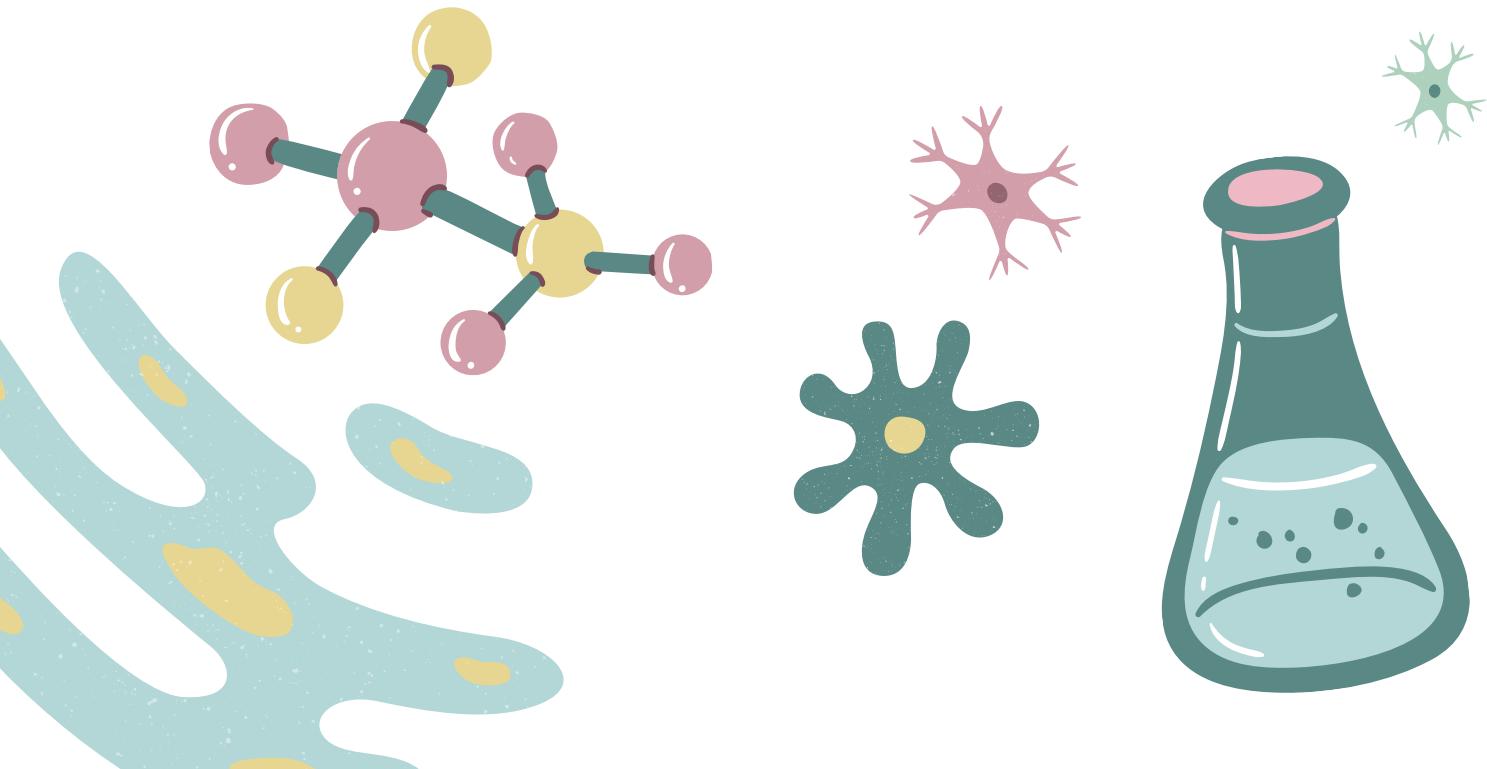




UNIT 4
(SPECIMEN - 2024)

CALCULATIONS SHEET

DR YAHIA ABDELMONEIM
(THE BIOLOGY TEAM)



Q1) (iv) The volume of an Ebola virus is approximately $7.76 \times 10^4 \text{ nm}^3$.

Tobacco mosaic virus (TMV) is approximately 300 nm long and 80 nm in diameter.

Calculate how many times larger Ebola virus is than TMV.

Assume that TMV is a cylinder in shape.

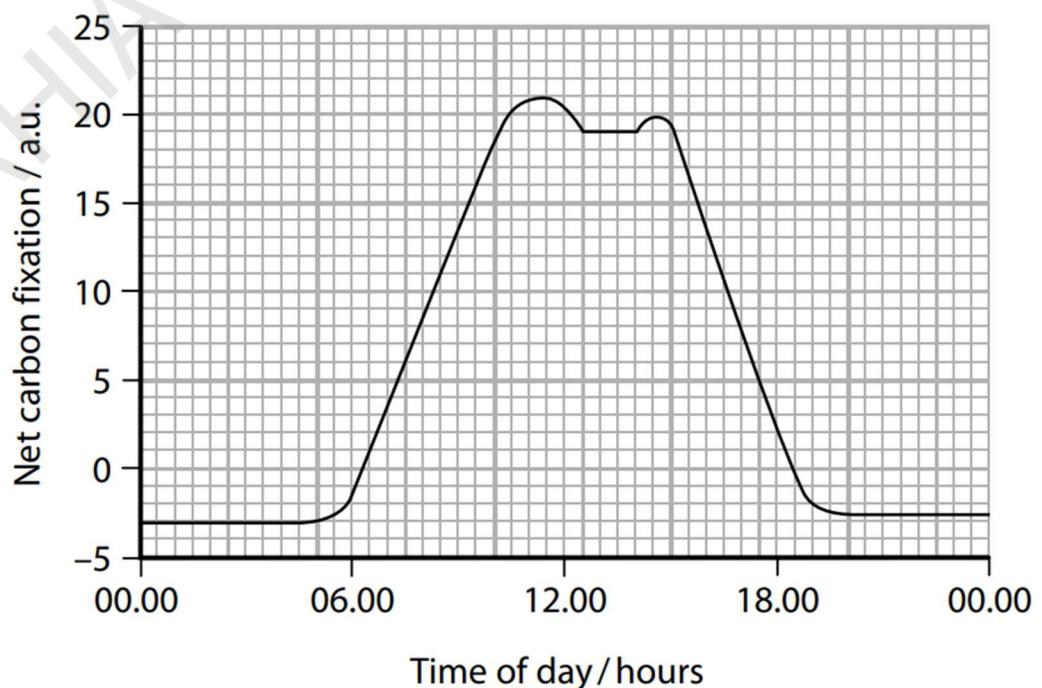
The volume of a cylinder is calculated using the formula

$$V = \pi r^2 l$$

(2)

Answer.....

Q2) (b) The graph shows the net carbon fixation in a plant over a period of 24 hours.



(i) Calculate the rate of decrease of net carbon fixation at 12.00 hours.

Include units in your answer.

(3)

Answer.....

Q3) (b) (i) The growth rate constant will be at its highest in the temperature range of 5 °C to 50 °C.

Calculate the growth rate constant (k) of bacteria that have increased from 5×10^3 cells per cm^3 to 1.3×10^5 cells per cm^3 in 4 hours.

(3)

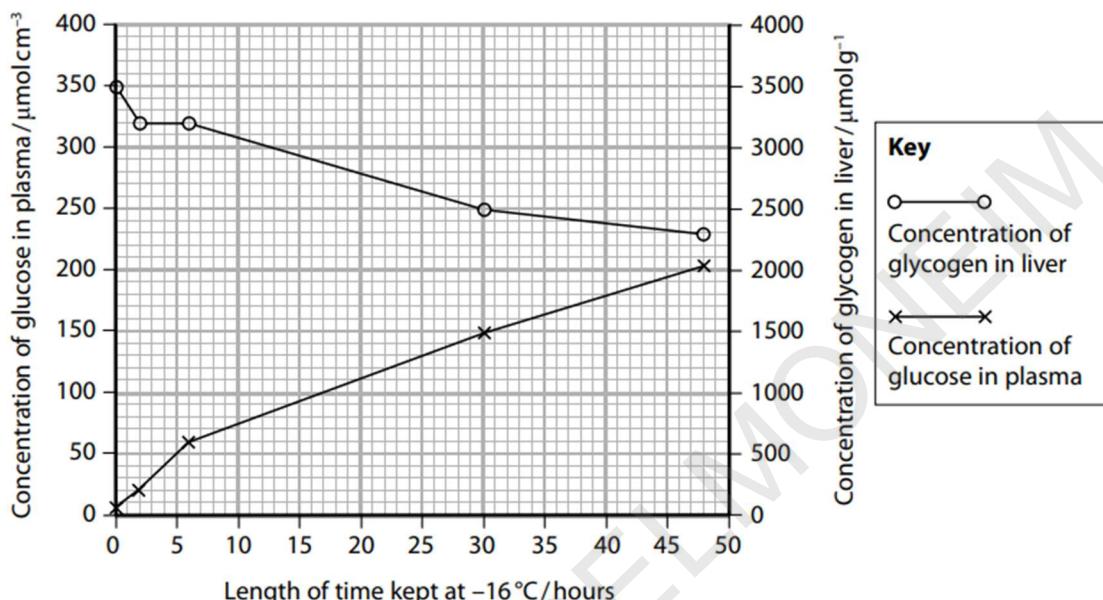
$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

Answer.....

Q4)

- (a) Scientists kept a wood frog from Alaska at -16°C . The scientists measured the concentration of glycogen in the liver and the concentration of glucose in the plasma over a period of 48 hours.

The graph shows the results.



- (b) The scientists found that wood frogs from Alaska had higher concentrations of glucose in their plasma than wood frogs from Ohio.

The scientists also found that the wood frogs from Alaska had higher concentrations of other solutes, such as urea, in their plasma.

The table shows the mean concentration of urea in the plasma of these frogs.
The table also shows the standard deviations.

Type of wood frogs	Mean concentration of urea in plasma / $\mu\text{mol cm}^{-3}$	Standard deviation
from Alaska	106	10
from Ohio	28	5

- (i) Calculate the percentage difference in the mean concentration of urea in the plasma of the wood frogs from Alaska compared with the wood frogs from Ohio.

(1)

Answer..... %

Q5) (ii) Which of the following are the units for NPP?

(1)

- A $\text{kg m}^{-1} \text{yr}^{-1}$
- B $\text{kg m}^{-2} \text{yr}^{-2}$
- C $\text{kJ m}^{-1} \text{yr}^{-1}$
- D $\text{kJ m}^{-2} \text{yr}^{-1}$

(iii) In this forest, the total NPP was 11 700 units.

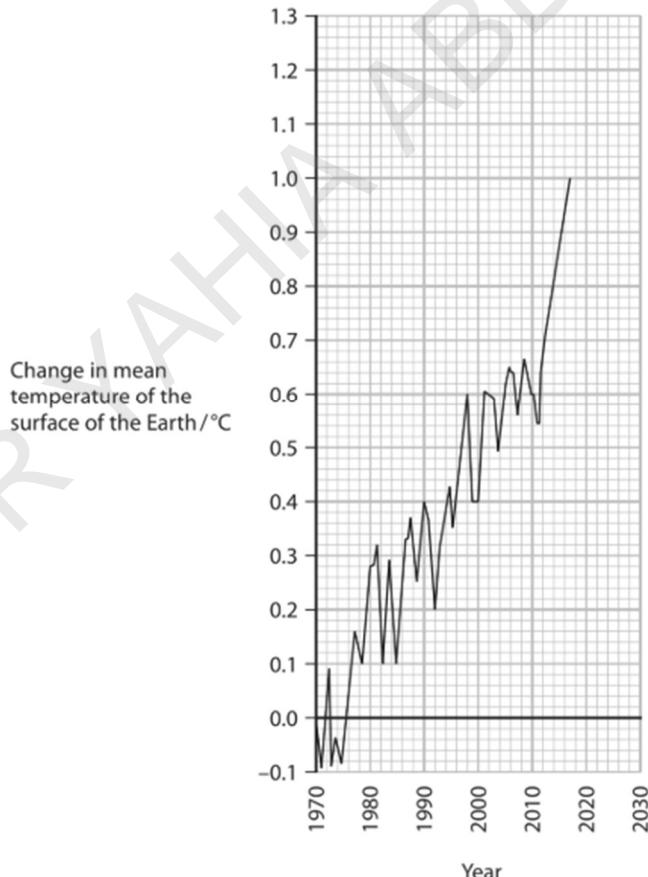
The leaves contained 34% of the NPP and the wood contained 39% of the NPP.

Calculate the NPP content in the roots.

(2)

Answer units

Q6) 3 The graph shows the changes in mean temperature of the surface of the Earth from 1970 to 2017.



(b) What is the estimated change in the mean temperature of the surface of the Earth in 2030?

(1)

- A 1.3
- B 1.1
- C 0.8
- D 0.2

Q7)

Malaysia is covered by large areas of rainforest. These rainforests have one of the highest biodiversities in the world.

However, the rate of loss of rainforest in Malaysia is one of the highest in the world.

(a) (i) From 2000 to 2012, Malaysia lost 14.4% of its rainforest. This is equivalent to 47 278 km².

Calculate the area of Malaysia covered by rainforest in 2000.

Give your answer in standard form.

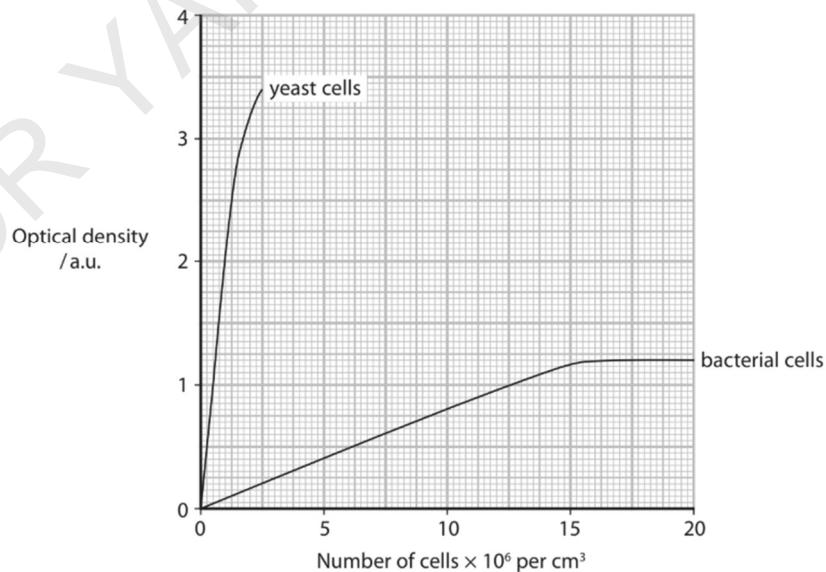
(3)

Answer km²

Q8)

The number of cells in the sample is determined using a calibration curve.

The graph shows a calibration curve for bacterial cells and yeast cells.



- (b) Calculate how many times more bacterial cells there are than yeast cells if both samples have an optical density of 1.0 a.u.

(2)

Answer

- (d) A liquid medium was inoculated with 6×10^3 bacterial cells and the culture was incubated for a period of time.

At the end of this incubation period, there were 1.2×10^7 bacterial cells.

Calculate the time (t) of this incubation period.

Use a value of 0.963 for the growth rate constant (k) and the equation

$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

(3)

Answer

Q9)

- (b) Scientists have synthesised two different types of evasin, E1 and E2.

The number of amino acids in E1 is 98. The molecular mass of this evasin is 10.9 kDa.

The number of amino acids in E2 is 80.

- (i) Calculate the predicted molecular mass of E2.

