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NATIONAL LEVEL SCIENCE TALENT SEARCH EXAMINATION (UPDATED)

CLASS - 11 (PCM)

Question Paper Code : UN444

KEY

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11. A	12. A	13. D	14. B	15. C	16. D	17. D	18. D	19. D	20. C
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SOLUTIONS

MATHEMATICS

1. **(C)** The total number of subsets of given set is $2^9 = 512$

   number of subsets containing only even numbers $= 2^4 = 16$

   $\therefore$ Required number of ways

   $= 512 - 16 = 496$

2. **(B)** $a \sin^2\theta + b \cos^2\theta = c$

   On dividing both sides by $\cos^2\theta$

   $a \tan^2\theta + b = c \sec^2\theta$

   $\Rightarrow a \tan^2\theta + b = c(1+\tan^2\theta)$

   $\Rightarrow a \tan^2\theta + b = c + c \tan^2\theta$

   $\Rightarrow b = c + c \tan^2\theta - a \tan^2\theta$

   $\Rightarrow (c - a) \tan^2\theta = (b - c)$

   $\Rightarrow \tan^2\theta = \dfrac{b-c}{c-a}$ or $\dfrac{c-b}{a-c}$

3. **(D)** Given, $a_n = 6^n - 5n$, $n = 1, 2, 3, ...$

   We take; $6^n = (1 + 5)^n$

   Expand with binomail expansion

   $6^n = {}^nC_0 + {}^nC_1\, 5 + {}^nC_2\, 5^2 + {}^nC_3\, 5^3 + ...$

   $6^n = 1 + n.5 + {}^nC_2\, 25 + {}^nC_3\, 53 + ...$

   $(6^n - 5n) = 1 + 25\, \{{}^nC_2 + {}^nC_3\, .5 + ...\}$

$(6^n - 5n) = 1 + 25.k$

where k = positive integer.

Hence, $a_n = 6^n - 5n$ divided by 25 and leave the remainder = 1

4. **(C)** $\left(\sqrt{3}+i\right)^7 + \left(\sqrt{3}-i\right)^7$

Let $\sqrt{3}+i = z$

$z = \left(\sqrt{3}+i\right) = r\left(\cos\theta + i\sin\theta\right)$

Then, $r\cos\theta = \sqrt{3}$ .... (i)

$r\sin\theta = 1$ .... (ii)

Eq. (i) + Eq. (ii), we get

$r^2(\sin^2\theta + \cos^2\theta) = 3+1$

$\Rightarrow r^2 = 4$

$\Rightarrow r = 2$

Eq. (ii) ÷ Eq. (i), we get

$$\Rightarrow \tan\theta = \frac{1}{\sqrt{3}} = \tan\frac{\pi}{6}$$

$$\Rightarrow \theta = \frac{\pi}{6}$$

Then, $z = \left(\sqrt{3}+i\right) = 2\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

$$\Rightarrow \bar{z} = \left(\sqrt{3}+i\right) = 2\left(\cos\frac{\pi}{6} - i\sin\frac{\pi}{6}\right)$$

Then, $\left(\sqrt{3}+i\right)^7 + \left(\sqrt{3}-i\right)^7$

$$= \left[2\left\{\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right\}\right]^7 + \left[2\left\{\cos\frac{\pi}{6} - i\sin\frac{\pi}{6}\right\}\right]^7$$

$$= 2^7\left\{\cos\frac{7\pi}{6} + i\sin\frac{7\pi}{6}\right\} + 2^7\left\{\cos\frac{7\pi}{6} - i\sin\frac{7\pi}{6}\right\}$$

$$= 2^7\left\{\cos\frac{7\pi}{6} + i\sin\frac{7\pi}{6} + \cos\frac{7\pi}{6} - i\sin\frac{7\pi}{6}\right\}$$

$$= 2^7.2\cos\frac{7\pi}{6}$$

$$= 2^8.\cos(\pi + \pi/6)$$

$$= -2^8.\cos\frac{\pi}{6}$$

$$= -2^8.\frac{\sqrt{3}}{2}$$

$$= -2^7.\sqrt{3} = -128\sqrt{3}$$

5. **(A)** $\frac{5-3x}{3} \le \frac{x-30}{6}$

$2(5-3x) \le x - 30$

$10 - 6x \le - x - 30$

$40 \le 7x$

$$x \ge \frac{40}{7}$$

6. **(C)** Total number of points in a plane is 30.

