Questions

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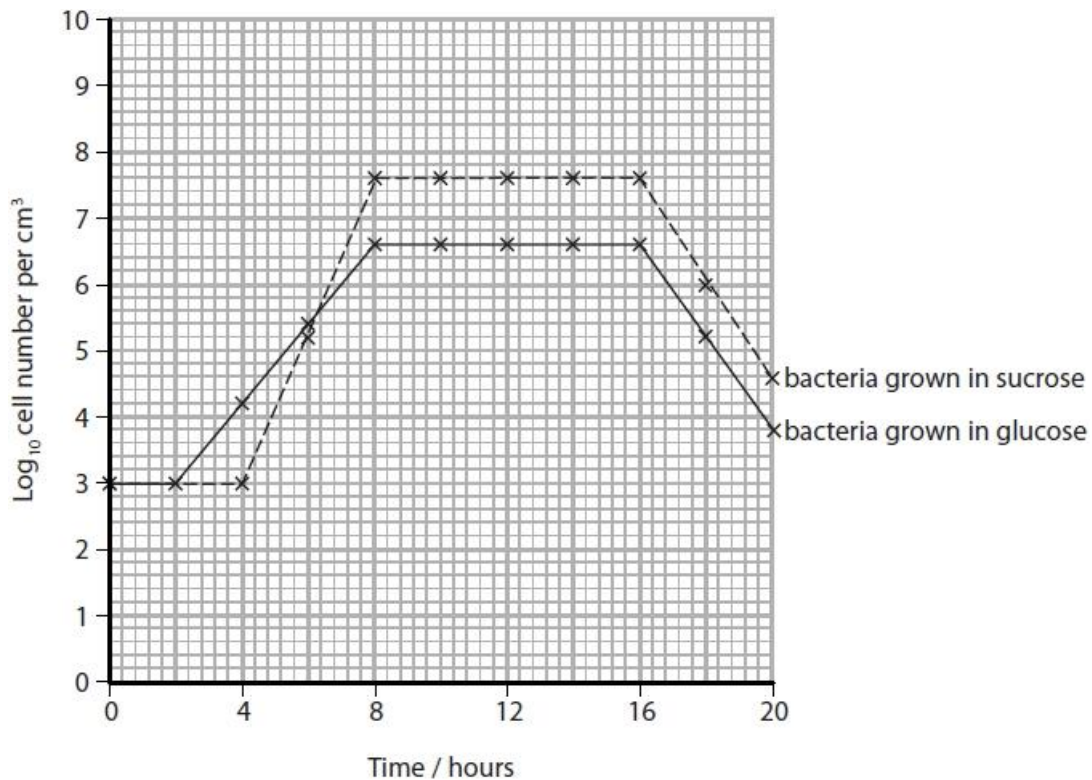
(i) Calculate how many times faster the bacteria in sucrose reproduce than the bacteria in glucose, during the log phase.

