = \frac{-5}{2}t + 10$

$\frac{dv}{dt} = \frac{-5}{2}t + 10$

$\int_u^v dv = \int_0^t \left(\frac{-5}{2}t + 10\right)dt$

$v = \frac{-5}{4}t^2 + 10t + u$

For same initial velocity

$v = u$

$\frac{-5}{4}t^2 + 10t + u = u$

$t = 0, 8$

20. (AC)

w.r.t. to observer (V_x) football/obs. = 11 – 11 = 0

So, Motion of the ball as seen from observer will be purely vertical with initial velocity $11\sqrt{3}$ upwards.

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TOPIC: ATOMIC STRUCTURE

SOLUTIONS

21. (D)

$$E = \frac{-13.6\,z^2}{n^2}$$

as move away from the nucleus the energy increases, hence energy is maximum at infinite distance from the nucleus.

22. (D)

When electron jump higher level to lower level, it emit the photon. But if electron from lower level to higher level, It absorb
photon. Hence '1s' only absorb photon because it is lowest energy level.

23. (B)

In balmer series, electron jumps higher energy level to 2nd energy level. Hence third line form when electron jump fifth energy level to 2 energy level.
$5 \rightarrow 2$

24. (A)

${}_{37}Rb = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 5s^1$
For valence electron i.e. $5s^1$

n	ℓ	m	s
5	0	0	$+\frac{1}{2}$

25. (C)

$n > \ell,\ m = -\ell \text{ to } +\ell$

n	ℓ	s
3	2	$\frac{1}{2}$

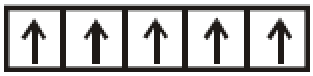
The value of m is wrong
For ℓ = 2, m = –2, –1, 0, +1, +2

26. (B)

Hund's rule

27. (C)

$Fe^{3+} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$



28. (A)

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + \frac{1}{2}mv^2$$

$$K.E. = hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)$$

$$\left(\frac{h^2}{2m\lambda_e^2}\right) = hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right) \qquad \left(\therefore \lambda = \frac{h}{\sqrt{2m\ K.E.}}\right)$$

$$\lambda_e^2 = \frac{\lambda\ \lambda_0\ h}{[\lambda_0 - \lambda]\ 2mc}$$

$$\lambda_e = \left[\frac{h\ \lambda\ \lambda_0}{2mc\,[\lambda_0 - \lambda]}\right]^{\frac{1}{2}}$$

29. (C)

m_n = mass of neutron ; m_p = mass of proton

$\frac{m_n}{2}$ $\qquad\qquad$ $2m_p$

Atomic mass $\Rightarrow (m_n + m_p)$ $\qquad [m_n \simeq m_p]$

$\Rightarrow (8+6) = 14\ m_p$

Atomic mass $\Rightarrow (4+12) = 16\ m_p$

% increase $= \frac{16-14}{14} \times 100 = 14.28\%$

30. (C)

(I) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

(II) Maximum no. of electron in subshell $= 2(2\ell+1)$

(III) For $\ell = 0$, m = 0 only

(IV) Radial node = $n - \ell - 1$

31. (B)

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

For shortest wave length of Balmer series $n_2 = \infty, n_1 = 2$

$$\frac{1}{\lambda} = R_H\, \cancel{z}^2\left[\frac{1}{4} - \frac{1}{\infty}\right] \qquad \lambda = \frac{4}{4R_H} = \frac{1}{R_H} = x$$

For longest wave length of Paschan series $n_2 = 4,\ n_1 = 3$

$$\frac{1}{\lambda} = R_H \cancel{z}^2\left[\frac{1}{9} - \frac{1}{16}\right] \qquad \frac{1}{\lambda} = R_H \cancel{z}^2\left[\frac{7}{9\times16}\right]$$

$$\lambda = \frac{9\times16}{9\times7}\times\frac{1}{R_H} \Rightarrow \lambda = \frac{16}{7}x$$

32. (A)

$$\lambda = \frac{h}{\sqrt{2\,M\,K.E.}} \qquad \lambda \propto \frac{1}{\sqrt{ME}}$$

$$\lambda_e \propto \frac{1}{\sqrt{M_e \times 16E}} \quad ; \quad \lambda_{p^+} \propto \frac{1}{\sqrt{M_p \times 4E}}$$

$$\lambda_\alpha \propto \frac{1}{\sqrt{4M_p \times E}} \quad ; \quad \text{As } m_e << m_p$$

hence $\lambda_e > \lambda_{p^+} = \lambda_\alpha$

33. (B)

