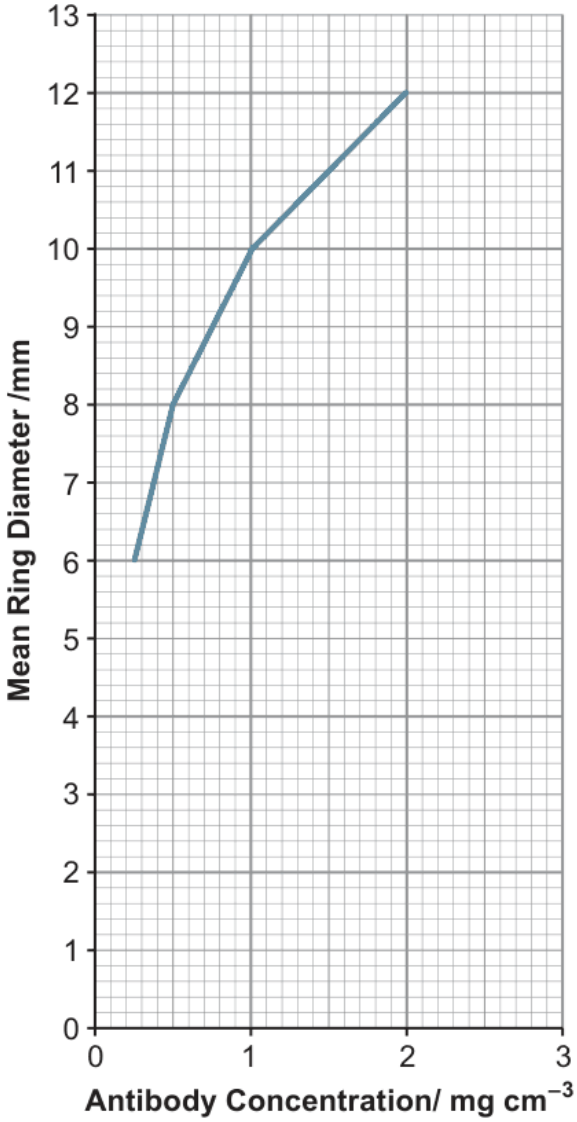
Graphs and Geometry (Maths Skills MS3 and MS4): Eduqas A Level Biology Exam Questions

20 questions · 44 marks · about 53 minutes. Answer in the spaces, then check the mark schemes at the end.

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(e) Radial Immuno Diffusion is a quantitative technique used to estimate antibody concentration. Agar plates are set up with a known concentration of antibody included in the agar. Pure antigens are added to the centre of each plate. The antigens diffuse through the agar and form antigen-antibody complexes which can be seen as a precipitation ring. The diameter of the ring is used to plot a calibration curve to estimate the concentration of antibodies in the blood samples as shown below.



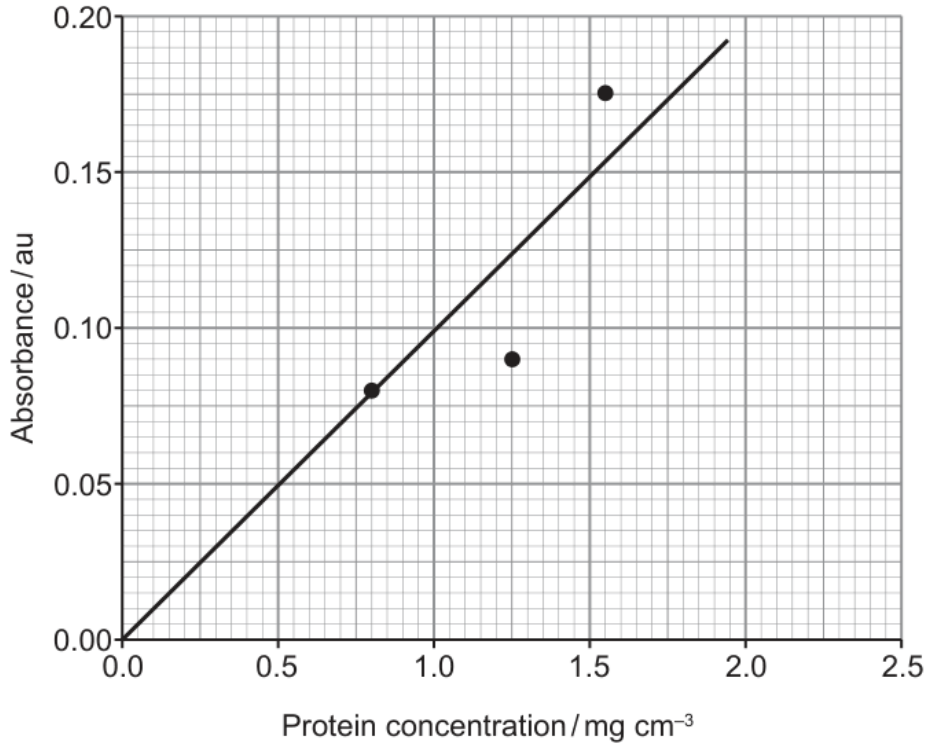
(i) Use the graph to estimate the antibody concentration of the sample taken before vaccination and after. **Write your answers in the table below**. [1]

Sample	Ring diameter / mm	Antibody Concentration / mg cm^{-3}
Before Vaccination	7	
Following Vaccination	11	

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The concentration of ACP in mung bean leaves of different ages was investigated. A standard curve was produced using three known concentrations of protein. The samples of protein were mixed with a reagent and the absorbance of light of the protein and reagent measured using a colorimeter. The standard curve is shown in **Graph 1.3**.

Graph 1.3



Leaves of different ages were collected. Protein was extracted from the leaves and the sample placed with the reagent in a colorimeter. **Table 1.4** shows the concentration of protein found in the different leaf extracts.

Table 1.4

Age of leaf / days	Protein concentration / mg cm^{-3}
1	2.1
2	1.9
3	1.7
4	1.0
5	.....
6	0.2

(ii) The extract from the day 5 leaf was tested and the absorbance was found to be 0.04 au. **Use the standard curve in Graph 1.3** to determine the protein

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He observed that when food is more than 70 m away from the hive they perform a "waggle dance" in the hive. As shown in figure 10.6.

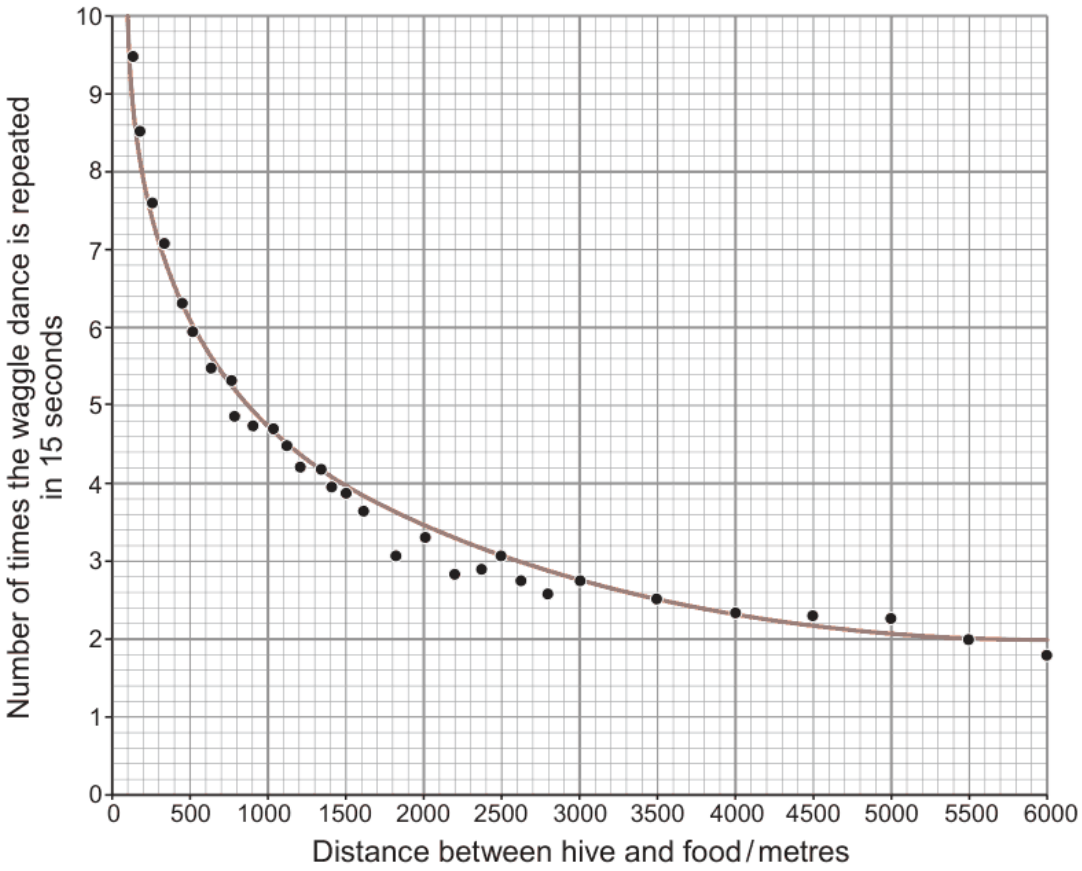
Figure 10.6



waggle dance
(food more than 70 m away)