Out of them, 8 points are collinear.

∴ Total number of straight lines formed

$= {}^{30}C_2 - {}^{8}C_2 + 1$

$$= \frac{30\times29}{2} - \frac{8\times7}{2\times1} + 1$$

$= 435 - 28 + 1 = 408$

7. **(A)** $(1 + 2x + 3x^2)^{10}$

$= a_0 + a_1x + a_2x^2 + ... + a_{20}x^{20}$

$= \{1 + x(2 + 3x)\}^{10}.$

Then by binomial expansion

$= {}^{10}C_0 + {}^{10}C_1\, x\,(2+3x) + {}^{10}C_2\, x^2(2+3x)^2 + ...$

Now, the coefficient of x in this expansion $(a_1) = 2\ {}^{10}C_1$

∴ $a_1 = 2(10) = 20$

and the coefficient of x^2 in this expansion (a_2)

$= 3.{}^{10}C_1 + 4.{}^{10}C_2$

ie, $a_2 = 3(10) + 4(45)$

$= 30 + 180$

$= 210$

So, $\frac{a_2}{a_1} = \frac{210}{20} = 10.5$

8. **(A)** $\cos(x-y)$, $\cos x$, $\cos(x+y)$ are in HP.

Then, $\cos x = \dfrac{2\cos(x-y)\cos(x+y)}{\cos(x+y)+\cos(x-y)}$

$$\cos x = \frac{\cos 2x + \cos 2y}{2\cos x.\cos y}$$

$$\cos x = \frac{2\cos^2 x + 2\cos^2 y - 2}{2\cos x.\cos y}$$

$$\cos^2 x.\cos y = \cos^2 x + \cos^2 y - 1$$

$$\cos^2 x(\cos y - 1) = (\cos^2 y - 1)$$

$$\cos^2 x(1 - \cos y) = (1 - \cos^2 y)$$

$$\cos^2 x\left(2\sin^2\frac{y}{2}\right) = \sin^2 y$$

$$\cos^2 x\left(2\sin^2\frac{y}{2}\right) = \left(2\sin\frac{y}{2}.\cos\frac{y}{2}\right)^2$$

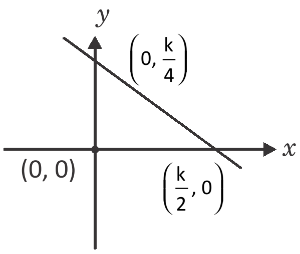
$$\cos^2 x\left(2\sin^2\frac{y}{2}\right) = 4\sin^2\frac{y}{2}.\cos^2\frac{y}{2}$$

$$\cos^2 x = \left(2\cos^2\frac{y}{2} - 1\right) + 1$$

$$\cos y + 1 = \cos^2 x$$

or $\quad 1 + \cos y = \cos^2 x$

9. **(C)** A straight line L is perpendicular to the line $4x - 2y = 1$ therefore the equation of the line is $2x + 4y = k$ $\quad\rightarrow (1)$



Also, the line (i) form a Δ of area 4 unit^2 with the coordinate axes, then

$$A\left(\frac{k}{2}, 0\right), O(0, 0)\ B\left(0, \frac{k}{4}\right)$$

$$\frac{1}{2}\left|\frac{k}{2}\left(-\frac{k}{4}\right)\right| = 4$$

$$\frac{k^2}{16} = 4$$

$$k^2 = 64$$

$$k = \pm 8$$

$$2x + 4y \pm 8 = 0$$

10. **(C)** Given, conjugate lines are

$2x + 3y + 12 = 0$ .... (i)

and $\quad x - y + k = 0$ .... (ii)

We know, that two lines are said to be conjugate with respect to a curve, if each passes through the pole of the polar of that curve.

