UNIT 11

EXPONENTS AND POWERS

(A) Main Concepts and Results

- Exponents are used to express large numbers in shorter form to make them easy to read, understand, compare and operate upon.
- $a \times a \times a \times a = a^4$ (read as 'a' raised to the exponent 4 or the fourth power of a), where 'a' is the base and 4 is the exponent and a^4 is called the exponential form. $a \times a \times a \times a$ is called the expanded form.
- For any non-zero integers 'a' and 'b' and whole numbers m and n,

(i) $a^m \times a^n = a^{m+n}$

(ii) $a^m \div a^n = a^{m-n}$, $m > n$

(iii) $(a^m)^n = a^{mn}$

(iv) $a^m \times b^m = (ab)^m$

(v) $a^m \div b^m = \left(\frac{a}{b}\right)^m$

(vi) $a^0 = 1$

(vii) $(-1)^{\text{even number}} = 1$

(viii) $(-1)^{\text{odd number}} = -1$

- Any number can be expressed as a decimal number between 1.0 and 10.0 (including 1.0) multiplied by a power of 10. Such form of a number is called its standard form or scientific notation.

(B) Solved Examples

In Examples 1 to 3, there are four options, out of which one is correct. Write the correct one.

Example 1: Out of the following, the number which is not equal to $\frac{-8}{27}$ is

(a) $-\left(\frac{2}{3}\right)^3$ (b) $\left(\frac{-2}{3}\right)^3$

(c) $-\left(\frac{-2}{3}\right)^3$ (d) $\left(\frac{-2}{3}\right)\times\left(\frac{-2}{3}\right)\times\left(\frac{-2}{3}\right)$

Solution: Correct answer is (c).

Example 2: $(-7)^5 \times (-7)^3$ is equal to

(a) $(-7)^8$ (b) $-(7)^8$ (c) $(-7)^{15}$ (d) $(-7)^2$

Solution: Correct answer is (a).

Example 3: For any two non-zero integers x any y, $x^3 \div y^3$ is equal to

(a) $\left(\frac{x}{y}\right)^0$ (b) $\left(\frac{x}{y}\right)^3$

(c) $\left(\frac{x}{y}\right)^6$ (d) $\left(\frac{x}{y}\right)^9$

Solution: Correct answer is (b).

MULTIPLYING POWERS WITH THE SAME BASE

Words	Numbers	Algebra
To multiply powers with the same base, keep the base and add the exponents.	$3^5 \times 3^8 = 3^{5+8} = 3^{13}$	$b^m \times b^n = b^{m+n}$

In Examples 4 and 5, fill in the blanks to make the statements true.

Example 4: $\left(5^7 \div 5^6\right)^2 =$ _____

Solution: 5^2

Example 5: $\frac{a^7b^3}{a^5b}$ = _____

Solution: $(ab)^2$

In Examples 6 to 8, state whether the statements are True or False:

Example 6: In the number 7^5, 5 is the base and 7 is the exponent.

Solution: False

A power is written in **base and exponent form** as follows:

The base is the number that is being repeated as a factor in the multiplication.

5^2

The exponent tells you how many times the base is repeated as a factor in the multiplication

For example $7.7 = 7^2$, $3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 = 3^5$.

Example 7: $\frac{a^4}{b^3} = \frac{a+a+a+a}{b+b+b}$

Solution: False

Example 8: $a^b > b^a$ is true, if $a = 3$ and $b = 4$; but false, if $a = 2$ and $b = 3$.

Solution: True

Example 9: By what number should we multiply 3^3 so that the product may be equal to 3^7?

Solution: Let 3^3 be multiplied by x so that the product may be equal to 3^7.

According to question,

$3^3 \times x = 3^7$

or $x = 3^7 \div 3^3$

$= (3)^{7-3}$ (Using $a^m \div a^n = (a)^{m-n}$)

$= 3^4$

$= 81$

Therefore, 3^3 should be multiplied by 81 so that the product is equal to 3^7.

Example 10: Find x so that $\left(\frac{5}{3}\right)^5 \times \left(\frac{5}{3}\right)^{11} = \left(\frac{5}{3}\right)^{8x}$

Solution: Given $\left(\frac{5}{3}\right)^5 \times \left(\frac{5}{3}\right)^{11} = \left(\frac{5}{3}\right)^{8x}$

So, $\frac{5^5}{3^5} \times \frac{5^{11}}{3^{11}} = \left(\frac{5}{3}\right)^{8x}$ $\left\{\text{Using } \left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}\right\}$

or $\frac{5^5 \times 5^{11}}{3^5 \times 3^{11}} = \left(\frac{5}{3}\right)^{8x}$

or $\frac{(5)^{16}}{(3)^{16}} = \left(\frac{5}{3}\right)^{8x}$ $\{\text{Using } a^m \times a^n = (a)^{m+n}\}$

or $\left(\frac{5}{3}\right)^{16} = \left(\frac{5}{3}\right)^{8x}$

or $16 = 8x$

Thus, $8x = 16$

Therefore, $x = 2$

Example 11: Express 648 in exponential notation.

