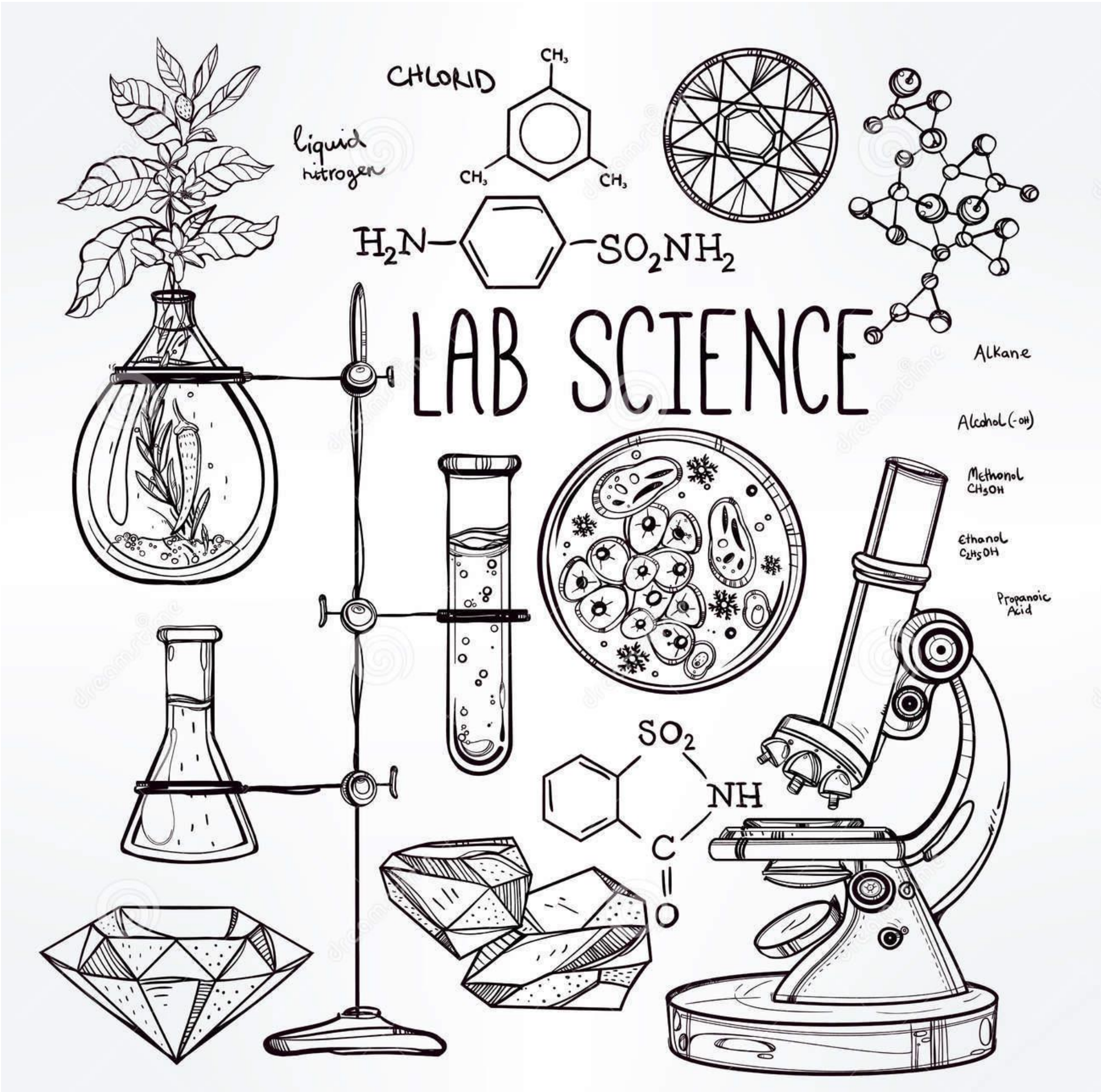
AQA Applied Science Level 3

Bridging work Part 1 – Maths skills



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Introduction

Welcome to Applied Science at The Blue Coat Sixth Form!

