

Standard form: IGCSE Maths worksheet with answers

Cambridge IGCSE Mathematics 0580 (Extended). Standard form is how very large and very small numbers are written so that they are easy to compare and calculate with. Read the notes, then work through the 24 questions. Full working is given in the answers at the end.

What you need to know

Definition. A number is in **standard form** when it is written as $a \times 10^n$, where $1 \leq a < 10$ and n is an integer (a positive or negative whole number, or zero).

So 3.2×10^5 is in standard form, but 32×10^4 and 0.32×10^6 are not.

Writing large numbers in standard form

Move the decimal point until there is exactly one non-zero digit in front of it. The number of places you moved it is the power of 10, and for a number bigger than 10 the power is positive.

- $4\,560\,000 = 4.56 \times 10^6$ (the point moved 6 places to the left)
- $93\,000 = 9.3 \times 10^4$

Writing small numbers in standard form

For a number between 0 and 1, move the point to the right until it sits just after the first non-zero digit. The power of 10 is negative.

- $0.000\,072 = 7.2 \times 10^{-5}$ (the point moved 5 places to the right)
- $0.0031 = 3.1 \times 10^{-3}$

Converting back to an ordinary number

A positive power moves the point to the right, filling the gaps with zeros; a negative power moves it to the left.

- $3.1 \times 10^4 = 31\,000$
- $2.5 \times 10^{-3} = 0.0025$

Multiplying and dividing

Deal with the front numbers and the powers of 10 separately. Multiply or divide the front numbers, and use the index laws for the powers: add them when multiplying, subtract them when dividing. Then check that the front number is still between 1 and 10 and adjust it if not.

- $(4 \times 10^3) \times (5 \times 10^6) = 20 \times 10^9 = 2 \times 10^{10}$
- $(3 \times 10^2) \div (6 \times 10^5) = 0.5 \times 10^{-3} = 5 \times 10^{-4}$

Take care with negative powers: $10^3 \times 10^{-5} = 10^{-2}$, but $10^3 \div 10^{-5} = 10^3 - (-5) = 10^8$.

Adding and subtracting



You can only add or subtract the front numbers when the powers of 10 are the same. If they differ, rewrite one number with the other's power (usually the larger), add or subtract, then put the answer back into standard form.

$$\bullet \quad 3.2 \times 10^5 + 4.1 \times 10^4 = 3.2 \times 10^5 + 0.41 \times 10^5 = 3.61 \times 10^5$$

Using a calculator

Scientific calculators have a key marked $\times 10^x$ or EXP. To enter 3.2×10^5 , press 3.2, then that key, then 5. Do not type the $\times$ and the 10 yourself, or the order of operations goes wrong. Put each number inside brackets when you divide. A display of 1.6E4 means 1.6×10^4 ; write the answer out properly on paper.

Rounding to significant figures

The first significant figure is the first non-zero digit. In standard form the front number already starts with it, so round the front number and keep the power of 10. Unless told otherwise, give non-exact answers to 3 significant figures.

- 3.456×10^7 to 2 significant figures is 3.5×10^7
- 9.96×10^3 to 2 significant figures is 10.0×10^3 , which must be rewritten as 1.0×10^4

Worked example 1. Without a calculator, work out $(6.4 \times 10^5) \times (2.5 \times 10^{-2})$, giving your answer in standard form.

Front numbers: $6.4 \times 2.5 = 16$. Powers: $10^5 \times 10^{-2} = 10^3$.

So the product is 16×10^3 . This is not in standard form because 16 is bigger than 10, so write 16 as 1.6×10^1 : $16 \times 10^3 = 1.6 \times 10^1 \times 10^3 = 1.6 \times 10^4$.

Worked example 2. Work out $7.5 \times 10^{-3} - 9 \times 10^{-4}$, giving your answer in standard form.

The powers are different, so rewrite the second number with the power 10^{-3} : $9 \times 10^{-4} = 0.9 \times 10^{-3}$. Now subtract the front numbers: $7.5 - 0.9 = 6.6$.

Answer: 6.6×10^{-3} . Check with ordinary numbers: $0.0075 - 0.0009 = 0.0066$.

Exam tip. An answer such as 36.1×10^4 scores the method marks but loses the final mark: check that the front number is at least 1 and less than 10. In word problems, make the units match before you calculate.

Worksheet

Give every answer in standard form unless the question says otherwise. Marks are in square brackets. Questions 7 to 14 are non-calculator; show your working.