Solution: $648 = 2 \times 2 \times 2 \times 3 \times 3 \times 3 \times 3$

$= 2^3 \times 3^4$

2	648
2	324
2	162
3	81
3	27
3	9
3	3
	1

Example 12: Express 2,36,00,000 in standard form.

Solution: 236,00,000

$= \frac{236,00,000}{100,00,000} \times 100,00,000$

$= 2.36 \times 10^7$

Example 13: Which of the two is larger : 3^{12} or 6^6?

Solution: $3^{12} = 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3 = 531441$

$6^6 = 6 \times 6 \times 6 \times 6 \times 6 \times 6 = 46656$

So, 3^{12} is greater.

Application on Problem Solving Strategy

Example 14

Find x such that $\left(\frac{1}{5}\right)^5 \times \left(\frac{1}{5}\right)^{19} = \left(\frac{1}{5}\right)^{8x}$

Solution:  **Understand and Explore the Problem**

- What are you trying to find?
  The value of x for the given equation.

 **Plan a Strategy**

- You know the laws of exponents. Apply those laws in the given equation to find the value of x.

 **Solve**

- Given, $\left(\frac{1}{5}\right)^5 \times \left(\frac{1}{5}\right)^{19} = \left(\frac{1}{5}\right)^{8x}$

  Using the law of exponents, $a^m \times a^n = a^{m+n}$, we get

  $$\left(\frac{1}{5}\right)^{5+19} = \left(\frac{1}{5}\right)^{8x}$$

  $$\left(\frac{1}{5}\right)^{24} = \left(\frac{1}{5}\right)^{8x}$$

  On both the sides, powers have the same base. So, their exponents must be equal

  Therefore, $24 = 8x$

  or $x = \frac{24}{8} = 3$

  Hence, the value of x is 3.

Revise

- Substitute the value of x in the equation and check if it satisfies the equation.

$$\text{LHS} = \left(\frac{1}{5}\right)^{5} \times \left(\frac{1}{5}\right)^{19} = \left(\frac{1}{5}\right)^{5+19} = \left(\frac{1}{5}\right)^{24}$$

$$\text{RHS} = \left(\frac{1}{5}\right)^{8x} = \left(\frac{1}{5}\right)^{8\times 3} = \left(\frac{1}{5}\right)^{24}$$

LHS = RHS

Hence, the equation is satisfied with $x = 3$. So, our answer is correct.

Think and Discuss

1. Try to find the value of x given in the question by changing $\frac{1}{5}$ to $\frac{3}{2}$. What difference do you find in the value of x? What do you infer from your answer?
2. Can you find the value of x if the equation is changed to $(5)^x \div (5)^2 = (5)^3$?

(C) Exercise

In questions 1 to 22, there are four options, out of which one is correct. Write the correct one.

1. $[(-3)^2]^3$ is equal to

(a) $(-3)^8$ (b) $(-3)^6$ (c) $(-3)^5$ (d) $(-3)^{23}$

2. For a non-zero rational number x, $x^8 \div x^2$ is equal to

(a) x^4 (b) x^6 (c) x^{10} (d) x^{16}

3. x is a non-zero rational number. Product of the square of x with the cube of x is equal to the

