

PEARSON EDEXCEL A-LEVEL BIOLOGY B • 9B10

BIOLOGY



EXAM QUESTION PACK

TOPIC 6: MICROBIOLOGY AND PATHOGENS
MICROBIAL TECHNIQUES

SCORE

/82

PERCENTAGE

%

STEMUP

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Q1.

Bacteria were cultured in two different types of medium.

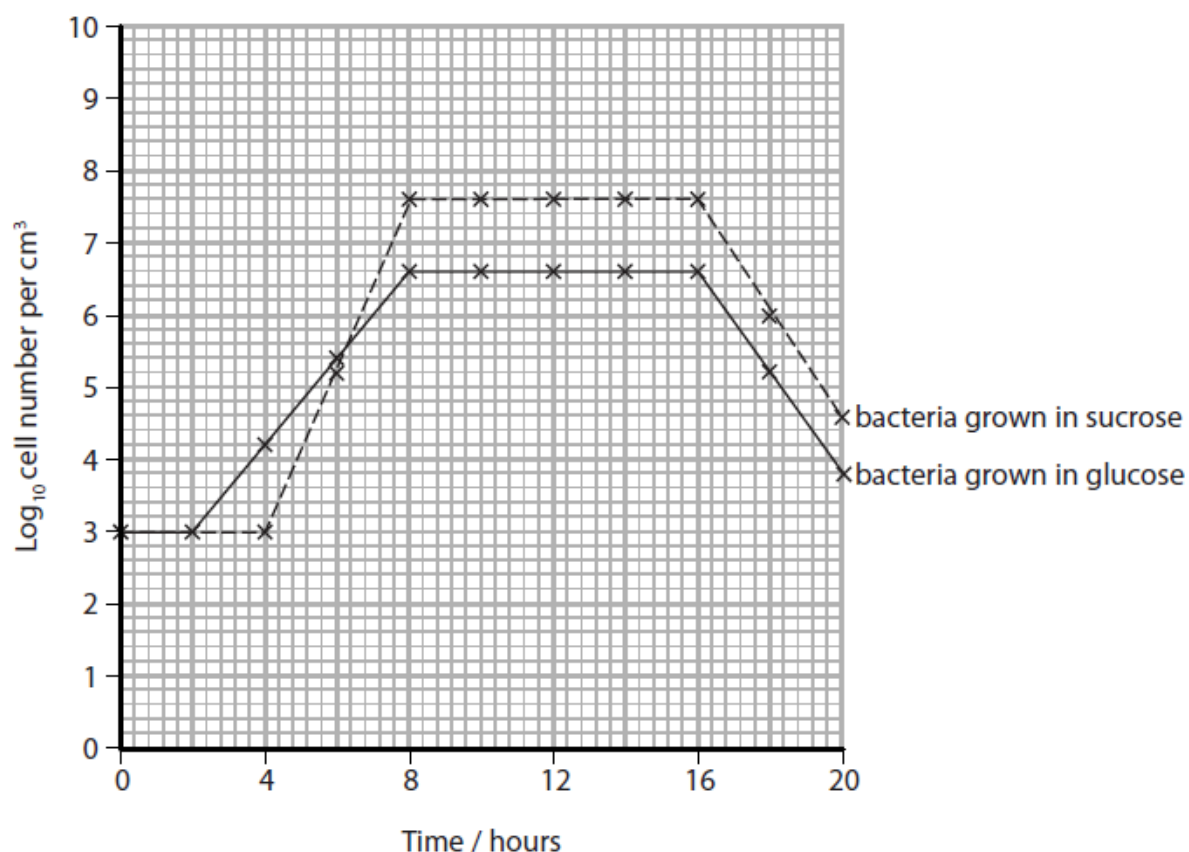
One medium contained glucose as the energy source and the other contained sucrose.

The same molar concentrations of glucose and sucrose were used.

Bacteria were grown in each medium for 20 hours.

Every two hours, the numbers of bacteria were determined using dilution plating and an optical method (turbidity).

The graph shows the results from the dilution plating.



(i) Calculate how many times faster the bacteria in sucrose reproduce than the bacteria in glucose, during the log phase.

(2)

Answer

(ii) Analyse the data to explain why the growth curve for sucrose is different from the growth curve for glucose.

(2)

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(iii) On the graph, draw a curve to show the number of bacteria grown in glucose as determined by the optical method.

(1)

(Total for question = 5 marks)

Q2.

Antibiotics are widely used to treat infections.

Some antibiotics are bactericidal.

Describe how you would use aseptic techniques to transfer bacterial cells growing on an agar plate to a tube containing a sterile broth.

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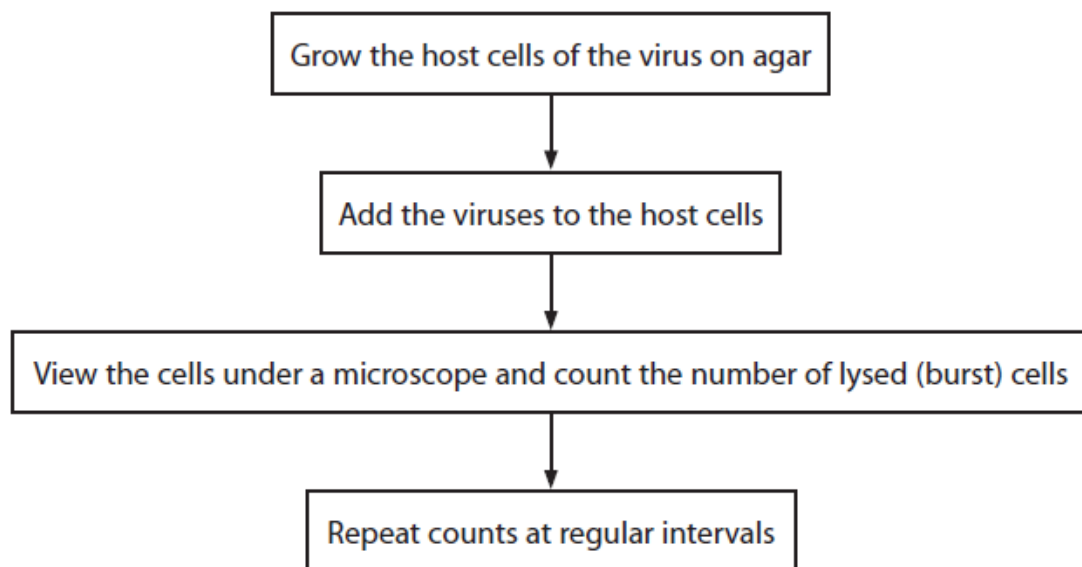
(Total for question = 5 marks)

Q3.