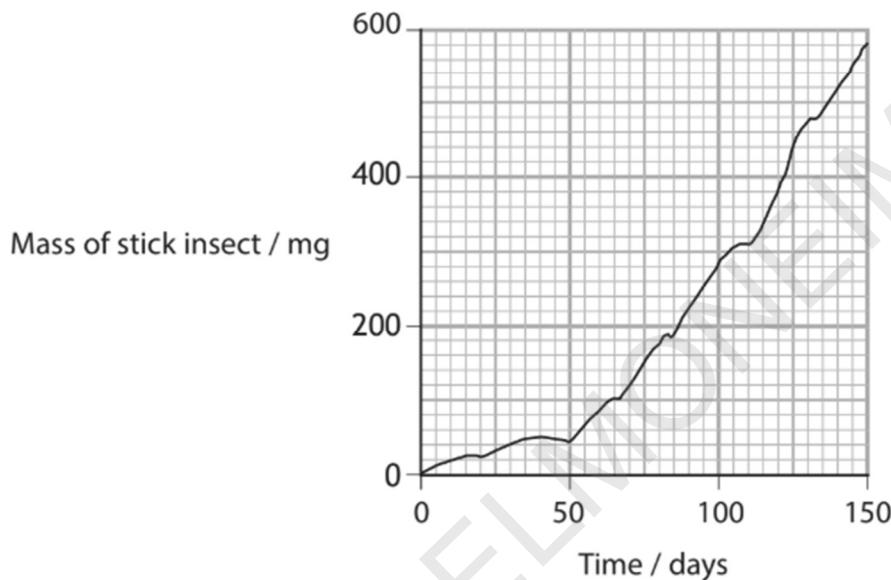
(2)

Answer kDa

Q10)

A student suggested that the increase in mass of a stick insect would be the same as the mass of leaves that it ate.

The graph below shows the mass of a stick insect recorded each day for 150 days.



(a) Calculate the mean daily increase in mass of this insect from day 10 to day 130.

(2)

Answer mg

(b) From day 10 to day 130, the stick insect ate 5 g of leaves.

Calculate the efficiency of mass transfer between trophic levels 1 and 2.

(2)

Answer %

Q11) (ii) Many treatments use 1 g curcumin extract.

A sample of turmeric contains 3% curcumin.

Which is the mass of turmeric for one treatment?

(1)

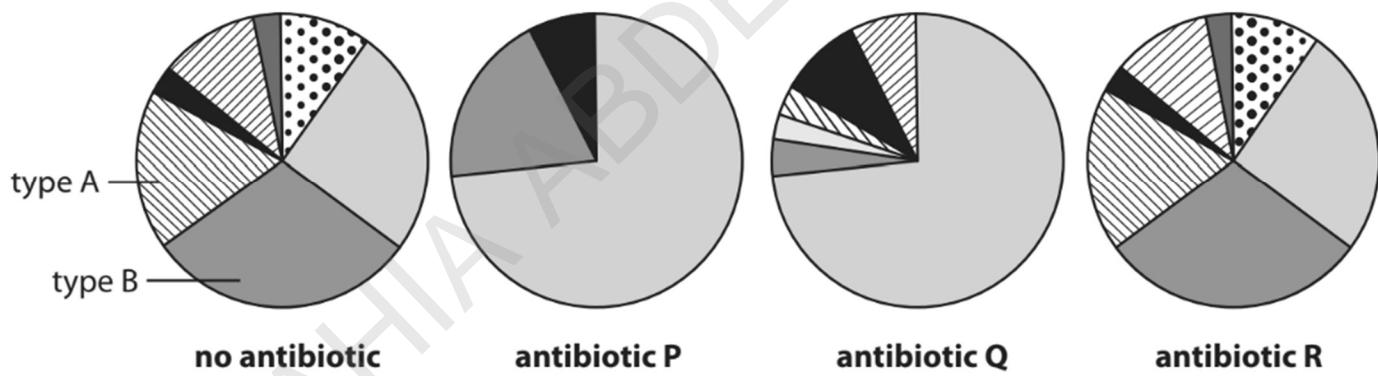
- A 0.03 g
- B 3.33 g
- C 33.3 g
- D 33.4 g

Q12)

(c) One problem of taking antibiotics is their effect on gut flora.

The diagrams show the effects of three antibiotics, P, Q and R, on the proportion of different types of gut flora.

Each section in each of the diagrams represents a different type of gut flora.



(iii) The number of type A in gut flora in the absence of antibiotics is 6 000 000.

Estimate the number of type B in gut flora in the absence of antibiotics.

Give your answer in standard form.

(1)

Answer.....

Q13)

- (b) Fragments of double-stranded DNA move through the gel at a relative rate (M_r) that is inversely proportional to the log of their molecular weight (MW).

- (i) Complete the table using the equation:

$$M_r = \frac{1}{\log_{10} MW}$$

(2)

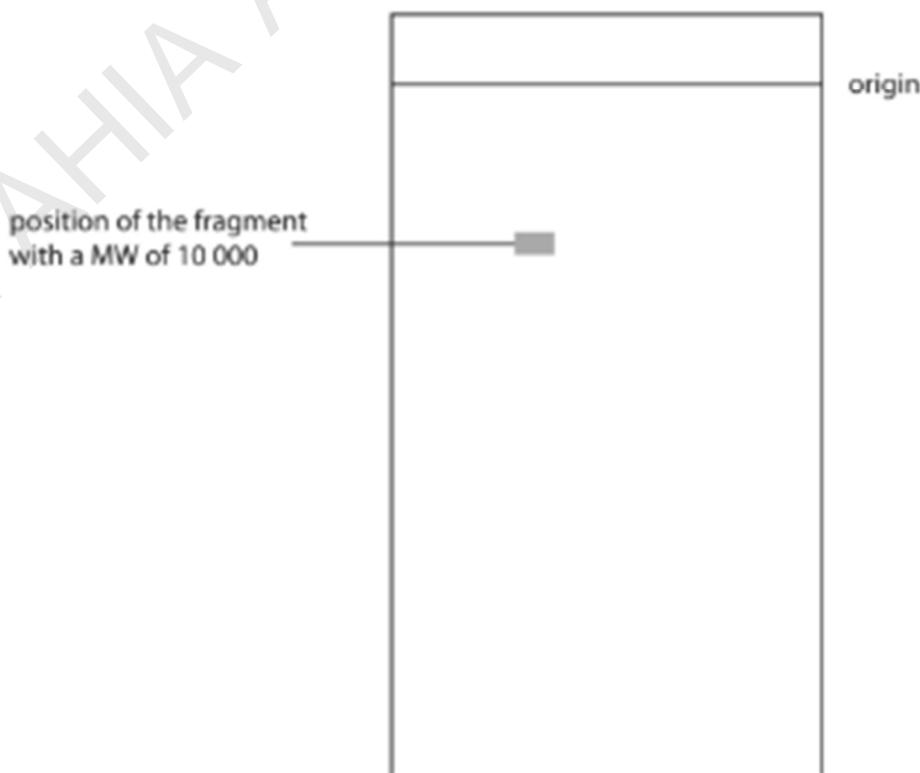
Molecular weight of DNA fragment (MW)	Relative rate of movement (M_r)
100 000	
10 000	0.25
	0.34

- (ii) The diagram shows the position of a DNA fragment with a MW of 10 000, after gel electrophoresis.

Complete the diagram to show the position of a DNA fragment with a MW of 100 000.

Use the information in the question.

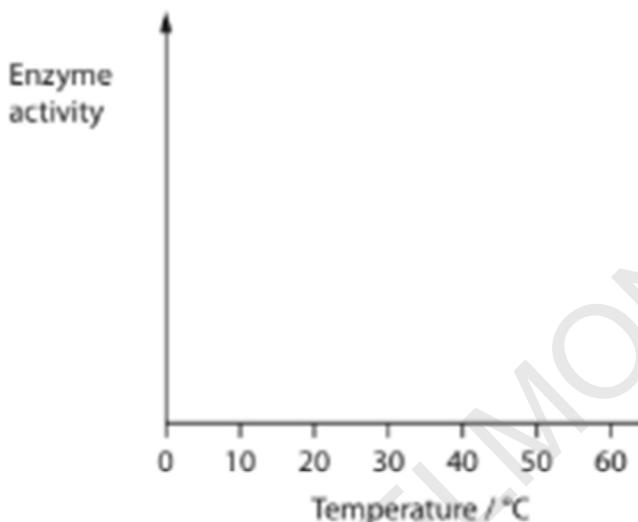
(1)



- Q14)** (i) Sketch the graph for enzyme activity plotted against temperature for this enzyme.

Use the data from this investigation.

(2)



- (ii) Calculate the Q_{10} for this enzyme, using the data from this investigation, shown in the first graph.

Use the formula

$$Q_{10} = \frac{R_{t+10}}{R_t}$$

where R_t is the initial rate of reaction at t °C

and R_{t+10} is the initial rate of reaction at $t + 10$ °C.

(4)

Answer _____

- (b) A quince fruit is made up of cells and contains a lot of juice.

The table shows the composition of carbohydrates in the juice of one species of quince.

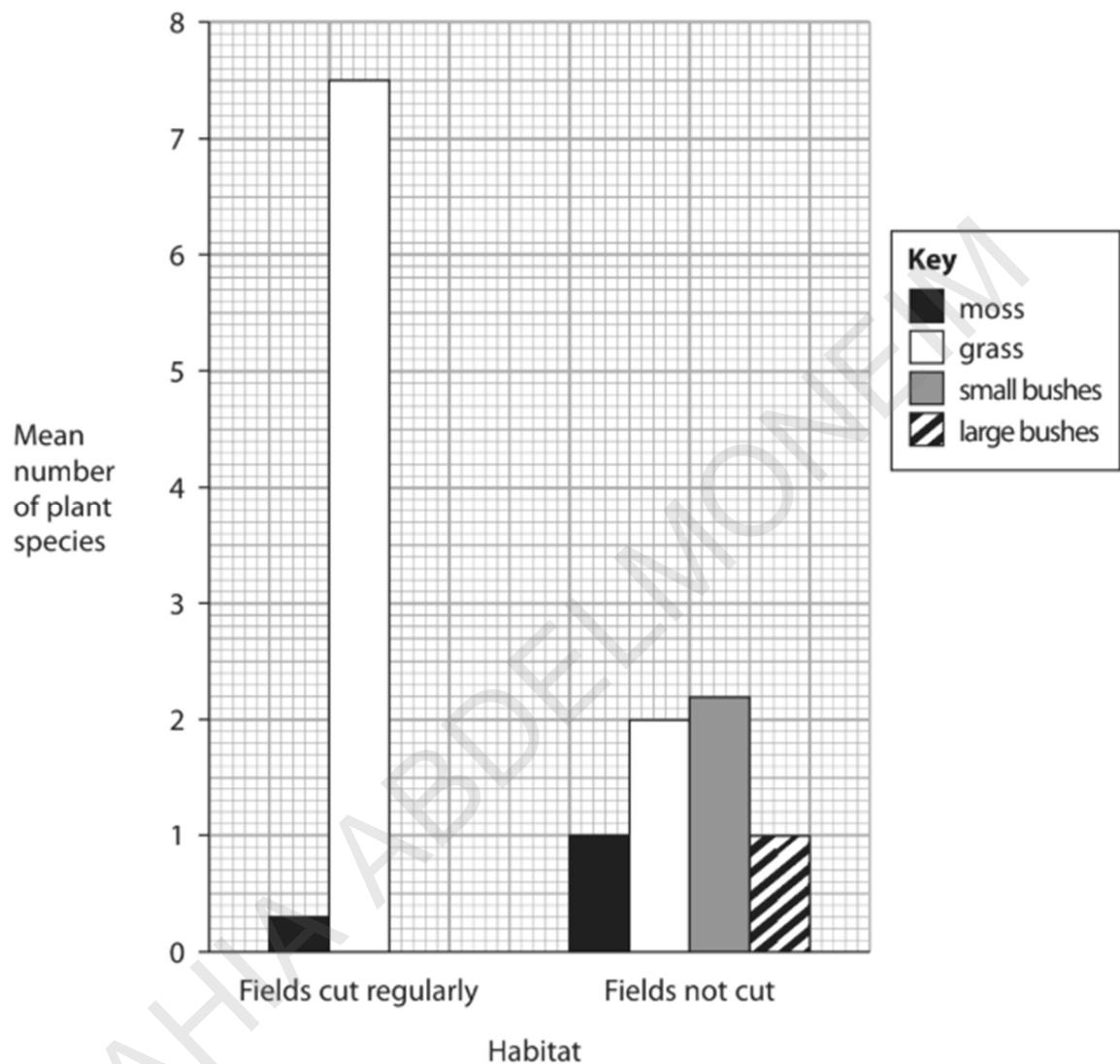
Type of carbohydrate	Name of carbohydrate	Concentration of carbohydrate / mg per 100 cm ³ juice
monosaccharide	fructose	817.2
	glucose	308.3
	inositol	8.3
	rhamnose	12.4
	sorbitol	121.1
	xylose	94.0
disaccharide	sucrose	57.0
trisaccharide	raffinose	8.3
tetrasaccharide	stachyose	9.5

- (i) Complete the table to show the ratio of the concentrations of the four types of carbohydrate.

(2)

Type of carbohydrate	Ratio
monosaccharide	
disaccharide	
trisaccharide	
tetrasaccharide	

Q15) The graph shows some of the results from this investigation.



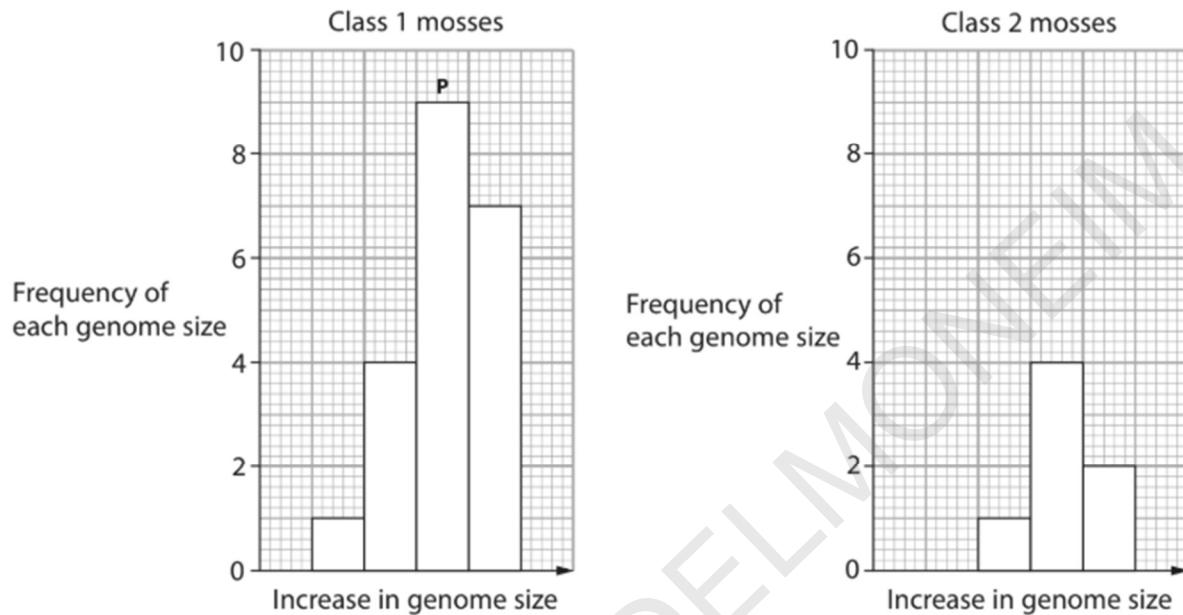
- (ii) What is the percentage increase in the number of species of moss between the fields cut regularly and the fields not cut?

