

NCERT Solutions for Class 11 Maths Chapter 8

Binomial Theorem Class 11

Chapter 8 Binomial Theorem Exercise 8.1, 8.2, miscellaneous Solutions

Exercise 8.1 : Solutions of Questions on Page Number : 166

Q1 :

Expand the expression $(1 - 2x)^5$

Answer :

By using Binomial Theorem, the expression $(1 - 2x)^5$ can be expanded as

$$\begin{aligned} (1 - 2x)^5 &= {}^5C_0(1)^5 - {}^5C_1(1)^4(2x) + {}^5C_2(1)^3(2x)^2 - {}^5C_3(1)^2(2x)^3 + {}^5C_4(1)^1(2x)^4 - {}^5C_5(2x)^5 \\ &= 1 - 5(2x) + 10(4x^2) - 10(8x^3) + 5(16x^4) - (32x^5) \\ &= 1 - 10x + 40x^2 - 80x^3 + 80x^4 - 32x^5 \end{aligned}$$

Q2 :

Expand the expression $\left(\frac{2}{x} - \frac{x}{2}\right)^5$

Answer :

By using Binomial Theorem, the expression $\left(\frac{2}{x} - \frac{x}{2}\right)^5$ can be expanded as

$$\begin{aligned} \left(\frac{2}{x} - \frac{x}{2}\right)^5 &= {}^5C_0\left(\frac{2}{x}\right)^5 - {}^5C_1\left(\frac{2}{x}\right)^4\left(\frac{x}{2}\right) + {}^5C_2\left(\frac{2}{x}\right)^3\left(\frac{x}{2}\right)^2 \\ &\quad - {}^5C_3\left(\frac{2}{x}\right)^2\left(\frac{x}{2}\right)^3 + {}^5C_4\left(\frac{2}{x}\right)\left(\frac{x}{2}\right)^4 - {}^5C_5\left(\frac{x}{2}\right)^5 \\ &= \frac{32}{x^5} - 5\left(\frac{16}{x^4}\right)\left(\frac{x}{2}\right) + 10\left(\frac{8}{x^3}\right)\left(\frac{x^2}{4}\right) - 10\left(\frac{4}{x^2}\right)\left(\frac{x^3}{8}\right) + 5\left(\frac{2}{x}\right)\left(\frac{x^4}{16}\right) - \frac{x^5}{32} \\ &= \frac{32}{x^5} - \frac{40}{x^3} + \frac{20}{x} - 5x + \frac{5}{8}x^3 - \frac{x^5}{32} \end{aligned}$$

Q3 :

Expand the expression $(2x - 3)^6$

Answer :

By using Binomial Theorem, the expression $(2x - 3)^6$ can be expanded as

$$\begin{aligned} (2x - 3)^6 &= {}^6C_0 (2x)^6 - {}^6C_1 (2x)^5 (3) + {}^6C_2 (2x)^4 (3)^2 - {}^6C_3 (2x)^3 (3)^3 \\ &\quad + {}^6C_4 (2x)^2 (3)^4 - {}^6C_5 (2x)(3)^5 + {}^6C_6 (3)^6 \\ &= 64x^6 - 6(32x^5)(3) + 15(16x^4)(9) - 20(8x^3)(27) \\ &\quad + 15(4x^2)(81) - 6(2x)(243) + 729 \\ &= 64x^6 - 576x^5 + 2160x^4 - 4320x^3 + 4860x^2 - 2916x + 729 \end{aligned}$$

Q4 :

Expand the expression $\left(\frac{x}{3} + \frac{1}{x}\right)^5$

Answer :

By using Binomial Theorem, the expression $\left(\frac{x}{3} + \frac{1}{x}\right)^5$ can be expanded as

$$\begin{aligned} \left(\frac{x}{3} + \frac{1}{x}\right)^5 &= {}^5C_0 \left(\frac{x}{3}\right)^5 + {}^5C_1 \left(\frac{x}{3}\right)^4 \left(\frac{1}{x}\right) + {}^5C_2 \left(\frac{x}{3}\right)^3 \left(\frac{1}{x}\right)^2 \\ &\quad + {}^5C_3 \left(\frac{x}{3}\right)^2 \left(\frac{1}{x}\right)^3 + {}^5C_4 \left(\frac{x}{3}\right) \left(\frac{1}{x}\right)^4 + {}^5C_5 \left(\frac{1}{x}\right)^5 \\ &= \frac{x^5}{243} + 5\left(\frac{x^4}{81}\right)\left(\frac{1}{x}\right) + 10\left(\frac{x^3}{27}\right)\left(\frac{1}{x^2}\right) + 10\left(\frac{x^2}{9}\right)\left(\frac{1}{x^3}\right) + 5\left(\frac{x}{3}\right)\left(\frac{1}{x^4}\right) + \frac{1}{x^5} \\ &= \frac{x^5}{243} + \frac{5x^3}{81} + \frac{10x}{27} + \frac{10}{9x} + \frac{5}{3x^3} + \frac{1}{x^5} \end{aligned}$$

Q5 :

Expand $\left(x + \frac{1}{x}\right)^6$

Answer :

By using Binomial Theorem, the expression $\left(x + \frac{1}{x}\right)^6$ can be expanded as

$$\begin{aligned} \left(x + \frac{1}{x}\right)^6 &= {}^6C_0(x)^6 + {}^6C_1(x)^5\left(\frac{1}{x}\right) + {}^6C_2(x)^4\left(\frac{1}{x}\right)^2 \\ &\quad + {}^6C_3(x)^3\left(\frac{1}{x}\right)^3 + {}^6C_4(x)^2\left(\frac{1}{x}\right)^4 + {}^6C_5(x)\left(\frac{1}{x}\right)^5 + {}^6C_6\left(\frac{1}{x}\right)^6 \\ &= x^6 + 6(x)^5\left(\frac{1}{x}\right) + 15(x)^4\left(\frac{1}{x^2}\right) + 20(x)^3\left(\frac{1}{x^3}\right) + 15(x)^2\left(\frac{1}{x^4}\right) + 6(x)\left(\frac{1}{x^5}\right) + \frac{1}{x^6} \\ &= x^6 + 6x^4 + 15x^2 + 20 + \frac{15}{x^2} + \frac{6}{x^4} + \frac{1}{x^6} \end{aligned}$$

Q6 :

Using Binomial Theorem, evaluate $(96)^3$

Answer :

96 can be expressed as the sum or difference of two numbers whose powers are easier to calculate and then, binomial theorem can be applied.

It can be written that, $96 = 100 - 4$

$$\begin{aligned} \therefore (96)^3 &= (100 - 4)^3 \\ &= {}^3C_0(100)^3 - {}^3C_1(100)^2(4) + {}^3C_2(100)(4)^2 - {}^3C_3(4)^3 \\ &= (100)^3 - 3(100)^2(4) + 3(100)(4)^2 - (4)^3 \\ &= 1000000 - 120000 + 4800 - 64 \\ &= 884736 \end{aligned}$$

Q7 :

Using Binomial Theorem, evaluate $(102)^5$

Answer :

102 can be expressed as the sum or difference of two numbers whose powers are easier to calculate and then, Binomial Theorem can be applied.