Moving from GCSE Science to Level 3 Applied Science can be a daunting leap. You'll be expected to remember a lot of facts, equations, definitions, and develop the independence skills required to research and write scientific reports. This bridging pack has been designed to consolidate some key skills and knowledge from your GCSEs, which if mastered will allow you to get a head start in advance of the academic year starting in September.

How should I use this booklet?

Review a topic by reading through the appropriate section. Then test your understanding of this topic by answering the practice questions. Follow this up MiB (make it better). This is when you compare your answers to the practice questions with those provided at the end of the booklet, and you annotate your answers with ticks/crosses in a different colour pen. For any you got incorrect, write the correct answer and use this to figure out where you went wrong. Set a target to complete one topic in a day.

Good luck!

Units and prefixes

A key criterion for success in Science lies in the use of correct units and the management of numbers. The units scientists use are from the Système Internationale – the SI units.

To accommodate the huge range of dimensions in our measurements they may be further modified using appropriate prefixes. For example, one thousandth of a second is a millisecond (ms). Some of these prefixes are illustrated in the table below. You need to be familiar with the prefixes, its symbol and the multiplication factor in powers of 10.

Multiplication factor	Prefix	Symbol
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n

Practice questions

1 A burger contains 4 500 000 J of energy. Write this in:

a kilojoules

b megajoules.

2 HIV is a virus with a diameter of between 9.0×10^{-8} m and 1.20×10^{-7} m.

Write this range in nanometres.

Powers and indices

Ten squared = $10 \times 10 = 100$ and can be written as 10^2. This is also called 'ten to the power of 2'.

Ten cubed is 'ten to the power of three' and can be written as $10^3 = 1000$.

The power is also called the **index**.

Fractions have negative indices:

one tenth = $10^{-1} = \frac{1}{10} = 0.1$

one hundredth = $10^{-2} = \frac{1}{100} = 0.01$

Any number to the **power of 0** is equal to **1**, for example, $29^0 = 1$.

If the index is 1, the value is unchanged, for example, $17^1 = 17$.

When **multiplying powers of ten**, you must **add the indices**.

So 100 × 1000 = 100 000 is the same as $10^2 \times 10^3 = 10^{2+3} = 10^5$

When **dividing powers of ten**, you must **subtract the indices**.

So $\frac{100}{1000} = \frac{1}{10} = 10^{-1}$ is the same as $\frac{10^2}{10^3} = 10^{2-3} = 10^{-1}$

But you can **only do this** when the numbers with the indices are the **same**.

So $10^2 \times 2^3 = 100 \times 8 = 800$

And you **can't do this** when **adding** or **subtracting**.

$10^2 + 10^3 = 100 + 1000 = 1100$

$10^2 - 10^3 = 100 - 1000 = -900$

Remember: You can only add and subtract the indices when you are multiplying or dividing the numbers, not adding or subtracting them.

Practice questions

1 Calculate the following values. Give your answers using indices.

a $10^8 \times 10^3$ **b** $10^7 \times 10^2 \times 10^3$ **c** $10^3 + 10^3$ **d** $10^2 - 10^{-2}$

2 Calculate the following values. Give your answers with and without using indices.

a $10^5 \div 10^4$ **b** $10^3 \div 10^6$ **c** $10^2 \div 10^{-4}$ **d** $100^2 \div 10^2$

Converting units

When doing calculations, it is important to express your answer using **sensible numbers**. For example, an answer of **6230 µm** would have been more **meaningful** expressed as **6.2 mm**.

If you convert between units and round numbers properly, it allows quoted measurements to be understood within the scale of the observations.

To convert 488 889 m into km:

A kilo is **10^3** so you need to divide by this number, or move the decimal point three places to the left.

$488\ 889 \div 10^3 = 488.889$ km

However, suppose you are converting from mm to km: you need to go from 10^3 to 10^{-3}, or move the decimal point six places to the left.