(1)

- A 23.3
- B 70.0
- C 233.3
- D 333.3

- (b) In another investigation, the genome size of 30 species of moss was determined. Each species of moss belonged to one of two classes of moss.

The graphs show the frequency of each genome size in the class 1 mosses and some of the class 2 mosses.



- (ii) One genome size is missing from the graph for class 2 mosses.

Calculate the frequency of this genome size.

(1)

Answer.....

- (iii) The mean value for the genome size of class 1 mosses was 0.449 a.u. and the mean value for class 2 mosses was 0.920 a.u.

Calculate the ratio of the genome size of class 1 mosses to the genome size of class 2 mosses.

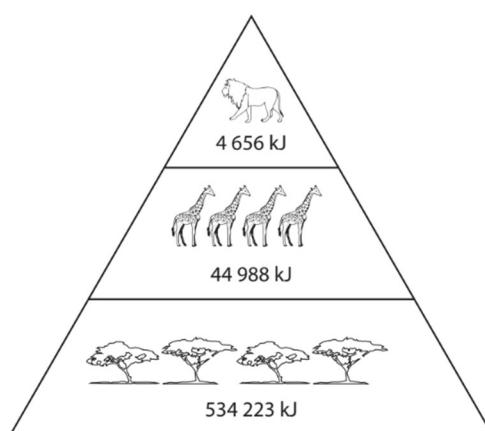
(1)

Answer.....

Q16)

Lions, giraffes and acacia trees are found on the African Plains.

The diagram shows the energy in the trophic levels that these organisms occupy.



- (b) Calculate the efficiency of energy transfer between trophic level one and trophic level two.

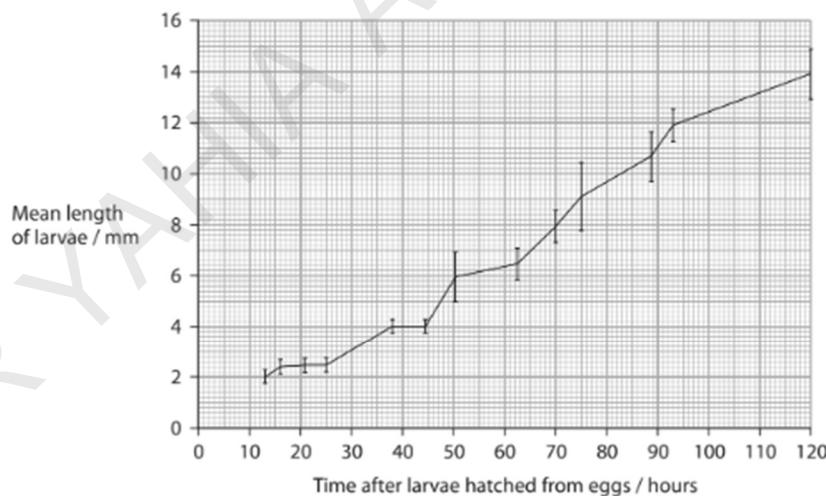
(1)

Answer.....%

- (b) The larvae of one species of blowfly can be used to estimate the time of death.

Q17)

The graph shows the mean length of larvae from this species incubated at 10.62 °C.



- (i) Calculate the mean growth rate of these larvae from 25 to 120 hours.

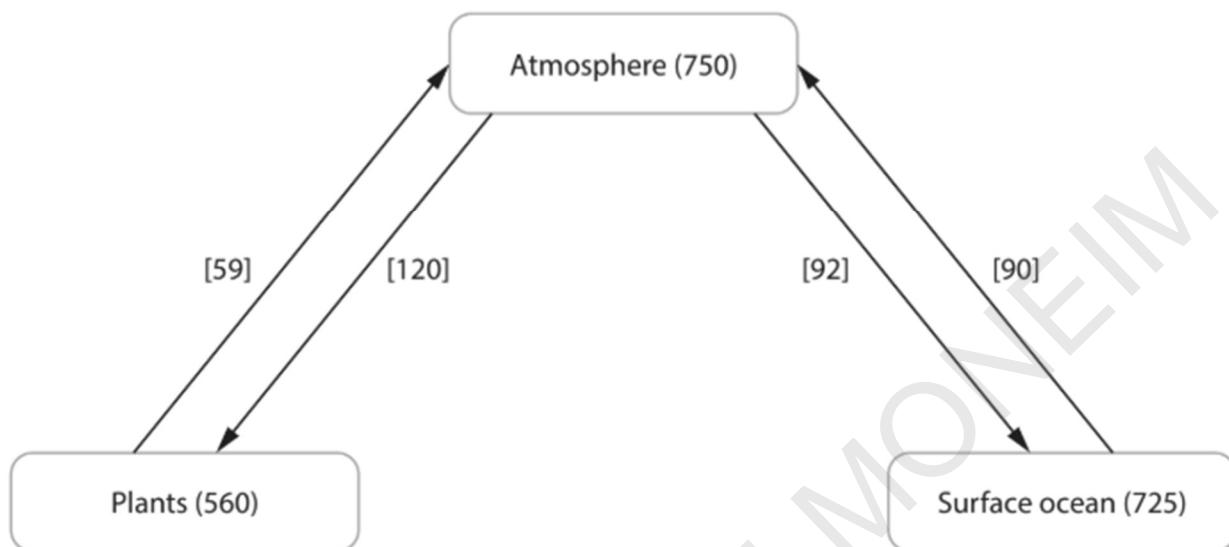
Include the units with your answer.

(2)

Answer.....

Q18)

The diagram shows part of the carbon cycle.



Key

The numbers in smooth brackets () show the mass of carbon in petagrams found in either the atmosphere, plants or surface ocean.

The numbers in square brackets [] show the mass of carbon in petograms transferred between the atmosphere and the plants or surface ocean per year.

A petagram is equal to 10^{15} grams.

- (ii) Calculate the increase in the mass of carbon in plants as a result of carbon exchange between the plants and the atmosphere in one year.

Give your answer in kilograms.

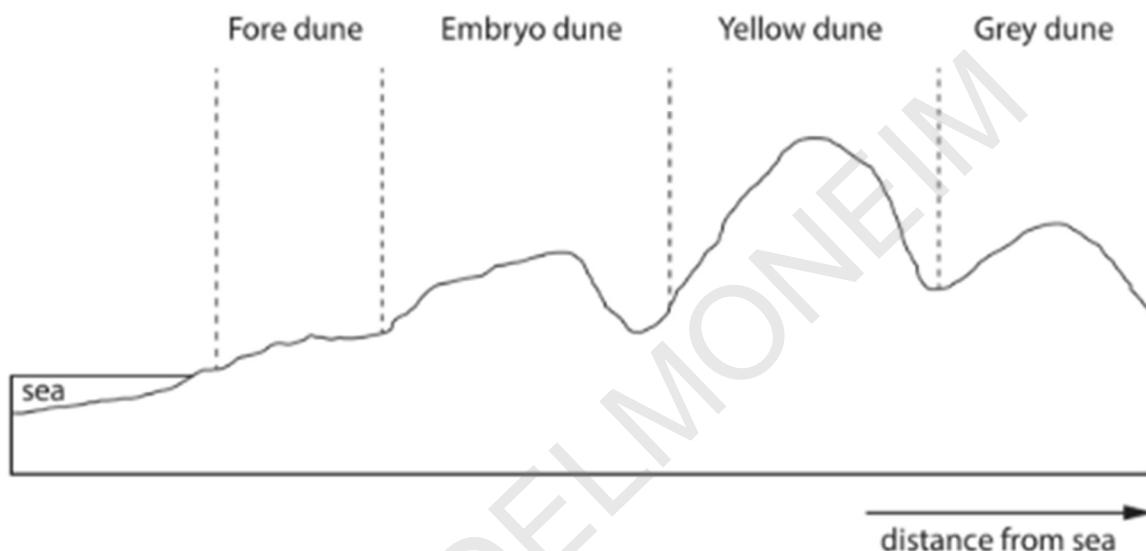
(1)

Answer..... kg

Q19) Stages of succession can be seen on different parts of a sand dune system.

The greater the distance of the sand dune from the sea, the later the stage of succession.

The diagram shows a sand dune system and the table gives some information about the different types of sand dune in this system.



Information	Fore dune	Embryo dune	Yellow dune	Grey dune
Soil depth / cm	<0.5	0.5	1.0	8.0
Percentage of organic matter (%)	<1.0	1.0	2.5	5.0
pH	8.5	8.0	7.0	6.5
Percentage of bare ground (%)	>97	97	70	10
Number of different plant species	2	3	6	15
Typical plant species	sea rocket saltwort	sea couch grass lyme grass marram grass	marram grass red fescue grass sea holly	range of different meadow plants

- (a) (i) The pH of a solution is a measure of the concentration of hydrogen ions in that solution.

It is a log scale e.g. a solution of pH 5 contains 10^{-5} mol dm⁻³ of hydrogen ions.

What is the difference in concentration of hydrogen ions in a fore dune compared with a grey dune?

(1)

- A a fore dune has 2 times more hydrogen ions than the grey dune
- B a fore dune has 2 times fewer hydrogen ions than the grey dune
- C a fore dune has 100 times more hydrogen ions than the grey dune
- D a fore dune has 100 times fewer hydrogen ions than the grey dune

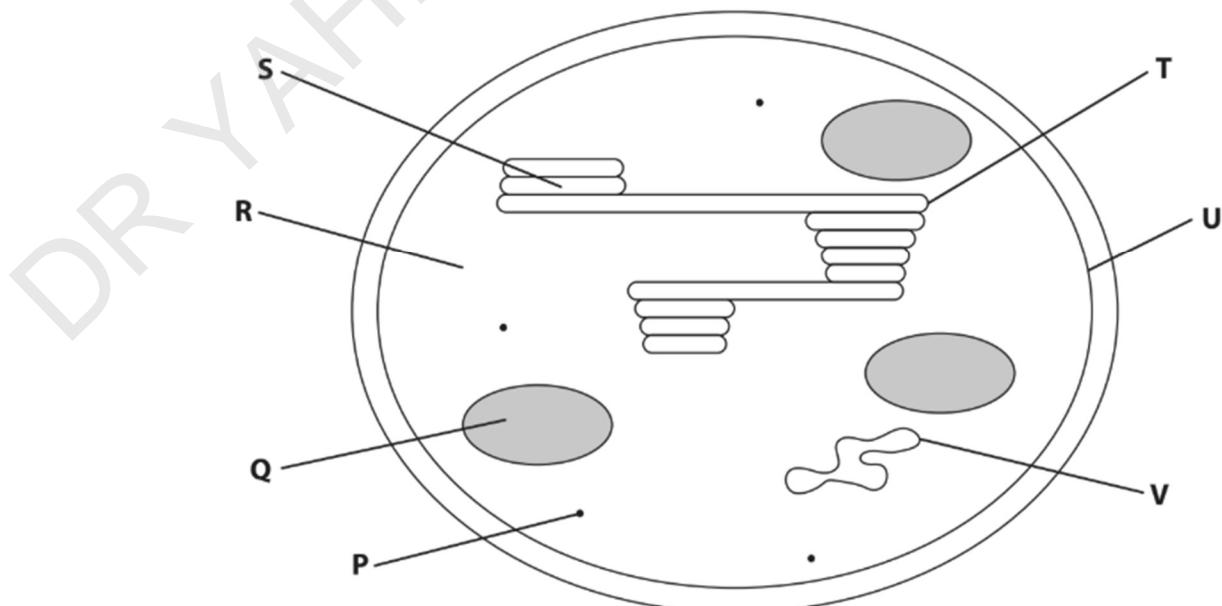
- (ii) Calculate the percentage increase in the number of plant species on the grey dune compared with the fore dune.

(1)

Answer..... %

Q20) The structure of a chloroplast is related to its role in photosynthesis.

The diagram shows a chloroplast.



(iii) The length of this chloroplast is 7.5 μm .

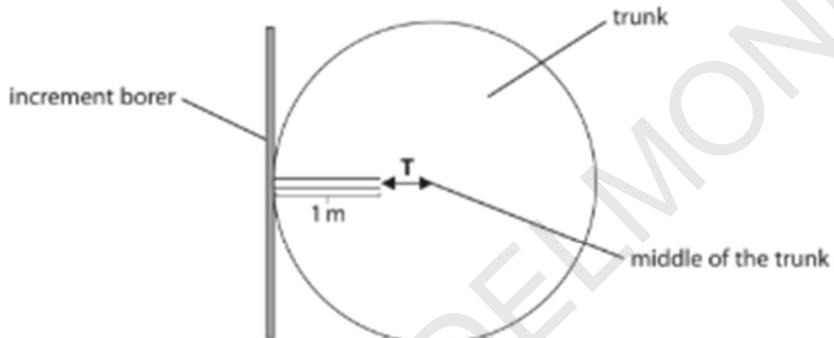
Calculate the magnification of this diagram.

(1)

Answer

Q21)

(a) The diagram shows an increment borer pushed into the trunk of a large Redwood tree.



An increment borer 1 m long was inserted into a Redwood tree. The borer did not reach the middle of the trunk. The distance from the end of the borer to the middle of the trunk is T cm.

(i) Calculate the radius (r) of a tree with a circumference (C) of 8 m.

$$\text{Use the formula: } r = \frac{C}{2\pi}$$

Give your answer to **two** decimal places.

(1)

Answer m

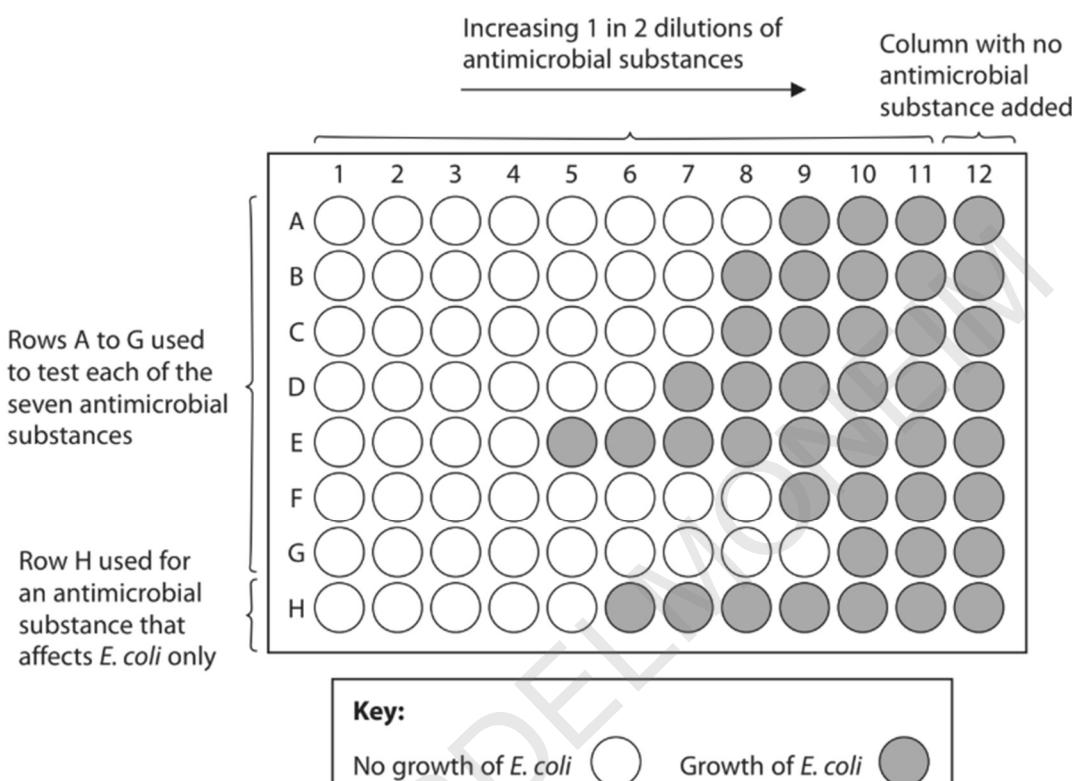
(ii) Calculate the distance T as a percentage of this radius.