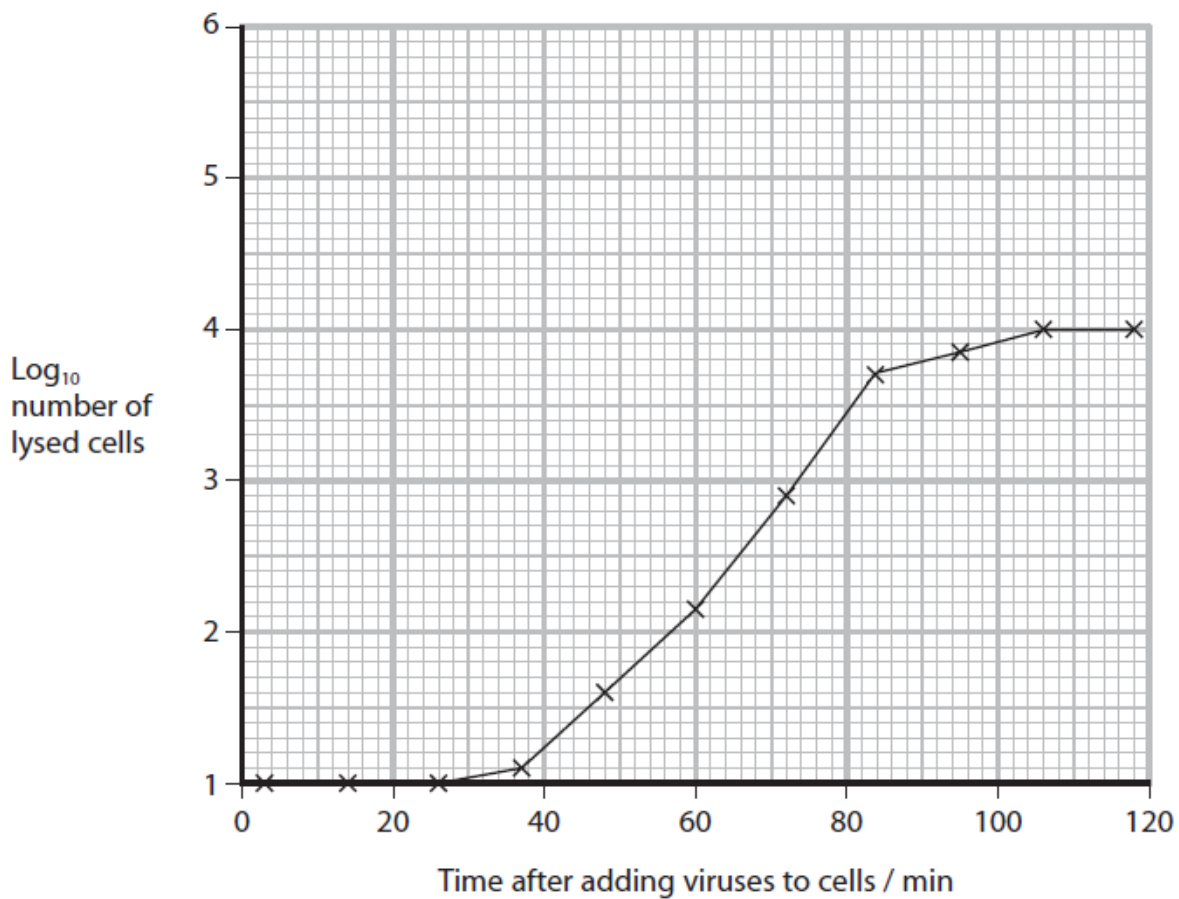
Bacteria are the host cells for λ (lambda) phage viruses.

Viruses can be cultured and a growth curve can be produced.

The flow chart shows how this can be done.



The graph shows a growth curve for viruses.



(i) Explain why there was a delay before the number of lysed cells started to increase.

(3)

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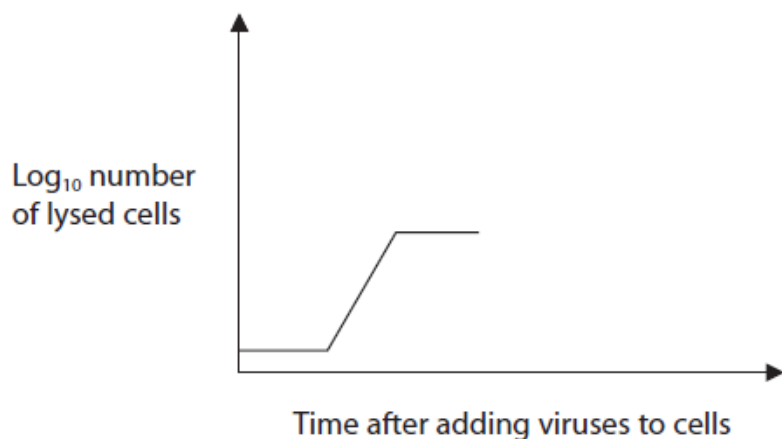
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(ii) Calculate the mean rate of increase in the actual number of lysed cells between 50 minutes and 90 minutes.

(2)

Answer cells min⁻¹

(iii) A sketch has been made of this growth curve.



Complete this sketch to predict the shape of the growth curve after 120 minutes, assuming there is an excess of host cells.

(2)

(Total for question = 7 marks)

Q4.

Skin flora include bacteria that live on the skin.

Different parts of the body have different types of bacteria present.

Skin flora are beneficial as they inhibit the growth of pathogenic bacteria on the skin.

Skin flora compete for nutrients and space or secrete toxic chemicals.

The following are types of bacteria found in the female genital tract:

- *Escherichia coli*
- *Klebsiella species*
- *Lactobacillus species*
- *Staphylococcus species*.

(i) Describe how these types of bacteria present in the female genital tract could be identified.