The number of times the waggle dance is repeated in a unit of time depends on the distance between the hive and the food. This is shown in figure 10.7.

Figure 10.7



(iii) I. Using the graph, complete the table below by calculating the difference in the number of times the waggle dance is repeated in 15 seconds between 100

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2. **Image 2.1** shows a large, fast swimming fish known as a wahoo, *Acanthocybium solandri*. It lives in warm tropical seas, where it may reach swim speeds of 80–90 km per hour.

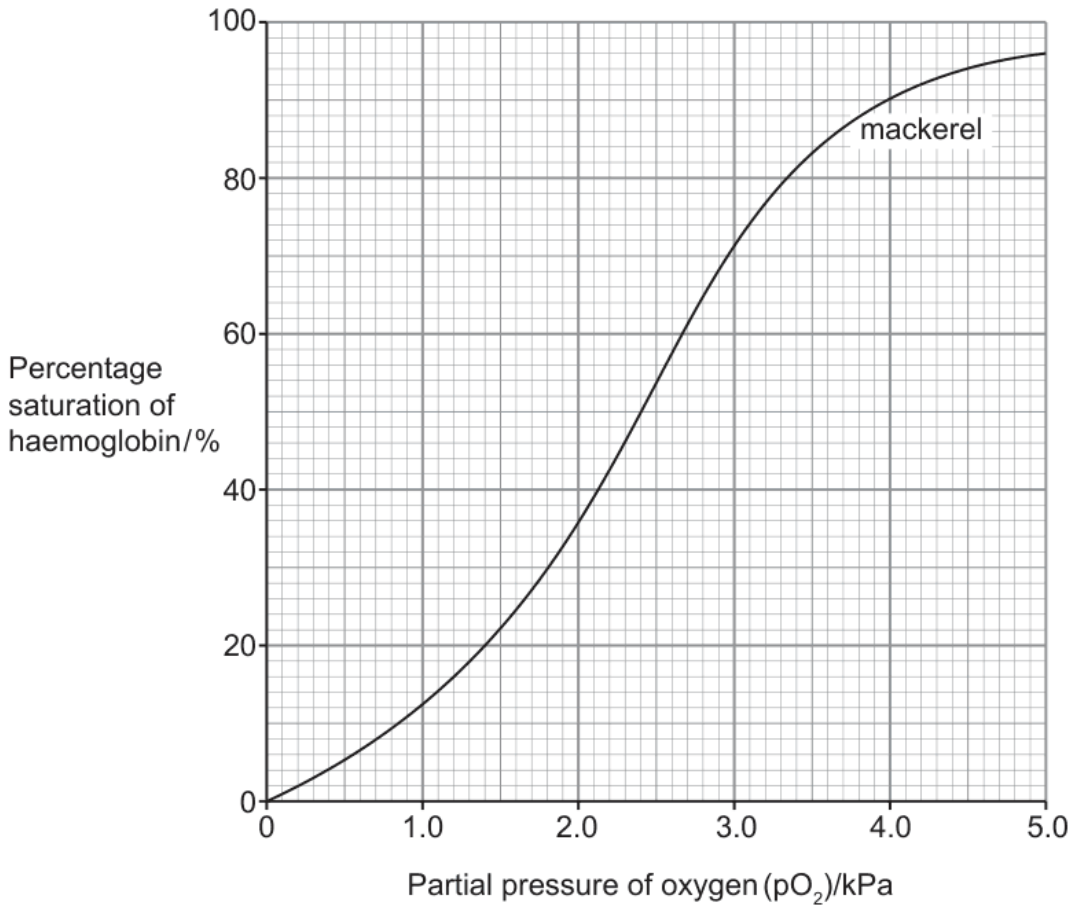
Image 2.1



Mackerel, *Scomber scombrus*, is a similar species of fish that lives in temperate regions where cooler water causes its body temperature to be lower than that of the wahoo.

Graph 2.2 shows an oxyhaemoglobin dissociation curve for mackerel haemoglobin.

Graph 2.2



(a) The p50 is the partial pressure (pO_2) at which haemoglobin (Hb) is 50% saturated with oxygen.
The p50 for haemoglobin from a wahoo was found to be 3.5 kPa.

(i) **On Graph 2.2,**

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Question 4 · AS Component 2 · June 2023 · Q2(a)(ii) · 1 mark

(ii) Using **Graph 2.2**, determine the difference between the percentage saturation of haemoglobin of a mackerel and a wahoo at a pO_2 of 3.5 kPa. [1]

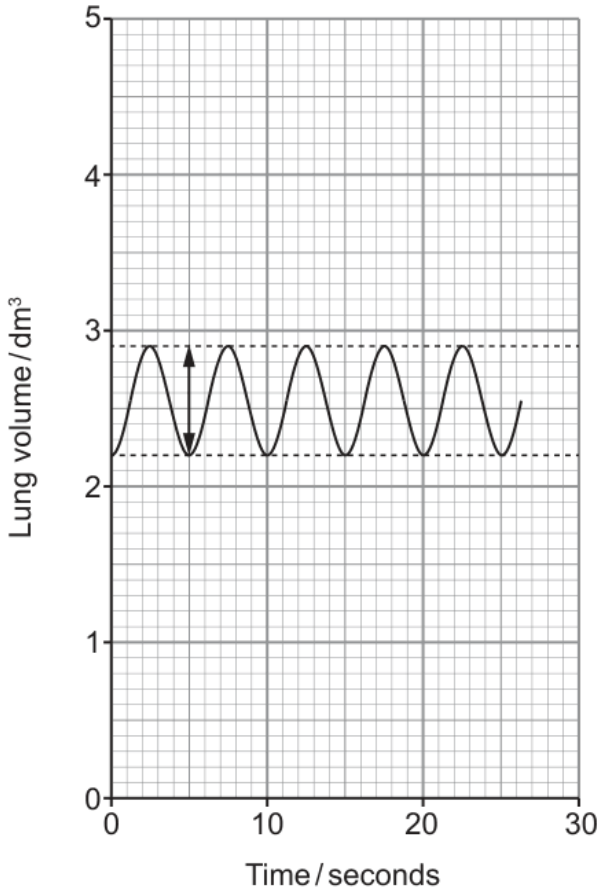
Percentage difference = ... %

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

Graph 5.2 illustrates the changes in lung volume for an adult human while breathing at rest.

The arrow on **Graph 5.2** represents the volume change as this individual breathes in or out.