(a) second power of x (b) third power of x

(c) fifth power of x (d) sixth power of x

4. For any two non-zero rational numbers x and y, $x^5 \div y^5$ is equal to

(a) $(x \div y)^1$ (b) $(x \div y)^0$ (c) $(x \div y)^5$ (d) $(x \div y)^{10}$

5. $a^m \times a^n$ is equal to

(a) $(a^2)^{mn}$ (b) a^{m-n} (c) a^{m+n} (d) a^{mn}

6. $(1^0 + 2^0 + 3^0)$ is equal to

(a) 0 (b) 1 (c) 3 (d) 6

7. Value of $\frac{10^{22} + 10^{20}}{10^{20}}$ is

(a) 10 (b) 10^{42} (c) 101 (d) 10^{22}

8. The standard form of the number 12345 is

(a) 1234.5×10^1 (b) 123.45×10^2

(c) 12.345×10^3 (d) 1.2345×10^4

9. If $2^{1998} - 2^{1997} - 2^{1996} + 2^{1995} = K.2^{1995}$, then the value of K is

(a) 1 (b) 2 (c) 3 (d) 4

10. Which of the follwing is equal to 1?

(a) $2^0 + 3^0 + 4^0$ (b) $2^0 \times 3^0 \times 4^0$

(c) $(3^0 - 2^0) \times 4^0$ (d) $(3^0 - 2^0) \times (3^0 + 2^0)$

11. In standard form, the number 72105.4 is written as 7.21054×10^n where n is equal to

(a) 2 (b) 3 (c) 4 (d) 5

12. Square of $\left(\frac{-2}{3}\right)$ is

(a) $\frac{-2}{3}$ (b) $\frac{2}{3}$ (c) $\frac{-4}{9}$ (d) $\frac{4}{9}$

DIVIDING POWERS WITH THE SAME BASE

Words	Numbers	Algebra
To divide powers with the same base, keep the base and subtract the exponents.	$\frac{6^9}{6^4} = 6^{9-4} = 6^5$	$\frac{b^m}{b^n} = b^{m-n}$

Key Concept

Product of Powers Property

Words	To multiply powers with the same base, add their exponents.
Algebra	$a^m \cdot a^n = a^{m+n}$ Numbers $5^6 \cdot 5^3 = 5^{6+3} = 5^9$

13. Cube of $\left(\frac{-1}{4}\right)$ is

(a) $\frac{-1}{12}$ (b) $\frac{1}{16}$ (c) $\frac{-1}{64}$ (d) $\frac{1}{64}$

14. Which of the following is not equal to $\left(\frac{-5}{4}\right)^4$?

(a) $\frac{(-5)^4}{4^4}$ (b) $\frac{5^4}{(-4)^4}$

(c) $-\frac{5^4}{4^4}$ (d) $\left(-\frac{5}{4}\right)\times\left(-\frac{5}{4}\right)\times\left(-\frac{5}{4}\right)\times\left(-\frac{5}{4}\right)$

15. Which of the following is not equal to 1 ?

(a) $\frac{2^3\times3^2}{4\times18}$ (b) $\left[(-2)^3\times(-2)^4\right]\div(-2)^7$

(c) $\frac{3^0\times5^3}{5\times25}$ (d) $\frac{2^4}{(7^0+3^0)^3}$

16. $\left(\frac{2}{3}\right)^3\times\left(\frac{5}{7}\right)^3$ is equal to

(a) $\left(\frac{2}{3}\times\frac{5}{7}\right)^9$ (b) $\left(\frac{2}{3}\times\frac{5}{7}\right)^6$ (c) $\left(\frac{2}{3}\times\frac{5}{7}\right)^3$ (d) $\left(\frac{2}{3}\times\frac{5}{7}\right)^0$

17. In standard form, the number 829030000 is written as $K\times10^8$ where K is equal to

(a) 82903 (b) 829.03 (c) 82.903 (d) 8.2903

18. Which of the following has the largest value?

(a) 0.0001 (b) $\frac{1}{10000}$ (c) $\frac{1}{10^6}$ (d) $\frac{1}{10^6} \div 0.1$

19. In standard form 72 crore is written as

(a) 72×10^7 (b) 72×10^8 (c) 7.2×10^8 (d) 7.2×10^7

20. For non-zero numbers a and b, $\left(\frac{a}{b}\right)^m \cdot \left(\frac{a}{b}\right)^n$, where $m > n$, is equal to

(a) $\left(\frac{a}{b}\right)^{mn}$ (b) $\left(\frac{a}{b}\right)^{m+n}$ (c) $\left(\frac{a}{b}\right)^{m-n}$ (d) $\left(\left(\frac{a}{b}\right)^m\right)^n$

21. Which of the following is not true?

(a) $3^2 > 2^3$ (b) $4^3 = 2^6$ (c) $3^3 = 9$ (d) $2^5 > 5^2$

22. Which power of 8 is equal to 2^6?

(a) 3 (b) 2 (c) 1 (d) 4

In questions 23 to 39, fill in the blanks to make the statements true.

23. $(-2)^{31} \times (-2)^{13} = (-2)^{\_\_\_}$

24. $(-3)^8 \div (-3)^5 = (-3)^{\_\_\_}$

25. $\left(\frac{11}{15}\right)^4 \times (\_\_\_)^5 = \left(\frac{11}{15}\right)^9$

26. $\left(\frac{-1}{4}\right)^3 \times \left(\frac{-1}{4}\right)^{\_\_\_} = \left(\frac{-1}{4}\right)^{11}$

COPY AND COMPLETE THE TABLE

Expression	Expression Written Using Repeated Multiplication	Number of Factors	Simplified Expression
$2^2 \cdot 2^4$	$(2 \cdot 2) \times (2 \cdot 2 \cdot 2 \cdot 2)$	6	2^6
$3^5 \cdot 3^5$	$(3 \cdot 3 \cdot 3) \times (3 \cdot 3 \cdot 3 \cdot 3 \cdot 3)$	_____	_____
$a^2 \cdot a^3$	_____	_____	_____

