AQA, OCR, Edexcel

A Level

A Level Biology

Maths Questions: 81 Marks

Name: Maths Skills for A level Biology

Guidance

1. Read each question carefully.
2. Don't spend too long on each question.
3. Attempt every question.
4. Always show your workings.

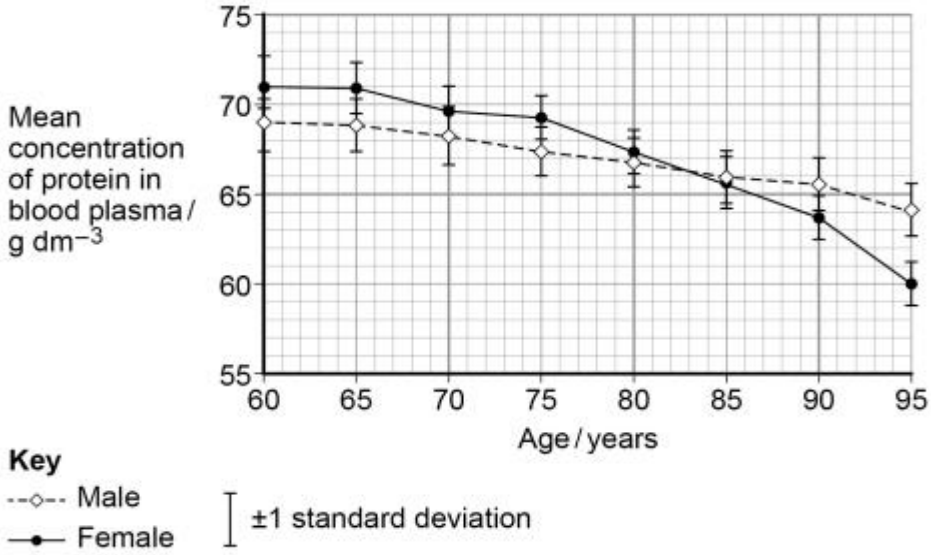
Revise A Level Biology:
www.MathsMadeEasy.co.uk/a-level-biology-revision/

1.

Scientists investigated how the concentration of protein in blood plasma changes in people between the ages of 60 and 95.

Figure 4 shows the scientists' results. The bars show ±1 standard deviation.

Figure 4



What is the difference between males and females in the fall in mean concentration of protein in blood plasma between 60 and 95 years?

[1 mark]

Answer = _____ g dm^{-3}

1.b.

Use **Figure 4** to calculate the rate of change of the mean concentration of protein in the blood plasma of males between the ages of 60 and 95.

Show your working.

[2 marks]

Answer = _____ g dm^{-3} $year^{-1}$

2.

The scientists used a statistical test to determine whether there was a significant difference in the amino acid concentration in the two types of white wine.
They obtained a value for P of 0.04.

Name the statistical test the scientists used and give a reason for your answer.

Was the difference significant? Give a reason for your answer.

[3 marks]

Name of statistical test _____

Reason for choice _____

_____

_____

Explanation of test result _____

_____

_____

_____

_____

_____

3.

A student used 3 disinfectants on 3 petri dishes of bacterial solution of volume 0.5m^3

The three disinfectants used by the student were Lysol, propan-2-ol and ammonia.

Table 1 shows the student's results.

Table 1

Concentration of disinfectant / arbitrary units	Number of colonies of bacteria		
	Lysol	Propan-2-ol	Ammonia
0	300	300	300
5	0	290	300
10	0	195	295
15	0	0	275
20	0	0	240

The liquid culture the student transferred was diluted by 1 in 10 000 (10^{-4}).

Use information in this question to calculate how many bacteria were present in 1 cm^3 of undiluted liquid culture.

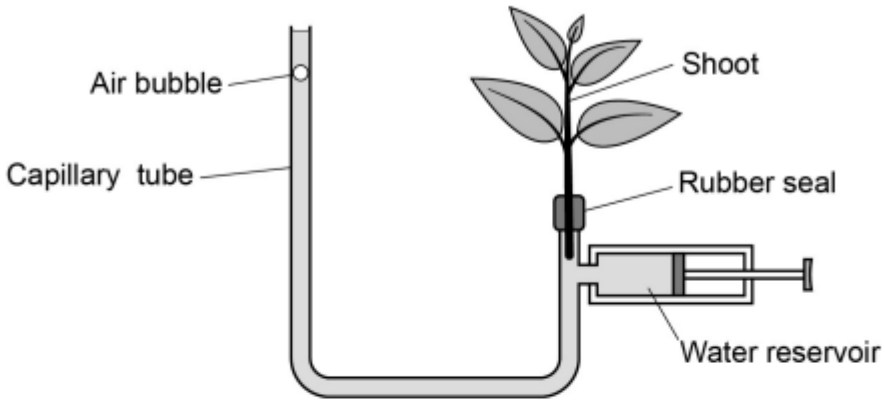
[2 marks]

Answer = _____

4.

