

PEARSON EDEXCEL A-LEVEL BIOLOGY B • 9B10

BIOLOGY



EXAM QUESTION PACK

TOPIC 6: MICROBIOLOGY AND PATHOGENS
BACTERIA AS PATHOGENS

SCORE

/62

PERCENTAGE

%

STEMUP

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Q1.

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 the advantages of using this technique in public health laboratories.

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Q2. Human diseases can be caused by many different types of organism, such as bacteria and viruses.

(a) Give **two** differences between the genetic material of bacteria and viruses.

(2)

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(b) Tuberculosis (TB) is caused when droplets, containing the bacterium *Mycobacterium tuberculosis*, are inhaled into the lungs.

In the lungs, large numbers of the bacterium are formed rapidly. These can be ingested by macrophages. Eventually, tubercles (tissue masses), containing dormant bacteria inside macrophages, may form.

(i) Describe how macrophages ingest the bacteria.

(2)

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(ii) Suggest why treatment with antibiotics may not be effective against the dormant bacteria in the tubercles.

(2)

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(iii) TB can be prevented by vaccination. Explain how a person can develop artificial active immunity following vaccination.

(3)

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(c) In a person with TB, the dormant bacteria in tubercles may be activated after several years. The bacteria multiply rapidly, resulting in severe lung damage.

The bacteria are released from the tubercles. These bacteria can inhibit the activity of T cells and infect other organs.

Explain why the activity of these bacteria and the inhibition of T cells means that a person may quickly develop severe symptoms leading to death.

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(Total for Question = 13 marks)

Q3.

Which of the four statements describes the *Salmonella* endotoxin?

(1)

- ☐ **A** lipopolysaccharide in the cell wall membrane
- ☐ **B** lipopolysaccharide secreted by the cell
- ☐ **C** polypeptide in the cell wall membrane
- ☐ **D** polypeptide secreted by the cell

Q4.

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.

(3)

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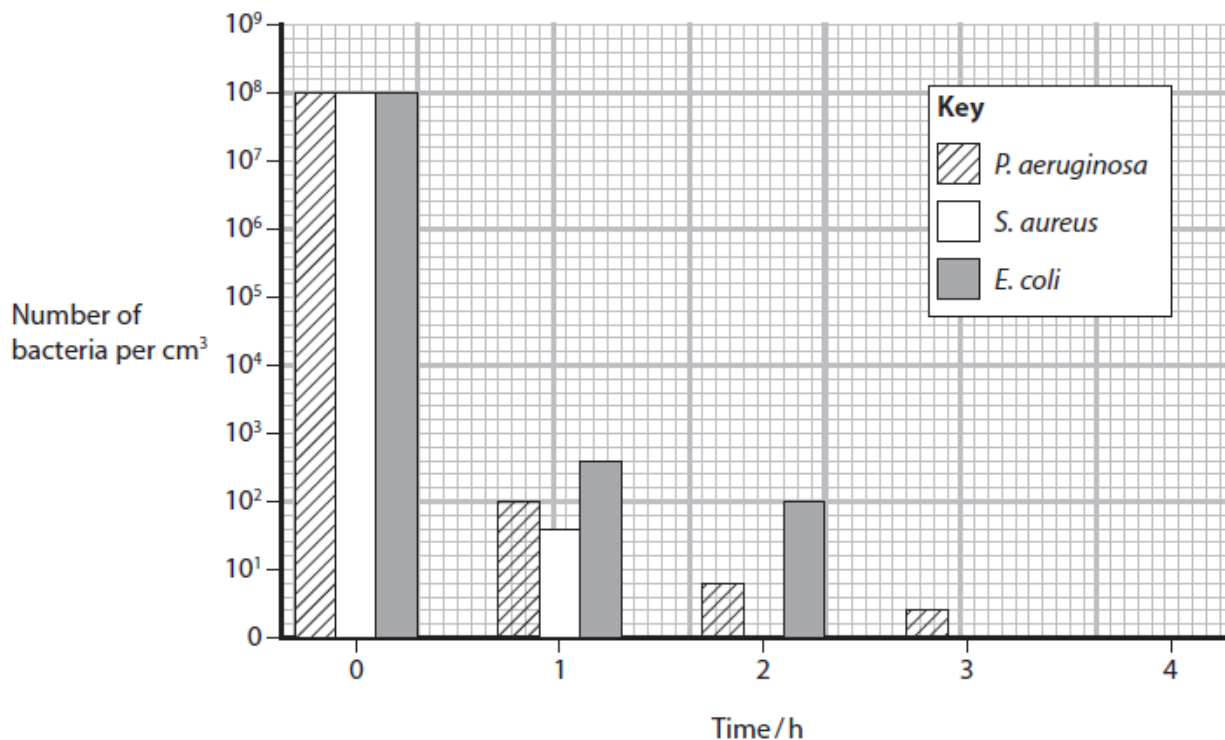
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(ii) In this investigation, living bacteria of each species were exposed to UV radiation for four hours.