It can be written that, $102 = 100 + 2$

$$\begin{aligned}
 \therefore (102)^5 &= (100+2)^5 \\
 &= {}^5C_0(100)^5 + {}^5C_1(100)^4(2) + {}^5C_2(100)^3(2)^2 + {}^5C_3(100)^2(2)^3 \\
 &\quad + {}^5C_4(100)(2)^4 + {}^5C_5(2)^5 \\
 &= (100)^5 + 5(100)^4(2) + 10(100)^3(2)^2 + 10(100)^2(2)^3 + 5(100)(2)^4 + (2)^5 \\
 &= 10000000000 + 1000000000 + 40000000 + 800000 + 8000 + 32 \\
 &= 11040808032
 \end{aligned}$$

Q8 :

Using Binomial Theorem, evaluate $(101)^4$

Answer :

101 can be expressed as the sum or difference of two numbers whose powers are easier to calculate and then, Binomial Theorem can be applied.

It can be written that, $101 = 100 + 1$

$$\begin{aligned}
 \therefore (101)^4 &= (100+1)^4 \\
 &= {}^4C_0(100)^4 + {}^4C_1(100)^3(1) + {}^4C_2(100)^2(1)^2 + {}^4C_3(100)(1)^3 + {}^4C_4(1)^4 \\
 &= (100)^4 + 4(100)^3 + 6(100)^2 + 4(100) + (1)^4 \\
 &= 100000000 + 4000000 + 60000 + 400 + 1 \\
 &= 104060401
 \end{aligned}$$

Q9 :

Using Binomial Theorem, evaluate $(99)^5$

Answer :

99 can be written as the sum or difference of two numbers whose powers are easier to calculate and then, Binomial Theorem can be applied.

It can be written that, $99 = 100 - 1$

$$\begin{aligned}
 \therefore (99)^5 &= (100-1)^5 \\
 &= {}^5C_0(100)^5 - {}^5C_1(100)^4(1) + {}^5C_2(100)^3(1)^2 - {}^5C_3(100)^2(1)^3 \\
 &\quad + {}^5C_4(100)(1)^4 - {}^5C_5(1)^5 \\
 &= (100)^5 - 5(100)^4 + 10(100)^3 - 10(100)^2 + 5(100) - 1 \\
 &= 10000000000 - 5000000000 + 100000000 - 100000 + 500 - 1 \\
 &= 10010000500 - 500100001 \\
 &= 9509900499
 \end{aligned}$$

Q10 :

Using Binomial Theorem, indicate which number is larger $(1.1)^{10000}$ or 1000.

Answer :

By splitting 1.1 and then applying Binomial Theorem, the first few terms of $(1.1)^{10000}$ can be obtained as

$$\begin{aligned}
 (1.1)^{10000} &= (1+0.1)^{10000} \\
 &= {}^{10000}C_0 + {}^{10000}C_1(1.1) + \text{Other positive terms} \\
 &= 1 + 10000 \times 1.1 + \text{Other positive terms} \\
 &= 1 + 11000 + \text{Other positive terms} \\
 &> 1000
 \end{aligned}$$

Hence, $(1.1)^{10000} > 1000$

Q11 :

Find $(a+b)^4 - (a-b)^4$. Hence, evaluate $(\sqrt{3} + \sqrt{2})^4 - (\sqrt{3} - \sqrt{2})^4$.

Answer :

Using Binomial Theorem, the expressions, $(a+b)^4$ and $(a-b)^4$, can be expanded as

$$\begin{aligned}
 (a+b)^4 &= {}^4C_0a^4 + {}^4C_1a^3b + {}^4C_2a^2b^2 + {}^4C_3ab^3 + {}^4C_4b^4 \\
 (a-b)^4 &= {}^4C_0a^4 - {}^4C_1a^3b + {}^4C_2a^2b^2 - {}^4C_3ab^3 + {}^4C_4b^4 \\
 \therefore (a+b)^4 - (a-b)^4 &= {}^4C_0a^4 + {}^4C_1a^3b + {}^4C_2a^2b^2 + {}^4C_3ab^3 + {}^4C_4b^4 \\
 &\quad - [{}^4C_0a^4 - {}^4C_1a^3b + {}^4C_2a^2b^2 - {}^4C_3ab^3 + {}^4C_4b^4] \\
 &= 2({}^4C_1a^3b + {}^4C_3ab^3) = 2(4a^3b + 4ab^3) \\
 &= 8ab(a^2 + b^2)
 \end{aligned}$$

By putting $a = \sqrt{3}$ and $b = \sqrt{2}$, we obtain

$$\begin{aligned}
 (\sqrt{3} + \sqrt{2})^4 - (\sqrt{3} - \sqrt{2})^4 &= 8(\sqrt{3})(\sqrt{2})\{(\sqrt{3})^2 + (\sqrt{2})^2\} \\
 &= 8(\sqrt{6})\{3 + 2\} = 40\sqrt{6}
 \end{aligned}$$

Q12 :

Find $(x+1)^6 + (x-1)^6$. Hence or otherwise evaluate $(\sqrt{2}+1)^6 + (\sqrt{2}-1)^6$.

Answer :

Using Binomial Theorem, the expressions, $(x+1)^6$ and $(x-1)^6$, can be expanded as

$$\begin{aligned}
 (x+1)^6 &= {}^6C_0x^6 + {}^6C_1x^5 + {}^6C_2x^4 + {}^6C_3x^3 + {}^6C_4x^2 + {}^6C_5x + {}^6C_6 \\
 (x-1)^6 &= {}^6C_0x^6 - {}^6C_1x^5 + {}^6C_2x^4 - {}^6C_3x^3 + {}^6C_4x^2 - {}^6C_5x + {}^6C_6 \\
 \therefore (x+1)^6 + (x-1)^6 &= 2[{}^6C_0x^6 + {}^6C_2x^4 + {}^6C_4x^2 + {}^6C_6] \\
 &= 2[x^6 + 15x^4 + 15x^2 + 1]
 \end{aligned}$$

By putting $x = \sqrt{2}$, we obtain

$$\begin{aligned}
 (\sqrt{2}+1)^6 + (\sqrt{2}-1)^6 &= 2\left[(\sqrt{2})^6 + 15(\sqrt{2})^4 + 15(\sqrt{2})^2 + 1\right] \\
 &= 2(8 + 15 \times 4 + 15 \times 2 + 1) \\
 &= 2(8 + 60 + 30 + 1) \\
 &= 2(99) = 198
 \end{aligned}$$

Q13 :

Show that $9^{n+1} - 8n - 9$ is divisible by 64, whenever n is a positive integer.