(1)

Answer %

Q22)

- (c) The diagram shows the results of the MIC assay from this investigation.



- (iv) Calculate how many times more effective the antimicrobial substance used in row **G** is than the antimicrobial substance used in row **E**.

(2)

Answer

Q23)

- (a) The first part of the study was carried out in a laboratory.

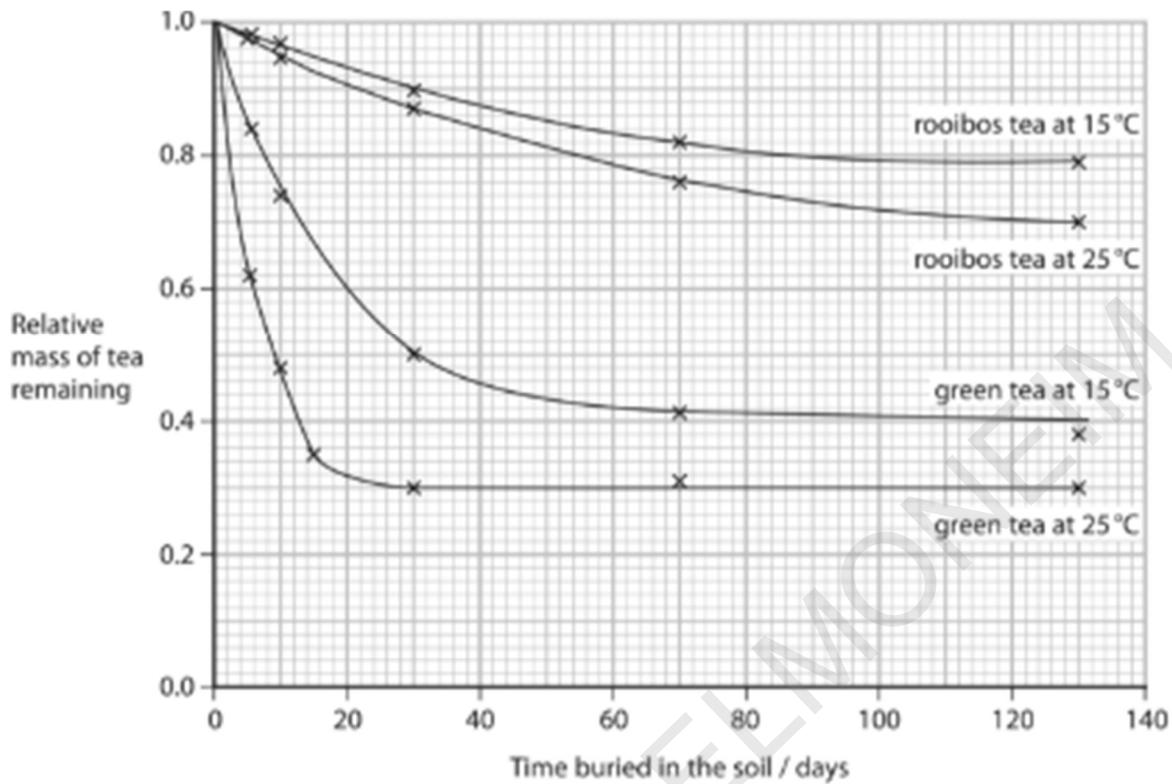
Two types of tea were used, green tea and rooibos tea.

A number of unused teabags containing each type of tea were buried in soil at two different temperatures, 15 °C and 25 °C.

The mass of tea in each teabag had been determined before they were buried.

At regular intervals teabags were dug up, dried, and the remaining tea reweighed.

The graph shows the results of this study.



- (i) The teabags had to be dried before weighing to remove water.

One teabag contained 28 g of tea when it was buried. When it was dug up it had a wet mass of 42 g. The water content of this teabag was calculated to be 50%.

Calculate the mass of organic matter lost during this study.

(1)

Answer g

- (ii) Calculate the rate at which the relative mass of the green tea decreases in the teabags buried at 15 °C at day 30.

(2)

Answer

Q24)

- (b) Voronoi diagrams were used to present some of the data.

Two Voronoi diagrams are shown.

Diagram A shows the biomasses of groups of organisms.

Diagram B shows the biomasses of the organisms in the animals group.

The biomass is given in gigatons of carbon (Gt C), where $1 \text{ Gt C} = 10^{15} \text{ g of carbon}$.

Diagram A

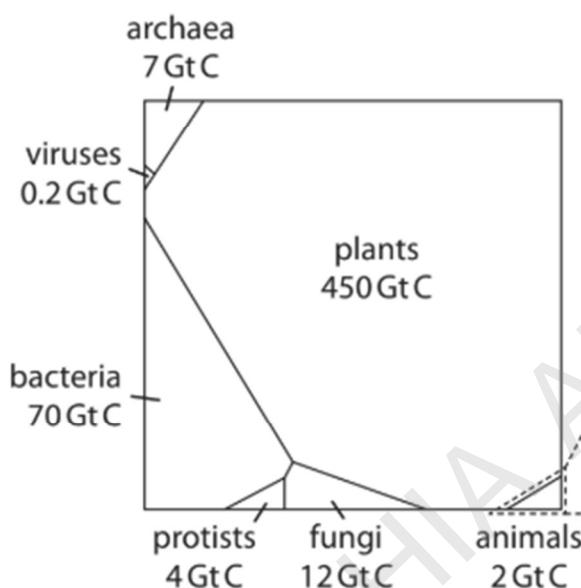
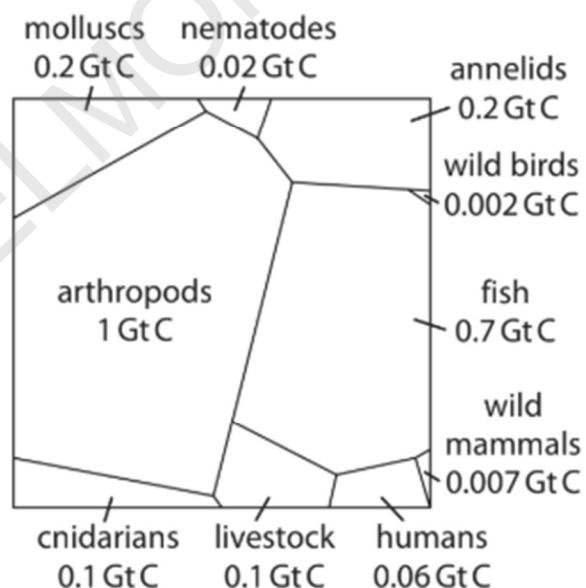


Diagram B



The area of each polygon is proportional to the biomass of that organism. The shape of each polygon has no meaning.

- (i) Calculate the percentage of biomass in organisms belonging to the domain Eukarya.

Use the information in diagram A.

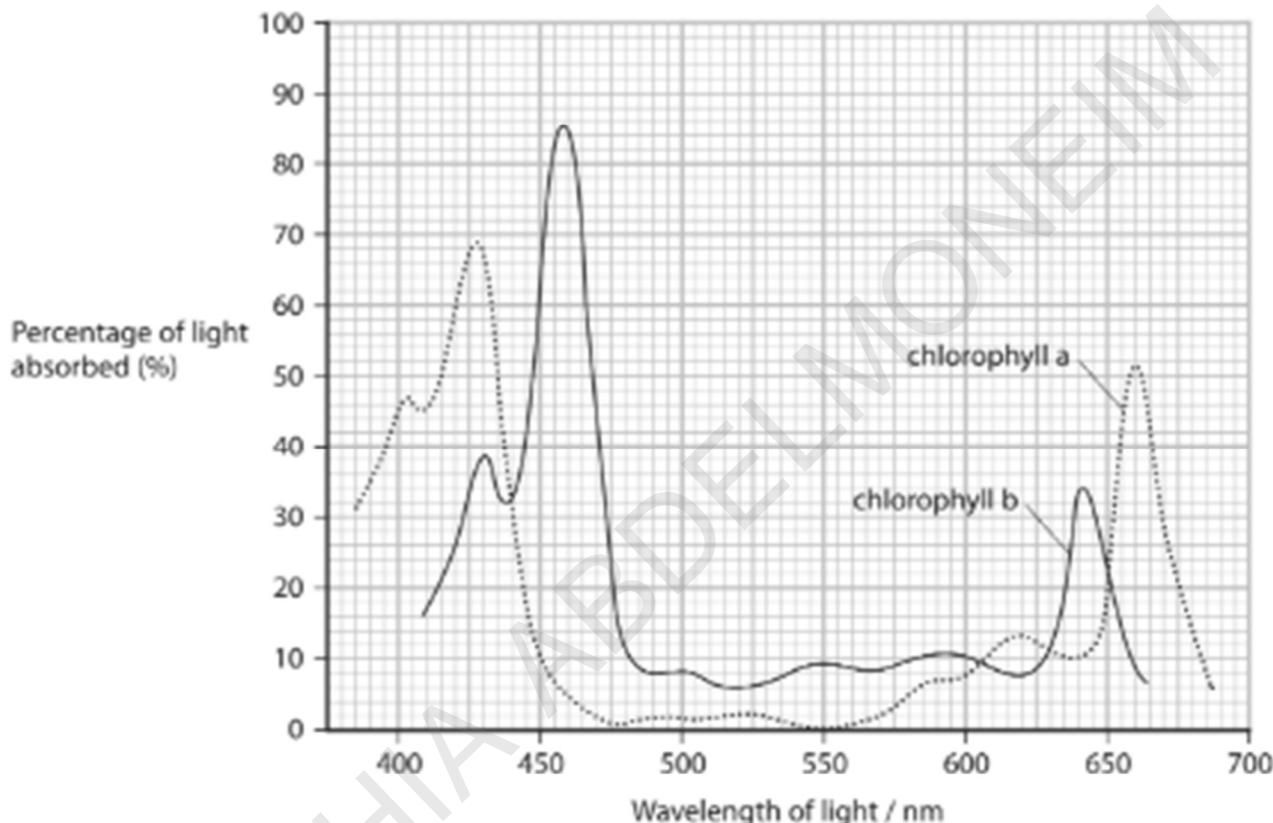
(2)

Answer %

Q25)

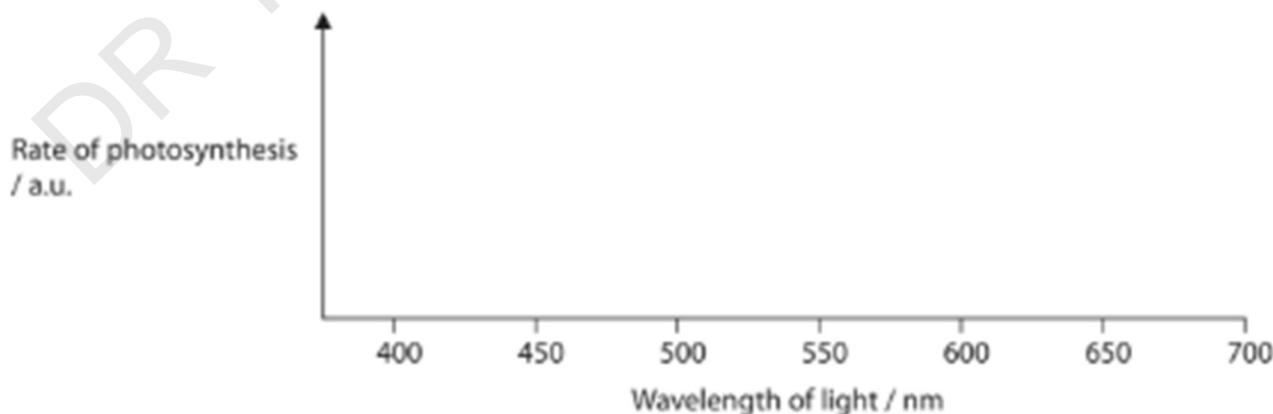
- 2 Thylakoid membranes contain chloroplast pigments and molecules of ATP synthase. These membranes are the site of the light-dependent reactions.

- (a) The graph shows the absorption spectra of two chloroplast pigments from one plant.



- (i) Draw the action spectrum for this plant on the axes below.

(2)



- (ii) Calculate how many times greater the percentage of light absorbed by chlorophyll b is than that absorbed by chlorophyll a, at their maximum absorptions.

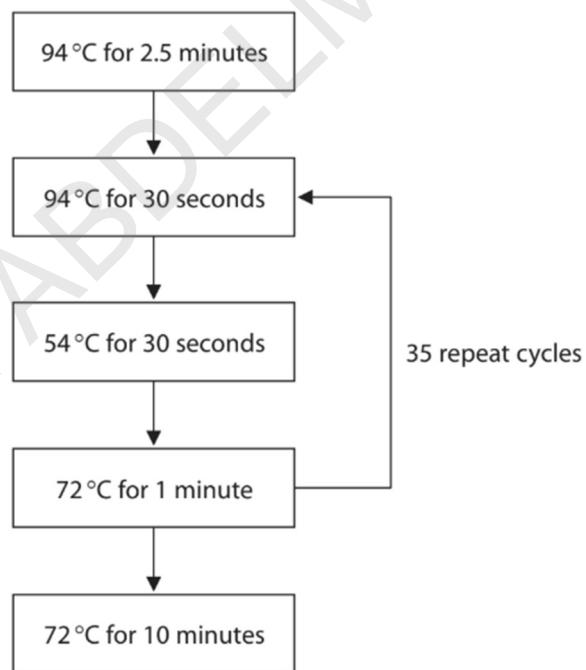
(1)

Answer

Q26)

- (b) The mtDNA was isolated from these two species of crow and amplified using the polymerase chain reaction (PCR).

The diagram shows details of the process used.



- (ii) Calculate the total length of time, in hours, that this process would take.

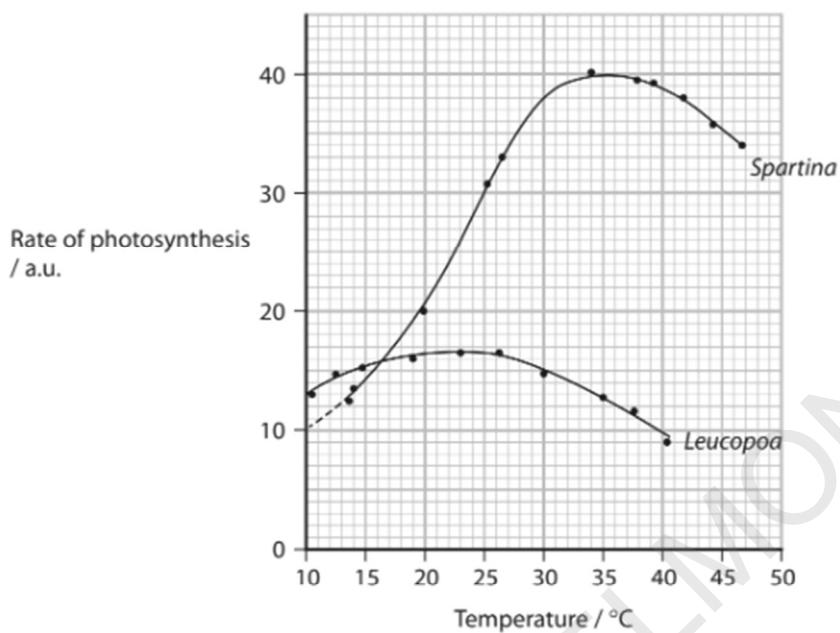
Give your answer to two decimal places.