A student used a potometer to measure the movement of water through the shoot of a plant. The potometer is shown in **Figure 5**. As water is lost from the shoot, it is replaced by water from the capillary tube.

Figure 5



In one experiment, the air bubble moved 7.5 mm in 15 minutes. The diameter of the capillary tube was 1.0 mm.

Calculate the rate of water uptake by the shoot in this experiment.

Give your answer in mm^3 per hour. Show your working.
(The area of a circle is found using the formula, area = πr^2)

[2 marks]

_____ $mm^3\ hour^{-1}$

5.

Ecologists investigated changes in grassland communities on large islands off the coast of Scotland between 1975 and 2010. On each island, they used data from a number of sites to determine the change in mean species richness and the change in mean index of diversity.

Table 1 shows plant species recorded at one site, on one island, in 1975.

Table 1

Species	**Number of individuals**
Hydrocotyle vulgaris	3
Plantago maritima	19
Ranunculus acris	3
Hieracium pilosella	3
Calliergon cuspidatum	10
Prunella vulgaris	16
Pseudoscleropodium purum	6

Calculate the index of diversity for this site using the formula:

$$d = \frac{N(N-1)}{\Sigma n(n-1)}$$

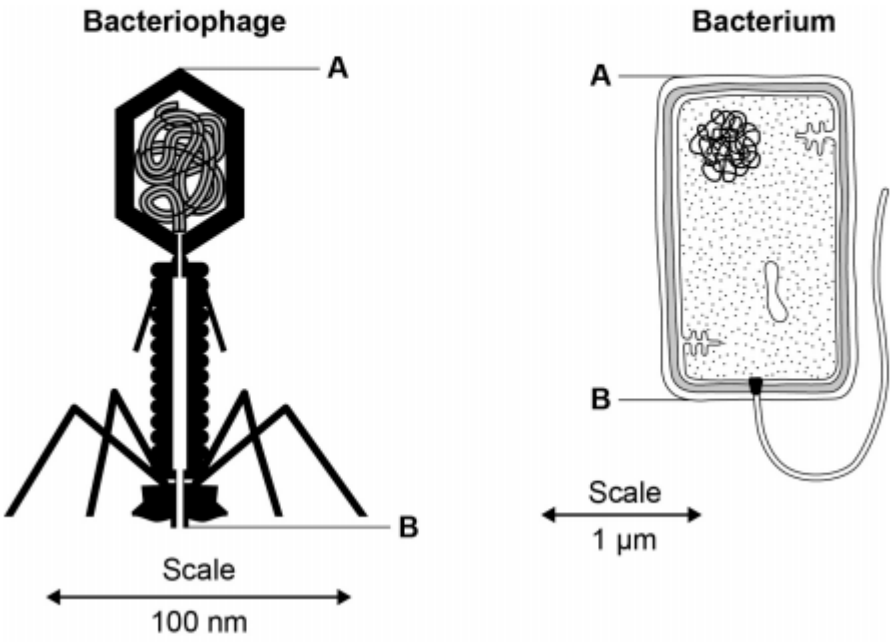
[2 marks]

6.

Bacteriophages are viruses that kill bacteria.

Figure 2 shows drawings of a bacteriophage and a bacterium.

Figure 2



Using the scales in **Figure 2**, calculate how many times longer the bacterium is than the bacteriophage.

Use the distance between the points labelled **A** and **B** on each drawing in your calculations. Show your working.

[2 marks]

The bacterium is _____ times longer

7.

The scientists also measured the mean rate of flow of blood plasma into the kidneys.

The results the scientists obtained are shown in **Table 2**.

Table 2

Group	Mean rate of flow of blood plasma into the kidneys / $cm^3\ min^{-1}$
A (furosemide)	380
B (CVT)	342
C (placebo)	295

The mean rate of flow of blood plasma is 60% of the mean rate of blood flow into the kidneys.

How much greater is the flow of blood into the kidneys with furosemide than with group **C** (placebo) over the 4 hours of the investigation? Give your answer in cm^3.

[1 mark]

Answer = _____ cm^3

8.

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 = _____

9.

The student found that the coloured liquid moved 1.5 cm in 24 hours. The diameter of the lumen (hole) of the capillary tubing was 1 mm.

The volume of a capillary tubing is given by $\pi r^2 l$, where π is 3.14 and l = length.

Calculate the volume of gas produced in $cm^3\ hour^{-1}$.
Show your working.

[2 marks]

Answer = _____ $cm^3\ hour^{-1}$

10.

A type of malignant tumour cell divides every 8 hours.

Starting with one of these cells, how many tumour cells will be present after 4 weeks?
Assume none of these cells will die.

Give your answer in standard form.