Answer :

In order to show that $9^{n+1} - 8n - 9$ is divisible by 64, it has to be proved that,

$$9^{n+1} - 8n - 9 = 64k, \text{ where } k \text{ is some natural number}$$

By Binomial Theorem,

$$(1+a)^m = {}^m C_0 + {}^m C_1 a + {}^m C_2 a^2 + \dots + {}^m C_m a^m$$

For $a = 8$ and $m = n+1$, we obtain

$$\begin{aligned} (1+8)^{n+1} &= {}^{n+1} C_0 + {}^{n+1} C_1 (8) + {}^{n+1} C_2 (8)^2 + \dots + {}^{n+1} C_{n+1} (8)^{n+1} \\ \Rightarrow 9^{n+1} &= 1 + (n+1)(8) + 8^2 \left[{}^{n+1} C_2 + {}^{n+1} C_3 \times 8 + \dots + {}^{n+1} C_{n+1} (8)^{n-1} \right] \\ \Rightarrow 9^{n+1} &= 9 + 8n + 64 \left[{}^{n+1} C_2 + {}^{n+1} C_3 \times 8 + \dots + {}^{n+1} C_{n+1} (8)^{n-1} \right] \\ \Rightarrow 9^{n+1} - 8n - 9 &= 64k, \text{ where } k = {}^{n+1} C_2 + {}^{n+1} C_3 \times 8 + \dots + {}^{n+1} C_{n+1} (8)^{n-1} \text{ is a natural number} \end{aligned}$$

Thus, $9^{n+1} - 8n - 9$ is divisible by 64, whenever n is a positive integer.

Q14 :

Prove that $\sum_{r=0}^n 3^r {}^n C_r = 4^n$.

Answer :

By Binomial Theorem,

$$\sum_{r=0}^n {}^n C_r a^{n-r} b^r = (a+b)^n$$

By putting $b=3$ and $a=1$ in the above equation, we obtain

$$\begin{aligned} \sum_{r=0}^n {}^n C_r (1)^{n-r} (3)^r &= (1+3)^n \\ \Rightarrow \sum_{r=0}^n 3^r {}^n C_r &= 4^n \end{aligned}$$

Hence, proved.

Exercise 8.2 : Solutions of Questions on Page Number : 171

Q1 :

Find the coefficient of x^5 in $(x + 3)^8$

Answer :

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by $T_{r+1} = {}^n C_r a^{n-r} b^r$.

Assuming that x^5 occurs in the $(r + 1)^{\text{th}}$ term of the expansion $(x + 3)^8$, we obtain

$$T_{r+1} = {}^8 C_r (x)^{8-r} (3)^r$$

Comparing the indices of x in x^5 and in T_{r+1} , we obtain

$$r = 3$$

$${}^8 C_3 (3)^3 = \frac{8!}{3!5!} \times 3^3 = \frac{8 \cdot 7 \cdot 6 \cdot 5!}{3 \cdot 2 \cdot 5!} \cdot 3^3 = 1512$$

Thus, the coefficient of x^5 is

Q2 :

Find the coefficient of $a^5 b^7$ in $(a - 2b)^{12}$

Answer :

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by $T_{r+1} = {}^n C_r a^{n-r} b^r$.

Assuming that $a^5 b^7$ occurs in the $(r + 1)^{\text{th}}$ term of the expansion $(a - 2b)^{12}$, we obtain

$$T_{r+1} = {}^{12} C_r (a)^{12-r} (-2b)^r = {}^{12} C_r (-2)^r (a)^{12-r} (b)^r$$

Comparing the indices of a and b in $a^5 b^7$ and in T_{r+1} , we obtain

$$r = 7$$

Thus, the coefficient

$$\text{of } a^5 b^7 \text{ is } {}^{12} C_7 (-2)^7 = -\frac{12!}{7!5!} \cdot 2^7 = -\frac{12 \cdot 11 \cdot 10 \cdot 9 \cdot 8 \cdot 7!}{5 \cdot 4 \cdot 3 \cdot 2 \cdot 7!} \cdot 2^7 = -(792)(128) = -101376$$

Q3 :

Write the general term in the expansion of $(x^2 - y)^6$

Answer :

It is known that the general term T_{r+1} (which is the $(r + 1)^{\text{th}}$ term) in the binomial expansion of $(a + b)^n$ is given

$$\text{by } T_{r+1} = {}^n C_r a^{n-r} b^r.$$

Thus, the general term in the expansion of $(x^2 - y)^6$ is

$$T_{r+1} = {}^6C_r (x^2)^{6-r} (-y)^r = (-1)^r {}^6C_r x^{12-2r} y^r$$

Q4 :

Write the general term in the expansion of $(x^2 - yx)^{12}$, $x \neq 0$

Answer :

It is known that the general term T_{r+1} (which is the $(r + 1)^{\text{th}}$ term) in the binomial expansion of $(a + b)^n$ is given

by $T_{r+1} = {}^nC_r a^{n-r} b^r$.

Thus, the general term in the expansion of $(x^2 - yx)^{12}$ is

$$T_{r+1} = {}^{12}C_r (x^2)^{12-r} (-yx)^r = (-1)^r {}^{12}C_r x^{24-2r} y^r x^r = (-1)^r {}^{12}C_r x^{24-r} y^r$$

Q5 :

Find the 4th term in the expansion of $(x - 2y)^{12}$.

Answer :

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by $T_{r+1} = {}^nC_r a^{n-r} b^r$.

Thus, the 4th term in the expansion of $(x - 2y)^{12}$ is

$$T_4 = T_{3+1} = {}^{12}C_3 (x)^{12-3} (-2y)^3 = (-1)^3 \cdot \frac{12!}{3!9!} \cdot x^9 \cdot (2)^3 \cdot y^3 = -\frac{12 \cdot 11 \cdot 10}{3 \cdot 2} \cdot (2)^3 x^9 y^3 = -1760x^9 y^3$$

Q6 :

Find the 13th term in the expansion of $\left(9x - \frac{1}{3\sqrt{x}}\right)^{18}$, $x \neq 0$.

Answer :

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by $T_{r+1} = {}^nC_r a^{n-r} b^r$.

Thus, 13th term in the expansion of $\left(9x - \frac{1}{3\sqrt{x}}\right)^{18}$ is

$$\begin{aligned}
 T_{13} = T_{12+1} &= {}^{18}C_{12} (9x)^{18-12} \left(-\frac{1}{3\sqrt{x}}\right)^{12} \\
 &= (-1)^{12} \frac{18!}{12!6!} (9)^6 (x)^6 \left(\frac{1}{3}\right)^{12} \left(\frac{1}{\sqrt{x}}\right)^{12} \\
 &= \frac{18 \cdot 17 \cdot 16 \cdot 15 \cdot 14 \cdot 13 \cdot 12!}{12! \cdot 6 \cdot 5 \cdot 4 \cdot 3 \cdot 2} \cdot x^6 \cdot \left(\frac{1}{x^6}\right) \cdot 3^{12} \left(\frac{1}{3^{12}}\right) \quad \left[9^6 = (3^2)^6 = 3^{12}\right] \\
 &= 18564
 \end{aligned}$$

Q7 :

$$\left(3 - \frac{x^3}{6}\right)^7$$

Find the middle terms in the expansions of

Answer :

It is known that in the expansion of $(a + b)^n$, if n is odd, then there are two middle terms, namely, $\left(\frac{n+1}{2}\right)^{\text{th}}$ term and $\left(\frac{n+1}{2} + 1\right)^{\text{th}}$ term.

