Arithmetic and Numerical Skills (MS 0): AQA A Level Biology Exam Ques

17 questions · 32 marks · about 42 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · AS Paper 2 · June 2016 · Q02.1 · 1 mark

0 2 A student investigated the distribution of stomata on leaves from two species of plant. She removed small pieces from the lower surface of the leaves of each plant species. She mounted these pieces on separate microscope slides. She then counted the number of stomata in several parts of the epidermis on each piece of leaf tissue using an optical microscope.

0 2 . 1 Suggest appropriate units the student should use to compare the distribution of stomata on leaves.

[1 mark]

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0 6 Ammonia in soil is oxidised to nitrites and nitrates by species of nitrifying bacteria.

Scientists investigated whether two soils with a different pH contained different communities of nitrifying bacteria. These communities consist of all the nitrifying bacteria of different species in each soil. They took samples of soil from two sites, **A** and **B**.

They measured the pH of the samples and found that

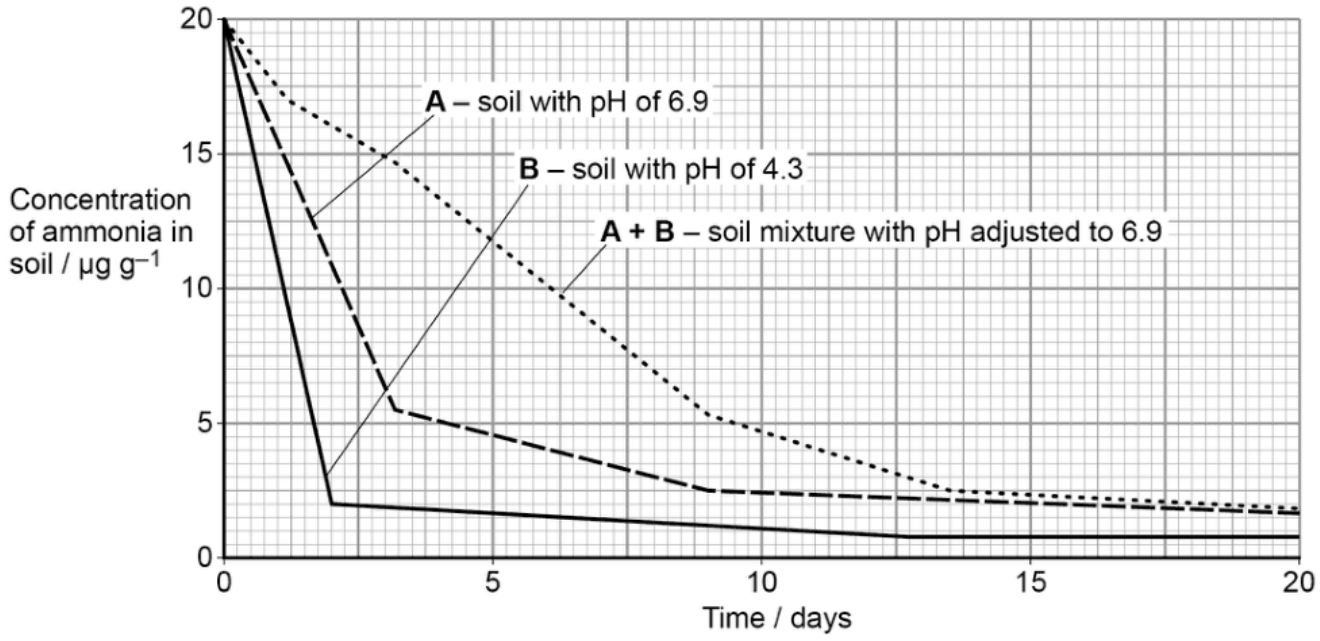
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

The scientists measured the concentration of ammonia in soil samples over 20 days. Each sample contained the same concentration of ammonia at the start and had the same mass. They recorded the concentration of ammonia in

- soil **A** with a pH of 6.9
- soil **B** with a pH of 4.3
- a mixture of equal masses of soils **A** and **B** with its pH adjusted to 6.9

Their results are shown in **Figure 6**.

Figure 6



0 6 . 1 The scientists used units of µg g^{-1} for the concentration of ammonia in soil.