[2 marks]

Answer = _____

11.

Horses or rabbits can be used to produce antivenoms.
When taking blood to extract antibody, 13 cm^3 of blood is collected per kg of the animal's body mass.
The mean mass of the horses used is 350 kg and the mean mass of the rabbits used is 2 kg

Using only this information, suggest which animal would be better for the production of antivenoms.
Use a calculation to support your answer.

[2 marks]

12.

The scientists tested their null hypothesis using the chi-squared statistical test.
After 1 cycle their calculated chi-squared value was 350
The critical value at P=0.05 is 3.841

What does this result suggest about the difference between the observed and expected results and what can the scientists therefore conclude?

[2 marks]

13.

A scientist measured the rate of removal of amino acids from a polypeptide with and without an enzyme present. With the enzyme present, 578 amino acids were released per second. Without the enzyme, 3.0×10^{-9} amino acids were released per second.

Calculate by how many times the rate of reaction is greater with the enzyme present. Give your answer in standard form.

[2 marks]

Answer = _____ times faster

14.

Lactulose can also be used to treat people who have too high a concentration of hydrogen ions (H^+) in their blood.

The normal range for blood H^+ concentration is 3.55×10^{-8} to 4.47×10^{-8} mol dm^{-3}

A patient was found to have a blood H^+ concentration of 2.82×10^{-7} mol dm^{-3}

Calculate the minimum percentage decrease required to bring the patient's blood H^+ concentration into the normal range.

[2 marks]

Answer =

15.

Replication of mitochondrial DNA (mtDNA) is different from that of nuclear DNA.

The replication of the second strand of mtDNA **only** starts after two-thirds of the first strand of mtDNA has been copied.

A piece of mtDNA is 16 500 base pairs long and is replicated at a rate of 50 nucleotides per second.

Tick (✔) the box that shows how long it would take to copy this mtDNA.

[1 mark]

A 330 seconds ☐

B 440 seconds ☐

C 550 seconds ☐

D 660 seconds ☐

16.

Some prokaryotic cells can divide every 30 minutes. A liquid culture contained a starting population of 1.35×10^4 cells.

Assuming each cell divides every 30 minutes, calculate how many cells there will be after 3 hours. Assume no cells die during this time.

[2 marks]

Answer =

17.

The hydrolysis of 1 dm^3 of a 1 mol dm^{-3} solution of ATP releases 30 500 J of energy.

60% of the energy released during the hydrolysis of 1 mol dm^{-3} of ATP is released as heat; the rest is used for muscle contraction.

The student added 0.05 cm^3 of ATP solution to slide **D**.

Calculate the energy available from ATP for contraction of the muscle on this slide.

[3 marks

Answer = _____ J

18.

A scientist calculated the surface area of a large number of frog eggs. He found that the mean surface area was 9.73 mm^2. Frog eggs are spherical.

The surface area of a sphere is calculated using this equation

$$\text{Surface area} = 4\pi r^2$$

where r is the radius of a sphere

$$\pi = 3.14$$

Use this equation to calculate the mean diameter of a frog egg.

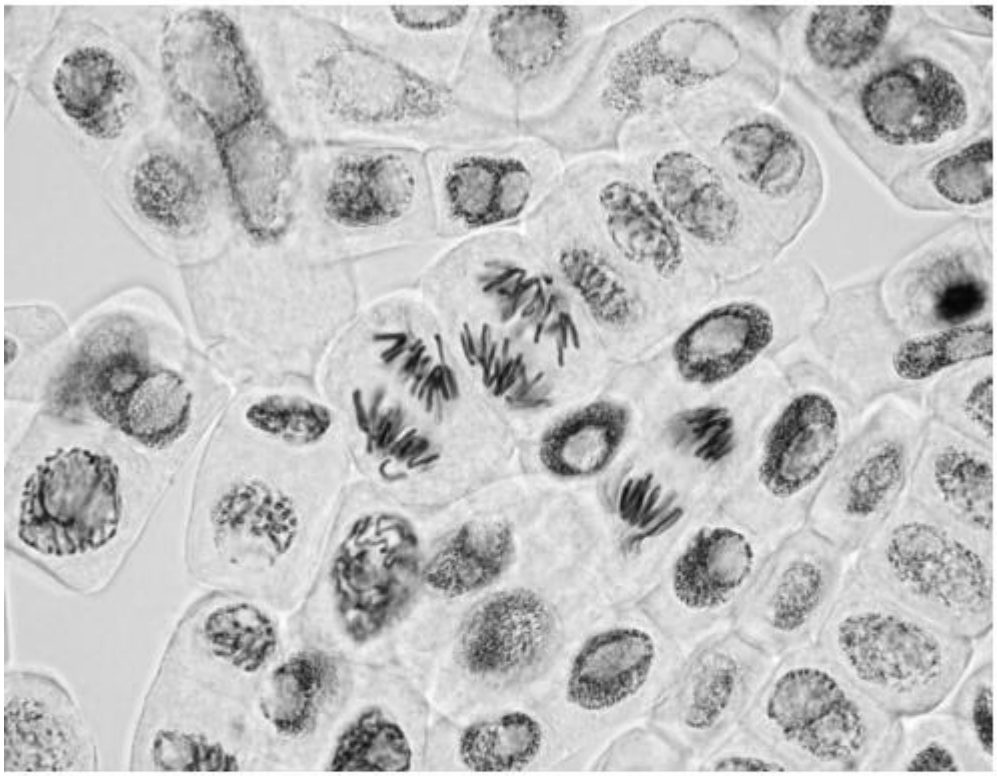
Show your working.

