

# Prime Factorization with Exponents

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Score: \_\_\_\_\_ / 24

## Q Quick Review

The **prime factorization** of a whole number writes it as a product of *prime numbers* only — numbers like 2, 3, 5, 7, 11 that have no factors besides 1 and themselves. A **factor tree** helps: keep breaking a number into two factors until every branch ends in a prime. When the same prime shows up more than once, gather the copies into an **exponent**, so  $2 \times 2 \times 2 = 2^3$ . Every whole number greater than 1 has exactly *one* prime factorization, so this is like a number’s fingerprint. It also makes finding the GCF and LCM much easier.

◇ **Example:** Write the prime factorization of 72 using exponents.

⇒ Build a factor tree. Start by splitting  $72 = 8 \times 9$ . Now break each branch:  $8 = 2 \times 2 \times 2$  and  $9 = 3 \times 3$ . Every branch now ends in a prime, so  $72 = 2 \times 2 \times 2 \times 3 \times 3$ . Finally, collect the repeats into exponents — there are three 2s and two 3s — which gives  $2^3 \times 3^2$ . (Quick check:  $8 \times 9 = 72$ .)

**Answer:**  $72 = 2^3 \times 3^2$

## PRACTICE

Write the prime factorization of each number using exponents.

- |        |       |         |       |
|--------|-------|---------|-------|
| 1. 12  | _____ | 11. 50  | _____ |
| 2. 18  | _____ | 12. 60  | _____ |
| 3. 20  | _____ | 13. 64  | _____ |
| 4. 24  | _____ | 14. 75  | _____ |
| 5. 27  | _____ | 15. 80  | _____ |
| 6. 30  | _____ | 16. 90  | _____ |
| 7. 36  | _____ | 17. 100 | _____ |
| 8. 40  | _____ | 18. 120 | _____ |
| 9. 45  | _____ | 19. 144 | _____ |
| 10. 48 | _____ | 20. 200 | _____ |

### ◆ Word Problems

21. A music teacher has 84 stickers to share. Write the prime factorization of 84 using exponents. \_\_\_\_\_
22. A number’s prime factorization is  $2^3 \times 3$ . What is the number? \_\_\_\_\_
23. Two gears have  $2^2 \times 3$  and  $2 \times 3^2$  teeth. Using prime factorizations, find the least common multiple of their tooth counts. \_\_\_\_\_
24. Nina says the prime factorization of 30 is  $1 \times 2 \times 3 \times 5$ . What mistake did she make? \_\_\_\_\_



## Answer Keys

- |   |  |
|---|--|
| <p>1. <math>2^2 \times 3</math></p> <p>2. <math>2 \times 3^2</math></p> <p>3. <math>2^2 \times 5</math></p> <p>4. <math>2^3 \times 3</math></p> <p>5. <math>3^3</math></p> <p>6. <math>2 \times 3 \times 5</math></p> <p>7. <math>2^2 \times 3^2</math></p> <p>8. <math>2^3 \times 5</math></p> <p>9. <math>3^2 \times 5</math></p> <p>10. <math>2^4 \times 3</math></p> <p>11. <math>2 \times 5^2</math></p> <p>12. <math>2^2 \times 3 \times 5</math></p> | <p>13. <math>2^6</math></p> <p>14. <math>3 \times 5^2</math></p> <p>15. <math>2^4 \times 5</math></p> <p>16. <math>2 \times 3^2 \times 5</math></p> <p>17. <math>2^2 \times 5^2</math></p> <p>18. <math>2^3 \times 3 \times 5</math></p> <p>19. <math>2^4 \times 3^2</math></p> <p>20. <math>2^3 \times 5^2</math></p> <p>21. <math>84 = 2^2 \times 3 \times 7</math></p> <p>22. 24</p> <p>23. 36</p> <p>24. 1 is not prime; <math>30 = 2 \times 3 \times 5</math></p> |
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### Step-by-Step Explanations

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|--|--|
| <p>1. <math>12 = 4 \times 3 = 2 \times 2 \times 3</math>, which is <math>2^2 \times 3</math>.</p> <p>2. <math>18 = 2 \times 9 = 2 \times 3 \times 3 = 2 \times 3^2</math>.</p> <p>3. <math>20 = 4 \times 5 = 2 \times 2 \times 5 = 2^2 \times 5</math>.</p> <p>4. <math>24 = 8 \times 3 = 2 \times 2 \times 2 \times 3 = 2^3 \times 3</math>.</p> <p>5. <math>27 = 3 \times 9 = 3 \times 3 \times 3 = 3^3</math>.</p> <p>6. <math>30 = 2 \times 15 = 2 \times 3 \times 5</math>; each prime appears once.</p> <p>7. <math>36 = 4 \times 9 = 2 \times 2 \times 3 \times 3 = 2^2 \times 3^2</math>.</p> <p>8. <math>40 = 8 \times 5 = 2 \times 2 \times 2 \times 5 = 2^3 \times 5</math>.</p> <p>9. <math>45 = 9 \times 5 = 3 \times 3 \times 5 = 3^2 \times 5</math>.</p> <p>10. <math>48 = 16 \times 3 = 2 \times 2 \times 2 \times 2 \times 3 = 2^4 \times 3</math>.</p> <p>11. <math>50 = 2 \times 25 = 2 \times 5 \times 5 = 2 \times 5^2</math>.</p> <p>12. <math>60 = 4 \times 15 = 2 \times 2 \times 3 \times 5 = 2^2 \times 3 \times 5</math>.</p> <p>13. <math>64 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 2^6</math>.</p> | <p>14. <math>75 = 3 \times 25 = 3 \times 5 \times 5 = 3 \times 5^2</math>.</p> <p>15. <math>80 = 16 \times 5 = 2^4 \times 5</math>.</p> <p>16. <math>90 = 2 \times 45 = 2 \times 3 \times 3 \times 5 = 2 \times 3^2 \times 5</math>.</p> <p>17. <math>100 = 4 \times 25 = 2 \times 2 \times 5 \times 5 = 2^2 \times 5^2</math>.</p> <p>18. <math>120 = 8 \times 15 = 2^3 \times 3 \times 5</math>.</p> <p>19. <math>144 = 16 \times 9 = 2^4 \times 3^2</math>.</p> <p>20. <math>200 = 8 \times 25 = 2^3 \times 5^2</math>.</p> <p>21. <math>84 = 4 \times 21 = 2 \times 2 \times 3 \times 7</math>. Collecting the two 2s gives <math>2^2 \times 3 \times 7</math>.</p> <p>22. <math>2^3 = 8</math> and then <math>8 \times 3 = 24</math>, so the number is 24.</p> <p>23. Take the highest power of each prime that appears: <math>2^2</math> and <math>3^2</math>. The LCM is <math>2^2 \times 3^2 = 4 \times 9 = 36</math>.</p> <p>24. The number 1 is not a prime number, so it should never appear in a prime factorization. The correct answer is just <math>2 \times 3 \times 5</math>.</p> |
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