(2)

Answer hours

Q27)

(b) The graph shows the rate of photosynthesis in two types of plant, *Spartina* and *Leucopoa*, at different temperatures.



(i) Which could be the units for rate of photosynthesis?

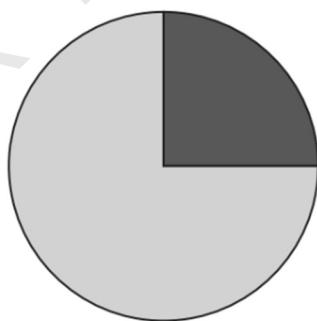
(1)

- A mg CO₂ produced mm⁻² hr⁻¹
- B mg CO₂ produced mm⁻¹ hr⁻²
- C mg CO₂ used mm⁻² hr⁻¹
- D mg CO₂ used mm⁻¹ hr⁻²

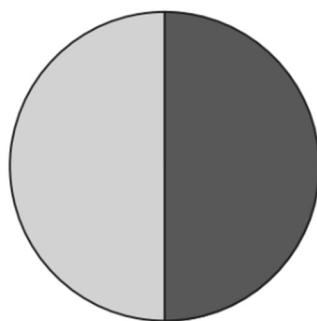
Q28)

(b) The diagram shows the impact of food production on three environmental factors.

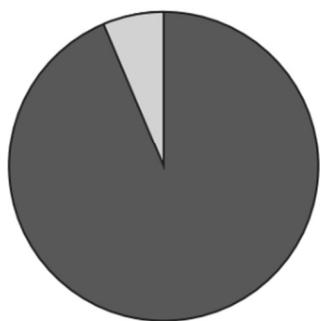
Greenhouse gases



Habitable land use



Biodiversity of mammals



not related to food production related to food production

(ii) Land occupies 149 million km² of the surface of the Earth.

Habitable land is 71% of this area and some of it is used for food production.

Calculate the area of the surface of the Earth used in food production.

Express your answer in standard form.

(3)

Answer km²

(iii) Estimate the effect of food production on the ratio of biodiversity of mammals.

(1)

Answer

Q29)

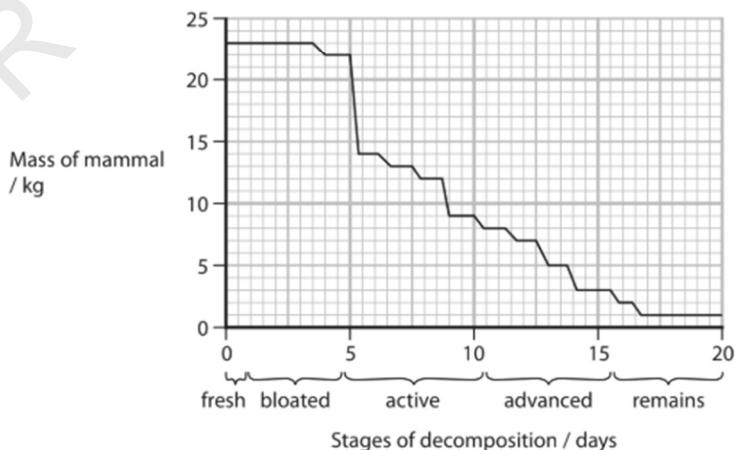
(b) A study looked at the succession of insects associated with the decomposition of a dead mammal in the Andean Coffee region.

In this study, a mammal was killed, placed inside a metal cage in this region and left until it had completely decomposed.

The body of this mammal was monitored regularly.

The stages of decomposition were identified and various measurements were taken and recorded. Insects in the different stages of their lifecycle were collected and identified.

The graph shows the changes in mass of this mammal during the decomposition period.



(ii) Calculate the rate of change in mass between day 5 and day 15 of decomposition.

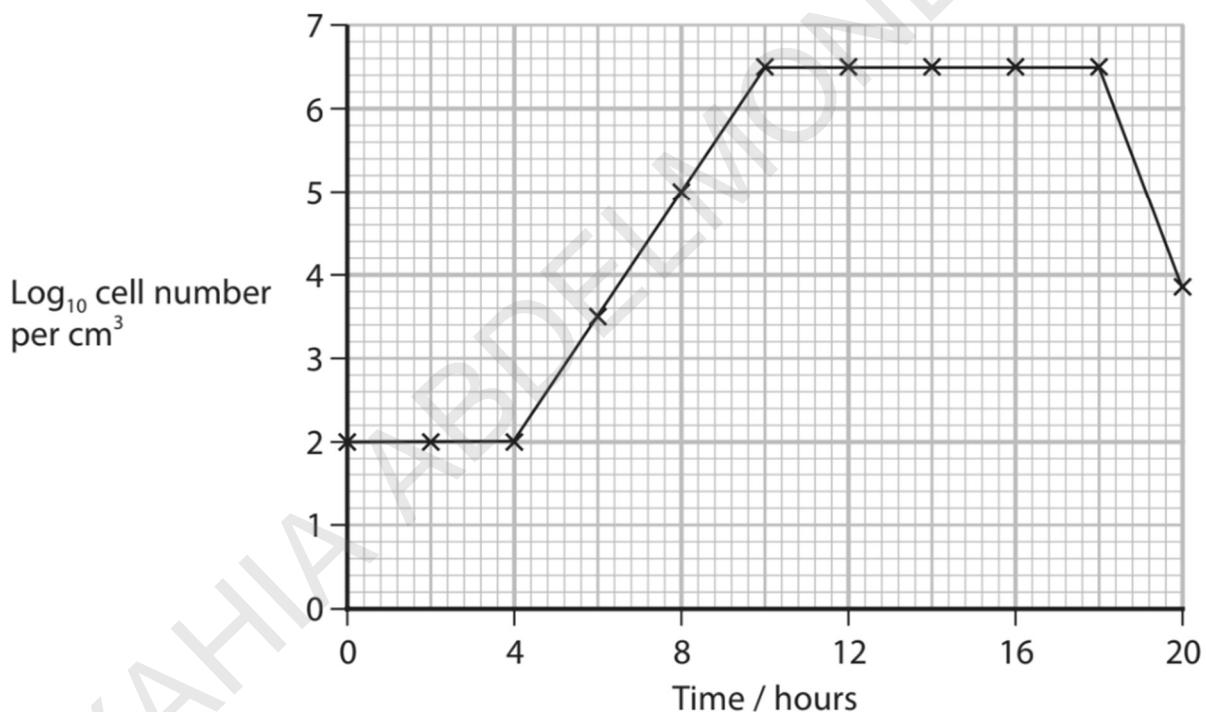
Express your answer in kg hr^{-1} .

Give your answer to two decimal places.

(2)

Answer kg hr^{-1}

Q30) (c) The graph shows the bacterial growth curve for this culture.



(iii) Calculate the growth rate constant (k) of these bacteria between 4 hours and 10 hours.

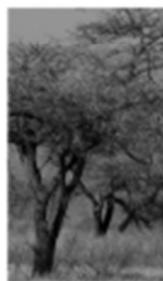
(2)

Use the equation:
$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

Give your answer to two decimal places.

Answer

Q31) 5 The table shows the energy content in the three trophic levels of a food chain from an African plain.

Trophic level	Organism	Energy content
3	Lion 	920
2	Gerenuk 	8825
1	Tree 	90480

(a) (i) Which are the units for the energy content of these organisms?

(1)

- A $\text{kJ m}^{-1} \text{year}^{-1}$
- B $\text{kJ m}^{-1} \text{year}^{-2}$
- C $\text{kJ m}^{-2} \text{year}^{-1}$
- D $\text{kJ m}^{-2} \text{year}^{-2}$

(ii) The energy content of the tree is the net primary productivity (NPP).

What is the relationship between NPP, gross primary productivity (GPP) and respiration (R)?

(1)

- A $NPP = GPP + R$
- B $NPP = GPP - R$
- C $NPP = GPP \times R$
- D $NPP = GPP \div R$

(iii) Calculate the ratio of the energy contents shown in these trophic levels:

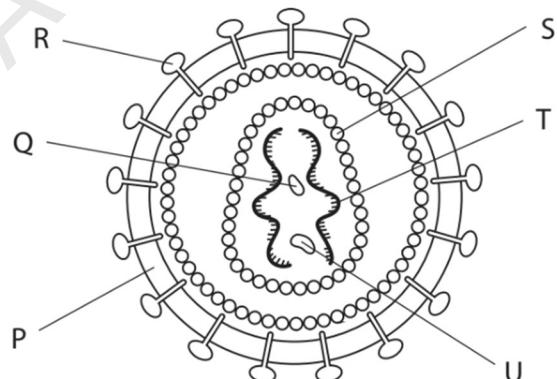
trophic level 1 : trophic level 2 : trophic level 3

(1)

Answer

The diagram shows a human immunodeficiency virus (HIV).

Q32)



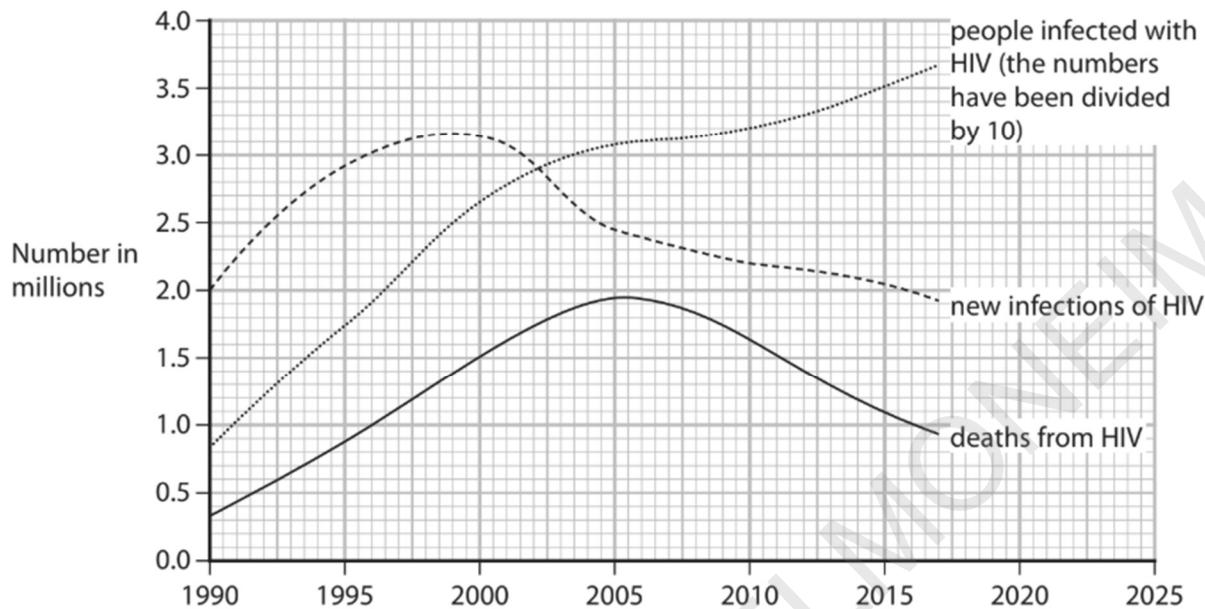
(iv) The diameter of HIV is 120 nm.

Which is the approximate magnification of this drawing?

(1)

- A $\times 500$
- B $\times 5000$
- C $\times 50000$
- D $\times 500000$

- (b) The graph shows the number of HIV infections and the number of deaths from HIV in the world from 1990 to 2017.



- (ii) Calculate the mean rate of increase in the number of people infected with HIV from 2005 to 2010.

Express your answer in standard form to an appropriate number of significant figures.

(2)

Answer mean number of infections year⁻¹

Q33) Tasmanian devils are found in Tasmania.

The population of Tasmanian devils has fallen drastically due to a fatal cancer. This cancer first appeared in the mid-1990s.

There are only a few regions in Tasmania left where healthy Tasmanian devils can still be found.

- (a) The number of Tasmanian devils is estimated to have fallen from 150 000 in the mid-1990s to 25 000 in 2020.

Calculate the percentage decrease in the number of Tasmanian devils from the mid-1990s to 2020.

(1)

Answer %

Q34)

- (b) (i) The graph shows the changes in environmental temperature before and after a volcanic eruption.



- (iii) The eruption of one volcano resulted in 5×10^7 metric tons of carbon dioxide entering the atmosphere in one year.

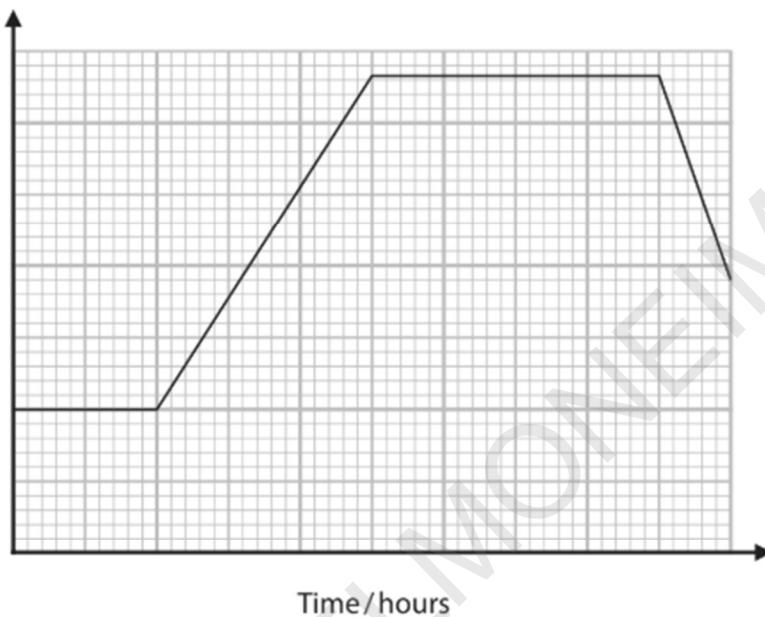
The mass of carbon dioxide released into the atmosphere in one year by anthropogenic activities was 3.5×10^{10} metric tons.

Calculate how many volcanic eruptions would need to occur, in one year, to produce as much carbon dioxide as anthropogenic activities.

(1)

Answer

- Q35)** 1 The graph shows a bacterial growth curve, produced by counting the number of bacterial colonies using the dilution plating technique.



- (a) Which label should be used for the y-axis of this graph?

(1)

- A \log_{10} number of living bacterial cells
- B \log_{10} total number of bacterial cells
- C number of living bacterial cells
- D total number of bacterial cells

- Q36)** (a) The core of mud removed has a diameter of 80 mm and a length of 900 mm.

Which is the volume of this core of mud?

