# Maths skills – M0 Arithmetic and numerical computation

### M0.1 – Recognise and make use of appropriate units in calculations

Section M0.1 explains the importance of using appropriate units in calculations and being able to convert between them. If your measurement is getting larger, for example from nm to mm, then you need to divide by the appropriate factor. If your measurement is getting smaller, for example from cm to mm then you need to multiply. There are many typical measures including distance (or length), mass, time etc. each with multiple units to convert between, and it is important for learners to choose the most appropriate unit to use.

Rates of change show a quantity per a unit of time, with the unit of time always expressed as “to the minus 1”. Other examples have rate of change measured as quantity per length, again with the unit of length being made into negative powers. In some cases learners will need to combine two or more units.

### M0.2 – Recognise and use expressions in decimal and standard form

You are usually expected to record raw data to the same number of decimal places, which is simply how many digits come after the decimal point. When adding and subtracting decimals the answer should be given using the lowest number of decimal places used in the calculation. This involves rounding off the number to a certain point depending on how many decimal places you are recording, with rounding up being required if the next number is 5 or above.

Many numbers in biology, particularly with calculations involving large or small numbers, will be written in standard form, in the format:

***a*** *× 10****n***

where ***n*** is a whole number (also known as an integer)

and ***a*** is between the values of 1 and 10.

You need to remember the “power laws” in order to deal with the value of ***n***.

You are expected to be able to express results in standard form and to also convert between standard and decimal forms.

### M0.3 – Use ratios, fractions and percentage

Section M0.3 explains the use of ratios, fractions and percentages in calculating percentage yields and percentage change, surface area to volume ratios and phenotypic ratios as well as using scales for measuring.

A percentage is simply a fraction out of 100 and is used to calculate what quantity a “part” is out of a “whole”. By dividing the “part” by the “whole” and multiplying by 100, it is converted into a percentage. Percentages can be used to determine how much a quantity has increased or decreased by (percentage change) as well as calculating the efficiency of reactions using how much product is formed (percentage yield).

Ratios are used to describe the relationship between values and is reported as “x : 1”. Ratios are most commonly used to describe the relationship between surface area and volume (surface area to volume ratios) or in genetics in comparing offspring (phenotypic ratios).

### M0.4 – Estimate results

Estimating allows you to see whether the answer you’ve calculated makes sense or whether you may have made a mistake. Sometimes this may involve working out an answer based on an already known quantity, such as the average weight of a human being 70 kg. Other times you need to round a value up or down to create nicer numbers to work with. Estimating is very useful for spotting mistakes made with units, decimal points or general mistakes with putting in the wrong number.

### M0.5 – Use calculators to find and use power, exponential and logarithm functions

Different models of calculators have different buttons to enter powers and logarithms. Some examples of different calculator symbols for powers include: ‘*xy*’, ‘10*x*’, ‘^’ and ‘exp’.

The two most useful logarithm bases are base-10 (common logs) or base-e (natural logs). Common logs are written as “log(x)” and have the calculator button “log”. Natural logs are written as “ln(x)” and have the calculator button “ln”.

You will be expected to be able to estimate the number of bacteria grown over a certain length of time. Bacterial cells multiply exponentially. The formula to find the number of cells after $n$ generations is:

$$N=N\_{0}×2^{n}$$

where *N*0 = initial number and *n =* division number.

### Questions:

1. Convert each of the following into mm.

| (a) 100 nm |  |
| --- | --- |
| (b) 2 µm |  |
| (c) 3 m |  |
| (d) 20 km |  |

2. Volumes.

| (a) | How many nm3 in a mm3? |  |
| --- | --- | --- |
| (b) | How many nm3 in a μm3? |  |

3. Use correct notation to express the following:

| (a) | 20 m per second |  |
| --- | --- | --- |
| (b) | 14 breaths per minute |  |
| (c) | 360 dm3 per hour |  |
| (d) | 103 bacteria per hour |  |

4. Convert these into standard form, to one decimal place.

| (a) | 0.3 |  |
| --- | --- | --- |
| (b) | 0.0056 |  |
| (c) | 0.000000000000056 |  |
| (d) | 0.0000016 |  |

5. Convert each of the following into nm.

| (a) | 24 m |  |
| --- | --- | --- |
| (b) | 70 µm |  |
| (c) | 0.03 µm |  |
| (d) | 18 mm |  |

6. Calculate the following giving answers in standard form.

|  |  |  |
| --- | --- | --- |
| (a) | (2 x 105) x (3 x 105) |  |
| (b) | (5 x 102) x (3 x 103) |  |
| (c) | (4 x 10-6) x (1 x 105) |  |
| (d) | (5 x 10-3) x (5 x 10-3) |  |

7. A 10 m*l* starter culture of bacteria was incubated overnight. A serial dilution was then used to make a 1 x 10-3dilution of the resulting culture. A 10 μ*l* sample of this dilution was spread on an agar plate to identify individual colonies.