(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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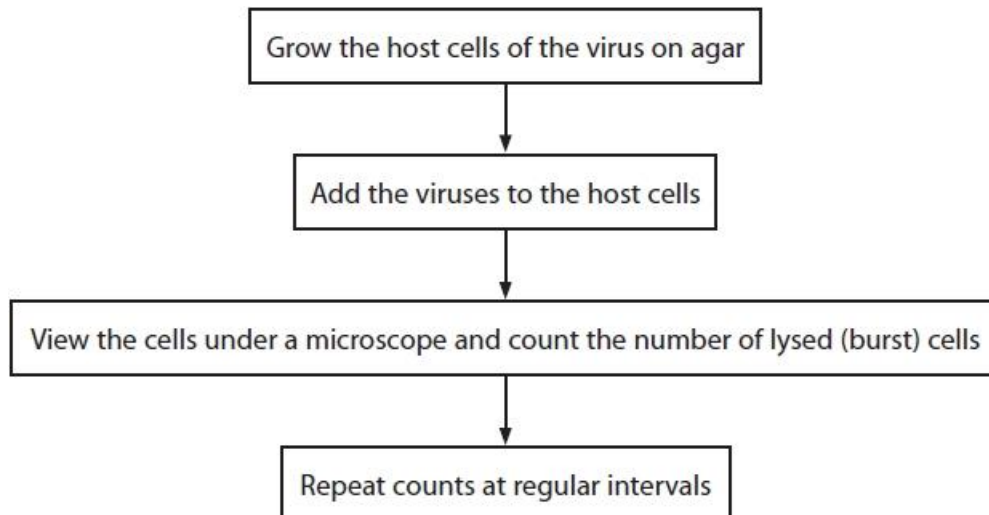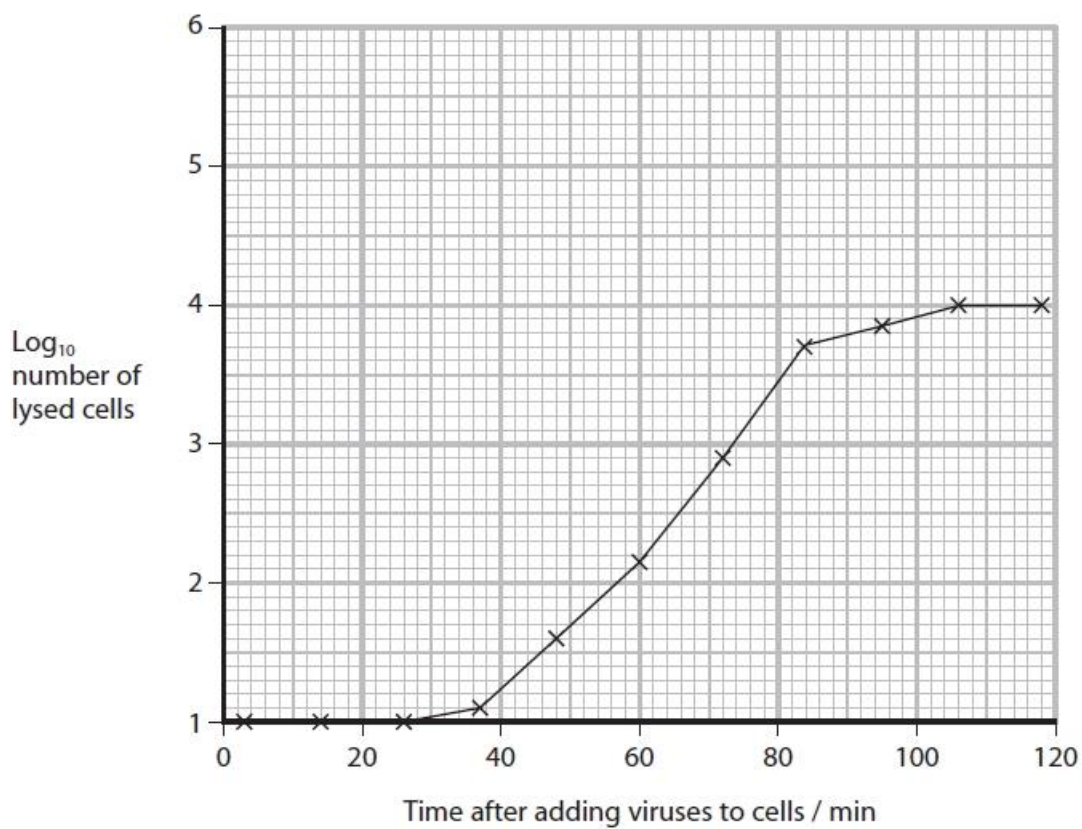
(Total for question = 5 marks)

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.

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┌─────────────────────────────────────┐
│  Grow the host cells of the virus on agar  │
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                    ▼
┌─────────────────────────────────────┐
│   Add the viruses to the host cells  │
└─────────────────────────────────────┘
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┌──────────────────────────────────────────────────────────────┐
│ View the cells under a microscope and count the number of lysed (burst) cells │
└──────────────────────────────────────────────────────────────┘
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┌─────────────────────────────────────┐
│     Repeat counts at regular intervals    │
└─────────────────────────────────────┘
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The graph shows a growth curve for viruses.