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)

Q5.

The pathogenic effects of bacteria can be due to the toxins they release.

Endotoxins are released by Gram negative bacteria.

(i) Name **one** type of Gram negative bacteria that releases endotoxins.

(1)

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(ii) Give **one** difference between the structure of Gram negative bacteria and Gram positive bacteria.

(1)

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(Total for question = 2 marks)

Q6.

Endotoxins are usually less toxic than exotoxins.

The LD₅₀ value is the mass of the chemical per kg of body mass that would kill half the number of rodent animals.

The LD₅₀ value can be used to indicate how toxic a chemical is.

One endotoxin has an LD₅₀ value of 11 ng kg⁻¹.

The mean body mass of a group of rodents is 28 g.

Calculate the mass of endotoxin given to each rodent that would kill half of the rodents in this group.

(1)

Answer ng

(ii) State **two** differences, other than toxicity, between endotoxins and exotoxins.

(2)

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(Total for question = 3 marks)

Q7.

Antibiotics have been developed to control bacterial infections.

(a) Name **one** bacterium which causes symptoms of infection by producing exotoxins.

(1)

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(b) Explain how an antibiotic has a bacteriostatic effect on bacteria.

(2)

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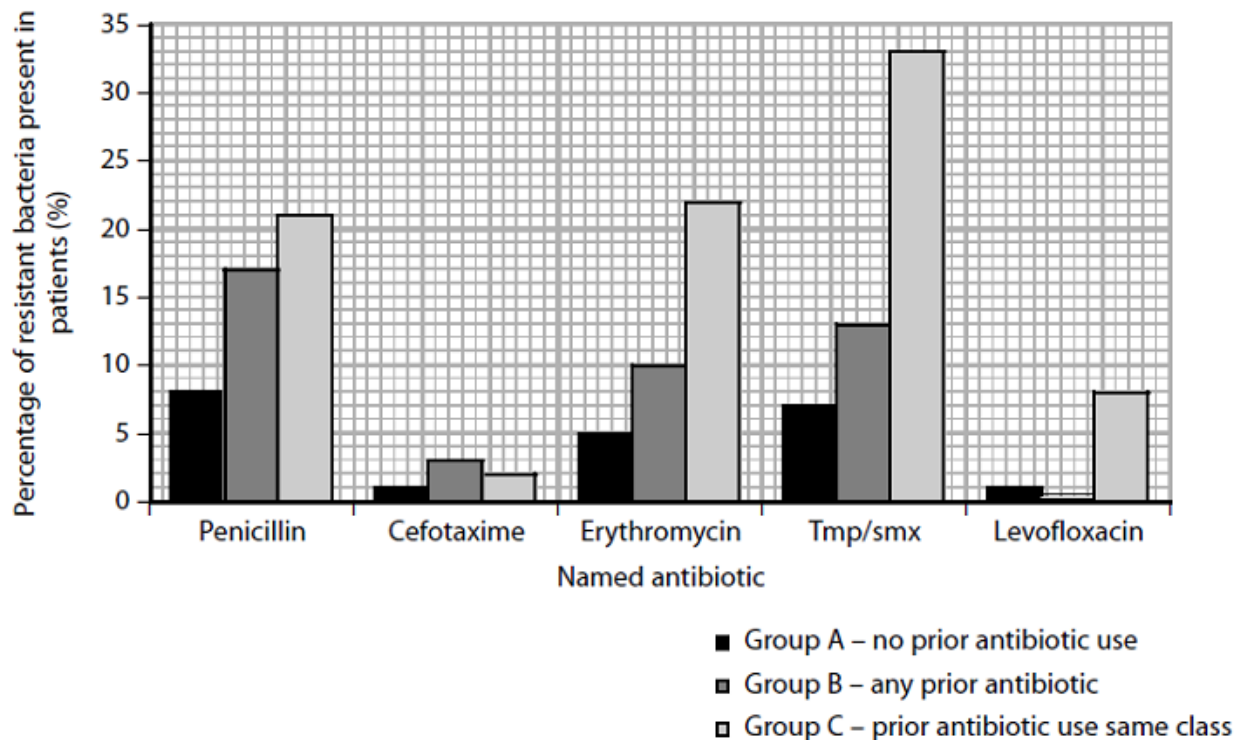
*(c) Bacterial resistance to common antibiotics is an increasingly serious problem facing doctors treating a wide range of infections.

The graph below shows the percentage of resistant bacteria in patients being treated with antibiotics for *Streptococcus pneumoniae* infections.