Graph 5.2



(ii) Using the data in **Graph 5.2** calculate the total volume of air inspired in one minute when this individual is breathing normally at rest. [2]

Total volume inspired in one minute = ... dm^3

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

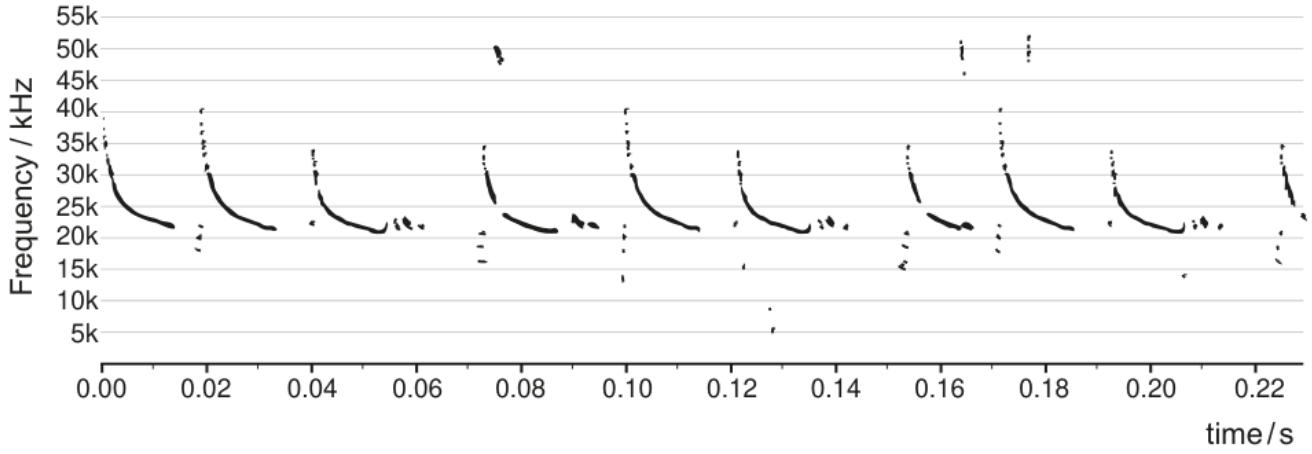
Question 6 · information from earlier in the question

(b) At the taxonomic level of Species, many different features may be used to classify organisms. Individual bat species make high frequency sounds within specific ranges that suit their environment and prey types. This means that we can identify many bats simply by listening to their calls with bat detectors.

The table below shows the properties of the sounds bat species use for echolocation.

Species of bat	Frequency range kHz
Soprano pipistrelle	55.1 - 79.6
Common pipistrelle	41.9 - 68.8
Noctule	18.3 - 37.9
Lesser horseshoe	83.4 - 114

The trace below is a recording (sonogram) of a bat call.



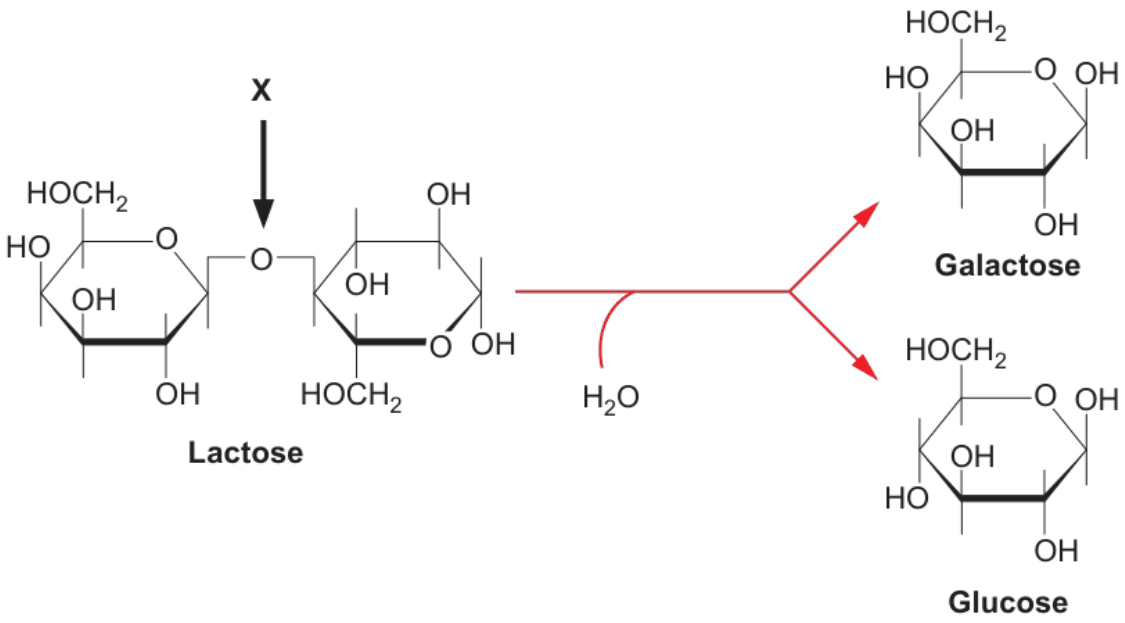
Question 6 · AS Component 2 · June 2016 · Q2(b)(ii) · 2 marks

(ii) Assuming each mark (small curve) on the sonogram is a single sound pulse, calculate the number of pulses per second from the sonogram. Show your working. [2]

Number of pulses per second = ...

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3. Some people cannot drink cow's milk as they are lactose intolerant. They lack the enzyme lactase that catalyses the breakdown of lactose into galactose and glucose.



Students investigated the effect of inhibition of lactase by galactose.
They added a fixed concentration of lactase to different concentrations of lactose solution and measured the rate of monosaccharide formation. The experiment was repeated with a fixed concentration of galactose added to the lactose solutions. All volumes used were controlled for each solution in both experiments.

The results are shown below.

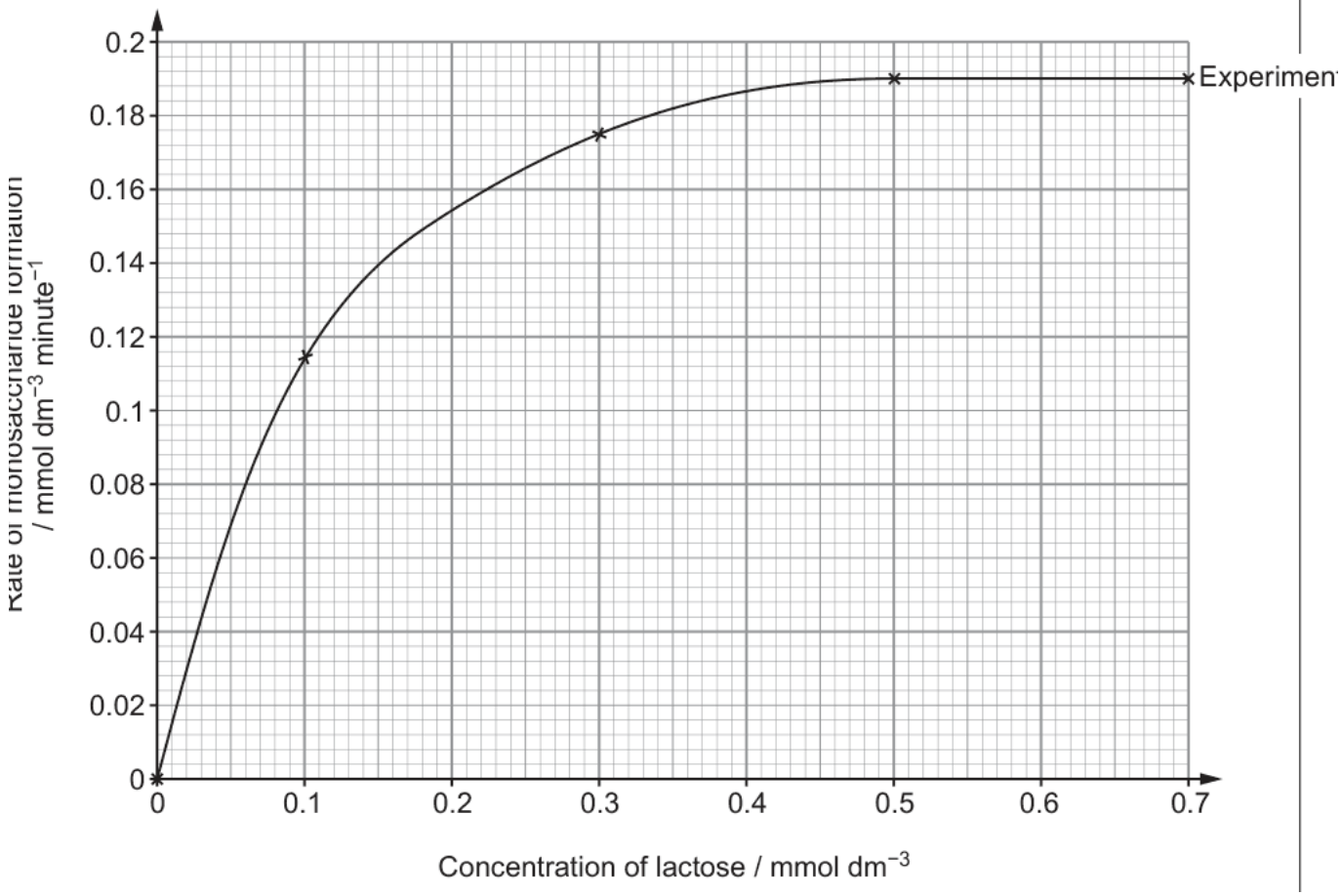
Concentration of lactose / mmol dm^{-3}	**Rate of monosaccharide formation / mmol dm^{-3} $minute^{-1}$**	
	Experiment 1 (without galactose)	**Experiment 2 (with galactose)**
0.00	0.000	0.000
0.10	0.115	0.050
0.30	0.176	0.130
0.50	0.190	0.180
0.70	0.190	0.190

