CHEMISTRY

Chemistry and Measurements

(Lecture PPTs)

Significant Figures

CORE CHEMISTRY SKILL

Counting Significant Figures

In a measured number, the **significant figures (SFs)** are all the digits including the estimated digit.

All nonzero numbers are counted as significant figures.

Zeros may or may not be significant, depending on their position in the number.

Rules for Significant Figures

A number is a significant figure (SF) if it is or has the following:

TABLE 2.2 Significant Figures in Measured Numbers

Rule	Measured Number	Number of Significant Figures
1. A number is a *significant figure* if it is		
a. not a zero	4.5 g 122.35 m	2 5
b. a zero between nonzero digits	205 °C 5.008 kg	3 4
c. a zero at the end of a decimal number	50. L 16.00 mL	2 4
d. in the coefficient of a number written in scientific notation	4.8×10^{5} m 5.70×10^{-3} g	2 3
2. A zero is *not significant* if it is		
a. at the beginning of a decimal number	0.0004 s 0.075 cm	1 2
b. used as a placeholder in a large number without a decimal point	850 000 m 1 250 000 g	2 3

Counting Significant Figures

All nonzero numbers in a measured number are significant.

Measurement	Number of Significant Figures
38.15 cm	4
5.6 ft	2
65.6 lb	3
122.55 m	5

Zeros Between Digits

Zeros between nonzero digits are significant.

Measurement	Number of Significant Figures
50.08 km	4
201 min	3
0.0702 lb	3
0.40505 m	5

Zeros: Decimal Numbers

Zeros at the end of decimal numbers are significant.

Measurement	Number of Significant Figures
200. min	3
40.00 g	4

Zeros: Decimal Numbers

Zeros at the beginning of decimal numbers are *not significant*.

Measurement	Number of Significant Figures
0.440 km	3
0.022 g	2
0.003 s	1

Zeros: Nondecimal Numbers

Zeros used as placeholders in a large number without a decimal point are *not significant*.

Measurement	Number of Significant Figures
44 000 km	2
810 cm	2
6 150 000 g	3

Zeros: Scientific Notation

Zeros in the coefficient of numbers written in scientific notation are significant.

Measurement	Number of Significant Figures
4.90×10^{3} m	3
8.0×10^{-3} kg	2
6.0330×10^{-5} L	5

Zeros: Scientific Notation

Keep only the significant zeros when writing numbers in scientific notation.

Measurement	Number of Significant Figures	Scientific Notation
500. g	3	5.00×10^{2} g
400 000 m	1	4×10^{5} m
0.30 cm	2	3.0×10^{-1} cm

Learning Check

Identify the significant and nonsignificant zeros in each of the following numbers, and write each number in the correct scientific notation:

A. 0.002 650 m

B. 43.026 g

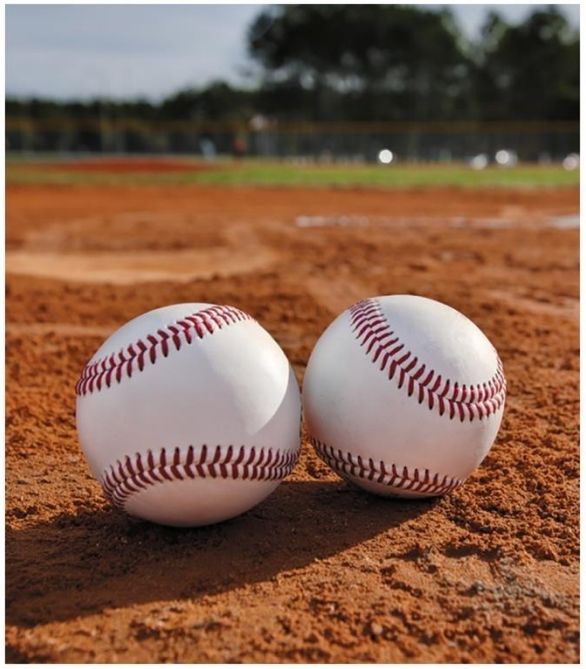
C. 1 044 000 L

Exact Numbers

Exact numbers are

- those numbers obtained by counting items.
- definitions that compare two units in the same measuring system.