Suggest why, in this investigation, the scientists used these units. **[2 marks]**

µg _____

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Question 3 · A level Paper 2 · June 2025 · Q03.2 · 2 marks

0 3 . 2 The student then used a calorimeter to determine the chemical energy stored in a sample of lettuce leaves with a dry mass of 1.50 g

The 1.50 g sample was fully combusted in a calorimeter.

The volume of water in the calorimeter was 150 cm^3

The increase in temperature of the water was 18.2 °C

4.18 J of heat energy are required to increase the temperature of 1 cm^3 of water by 1 °C

Use this information to calculate the heat energy released, in kJ g^{-1}, of dry mass of lettuce leaves.

Show your working.

[2 marks]

Answer _____ kJ g^{-1}

Question 4 · AS Paper 2 · June 2024 · Q02.2 · 2 marks

0 2 . 2 A haemocytometer is a special microscope slide that can be used to determine the mean number of red blood cells in 0.004 mm^3 of blood.

- A researcher prepared a 10^{-3} dilution of a sample of blood from an adult.
- Using a haemocytometer, the researcher determined that the mean number of red blood cells in 0.004 mm^3 of the diluted blood sample was 21

The volume of blood in the body of the adult was 4.8 dm^3

Calculate the total number of red blood cells in the body of this adult.

Show your working.

[2 marks]

Answer _____

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Question 5 · information from earlier in the question

1 0 Read the following passage.

Lake Malawi in East Africa has more species of fish than any other lake in the world. Many of these species have evolved from a common ancestor. Lake Malawi is one of the largest lakes in the world and was formed several million years ago. Since then, the water level has fluctuated greatly. As a result, what is now a large lake was at one time many smaller, separate lakes.

The country of Malawi has a total area of 118 000 km^2. The actual land area is only 94 080 km^2, because approximately one-fifth of the country is Lake Malawi.

In December 1990, forests covered 41.4% of the actual land area of Malawi. In December 2016, forests covered 26.4% of the actual land area of Malawi.

Deforestation and farming along the shores of Lake Malawi have caused increased soil erosion and loss of nutrients into the lake. This has resulted in a decrease in some fish populations. The mark-release-recapture method can be used to estimate the size of a fish population. However, this method can produce unreliable results in very large lakes.

Use the information in the passage and your own knowledge to answer the following questions.

Question 5 · A level Paper 2 · November 2021 · Q10.2 · 2 marks

1 0 . 2 The percentage of forest cover in Malawi decreased between December 1990 and December 2016 (lines 9–10).

Calculate the mean loss of forest cover in km^2 per week during this time period.

[2 marks]

Answer _____ km^2 per week

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Question 6 · AS Paper 2 · June 2019 · Q02.3 · 2 marks

0 2 . 3 Scientists measured the oxygen carrying capacity of seal blood.
They found the haemoglobin in a 190 kg seal contained 1.07×10^4 cm^3 oxygen.
When the seal dived, it used 5.2 cm^3 oxygen per minute per kg of body mass.

Use this information to calculate the maximum number of minutes the seal can remain under water. Assume that all of the oxygen attached to the haemoglobin is released during the dive.

[2 marks]

Answer = _____ minutes

Question 7 · A level Paper 3 · June 2025 · Q04.3 · 2 marks

0 4 . 3 Antibodies are proteins produced and secreted by plasma cells.

Once activated, a single B cell divides and produces 4000 plasma cells.

Each one of these plasma cells produces 2000 molecules of antibody **Q** per second.

A human male has a blood volume of 5.4 dm^3

Calculate the total number of molecules of antibody **Q** per cm^3 of blood 24 hours after the production of these plasma cells.

[2 marks]

Answer = _____ molecules of antibody **Q** per cm^3 of blood

Question 8 · information from earlier in the question

0 9 Scientists dissected gills from several species of fish. They recorded:

- the mass of the whole fish
- the total number of gill filaments
- the mean length of one filament
- the mean number of lamellae per mm
- the mean surface area of one lamella.

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Question 8 · AS Paper 2 · June 2023 · Q09.2 · 2 marks

0 9 . 2 From these measurements, the scientists calculated the total surface area of the gas exchange surface on the gills of each fish species.

Calculate the total surface area of the gills of a fish with the following measurements:

- total number of gill filaments = 595
- mean length of one filament = 2.86 mm
- mean number of lamellae per mm = 16
- mean surface area of one lamella = 0.66 mm^2

Give your answer in mm^2 **and** to an appropriate number of significant figures.