[2 marks]

19.

Figure 2 shows the cells the student saw in one field of view. He used this field of view to calculate the length of time these onion cells spent in anaphase of mitosis.

Figure 2



Scientists have found the mean length of time spent by onion cells in anaphase of mitosis is 105 minutes. They also found the cell cycle of cells in the onion root shown in **Figure 2** takes 1080 minutes.

32 whole cells are shown in **Figure 2**.

Use this information and **Figure 2** to calculate the length of time the cells of this onion root are in anaphase **and** then calculate the percentage difference between your answer and the mean length of time found by the **scientists**.

Show your working.

[2 marks]

20.

A scientist prepared the following mixtures:

- 15 g cellulose with 0.2 mol dm^{-3} endocellulase
- 15 g cellulose with 0.2 mol dm^{-3} exocellulase
- 15 g cellulose with 0.2 mol dm^{-3} endocellulase and 0.2 mol dm^{-3} exocellulase.

The mixtures had identical total volumes. She determined the mass of cellulose remaining after 48 hours.

Her results are shown in **Table 4**.

Table 4

Time / hours	Mass of cellulose remaining / g		
	Endocellulase	Exocellulase	Endocellulase + exocellulase
48	11.9	14.8	9.2

Use information from **Table 4** to calculate the rate of digestion of cellulose when both enzymes are present.

Give your answer in g min^{-1} and in standard form.
Show your working.

[2 marks]

Answer = _____ g min^{-1}

21.

Using an optical microscope, the student determined there were 15 cells in 0.004 mm^3 of the 1 in 1000 dilution of the culture.

Calculate the number of cells in 1cm^3 of undiluted liquid culture.

[2 marks]

Answer = _____ Number of cells

22.

Approximately 11 percent of people with CLL also have mutations of a gene called *NOTCH1*. This leads to production of a non-functional transcription factor associated with CD20 production.

The doctors determined the median percentage of B cells destroyed by Rituximab in people with CLL who had the *NOTCH1* mutation and those who did not.

The doctors' results are shown in **Table 1**.

Table 1

	Median percentage of B cell destroyed by Rituximab
In people with CLL who had the *NOTCH1* mutation	**4**
In people with CLL who did **not** have *NOTCH1* mutation	**22**

Human blood contains (approximately) 1.0×10^9 B cells per dm^3.

Use the median values in **Table 1** to calculate the difference between the number of B cells per dm^3 in the blood of people treated with Rituximab with the *NOTCH1* mutation and people without the *NOTCH1* mutation.

Express your answer in standard form. Show your working.

[2 marks]

_____ cells per dm^3

23.

A scientist measured the diameter of a polar body and the diameter of the nucleus inside it. The diameter of the polar body was 10.4 μm and the diameter of the nucleus was 7.0 μm. The density of mitochondria in the cytoplasm of the polar body (outside of the nucleus) was 0.08 mitochondria per μm^3.

Calculate the number of mitochondria in the polar body. You should assume polar bodies and nuclei are spherical.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

Show your working.

[2 marks]

Number of mitochondria = _____

24.