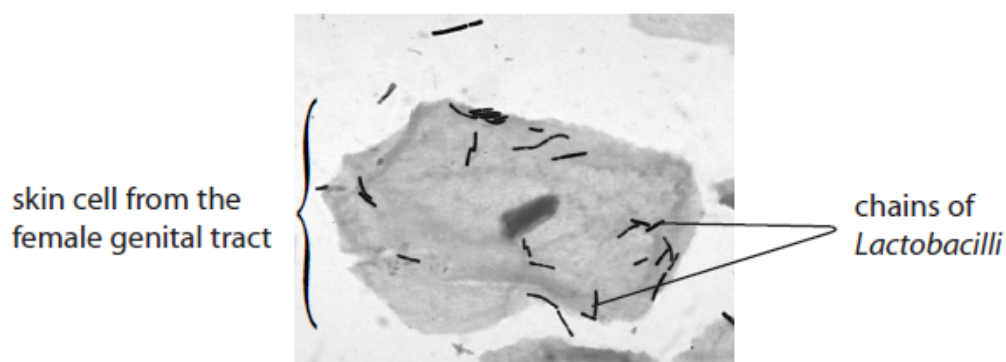
(4)

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(ii) The photograph shows *Lactobacilli* on a skin cell from the female genital tract.



Source: © Janice Carr Content Providers (s): CDC/Dr. Mike Miller

Lactobacilli metabolise glycogen into lactic acid.

Explain how *Lactobacilli* inhibit the growth of pathogenic bacteria in the female genital tract.

(3)

(Total for question = 7 marks)

Q5.

An investigation was carried out to compare the aerobic respiration of different sugars by yeast.

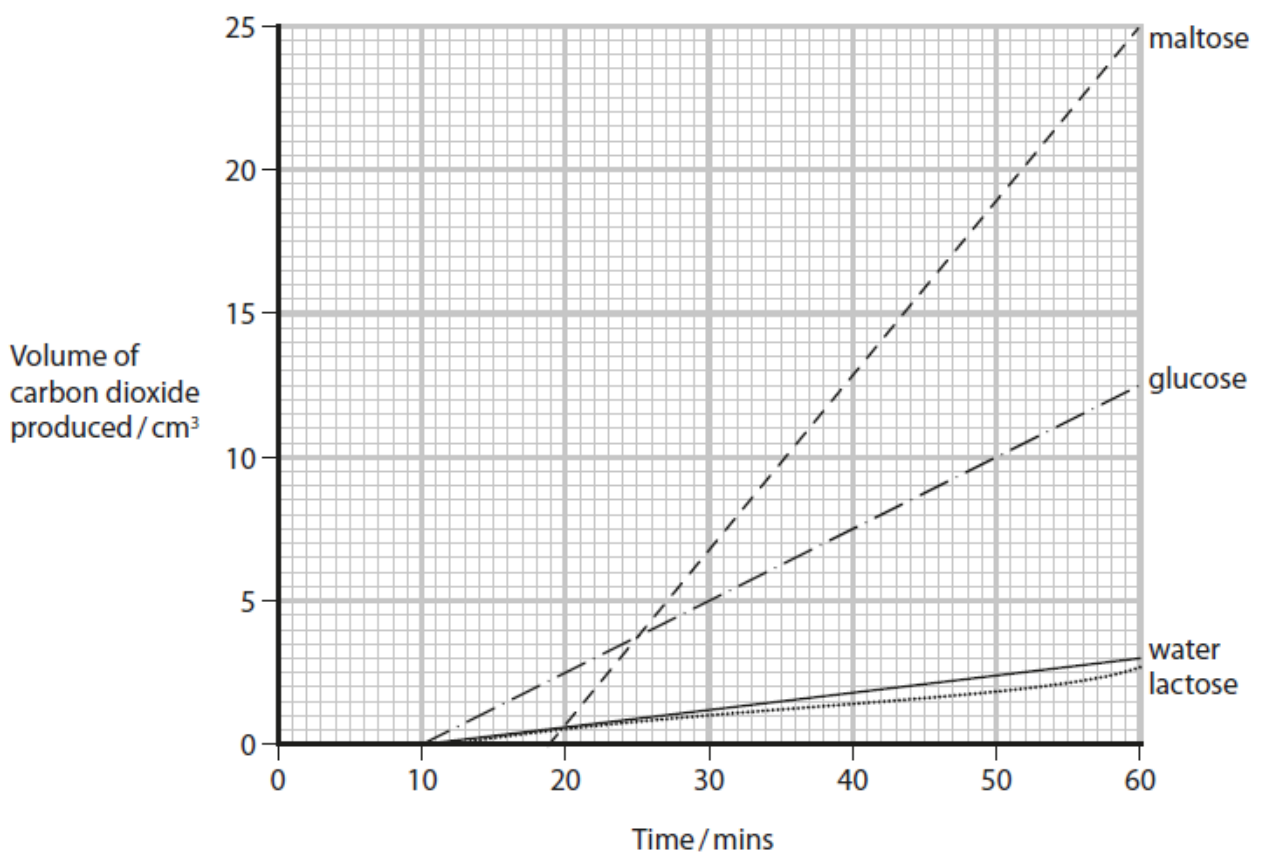
A suspension of yeast was used to produce three cultures, each one with a different sugar.

A control was set up that had a suspension of yeast cultured with water only.

The volume of carbon dioxide produced was measured.

The mass of yeast and the concentration of each sugar were controlled.

The graph shows the results of this investigation.



(i) Give one difference between the structure of glucose and the structure of maltose.

(1)

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(ii) Explain the results for the yeast cultured with glucose and the yeast cultured with maltose.

(2)

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(Total for question = 3 marks)

Q6.

An investigation was carried out to compare the aerobic respiration of different sugars by yeast.