Show your working.

[2 marks]

_____ mm^{-}

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Tomato plants grow best in high light intensities. To increase the yield of tomato plants, a farmer uses LED lightbulbs to provide additional light.

The increase in dry mass (D) produced when using additional light can be calculated using this equation.

$$D = \frac{L}{0.4F}$$

Where
L = light used in photosynthesis
F = GPP to NPP conversion factor for tomato plants

Table 5 shows some of these values for LED lightbulbs.

Table 5

L / MJ m^{-2} h^{-1}	F / MJ kg^{-1}
2.87×10^{-2}	20

0 5 . 4 Use the equation and **Table 5** to calculate the increase in dry mass produced when using LED lightbulbs.

Give your answer in standard form **and** give the units.

[2 marks]

Answer _____ Units _____

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Question 10 · AS Paper 2 · June 2019 · Q08.2 · 1 mark

Scientists investigated differences between 260 North American bird species by comparing the base sequence of a gene in mitochondrial DNA. They compared the gene base sequence of each bird with all of the other 259 species. For each comparison they calculated the percentage difference in base sequence.

0 8 . 2 **Figure 9** shows the base sequence for part of the gene in two species.

Figure 9

Species 1	A	G	C	T	G	C	C	T	A	G	A
Species 2	A	T	G	T	G	G	C	A	A	G	A

Calculate the percentage difference in base sequence for these base sequences.

[1 mark]

Answer = _____ %

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In tomato plants, the genes for height and for the type of leaf are on the same homologous pair of chromosomes. The allele **T**, for a tall plant, is dominant to the allele **t**, for a dwarf plant. The allele **M**, for normal leaves, is dominant to the allele **m**, for mottled leaves.

A biologist carried out crosses between parent plants heterozygous for both genes and examined the offspring produced. The position of the two alleles for both genes was the same in each parent plant as shown in **Figure 7**. The phenotypes and number of offspring produced are shown in **Table 3**.

Figure 7

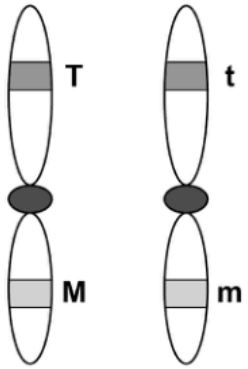


Table 3

Phenotype of offspring	Number of offspring
Tall plants and normal leaves	1860
Tall plants and mottled leaves	68
Dwarf plants and normal leaves	57
Dwarf plants and mottled leaves	580

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Question 11 · A level Paper 2 · June 2018 · Q06.4 · 2 marks

0 6 . 4 Complete **Table 4** to show the expected ratio of phenotypes if the same cross had been carried out but the genes for height of plant and for the type of leaf were on different homologous pairs of chromosomes.

[2 marks]

Table 4

Phenotype of offspring	Ratio of offspring

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0 8 . 3 A scientist investigated changes in a diseased heart and changes in a healthy heart during cardiac cycles.

For each heart, the scientist obtained a value for:

- the mean blood volume in a full ventricle just before the ventricle contracts (**BVB**)
- the mean ejection fraction (**EF**).

The **EF** is the proportion of blood pumped out of a full ventricle in one heartbeat.

The **EF** is calculated using this formula:

$$\text{EF} = \frac{\text{Blood volume pumped out of a full ventricle in one heartbeat (stroke volume)}}{\text{BVB}}$$

Table 5 shows the scientist's results.

Table 5

	Diseased heart	**Healthy heart**
Mean **BVB** / cm^3	100	120
Mean **EF**	0.45	0.58

Using **Table 5**, a student calculated that the percentage change in the stroke volume of the diseased heart compared with the stroke volume of a healthy heart is –30%.

The student's answer is wrong because the final step of the calculation was performed incorrectly.

Using the equation and **Table 5**, calculate the correct percentage change in the stroke volume of the diseased heart compared with the stroke volume of the healthy heart.

Identify the mathematical error in the final step of the student's calculation.