Use the formula: $V = \pi r^2 l$

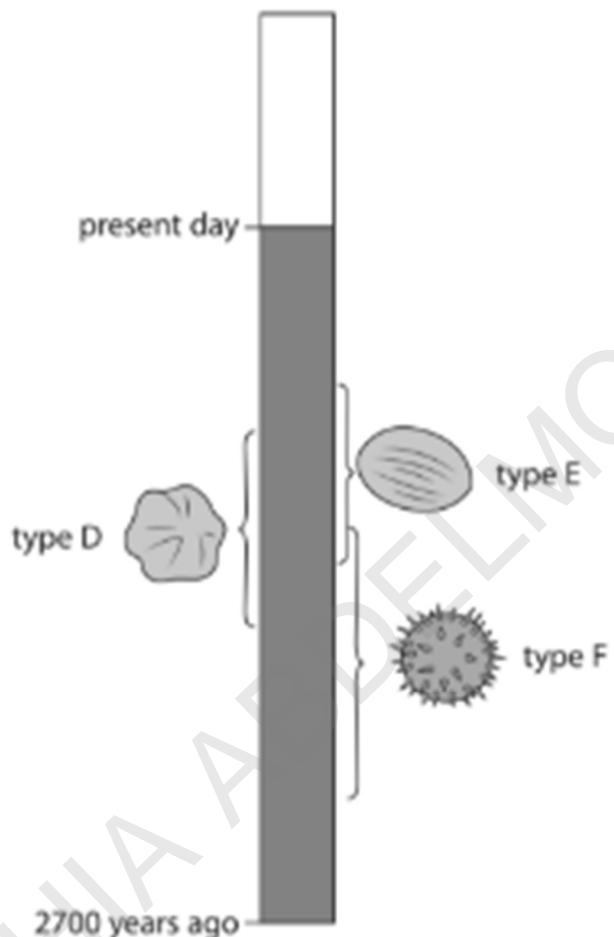
Use $\pi = 3.142$

(1)

- A 4524 cm^3
- B 4525 cm^3
- C 18097 cm^3
- D 18098 cm^3

- (b) The scale diagram shows where three types of pollen grain were found in a core of mud.

The depth of the mud is proportional to how long ago the mud was deposited.



- (i) Calculate how many years the plants producing type D pollen grains were present in this rainforest.

(2)

Answer years

Q37)

Human serum albumin is a globular protein found in blood plasma.

Albumin has a molecular mass of 66 300 daltons.

It consists of 585 amino acids.

At pH 7.4 albumin has over 200 negative charges on the surface of each molecule.

(a) (i) Calculate the mean molecular mass of an amino acid in albumin.

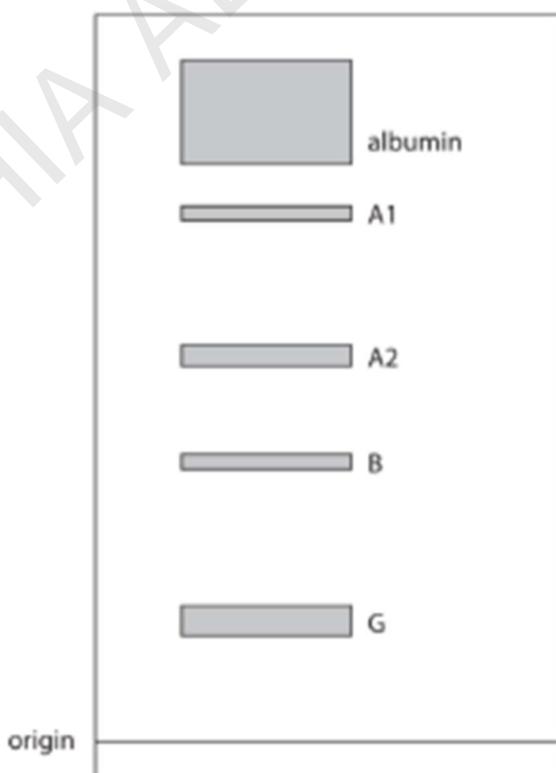
Give your answer to an appropriate number of significant figures.

(1)

Answer daltons

(b) Albumin can be separated from other proteins in blood plasma, A1, A2, B and G, by gel electrophoresis.

The diagram shows the banding pattern produced on separation of these proteins by gel electrophoresis.



(i) Protein G has a concentration in blood plasma in the range 0.700 g dm^{-3} to 1.700 g dm^{-3} .

Albumin has a concentration in blood plasma in the range 0.525 g dm^{-3} to 1.275 g dm^{-3} .

Calculate the maximum difference in the concentration of these two proteins.

(1)

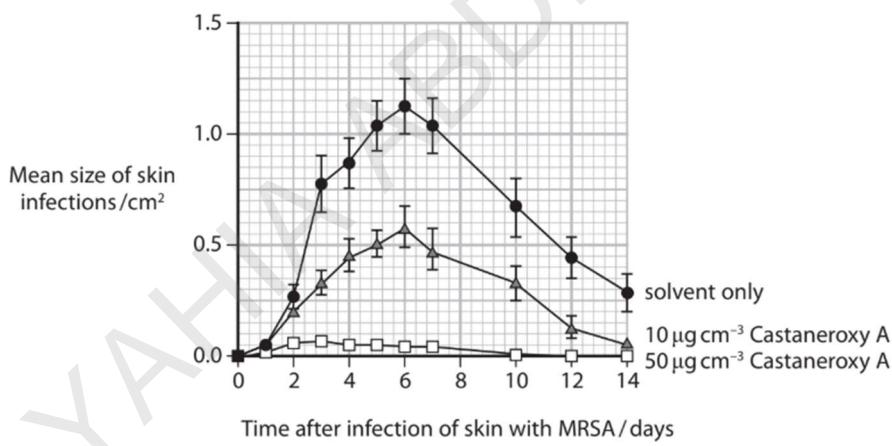
Answer g dm^{-3}

Q38)

(d) In an investigation, patients who had developed skin infections were divided into three groups.

Two groups were each treated with a different concentration of Castaneroxy A. The other group was treated with only the solvent that was used in the treatment.

The graph shows the results of these treatments on the mean size of the skin infections.



(iii) The leaves of the chestnut tree contain 0.0019 %, by mass, of Castaneroxy A.

Calculate the mass of leaves, in kilograms, that would be needed to produce 1 dm^3 of Castaneroxy A at a concentration of $50 \mu\text{g cm}^{-3}$.

Give your answer to the nearest kilogram.

(3)

Answer kg

Q39)

Plants store biomass both above and below ground.

- (a) Scientists have found that on average, 24% of plant biomass is underground in the roots.

The total plant biomass underground contains 113 gigatonnes of carbon. This is equivalent to the mass of carbon dioxide emissions produced by humans in 10 years.

One gigatonne is 1×10^{12} kg.

Calculate the mass of carbon dioxide, in kilograms, produced by humans in one year.

Give your answer in standard form.

(2)

Answer kg

Q40)

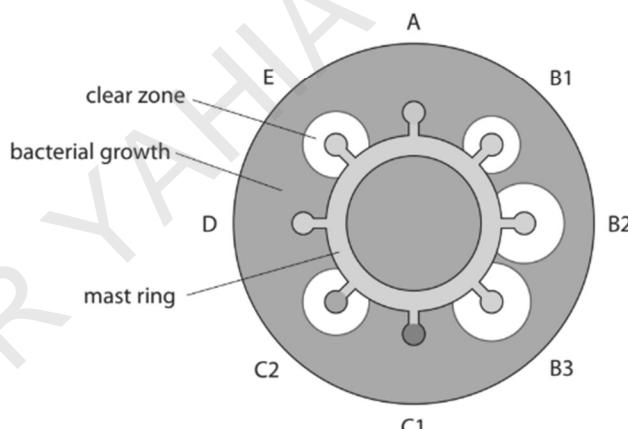
- 1 The resistance of bacteria to antibiotics can be studied using a mast ring.

A mast ring is made of filter paper.

Each part of the mast ring contains a different type of antibiotic or different mass of the same antibiotic.

The diagram shows a mast ring placed on agar in a Petri dish that has been spread with bacteria.

The table shows the mass of each antibiotic in the mast ring.



Part of mast ring	Antibiotic and its mass
A	100 µg antibiotic A
B1	1 µg antibiotic B
B2	10 µg antibiotic B
B3	0.5 mg antibiotic B
C1	20 µg antibiotic C
C2	200 µg antibiotic C
D	100 µg antibiotic D
E	100 µg antibiotic E

- (b) How much more antibiotic is in part B3 than in part B2?

(1)

- A 0.5 times
- B 5.0 times
- C 50.0 times
- D 500.0 times

Q41)

(b) Disposing of plastic waste is a global problem as it is very difficult to recycle.

- (i) In 2018, 8.3×10^{12} kg of plastic was produced.

Only 8.7% of this plastic was recycled.

Calculate the mass of plastic that was **not** recycled.

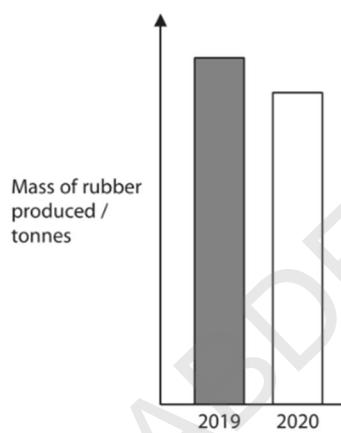
Express your answer in standard form to one decimal place.

(2)

Answer..... kg

Q42)

(a) The graph shows the mass of rubber produced in Thailand in 2019 and 2020.



In 2020, Thailand produced 4.37 million tonnes of rubber.

Estimate the mass of rubber produced in Thailand in 2019.

(1)

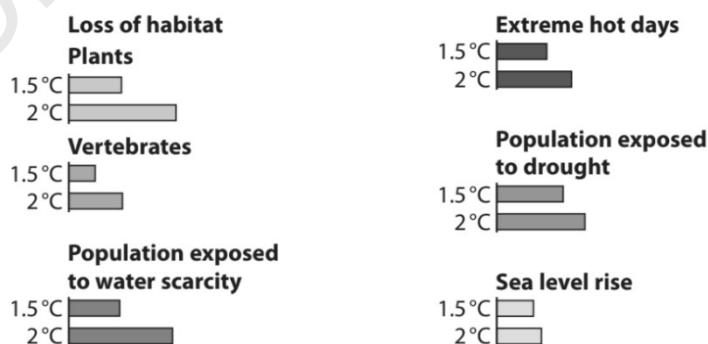
Answer..... tonnes

Q43)

Global warming is one consequence of anthropogenic climate change.

The diagram shows a model of some of the effects an increase in temperature of either 1.5°C or 2°C could have on the environment.

Increasing impacts from 1.5°C to 2°C



- (ii) Calculate the percentage increase in the population exposed to drought if the temperature increased by 2°C and not 1.5°C.

Assume the bars in the diagram are drawn to scale.

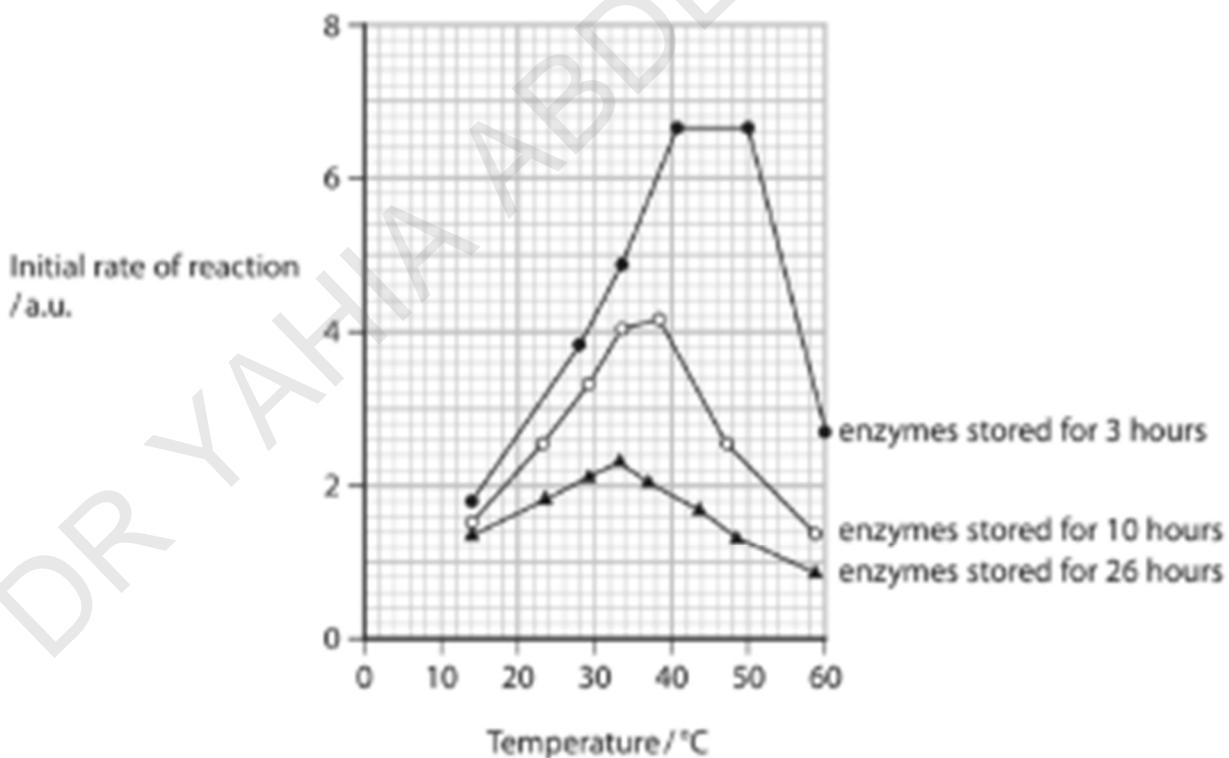
(1)

Answer %

Q44)

- (c) Enzymes were stored for different lengths of time.
The effect on the initial rate of reaction was investigated.

The graph shows the results of this investigation.



- (ii) Calculate the Q_{10} for this enzyme stored for 3 hours.

Use the formula

$$Q_{10} = \frac{R_{t+10}}{R_t}$$

where R_t is the initial rate of reaction at 20°C.

(3)

Answer.....

Q45)

Infection with *Mycobacterium tuberculosis* results in tuberculosis (TB), which is one of the top ten causes of death in the world.

- (a) In 2019, an estimated 1.2 million children, 3.2 million women and 5.6 million men developed TB.

Calculate the ratio of children to women to men who developed TB.

(1)

Answer.....

Q46)

- (a) Hank weighed 227 kg, which is 1.7 times more than the mean mass of a typical large black bear and 5 times more than the mass of a typical small black bear.
- (i) Calculate the difference in mass between a typical large black bear and a typical small black bear.

(2)

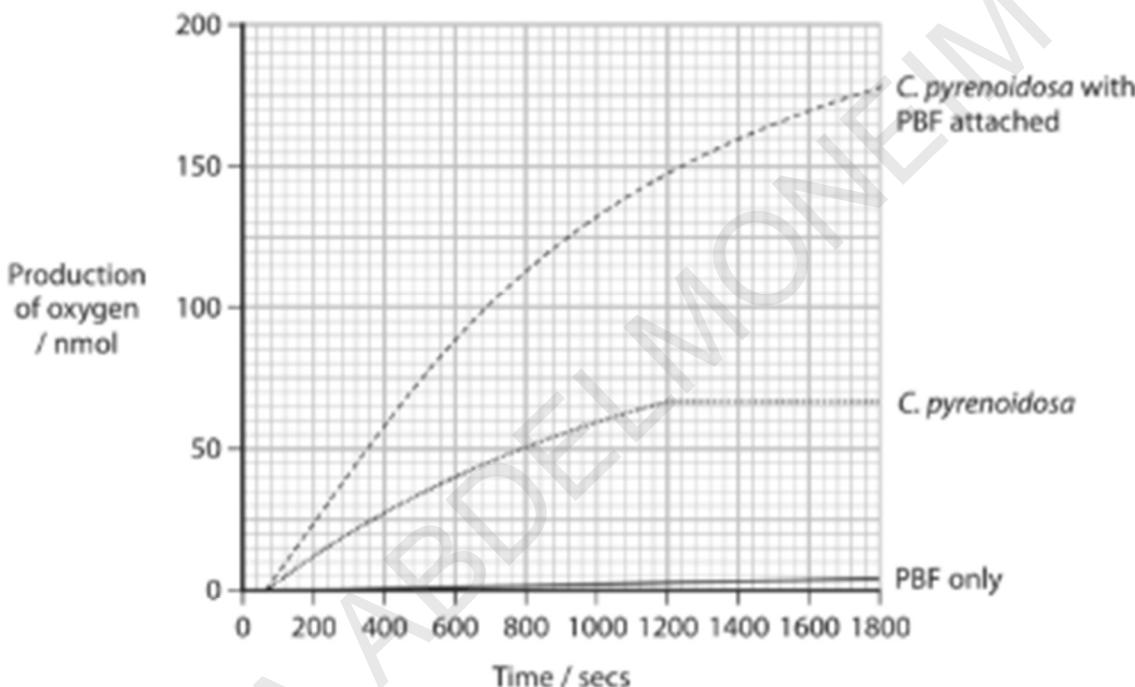
Answer kg

- Q47)** (a) In an investigation, scientists attached a molecule called PBF to the cell surface of a species of green algae, *C. pyrenoidosa*.