Therefore, the middle terms in the expansion of $\left(3 - \frac{x^3}{6}\right)^7$ are $\left(\frac{7+1}{2}\right)^{\text{th}} = 4^{\text{th}}$ term and $\left(\frac{7+1}{2} + 1\right)^{\text{th}} = 5^{\text{th}}$ term

$$\begin{aligned}
 T_4 = T_{3+1} &= {}^7C_3 (3)^{7-3} \left(-\frac{x^3}{6}\right)^3 = (-1)^3 \frac{7!}{3!4!} \cdot 3^4 \cdot \frac{x^9}{6^3} \\
 &= -\frac{7 \cdot 6 \cdot 5 \cdot 4!}{3 \cdot 2 \cdot 4!} \cdot 3^4 \cdot \frac{1}{2^3 \cdot 3^3} \cdot x^9 = -\frac{105}{8} x^9
 \end{aligned}$$

$$\begin{aligned}
 T_5 = T_{4+1} &= {}^7C_4 (3)^{7-4} \left(-\frac{x^3}{6}\right)^4 = (-1)^4 \frac{7!}{4!3!} (3)^3 \cdot \frac{x^{12}}{6^4} \\
 &= \frac{7 \cdot 6 \cdot 5 \cdot 4!}{4! \cdot 3 \cdot 2} \cdot \frac{3^3}{2^4 \cdot 3^4} \cdot x^{12} = \frac{35}{48} x^{12}
 \end{aligned}$$

Thus, the middle terms in the expansion of $\left(3 - \frac{x^3}{6}\right)^7$ are $-\frac{105}{8} x^9$ and $\frac{35}{48} x^{12}$.

Q8 :

Find the middle terms in the expansions of $\left(\frac{x}{3} + 9y\right)^{10}$

Answer :

It is known that in the expansion $(a + b)^n$, if n is even, then the middle term is $\left(\frac{n}{2} + 1\right)^{\text{th}}$ term.

Therefore, the middle term in the expansion of $\left(\frac{x}{3} + 9y\right)^{10}$ is $\left(\frac{10}{2} + 1\right)^{\text{th}} = 6^{\text{th}}$ term

$$\begin{aligned} T_6 = T_{5+1} &= {}^{10}C_5 \left(\frac{x}{3}\right)^{10-5} (9y)^5 = \frac{10!}{5!5!} \cdot \frac{x^5}{3^5} \cdot 9^5 \cdot y^5 \\ &= \frac{10 \cdot 9 \cdot 8 \cdot 7 \cdot 6 \cdot 5!}{5 \cdot 4 \cdot 3 \cdot 2 \cdot 5!} \cdot \frac{1}{3^5} \cdot 3^{10} \cdot x^5 y^5 && [9^5 = (3^2)^5 = 3^{10}] \\ &= 252 \times 3^5 \cdot x^5 \cdot y^5 = 61236 x^5 y^5 \end{aligned}$$

Thus, the middle term in the expansion of $\left(\frac{x}{3} + 9y\right)^{10}$ is $61236 x^5 y^5$.

Q9 :

In the expansion of $(1 + a)^{m+n}$, prove that coefficients of a^m and a^n are equal.

Answer :

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by $T_{r+1} = {}^n C_r a^{n-r} b^r$.

Assuming that a^m occurs in the $(r + 1)^{\text{th}}$ term of the expansion $(1 + a)^{m+n}$, we obtain

$$T_{r+1} = {}^{m+n} C_r (1)^{m+n-r} (a)^r = {}^{m+n} C_r a^r$$

Comparing the indices of a in a^m and in T_{r+1} , we obtain

$$r = m$$

Therefore, the coefficient of a^m is

$${}^{m+n} C_m = \frac{(m+n)!}{m!(m+n-m)!} = \frac{(m+n)!}{m!n!} \quad \dots(1)$$

Assuming that a^n occurs in the $(k + 1)^{\text{th}}$ term of the expansion $(1 + a)^{m+n}$, we obtain

$$T_{k+1} = {}^{m+n} C_k (1)^{m+n-k} (a)^k = {}^{m+n} C_k (a)^k$$

Comparing the indices of a in a^n and in T_{k+1} , we obtain

$$k = n$$

Therefore, the coefficient of a^n is

$${}^{m+n}C_n = \frac{(m+n)!}{n!(m+n-n)!} = \frac{(m+n)!}{n!m!} \quad \dots(2)$$

Thus, from (1) and (2), it can be observed that the coefficients of a^m and a^n in the expansion of $(1+a)^{m+n}$ are equal.

Q10 :

The coefficients of the $(r-1)^{\text{th}}$, r^{th} and $(r+1)^{\text{th}}$ terms in the expansion of $(x+1)^n$ are in the ratio 1:3:5. Find n and r .

Answer :

It is known that $(k+1)^{\text{th}}$ term, (T_{k+1}) , in the binomial expansion of $(a+b)^n$ is given by $T_{k+1} = {}^nC_k a^{n-k} b^k$.

Therefore, $(r-2)^{\text{th}}$ term in the expansion of $(x+1)^n$ is $T_{r-2} = {}^nC_{r-2} (x)^{n-(r-2)} (1)^{(r-2)} = {}^nC_{r-2} x^{n-r+2}$.

r^{th} term in the expansion of $(x+1)^n$ is $T_r = {}^nC_{r-1} (x)^{n-(r-1)} (1)^{(r-1)} = {}^nC_{r-1} x^{n-r+1}$.

$(r+1)^{\text{th}}$ term in the expansion of $(x+1)^n$ is $T_{r+1} = {}^nC_r (x)^{n-r} (1)^r = {}^nC_r x^{n-r}$.