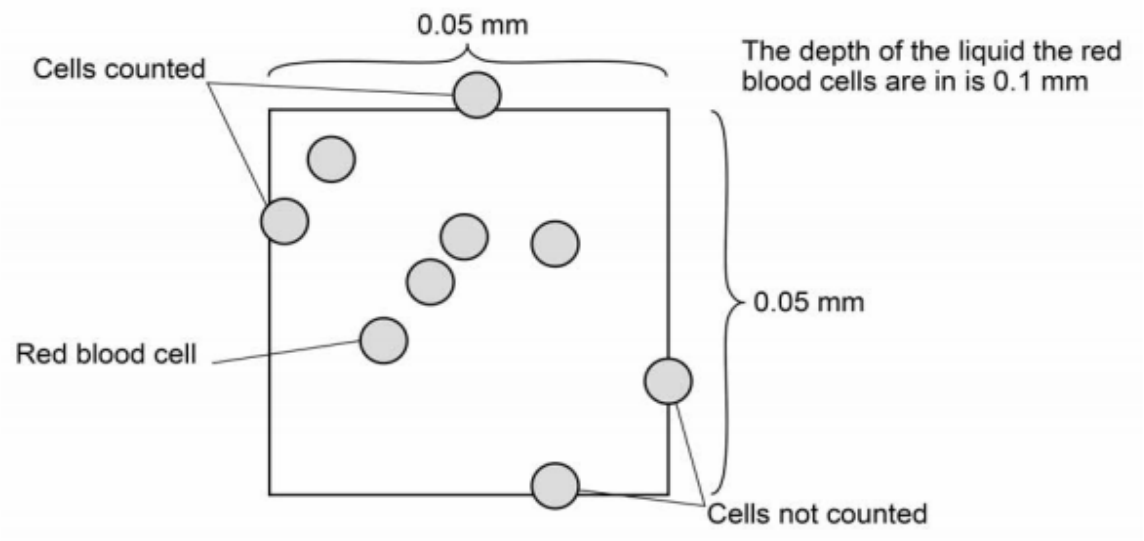
A haemocytometer is a special microscope slide which can be used to count the numbers of blood cells in a sample of blood.

- The surface of the slide has many small, equal-sized squares marked on it.
- The depth of the liquid under each square is 0.1 mm
- When counting, cells that touch top or left lines are counted but cells that touch right or bottom lines are not counted.

A doctor used a haemocytometer to determine the number of red blood cells per mm^3 in a blood sample. He diluted the original blood sample by a factor of 200 times before putting some on a haemocytometer.

Figure 4 shows the distribution of cells in a typical small square.

Figure 4



The doctor counted the red blood cells in many small squares.
The **mean** number of red blood cells per small square was 7
The original blood sample was diluted by a factor of 200 times.

Calculate the number of red blood cells per mm^3 in the original blood sample.
Give your answer in standard form. **[2 marks]**

Answer = _____ red blood cells per mm^3

25a and 25b

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

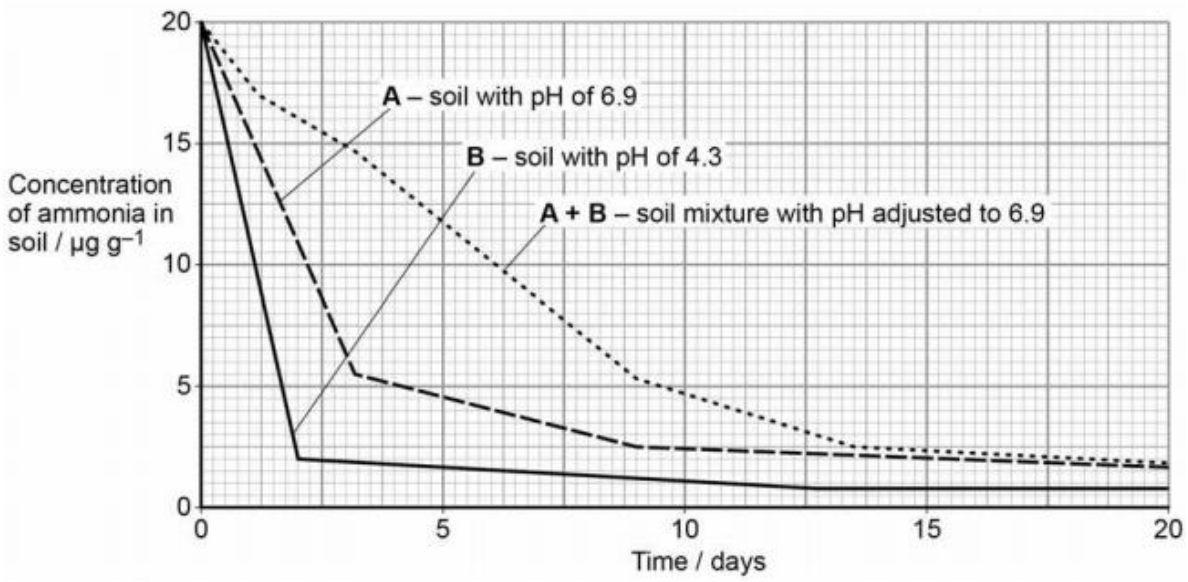
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

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



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 _____

_____

_____

_____

_____

g^{-1} _____

_____

_____

_____

_____

Calculate the difference in the rate of breakdown of ammonia per day between day 0 and day 2 in soil **A** and soil **B**.