These algae are photosynthetic organisms and PBF absorbs green light.

The scientists measured the production of oxygen by *C. pyrenoidosa*, *C. pyrenoidosa* with PBF attached and PBF only.

The graph shows the results of this investigation.



- (i) Calculate the rate of production of oxygen at 1200 seconds for *C. pyrenoidosa* with PBF attached.

(3)

Answer

nmol secs⁻¹

Q48)

(b) In 2019, there were an estimated 229 million cases of malaria worldwide.

The number of deaths was estimated at 4.09×10^5 per year.

(i) Which is the approximate death rate from malaria in 2019?

(1)

- A 1 in 180
- B 1 in 600
- C 1 in 1800
- D 1 in 6000

(ii) In 2019, 274 000 young children died from malaria.

Which is the ratio of deaths in young children to deaths in other age groups?

(1)

- A 0.7:1.0
- B 1.0:0.5
- C 1.0:1.5
- D 2.0:1.0

Q49)

(a) Whale faeces add nutrients containing nitrogen to the water.

(i) There are 345 Right whales in the Gulf of Maine and together they release 15.9 kg of nitrogen per day.

Calculate the mass of nitrogen released by one Right whale in a year.

(1)

Answer kg per year

(b) There are 1.3 million whales in the oceans.

Scientists believe that if the number of whales could be restored to their original numbers, this would have a significant effect on climate change.

(i) There were approximately 5 million whales before modern commercial whaling.

Calculate the percentage decrease in the number of whales due to commercial whaling.

(1)

Answer %

- (ii) Calculations have shown that if numbers could be restored, 1.7×10^9 US tons of carbon dioxide could be removed from the atmosphere per year.

A US ton is equivalent to 907 kg.

Calculate the mass of carbon dioxide, in kg, that could be removed from the atmosphere in one year.

Give your answer in standard form.

(1)

Answer kg

Q50)

- (e) The length of a cell was measured. It was found to be 0.0085 cm long.

The ratio of the length of this cell to the length of a chloroplast was 11.7:1.

Calculate the length of this chloroplast.

Give your answer in μm to 2 significant figures.

(2)

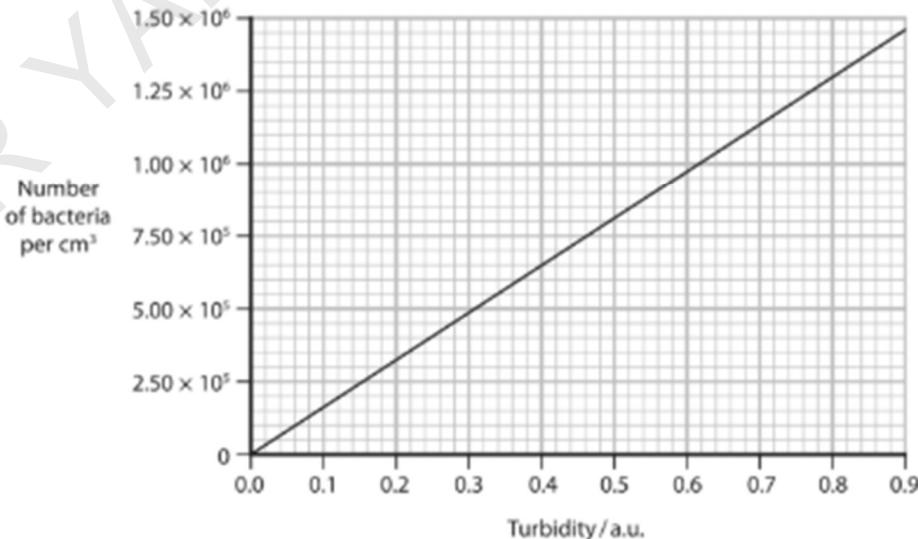
Answer μm

- 3 The growth of bacteria in a liquid culture was investigated over a 14 hour period, using an optical method (turbidity).

Q51)

A calibration curve was used to convert the turbidity readings into the number of bacteria per cm^3 of liquid culture.

The graph shows the calibration curve used.



The table shows the results for the first 10 hours of culture.

Time of culture / hours	Turbidity / a.u.	Increase in cell number in each two hour period
0	0.01	
2	0.01	0
4	0.04	5.0×10^4
6	0.56	
8	0.80	4.0×10^5
10	0.80	0

- (a) Complete the table to show the increase in cell number between 4 and 6 hours of culture.

(1)

Q52)

Human breast milk supports the growth and development of a baby.

One important component is a group of carbohydrates called oligosaccharides. These contain between three and ten monosaccharide units.

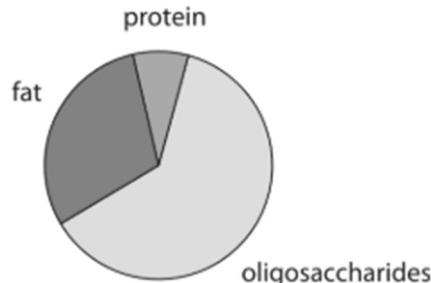
- (a) During the first few days after birth, the milk produced is called colostrum. By two weeks, the composition of the milk has changed and it is called mature breast milk.

The charts show some of the nutritional components of colostrum and mature breast milk.

Colostrum



Mature breast milk



Estimate the percentage composition of oligosaccharides in the colostrum.

(1)

Answer..... %

Q53) Cultivation of seaweed for food is well-established in Asia.

- (a) In 2017, the global harvest of seaweed was 32.9 million tonnes. Of this, 96.6% was cultivated.

Calculate the mass of cultivated seaweed.

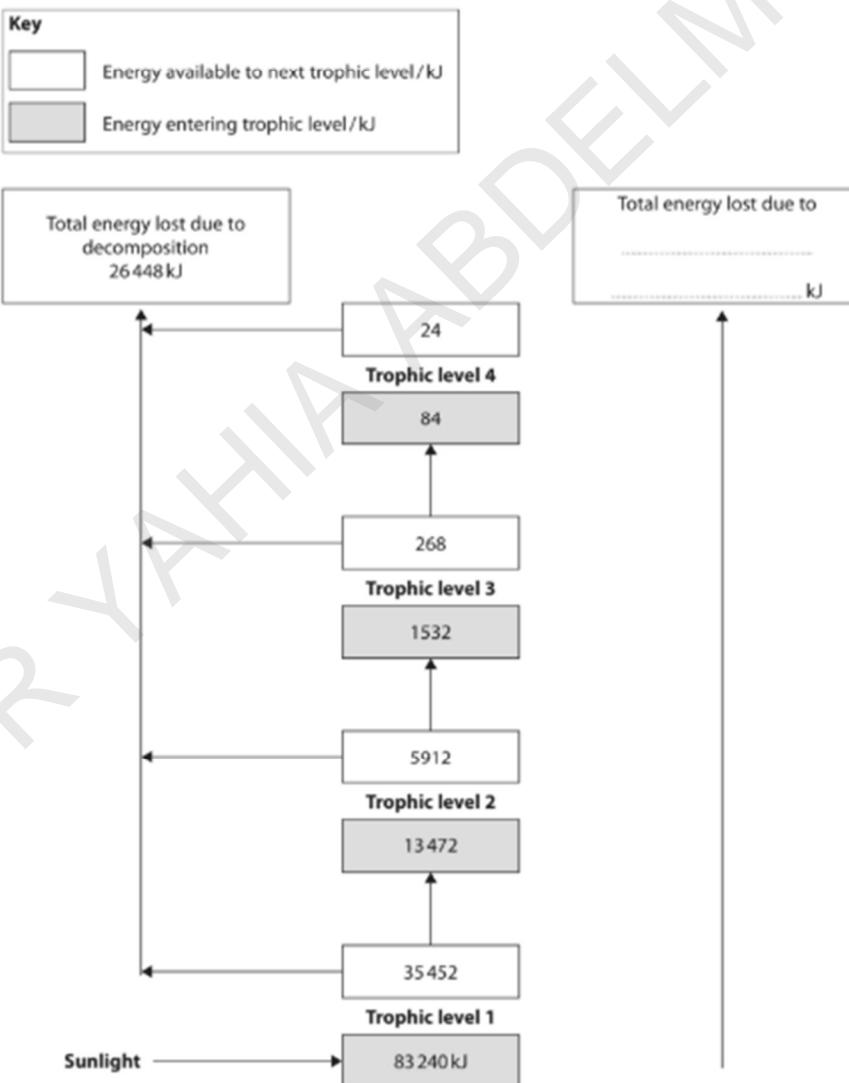
Give your answer in standard form.

(1)

Q54) 8 The trophic level of an organism is the position it occupies in a food chain.

- (a) The diagram shows the energy flow between trophic levels of a food chain.

Answer tonnes



- (i) Calculate the net primary productivity (NPP) as a percentage of the gross primary productivity (GPP) in this food chain.

(2)

Answer %

- (ii) Complete the right-hand side of the diagram by adding:

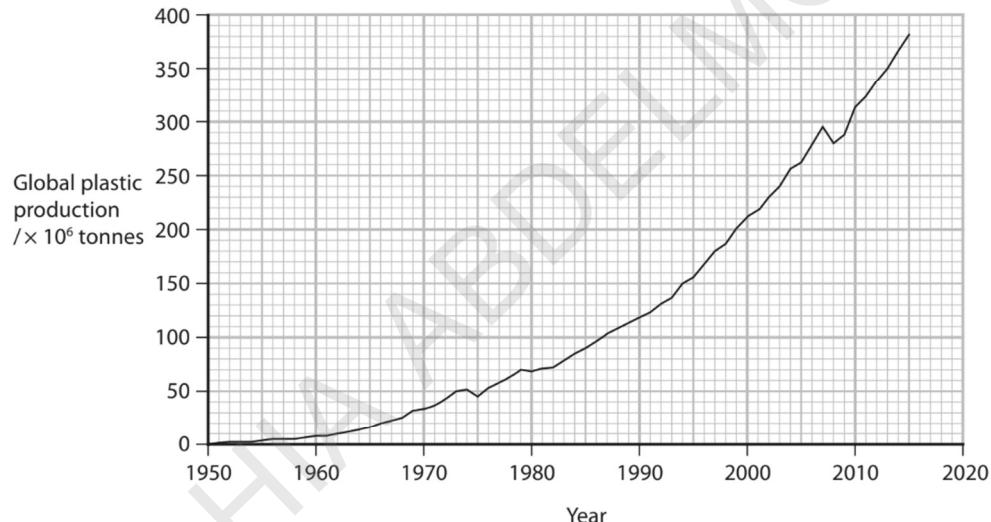
- arrows
- the missing information in the box.

(3)

Sea turtles can take in plastic debris when they eat. This plastic can harm the turtles.

Q55)

- (a) The graph shows the global production of plastics per year from 1950 to 2015.



- (i) Calculate the mean rate of global plastic production from 2000 to 2015.

Give your answer to 3 significant figures.

(2)

Answer million tonnes per year

- (ii) Estimate the global plastic production in 2023.

Use your calculated value from part (i).

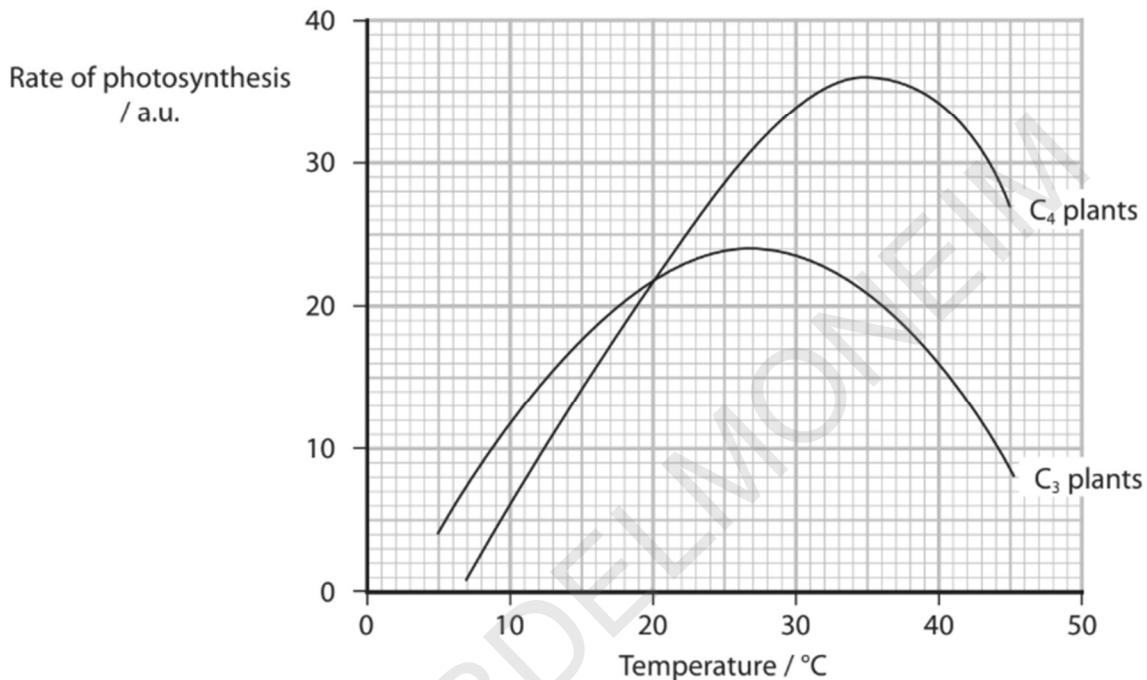
(1)

Answer million tonnes

Q56)

- (b) Two types of plant, C₃ and C₄, have slightly different pathways of light-independent reactions.

The graph shows how the rate of photosynthesis is affected by temperature in these two types of plant.



- (ii) Calculate the Q₁₀ for the enzymes in C₄ plants.

Use the formula:

$$Q_{10} = \frac{R_{t+10}}{R_t}$$

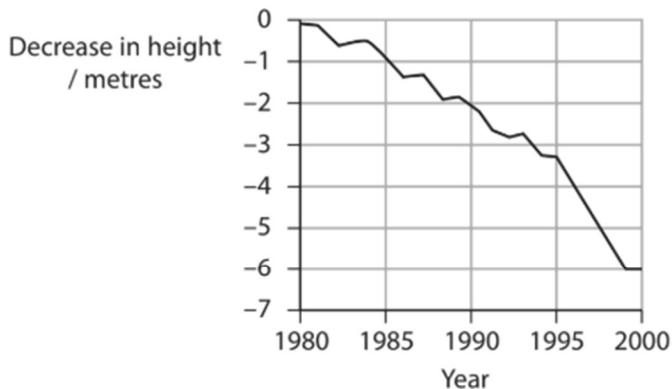
where R_t is the initial rate of reaction at 10 °C.

Give your answer as a whole number.

(2)

Answer

- Q57)** (a) The graph shows the decrease in height of a glacier from 1980 to 2000.