[3 marks]

Correct answer _____ %

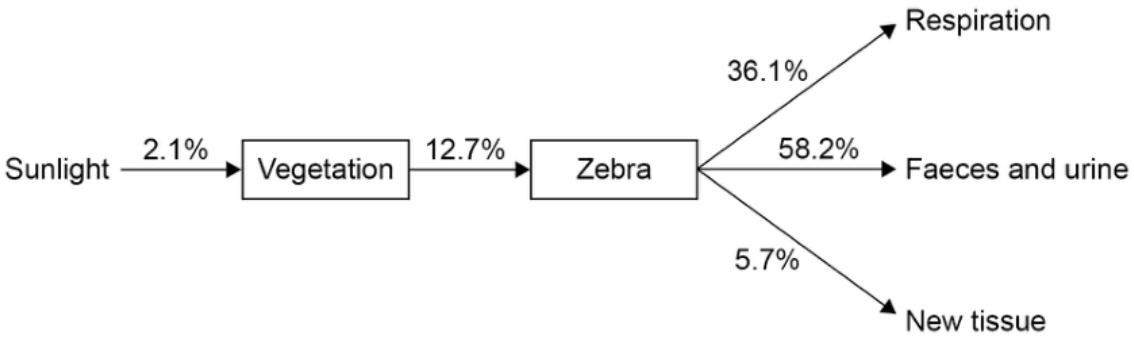
Mathematical error _____

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Question 13 · A level Paper 2 · June 2019 · Q01.2 · 1 mark

Figure 1 shows percentages of energy transferred from sunlight to a zebra in a grassland ecosystem.

Figure 1



0 1 . 2 Use **Figure 1** to calculate the percentage of sunlight energy that would be transferred into the faeces and urine of a zebra. Give your answer to 3 significant figures.

[1 mark]

Answer = _____ %

Question 14 · AS Paper 2 · June 2022 · Q02.4 · 2 marks

0 2 . 4 Apples consist of flesh tissue which surrounds core tissue where the seeds are located.

A student has an apple with a mass of 180 g
The ratio of flesh tissue to core tissue in this apple is 5:1
8% of the whole apple is sugar.

Calculate the mass of sugar in the flesh tissue.

Show your working.

[2 marks]

Answer _____ g

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Question 15 · information from earlier in the question

Plants and algae produce fuels called biofuels. Scientists have used *Chlorella* to produce biofuel. *Chlorella* is a genus of single-celled photosynthetic alga. *Chlorella* can be grown in open ponds and fermenters.

Question 15 · A level Paper 2 · November 2020 · Q03.5 · 2 marks

0 3 . 5 *Chlorella* cells can divide rapidly. A culture of 2000 *Chlorella* cells was set up in a fermenter. The cells divided every 90 minutes.

You can assume that there were no limiting factors and that no cells died during the 24 hours.

Calculate the number of cells in the culture after 24 hours.

Give your answer in standard form.

Show your working.

[2 marks]

Answer _____

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Question 16 · A level Paper 2 · June 2018 · Q03.6 · 2 marks

0 3 . 6 The following equation can be used to make predictions of the growth in the population of yeast cells under ideal laboratory conditions.

$$X_t = X_0 e^{rt}$$

X_t = the population after a certain time
X_0 = the population at the start
e = 2.72 (base of natural logarithm)
r = growth rate
t = time period in hours over which r applies

A population of 2000 yeast cells was left for 10 hours.
The value for the growth rate was 0.5

Assuming no yeast cells died, calculate the predicted size of the population after 10 hours. Show your working.

[2 marks]

Answer = _____

Question 17 · information from earlier in the question

A student investigated the growth rate of a freshwater marsh plant.

The growth rate (R) of a plant can be determined using this equation.

$$R = \frac{(\ln W_2 - \ln W_1)}{t}$$

Where
ln = natural logarithm
t = duration of the investigation in days
W_1 = plant biomass at the start of the investigation
W_2 = plant biomass at the end of the investigation

The student used the equation above; however, she substituted height for biomass. This was because she did not want to destroy the plants to measure their biomass.

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Question 17 · A level Paper 3 · November 2021 · Q04.4 · 2 marks

0 4 . 4 At the end of the investigation, the student noted the freshwater marsh plant had grown 268 mm in height, and now measured 387 mm. She calculated the rate of growth *(R)* to be 0.097 mm m^{-1} day^{-1}

Use this information and, **substituting height for biomass**, use the equation to calculate the duration of the student's investigation.

Give your answer to the nearest full day. Show your working.