(i) Explain why there was a delay before the number of lysed cells started to increase.
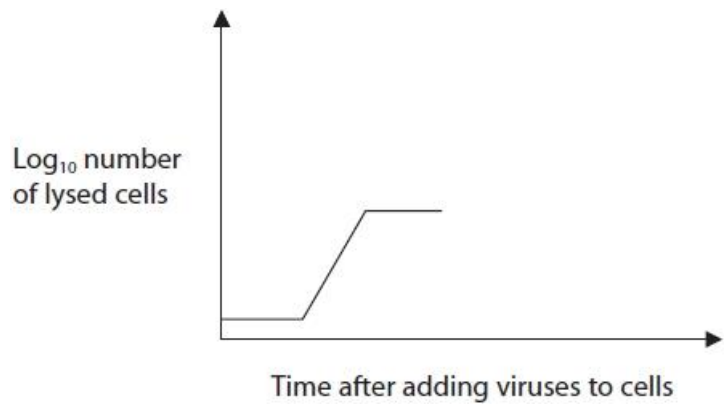
(3)

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(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.

skin cell from the
female genital tract

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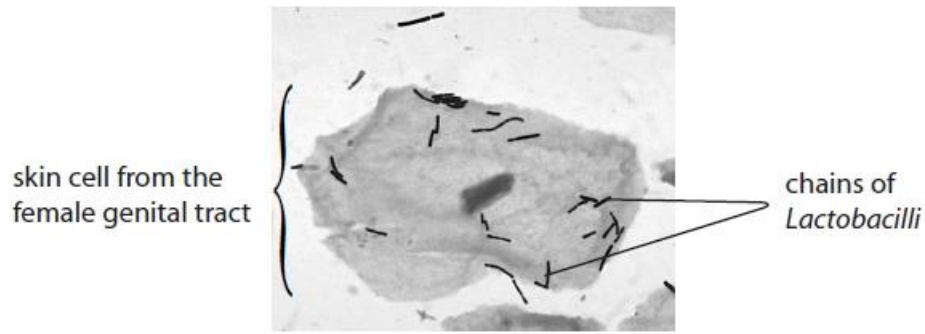
Source: © Janice Carr Content Providers (s): CDC/Dr. Mike Miller

Lactobacilli metabolise glycogen into lactic acid.
Explain how *Lactobacilli* inhibit the growth of pathogenic bacteria in the female genital tract.

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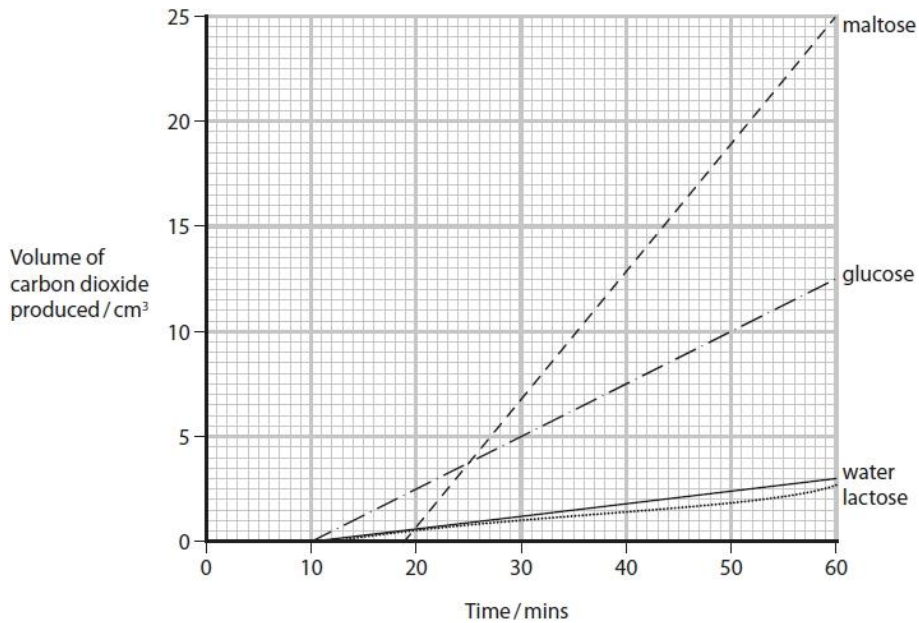
(i) Give one difference between the structure of glucose and the structure of maltose.