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow R_H\left(\frac{n_2^2 - n_1^2}{n_1^2\,n_2^2}\right)$$

$$\lambda \propto \frac{(n_2^2\,n_1^2)}{(n_2^2 - n_1^2)}$$

1st line of lymen series $n_2 = 2$, $n_1 = 1$

2nd line of lymen series $n_2 = 3$, $n_1 = 1$

3rd line of lymen series $n_2 = 4$, $n_1 = 1$

$$\lambda_{1^{st}} - \lambda_{2^{nd}} = R_H\left(\frac{2^2\times1^2}{2^2-1^2}\right) - R_H\left(\frac{3^2\times1^2}{3^2-1^2}\right)$$

$$= \frac{5}{24}R_H$$

$$\lambda_{2^{nd}} - \lambda_{3^{rd}} = R_H\left(\frac{3^2\times1^2}{3^2-1^2}\right) - R_H\left(\frac{4^2\times1^2}{4^2-1^2}\right)$$

$$= \frac{7}{120}R_H$$

34. (C)

Factual

35. (D)

For d_{yz}, xy and xz are nodal plane

node = $(n - \ell - 1) = 6 - 2 - 1 \Rightarrow 3$

36. (ABCD)

$$m_e = \frac{m_e\left(\text{in rest}\right)}{\sqrt{1-\left(\frac{u}{c}\right)^2}} \qquad u \to \text{speed of electron}$$

As $u \uparrow \Rightarrow m_e \uparrow$

37. (BD)

Species having same no. of neutrons are known as isotones.

38. (AC)

Rutherford model, factual.

39. (ABD)

(A) $v = 2.18\times10^6 \times \frac{Z}{n} \Rightarrow v \propto \frac{Z}{n}$

(B) $f = \frac{v}{2\pi r}$ or $f = \frac{v}{r} \propto \frac{Z/n}{n^2/Z} \quad f \propto \frac{Z^2}{n^3}$

(D) $r \propto \frac{n^2}{Z} \quad \left[T \propto \frac{n^3}{Z^2}\right] \quad F = \frac{mV^2}{r}$

$$F \propto \frac{v^2}{r} \propto \frac{\left(Z^2/n^2\right)}{n^2/Z} \qquad F \propto \frac{Z^3}{n^4}$$

So, Answer (A, B, D)

40. (AC)

(A) $Zn^{+2} \Rightarrow [Ar]\,3d^{10}$ unpaired electron = 0

$Cu^{+} \Rightarrow [Ar]\,3d^{10}$ unpaired electron = 0

(B) $Co^{+2} \Rightarrow [Ar]\,3d^{7}$ unpaired electron = 3

$Ni^{+2} \Rightarrow [Ar]\,3d^{8}$ unpaired electron = 2

(C) $Mn^{+4} \Rightarrow [Ar]\,3d^{3}$ unpaired electron = 3

$Co^{+2} \Rightarrow [Ar]\,3d^{7}$ unpaired electron = 3

(D) $Mg^{+2} \Rightarrow 1s^2\,2s^2\,2p^6$ unpaired electron = 0

$Sc^{+} = [Ar]4s^1\,3d^1$ unpaired electron = 2

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TOPIC: QUADRATIC EQUATION

SOLUTIONS

41. (B)
$D < 0 \Rightarrow (k-1)2 - 36 < 0 \Rightarrow (k+5)(k-7) < 0 \Rightarrow -5 < k < 7$

42. (A)
Let roots be p and q.
$(p+q)^2 = 9$ an d $(p-q)^2 = 16$
Solving, we get $pq = \frac{-7}{4}$ and $p+q=3$
Quadratic Equation is $x^2 - 3x - \frac{7}{4} = 0 \Rightarrow 4x^2 - 12x - 7 = 0$

43. (A)
Maximum $= \frac{-D}{4a} = \frac{49+12}{12} = \frac{121}{12}$

44. (A)
More than two roots. So, all coefficients are simultaneously 0.
$p^2 - 3p + 2 = 0 \Rightarrow (p-1)(p-2) = 0 \Rightarrow p = 1, 2$
$p^2 - 6p + 8 = 0 \Rightarrow (p-2)(p-4) = 0 \Rightarrow p = 2, 4$
$p - p^2 = 0 \Rightarrow p(1-p) = 0 \Rightarrow p = 0, 1$
No value of p satisfies these simultaneously

45. (B)
Imaginary roots of a quadratic equation with real coefficients always occur in conjugate pairs.