Let (x_1, y_1) be the pole of parabola

$y^2 = 8x$

It's polar is $yy_1 = 4(x + x_1)$

$\Rightarrow \quad 4x - y_1 y + 4x_1 = 0$

$\Rightarrow \quad 2x - \left(\dfrac{y_1}{2}\right) y + 2x_1 = 0$ .... (iii)

On comparing Eqs. (i) and (iii), we get

$\dfrac{-y_1}{2} = 3 \Rightarrow y_1 = -6$ and $2x_1 = 12 \Rightarrow x_1 = 6$

$\therefore$ Pole $(x_1, y_1) = (6, -6)$

Eq. (ii) also passes through pole $(6, -6)$

$\therefore\ 6 - (-6) + k = 0$

$\Rightarrow k = -12$

11. **(A)** Given equation of sphere is

$x^2 + y^2 + z^2 - 12x - 4y - 3z = 0$

$\therefore$ Centre of sphere is $\left(6, 2, \dfrac{3}{2}\right)$

$\therefore$ Radius of sphere $= \sqrt{(6)^2 + (2)^2 + \left(\dfrac{3}{2}\right)^2}$

$$= \sqrt{36 + 4 + \frac{9}{4}} = \sqrt{\frac{169}{4}} = \frac{13}{2}$$

12. **(A)** $\displaystyle\lim_{x\to 0}\frac{\tan x - \sin x}{x^2}$, $\quad\left(\text{from } \dfrac{0}{0}\right)$

By 'L' Hospital Rule

$$\lim_{x\to 0}\frac{\sec^2 x - \cos x}{2x}, \quad \left(\text{from } \frac{0}{0}\right)$$

Again, by 'L' Hospital Rule

$$\lim_{x\to 0}\frac{2\sec x.\sec x.\tan x + \sin x}{2}$$

$$= \frac{2.1.1.0 + 0}{2} = \frac{0}{2} = 0$$

13. **(D)** f(0) = 0, f(1) = 1, f(2) = 2

Given, $f(x) = f(x-2) + f(x-3)$, x = 3, 4, 5, ...

The given function is known as "Reccurrence function".

put x = 3, f(3) = f(1) + f(0)

= 1 + 0 = 1

put x = 4, f(4)= f(2) + f(1)

= 2 + 1 $\Rightarrow$ 3

put x = 5, f(5)= f(3) + f(2)

= 1 + 2 $\Rightarrow$ 3

put x = 6, f(6)= f(4) + f(3)

= 3 + 1 $\Rightarrow$ 3 + 1 $\Rightarrow$ 4

put x = 7, f(7)= f(5) + f(4)

= 3 + 3 $\Rightarrow$ 6

put x = 8, f(8)= f(6) + f(5)

= 3 + 4 $\Rightarrow$ 7

put x = 9, f(9)= f(7) + f(6)