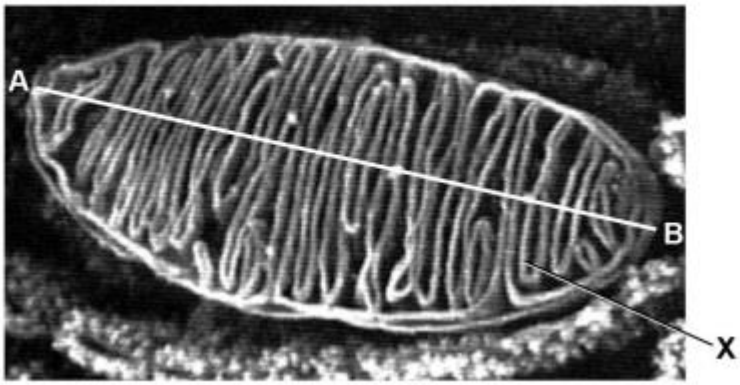
Show your working and the units for your answer. **[2 marks]**

Difference in rate = _____

26.

Figure 2 is a photograph (micrograph) of a mitochondrion taken using a scanning electron microscope.

Figure 2



The actual length of the mitochondrion between points **A** and **B** in **Figure 2** is 4 μm.

What is the magnification of the mitochondrion in **Figure 2**?

Show your working.

[2 marks]

27.

The scientists grew plant cells in a culture for 12 days. At the start, there were only a few cells in the culture. Each day, they determined the mass of sucrose hydrolysed by SPS in the plant cells in **1 hour**.

Table 2 shows their results.

Table 2

Day	Mass of sucrose hydrolysed by SPS in 1 hour / µg	Rate of hydrolysis of sucrose by SPS
0	0.07	
2	0.09	
4	0.11	
6	0.15	
8	0.20	
10	0.24	
12	0.24	

For each day, calculate the rate **per minute** of the reaction catalysed by SPS. Record the rates in standard form and plot a suitable graph of your processed data.

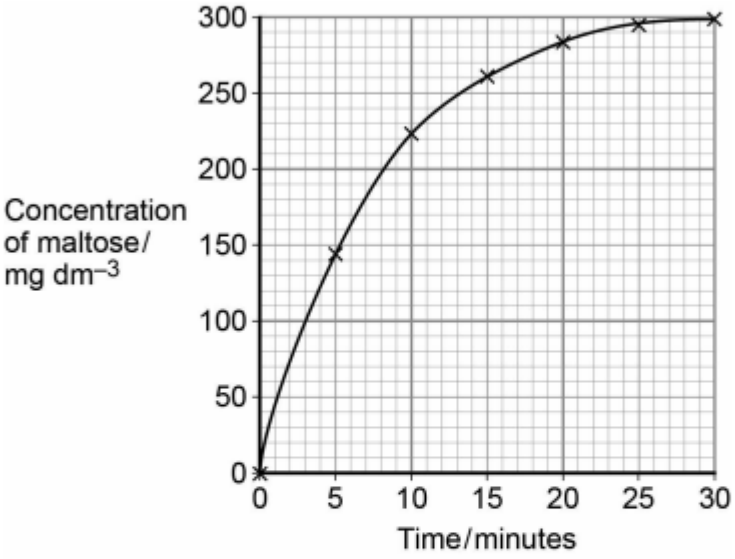
[3 marks]

28.

A scientist investigated the hydrolysis of starch.
He added amylase to a suspension of starch and measured the concentration of maltose in the reaction mixture at regular intervals.

His results are shown in **Figure 4**.

Figure 4



Determine the rate of the reaction **at** 10 minutes.
Show how you obtained your answer.

[2 marks]

Rate of reaction _____ mg dm^{-3} min^{-1}

29.

At the start of their investigation, the scientists made a solution of kinesin inhibitor (KI) with a concentration of 10 000 nmol dm^{-3}. They used this to make the other concentrations by a series of dilutions with water.

Describe how they made 100 cm^3 of 1000 nmol dm^{-3} solution of kinesin inhibitor.

[2 marks]

30.

Table 1 shows the volume of blood in a woman's left ventricle at different times during **one** second.

Table 1

Time / seconds	Volume of blood in left ventricle / cm^3
0.0	112
0.1	120
0.2	95
0.3	65
0.4	50
0.5	55
0.6	82
0.7	90
0.8	100
0.9	112
1.0	120

Use **Table 1** to calculate the heart rate in beats per minute.

31.

The stroke volume is the volume of blood pumped out of the left ventricle during one cardiac cycle.

Use **Table 1** to determine the stroke volume.