RAISING A POWER TO A POWER		
Words	**Numbers**	**Algebra**
To raise a power to a power, keep the base and multiply the exponents.	$(9^4)^5 = 9^{4 \cdot 5} = 9^{20}$	$(b^m)^n = b^{m.n}$

27. $\left[\left(\frac{7}{11}\right)^3\right]^4 = \left(\frac{7}{11}\right)^{\_\_}$

28. $\left(\frac{6}{13}\right)^{10} \div \left[\left(\frac{6}{13}\right)^5\right]^2 = \left(\frac{6}{13}\right)^{\_\_}$

29. $\left[\left(\frac{-1}{4}\right)^{16}\right]^2 = \left(\frac{-1}{4}\right)^{\_\_}$

30. $\left(\frac{13}{14}\right)^5 \div (\_\_)^2 = \left(\frac{13}{14}\right)^3$

31. $a^6 \times a^5 \times a^0 = a^{\_\_}$

32. 1 lakh = $10^{\_\_}$

33. 1 million = $10^{\_\_}$

34. $729 = 3^{\_\_}$

35. $432 = 2^4 \times 3^{\_\_}$

36. $53700000 = \_\_ \times 10^7$

37. $88880000000 = \_\_ \times 10^{10}$

38. $27500000 = 2.75 \times 10^{\_\_}$

39. $340900000 = 3.409 \times 10^{\_\_}$

40. Fill in the blanks with <, > or = sign.

(a) 3^2 _____ 15

(b) 2^3 _____ 3^2

(c) 7^4 _____ 5^4

(d) 10,000 _____ 10^5

(e) 6^3 _____ 4^4

In questions 41 to 65, state whether the given statements are True or False.

41. One million = 10^7

42. One hour = 60^2 seconds

43. $1^0 \times 0^1 = 1$

44. $(-3)^4 = -12$

45. $3^4 > 4^3$

46. $\left(\frac{-3}{5}\right)^{100} = \frac{-3^{100}}{-5^{100}}$

47. $(10 + 10)^{10} = 10^{10} + 10^{10}$

48. $x^0 \times x^0 = x^0 \div x^0$ is true for all non-zero values of x.

49. In the standard form, a large number can be expressed as a decimal number between 0 and 1, multiplied by a power of 10.

50. 4^2 is greater than 2^4.

51. $x^m + x^m = x^{2m}$, where x is a non-zero rational number and m is a positive integer.

52. $x^m \times y^m = (x \times y)^{2m}$, where x and y are non-zero rational numbers and m is a positive integer.

53. $x^m \div y^m = (x \div y)^m$, where x and y are non-zero rational numbers and m is a positive integer.

54. $x^m \times x^n = x^{m+n}$, where x is a non-zero rational number and m,n are positive integers.

55. 4^9 is greater than 16^3.

56. $\left(\frac{2}{5}\right)^3 \div \left(\frac{5}{2}\right)^3 = 1$

57. $\left(\frac{4}{3}\right)^5 \times \left(\frac{5}{7}\right)^5 = \left(\frac{4}{3}+\frac{5}{7}\right)^5$

58. $\left(\frac{5}{8}\right)^9 \div \left(\frac{5}{8}\right)^4 = \left(\frac{5}{8}\right)^4$

59. $\left(\frac{7}{3}\right)^2 \times \left(\frac{7}{3}\right)^5 = \left(\frac{7}{3}\right)^{10}$

60. $5^0 \times 25^0 \times 125^0 = (5^0)^6$

COPY AND COMPLETE THE TABLE

Expression	Expression Written Using Repeated Multiplication	On Multiplying Fractions	Quotient of Powers
$\left(\frac{2}{3}\right)^4$	$\frac{2}{3}.\frac{2}{3}.\frac{2}{3}.\frac{2}{3}$	$\frac{2.2.2.2}{3.3.3.3}$	$\frac{2^4}{3^4}$
$\left(\frac{-3}{y}\right)^3$	$\frac{-3}{y}.\frac{-3}{y}.\frac{-3}{y}$	$\frac{(-3)(-3)(-3)}{y.y.y}$	_____
$\left(\frac{a}{b}\right)^5$	_____	_____	_____

Key Concept

To be noted

Power of a Product Property

In Words To simplify a power of a product, find the power of each factor and multiply.