8 cookies
2 baseballs
1 ft = 12 in.
1 kg = 1000 g



Exact Numbers

Exact numbers are not measured, do not have a limited number of significant figures, and do not affect the number of significant figures in a calculation.

TABLE 2.3 Examples of Some Exact Numbers

Counted Numbers	Defined Equalities	
Items	Metric System	U.S. System
8 doughnuts	1 L = 1000 mL	1 ft = 12 in.
2 baseballs	1 m = 100 cm	1 qt = 4 cups
5 capsules	1 kg = 1000 g	1 lb = 16 oz

Learning Check

Identify the numbers below as measured or exact, and give the number of significant figures in each measured number.

A. 3 coins

B. The diameter of a circle is 7.902 cm.

C. 60 min = 1 h

Learning Check

State the number of significant figures in each of the following measurements:

A. 0.030 m

B. 4.050 L

C. 0.0008 g

D. 2.80 m

Learning Check

A. Which answer contains three significant figures?

(1) 0.4760 (2) 0.00476 (3) 4.076×10^3

B. All the zeros are significant in

(1) 0.00307 (2) 25.300 (3) 2.050×10^3

C. The number of significant figures in 5.80×10^2 is

(1) one (2) two (3) three

Significant Figures in Calculations

A calculator is helpful in working problems and doing calculations faster.

Learning Goal Adjust calculated answers to give the correct number of significant figures.

Rounding Off

KEY MATH SKILL
Rounding Off

In calculations,

- calculated answers are usually **rounded off**.
- **rounding rules** are used to obtain the correct number of significant figures.

Rules for Rounding Off

1. If the first digit to be dropped is *4 or less*, then it and all the following digits are dropped from the number.
2. If the first digit to be dropped is *5 or greater*, then the last retained digit of the number is increased by 1.

Rounding Off and Significant Figures

Number to Round Off	Three Significant Figures	Two Significant Figures
8.4234	8.42 (drop 34)	8.4 (drop 234)
14.780	14.8 (drop 80, increase the last retained digit by 1)	15 (drop 780, increase the last retained digit by 1)
3256	3260* (drop 6, increase the last retained digit by 1, add 0) (3.26×10^3)	3300* (drop 56, increase the last retained digit by 1, add 00) (3.3×10^3)

*The value of a large number is retained by using placeholder zeros to replace dropped digits.

Learning Check

Write the correct value when 3.145 g is rounded off to each of the following:

A. three SFs

B. two SFs

Learning Check

Adjust the following calculated answers to give answers with three significant figures:

A. 824.75 cm

B. 0.112 486 g

C. 5.3 L

Multiplication and Division with Measured Numbers

CORE CHEMISTRY SKILL
Using Significant Figures in Calculations

In multiplication or division, the final answer is written to have the same number of significant figures (SFs) as the measurement having *the fewest SFs*.

Example: $\dfrac{2.8 \times 67.40}{34.8} =$

Adding Significant Zeros

When the calculator answer is a small whole number and more significant figures are needed, we can add one or more zeros.

$$\underset{\text{Three SFs}}{\frac{8.00}{2.00}} = \underset{\text{Calculator display}}{4.} = \underset{\text{Final answer, two zeros added to give three SFs}}{4.00}$$

Learning Check

Perform the following calculation of measured numbers. Give the answer with the correct number of significant figures.

$$\frac{5.00\ \text{cm} \times 3.408\ \text{cm}}{2.0\ \text{cm}} =$$

Addition and Subtraction with SFs

In addition or subtraction, the final answer is written so that it has the same number of decimal places as the measurement having the *fewest decimal places*.

Example 1 Add the following measured numbers:

2.012	Thousandths place
61.09	Hundredths place
+ 3.0	Tenths place
66.102	Calculator display
66.1	Answer, rounded off to the tenths place

Addition and Subtraction with SFs

Example 2 Subtract the following measured numbers:

65.09	Hundredths place
− 3.0	Tenths place
62.09	Calculator display
62.1	Answer, rounded off to the tenths place

Learning Check

Add the following measured numbers:

82.409 mg

+ 22.0 mg