46. (C)
y-intercept is zero ⇒ Quadratic Expression at $x = 0$ is 0 ⇒ zero is a root of the equation

47. (A)
One root is positive, and one root is negative ⇒ zero lies between the roots
By location of roots, $(k-3) * f(0) < 0 \Rightarrow (k-3)(k-6) < 0$
$k \in (3, 6)$

48. (B)

$(x^2 + x + 5)(x^2 + x - 2) = 0 \Rightarrow x^2 + x + 5 = 0$ or $x^2 + x - 2 = 0$

Product of roots of $x^2 + x + 5 = 0$ is $\frac{c}{a} = 5\ (P_1)$

Product of roots of $x^2 + x - 2 = 0$ is $\frac{c}{a} = -2(P_2)$

Answer = $P_1 * P_2 = -10$

49. (B)

$D = 144 - 144 = 0 \Rightarrow D = 0 \Rightarrow$ roots are real and equal

50. (A)

$D \geq 0 \Rightarrow 1 - 4a \geq 0 \Rightarrow a \leq \frac{1}{4}$

$\frac{-b}{2a} < a \Rightarrow -\frac{1}{2} < a \Rightarrow a > -\frac{1}{2}$

$f(a) > 0 \Rightarrow a^2 + 2a > 0 \Rightarrow a(a+2) > 0 \Rightarrow a \in (-\infty, -2) \cup (0, \infty)$

The intersection of these three intervals is $0 < a \leq \frac{1}{4}$

51. (B)

By Vietta′s theorem, Product of roots $= \frac{(-1)^7 * 4}{1} = -4$

52. (B)

In the Quadratic Expression, $a < 0$ and $D < 0$.

So, $f(x) < 0\ \forall\ x \in R$.

So $f(10053)$ is negative.

53. (A)

$p(x)$ can be generalized as $p(x) = (x-4)(x-6)g(x) + (ax+b)$, where $(a, b) \in R$

By remainder theorem, $p(6) = 4 \Rightarrow 6a + b = 4$

$p(4) = 6 \Rightarrow 4a + b = 6$

Solving for a and b, we get $a = -1$ and $b = 10$

The required answer is $ax + b = -x + 10$

54. (A)

$x^2 + x + 1$ is always positive ($a > 0$ and $D < 0$)

The inequality reduces to $\frac{1}{x^2 - 4x + 3} \leq 0 \Rightarrow \frac{1}{(x-1)(x-3)} \leq 0 \Rightarrow x \in (1, 3)$

55. (B)

The expression is a perfect square if $D = 0$

$(2m - 4)^2 - 4(4 - m)(8m + 1) = 0 \Rightarrow 9m^2 - 27m = 0 \Rightarrow m = 0, 3$

56. (B, C, D)

The equation has two distinct roots ⇒ $D > 0$

Graph is concave down ⇒ $a < 0$

y-intercept is positive ⇒ $c > 0$ vertex lies in second quadrant ⇒ $\frac{-b}{2a} < 0 \Rightarrow -b > 0 \Rightarrow b < 0$

57. (B, C, D)

$A : x^2 - (2b - a^2)x + b^2 = 0$

B : $bx^2 + ax + 1 = 0$

C : $bx^2 + (2b - a^2)x + b = 0$

D : $x^2 + x(a + 2) + 1 + a + b = 0$

58. (A, B)

$(2a + 2b - p)x^2 - 2x(a - b)x + pc^2 = 0$

Equal roots $\Rightarrow D = 0$

$p = a + b \pm 2\sqrt{ab} \Rightarrow \left(\sqrt{a} \pm \sqrt{b}\right)^2$

59. (A, B, D)

The sets of roots which satisfy the above property are (0, 0), (1, 1), (1, 0), (ω, ω^2)

60. (A, C)

Necessary conditions are $D \geq 0, \frac{-b}{2a} > k$ and $a * f(k) > 0$