- (i) Calculate the mean drop in height from 1980 to 2000.

Give suitable units for your answer.

(1)

- Q58)**

Answer

- (b) In one year, it was estimated that 33.4 million people were infected with HIV. It was estimated that 30 % of these people were also infected with *Mtb*.
(ii) Calculate the number of people with both infections.

Give your answer in standard form.

(1)

Answer

Q59)

- (a) One species of yeast, *S. cerevisiae*, has a diameter from $5\text{ }\mu\text{m}$ to $10\text{ }\mu\text{m}$.

One type of bacteria, *S. aureus*, has a diameter from 500 nm to 1500 nm .

- (i) Calculate the smallest difference between the diameters of *S. cerevisiae* and *S. aureus*.

Give suitable units with your answer.

(1)

Answer

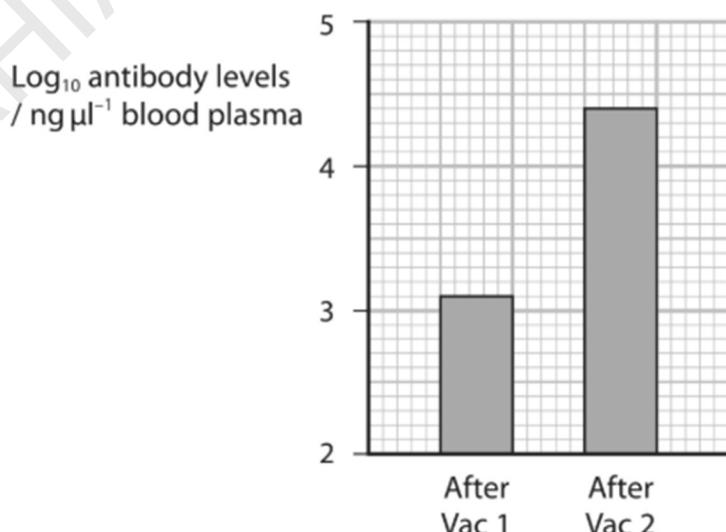
Q60)

- (c) The levels of antibodies following vaccinations were investigated.

There were two groups of people. Group 1 **had not** been infected with the virus, before the vaccine was given. Group 2 **had** been infected with the virus before the vaccine was given.

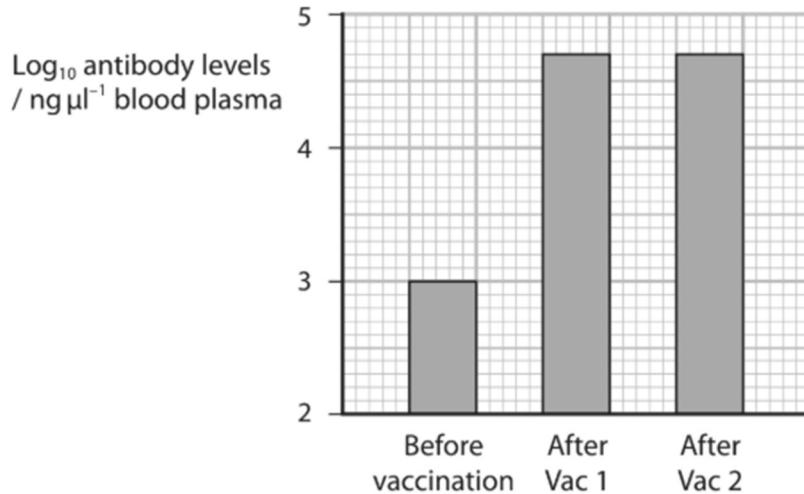
Both groups of people received two vaccinations, Vac 1 and Vac 2.

The graphs show the results of this investigation.



Group 1:

People who had not been infected
before the vaccine was given



Group 2:

People who had been infected
with the virus before the vaccine
was given

- (ii) In group 1, Vac 2 increased the levels of antibody more than Vac 1.

Calculate how many times greater this increase was.

(2)

Answer

Q61)

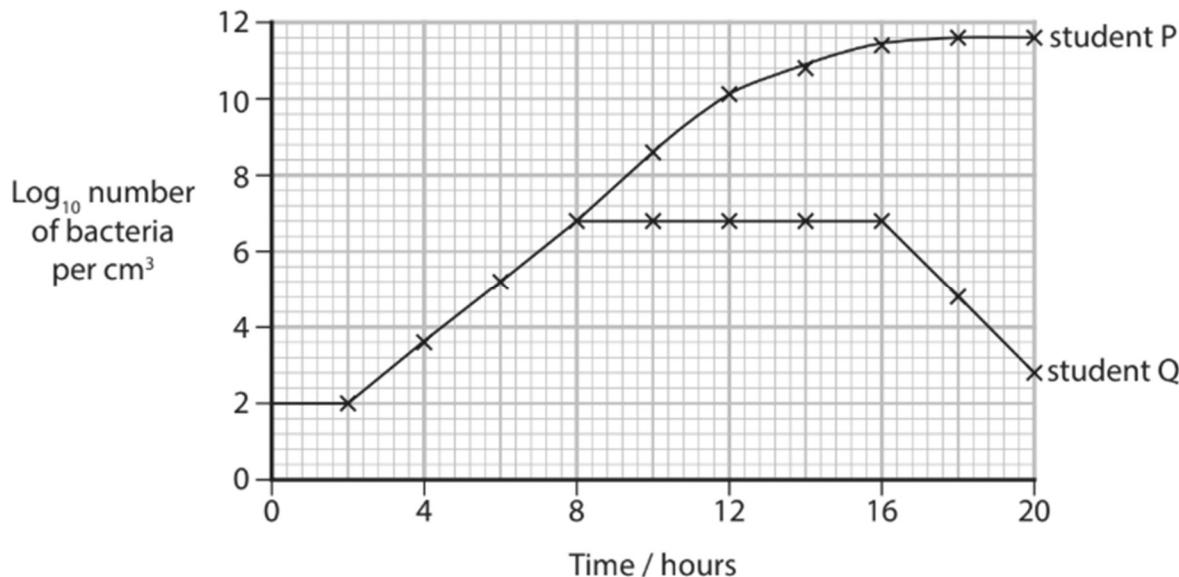
Two students, student P and student Q, each cultured bacteria in a liquid medium for 20 hours.

The culture conditions used by both students were identical.

Every two hours, each student removed a sample of the culture to count the number of bacteria.

Each student used a different method to count the number of bacteria in the samples.

The graph shows the bacterial growth curve that each student drew using their results.



- (b) Calculate the growth rate constant (k) of these bacteria between 2 hours and 6 hours of culture.

(2)

Use the equation:
$$k = \frac{\log_{10}N_t - \log_{10}N_0}{0.301 \times t}$$

where:

$\log_{10}N_t = \log_{10}$ number of cells at 6 hours

$\log_{10}N_0 = \log_{10}$ number of cells at 2 hours.

Answer

- (c) The number of bacteria in the samples taken after 10 hours were:

398 107 171 in the culture of student P

6309 573 in the culture of student Q.

- (i) Calculate the ratio of the number of bacteria in these two cultures.

(1)

Answer:1

Q62) In 2022, it was estimated that 92 million tonnes of textile waste was produced in the world.

Textile waste is either burned or buried underground in landfill sites.

- (a) It is estimated that by 2030, there will be 134 million tonnes of textile waste produced each year.

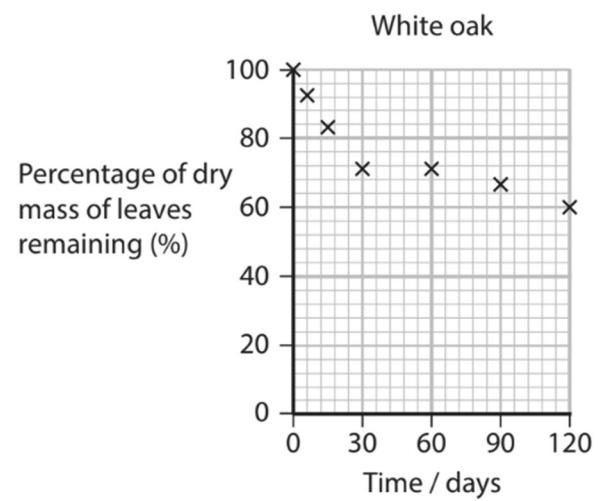
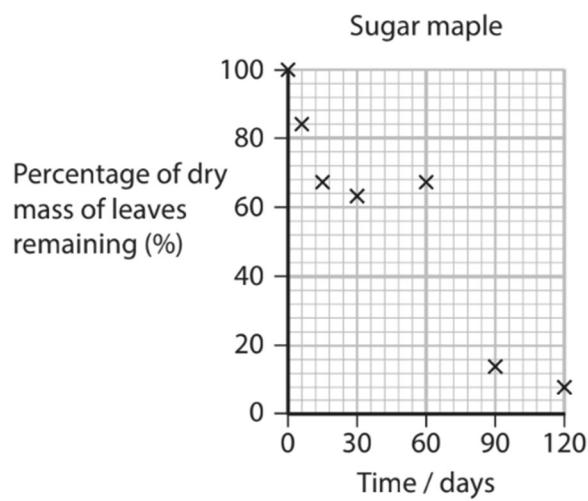
Calculate this increase in textile waste.

Give your answer in standard form.

(1)

Answer tonnes

Q63) (b) The graphs show the extent to which two types of leaf decomposed in 120 days.



- (ii) Calculate the rate of decrease in percentage dry mass between 30 days and 120 days for the sugar maple leaves.

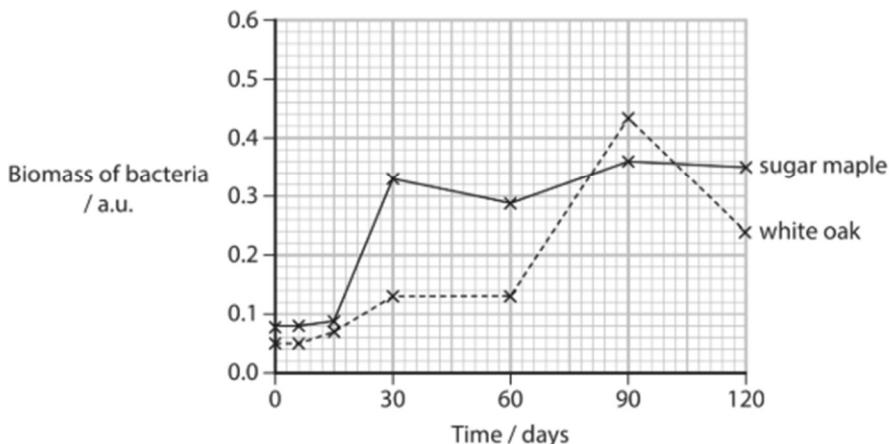
Give your answer to **two** significant figures.

(2)

Answer

- (c) The biomass of bacteria on the two types of leaf during the 120-day period was determined.

The graph shows the changes in biomass of bacteria on these leaves.



- (i) Calculate how many times greater the biomass of bacteria on the sugar maple leaves is after 30 days compared with the biomass of bacteria at 0 days.

(1)

Answer
.....

- (a) Samples of water were taken from 120 ponds. Of these, 74 of the ponds had been treated previously with antibiotics.

Q64)

Which of the following is the percentage of **untreated** ponds?

(1)

- A 38
- B 61
- C 62
- D 163

- (b) *Vibrio* were grown on agar containing different heavy metals at a range of concentrations.

The highest concentration of heavy metal tested was 3.2 mg cm^{-3} and the lowest concentration was $6.25 \mu\text{g cm}^{-3}$.

- (i) How many times does the highest concentration need to be diluted to make the lowest concentration?

(1)

- A 5.12
- B 51.2
- C 512
- D 5120

- Q65)** (b) In an American study, the light energy falling on one square metre of a field in one year was recorded as 1 700 000 kilocalories.

(i) Only one fifteenth of this light energy was converted into plant biomass.

Calculate the number of kilocalories of light energy converted into plant biomass.

Give your answer in standard form.

(1)

Answer kilocalories

- (ii) Only 6 kilocalories became animal biomass.

Calculate the number of kilojoules (kJ) of energy that became biomass.

1 kilocalorie = 4.2 kJ.

Give your answer to **two** significant figures.

(1)

Answer kJ

- (iii) In another field 154 000 kilocalories of energy was converted into plant biomass.

Only 25 kilocalories of this energy was passed onto the highest trophic level in a food chain.

Calculate the percentage of energy that was passed onto the highest trophic level.

(1)

Answer %

- Q66)** (b) An electron microscope with a resolution of 3.7 \AA can be used to study antigen-MHC complexes.

$$1\text{ }\mu\text{m} = 1 \times 10^4\text{ \AA}$$

- (i) Calculate the resolution of this electron microscope in nanometres.

(1)

Answer nm

- Q67)**

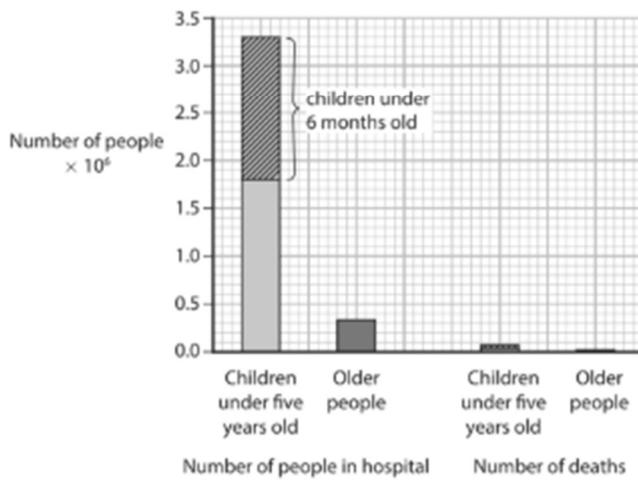
Respiratory syncytial virus (RSV) usually causes mild, cold-like symptoms from which most people recover.

Infection with RSV can be serious in young children and older people.

Currently, there are no approved vaccines against RSV, although there are some in clinical trials.

- (a) The graph shows the number of people who had to go to hospital in one country in one year.

The graph also shows the number of deaths in children under five years old and in older people in the same country in that year.



- (i) Which is the proportion of the children under five in hospital who are under 6 months old?

(1)

A $\frac{5}{11}$

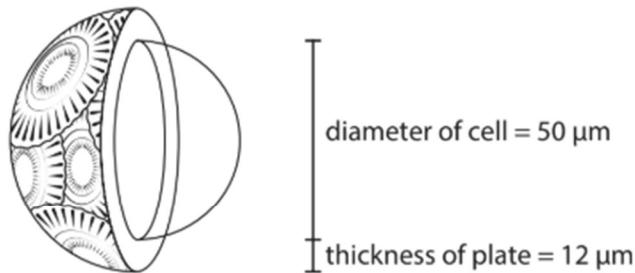
B $\frac{6}{11}$

C $\frac{5}{6}$

D $\frac{6}{5}$

- Q68)** (a) In one drop of seawater there are between 1 000 and 10 000 *E. huxleyi*.

The diagram shows the dimensions of one *E. huxleyi*.



Calculate the **total** volume of this *E. huxleyi*.

Give your answer in mm³.

Use the formula:

$$V = \frac{4}{3}\pi r^3$$

(3)

Answer mm³

- (b) Scientists think that *E. huxleyi* may have an impact on global warming and climate change.

E. huxleyi are continually producing the plates of calcium carbonate using the carbon dioxide they have taken in from the water.

- (i) One *E. huxleyi* can contain 12 plates.

It takes 75 minutes to produce one plate.

Calculate the number of **hours** it takes one *E. huxleyi* to produce 12 plates.

Assume only one plate at a time is made.

(1)

Answer hours