Standard form

N9 · Number · revision notes

Writing very large and very small numbers in standard form $A \times 10^n$, converting to and from ordinary numbers, ordering them and calculating with them, with and without a calculator. Expect 1 to 3 mark questions on both papers, often set in science or computing contexts.

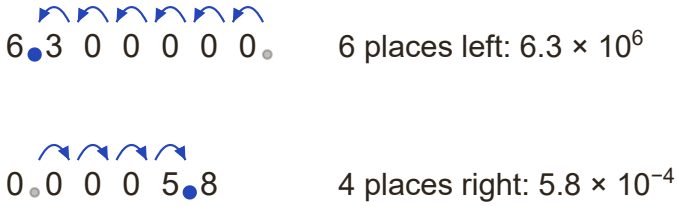
Key facts

- Standard form: $A \times 10^n$, with $1 \leq A < 10$ and n an integer
- $10^a \times 10^b = 10^{a+b}$ and $10^a \div 10^b = 10^{a-b}$
- Add or subtract: change to ordinary numbers first
- Large number → positive n; number between 0 and 1 → negative n
- $10^0 = 1$, $10^{-1} = 0.1$, $10^{-2} = 0.01$, $10^{-3} = 0.001$
- Fixing A: $12 \times 10^4 = 1.2 \times 10^5$ and $0.3 \times 10^4 = 3 \times 10^3$

Notes

What standard form is

- A number in standard form is written $A \times 10^n$, where $1 \leq A < 10$ and n is an integer.
- Large numbers have a positive power: 6,300,000 = 6.3×10^6
- Numbers between 0 and 1 have a negative power: 0.00058 = 5.8×10^{-4}
- n tells you how many places the digits move. To write the ordinary number, move the decimal point right for a positive n, left for a negative n



Count the hops needed to make a number between 1 and 10. Big numbers get a positive power; small numbers get a negative power.

- 45×10^3 is not in standard form, because 45 is not between 1 and 10. It is 4.5×10^4

Ordering

- Compare the powers of 10 first: the bigger power gives the bigger number. 2×10^{-3} is bigger than 9×10^{-5}, because −3 is greater than −5.
- If the powers are the same, compare the values of A

Multiplying and dividing

- Multiply or divide the A parts, and use the laws of indices on the powers of 10.

$$(3 \times 10^4) \times (6 \times 10^{-7}) = 18 \times 10^{-3}$$
$$= 1.8 \times 10^{-2}$$

$$(2 \times 10^5) \div (8 \times 10^2)$$
$$= 0.25 \times 10^3$$
$$= 2.5 \times 10^2$$

- Fixing A: if it is 10 or more, divide it by 10 and add 1 to the power. If it is less than 1, multiply it by 10 and subtract 1 from the power.

Adding, subtracting and calculators

- To add or subtract, change both to ordinary numbers (or to the same power of 10): $6.4 \times 10^5 - 8 \times 10^4$ = 640,000 − 80,000 = 560,000 = 5.6×10^5
- On a calculator, use the $\times 10^x$ (or EXP) key: 3.2×10^{-5} is typed 3.2, $\times 10^x$, (−), 5.
- Some calculators show answers like 1.8E−02. Always write this as 1.8×10^{-2}

How to answer each type of question

M = method mark, A = answer mark, B = a mark on its own, P = a process mark.

Convert to and from standard form 1 mark each **Grade 4**

1. Put the decimal point after the first non-zero digit to get A
2. Count how many places the point moves: that is n
3. Large number → positive n; small number → negative n

Example. (a) Write 0.000407 in standard form.
(b) Write 2.6×10^5 as an ordinary number.

Model answer.

(a) 4.07×10^{-4} (B1)

(b) 260,000 (B1)

Multiply or divide without a calculator

2 marks | Grade 5

1. Multiply (or divide) the A parts.
2. Add (or subtract) the powers of 10.
3. Adjust so that A is between 1 and 10.

Example. Work out $(5 \times 10^3) \times (7 \times 10^{-8})$
Give your answer in standard form.

Model answer.

$5 \times 7 = 35$ and $10^3 \times 10^{-8} = 10^{-5}$, so 35×10^{-5} (M1)

$= 3.5 \times 10^{-4}$ (A1)

Add or subtract in standard form

2 marks | Grade 5

1. Change both numbers to ordinary numbers (or to the same power of 10).
2. Add or subtract.
3. Change back to standard form if asked.

Example. Work out $4.2 \times 10^6 + 9 \times 10^5$
Give your answer in standard form.

Model answer.

4,200,000 + 900,000 (M1 for both as ordinary numbers, or both with the same power of 10)

= 5,100,000 = 5.1×10^6 (A1)

Problem in context using standard form

3 marks | Grade 6

1. Decide the operation: 'how many times', 'how long' or 'each' usually means divide; a total usually means multiply.
2. Calculate in standard form, showing the A parts and powers of 10.
3. Convert units at the end if needed, and check the answer is a sensible size.

Example. A computer can do 4×10^7 calculations every second.
How many minutes does it take the computer to do 1.2×10^{10} calculations?

Model answer.

$(1.2 \times 10^{10}) \div (4 \times 10^7)$ (P1)

$= 0.3 \times 10^3 = 300$ seconds (P1)

300 ÷ 60 = 5 minutes (A1)

Don’t lose marks

- Leaving A outside the range: 18×10^{-3} and 0.25×10^{3} are not in standard form.
- Getting the sign of the power wrong: 0.0005 = 5×10^{-4}, not 5×10^{4}
- Adding the A parts when the powers are different: $3 \times 10^{4} + 2 \times 10^{3}$ is 3.2×10^{4}, not 5×10^{4}
- Copying calculator notation, such as 4.5E11, as the answer.
- Counting the zeros instead of the places the decimal point moves.

More tips

Memory tricks

- Big number, positive power; small number, negative power.
- Check A: exactly one non-zero digit before the decimal point.
- 10^{3} is a thousand, 10^{6} a million, 10^{9} a billion; 10^{-3} is a thousandth.
- If A gets too big, 'A goes down, power goes up': $18 \times 10^{4} = 1.8 \times 10^{5}$

Exam technique

- If the question says 'Give your answer in standard form', an ordinary number loses the final mark.
- On the non-calculator paper, write the A parts and the powers of 10 separately before combining them.
- In context questions, include units and check that the size of your answer makes sense.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Write large numbers in standard form**
Place the point after the first digit and count the moves: 45,000 = 4.5×10^{4}

Grade 4 — **Write small numbers in standard form**
A number between 0 and 1 has a negative power: 0.00072 = 7.2×10^{-4}

Grade 4 — **Change standard form to ordinary numbers**
3.06×10^{5} = 306,000 and 3.06×10^{-3} = 0.00306.

Grade 4 — **Order numbers in standard form**
Compare the powers of 10 first, then the values of A

Grade 4 — **Use a calculator with standard form**
Use the $\times 10^{x}$ key, and write the answer in proper standard form, not calculator notation.

Grade 5 — **Multiply and divide in standard form**
Deal with the numbers and the powers of 10 separately, then adjust: $12 \times 10^{9} = 1.2 \times 10^{10}$

Grade 5 — **Add and subtract in standard form**
Change to ordinary numbers first: $3.2 \times 10^{4} + 5 \times 10^{3}$ = 32,000 + 5000 = 3.7×10^{4}

Grade 6 — **Solve problems in standard form**
E.g. find how many times bigger one quantity is, or a total from a very small unit amount.

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