In Numbers $(5 \cdot 2)^4 = 5^4 \cdot 2^4$ In Algebra $(ab)^m = a^m \cdot b^m$

61. $876543 = 8 \times 10^5 + 7 \times 10^4 + 6 \times 10^3 + 5 \times 10^2 + 4 \times 10^1 + 3 \times 10^0$

62. $600060 = 6 \times 10^5 + 6 \times 10^2$

63. $4 \times 10^5 + 3 \times 10^4 + 2 \times 10^3 + 1 \times 10^0 = 432010$

64. $8 \times 10^6 + 2 \times 10^4 + 5 \times 10^2 + 9 \times 10^0 = 8020509$

65. $4^0 + 5^0 + 6^0 = (4 + 5 + 6)^0$

66. Arrange in ascending order :

$2^5, 3^3, 2^3 \times 2, (3^3)^2, 3^5, 4^0, 2^3 \times 3^1$

67. Arrange in descending order :

$2^{2+3}, (2^2)^3, 2 \times 2^2, \frac{3^5}{3^2}, 3^2 \times 3^0, 2^3 \times 5^2$

68. By what number should $(-4)^5$ be divided so that the quotient may be equal to $(-4)^3$?

69. Find m so that $\left(\frac{2}{9}\right)^3 \times \left(\frac{2}{9}\right)^6 = \left(\frac{2}{9}\right)^{2m-1}$

70. If $\frac{p}{q} = \left(\frac{3}{2}\right)^2 \div \left(\frac{9}{4}\right)^0$, find the value of $\left(\frac{p}{q}\right)^3$.

71. Find the reciprocal of the rational number $\left(\frac{1}{2}\right)^2 \div \left(\frac{2}{3}\right)^3$

72. Find the value of :

(a) 7^0 (b) $7^7 \div 7^7$

(c) $(-7)^{2 \times 7 - 6 - 8}$ (d) $(2^0 + 3^0 + 4^0)(4^0 - 3^0 - 2^0)$

(e) $2 \times 3 \times 4 \div 2^0 \times 3^0 \times 4^0$ (f) $(8^0 - 2^0) \times (8^0 + 2^0)$

73. Find the value of n, where n is an integer and

$$2^{n-5} \times 6^{2n-4} = \frac{1}{12^4 \times 2}.$$

74. Express the following in usual form:

(a) 8.01×10^7

(b) 1.75×10^{-3}

75. Find the value of

(a) 2^5 (b) (-3^5) (c) $-(-4)^4$

76. Express the following in exponential form :

(a) $3 \times 3 \times 3 \times a \times a \times a \times a$

(b) $a \times a \times b \times b \times b \times c \times c \times c \times c$

(c) $s \times s \times t \times t \times s \times s \times t$

77. How many times of 30 must be added together to get a sum equal to 30^7?

78. Express each of the following numbers using exponential notations:

(a) 1024 (b) 1029 (c) $\frac{144}{875}$

79. Identify the greater number, in each of the following:

(a) 2^6 or 6^2 (b) 2^9 or 9^2 (c) 7.9×10^4 or 5.28×10^5

COPY AND COMPLETE THE TABLE

Expression	Expression Written Using Repeated Multiplication	Number of Factors	Simplified Expression
$(4^3)^2$	$(4^3)\ (4^3) = (4 \cdot 4 \cdot 4)\ (4 \cdot 4 \cdot 4)$	6	4^6
$(7^2)^3$	$(7^2)\ (7^2)\ (7^2) = (7 \cdot 7)\ (7 \cdot 7)\ (7 \cdot 7)$	_____	$7^{\_\_}$
$(x^5)^4$	_____	_____	_____

Key Concept

To be noted

Power of a Power Property

Words To simplify a power of a power, multiply exponents.

Numbers $(5^4)^2 = 5^{4 \cdot 2} = 5^8$ Algebra $(a^m)^n = a^{mn}$

80. Express each of the following as a product of powers of their prime factors:

(a) 9000 (b) 2025 (c) 800

81. Express each of the following in single exponential form:

(a) $2^3 \times 3^3$ (b) $2^4 \times 4^2$ (c) $5^2 \times 7^2$ (d) $(-5)^5 \times (-5)$

(e) $(-3)^3 \times (-10)^3$ (f) $(-11)^2 \times (-2)^2$

82. Express the following numbers in standard form:

(a) 76,47,000 (b) 8,19,00,000

(c) 5, 83,00,00,00,000 (d) 24 billion

83. The speed of light in vaccum is 3×10^8 m/s. Sunlight takes about 8 minutes to reach the earth. Express distance of Sun from Earth in standard form.

84. Simplify and express each of the following in exponential form:

(a) $\left[\left(\frac{3}{7}\right)^4 \times \left(\frac{3}{7}\right)^5\right] \div \left(\frac{3}{7}\right)^7$ (b) $\left[\left(\frac{7}{11}\right)^5 \div \left(\frac{7}{11}\right)^2\right] \times \left(\frac{7}{11}\right)^2$

(c) $(3^7 \div 3^5)^4$ (d) $\left(\frac{a^6}{a^4}\right) \times a^5 \times a^0$

(e) $\left[\left(\frac{3}{5}\right)^3 \times \left(\frac{3}{5}\right)^8\right] \div \left[\left(\frac{3}{5}\right)^2 \times \left(\frac{3}{5}\right)^4\right]$ (f) $(5^{15} \div 5^{10}) \times 5^5$

Division of Powers Rule

When you are dividing two powers with the same base, subtract the second exponent from the first to give you the exponent of the answer.