= 6 + 4 $\Rightarrow$ 10

Hence, f(9) = 10

14. **(B)** Now, $\tan(x - y)\tan y$

$$= \frac{\sin(x-y)\sin y}{\cos(x-y)\cos y} \times \frac{2}{2}$$

$$= \frac{\cos(x-2y) - \cos(x)}{\cos(x-2y) + \cos(x)}$$

$$= \frac{1 - \frac{\cos x}{\cos(x-2y)}}{1 + \frac{\cos(x)}{\cos(x-2y)}}$$

$$= \frac{1-\lambda}{1+\lambda}$$

$$\left(\text{Given, } \lambda = \frac{\cos x}{\cos(x-2y)}\right)$$

15. **(C)** Let $z = x + iy$

Given, $\left|\frac{z+2i}{2z+i}\right| < 1$

$$\Rightarrow \frac{\sqrt{(x)^2 + (y+2)^2}}{\sqrt{(2x)^2 + (2y+1)^2}} < 1$$

$\Rightarrow x^2 + y^2 + 4 + 4y < 4x^2 + 4y^2 + 1 + 4y$

$\Rightarrow 3x^2 + 3y^2 > 3$

$\Rightarrow x^2 + y^2 > 1$

16. **(D)**

M M M M M M M M M M
W W W W W W W W W W W

First, we arrange 10 men in a row at alternate position.

So, number of ways formula = 10!

Now, 6 women can arrange in 11 positions

So, number of ways for women = ${}^{11}P_6$

Required number of ways = $10! \times {}^{11}P_6$

$$= \frac{10!\,11!}{5!}$$

17. **(D)** Given expansion is $\left(\frac{x^2}{a} - \frac{b}{x}\right)^{11}$.

$\therefore$ The general term is

$$T_{r+1} = {}^{11}C_r \left(\frac{x^2}{a}\right)^{11-r} \left(-\frac{b}{x}\right)^r$$

$$= {}^{11}C_r\, (x)^{22-3r}\, (-b)^r \left(\frac{1}{a}\right)^{11-r}$$

$\therefore$ For coefficient x^7, put 22 – 3r = 7

$\Rightarrow$ 3r = 15

$\Rightarrow$ r = 5

$$\therefore T_6 = {}^{11}5_5 \left(\frac{1}{a}\right)^6 (-b)^5$$

and for coefficient of x^4, put 22 – 3r = 4

$\Rightarrow$ 3r = 18 $\Rightarrow$ r = 6

$$\text{and } T_7 = {}^{11}C_6 \left(\frac{1}{a}\right)^6 (-b)^6$$

According to the given condition,

$T_6 + T_7 = 0$

$$\therefore {}^{11}C_5 \left(\frac{1}{a}\right)^6 (-b)^5 + {}^{11}C_6 \left(\frac{1}{a}\right)^5 (-b)^6 = 0$$

$$\Rightarrow {}^{11}C_5 \left(\frac{1}{a}\right)^5 (-b)^5 \left(\frac{1}{a} - b\right) = 0$$

$$\Rightarrow \frac{1}{a} - b = 0$$

$\Rightarrow$ ab = 1

18. **(D)** Let l = ar, b = a, h = $\frac{a}{r}$

Given ar × a × $\frac{a}{r}$ = 216 cm^3

$a^3 = 216\ cm^3$

$a = 6$ cm

Given $2\left[ar \times a + a \times \frac{a}{r} + ar \times \frac{a}{r}\right] = 252\ cm^2$

$a^2\left[r + \frac{1}{r} + 1\right] = 126\ cm^2$

$36\left[\frac{r^2+1+r}{r}\right] = 126$

$\frac{r^2+1+r}{r} = \frac{7}{2}$

$2r^2 + 2 + 2r = 7r$

$2r^2 - 5r + 2 = 0$

$r = 2$ (or) $\frac{1}{2}$

If a = 6 & r = 2 then l = 12 cm, b = 6 cm, h = 3 cm

If a = 6 & r = $\frac{1}{2}$ then l = 3 cm, b = 6 cm,

h = 12 cm

19. **(D)** The given equation of family of lines

$8x^2 - 24xy + 18y^2 - 6x + 9y - 5 = 0$ ....(i)

Comparing with

$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$

Then, $\begin{cases} a = 8, & h = -12, \ b = 18 \\ g = -3, & f = 9/2, \ c = -5 \end{cases}$