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

Question 7 · AS Component 1 · June 2019 · Q3(b)(ii) · 2 marks

(ii) The results for Experiment 1 have been plotted on the graph paper below.

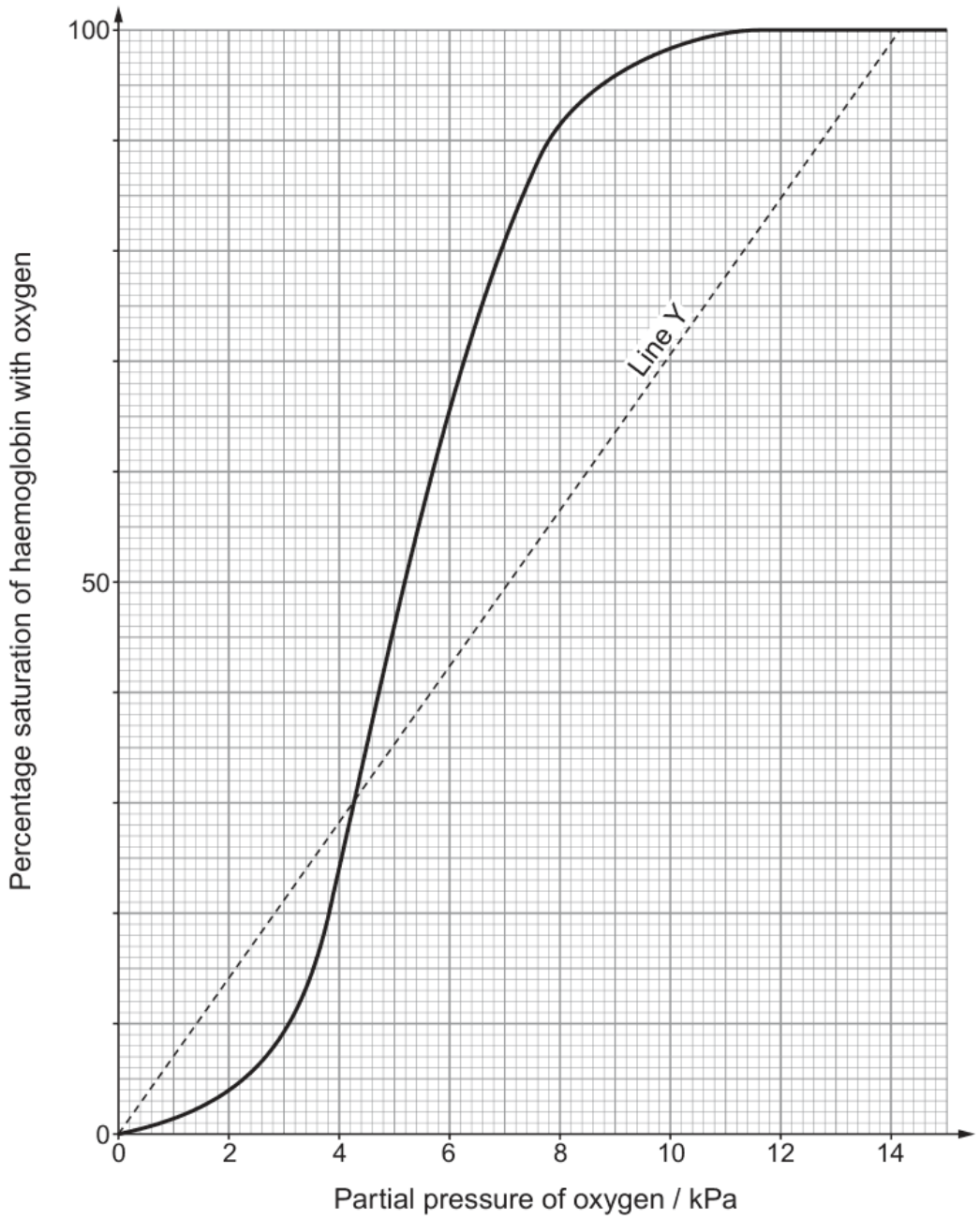
Plot the results for Experiment 2 **on the same axes**. [2]



Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

Question 8 · AS Component 2 · June 2019 · Q3(a)(i) · 2 marks

3. The diagram below shows the oxygen dissociation curve for adult human haemoglobin.



(a) The curve shows a sigmoid (S-shaped) relationship between partial pressure of oxygen and saturation of haemoglobin with oxygen. Line Y shows the theoretical linear relationship.

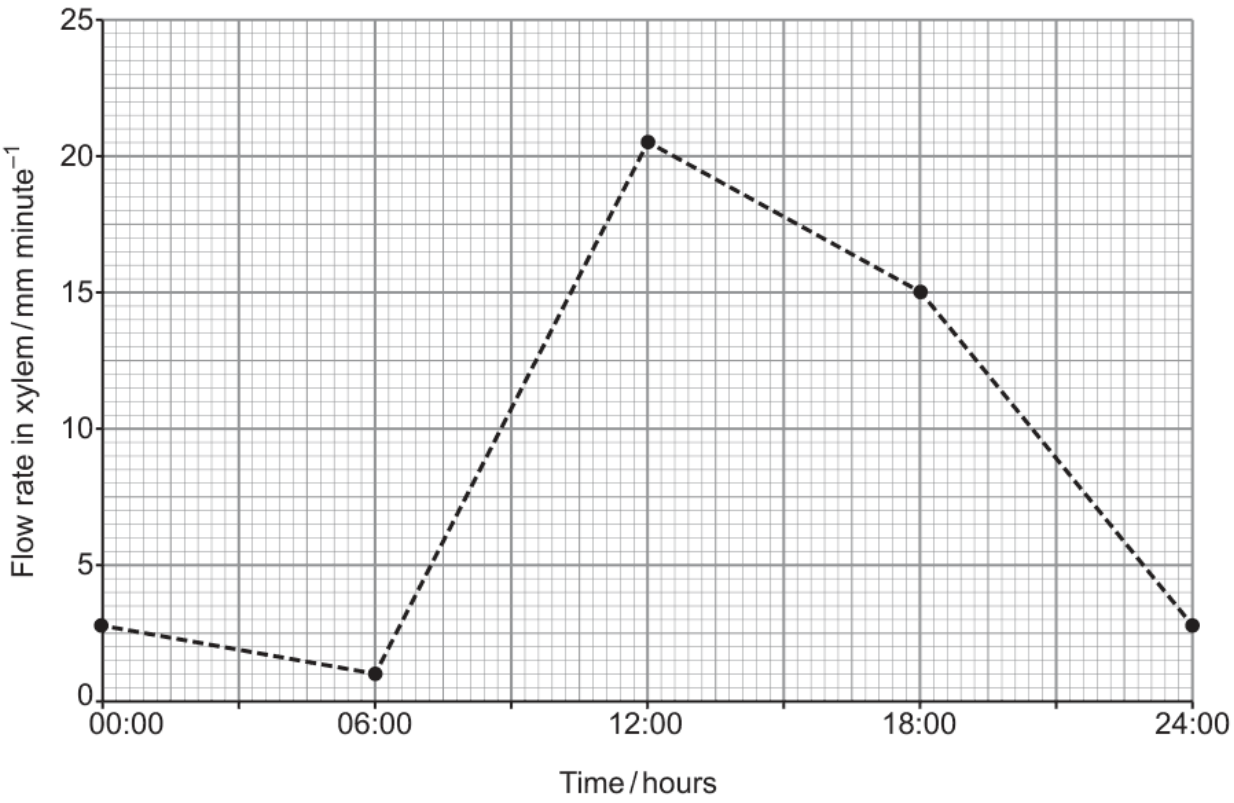
(i) Using the sigmoid curve the percentage decrease in the haemoglobin saturation between 6 kPa and 2 kPa is 15.5 % per kPa.