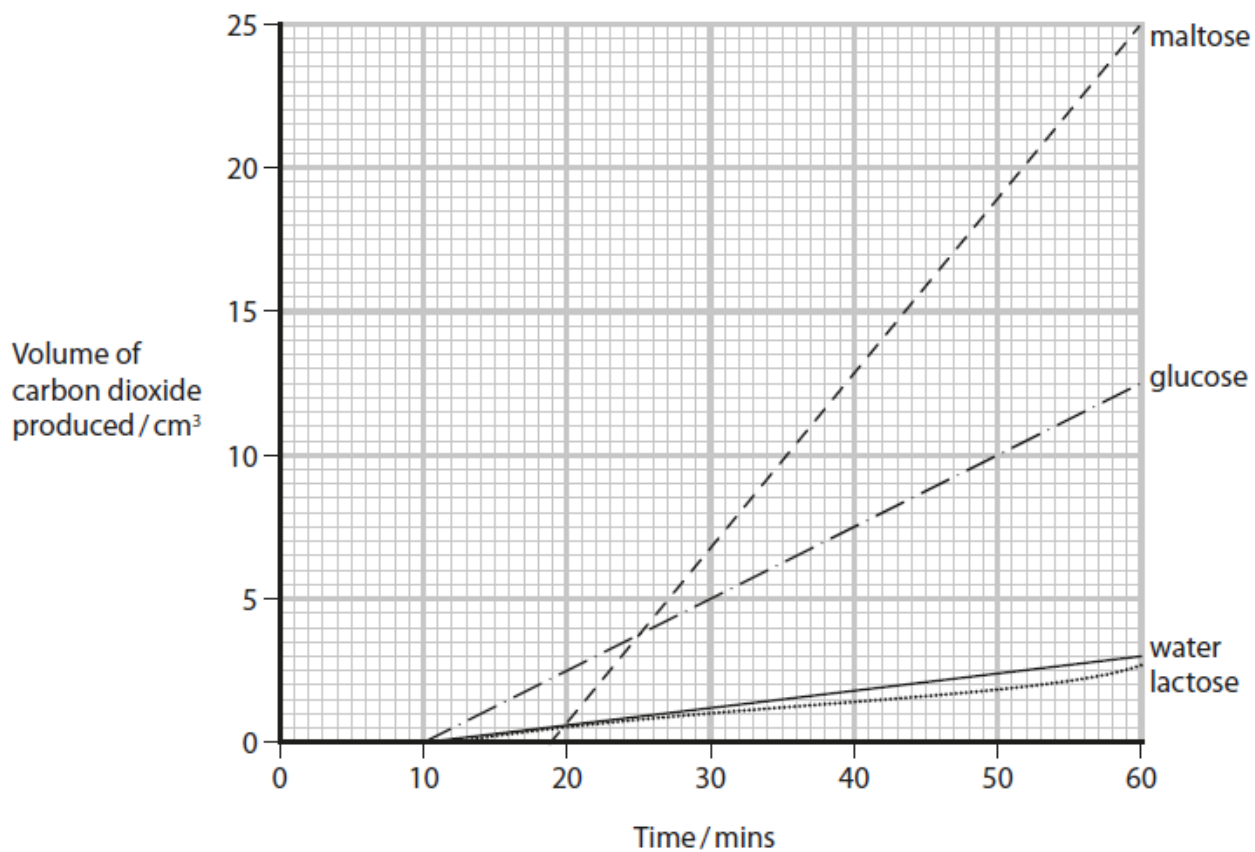
A suspension of yeast was used to produce three cultures, each one with a different sugar.

A control was set up that had a suspension of yeast cultured with water only.

The volume of carbon dioxide produced was measured.

The mass of yeast and the concentration of each sugar were controlled.

The graph shows the results of this investigation.



Explain the results for the yeast cultured with lactose.

(2)

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(Total for question = 2 marks)

Q7.

Ultraviolet (UV) radiation damages DNA and is used in microbiology to produce aseptic conditions.

The effectiveness of UV radiation was investigated, using three species of pathogenic bacteria.

The table provides information about the bacteria used in this investigation.

Bacteria	Gram staining	Infected part of body
<i>P. aeruginosa</i>	negative	blood
<i>S. aureus</i>	positive	lung
<i>E. coli</i>	negative	intestine

(i) Compare and contrast the structure of the wall of Gram positive bacteria and Gram negative bacteria.

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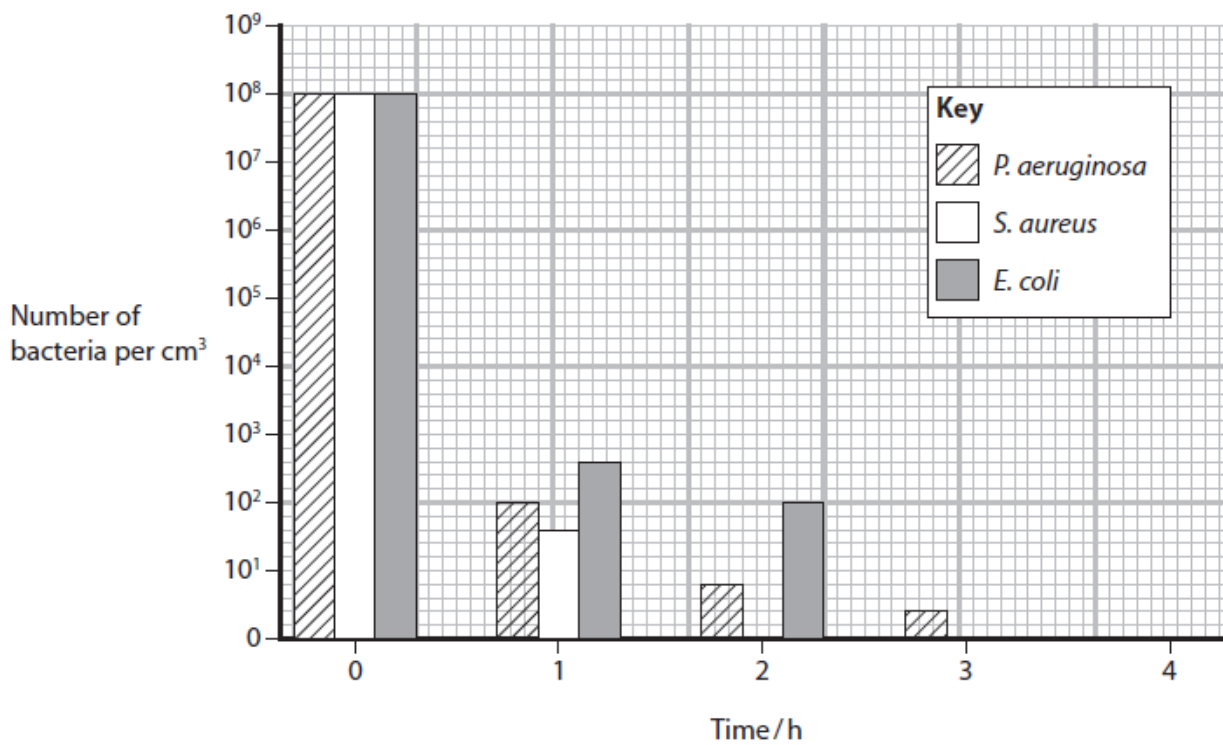
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(ii) In this investigation, living bacteria of each species were exposed to UV radiation for four hours.