We know that, the distance between two lines represented by

$8x^2 - 24xy + 18y^2 - 6x + 9y - 5 = 0$ is

$$2\sqrt{\left[\frac{(g^2 - ac)}{a(a+b)}\right]} = 2\sqrt{\left\{\frac{9+40}{8(8+18)}\right\}}$$

$$= 2\sqrt{\frac{49}{208}} = \frac{7}{\sqrt{52}}$$

$$= \frac{7}{2\sqrt{13}}$$

20. **(C)** $\lim_{x\to\infty}\left(\frac{x+5}{x+2}\right)^{x+3} = \lim_{x\to\infty}\left(1+\frac{3}{x+2}\right)^{x+3}$

$$= \lim_{x\to\infty}\left[\left(1+\frac{3}{x+2}\right)^{\frac{x+2}{3}}\right]^{\frac{3(x+3)}{x+2}}$$

$$= e^{\lim_{x\to\infty} 3\left(\frac{1+\frac{3}{x}}{1+\frac{2}{x}}\right)} = e^3$$

21. **(B)** Given, $f(x) = x^3 + 3x - 2$

On differentiating w.r.t. x, we get

$f'(x) = 3x^2 + 3$

Put $f'(x) = 0 \Rightarrow 3x^2 + 3 = 0$

$\Rightarrow x^2 = -1$

$\therefore$ $f(x)$ is either increasing or decreasing.

At $x = 2$, $f(2) = 2^3 + 3(2) - 2 = 12$

At $x = 3$, $f(3) = 3^3 + 3(3) - 2 = 34$

$\therefore$ $f(x) \in [12, 34]$.

22. **(B)** Consider,

$(1 + \cos 10°) + (\cos 20° + \cos 30°)$

$= 2\cos^2 5° + 2\cos 25° \cos 5°$

$= 2\cos 5° (\cos 5° + \cos 25°)$

$= 2 \cos 5° (2\cos 15° \cos 10°)$

$= 4 \cos 5° \cos 10° \cos 15°$

23. **(C)** There are two cases arise.

Case I: When 5 questions are selected from first 6 questions and next 5 questions are selected from 7 questions.

$\therefore$ Number of ways = ${}^6c_5 \times {}^7c_5$

$= 6 \times \frac{7 \times 6}{2 \times 1}$

$= 126$

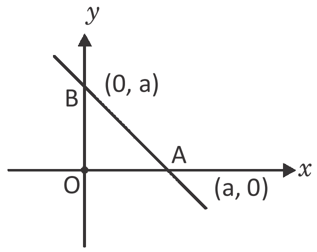
Case II: When 6 questions are selected from first 6 questions and next 4 questions are selected from 7 questions.

$\therefore$ Number of ways = ${}^6C_6 \times {}^7C_4$

$= 1 \times \frac{7 \times 6 \times 5}{3 \times 2} = 35$

$\therefore$ Required number of ways = 126 + 35 = 161

24. **(B)** The equation of line AB which makes an equal intercepts on positive x and y axes are



$\frac{x}{a} + \frac{y}{a} = 1$

ie, $x + y = a$

Distance of Eq. (i) from origin = 1

$\left|\frac{0+0-a}{\sqrt{1+1}}\right| = 1, \left|\frac{-a}{\sqrt{2}}\right| = 1$

$\Rightarrow a = \sqrt{2}$

From Eq. (i), $x + y = \sqrt{2}$ .... (i)

Also given line,

$2x - y = -3 - \sqrt{2}$ .... (ii)

The intersection point of line (ii) and line (iii) is

$(x_0, y_0) = (-1, \sqrt{2}+1)$

So, $2x_0 + y_0 = 2(-1) + \sqrt{2} + 1$

$= -2 + \sqrt{2} + 1 = (\sqrt{2} - 1)$

Hence, $2x_0 + y_0 = \sqrt{2} - 1$

25. **(B)** Q $f(x+y) = f(x) f(y), \forall x, y \in R$ .... (i)

Put $x = y = 1$, we get

$f(2) = f(1).f(1) = 9$ [Q $f(2) = 9$]