[2 marks]

_____ days

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Mark schemes

Question 1 · AS Paper 2 · June 2016 · Q02.1 · 1 mark

02.1	Stomata per mm^2 or cm^2 **OR** Number per mm^2 or cm^2;	1	Accept: mm^{-2} or cm^{-2}. Reject: per μm^2 or μm^{-2}. Reject: the use of a solidus / as being equivalent to per. Ignore: 'amount'.

Question 2 · A level Paper 3 · June 2018 · Q06.1 · 2 marks

06.1	1. (µg because) very little ammonia (in soil); 2. (µg because) avoids use of (lots of) decimal places (in their results) / avoids the use of powers of 10 / avoids the use of standard form; 3. (g^{-1}) to allow comparisons (between samples);	2 max	2. Accept makes numbers more manageable 2. Accept makes easier to plot graph

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03.2	7.6 / 7.61 / 7.608 / 7.6076 (kJ g^{-1}) = **2 marks**;; Incorrect, but **answer** shows 76 (ignore any subsequent numbers, position of decimal point and preceding/subsequent zeros i.e. incorrect conversion) = **1 mark** **OR** Incorrect **answer** of 11.4 (kJ g^{-1}) (ignore any subsequent numbers i.e. no division by 1.5.) = **1 mark** **OR** Incorrect **answer** of 0.05 (kJ g^{-1}) (ignore any subsequent numbers i.e. not multiplied by 150) = **1 mark** **OR** Incorrect **answer** of 1.8 (kJ g^{-1}) (ignore any subsequent numbers i.e. not multiplied by 4.18) = **1 mark** **OR** Incorrect **answer** of 0.418 / 0.42 (kJ g^{-1}) (ignore any subsequent numbers i.e. not multiplied by 18.2) = **1 mark** **OR** Incorrect **answer** of 17 (kJ g^{-1}) (ignore any subsequent numbers i.e. multiplied rather than divided by 1.5) = **1 mark;**	2 (2 x AO2)

Accept 8 for **2 marks**.

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Question 4 · AS Paper 2 · June 2024 · Q02.2 · 2 marks

02.2	Correct answer of 3 / 2.5 / 2.52 x 10^{13} in any correct mathematical form = **2 marks**;; Incorrect but shows 5250 in any correct mathematical form = **1 mark** **OR** Incorrect but answer shows first three numbers as 252 = **1 mark**;	2 (2 x AO2)

Question 5 · A level Paper 2 · November 2021 · Q10.2 · 2 marks

10.2	1. Correct answer of 10/10.4 **= 2 marks**;; 2. Working shows 14,112 = **1 mark** **OR** 13.09/13.1 = **1 mark**; 2	1. Ignore any numbers after 10.4

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02.3	Correct answer for 2 marks 10.8 to 11 (mins) **OR** 10 minutes and 48 seconds = 2 marks;; Accept for 1 mark, 10.48 minutes **OR** Reference to 2057.7 to 2058 (10 700 ÷ 5.2, time oxygen would last if its mass was 1 kg) **OR** Reference to 56 to 56.3 (10700 ÷ 190, oxygen in 1 kg of seal) **OR** Reference to 988 (5.2 x 190, oxygen used min^{-1} by the seal) **OR** Incorrect answer with correct answer shown in working	2
TOTAL		**6**

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Question 7 · A level Paper 3 · June 2025 · Q04.3 · 2 marks

04.3	Correct answer of 128 000 000/1.28 × 10^8/ 1.3 × 10^8 /1 × 10^8 = **2 marks**;; Answer shows 128 (ignore position of decimal point and preceding/subsequent zeroes, incorrect order of magnitude) = **1 mark** **OR** Evidence of 691 200 000 000/6.912 × 10^{11}/ 6.9 × 10^{11} (total number produced in 24 hours in 5.4 dm^3) = **1 mark** **OR** Evidence of 4000 × 2000 × 60 × 60 × 24 (total number produced in 24 hours in 5.4 dm^3) = **1 mark** **OR** Evidence of 5 333 333.333/5.3 × 10^6/5 × 10^6 (total number produced in one hour per cm^3 of blood) = **1 mark** **OR** Evidence of 32 000/3.2 × 10^4 (number produced from one plasma cell per cm^3 of blood) = **1 mark**;	2 (2 x AO2)	Accept any correct rounding