Therefore, the coefficients of the $(r-2)^{\text{th}}$, r^{th} , and $(r+1)^{\text{th}}$ terms in the expansion of $(x+1)^n$ are ${}^nC_{r-2}$, ${}^nC_{r-1}$, and nC_r respectively. Since these coefficients are in the ratio 1:3:5, we obtain

$$\frac{{}^nC_{r-2}}{{}^nC_{r-1}} = \frac{1}{3} \quad \text{and} \quad \frac{{}^nC_{r-1}}{{}^nC_r} = \frac{3}{5}$$

$$\frac{{}^nC_{r-2}}{{}^nC_{r-1}} = \frac{n!}{(r-2)!(n-r+2)!} \times \frac{(r-1)!(n-r+1)!}{n!} = \frac{(r-1)(r-2)!(n-r+1)!}{(r-2)!(n-r+2)(n-r+1)!}$$

$$= \frac{r-1}{n-r+2}$$

$$\begin{aligned} \therefore \frac{r-1}{n-r+2} &= \frac{1}{3} \\ \Rightarrow 3r-3 &= n-r+2 \\ \Rightarrow n-4r+5 &= 0 \quad \dots(1) \\ \frac{{}^n C_{r-1}}{{}^n C_r} &= \frac{n!}{(r-1)!(n-r+1)!} \times \frac{r!(n-r)!}{n!} = \frac{r(r-1)!(n-r)!}{(r-1)!(n-r+1)(n-r)!} \\ &= \frac{r}{n-r+1} \end{aligned}$$

$$\begin{aligned} \therefore \frac{r}{n-r+1} &= \frac{3}{5} \\ \Rightarrow 5r &= 3n-3r+3 \\ \Rightarrow 3n-8r+3 &= 0 \quad \dots(2) \end{aligned}$$

Multiplying (1) by 3 and subtracting it from (2), we obtain

$$\begin{aligned} 4r &= 12 = 0 \\ \Rightarrow r &= 3 \end{aligned}$$

Putting the value of r in (1), we obtain

$$\begin{aligned} n &= 12 + 5 = 0 \\ \Rightarrow n &= 7 \end{aligned}$$

Thus, $n = 7$ and $r = 3$

Q11 :

Prove that the coefficient of x^n in the expansion of $(1+x)^{2n}$ is twice the coefficient of x^n in the expansion of $(1+x)^{2n-1}$.

Answer :

It is known that $(r+1)^{th}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by $T_{r+1} = {}^n C_r a^{n-r} b^r$.

Assuming that x^n occurs in the $(r+1)^{th}$ term of the expansion of $(1+x)^{2n}$, we obtain

$$T_{r+1} = {}^{2n} C_r (1)^{2n-r} (x)^r = {}^{2n} C_r (x)^r$$

Comparing the indices of x in x^n and in T_{r+1} , we obtain

$$r = n$$

Therefore, the coefficient of x^n in the expansion of $(1+x)^{2n}$ is

$${}^{2n} C_n = \frac{(2n)!}{n!(2n-n)!} = \frac{(2n)!}{n!n!} = \frac{(2n)!}{(n!)^2} \quad \dots(1)$$

Assuming that x^n occurs in the $(k+1)^{\text{th}}$ term of the expansion $(1+x)^{2n-1}$, we obtain

$$T_{k+1} = {}^{2n-1}C_k (1)^{2n-1-k} (x)^k = {}^{2n-1}C_k (x)^k$$

Comparing the indices of x in x^n and T_{k+1} , we obtain

$$k = n$$

Therefore, the coefficient of x^n in the expansion of $(1+x)^{2n-1}$ is

$$\begin{aligned} {}^{2n-1}C_n &= \frac{(2n-1)!}{n!(2n-1-n)!} = \frac{(2n-1)!}{n!(n-1)!} \\ &= \frac{2n \cdot (2n-1)!}{2n \cdot n!(n-1)!} = \frac{(2n)!}{2 \cdot n!n!} = \frac{1}{2} \left[\frac{(2n)!}{(n!)^2} \right] \quad \dots(2) \end{aligned}$$

From (1) and (2), it is observed that

$$\begin{aligned} \frac{1}{2} ({}^{2n}C_n) &= {}^{2n-1}C_n \\ \Rightarrow {}^{2n}C_n &= 2 ({}^{2n-1}C_n) \end{aligned}$$

Therefore, the coefficient of x^n in the expansion of $(1+x)^{2n}$ is twice the coefficient of x^n in the expansion of $(1+x)^{2n-1}$.

Hence, proved.

Q12 :

Find a positive value of m for which the coefficient of x^2 in the expansion $(1+x)^m$ is 6.

Answer :

It is known that $(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by $T_{r+1} = {}^nC_r a^{n-r} b^r$.

Assuming that x^2 occurs in the $(r+1)^{\text{th}}$ term of the expansion $(1+x)^m$, we obtain

$$T_{r+1} = {}^mC_r (1)^{m-r} (x)^r = {}^mC_r (x)^r$$

Comparing the indices of x in x^2 and in T_{r+1} , we obtain

$$r = 2$$

Therefore, the coefficient of x^2 is mC_2 .

It is given that the coefficient of x^2 in the expansion $(1+x)^m$ is 6.

$$\begin{aligned} \therefore {}^m C_2 &= 6 \\ \Rightarrow \frac{m!}{2!(m-2)!} &= 6 \\ \Rightarrow \frac{m(m-1)(m-2)!}{2 \times (m-2)!} &= 6 \\ \Rightarrow m(m-1) &= 12 \\ \Rightarrow m^2 - m - 12 &= 0 \\ \Rightarrow m^2 - 4m + 3m - 12 &= 0 \\ \Rightarrow m(m-4) + 3(m-4) &= 0 \\ \Rightarrow (m-4)(m+3) &= 0 \\ \Rightarrow (m-4) = 0 \text{ or } (m+3) &= 0 \\ \Rightarrow m = 4 \text{ or } m = -3 \end{aligned}$$

Thus, the positive value of m , for which the coefficient of x^2 in the expansion

$(1+x)^m$ is 6, is 4.

Exercise Miscellaneous : Solutions of Questions on Page Number : 175

Q1 :

Find a , b and n in the expansion of $(a+b)^n$ if the first three terms of the expansion are 729, 7290 and 30375, respectively.

Answer :

It is known that $(r+1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a+b)^n$ is given by $T_{r+1} = {}^n C_r a^{n-r} b^r$.

The first three terms of the expansion are given as 729, 7290, and 30375 respectively.