$\Rightarrow f(1)^2 = 9 \Rightarrow f(1) = 3$

Now, put $x = 2$ and $y = 1$ in Eq. (i), we get

$f(3) = f(2).f(1) = 3^2.3 = 3^3$

Now, put $x = 3$ and $y = 1$ in Eq. (i), we get

$f(4) = f(3).f(1) = 3^3.3 = 3^4$

Again, put $x = 4$ and $y = 2$ in Eq. (i), we get

$f(6) = f(4).f(2) = 3^4.3^2 = 3^6$

Alternative Method

We have,

$f(x + y) = f(x) f(y), \forall x, y \in R$

and $f(2) = 9$

Now, $f(1+1) = f(1).f(1)$

$\Rightarrow f(2) = \{f(1)\}^2$

$\Rightarrow \{f(1)\} = \sqrt{\{f(2)\}}$ .... (ii)

Now, $f(6) = f(1 + 1 + 1 + 1 + 1 + 1)$

$= f(1).f(1).f(1).f(1).f(1).f(1)$

$= \{f(1)\}^6$ [using Eq. (ii)]

$= \left[\sqrt{\{f(2)\}}\right]^6 = [f(2)]^3$

$= (9)^3$ [using Eq. (i)]

$= (3)^6$

PHYSICS

26. **(B)** $\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_1}$

For given $(T_1 - T_2) = 20°$ in each case, efficiency is highest when T_1 is lowest.

The correct combination of working temperature is 40 K, 20 K, to achieve the highest efficiency of Carnot's engine.

27. **(C)** $d = 0.005$ mm $= 0.005 \times 10^{-3}$ m, $R = 10/2 = 5$ cm $= 0.05$ m, $\sigma = 0.072$ N m^{-1}

Force required $= \frac{2\sigma}{d} \times \pi R^2$

$= \frac{2 \times 0.072 \times 3.14 \times (0.05)^2}{0.005 \times 10^{-3}} = 226$ N

28. **(B)** According to the law of conservation of angular momentum; $m v_A \times OA = m v_B \times OB$;

or $v_B / v_A = OA / OB = x$

29. **(A)** $x = (m_1x_1 + m_2x_2 + m_3x_3)/ m_1 + m_2 + m_3 = (2 \times 1 + 2 \times 2 + 2 \times 3)/ 6 = 2.$

Similarly $y = 2$.

30. **(B)** Relative velocity of train w.r.t. car = velocity of train - velocity of car. Hence, velocity of train = 8 m s^{-1} eastward + 15 m s^{-1} northward. Magnitude of velocity $= (8^2 + 15^2)^{1/2} = 17$ m s^{-1}.

31. **(D)** $\text{Area} = \pi r^2 = \frac{22(1.22)^2}{7} = 4.6778 \text{ sq m.}$

$= 4.68\ m^2$, having three significant digits.

32. **(C)** Let the origin be at the C atom. Then:

$$R_{cm} = \frac{12 \times 0 + 16 \times 0.12 \text{ nm}}{12 + 16} \cong 0.07 \text{ nm}$$

33. **(D)** [Frequency] = T^{-1}

[Angular frequency] = T^{-1}

[Angular velocity] = T^{-1}

[Velocity gradient] = T^{-1}

[Potential energy gradient] $= \frac{ML^2T^{-2}}{L}$

= MLT^{-2} = [force]

34. **(D)** $F = YA l/L = 90 \times 10^9 \times 10^{-6} \times 1 / 2$

= 45000 N.

35. **(C)** For the first 30 minutes, distance travelled = 15 × 1800 = 27000 m

For the next 20 minutes, distance travelled = 25 × 1200 = 30000 m

Total distance travelled = 27000 + 30000 = 57000 m

The total time taken = 1800 + 1200 + 120 = 3120 s

Average speed

$$= \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{57000}{3120} = 18.3 \text{ m/s}$$

36. **(A)** Forces are represented by vectors and can be added and subtracted. Therefore, an 8 N force to the left added to a 20 N force to the right yields a net force of 20 – 8 = 12 N to the right. Then Newton's second law gives $a = F_{net}/m$ = (12 N to the right) / (4kg) = 3 m/s^2 to the right.