$(a^m \div a^n = a^{(m-n)})$

COPY AND COMPLETE THE TABLE			
Expression	**Expression Written Using Repeated Multiplication**	**Simplified Expression**	**Quotient as a Power**
$\frac{3^8}{3^3}$	$\frac{3.3.3.3.3.3.3.3}{3.3.3}$	3 . 3 . 3 . 3 . 3	3^5
$\frac{6^5}{6^3}$	$\frac{6.6.6.6.6}{6.6.6}$	____	6^{-}
$\frac{a^7}{a^4}$	$\frac{a.a.a.a.a.a.a}{a.a.a.a}$	____	____

85. Evaluate

(a) $\frac{7^8 \times a^{10} b^7 c^{12}}{7^6 \times a^8 b^4 c^{12}}$ (b) $\frac{5^4 \times 7^4 \times 2^7}{8 \times 49 \times 5^3}$ (c) $\frac{125 \times 5^2 \times a^7}{10^3 \times a^4}$

(d) $\frac{3^4 \times 12^3 \times 36}{2^5 \times 6^3}$ (e) $\left(\frac{6 \times 10}{2^2 \times 5^3}\right)^2 \times \frac{25}{27}$ (f) $\frac{15^4 \times 18^3}{3^3 \times 5^2 \times 12^2}$

(g) $\frac{6^4 \times 9^2 \times 25^3}{3^2 \times 4^2 \times 15^6}$

Look for a pattern in the table to extend what you know about exponents to find more about negative exponents.

10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}
10 * 10	10	1	$\frac{1}{10}$	100	2000
100	10	1	$\frac{1}{10} = 0.1$	$\frac{1}{100} = 0.01$	$\frac{1}{1000} = 0.001$

÷10 ÷10 ÷10 ÷10 ÷10

Any Number Raised to the Power 0 is 1

Any number that has an exponent of 0 is equal to ***1.***

So, $2^0 = 1$, $3^0 = 1$, $10^0 = 1$, $\left(\frac{1}{2}\right)^0 = 1$.

For any number $a \neq 0$, $a^0 = 1$.

You can show this by using the **division of powers rule.**

If you start with 1000, and keep **dividing by 10**, you get this pattern:

$1000 = 10^3$ *Now divide* by 10 : $10^3 \div 10^1 = 10^{(3-1)} = 10^2$

$100 = 10^2$ *Now divide* by 10 : $10^2 \div 10^1 = 10^{(2-1)} = 10^1$

$10 = 10^1$ *Now divide* by 10 : $10^1 \div 10^1 = 10^{(1-1)} = 10^0$

$1 = 10^0$

When you divide 10 by 10, you have $10^1 \div 10^1 = 10^{(1-1)} = 10^0$.

You also know that 10 divided by 10 is 1. So you can see that $10^0 = 1$.

This pattern works for any base.

For instance, $6^1 \div 6^1 = 6^{(1-1)} = 6^0$, and 6 divided by 6 is 1. $6^0 = 1$.

86. Express the given information in Scientific notation (standard form) and then arrange them in ascending order of their size.

Sl.No.	Deserts of the World	Area (Sq. Kilometres)
1.	Kalahari, South Africa	932,400
2.	Thar, India	199,430
3.	Gibson, Australia	155,400
4.	Great Victoria, Australia	647,500
5.	Sahara, North Africa	8,598,800

Think and Discuss

1. **Explain** why the exponents cannot be added in the product $14^3 \times 18^3$.
2. **List** two ways to express 4^5 as a product of powers.

87. Express the given information in Scientific notation and then arrange them in descending order of their size.

Sl.No.	Name of the Planet	Mass (in kg)
1.	Mercury	330000000000000000000000
2.	Venus	4870000000000000000000000
3.	Earth	5980000000000000000000000
4.	Mars	642000000000000000000000
5.	Jupiter	1900000000000000000000000000
6.	Saturn	569000000000000000000000000
7.	Uranus	869000000000000000000000000
8.	Neptune	1020000000000000000000000000
9.	Pluto	13100000000000000000000

Think and Discuss

1. **Explain** the difference between $(-5)^2$ and -5^2.
2. **Compare** 3×2, 3^2 and 2^3.
3. **Show** that $(4 - 11)^2$ is not equal to $4^2 - 11^2$.

The 1/4th of a cube unit contains about 97,700,000,000,000,000,000,000 atoms. The average size of an atom is about 0.00000003 centimetre across.

Scientific notation is a shorthand way of writing such numbers.