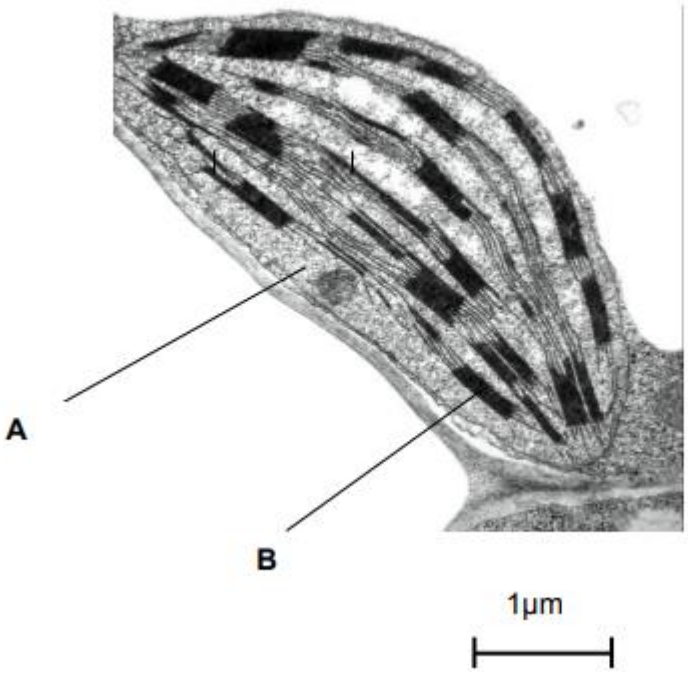
[1 mark]

Stroke volume = _____ cm^3

32.

Figure 1 shows a photograph of a chloroplast taken with an electron microscope.

Figure 1



Calculate the length of the chloroplast shown in **Figure 1**.

[1 mark]

33.

Describe how you would use a 1.0 mol dm^{-3} solution of sucrose to produce 30 cm^3 of a 0.15 mol dm^{-3} solution of sucrose.

[2 marks]

34.

The student counted the number of cells she observed in each stage of mitosis.
Of the 200 cells she counted, only six were in anaphase.

One cell cycle of onion root tissue takes 16 hours. Calculate how many minutes these cells spend in anaphase.

Show your working.

[2 marks]

Answer = _____ minutes

35a and 35b

A student investigated the distribution of plants in a heathland.
Table 2 shows the number of plants he found in a sample area of 1 m^2.

Table 2

Species of plant	Number counted in 1 m^2
Common heather	2
Red fescue	14
Vetch	2
White clover	8

What is the species richness of this sample?

[1 mark]

Calculate the index of diversity of this sample. Show your working.

Use the following formula to calculate the index of diversity.

$$d = \frac{N(N-1)}{\Sigma n(n-1)}$$

where N is the total number of organisms of all species
and n is the total number of organisms of each species

[2 marks]

Index of diversity = _____

36.

After 10 minutes, the tap attached to tube **A** was closed and the syringe was attached to tube **B**. Every minute, the syringe plunger was moved until the levels in the U-tube were the same. The reading on the syringe volume scale was then recorded.

The results are shown in **Table 1**.

Table 1

Time / minutes	Reading on syringe volume scale / cm^3
0	0.84
1	0.81
2	0.79
3	0.76
4	0.73
5	0.70
6	0.68
7	0.66
8	0.63
9	0.62
10	0.58

The mass of the seeds was 1.6 g. Use the information in **Table 1** to calculate the rate of oxygen consumption in $cm^3\,g^{-1}\,hour^{-1}$ by the seeds.

Show your working.

[2 marks]

Rate = $cm^3\,g^{-1}\,hour^{-1}$

37.

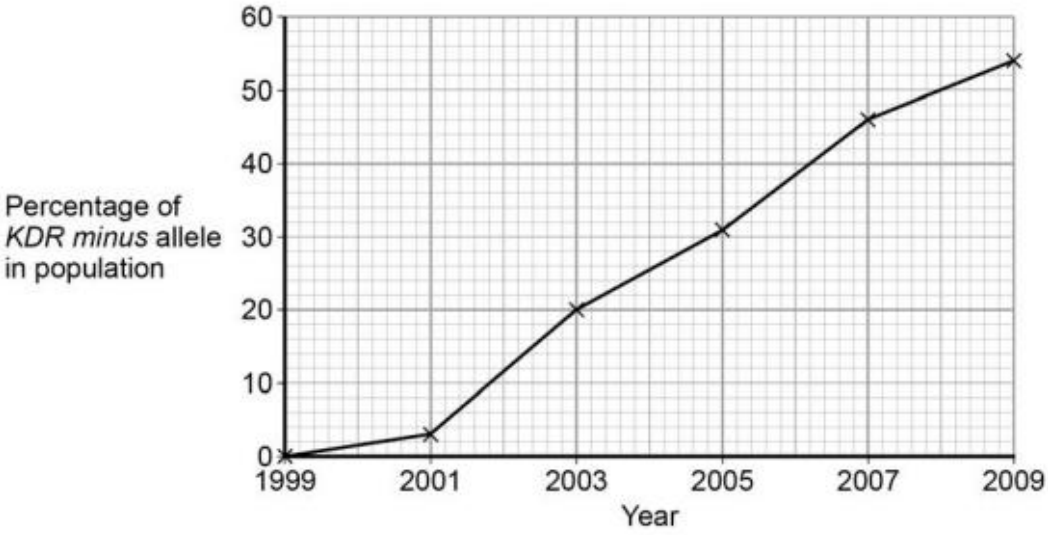
Malaria is a disease that is spread by insects called mosquitoes. In Africa, DDT is a pesticide used to kill mosquitoes, to try to control the spread of malaria.