333 mm is 0.000 333 km

Alternatively, if you want to convert from 333 mm to nm, you would have to go from 10^{-9} to 10^{-3}, or move the decimal point six places to the right.

333 mm is 333 000 000 nm

Practice questions

1 Calculate the following conversions:

a 0.004 m into mm

b 130 000 ms into s

c 31.3 ml into µl

d 104 ng into mg

2 Give the following values in a different unit so they make more sense to the reader.

Choose the final units yourself. (Hint: make the final number as close in magnitude to zero as you can. For example, you would convert 1000 m into 1 km.)

a 0.000 057 m

b 8 600 000 µl

c 68 000 ms

d 0.009 cm

Decimal numbers

A decimal number has a decimal point. Each figure before the point is a whole number, and the figures after the point represent fractions.

The number of decimal places is the number of figures after the decimal point. For example, the number 47.38 has 2 decimal places, and 47.380 is the same number to 3 decimal places.

In science, you must write your answer to a **sensible number of decimal places**.

Practice questions

1 New antibiotics are being tested. A student calculates the area of clear zones in Petri dishes in which the antibiotics have been used. List these in order from smallest to largest.

0.214 cm^2 0.03 cm^2 0.0218 cm^2 0.034 cm^2

2 A student measures the heights of a number of different plants. List these in order from smallest to largest.

22.003 cm 22.25 cm 12.901 cm 12.03 cm 22 cm

Standard form

At times, scientists need to work with numbers that are very small, such as dimensions of organelles, or very large, such as populations of bacteria. In such cases, the use of scientific notation or standard form is very useful, because it allows the numbers to be written easily.

Standard form is expressing numbers in powers of ten, for example, 1.5×10^{7} microorganisms.

Look at this worked example. The number of cells in the human body is approximately 37 200 000 000 000. To write this in standard form, follow these steps:

Step 1: Write down the smallest number between 1 and 10 that can be derived from the number to be converted. In this case it would be 3.72

Step 2: Write the number of times the decimal place will have to shift to expand this to the original number as powers of ten. On paper this can be done by hopping the decimal over each number like this:

until the end of the number is reached.

In this example that requires 13 shifts, so the standard form should be written as 3.72×10^{13}.

For very small numbers the same rules apply, except that the decimal point has to hop backwards. For example, 0.000 000 45 would be written as 4.5×10^{-7}.

Practice questions

1 Change the following values to standard form.

a 3060 kJ **b** 140 000 kg **c** 0.000 18 m **d** 0.000 004 m

2 Give the following numbers in standard form.

a 100 **b** 10 000 **c** 0.01 **d** 21 000 000

3 Give the following as decimals.

a 10^{6} **b** 4.7×10^{9} **c** 1.2×10^{12} **d** 7.96×10^{-4}

Significant figures

Click here to view an epic video on sig figs

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

7.88   25.4   741

Bigger and smaller numbers with 3 significant figures:

0.000 147   0.0147   0.245   39 400   96 200 000 (notice that the zeros before the figures and after the figures are not significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207   4050   1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^{8}

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:

590 (to 3.s.f.) or 5.90×10^{2}

Remember: For calculations, use the **same number of figures** as the data in the question with the **lowest number of significant figures**. It is not possible for the answer to be more accurate than the data in the question.

Practice questions

1 Write the following numbers to **i** 2 s.f. and **ii** 3 s.f.

	2 s.f.	3 s.f
7644 g		
27.54 m		
4.3333 g		
5.995×10^{2} cm^{3}		

2 The average mass of oxygen produced by an oak tree is 11800 g per year. Give this mass in standard form and quote your answer to 2 significant figures.

Rearranging equations

Rearranging equations is a vital skill required in Applied Science. In GCSE, you may have relied on the triangle method for rearranging equations and though useful, it is limited to equations with only 3 variables. In this section, you will review what you learned in GCSE and learn how to manipulate equations more complex equations.

