M.Sc. (Semester-II) Forensic Science, FS-201 Forensic Analytical Chemistry

Rounding off rules:

If the digit following the last significant figure is greater than 5, the number is rounded up to the next higher digit. If it is less than 5, the number is rounded to present value of the last significant figure.
Example: 9.47 = 9.5 and 9.43 = 9.4

If the last digit is a 5, the number is rounded off to the nearest even digit (always round to the even number if the last digit is a 5). It is called even number rule.
Example: 8.65 = 8.6, 8.75 = 8.8 and 8.55 = 8.6

Points to be noted:

1. The even number rule applies only when the digit dropped is exactly 5.
Example: 8.65 = 8.6 and 8.651 = 8.7
2. All the non-significant digits should be rounded off at once.
Example: 8.546 = 8.5

Significant figure conventions:

The term “digit” represents any one of the ten numerals including zero. A significant figure is a digit in which it denotes the amount or quantity in the place in which it stands.

The total number of significant figures in a given number is all of the certain digits plus the first uncertain digit.

Rules for determining total number of significant figures in a given number:

1. Express data in scientific notation to avoid confusion in determining whether terminal zeros are significant or not.
2. Disregard all initial zeros.
3. Disregard all final zeros unless they follow a decimal point.
4. All the remaining digits including zeros between the non-zero digits are significant.

Examples:
1.2680 and 1.0062: 5 significant figures (zeros are significant).
0.0025: 2 significant figures (zeros are not significant).
30.24 and 0.03024: 4 significant figures.

Significant figures in numerical computations:

Addition and Subtraction:

For addition and subtraction, the number of significant figures can be found by visual inspection.

For example, in the expression, 3.4 + 0.020 + 7.31 = 10.730, the second and third decimal places in the answer cannot be significant because 3.4 is uncertain in the first decimal place. **Therefore the correct answer is 10.7**

When adding and substracting numbers in scientific notation, express the numbers to the same power of ten.

For example,

2.432×10^6 = 2.432×10^6
$+ 6.512 \times 10^4$ = 0.06512×10^6
$- 1.227 \times 10^5$ = 0.1227×10^6

2.37442×10^6

The correct answer is 2.374×10^6.

<u>Multiplication and Division:</u>

Consider the example: (24 × 4.52)/100.0 = 1.0848

The following steps to be followed for the multiplication and division

1. Multiply the answer with the highest relative uncertainty amongst number involved in the operation.
In the above operation the answer, 1.0848 (without considering the significant figure rules) is multiplied with 1/24 (highest relative uncertainty amongst number involved in the operation). Accordingly, 1.0848 × 1/24 = 0.0452. (Note: We have to assume that one unit uncertainty is present in any given number. Therefore, the relative uncertainty present in the above numbers are 1/24, 1/452 and 1/1000, respectively.)

2. Find out at what decimal place, the first non-zero digit appears, then as many decimal places can be kept in the answer.
In the number, 0.0452 the first non-zero digit is observed at the second decimal place. Therefore the answer can have two decimal places.
Thus the correct answer is 1.08

<u>Log and Antilog:</u>
The following rules apply for log and antilog.

1. In a log of a number keep as many digits to the right of the decimal point as there are significant figures in the original number.
Example: $\log(6.000\times10^{-5}) = -4.2218488$
The number 6.000×10^{-5} has 4 significant figures. As per the above rule, the answer can have 4 decimal places. **The correct answer is -4.2218**

2. In a antilog of a number, keep as many digits as there are digits to the right of the decimal point in the original number.
Example: antilog(12.5) = 3.162277×10^{12}
The number 12.5 has one decimal place. As per the above rule the answer can have one significant figure. **The correct answer is 3×10^{12}**

Error propagation in arithmetic calculations:

Type of calculation	**Example**	**Standard deviation of y**
Addition and subtraction	y = a + b - c y(±Sy) = a(±Sa) + b(±Sb) - c(±Sc)	Sy = $\sqrt{Sa^2 + Sb^2 + Sc^2}$
Multiplication and division	y = $\frac{a\times b}{c}$ y = $\frac{a(\pm Sa)\times b(\pm Sb)}{c(\pm Sc)}$	Sy = $y \times \sqrt{(\frac{Sa}{a})^2 + (\frac{Sb}{b})^2 + (\frac{Sc}{c})^2}$
Log	y = log a y = log a(±Sa)	Sy = 0.434× $\frac{Sa}{a}$
Antilog	y = antilog a y = antilog a(±Sa)	Sy = y×2.303×Sa

a, b, and c represents experimental variables whose standard deviations are Sa, Sb, and Sc respectively. y and Sy are the final value after the mathematical operation and standard deviation associated with the final value.