37. **(A)** The work done on the crate by the mover is W = Fd = (300 N) (6 m) = 1,800 J. If this much work is done in 20 s, then the power delivered is P = W/t = (1,800 J) / (20 s) = 90 W.

38. **(C)** The average temperature of 94 °C and 86 °C is 90 °C, which is 70 °C above the room temperature. Under these conditions the pan cools to 8 °C in 2 minutes.

$$\frac{\text{Change in temperature}}{\text{Time}} = K\Delta T$$

$$\frac{8\ °C}{2 \text{ min}} = K(70°C)$$

The average of 69 °C and 71 °C is 70 °C, which is 50 °C above room temperature. K is the same for this situation as for the original.

$$\frac{2\ °C}{\text{Time}} = K(50°C)$$

When we divide above two equations, we get

$$\frac{8\ °C/2 \text{ min}}{2\ °C/\text{time}} = \frac{K(70\ °C)}{K(50\ °C)}$$

Time = 0.7 min = 42 s

39. **(C)** Resultant of three forces represented completely by three sides of a triangle taken in the same order is zero. Therefore, velocity of particle remains unaffected.

40. **(A)** As the ball rises, the initial kinetic energy is converted into potential energy. Also, the potential energy is directly proportional to the height. When kinetic energy is reduced to 70%, the potential energy is 30%. It will happen at a height of 30 m.

CHEMISTRY

41. **(C)** As there are three electrons in the valence shell of group 13 elements they show + 3 oxidation state. Also in case of heavier members, due to inert pair effect, + 1 oxidation state is most stable.

42. **(B)** Mass of one mole of the oxide

$$= \frac{100}{30.4} \times 14 \text{ g}$$

∴ Density of the oxide relative to O_2

$$= \frac{(100/30.4) \times 14}{32} = 1.44$$

43. **(A)** Hydrogen has ionization enthalpy value which is too high as compared to alkali metals and too low as compared to halogens and thus cannot be placed in any of these two groups.

44. **(D)** Average kinetic energy of methane

molecule $= \frac{3}{2} \times \frac{RT}{N_A}$

$$= \frac{3}{2} \times \frac{8.314\ J\ K^{-1}\ mol^{-1} \times 300\ K}{6.023 \times 10^{23}\ molecule\ mol^{-1}}$$

$\overline{\varepsilon}_k = 6.21 \times 10^{-21}$ J molecule^{-1}

Total kinetic energy of 32 g methane

$$= n \times \frac{3}{2} RT = \frac{w}{M} \times \frac{3}{2} RT$$

$$= \frac{32\ g}{16\ g/mol} \times \frac{3}{2} \times 8.314\ J\ K^{-1} mol^{-1} \times 300\ K$$

= 7482.6 J

45. **(C)** In (iii), H_2O donates a proton and in (iv), H_2O accepts proton.

46. **(B)** The electronic configurations of these elements are

V : $1s^2\ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ 3d^3\ 4s^2$

Cr : $1s^2\ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ 3d^5\ 4s^1$

Mn : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

Fe : $1s^2\ 2p^2\ 2p^6\ \ 3s^2\ 3p^6\ 3d^6\ 4s^2$

In the case of chromium, the second electron has to be removed from the half-filled d-shell which is more stable.

47. **(C)** The weights of oxygen which combine with the fixed weight of nitrogen (= 28 g) in N_2O, NO, N_2O_3, N_2O_4 and N_2O_5 are 16, 32, 48, 64 and 80 g respectively. They are in the ratio 1 : 2 : 3 : 4 : 5. This proves the law of multiple proportions.