Calculate the equivalent **percentage decrease per kPa** for the linear relationship shown in the graph. [2]

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Graph 5.5 shows the flow rate in the xylem of beech trees.

Graph 5.5



(ii) Use readings from **Graph 5.5** to calculate the rate of increase in flow rate in xylem between 06:00 hours and 12:00 hours. State the unit for your answer. [3]

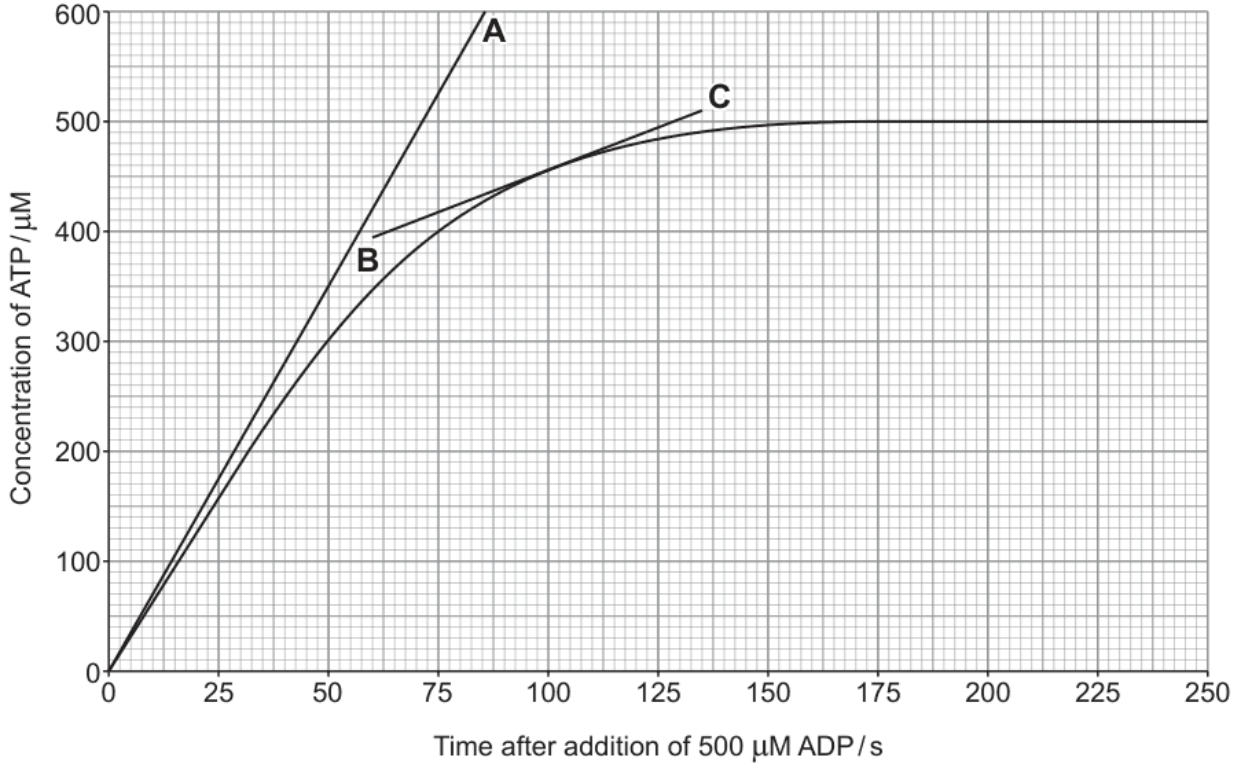
Increase in flow rate = ...

Unit = ...

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

(c) A laboratory experiment was carried out on isolated mitochondria to determine the rate of ATP synthesis. Isolated mitochondria were mixed with 500μM of ADP and excess inorganic phosphate. The concentration of ATP was recorded every 25 seconds over a period of 250 seconds. The results are shown in **Graph 1.3**.

Graph 1.3



(i) Use the tangent marked **B–C** to calculate the rate at 100 seconds following the addition of ADP and **state the unit** of your calculated value.
Show how you obtained the values used in your calculation on Graph 1.3.

[4]

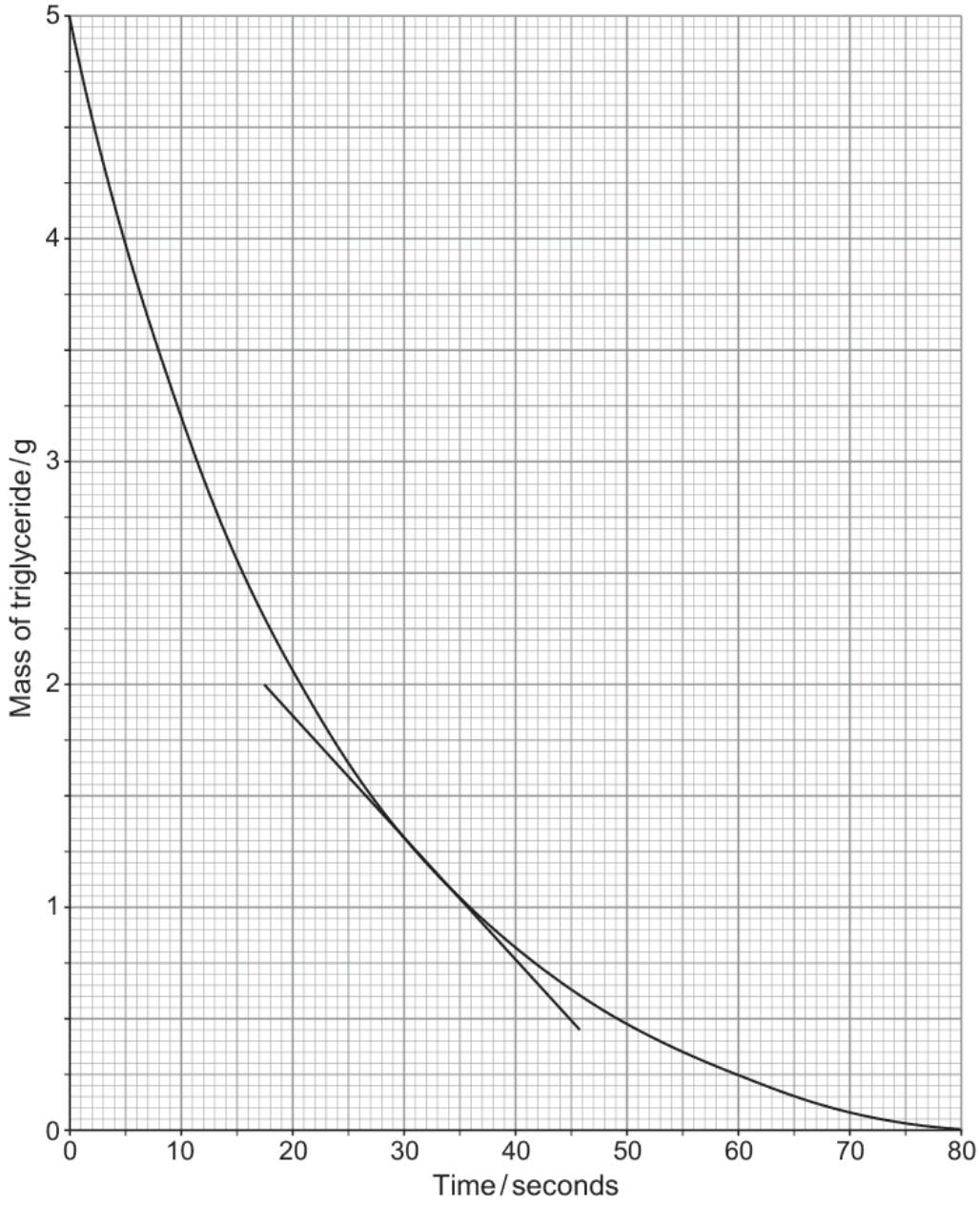
Rate at 100 s = ... unit = ...