To express any number in scientific notation, write it as the product of a power of ten and a number greater than or equal to 1 but less than 10.

In scientific notation, the number of atoms in a quarter is 9.77×10^{22}, and the size of each atom is 3.0×10^{-8} centimetres across.

Real-Life Math

1. **Explain** the benefit of writing numbers in scientific notation.
2. **Describe** how to write 2.977×10^6 in normal form.
3. **Determine** which measurement would be least likely to be written in scientific notation: size of bacteria, speed of a car, or number of stars in a galaxy.

88. Write the number of seconds in scientific notation.

Sl. No.	Unit	Value in Seconds
1.	1 Minute	60
2.	1 Hour	3,600
3.	1 Day	86,400
4.	1 Month	2,600,000
5.	1 Year	32,000,000
6.	10 Years	3,20,000,000

89. In our own planet Earth, 361,419,000 square kilometre of area is covered with water and 148,647,000 square kilometre of area is covered by land. Find the approximate ratio of area covered with water to area covered by land by converting these numbers into scientific notation.

Real-Life Math

Astronomical Figures The distances from the sun to each of the nine planets in our solar system varies from about 57904280 km to 5899855100 km! These distances are easier to write in shorthand: 5.79×10^7 km and 5.899×10^9 km. The distance from the sun to the star nearest to it, Proxima Centauri, is about 40233600000000 km. It would be much easier for an astronomer to write this distance as 4.023×10^{13} km.

Mars, the fourth planet in our solar system, is 2.269×10^8 km from the sun.

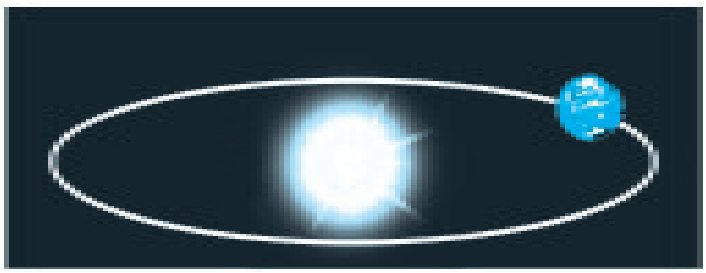
90. If $2^{n+2} - 2^{n+1} + 2^n = c \times 2^n$, find the value of c.

91. A light year is the distance that light can travel in one year.

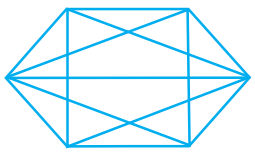
1 light year = 9,460,000,000,000 km.

(a) Express one light year in scientific notation.

(b) The average distance between Earth and Sun is 1.496×10^8 km. Is the distance between Earth and the Sun greater than, less than or equal to one light year?



92. **Geometry Application :** The number of diagonals of an n-sided figure is $\frac{1}{2}(n^2 - 3n)$. Use the formula to find the number of diagonals for a 6-sided figure (hexagon).



93. **Life Science :** Bacteria can divide in every 20 minutes. So 1 bacterium can multiply to 2 in 20 minutes. 4 in 40 minutes, and so on. How many bacteria will there be in 6 hours? Write your answer using exponents, and then evaluate.

Most bacteria reproduce by a type of simple cell division known as binary fission. Each species reproduce best at a specific temperature and moisture level.

Writing Strategy

Write a Convincing Argument

Your ability to write a convincing argument proves that you have understanding of the concept. An effective argument should include the following four parts:

1. A goal
2. A response to the goal
3. Evidence to support the response
4. A summary statement

Write about it

Compare 10^2 and 2^{10}. For any two numbers, which usually gives the greater number, using the greater number as the base or as the exponent? Give atleast one exception.

Step 1 : Identify the goal

For any two numbers, explain whether using the greater number as the base or as the exponent will generally result in a greater number. Find one exception.

Step 2 : Provide a response to the goal

Using the greater number as the exponent usually gives the greater number.

Step 3 : Provide evidence to support your response

For the number 10 and 2. Using the greater number, 10, as the exponent will result in a greater number.

$10^2 = 100$

$2^{10} = 1024$

$100 < 1024$

$10^2 < 2^{10}$

Exception for the numbers 2 and 3, using the greater number, 3, as the exponent will not result in a greater number.

$3^2 = 9$

$2^3 = 8$

$9 > 8$

$3^2 > 2^3$

Step 4 : Summarise your argument

Generally, for any two numbers, using the greater number as the exponent instead of as the base will result in a greater number.

94. **Blubber** makes up 27 per cent of a blue whale's body weight. Deepak found the average weight of blue whales and used it to calculate the average weight of their blubber. He wrote the amount as $2^2 \times 3^2 \times 5 \times 17$ kg. Evaluate this amount.