48. **(B)** The anion is HCO_3 which gives the reaction as follows:

$$2NaHCO_3^- + MgCl_2 \rightarrow Mg(HCO_3)_2 + 2NaCl$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} \underset{\text{White ppt.}}{MgCO_3} + CO_2 + H_2O$$

49. **(D)** The reaction in which change in oxidation numbers of some of the atoms takes place is termed as a redox reaction.

(a) $\overset{+2+6-2}{CuSO_4} + \overset{-4+1}{4NH_3} \rightarrow \overset{+2\ -3-1\ \ +6-2}{[Cu(NH_3)_4]SO_4}$

No change in oxidation number of any of the atoms.

(b) $\overset{+1\ +6-2}{Na_2SO_4} + \overset{+2-1}{BaCl_2} \rightarrow \overset{+2+6-2}{BaSO_4} + \overset{+2-1}{2NaCl}$

No change in oxidation number of any one of the atoms.

(c) $\overset{+4-2}{SO_2} + \overset{+2-2}{H_2O} \rightarrow \overset{+1+4-2}{H_2SO_3}$

No change in oxidation number of any one of the atoms.

(d) $\overset{+2\ +6-2}{2CuSO_4} + \overset{+1-1}{4KI} \rightarrow \overset{+1-1}{Cu_2I_2} + \overset{+1\ +6-2}{2K_2SO_4} + \overset{0}{I_2}$

Oxidation number of Cu decreases from +2 to+1 and oxidation number of iodine increases from – 1 to 0.

Thus, out of the above four reactions, the reaction given in option (D) is a redox reaction.

50. **(C)** The process given in option (C) cannot go by itself after initiation.

51. **(D)** Dipole moment corresponding to 100% ionic character of KCl

= 1 unit charge × Interionic distance between K^+ and Cl^-

= $(1.602 \times 10^{-19}$ C) $(2.6 \times 10^{-10}$ m)

= 4.1652×10^{-29} C m

Actual dipole moment of KCl = 3.336 $\times 10^{-29}$ C m

Percentage of ionic character

$$= \frac{3.336 \times 10^{-29}\ C\ m}{4.1652 \times 10^{-29}\ Cm} \times 100 = 80.1$$

Thus, the percentage of ionic character in KCl is 80.1

52. **(B)** $E_n = -\frac{13.6}{n^2} eV,\ \Delta E = E_2 - E_1$

$$= -13.6\left(\frac{1}{2^2} - \frac{1}{1^2}\right) = 13.6 \times \frac{3}{4} = 10.2\ eV$$

53. **(D)** Higher the values of 'a' higher is the critical temperature.

54. **(B)** pH of buffer remains almost constant.

55. **(C)** Mg burns in air to form Mg_3N_2 which then reacts with H_2O to form NH_3.

CRITICAL THINKING

56. **(C)** Because the first two sentences are true, both John and David saw more movies than Suman. However, it is uncertain as to whether David saw more movies than John.

57. **(A)** All Fridays in March:

$$1st \xrightarrow{+7} 8th \xrightarrow{+7} 15th \xrightarrow{+7} 22nd \xrightarrow{+7} 29th$$

There are 31 days in March

Sat	Sun	Mon
30th	31st	1st

Since 1st April fell on Monday.

$$1st \xrightarrow{+7} 8th \xrightarrow{+7} 15th$$

15th April fell on a Monday in the same year.

58. **(D)** Closing the schools for a week and the parents withdrawing their wards from the local schools are independent issues, which must have been triggered by different individual causes.

59. **(C)**

Bench I [P] [T] (S)

Bench II [U] (Q)

Bench III [V] (R)

□ = Boy ○ = Girl

QRS are group of girls.

60. **(D)** The first sentence makes this statement true. There is no support for choice a. The passage tells us that the spa vacation is more expensive than the island beach resort vacation, but that doesn't necessarily mean that the spa is overpriced; therefore, choice b cannot be supported. And even though the paragraph says that the couple was relieved to find a room on short notice, there is no information to support choice c, which says that it is usually necessary to book at the spa at least six months in advance.

THE END