Converting

- Write the following numbers in standard form. (a) 530 000 (b) 0.000 81 (c) 20 300 000 [3]
- Write the following as ordinary numbers. (a) 4.7×10^3 (b) 9.02×10^{-5} (c) 1.5×10^8 [3]
- State which of the following are written in standard form. For each one that is not, explain why

and rewrite it correctly. (a) 12×10^3 (b) 0.4×10^{-2} (c) 7×10^0 (d) 3.05×10^{-6} [3]

4. Write in standard form. (a) 45.6×10^4 (b) 0.0072×10^{-3} [2]

5. Write in standard form, correct to 3 significant figures. (a) 7 384 915 (b) 0.000 060 985 [2]

6. Arrange these numbers in order of size, smallest first: 3.9×10^{-3} , 4.1×10^{-4} , 9.8×10^{-4} , 1.02×10^{-3} [2]

Calculations without a calculator

7. Calculate $(3 \times 10^4) \times (2 \times 10^7)$. [2]

8. Calculate $(4.5 \times 10^6) \times (6 \times 10^{-2})$. [2]

9. Calculate $(8.4 \times 10^9) \div (4 \times 10^3)$. [2]

10. Calculate $(2.4 \times 10^{-3}) \div (8 \times 10^2)$. [2]

11. Calculate $5.6 \times 10^4 + 8.3 \times 10^3$. [2]

12. Calculate $9.1 \times 10^{-2} - 6.5 \times 10^{-3}$. [2]

13. Calculate $(5 \times 10^{-3})^2$. [2]

14. Calculate the square root of 1.6×10^7 . [2]

Word problems

15. Light travels at 3×10^8 metres per second. Calculate the distance light travels in one hour. Give your answer in metres. [2]

16. The average distance from the Sun to the Earth is 1.5×10^{11} m. Using the speed of light from question 15, calculate how long light from the Sun takes to reach the Earth. Give your answer in seconds and then in minutes and seconds. [3]

17. A colony of bacteria contains 4×10^5 bacteria. The number of bacteria doubles every 20 minutes. Calculate the number of bacteria after 2 hours. [3]

18. A red blood cell has a diameter of about 7.5×10^{-6} m. Calculate how many red blood cells, placed side by side in a straight line, would stretch across 1 cm. Give your answer correct to 3 significant figures. [3]

19. The population of Pakistan is approximately 2.4×10^8 and the population of the world is approximately 8.1×10^9 . Calculate the percentage of the world's population that lives in Pakistan. Give your answer correct to 3 significant figures. [3]

20. The mass of one hydrogen atom is 1.67×10^{-27} kg. Calculate the mass of 6×10^{23} hydrogen atoms. Give your answer in kilograms, correct to 3 significant figures. [2]

21. A hard drive can store 2×10^{12} bytes. A photograph takes up 4.5×10^6 bytes. Calculate the greatest number of photographs that the empty drive can hold. Give your answer (a) as a whole number and (b) in standard form correct to 3 significant figures. [3]

22. A virus particle is 1.2×10^{-7} m long. A grain of sand is 3×10^{-4} m across. Calculate how many times longer the grain of sand is than the virus particle. [2]

Harder questions

23. The mass of the Earth is 5.97×10^{24} kg and the mass of the Moon is 7.35×10^{22} kg. (a) Calculate the total mass of the Earth and the Moon, correct to 3 significant figures. (b) Calculate how many times heavier the Earth is than the Moon, correct to 3 significant figures. [4]

24. A small cube of metal has sides of length 2.5×10^{-3} m. The density of the metal is 8.9×10^3 kg/m³. (a) Calculate the volume of the cube in m³. (b) Calculate the mass of the cube in kg, correct to 3 significant figures. (c) Calculate how many of these cubes are needed to make a total mass of 1 kg, correct to 3 significant figures. [4]