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

(c) A scientist determined the mass of fat in a 100 cm^3 sample of cow milk. He added lipase and measured the mass of triglyceride present over a period of time.

Graph 3.2 shows the result of this experiment.

Graph 3.2



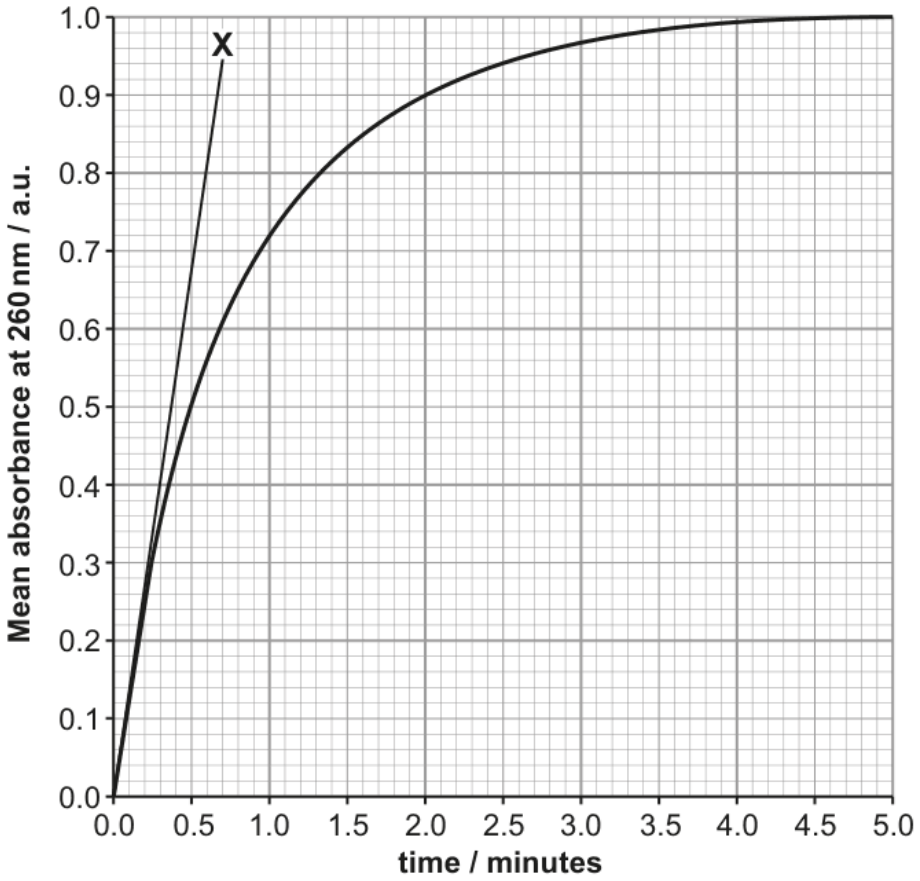
(i) A tangent has been drawn at 30 seconds, use this tangent to calculate the rate of digestion per second at that time. **Give your answer in standard form.** [3]

Rate = ... $g\,s^{-1}$

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

(b) The rate of digestion of DNA can be determined using a colorimeter. As DNA is digested it absorbs more light at a wavelength of 260 nm.

To determine the rate of reaction of DNase 1, $0.2\,cm^3$ of DNase 1 at $50\,ng\,cm^{-3}$ concentration were mixed with $1.8\,cm^3$ of synthetic single stranded DNA at a concentration of $200\,\mu g\,cm^{-3}$ in a cuvette. The absorbance of light at 260 nm was recorded at intervals for a period of five minutes. The experiment was repeated to give five results. The mean results are plotted on the graph below.



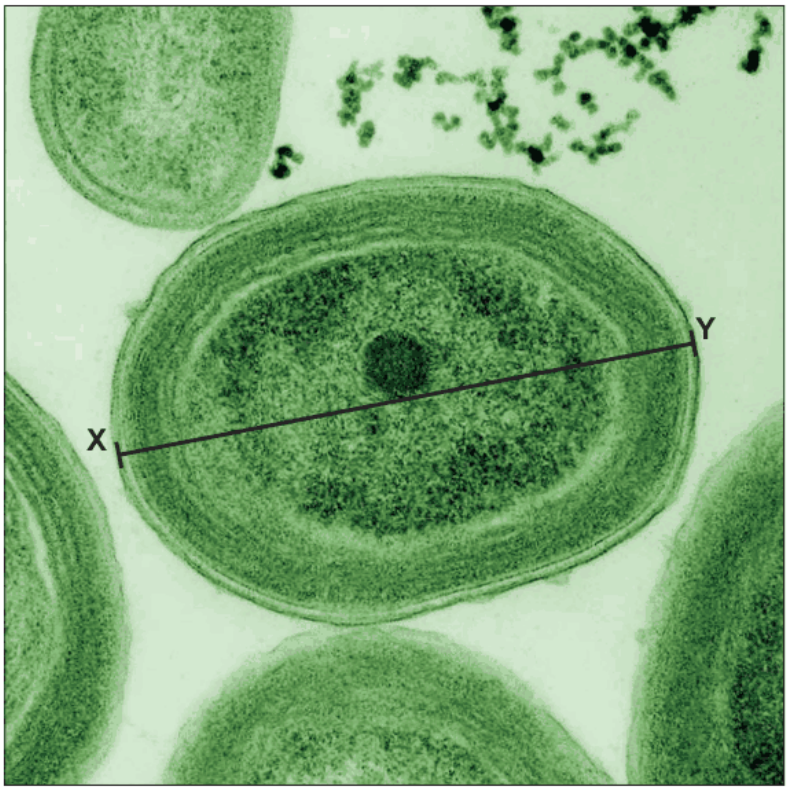
(i) The rate of reaction between 0 and 0.5 minutes was calculated as 1.0 a.u. $minute^{-1}$. Using the tangent drawn at **X**, calculate the initial rate for this reaction. [1]

Initial rate = ... a.u. $minute^{-1}$

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(e) *Prochlorococcus* is found in enormous numbers even in nutrient poor waters. **Image 1.5** shows a photomicrograph of a *Prochlorococcus* cell.

Image 1.5



X-Y = 0.6 μm

(i) Calculate the surface area : volume ratio of a *Prochlorococcus* cell which has a radius of 0.3 μm.
Express your ratio to the nearest whole numbers. [3]

Surface area of a sphere = $4\pi r^2$.

Volume of a sphere = $\frac{4}{3}\pi r^3$

$\pi = 3.14$

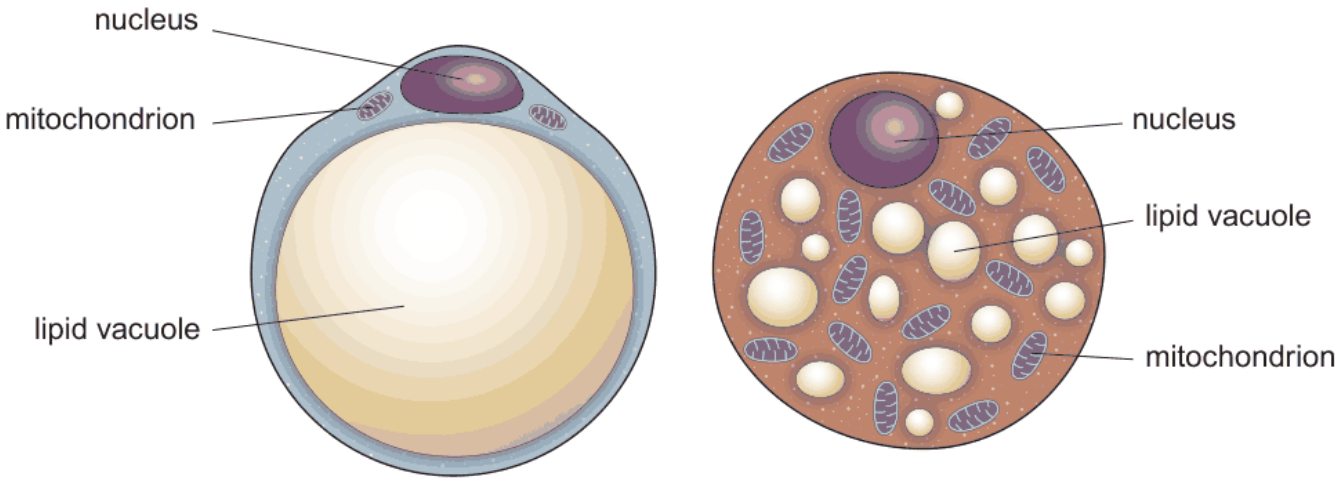
Surface area : volume ratio = ... : .....