Therefore, we obtain

$$T_1 = {}^n C_0 a^{n-0} b^0 = a^n = 729 \quad \dots(1)$$

$$T_2 = {}^n C_1 a^{n-1} b^1 = na^{n-1}b = 7290 \quad \dots(2)$$

$$T_3 = {}^n C_2 a^{n-2} b^2 = \frac{n(n-1)}{2} a^{n-2} b^2 = 30375 \quad \dots(3)$$

Dividing (2) by (1), we obtain

$$\begin{aligned} \frac{na^{n-1}b}{a^n} &= \frac{7290}{729} \\ \Rightarrow \frac{nb}{a} &= 10 \quad \dots(4) \end{aligned}$$

Dividing (3) by (2), we obtain

$$\begin{aligned} \frac{n(n-1)a^{n-2}b^2}{2na^{n-1}b} &= \frac{30375}{7290} \\ \Rightarrow \frac{(n-1)b}{2a} &= \frac{30375}{7290} \\ \Rightarrow \frac{(n-1)b}{a} &= \frac{30375 \times 2}{7290} = \frac{25}{3} \\ \Rightarrow \frac{nb}{a} - \frac{b}{a} &= \frac{25}{3} \\ \Rightarrow 10 - \frac{b}{a} &= \frac{25}{3} && [\text{Using (4)}] \\ \Rightarrow \frac{b}{a} &= 10 - \frac{25}{3} = \frac{5}{3} && \dots(5) \end{aligned}$$

From (4) and (5), we obtain

$$\begin{aligned} n \cdot \frac{5}{3} &= 10 \\ \Rightarrow n &= 6 \end{aligned}$$

Substituting $n = 6$ in equation (1), we obtain

$$\begin{aligned} a^6 &= 729 \\ \Rightarrow a &= \sqrt[6]{729} = 3 \end{aligned}$$

From (5), we obtain

$$\frac{b}{3} = \frac{5}{3} \Rightarrow b = 5$$

Thus, $a = 3$, $b = 5$, and $n = 6$.

Q2 :

Find a if the coefficients of x^2 and x^3 in the expansion of $(3 + ax)^9$ are equal.

Answer :

It is known that $(r + 1)^{\text{th}}$ term, (T_{r+1}) , in the binomial expansion of $(a + b)^n$ is given by $T_{r+1} = {}^nC_r a^{n-r} b^r$.

Assuming that x^2 occurs in the $(r + 1)^{\text{th}}$ term in the expansion of $(3 + ax)^9$, we obtain

$$T_{r+1} = {}^9C_r (3)^{9-r} (ax)^r = {}^9C_r (3)^{9-r} a^r x^r$$

Comparing the indices of x in x^2 and in T_{r+1} , we obtain

$$r = 2$$

Thus, the coefficient of x^2 is

$${}^9C_2 (3)^{9-2} a^2 = \frac{9!}{2!7!} (3)^7 a^2 = 36(3)^7 a^2$$

Assuming that x^3 occurs in the $(k+1)^{\text{th}}$ term in the expansion of $(3+ax)^9$, we obtain

$$T_{k+1} = {}^9C_k (3)^{9-k} (ax)^k = {}^9C_k (3)^{9-k} a^k x^k$$

Comparing the indices of x in x^2 and in T_{k+1} , we obtain

$$k = 3$$

Thus, the coefficient of x^3 is

$${}^9C_3 (3)^{9-3} a^3 = \frac{9!}{3!6!} (3)^6 a^3 = 84(3)^6 a^3$$

It is given that the coefficients of x^2 and x^3 are the same.

$$84(3)^6 a^3 = 36(3)^7 a^2$$

$$\Rightarrow 84a = 36 \times 3$$

$$\Rightarrow a = \frac{36 \times 3}{84} = \frac{104}{84}$$

$$\Rightarrow a = \frac{9}{7}$$

Thus, the required value of a is $\frac{9}{7}$.

Q3 :

Find the coefficient of x^5 in the product $(1+2x)^6(1-x)^7$ using binomial theorem.

Answer :

Using Binomial Theorem, the expressions, $(1+2x)^6$ and $(1-x)^7$, can be expanded as

$$\begin{aligned} (1+2x)^6 &= {}^6C_0 + {}^6C_1(2x) + {}^6C_2(2x)^2 + {}^6C_3(2x)^3 + {}^6C_4(2x)^4 \\ &\quad + {}^6C_5(2x)^5 + {}^6C_6(2x)^6 \\ &= 1 + 6(2x) + 15(2x)^2 + 20(2x)^3 + 15(2x)^4 + 6(2x)^5 + (2x)^6 \\ &= 1 + 12x + 60x^2 + 160x^3 + 240x^4 + 192x^5 + 64x^6 \end{aligned}$$

$$\begin{aligned}
 (1-x)^7 &= {}^7C_0 - {}^7C_1(x) + {}^7C_2(x)^2 - {}^7C_3(x)^3 + {}^7C_4(x)^4 \\
 &\quad - {}^7C_5(x)^5 + {}^7C_6(x)^6 - {}^7C_7(x)^7 \\
 &= 1 - 7x + 21x^2 - 35x^3 + 35x^4 - 21x^5 + 7x^6 - x^7 \\
 \therefore (1+2x)^6(1-x)^7 &= (1+12x+60x^2+160x^3+240x^4+192x^5+64x^6)(1-7x+21x^2-35x^3+35x^4-21x^5+7x^6-x^7)
 \end{aligned}$$

The complete multiplication of the two brackets is not required to be carried out. Only those terms, which involve x^5 , are required.

The terms containing x^5 are

$$\begin{aligned}
 &1(-21x^5) + (12x)(35x^4) + (60x^2)(-35x^3) + (160x^3)(21x^2) + (240x^4)(-7x) + (192x^5)(1) \\
 &= 171x^5
 \end{aligned}$$

Thus, the coefficient of x^5 in the given product is 171.

Q4 :

If a and b are distinct integers, prove that $a - b$ is a factor of $a^n - b^n$, whenever n is a positive integer.

[Hint: write $a^n = (a - b + b)^n$ and expand]

Answer :

In order to prove that $(a - b)$ is a factor of $(a^n - b^n)$, it has to be proved that

$a^n - b^n = k(a - b)$, where k is some natural number

It can be written that, $a = a - b + b$

$$\begin{aligned}
 \therefore a^n &= (a - b + b)^n = [(a - b) + b]^n \\
 &= {}^nC_0(a - b)^n + {}^nC_1(a - b)^{n-1}b + \dots + {}^nC_{n-1}(a - b)b^{n-1} + {}^nC_nb^n \\
 &= (a - b)^n + {}^nC_1(a - b)^{n-1}b + \dots + {}^nC_{n-1}(a - b)b^{n-1} + b^n \\
 \Rightarrow a^n - b^n &= (a - b) \left[(a - b)^{n-1} + {}^nC_1(a - b)^{n-2}b + \dots + {}^nC_{n-1}b^{n-1} \right] \\
 \Rightarrow a^n - b^n &= k(a - b) \\
 \text{where, } k &= \left[(a - b)^{n-1} + {}^nC_1(a - b)^{n-2}b + \dots + {}^nC_{n-1}b^{n-1} \right] \text{ is a natural number}
 \end{aligned}$$

This shows that $(a - b)$ is a factor of $(a^n - b^n)$, where n is a positive integer.

Q5 :

Evaluate $(\sqrt{3} + \sqrt{2})^6 - (\sqrt{3} - \sqrt{2})^6$.

Answer :

Firstly, the expression $(a + b)^6 - (a - b)^6$ is simplified by using Binomial Theorem.