Answers

1. (a) 5.3×10^5 (point moves 5 places). (b) 8.1×10^{-4} (point moves 4 places to the right). (c) 2.03×10^7 .
2. (a) $4.7 \times 10^3 = 4700$. (b) $9.02 \times 10^{-5} = 0.000\ 090\ 2$. (c) $1.5 \times 10^8 = 150\ 000\ 000$.
3. (a) No, 12 is not less than 10: 1.2×10^4 . (b) No, 0.4 is less than 1: 4×10^{-3} . (c) Yes: 7 is between 1 and 10 and 0 is an integer (the number is simply 7). (d) Yes.
4. (a) $45.6 = 4.56 \times 10^1$, so $45.6 \times 10^4 = 4.56 \times 10^5$. (b) $0.0072 = 7.2 \times 10^{-3}$, so $0.0072 \times 10^{-3} = 7.2 \times 10^{-6}$.
5. (a) $7.384\ 915 \times 10^6$; the fourth significant figure is 4, so round down: 7.38×10^6 . (b) 6.0985×10^{-5} ; the fourth significant figure is 8, so round up: 6.10×10^{-5} . Keep the zero, because 6.1×10^{-5} shows only 2 significant figures.
6. Compare the powers first (the 10^{-4} numbers are smaller than the 10^{-3} numbers), then the front numbers within each power. Order: 4.1×10^{-4} , 9.8×10^{-4} , 1.02×10^{-3} , 3.9×10^{-3} .
7. $3 \times 2 = 6$ and $10^4 \times 10^7 = 10^{11}$. Answer 6×10^{11} .
8. $4.5 \times 6 = 27$ and $10^6 \times 10^{-2} = 10^4$. This gives 27×10^4 , which is 2.7×10^5 in standard form.
9. $8.4 \div 4 = 2.1$ and $10^9 \div 10^3 = 10^6$. Answer 2.1×10^6 .
10. $2.4 \div 8 = 0.3$ and $10^{-3} \div 10^2 = 10^{-5}$. This gives 0.3×10^{-5} , which is 3×10^{-6} in standard form.
11. Make the powers the same: $8.3 \times 10^3 = 0.83 \times 10^4$. Then $5.6 + 0.83 = 6.43$, so the answer is 6.43×10^4 . Check: $56\ 000 + 8300 = 64\ 300$.
12. $6.5 \times 10^{-3} = 0.65 \times 10^{-2}$. Then $9.1 - 0.65 = 8.45$, so the answer is 8.45×10^{-2} .
13. $5^2 \times (10^{-3})^2 = 25 \times 10^{-6} = 2.5 \times 10^{-5}$.
14. Rewrite with an even power: $1.6 \times 10^7 = 16 \times 10^6$. The square root of 16 is 4 and the square root of 10^6 is 10^3 . Answer 4×10^3 .
15. One hour is $3600\text{ s} = 3.6 \times 10^3\text{ s}$. Distance = speed $\times$ time = $3 \times 10^8 \times 3.6 \times 10^3 = 10.8 \times 10^{11} = 1.08 \times 10^{12}\text{ m}$.
16. Time = distance $\div$ speed = $(1.5 \times 10^{11}) \div (3 \times 10^8) = 0.5 \times 10^3 = 500\text{ s} = 8\text{ minutes } 20\text{ seconds}$.
17. 2 hours = 120 minutes = 6 periods of 20 minutes, so the number doubles 6 times: $2^6 = 64$. Number = $4 \times 10^5 \times 64 = 256 \times 10^5 = 2.56 \times 10^7$.
18. Match the units first: $1\text{ cm} = 1 \times 10^{-2}\text{ m}$. Number of cells = $(1 \times 10^{-2}) \div (7.5 \times 10^{-6}) = (1 \div 7.5) \times 10^4 = 0.1333... \times 10^4 = 1333.3...$ Answer 1.33×10^3 cells.
19. $(2.4 \times 10^8) \div (8.1 \times 10^9) = (2.4 \div 8.1) \times 10^{-1} = 0.2963... \times 10^{-1} = 0.029\ 63...$ Multiply by 100: $2.963...%$, which is 2.96% to 3 significant figures.

20. Front numbers: $1.67 \times 6 = 10.02$. Powers: $10^{-27} \times 10^{23} = 10^{-4}$. Mass = $10.02 \times 10^{-4} \text{ kg} = 1.002 \times 10^{-3} \text{ kg} = 1.00 \times 10^{-3} \text{ kg}$ to 3 significant figures (about 1 gram).

21. $(2 \times 10^{12}) \div (4.5 \times 10^6) = (2 \div 4.5) \times 10^6 = 0.4444... \times 10^6 = 444\,444.4...$ (a) The drive cannot hold part of a photograph, so round down: 444 444 photographs. (b) 4.44×10^5 .

22. $(3 \times 10^{-4}) \div (1.2 \times 10^{-7}) = (3 \div 1.2) \times 10^{-4 - (-7)} = 2.5 \times 10^3$. The grain of sand is 2500 times longer.

23. (a) Write the Moon's mass with the power 10^{24} : $7.35 \times 10^{22} = 0.0735 \times 10^{24}$. Total = $5.97 + 0.0735 = 6.0435$, so the total mass is $6.04 \times 10^{24} \text{ kg}$ to 3 significant figures. (b) $(5.97 \times 10^{24}) \div (7.35 \times 10^{22}) = (5.97 \div 7.35) \times 10^2 = 0.8122... \times 10^2 = 81.22...$ The Earth is 81.2 times heavier than the Moon.

24. (a) Volume = $(2.5 \times 10^{-3})^3 = 15.625 \times 10^{-9} = 1.5625 \times 10^{-8} \text{ m}^3$. (b) Mass = density $\times$ volume = $8.9 \times 10^3 \times 1.5625 \times 10^{-8} = 13.906\,25 \times 10^{-5} \text{ kg} = 1.39 \times 10^{-4} \text{ kg}$ to 3 significant figures (about 0.14 g). (c) Number of cubes = $1 \div (1.390\,625 \times 10^{-4}) = 0.7191... \times 10^4 = 7191.0...$, which is 7.19 $\times 10^3$ cubes. Use the unrounded mass from (b); 1.39×10^{-4} gives 7194, which rounds the same.