(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.
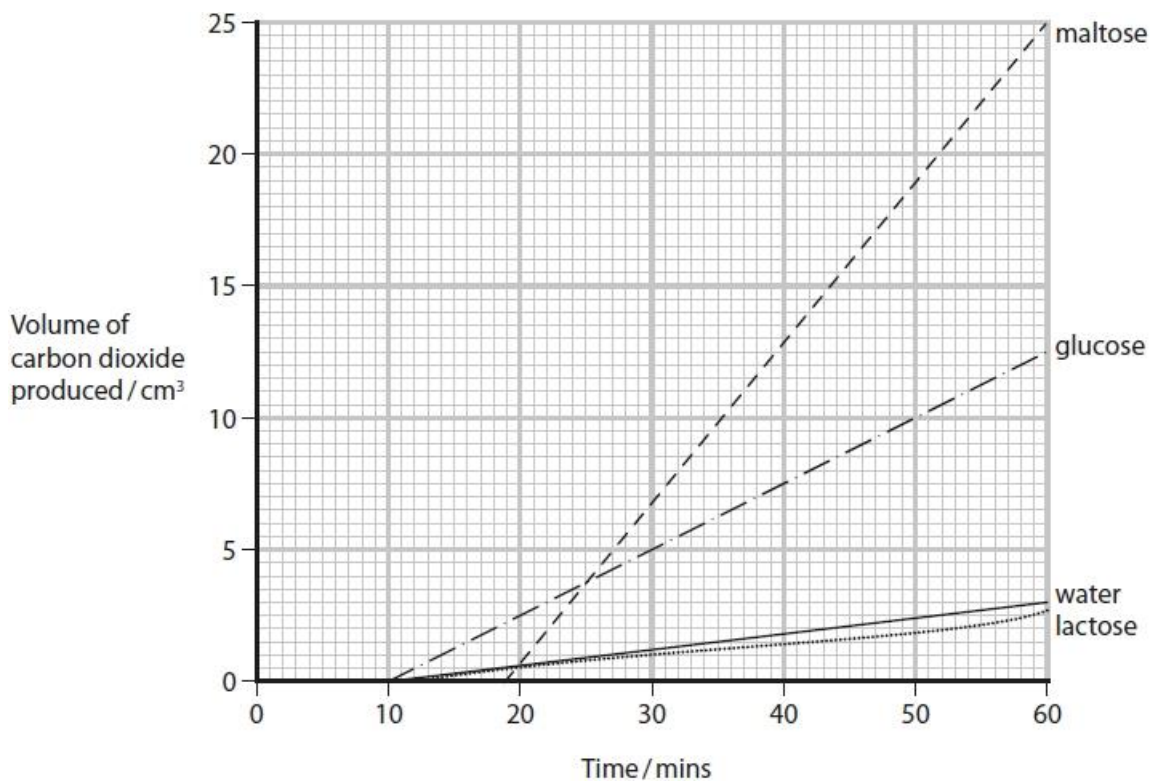
Explain the results for the yeast cultured with lactose.

(2)

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(Total for question = 2 marks)

Q7.

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 70 S 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)

Q8.

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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(Total for question = 7 marks)

Q9.

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.

(3)

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(Total for question = 10 marks)

Q10.

Aseptic conditions are used when growing bacteria in laboratories.

Justify two methods, other than UV radiation, for ensuring aseptic conditions.

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(Total for question = 2 marks)

Q11.

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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(Total for question = 2 marks)

Q12.

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 mm^3 .
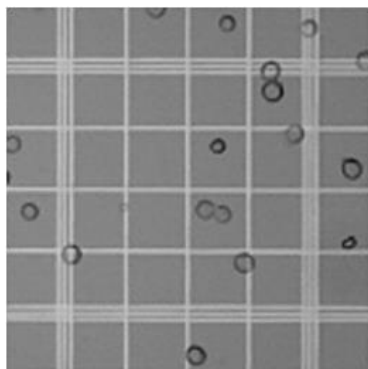
(Source: © Joseph Elsbernd/Flickr)

Calculate the number of yeast cells per mm^3.
Give your answer in standard form.