This can be done as

$$\begin{aligned}(a + b)^6 &= {}^6C_0 a^6 + {}^6C_1 a^5 b + {}^6C_2 a^4 b^2 + {}^6C_3 a^3 b^3 + {}^6C_4 a^2 b^4 + {}^6C_5 a b^5 + {}^6C_6 b^6 \\ &= a^6 + 6a^5 b + 15a^4 b^2 + 20a^3 b^3 + 15a^2 b^4 + 6ab^5 + b^6\end{aligned}$$

$$\begin{aligned}(a - b)^6 &= {}^6C_0 a^6 - {}^6C_1 a^5 b + {}^6C_2 a^4 b^2 - {}^6C_3 a^3 b^3 + {}^6C_4 a^2 b^4 - {}^6C_5 a b^5 + {}^6C_6 b^6 \\ &= a^6 - 6a^5 b + 15a^4 b^2 - 20a^3 b^3 + 15a^2 b^4 - 6ab^5 + b^6\end{aligned}$$

$$\therefore (a + b)^6 - (a - b)^6 = 2[6a^5 b + 20a^3 b^3 + 6ab^5]$$

Putting $a = \sqrt{3}$ and $b = \sqrt{2}$, we obtain

$$\begin{aligned}(\sqrt{3} + \sqrt{2})^6 - (\sqrt{3} - \sqrt{2})^6 &= 2\left[6(\sqrt{3})^5 (\sqrt{2}) + 20(\sqrt{3})^3 (\sqrt{2})^3 + 6(\sqrt{3})(\sqrt{2})^5\right] \\ &= 2\left[54\sqrt{6} + 120\sqrt{6} + 24\sqrt{6}\right] \\ &= 2 \times 198\sqrt{6} \\ &= 396\sqrt{6}\end{aligned}$$

Q6 :

Find the value of $(a^2 + \sqrt{a^2 - 1})^4 + (a^2 - \sqrt{a^2 - 1})^4$.

Answer :

Firstly, the expression $(x + y)^4 + (x - y)^4$ is simplified by using Binomial Theorem.

This can be done as

$$\begin{aligned}(x+y)^4 &= {}^4C_0x^4 + {}^4C_1x^3y + {}^4C_2x^2y^2 + {}^4C_3xy^3 + {}^4C_4y^4 \\ &= x^4 + 4x^3y + 6x^2y^2 + 4xy^3 + y^4\end{aligned}$$

$$\begin{aligned}(x-y)^4 &= {}^4C_0x^4 - {}^4C_1x^3y + {}^4C_2x^2y^2 - {}^4C_3xy^3 + {}^4C_4y^4 \\ &= x^4 - 4x^3y + 6x^2y^2 - 4xy^3 + y^4\end{aligned}$$

$$\therefore (x+y)^4 + (x-y)^4 = 2(x^4 + 6x^2y^2 + y^4)$$

Putting $x = a^2$ and $y = \sqrt{a^2 - 1}$, we obtain

$$\begin{aligned}(a^2 + \sqrt{a^2 - 1})^4 + (a^2 - \sqrt{a^2 - 1})^4 &= 2 \left[(a^2)^4 + 6(a^2)^2 (\sqrt{a^2 - 1})^2 + (\sqrt{a^2 - 1})^4 \right] \\ &= 2 \left[a^8 + 6a^4(a^2 - 1) + (a^2 - 1)^2 \right] \\ &= 2 \left[a^8 + 6a^6 - 6a^4 + a^4 - 2a^2 + 1 \right] \\ &= 2 \left[a^8 + 6a^6 - 5a^4 - 2a^2 + 1 \right] \\ &= 2a^8 + 12a^6 - 10a^4 - 4a^2 + 2\end{aligned}$$

Q7 :

Find an approximation of $(0.99)^5$ using the first three terms of its expansion.

Answer :

$$0.99 = 1 - 0.01$$

$$\begin{aligned}\therefore (0.99)^5 &= (1 - 0.01)^5 \\ &= {}^5C_0(1)^5 - {}^5C_1(1)^4(0.01) + {}^5C_2(1)^3(0.01)^2 \quad \text{(Approximately)} \\ &= 1 - 5(0.01) + 10(0.01)^2 \\ &= 1 - 0.05 + 0.001 \\ &= 1.001 - 0.05 \\ &= 0.951\end{aligned}$$

Thus, the value of $(0.99)^5$ is approximately 0.951.

Q8 :

Find n , if the ratio of the fifth term from the beginning to the fifth term from the end in the expansion

$$\left(\sqrt[4]{2} + \frac{1}{\sqrt[4]{3}} \right)^n \text{ is } \sqrt{6} : 1$$

of

Answer :

In the expansion, $(a + b)^n = {}^n C_0 a^n + {}^n C_1 a^{n-1} b + {}^n C_2 a^{n-2} b^2 + \dots + {}^n C_{n-1} a b^{n-1} + {}^n C_n b^n$,

Fifth term from the beginning $= {}^n C_4 a^{n-4} b^4$

Fifth term from the end $= {}^n C_{n-4} a^4 b^{n-4}$

Therefore, it is evident that in the expansion of $\left(\sqrt[4]{2} + \frac{1}{\sqrt[4]{3}}\right)^n$, the fifth term from the beginning

is ${}^n C_4 (\sqrt[4]{2})^{n-4} \left(\frac{1}{\sqrt[4]{3}}\right)^4$ and the fifth term from the end is ${}^n C_{n-4} (\sqrt[4]{2})^4 \left(\frac{1}{\sqrt[4]{3}}\right)^{n-4}$.

$${}^n C_4 (\sqrt[4]{2})^{n-4} \left(\frac{1}{\sqrt[4]{3}}\right)^4 = {}^n C_4 \frac{(\sqrt[4]{2})^n}{(\sqrt[4]{2})^4} \cdot \frac{1}{3} = {}^n C_4 \frac{(\sqrt[4]{2})^n}{2} \cdot \frac{1}{3} = \frac{n!}{6 \cdot 4!(n-4)!} (\sqrt[4]{2})^n \quad \dots(1)$$

$${}^n C_{n-4} (\sqrt[4]{2})^4 \left(\frac{1}{\sqrt[4]{3}}\right)^{n-4} = {}^n C_{n-4} \cdot 2 \cdot \frac{(\sqrt[4]{3})^4}{(\sqrt[4]{3})^n} = {}^n C_{n-4} \cdot 2 \cdot \frac{3}{(\sqrt[4]{3})^n} = \frac{6n!}{(n-4)!4!} \cdot \frac{1}{(\sqrt[4]{3})^n} \quad \dots(2)$$

It is given that the ratio of the fifth term from the beginning to the fifth term from the end is $\sqrt{6} : 1$. Therefore, from (1) and (2), we obtain

$$\frac{n!}{6 \cdot 4!(n-4)!} (\sqrt[4]{2})^n : \frac{6n!}{(n-4)!4!} \cdot \frac{1}{(\sqrt[4]{3})^n} = \sqrt{6} : 1$$

$$\Rightarrow \frac{(\sqrt[4]{2})^n}{6} : \frac{6}{(\sqrt[4]{3})^n} = \sqrt{6} : 1$$

$$\Rightarrow \frac{(\sqrt[4]{2})^n}{6} \times \frac{(\sqrt[4]{3})^n}{6} = \sqrt{6}$$

$$\Rightarrow (\sqrt[4]{6})^n = 36\sqrt{6}$$

$$\Rightarrow 6^{\frac{n}{4}} = 6^{\frac{5}{2}}$$

$$\Rightarrow \frac{n}{4} = \frac{5}{2}$$

$$\Rightarrow n = 4 \times \frac{5}{2} = 10$$

Thus, the value of n is 10.