Group A had never been given antibiotics.

Group B had been previously treated with other antibiotics.

Group C had been previously treated with the named antibiotic.



Analyse the data and use your knowledge of antibiotic resistance to evaluate the claim that soon doctors will be unable to treat most common bacterial infections with antibiotics.

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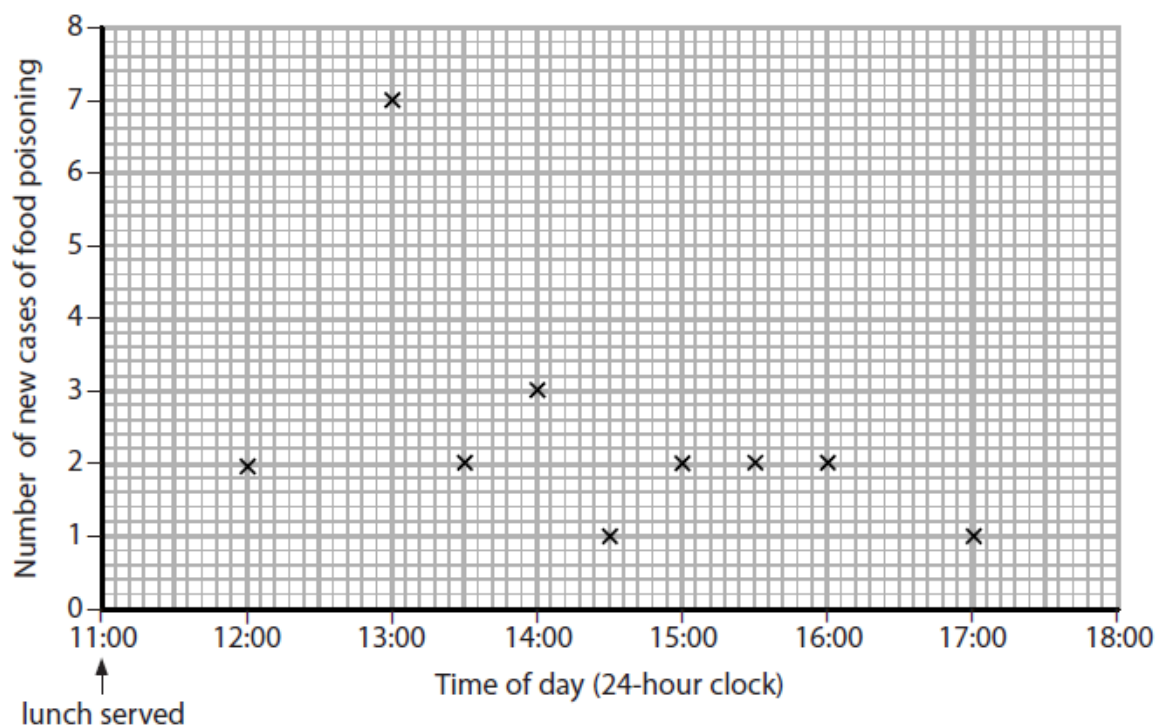
(Total for question = 12 marks)

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.

The Human Immunodeficiency Virus (HIV) infects cells of the human immune system.

(a) (i) Place a cross (☒) in the box next to the name of the type of cell in the human immune system that is infected by HIV.

(1)

☐ **A** B effector cell

☐ **B** B memory cell

☐ **C** T helper cell

☐ **D** T killer cell

(ii) Place a cross (☒) in the box next to the name of the enzyme used to produce DNA from viral RNA in an infected cell.

(1)

☐ **A** DNA polymerase

☐ **B** RNA polymerase

☐ **C** restriction endonuclease

☒ **D** reverse transcriptase

(b) An antibody, known as 2G12, has been isolated from the blood of an HIV patient.

(i) State **two** characteristic features of antibodies.

(2)

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*(ii) The antibody 2G12 is produced in response to part of a glycoprotein found on the surface of HIV. Synthetic molecules have been made that resemble this part of the glycoprotein. The antibody 2G12 binds to these synthetic molecules.

Using the information, suggest how this may enable scientists to develop a means of producing **active** immunity to HIV infection.

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(c) The table below shows some data about groups of people with HIV infection, in the United Kingdom in 2010.

Group	Numbers in the United Kingdom
People newly-diagnosed with HIV infection	6 630
People unaware of their HIV infection	21 625
People receiving treatment for HIV infection	65 000

Some of the figures shown in the table are estimates.

Suggest why data about HIV infections are often estimates.

(2)

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(Total for question = 11 marks)

Q10.

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

Which is the correct statement about *Salmonella*?