The numbers of living bacteria were counted each hour during the four-hour period.

The graph shows the results of this investigation.



Calculate the percentage change in numbers of living *E. coli* after two hours of exposure to UV radiation.

(2)

Answer %

(iii) A student concluded from this investigation that if food is exposed to UV radiation, it would remove all risk of food poisoning.

Criticise the validity of this conclusion.

(4)

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(Total for question = 9 marks)

Q8.

Antibiotics can affect bacteria.

The table describes the mode of action of four antibiotics.

Antibiotic	Mode of action
benzylpenicillin	disrupts peptidoglycan structure
streptomycin	binds to 70S ribosomes
ciprofloxacin	inhibits enzymes involved in prokaryotic DNA replication
rifamycin	inhibits prokaryotic RNA polymerase

A student compared the effectiveness of these four antibiotics on the growth of bacteria.

Devise a method that the student could use to obtain valid results.

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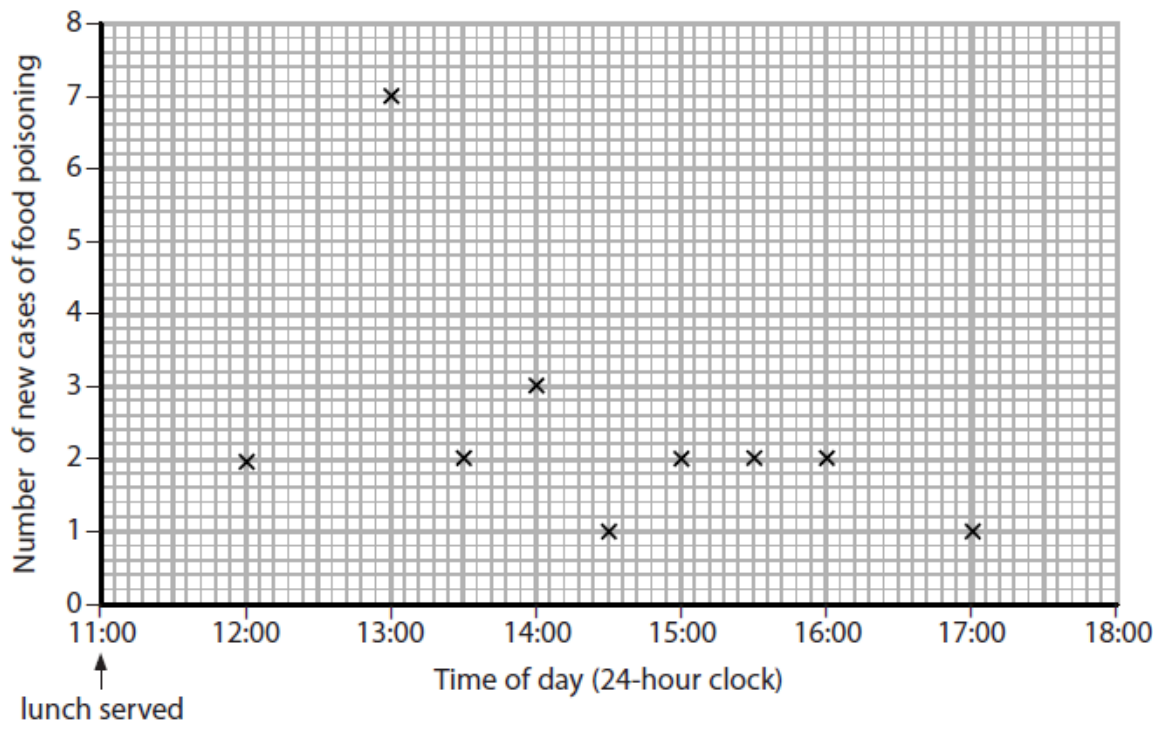
(Total for question = 5 marks)

Q9.

Food poisoning can be caused by food that is contaminated with pathogenic microorganisms.

A number of different bacteria can cause food poisoning.

The graph shows the number of new cases of food poisoning after a lunch party.



(i) Explain why it is likely that this food poisoning resulted from food contaminated with *Staphylococcus* rather than with *Salmonella*.

(3)

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(ii) Describe the techniques microbiologists could use to confirm that this food poisoning was caused by *Staphylococcus*.

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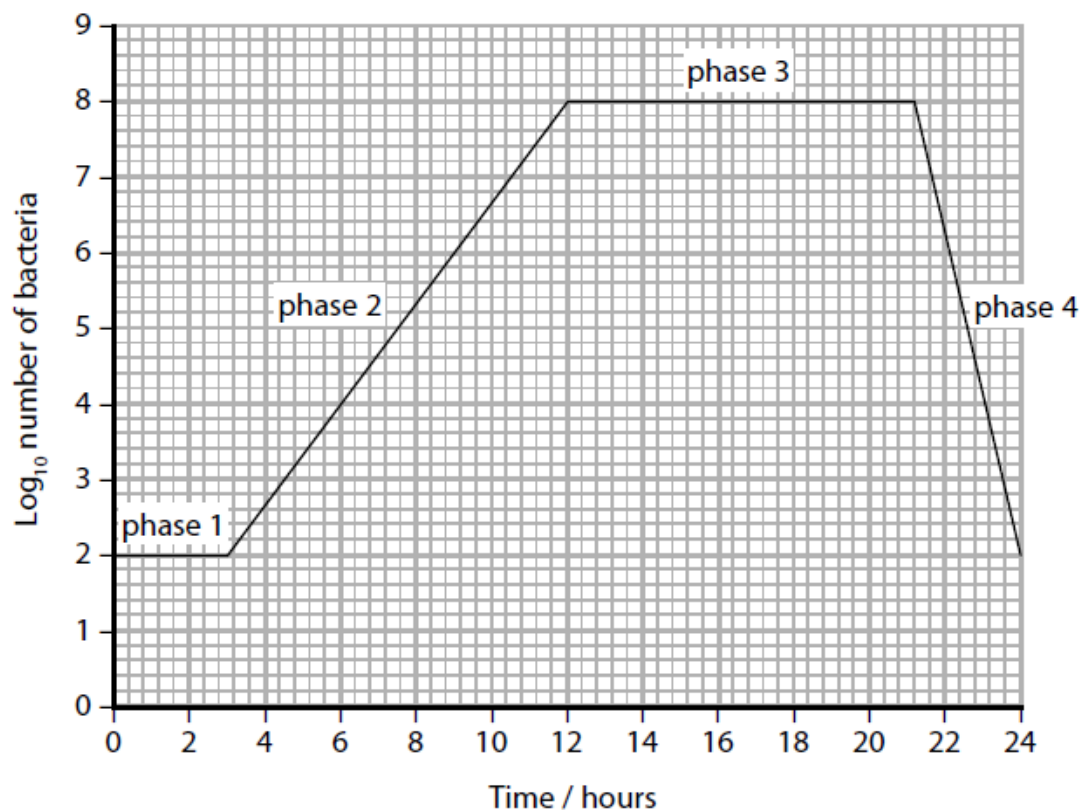
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(Total for question = 7 marks)

A broth culture for growing bacteria was set up.