Q9 :

Expand using Binomial Theorem

Answer : $\left(1 + \frac{x}{2} - \frac{2}{x}\right)^4, x \neq 0$

$$\left[\left(1 + \frac{x}{2}\right) - \frac{2}{x}\right]^4$$

Using Binomial Theorem, the given expression can be expanded as

$$= 1 + 2x + \frac{3x^2}{2} + \frac{x^3}{2} + \frac{x^4}{16} - \frac{8}{x} \left(1 + \frac{3x}{2} + \frac{3x^2}{4} + \frac{x^3}{8}\right) + \frac{8}{x^2} + \frac{24}{x} + 6 - \frac{32}{x^3} + \frac{16}{x^4}$$

$$= 1 + 2x + \frac{3}{2}x^2 + \frac{x^3}{2} + \frac{x^4}{16} - \frac{8}{x} - 12 - 6x - x^2 + \frac{8}{x^2} + \frac{24}{x} + 6 - \frac{32}{x^3} + \frac{16}{x^4}$$

$$= \frac{16}{x} + \frac{8}{x^2} - \frac{32}{x^3} + \frac{16}{x^4} - 4x + \frac{x^2}{2} + \frac{x^3}{2} + \frac{x^4}{16} - 5$$

$$= {}^4C_0 \left(1 + \frac{x}{2}\right)^4 - {}^4C_1 \left(1 + \frac{x}{2}\right)^3 \left(\frac{2}{x}\right) + {}^4C_2 \left(1 + \frac{x}{2}\right)^2 \left(\frac{2}{x}\right)^2 - {}^4C_3 \left(1 + \frac{x}{2}\right) \left(\frac{2}{x}\right)^3 + {}^4C_4 \left(\frac{2}{x}\right)^4$$

$$= \left(1 + \frac{x}{2}\right)^4 - 4 \left(1 + \frac{x}{2}\right)^3 \left(\frac{2}{x}\right) + 6 \left(1 + \frac{x}{2}\right)^2 \left(\frac{4}{x^2}\right) - 4 \left(1 + \frac{x}{2}\right) \left(\frac{8}{x^3}\right) + \frac{16}{x^4}$$

$$= \left(1 + \frac{x}{2}\right)^4 - \frac{8}{x} \left(1 + \frac{x}{2}\right)^3 + \frac{24}{x^2} + \frac{24}{x} + 6 - \frac{32}{x^3} - \frac{16}{x^2} + \frac{16}{x^4}$$

$$= \left(1 + \frac{x}{2}\right)^4 - \frac{8}{x} \left(1 + \frac{x}{2}\right)^3 + \frac{8}{x^2} + \frac{24}{x} + 6 - \frac{32}{x^3} + \frac{16}{x^4} \quad \dots(1)$$

Again by using Binomial Theorem, we obtain

$$\left(1 + \frac{x}{2}\right)^4 = {}^4C_0 (1)^4 + {}^4C_1 (1)^3 \left(\frac{x}{2}\right) + {}^4C_2 (1)^2 \left(\frac{x}{2}\right)^2 + {}^4C_3 (1) \left(\frac{x}{2}\right)^3 + {}^4C_4 \left(\frac{x}{2}\right)^4$$

$$= 1 + 4 \times \frac{x}{2} + 6 \times \frac{x^2}{4} + 4 \times \frac{x^3}{8} + \frac{x^4}{16}$$

$$= 1 + 2x + \frac{3x^2}{2} + \frac{x^3}{2} + \frac{x^4}{16} \quad \dots(2)$$

$$\left(1 + \frac{x}{2}\right)^3 = {}^3C_0 (1)^3 + {}^3C_1 (1)^2 \left(\frac{x}{2}\right) + {}^3C_2 (1) \left(\frac{x}{2}\right)^2 + {}^3C_3 \left(\frac{x}{2}\right)^3$$

$$= 1 + \frac{3x}{2} + \frac{3x^2}{4} + \frac{x^3}{8} \quad \dots(3)$$

From(1), (2), and (3), we obtain

Q10 :

Find the expansion of $(3x^2 - 2ax + 3a^2)^3$ using binomial theorem.

Answer :

Using Binomial Theorem, the given expression $(3x^2 - 2ax + 3a^2)^3$ can be expanded as

$$\begin{aligned} & [(3x^2 - 2ax) + 3a^2]^3 \\ &= {}^3C_0(3x^2 - 2ax)^3 + {}^3C_1(3x^2 - 2ax)^2(3a^2) + {}^3C_2(3x^2 - 2ax)(3a^2)^2 + {}^3C_3(3a^2)^3 \\ &= (3x^2 - 2ax)^3 + 3(9x^4 - 12ax^3 + 4a^2x^2)(3a^2) + 3(3x^2 - 2ax)(9a^4) + 27a^6 \\ &= (3x^2 - 2ax)^3 + 81a^2x^4 - 108a^3x^3 + 36a^4x^2 + 81a^4x^2 - 54a^5x + 27a^6 \\ &= (3x^2 - 2ax)^3 + 81a^2x^4 - 108a^3x^3 + 117a^4x^2 - 54a^5x + 27a^6 \quad \dots(1) \end{aligned}$$

Again by using Binomial Theorem, we obtain

$$\begin{aligned} & (3x^2 - 2ax)^3 \\ &= {}^3C_0(3x^2)^3 - {}^3C_1(3x^2)^2(2ax) + {}^3C_2(3x^2)(2ax)^2 - {}^3C_3(2ax)^3 \\ &= 27x^6 - 3(9x^4)(2ax) + 3(3x^2)(4a^2x^2) - 8a^3x^3 \\ &= 27x^6 - 54ax^5 + 36a^2x^4 - 8a^3x^3 \quad \dots(2) \end{aligned}$$

From (1) and (2), we obtain

$$\begin{aligned} & (3x^2 - 2ax + 3a^2)^3 \\ &= 27x^6 - 54ax^5 + 36a^2x^4 - 8a^3x^3 + 81a^2x^4 - 108a^3x^3 + 117a^4x^2 - 54a^5x + 27a^6 \\ &= 27x^6 - 54ax^5 + 117a^2x^4 - 116a^3x^3 + 117a^4x^2 - 54a^5x + 27a^6 \end{aligned}$$