Question 8 · AS Paper 2 · June 2023 · Q09.2 · 2 marks

09.2	Correct answer of 18 000/1.8 × 10^4 = **2 marks**;; **1 mark** for Correct answers not given to 2sf (17 969.952) **OR** Evidence of 1701.7 (total length of filaments) **OR** 27 227.2 – 27370 (total number of lamellae)	2 (2 x AO2)	Accept 17970/17969.9

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Question 9 · A level Paper 3 · June 2022 · Q05.4 · 2 marks

05.4	1. 3.5875×10^{-3}; 2 2. kg m^{-2} h^{-1}; (2 x AO2)	1. Accept any correct rounding eg 4×10^{-3} 2. Accept per m^2 **and/or** per hour 2. Accept kg/m^2/h 2. Accept kg h^{-1} m^{-2} 2. Reject kg^{-1} 2. Reject m^{-2} h^{-1} kg **OR** h^{-1} m^{-2} kg

Question 10 · AS Paper 2 · June 2019 · Q08.2 · 1 mark

08.2	36 to 36.4; 1	

Question 11 · A level Paper 2 · June 2018 · Q06.4 · 2 marks

06.4

One mark for each correct column;; 2

Phenotype of offspring	Ratio of offspring
Tall (plant and) normal (leaves)	9
Tall (plant and) mottled (leaves)	3
Dwarf (plant and) normal (leaves)	3
Dwarf (plant and) mottled (leaves)	1

Note: Accept correct phenotypes in any order for one mark and correct ratio in any order e.g. 3:9:3:1 for one mark However, phenotypes and ratio must match for two marks

Accept alternative wording e.g. short for dwarf

2. Accept $^{9}/_{16}$ $^{3}/_{16}$ $^{3}/_{16}$ $^{1}/_{16}$

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Question 12 · A level Paper 1 · June 2024 · Q08.3 · 3 marks

08.3	1. and 2. Correct answer of 35 / 35.1 / 35.3 / 35.7 / 36 / 40(%) = **2 marks**;; Accept for **1 mark**, incorrect answer but shows: Evidence of 45 (correct stroke volume for diseased heart) **OR** Evidence of 69.6 **OR** 70 (correct stroke volume for healthy heart) **OR**	3 (3 x AO3)	Accept positive or negative values
	Evidence of 24.6 **OR** 25 (correct difference between stroke volumes) **OR** Evidence of 48.6 to 50 (correct calculated volume change, not percentage change) 3. (Mathematical error) incorrect rounding;		

Question 13 · A level Paper 2 · June 2019 · Q01.2 · 1 mark

01.2	0.155;	1	Accept standard form e.g. 15.5×10^{-2}

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Question 14 · AS Paper 2 · June 2022 · Q02.4 · 2 marks

02.4	Correct answer for 2 marks = 12;; Accept for 1 mark, 30 (correct mass of apple core) **OR** 150 (correct mass of apple flesh) **OR** $0.08 / \frac{8}{100}$ × incorrect mass **calculated** using the ratio **OR** 14.4 (correct mass in whole apple);	2 (2 x AO2)

Question 15 · A level Paper 2 · November 2020 · Q03.5 · 2 marks

03.5	Correct answer of $1.31/1.3 \times 10^8$ (ignoring any subsequent numbers after 1.31) = **2 marks**;; Incorrect answer but shows 2^{16} = **1 mark**	2
	OR 65536 in any correct numerical form = **1 mark** **OR** Incorrect answer but shows 131 ignoring any subsequent numbers and ignoring any decimal point = **1 mark**;	

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Question 16 · A level Paper 2 · June 2018 · Q03.6 · 2 marks

03.6	1. Correct answer of 298000 or 297766 or 297765.59 or 296826 = **2 marks**;; 2. Incorrect answer but working shows 2000 × 2.72 = **1 mark**; **OR** Incorrect answer but working shows $2.72^{0.5 \times 10}$ / 2.72^{5} / $e^{0.5 \times 10}$ / = **1 mark**	2	1. Accept: any equivalent answer with appropriate rounding e.g. 2.98×10^{5}, 29.78×10^{4} etc.

Question 17 · A level Paper 3 · November 2021 · Q04.4 · 2 marks

04.4	1. Answer of 12 days = **2 marks**;; 2. 12.16 (12.15774433) **= 1 mark** **OR** 4 days (used 387 and 268, ie not calculated starting length) **= 1 mark;**	2

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