The resulting spread plate looked like this:



Calculate approximately how many bacteria were in the original culture:

8. Linoleic acid has the formula C18H32O2. What percentage of atoms in linoleic acid are:

| (a) | Carbon? |  |
| --- | --- | --- |
| (b) | Hydrogen? |  |
| (c) | Oxygen? |  |

9. In an experiment using catalase to catalyse the release of oxygen gas from a solution of hydrogen peroxide, the theoretical yield is 15.4 cm3. The actual yield was 9.8 cm3. What was the percentage yield for this enzymatic reaction?

|  |
| --- |

10. Convert the following to sensible units:

| (a) | 85000 g |  |
| --- | --- | --- |
| (b) | 0.0000008 *l* |  |
| (c) | 9000 μm |  |
| (d) | 5000000000 mg |  |

11. In one year a population of 80 rabbits had decreased by 10%, what is the total number of rabbits at the end of the year?

|  |
| --- |

12. Areas.

| (a) | How many nm2 in a mm2? |  |
| --- | --- | --- |
| (b) | How many nm2 in a μm2? |  |

13. Fill in the correct values for volume to 1 decimal place and calculate the mean

|  |  |  |
| --- | --- | --- |
| **Measurement** | **Volume (m*l*)****X** | **Volume (m*l*)**✓ |
| 1 | 4.85 |  |
| 2 | 7.0 |  |
| 3 | 7.14 |  |
| 4 | 5.99 |  |
|  | **Mean:**  |  |

14. 30 kittens were classified according to their coat colour:

|  |  |
| --- | --- |
| **Coat colour** | **Number of kittens** |
| Black | 17 |
| White | 4 |
| Ginger | 9 |

What was the ratio of black to white to ginger kittens?

| * 1. **:** \_\_\_ **:** \_\_\_
 |
| --- |

15. In an experiment, initial and final mass readings were taken. What is the change in mass?

|  |  |  |
| --- | --- | --- |
| Initial mass = 27.6g | Final mass = 22.25g | Change in mass =  |

16. Estimate answers, then check your estimates with a calculator:

a) 11.2 x 14.9 =

b) 5.9 x 13.2 =

c) 49.7/6.3 =

17. At the start of an experiment there are 100 bacterial cells in a culture. This bacterium divides (doubles) about every 20 minutes under standard conditions. How many cells will there be after 3 hours?

### Answers:

1. Convert each of the following into mm. (M0.1)

| (a) | 100 nm | 100 nm = 1 x 10-4 mm |
| --- | --- | --- |
| (b) | 2 µm | 2 µm = 2 x 10-3 mm |
| (c) | 3 m | 3 m = 3 x 103 mm |
| (d) | 20 km | 20 km = 2 x 107 mm |

2. Volumes. (M0.1)

| (a) | How many nm3 in a mm3? | 1018 |
| --- | --- | --- |
| (b) | How many nm3 in a μm3? | 109 |

3. Use correct notation to express the following: (M0.1)

| (a) | 20 m per second | 20 m s-1 |
| --- | --- | --- |
| (b) | 14 breaths per minute | 14 breaths min-1 |
| (c) | 360 dm3 per hour | 360 dm3 h-1 or 3.6 x 102 dm3 h-1 |
| (d) | 103 bacteria per hour | 103 bacteria h-1 |

4. Convert these into standard form, to one decimal place. (M0.2)

| (a) | 0.3 | 3.0 x 10-1 |
| --- | --- | --- |
| (b) | 0.0056 | 5.6 x 10-3 |
| (c) | 0.000000000000056 | 5.6 x 10-14 |
| (d) | 0.0000016 | 1.6 x 10-6 |

5. Convert each of the following into nm. (M0.1)

| (a) | 24 m | 24 m = 2.4 x 1010 nm |
| --- | --- | --- |
| (b) | 70 µm | 70 µm = 7 x 104 nm |
| (c) | 0.03 µm | 0.03 µm = 3 x 101 nm |
| (d) | 18 mm | 18 mm = 1.8 x 107 nm |