Dilution plating was used to determine the number of live bacteria in the culture over a period of 24 hours.

The graph below shows the number of live bacteria in the culture during this 24-hour period.



(a) Which is the correct order of the phases 1 to 4 shown on the graph?

(1)

- ☒ **A** lag, log, death, stationary
- ☒ **B** lag, log, stationary, death
- ☒ **C** log, lag, death, stationary
- ☒ **D** log, lag, stationary, death

*(b) Evaluate the use of dilution plating and optical methods for determining the number of bacterial cells in a culture.

(6)

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(c) Calculate the growth rate constant (k) for phase 2 of this culture, using the formula:

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

(4)

Answer

(Total for question = 11 marks)

Q11.

Salmonella are Gram negative bacteria found in the large intestine of humans.

A scientist studied the growth of *Salmonella*.

(i) *Salmonella* was isolated from a mixed culture of bacteria, using streak plating onto selective media.

Explain why this is a suitable method for isolating the *Salmonella*.

(4)

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(ii) The scientist made a broth culture of *Salmonella* at a concentration of 5×10^3 cells per cm^3 .

Ten hours later the concentration of *Salmonella* was 4×10^6 per cm^3 .

Calculate the exponential growth rate constant (k) for this culture of *Salmonella* using the formula

(3)

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

Answer

(iii) In this calculation, the scientist did not allow for the time that the *Salmonella* spent in the lag phase.

Explain the effect that this will have on the calculated value for the growth rate constant.

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(Total for question = 10 marks)

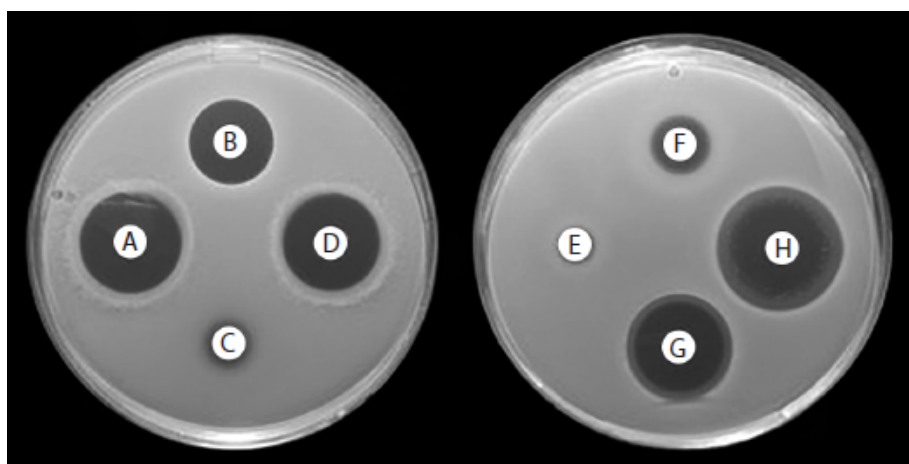
Q12.

A student read that more than half of raw chickens on sale in supermarkets are contaminated with bacteria from the genus *Campylobacter*.

Some species of *Campylobacter* cause food poisoning in humans.

The student carried out an experiment to test the effectiveness of various antibiotics against *Campylobacter*.

The photograph shows the student's agar plates at the end of the experiment.



The white circles labelled A-H are filter paper discs. These discs were soaked in different antibiotics then placed on the surface of the agar.

Explain how the student's method could ensure that the results from the two agar plates can be compared.

(3)

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Q13.

Salmonella can cause severe vomiting and diarrhoea.

Public health laboratories use the Salmonella Rapid Culture technique to confirm a *Salmonella* infection.

This can accurately identify *Salmonella* as purple stained colonies within 48 hours.

Previous methods for the identification of *Salmonella* infections took four days.



Explain why it is important that aseptic technique is used when carrying out the Salmonella Rapid Culture technique.

(2)

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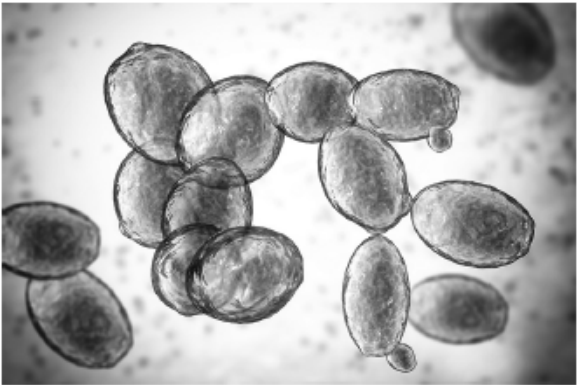
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Q14.

Yeast, *Saccharomyces cerevisiae*, is a single-celled organism used in brewing and baking. The photograph shows yeast cells seen using a light microscope.



(Source: © Kateryna Kon/Shutterstock)

A student counted the number of yeast cells, at 90-minute intervals, growing in a liquid culture at 30°C.

Describe two precautions that would prevent the yeast culture becoming contaminated with bacteria.

(2)

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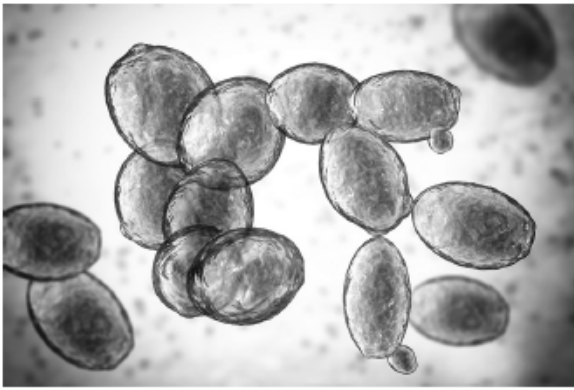
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(Total for question = 2 marks)

Q15.