95. **Life Science Application :** The major components of human blood are red blood cells, white blood cells, platelets and plasma. A typical red blood cell has a diameter of approximately 7×10^{-6} metres. A typical platelet has a diameter of approximately 2.33×10^{-6} metre. Which has a greater diameter, a red blood cell or a platelet?

96. A googol is the number 1 followed by 100 zeroes.

(a) How is a googol written as a power?

(b) How is a googol times a googol written as a power?

97. **What's the error?**

A student said that $\frac{3^5}{9^5}$ is the same as $\frac{1}{3}$. What mistake has the student made?

(D) Application

1. **Cross Word Puzzle**

Solve the given crossword and then fill up the given boxes in 1 and 2. Clues are given below for across as well as downward fillings. Also for across and down clues, clue number is written at the corner of boxes. Answers of clues have to fill up in their respective boxes.

Down 1 : In 10^6, 10 is the base and 6 is _____.

Down 2 : $a^n = 1$ only if n = _____.

Down 3 : Very large numbers can be expressed in standard form, also known as _____ notation.

Down 4 : The place of 6 in 5.632 is _____.

Down 5 : In 10^{-5}, – 5 is the exponent and 10 is the _____.

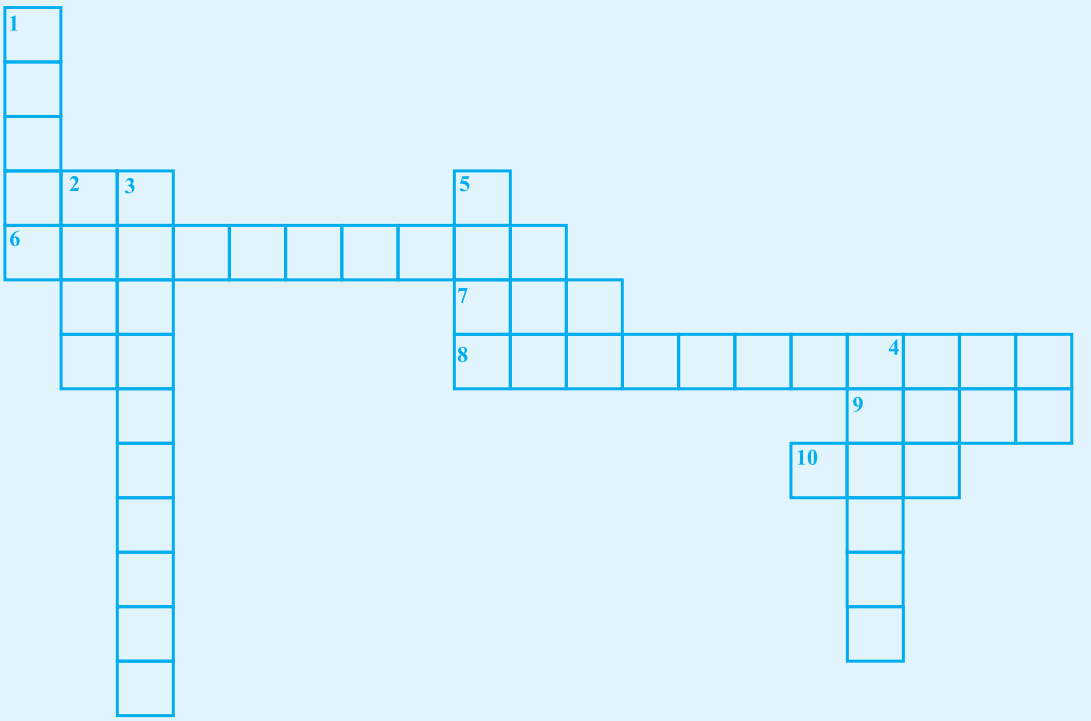
Across 6 : a^{-m} is the _____ of a^m.

Across 7 : $a^m \times a^n = a^x$, where x is the _____ of m and n.

Across 8 : 10^3 is called the _____ form of 1000.

Across 9 : $(-1)^p = 1$ is valid, where p is an _____ integer.

Down 10: $(1)^n = 1$ is valid for _____ value of n.



2. Cross Number Puzzle

Across

1. 5.724×10^3 is the standard form of _____.

2. The value of $\frac{21^3 \times 10^5 \times 125}{2^5 \times 3^3 \times 5^8}$ is _____.

3. The value of $2^{5\times2-3-2}$ is _____.

4. The value of $11^2 \times 3^2 - 11$ is _____.
5. The number 10^3 is the exponential form of _____.

Down

1. In 2^5, the exponent is _____.
6. The value of 3^5 is _____.
7. The value of $4 \times 10^4 + 3 \times 10^3 + 2 \times 10^2 + 7 \times 10$ is _____.
8. The cube of 8 is _____.
9. Square of -11 is _____.
10. The value of $(11)^2$ is _____.