6. Calculate the following giving answers in standard form. (M0.2)

|  |  |  |
| --- | --- | --- |
| (a) | (2 x 105) x (3 x 105) | 6 x1010 |
| (b) | (5 x 102) x (3 x 103) | 1.5 x 106 |
| (c) | (4 x 10-6) x (1 x 105) | 4 x 10-1 |
| (d) | (5 x 10-3) x (5 x 10-3) | 2.5 x 10-5 |

7. A 10 m*l* starter culture of bacteria was incubated overnight. A serial dilution was then used to make a 1 x 10-3dilution of the resulting culture. A 10 μ*l* sample of this dilution was spread on an agar plate to identify individual colonies. (M0.4)

The resulting spread plate looked like this:



Calculate approximately how many bacteria were in the original culture:

19 bacteria in 10 μ*l* spread plate

Dilution factor = 1 in 1000

19 x 1000 = 19,000 in 10 μ*l* of the original culture

Total volume of original culture = 10 m*l*

19000 x 1000 = 19,000,000 bacteria in the 10 m*l* starter culture

8. Linoleic acid has the formula C18H32O2. What percentage of atoms in linoleic acid are:

| (a) | Carbon? | 35% (18 of 52) |
| --- | --- | --- |
| (b) | Hydrogen? | 62% (32 of 52) |
| (c) | Oxygen? | 4% (2 of 52) |

 (M0.3)

9. In an experiment using catalase to catalyse the release of oxygen gas from a solution of hydrogen peroxide, the theoretical yield is 15.4 cm3. The actual yield was 9.8 cm3. What was the percentage yield for this enzymatic reaction? (M0.3)

| 100 x 9.8 / 15.4 = 64% |
| --- |

10. Convert the following to sensible units: (M0.1)

| (a) | 85000 g | 85 kg |
| --- | --- | --- |
| (b) | 0.0000008 *l* | 0.8 μ*l* or 8 x 10-1 μ*l* |
| (c) | 9000 μm | 9 mm |
| (d) | 5000000000 mg | 5000 kg or 5 x 103 kg |

11. In one year a population of 80 rabbits had decreased by 10%, what is the total number of rabbits at the end of the year? (M0.3)

| 80 x 0.9 = 72 rabbits |
| --- |

12. Areas. (M0.1)

| (a) | How many nm2 in a mm2? | 1012 |
| --- | --- | --- |
| (b) | How many nm2 in a μm2? | 106 |

13. Fill in the correct values for volume to 1 decimal place and calculate the mean.

|  |  |  |
| --- | --- | --- |
| **Measurement** | **Volume (m*l*)****X** | **Volume (m*l*)**✓ |
| 1 | 4.85 | 4.9 |
| 2 | 7.0 | 7.0 |
| 3 | 7.14 | 7.1 |
| 4 | 5.99 | 6.0 |
|  | **Mean:**  | 6.25 |

14. 30 kittens were classified according to their coat colour:

|  |  |
| --- | --- |
| **Coat colour** | **Number of kittens** |
| Black | 17 |
| White | 4 |
| Ginger | 9 |

What was the ratio of black to white to ginger kittens? (M0.3)

| * 1. **:** 0.4 **:** 1
 |
| --- |

15. In an experiment, initial and final mass readings were taken. What is the change in mass? (M0.2)

|  |  |  |
| --- | --- | --- |
| Initial mass = 27.6g | Final mass = 22.25g | Change in mass = 5.35 g = 5.4 g |

16. Estimate answers, then check your estimates with a calculator: (M0.4)

a) 11.2 x 14.9 estimate 🡪 11 x 15 = 165 calculator 🡪 166.9

b) 5.9 x 13.2 estimate 🡪 6 x 13 = 78 calculator 🡪 77.9

c) 49.7/6.3 estimate 🡪 48 / 6 = 8 calculator 🡪 7.9

17. At the start of an experiment there are 100 bacterial cells in a culture. This bacterium divides (doubles) about every 20 minutes under standard conditions. How many cells will there be after 3 hours? (M0.5)

60 min /20 min = 3 divisions per hour

3 x 3 = 9 divisions in 3 hours

$N=N\_{0}×2^{n}$ = 100 x 29 = 51200 bacterial cells = 5.12 x 104 bacterial cells

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