(2)

Answer .... per mm^3

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

(2)

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(Total for question = 4 marks)

Q13.

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 graph shows the results.
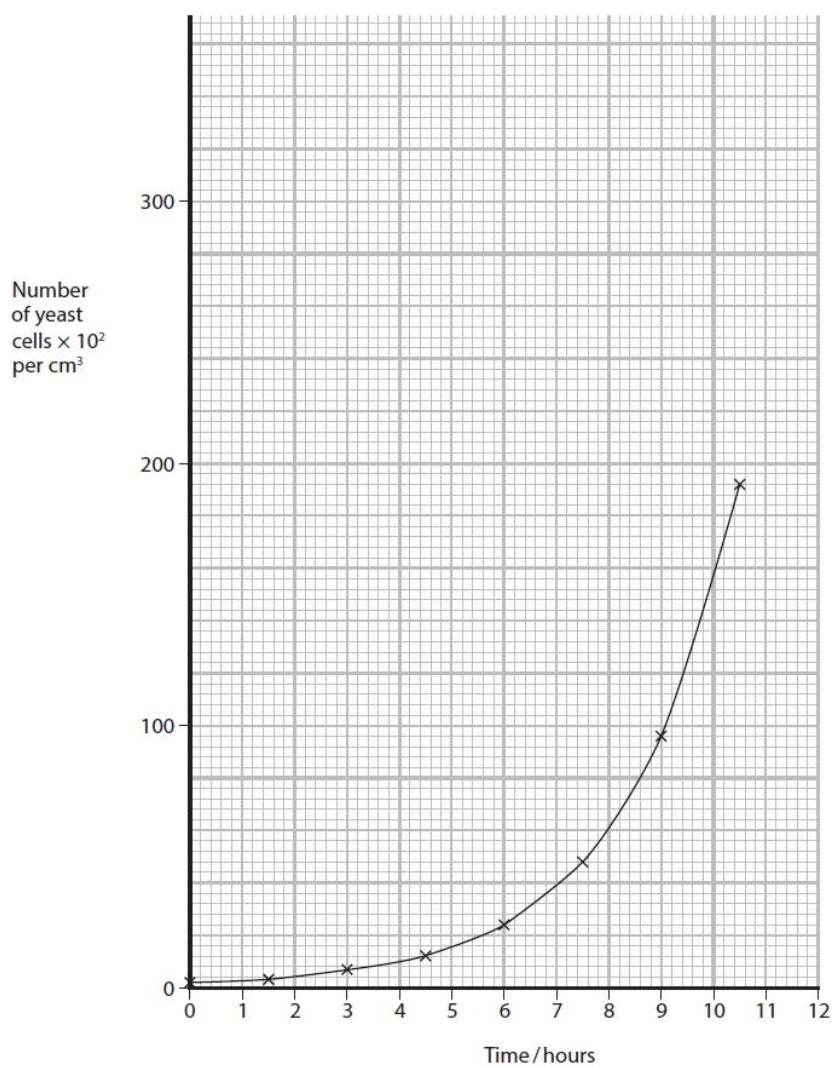
(i) Calculate the percentage increase in the number of yeast cells from 2 hours to 6 hours.

(2)

Answer .... %

(ii) Predict the number of cells per cm^3 of the culture at 12 hours.

Assume that the culture continues to grow at the same rate.

(1)

Answer .... $\times 10^2$ per cm^3

(Total for question = 3 marks)

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.

The student counted the yeast cells using a haemocytometer.

The table shows the number of cells counted using a haemocytometer.

Time /hours	Number of cells						
	1	2	3	4	5	Mean	Standard deviation (SD)
0.0	1	2	2	1	2	1.6	0.5
1.5	2	3	3	3	2	2.6	0.5
3.0	4	9	9	3	7	6.4	
4.5	13	10	12	9	16	12.0	2.7
6.0	43	31	18	14	15	24.2	12.5

(i) The student calculated the standard deviations using the following formula.