Mosquitoes have a gene called *KDR*. Today, some mosquitoes have an allele of this gene, *KDR minus*, that gives them resistance to DDT. The other allele, *KDR plus*, does not give resistance.

Scientists investigated the frequency of the *KDR minus* allele in a population of mosquitoes in an African country over a period of 10 years.

Figure 6 shows the scientists' results.

Figure 6



Use the Hardy–Weinberg equation to calculate the frequency of mosquitoes heterozygous for the *KDR* gene in this population in 2003.

Show your working.

[2 marks]

Frequency of heterozygotes in population in 2003 _____

38.

The efficiency with which the kidneys filter the blood can be measured by the rate at which they remove a substance called creatinine from the blood. The rate at which they filter the blood is called the glomerular filtration rate (GFR).

In 24 hours, a person excreted 1660 mg of creatinine in his urine. The concentration of creatinine in the blood entering his kidneys was constant at 0.01 mg cm^{-3}.

Calculate the GFR in cm^3 $minute^{-1}$.

[1 mark]

Answer = _____

39.

Table 1 shows the ecologists' results.

Table 1

Days after release	Number of marked insects remaining in population	Number of insects captured	Number of captured insects that were marked
1	1508	524	78
2	1430	421	30
3	1400	418	18
4	1382	284	2
5	1380	232	9

Calculate the number of insects on this island 1 day after release of the marked insects.

Show your working.

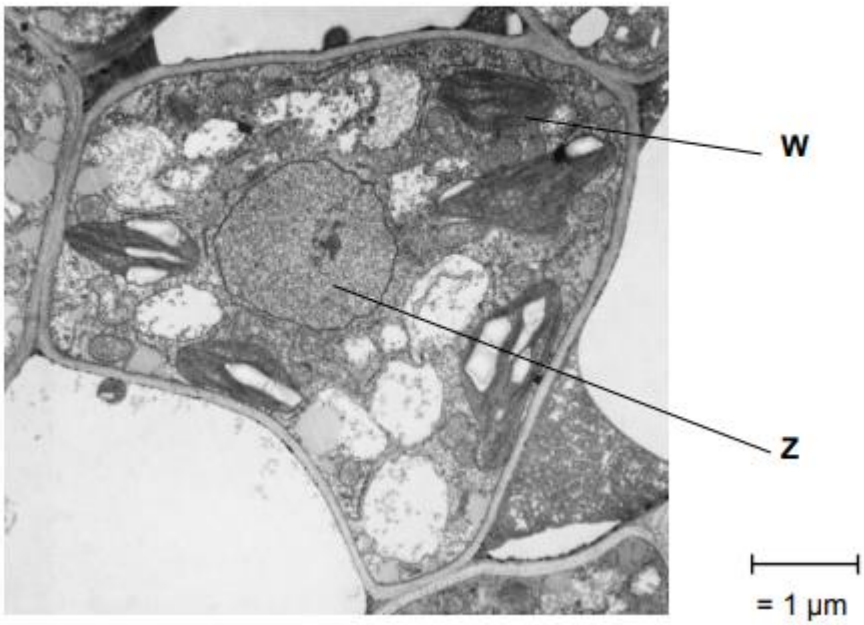
[2 marks]

Answer = _____

40.

Figure 1 shows a microscopic image of a plant cell.

Figure 1



Calculate the magnification of the image shown in **Figure 1**.

[1 mark]

41.

Metastatic melanoma (MM) is a type of skin cancer. It is caused by a faulty receptor protein in cell-surface membranes. There have been no very effective treatments for this cancer.

Dacarbazine is a drug that has been used to treat MM because it appears to increase survival time for some people with MM.

Doctors investigated the use of a new drug, called ipilimumab, to treat MM. They compared the median survival time (ST) for two groups of patients treated for MM:

- a control group of patients who had been treated with dacarbazine
- a group of patients who had been treated with dacarbazine and ipilimumab.

The ST is how long a patient lives after diagnosis.

The doctors also recorded the percentage of patients showing a significant reduction in tumours with each treatment.

The total number of patients in the investigation was 502.

Table 2 shows the doctors' results.

Table 2

Treatment	**Median survival time (ST) / months**	**Percentage of patients showing significant reduction in tumours**
Dacarbazine	9.1	10.3
Dacarbazine and ipilimumab	11.2	15.2

The doctors compared median survival times for patients in each group.

How would you find the median survival time for a group of patients?

[2 marks]