Yeast, *Saccharomyces cerevisiae*, is a single-celled organism used in brewing and baking. The photograph shows yeast cells seen using a light microscope.



(Source: © Kateryna Kon/Shutterstock)

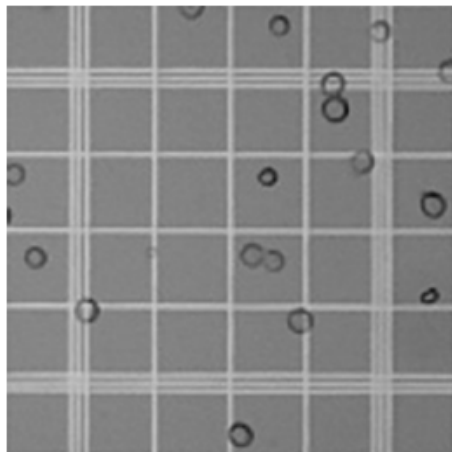
A student counted the number of yeast cells, at 90-minute intervals, growing in a liquid culture at 30°C.

The student counted the yeast cells using a haemocytometer.

This is a slide with chambers containing a known volume of liquid. The yeast cells are counted when viewed using a light microscope.

Any yeast cells totally within the counting square should be counted, along with those which overlap the top or left-hand side of the square.

(i) The volume of liquid in the counting square shown is 0.004 mm³.



(Source: © Joseph Elsbernd/Flickr)

Calculate the number of yeast cells per mm³.

Give your answer in standard form.

(2)

Answer per mm³

(ii) Identify two causes of inaccuracy in this method of counting cells.

(2)

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(Total for question = 4 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	- values read from graph per unit time and converted back from logs - subtraction of each pair and division done	(7.6= 39 810 717 and (6.6= 3 981 072 and (3.0=) 1000 or (4.2=) 15849 10 / 10.04 ACCEPT 1.9 / 1.92 / 2 / 82.5 / 82.54 / 83 for 1 mark	

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: (lag phase longer as) {sucrose has to be broken down / enzymes to breakdown sucrose had to be synthesised} (1) (reproduction faster) because sucrose has more {sugar / monosaccharides / energy} (1)	ACCEPT converse for glucose ACCEPT sucrase ACCEPT sucrose made of glucose and fructose / sucrose is a disaccharide and glucose is a monosaccharide	

Question Number	Answer	Additional Guidance	Mark
(iii)	a line that continues to go up after 8 hours and then levels off (around) 16 hours without dropping	log₁₀ cell number per cm³ time in hours • bacteria grown in sucrose • bacteria grown in glucose	

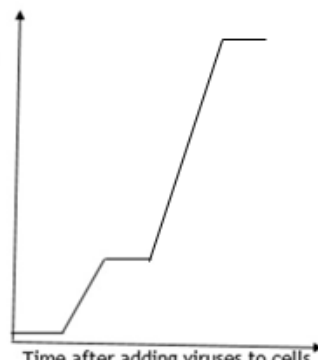
Q2.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to five of the following: - disinfect surfaces / use benchcoat (1) - work near Bunsen flame / work in a sterile cabinet (1) - flame top of tube (1) - heat wire loop (1) - open lid of Petri dish to a small extent (1) - allow wire loop to cool (1)		(5)

Q3.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: - virus to attach to host cells / {genetic material / DNA} to enter host cells (1) - synthesis of DNA (1) {protein synthesis / transcription <u>and</u> translation} (1) - assembly of new viruses (1)	ACCEPT virus {enters / infects} DO NOT ACCEPT RNA IGNORE nucleic acid DO NOT ACCEPT RNA unless already penalised in mp 1 / in the context of {proviruses / latency} ACCEPT capsid / capsomeres / tail / base plate / tail (fibres) / collar / J protein / enzymes / protease / permease / other named proteins will need to be checked DO NOT ACCEPT reverse transcriptase / integrase NB ACCEPT (time for) {replication / multiplication} of the virus in correct context if no other marks awarded.	(3) EXP

Question Number	Answer	Additional Guidance	Mark
(ii)	- correct values read from graph and divided by the time (1) - mean rate calculated (1)	3.8 and 1.7 and a division by 40 / 0.0525 / 3.147 IGNORE ref to logs 156 ecf wrong time value but correct answer to whole number e.g. (30 mins) 209 Correct answer only = 2 marks	(2) EXP

Question Number	Answer	Additional Guidance	Mark
(iii)	- line going up and (generally) levelling off (1) - increase greater than the first increase (1)	IGNORE a third increase 	(2) EXP

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to four of the following: - sample taken from the female genital tract (1) - bacteria grown on {selective / indicator} media (1) - bacteria grown on media containing different types of antibiotics (1) - use of {antibodies / DNA profiling} (1) - using {Gram staining / cell shape / colony shape / colony colour} (1)		(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: - because they grow on the skin cells preventing pathogenic bacteria from doing so (1) - because they use the glycogen so less {glucose / energy / glycogen} available for the pathogenic bacteria (1) - because they produce lactic acid which inhibits the growth of pathogenic bacteria (1) - because the low pH denatures the enzymes of the pathogenic bacteria (1)	ACCEPT below optimum pH	(3)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	glucose is a monosaccharide and maltose is {a disaccharide / made of two glucoses / made of two monosaccharides} (1)	ACCEPT maltose has a glycosidic bond and glucose does not glucose has 6 carbons and maltose has 12 glucose has the formula $C_6H_{12}O_6$ and maltose $C_{12}H_{22}O_{11}$ ACCEPT a labelled diagram	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: - neither sugars respired immediately because the yeast need to {acclimatise / adjust to the conditions} (1) - delay is longer for maltose as {enzymes need to be synthesised / maltose needs to be broken down into glucose} (1) - respiration of maltose is faster (than glucose) as maltose has {twice the number of sugar units / more glucoses / more hydrogens} (1)	ACCEPT glycosidic bonds have to be broken ACCEPT because maltose contains more energy / maltose is a disaccharide and glucose is a monosaccharide	(2)

Q6.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: - lactose is not {respired / used} as the yeast do not produce {the appropriate enzymes / lactase} (1) - sugars in the cytoplasm are {used / respired} (1)	ACCEPT yeast cannot break lactose down NB at least one reference to respiration for both marks to be awarded	(2)