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Calculate the standard deviation for the sample at 3 hours.

(3)

(ii) The student concluded that the yeast population doubles every 90 minutes.

Comment on the validity of this conclusion.

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(Total for question = 6 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		
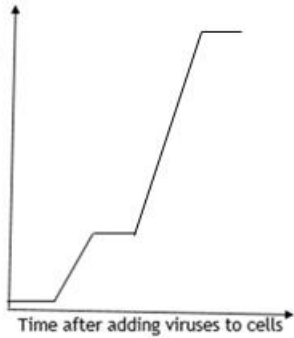
Q2.

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 Log₁₀ number of lysed cells vs Time after adding viruses to cells	(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
	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)

Q8.

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 estroyed} **(1)** • *Staphylococcus* releases exotoxins / endotoxins come from *Salmonella* **(1)**	**Accept** soon after meal / quickly / by {12 / 1} o clock **Do not accept** *Staphylococcus* is an exotoxin / *Salmonella* 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 *Staphylococcus*) **(1)** • use Gram stain to show presence of Gram positive bacteria **(1)** • grow on selective media that identify {*Staphylococcus* / eliminates other bacteria} **(1)** • use antibodies against *Staphylococcus* **(1)**	**Accept** a description of how this is done e.g. streak plating from a faecal sample **Accept** *Staphylococci* will appear purple with Gram stain **Accept** differential media / selective agar / named example e.g. mannitol salt agar / with antibiotics	**(4)**

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to four of the following: • medium allows only {*Salmonella* / 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 x 10³ = 3.6989700043 and log 4 x 10⁶ = 6.6020599913 (6.6020599913 - 3.6989700043) ÷ (0.301 × 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 *Salmonella* will not be replicating (in lag phase) (1)	**ACCEPT** converse for actual value **ACCEPT** converse for actual value **ACCEPT** dividing / growing	(3)

Q10.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to two of the following: • {flame / sterilise / autoclave} apparatus to kill bacteria (1) • clean surfaces with {bleach / disinfectant / alcohol} to kill bacteria (1) • open lid of Petri dish slightly to prevent access by bacteria (1) • work near Bunsen flame to {create updraft / prevent bacteria settling} (1)	Accept microbes / spores for all points	(2)

Q11.

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)

Q12.

Question Number	Answer	Additional Guidance	Mark
(i)	• Correct calculation of number of cells (1) • Conversion to standard form (1)	Example of calculation $\dfrac{7 \text{ divided by } 0.004}{8}$ = $\begin{array}{l}1750 \text{ per mm}^3 \\ 2000 \text{ per mm}^3\end{array}$ $1.75 / 1.8 / 2 \times 10^3$ 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)**

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of difference (1) • calculation of % increase (1)	Example of calculation 2400 – 400 = 2000 24 – 4 = 20 $\frac{2000}{400}$ x 100 = 500 (%) $\frac{20}{4}$ x 100 = 500 Correct answer with no working gets 2 marks	**Grad (2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• correct answer (1)	384 ($\times 10^2$ per cm^3) Accept 360 to 400 ($\times 10^2$ per cm^3)	**Grad (1)**

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of $\Sigma (x - \bar{x})^2$ (1) • divided by {4 / n-1} (1) • calculation of SD (1)	Example of calculation 31.2 7.8 2.8 2.498 / 2.5 gets mp1 if some working shown (31.2 divided by 5) Correct answer with no working gains 3 marks	**Exp (3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer including the following: • SD for times 0, 1.5, 3 and 4.5 hours are non-overlapping, so this conclusion is likely to be valid (1) • SD for 6 hours overlaps with SD for 4.5 hours, so this conclusion is not likely to be valid (1) • description of possible error (1) • value of 43 may be an anomalous result (so this conclusion may not be valid) (1)	 Accept SD for 6 hours overlaps with SD for 4.5 hours with comment on difference / significance Accept eg dilution error, measurement error, counting error	 **Exp (3)**