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Question 14 · AS Component 1 · June 2019 · Q2(b)(iv) · 2 marks

Adipose tissue is found in mammals in two different forms: white adipose tissue and brown adipose tissue. The distribution of each form varies depending upon the species. Seals, which live in cold water, have a thick layer of white adipose tissue under their skin. In addition, other areas of a seal's body have a high proportion of brown adipose tissue.

Drawings of the cells that make up each type of adipose tissue are shown below.



white fat cell **brown fat cell**

(iv) The diameter of the lipid vacuole in the white fat cell measured 80 μm. Calculate the volume of the lipid vacuole located in the white fat cell. Use the formula given. [2]

$$\text{Volume} = \frac{4}{3}\pi r^3$$

$\pi = 3.14$

Volume = ... μm^3

Questions, mark schemes and examiners' report extracts © WJEC CBAC Ltd (Eduqas).

Table 5.3 shows the mean volume of the beads produced together with the number of beads of each diameter that can be made from 10 cm^3 sodium alginate / enzyme mix.

Table 5.3

Diameter of bead / cm	Mean volume of one bead / cm^3	Number of beads made from 10 cm^3 sodium alginate / enzyme mix
0.2	.....	.....
0.3	0.014	710
0.4	0.034	290
0.5	0.065	150

(c) (i) I. Calculate the mean volume of the 0.2 cm diameter beads.

Volume of a sphere = $\frac{4}{3}\pi r^3$

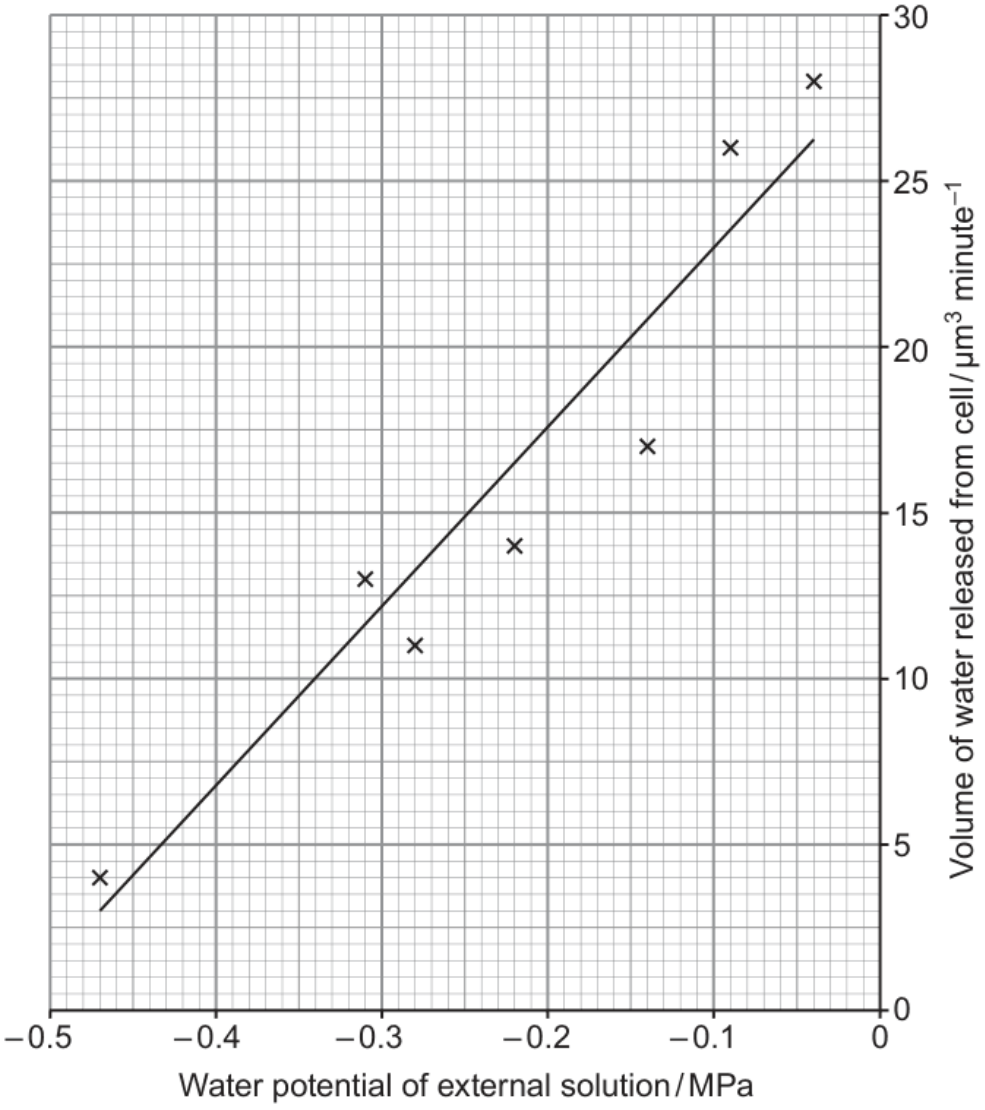
Where π = 3.142

Express your answer to 2 significant figures.

Write your answer in the table. [3]

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(b) *Chlamydomonas* lives in freshwater. When viewed under a light microscope, the contractile vacuoles are seen to fill and empty on a regular basis. They are involved in regulating the water content of the cell.
The graph shows the volume of water released from a cell of *Chlamydomonas* per minute at different water potentials of external solution.
A line of best fit is drawn.



(i) The diameter of a contractile vacuole reaches a maximum of 2 µm.
Calculate the volume of a contractile vacuole and use this to calculate the number of times the contractile vacuole fills and empties each minute at an external water potential of –0.24 MPa. **Give your answer to one decimal place.** [3]

volume of sphere = $\frac{4}{3}\pi r^3$;
π = 3.142

Volume of contractile vacuole = ...

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(i) parts of the pulmonary circulation ....

(ii) blood pressure is maintained by elastic recoil ....

(iii) blood flow is maintained by contraction of skeletal muscle and breathing movements ....

(b) Use the information provided in the table below to answer the questions that follow.

	Total number of vessels	Mean length /cm	Mean diameter /cm	Total cross-sectional area /cm^2	Total blood volume /cm^3	Rate of blood flow /$cm^3\ s^{-1}$
aorta	1	40	1.0	0.8	32	28
other large arteries	40	20	0.3	3	60	7.8
arterioles	4×10^7	0.2	0.002	124	25	1.18
capillaries	1.2×10^9	0.1	0.0008	.....	60	0.036

(i) Using the formula below calculate the **total cross-sectional area** of the capillaries. **Express your answer to three significant figures.** [3]

cross-sectional area = πr^2

(π = 3.142)

Total cross-sectional area = ... cm^2

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5. (a) An investigation was carried out on the effect of surface area on osmosis. A brief method is shown below:

- Four cylinders were taken from the cortex of a carrot using a 15 mm diameter cork borer and each cut to 40 mm in length.
- The initial mass of each cylinder was recorded.
- Each cylinder was cut into a different number of equal length pieces to increase the surface area.
- The cylinder pieces were placed in a sucrose solution of 0.1 M and left for 24 hours.
- The final mass of the cylinder pieces was recorded.