Whatever is done to one side of an equals sign must be done to the other also. Take, for example, the equation:

$$a = b + c$$

a is the subject. To make b the subject, one must look at what is done to b and do the **inverse** to both sides. In the above equation, c is added to b, so b is made the subject by **subtracting** c from both sides of the equals sign:

• Subtracting c:

$$a - c = b + c - c$$

• Simplifying the right hand side:

$$a - c = b$$

• Writing b as the subject:

$$b = a - c$$

Addition and **subtraction** are inverse operations.
Multiplication and division are inverse operations.
Powers and **roots** are inverse operations.

Worked example 1

Make y the subject of

$$x = 2 \times y + z$$

The last operation on y is the addition of z, so subtract z from both sides.

$$x - z = 2 \times y$$

y is multiplied by 2, so divide both sides of the equation by 2.

$$\frac{(x - z)}{2} = y$$

Worked example 2

Make g the subject of $5\sqrt{g} = h + j$

Isolate the g by removing the multiplication by 5. Do this by dividing both sides by 5

$$\sqrt{g} = \frac{(h+j)}{5}$$

Remove the square root, by squaring both sides

$$g = \frac{(h+j)^2}{25}$$

Practice questions

1. Make *m* the subject of $E = mgh$

2. Make P_2 the subject of $P_1V_1 = P_2V_2$

3. Make *r* the subject of $F = \frac{kQ_1Q_2}{r^2}$

4. Make *v* the subject of $E = \frac{1}{2}mv^2$

5. If *u*=0, make t the subject of $s = ut + \frac{1}{2}at^2$

6. Make *T* the subject of $r(\frac{2\pi}{T})^2 = \frac{GM}{r^2}$

Answers

Units and prefixes

1 **a** 1 kJ = 1000 J, so 4 500 000 J = 4 500 000/1000 kJ = 4500 kJ

b 1 MJ = 1000 kJ, so 4500 kJ = 4.5 MJ

2 1 m = 10^9 nm (there are a billion nanometres in a metre)

9.0×10^{-8} m = $9.0 \times 10^{-8} \times 10^9$ nm = $9.0 \times 10^{-8+9}$ nm = 9.0×10 nm = 90 nm

1.20×10^{-7} m = $1.20 \times 10^{-7} \times 10^9$ nm = $1.20 \times 10^{-7+9}$ nm = 1.20×100 nm = 120 nm

Range = 90 nm to 120 nm

Power and indices

1 **a** 10^{11} **b** 10^{12} **c** 1000 + 1000 = 2000 **d** 100 − 0.01 = 99.99

2 **a** 10^1 or 10 **b** 10^{-3} or 0.001 **c** 10^6 or 1 000 00 **d** $100^2 \div 100 = 100$ or 10^2

Converting units

1 **a** 4 mm **b** 130 s **c** 31 300 µl **d** 0.000 104 mg

2 **a** 57 µm **b** 8.6 L or 8.6 dm^3 **c** 68 s **d** 0.09 mm

Decimal numbers

1 0.0214 cm^2 0.0218 cm^2 0.03 cm^2 0.034 cm^2

2 12.03 cm 12.901 cm 22 cm 22.003 cm 22.25 cm

Standard form

1 **a** 3.06×10^{3} kJ **b** 1.4×10^{5} kg **c** 1.8×10^{-4} m **d** 4×10^{-6} m

2 **a** 1×10^{2} **b** 1×10^{4} **c** 1×10^{-2} **d** 2.1×10^{7}

3 **a** 1 000 000 **b** 4 700 000 000 **c** 1 200 000 000 000 **d** 0.000 796

Significant figures

1 **a** 7600 g / 7640 g **b** 28 m / 27.5 m **c** 4.3 g / 4.33 g **d** 6.0×10^{2} m / 5.00×10^{2} m

2 1.2×10^{4} g

Rearranging equations

1 $m = \frac{E}{gh}$

2 $P_2 = \frac{P_1V_1}{V_2}$

3 $r = \sqrt{\frac{kQ_1Q_2}{F}}$

4 $v = \sqrt{\frac{2E}{m}}$

5 $t = \sqrt{\frac{2s}{a}}$

6 $T = \frac{2\pi}{\sqrt{\frac{GM}{r^3}}}$