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to three of the following: Similarity - both have peptidoglycan (1) Two differences from: - positive has {more / thicker layer of} peptidoglycan than negative / positive has a thicker cell wall than negative (1) - positive has teichoic acid, negative does not (1) - negative has outer membrane, positive does not (1) - negative (most) has periplasmic space, positive does not (1) - negative has {more lipid / lipopolysaccharide / porin proteins}, positive does not (1)	Accept periplasm	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	- subtraction using values from graph (1) - calculation of percentage change (1)	$10^8 - 10^2 = 99\,999\,900$ $\div 10^8 \times 100 = 99.9999$ Correct answer gains full marks, with no working shown.	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: - it is effective if irradiation longer than 3 hours (1) - it is effective against E. coli which infect the intestine (1) - not all species of {pathogenic bacteria / bacteria causing food poisoning} investigated / only three types of bacteria investigated (1) - toxins may remain in food (1)	Accept effectiveness depends on how long it is irradiated for	(4)

Q8.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to five of the following points: • same species of bacteria (1) • same {concentration / volume} of antibiotic (1) • use {agar / broth / culture medium} (1) • incubate between 20 °C and 25 °C for stated time (1) • measure {zone of inhibition / turbidity} (1) • use of described aseptic technique (1)	DO NOT ACCEPT less than 24 hours e.g. use of Bunsen burner / flame loop / swab bench	(5)

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: - because the food poisoning was happening {after one hour /within a few hours} of the meal (1) - indicating that exotoxins caused the food poisoning (1) - because endotoxins are only present after {about 12 hours / several hours / when the bacterial cells are destroyed} (1) <i>Staphylococcus</i> releases exotoxins / endotoxins come from <i>Salmonella</i> (1)	Accept soon after meal / quickly / by {12 / 1} o'clock Do not accept <i>Staphylococcus</i> is an exotoxin / <i>Salmonella</i> is an endotoxin	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to any four of the following: - isolate the bacteria from the {food / patient / faeces / vomit} (1) - look at the colonies to see if they have a {characteristic / named characteristic} (of <i>Staphylococcus</i>) (1) - use Gram stain to show presence of Gram positive bacteria (1) - grow on selective media that identify {<i>Staphylococcus</i> / eliminates other bacteria} (1) - use antibodies against <i>Staphylococcus</i> (1)	Accept a description of how this is done e.g. streak plating from a faecal sample Accept <i>Staphylococci</i> will appear purple with Gram stain Accept differential media / selective agar / named example e.g. mannitol salt agar / with antibiotics	(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	B		(1)

Question Number	Indicative content
*(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • Dilution plating takes longer to obtain a result but optical methods are quicker • Because incubation period needed for dilution plating • Because need to do serial dilutions to find correct concentration for dilution plating • Dilution plating counts living cells but optical methods measure living and dead cells • Dilution plating gives direct count but optical methods give turbidity reading • To calculate original concentration of bacterial cells, the volume of diluted suspension added to each agar plate needs to be known / optical methods require use of calibration curves • Dilution plating requires easily available apparatus but optical methods require colorimeter / spectrophotometer • Dilution plating has risk of error if colonies run into each other but optical methods produce error if tube not shaken

Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.
Level 3	5-6	A scientific judgement is made that is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	$\log_{10} N_t = 8$ and $\log_{10} N_0 = 2$ (1) $\log_{10} N_t - \log_{10} N_0 = 6$ (1) $t = 9$ (1) $k = 2.215$ (1) [ecf applies for mps 2, 3 and 4]	Correct answer gains full marks with no working	(4)

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to four of the following: - medium allows only {<i>Salmonella</i> / certain bacteria} to grow (1) {culture / colonies / bacteria} is spread out on the {agar / medium} (1) - because this separates out individual bacteria (1) - so that colonies are {discrete / separate / individual} (1) - so only one type of {bacteria / colony} can be picked up (1)	ACCEPT in context of {named media / antibiotic-containing media}	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	- log of the values taken (1) - substitution of values into equation (and evaluating correctly) (1) - k given to an appropriate number of decimal places (1)	$\log 5 \times 10^3 = 3.6989700043$ and $\log 4 \times 10^6 = 6.6020599913$ $(6.6020599913 - 3.6989700043) \div (0.301 \times 10) = 0.9644817233$ ACCEPT correct value for rounded up values substituted 0.964 / 0.96 CE applies from mp 1 only	(3)

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: - the value for t used in the calculated value is greater than the actual value (1) - therefore the calculated value for k will be smaller (1) - because the <i>Salmonella</i> will not be replicating (in lag phase) (1)	ACCEPT converse for actual value ACCEPT converse for actual value ACCEPT dividing / growing	(3)

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A explanation that makes reference to three of the following: • both plates prepared with nutrient agar of the same composition, to provide both bacterial populations with the same resources for growth (1) • both plates seeded with the same volume of the same culture of <i>Campylobacter</i>, so all antibiotics are acting on the same bacterial population (1) • use of aseptic technique such as 'flaming' instruments or working in { updraught of flame / flow hood } , to reduce risk of contamination of either plate with extraneous bacteria (1) • both plates should be incubated at the same temperature for the same length of time, to give equal opportunity for bacterial growth (1)		(3)

Q13.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: - because public health workers could become infected with <i>Salmonella</i> (1) - because cross-contamination could lead to false identification of bacteria (1)		(2)

Q14.

Question Number	Answer	Additional Guidance	Mark
	A description that includes the following: Two relevant techniques to prevent bacterial growth described (2)	eg use of sterile / autoclaved equipment flaming neck of bottle / transfer loops working next to (lit) Bunsen burner disinfection of bench use of selective medium / antibiotics in medium Ignore partial removal of lid	Exp (2)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	- Correct calculation of number of cells (1) - Conversion to standard form (1)	Example of calculation 7 divided by 0.004 = 1750 per mm³ 8 2000 per mm³ 1.75 / 1.8 / 2 x 10³ Correct answer with no working gets 2 marks	Grad (2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that includes two of the following: • {yeast cells may not be evenly distributed / sample may not be representative} (1) • yeast cells may be {reproducing / budding / undergoing cell division} (so hard to know whether to count one or two) (1) • difficult to decide if they are touching the sides of the counting square (1)	Accept clumping / overlapping of cells may occur Accept this method counts dead cells (as well as live) Ignore human error / miscounting unqualified Ignore ref to air bubbles / artefacts / cells moving	Exp (2)