The volumes and surface areas for each cylinder are shown in **Table 5.1**.

Table 5.1

Cylinder	Number of pieces	Radius / mm	Length of each piece / mm	Total surface area / mm^2	Volume / mm^3	Surface area: Volume ratio
A	1	7.5	40	2237	7068	0.32 : 1
B	2	7.5	20	2591	7068	0.37 : 1
C	4	7.5	10	3297	7068	0.47 : 1
D	8	7.5	5	.....	7068	..... :1

(i) Complete **Table 5.1** for cylinder **D** by:

I. Calculating the total surface area. [2]

Use the formula $n(2\pi rh + 2\ \pi r^2)$
Where n = number of pieces
r = radius
h = length of each piece

Use $\pi = 3.14$

Space for working

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Question 19 · A level Component 3 · June 2017 · Q5(c)(iv)I · 2 marks

(iv) The agar contained 0.02 g cm^{-3} milk protein. The clear zone surrounding bacterial colonies was due to the digestion of milk protein.

The clear zone surrounding strain **3** was found to be 13 mm in diameter using a 3 mm depth of agar.

I. Calculate the volume of the agar in the clear zone. Express your answer to one decimal place. [2]

[π = 3.142; volume of a cylinder = $\pi r^2 h$; h = depth of agar]

Volume of agar in clear zone = ... cm^3

Question 20 · A level Component 2 · June 2024 · Q1(b)(iii)I · 3 marks

The dimensions of the placenta can be found using scans.

(iii) The volume of a placenta was found to be 1227 cm^3, with a diameter of 25 cm.

I. Use the following formula to find the thickness of the placenta.
Assume the placenta is the same thickness across its diameter.
Show your working. [3]

Volume = $\pi r^2 h$
Where r = radius of placenta
h = thickness of placenta
π = 3.14

Thickness of placenta = ... cm

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Mark schemes

Question 1 · A level Component 3 · June 2017 · Q7(e)(i) · 1 mark

(e)	(i)	0.35-0.40 **and** 1.5 (1) Ignore decimal places	1	1	1

Question 2 · AS Component 1 · June 2023 · Q1(c)(ii) · 1 mark

(ii)	$0.4\ mg\ cm^{-3}$	1	1	1	1

Question 3 · A level Component 3 · June 2019 · Q10(d)(iii)I · 1 mark

(iii)	I	10.0 – 6.0 = 4.0 turns (1) Accept 3 - 4		1	1	1

Question 4 · AS Component 2 · June 2023 · Q2(a)(ii) · 1 mark

		(ii)		33% Ecf from (i) I		1	1	1	

Question 5 · AS Component 2 · June 2023 · Q5(b)(ii) · 2 marks

(ii)	$8.4\ dm^{-3}$ (2) If incorrect award one mark for Volume of 1 breath = 0.7 (1) Number of breaths in 10 seconds x 6/no of breaths in 20 seconds X 3 = 12 (1)	2	2	2

Question 6 · AS Component 2 · June 2016 · Q2(b)(ii) · 2 marks

(ii)	Should use at least 4 pulses to gain two marks Accept figures in range 40-45 = 2 marks Award 1 mark if number of pulses/ time is seen but incorrect answer (reject number of pulses higher than 10)	2	2	1	1

Question 7 · AS Component 1 · June 2019 · Q3(b)(ii) · 2 marks

	(ii)		Correct data points (1) Correct line (1)	2	2	2	2

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Question 8 · AS Component 2 · June 2019 · Q3(a)(i) · 2 marks

3	(a) (i)	7- 7.25 % per kPa = 2 marks If incorrect award 1 mark for (Anything in range 28 – 29)/4 = 1 mark	2	2	2	

Question 9 · AS Component 2 · June 2025 · Q5(c)(ii) · 3 marks

(ii)	3.25 / 3.3 (2 marks) $\frac{19.5}{6}$ (1 marks) Unit = mm minute^{-1} hour^{-1}(1 mark) 0.542 / correct rounding (2 marks) $\frac{19.5}{360}$ (1 mark) Unit = mm minute^{-1} minute^{-1} / mm minute^{-2} (1 mark)	3	3	3	

Question 10 · A level Component 1 · June 2024 · Q1(c)(i) · 4 marks

(c)	(i)	**Correct rate** 1.53…(2) Accept values in the range 1.45 – 1.6 if rate calculated incorrectly award 1 mark for calculation using their values e.g. 510 – 395 / 135 – 60 (1) Must be clearly change in y / change in x **Correct unit** µM s^{-1} or µM /s (1) Reject µM /s^{-1} **Lines drawn on graph** to show where values were taken (1) Must have enough lines to give 2 values of x and y	4	4	4	

Question 11 · A level Component 3 · Autumn 2020 · Q3(c)(i) · 3 marks

(c)	(i)	5.5 x10^{-2} = 3 marks Allow answers in range 5.3 to 5.7x10^{-2} 0.055 = 2 marks 1.1/ 20 (1)	3	3	3

Question 12 · AS Component 1 · June 2017 · Q5(b)(i) · 1 mark

(b)	(i)	Accept range 1.32 – 1.38 accept rounding to 1d.p.	1	1	1

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Question 13 · A level Component 1 · Autumn 2020 · Q1(e)(i) · 3 marks

(e)	(i)	Ratio = 10 : 1 = 3 marks Ratio = 1.1304 : 0.1130 = 2 marks If incorrect award 1 mark for either of SA 4 x3.14 x 0.09. = 1.1304 (1) Vol 4/3 x 3.14 x 0.027 = 0.1130 (1)	3	3	3

Question 14 · AS Component 1 · June 2019 · Q2(b)(iv) · 2 marks

	(iv)	Accept range between 261 248 to 268 083 (μm^3) 2 marks $\frac{4}{3}\pi.40.^3$ 1 mark Accept standard form	2	2	2

Question 15 · AS Component 1 · Autumn 2021 · Q5(c)(i)I · 3 marks

(c)	(i)	I	0.0042 = 3 marks If incorrect award 2 marks for 0.0041……. If incorrect award 1 marks for Volume of 1 bead = 4/3 x 3.142 x 0.1^3	3	3	3 3

Question 16 · AS Component 1 · June 2018 · Q5(b)(i) · 3 marks

(b)	(i)	4/3 x 3.142 x 1^3 = 4.189/4.19/4.2 (μm^3)1 mark for volume volume of water released at -0.24MPa = 15.5μm^3 1 mark for graph reading 15.5/4.189 = 3.7 = 3 marks **ecf if incorrect volume used**	3	3	3

Question 17 · A level Component 3 · June 2018 · Q2(b) · 3 marks

(b)	(i)	603 = 3 marks If incorrect award 2 marks for 603.264 or [603.1858... if use π on calculator]	3		
		If incorrect award 1 mark for sight of 3.142 x 0.0004^2 or 5.03 x 10^{-7} or 0.00000050272 [not used total cross section] 3.142 x 0.0008^2x 1.2 x 10^9 or 2410 or 2412.7 or 2413 [not used radius as 0.0004]		3	3

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Question 18 · AS Component 1 · June 2024 · Q5(a)(i)I · 2 marks

5	(a)	(i)	I	SA = 4710 using 3.14 or 4712 using calc pi (2) If incorrect award 1 mark for 2 x 3.14 x 7.5 x 5 or 235.5 (using 3.14) 235.6 (using calculator) 2 x 3.14 x 7.5^2 or 353.25 353.4 (using calculator) 588.75 (not multiplied by n)	2	2	2	2

Question 19 · A level Component 3 · June 2017 · Q5(c)(iv)I · 2 marks

(iv)	I	0.4 cm^3 = 2 marks If incorrect allow the following for 1 mark $3.142/\pi \times 0.65^2 \times 0.3$ 0.398/ 0.3982485		2	2	2	

Question 20 · A level Component 2 · June 2024 · Q1(b)(iii)I · 3 marks

(iii)	I	Award three marks for 2.5 cm thick (2.501) **If incorrect award two marks** 25 mm 1227/3.14x156.25 1227/3.14x12.5 x12.5 **If incorrect award one mark** 1227/3.14x 625 (diameter) 0.62 (use diameter)	3	3	3	

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