(1)

- ☐ **A** *Salmonella* has a thick peptidoglycan cell wall and produces endotoxins
- ☐ **B** *Salmonella* has a thick peptidoglycan cell wall and produces exotoxins
- ☐ **C** *Salmonella* has a thin peptidoglycan cell wall and produces endotoxins
- ☐ **D** *Salmonella* has a thin peptidoglycan cell wall and produces exotoxins

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: • <i>Salmonella</i> food poisoning can spread easily (1) • therefore early identification means quicker treatment and containment of infection (1) • so that the correct antibiotic can be used to help prevent spread of infection and prevent antibiotic resistance if wrong antibiotic used (1)		(3)

Q2.

Question Number	Answer	Additional Guidance	Mark
(a)	1. bacteria have DNA, viruses have DNA or RNA ; 2. idea that bacteria have {circular / eq} genetic material, viruses have {linear / straight} ; 3. bacterial DNA is double-stranded, viral {DNA / RNA} is single (or double) stranded / eq; 4. bacteria (may) have plasmids, viruses do not have plasmids / eq;	NB piece answers together throughout Do not accept in context of plasmid	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	- reference to {phagocytosis / endocytosis / engulfing} ; - credit details of phagocytosis ; - reference to bacterium inside a {vacuole / vesicle / phagolysosome} ;	eg formation of {pseudopodia / membrane extensions around bacteria} / cytoplasmic streaming / binding to bacteria Not phagolysosome	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	- idea that bacteria need to be accessible to antibiotics ; - idea of bacteria inside macrophages ; - reference to waxy layer of (these) bacteria ; - idea that (bacteriostatic) antibiotics affect dividing bacteria; - reference to antibiotic resistance (of these bacteria) ;	Not bacteriocidal antibiotics	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	- idea of {dead / attenuated / eq} {organisms / pathogen / bacterium / eq} put into person; - reference to (stimulation of) {specific / primary} (immune) response ; - credit details of T helper cell activation ; - credit details of B cell activation ; - credit details of T killer cell activation ; - reference to production of memory cells ;	NB not simply crediting ref to vaccination as in stem of question Accept antigen eg macrophages as APCs eg involvement of cytokines, B cells as APCs eg involvement of cytokines, infected cells as APCs	(3)

Question Number	Answer	Additional Guidance	Mark
(c)	- reference to {further lung damage / severe breathing problems / eq} ; - idea that the <i>Mycobacterium</i> get into the {blood / lymph}; - idea that organ failure (leads to death) ; - idea of {reduced / weakened} immune response (due to a loss of T cells) ; - credit detail of role of T (helper) cells ; - credit detail of effect of no T killer cells ; - credit detail of effect of no B cells ; - ref to {secondary / opportunistic / other} infections (causing death) ;	eg cannot obtain enough oxygen eg production of cytokines eg infected cells will not be destroyed eg no antibody produced	(4)

Q3.

Question Number	Answer	Additional guidance	Mark
	A (lipopolysaccharide in the cell wall membrane)		(1)

Q4.

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)	$10^8 - 10^2 = 99\,999\,900$ $\div 10^8 \times 100 = \mathbf{99.9999}$ 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)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	<i>Salmonella</i> (species) (1)	Candidates may name other types of bacteria, each of which will need looking up ACCEPT phonetic spellings ACCEPT <i>Shigella</i>, <i>Neisseria</i>, <i>Escherichia</i>, <i>Pseudomonas</i>, <i>Klebsiella</i>, <i>Proteus</i>, <i>Providencia</i>, <i>Escherichia</i>, <i>Morganella</i>, <i>Aeromonas</i>, <i>Citrobacter</i> ACCEPT specific examples e.g. <i>E.coli</i> IGNORE pathogens DO NOT ACCEPT gram positive bacteria e.g. <i>Actinomyces</i>, <i>Clostridium</i>, <i>Mycobacterium</i>, <i>Streptococci</i>, <i>Staphylococci</i>, <i>Nocardia</i>	(1) EXP

Question Number	Answer	Additional Guidance	Mark
(ii)	gram negative bacteria have {a thinner peptidoglycan cell wall / an (outer) lipopolysaccharide (layer) / an outer membrane } (1)	ACCEPT converse for gram positive bacteria ACCEPT less peptidoglycan murein for peptidoglycan larger periplasm (space) no teichoic acid (in cell wall)	(1) GRAD

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	0.308 / 0.31 / 0.3 (1)		(1) GRAD

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to two of the following: - endotoxins released from Gram negative bacteria (only) but exotoxins released from both Gram negative and Gram positive bacteria (1) - endotoxins are lipopolysaccharides but exotoxins are proteins (1) - endotoxins released from {dead / broken down} bacteria but exotoxins are released from living bacteria (1) - effect of endotoxins is later (1)	DO NOT PIECE TOGETHER	(2) EXP

Q7.

Question Number	Correct Answer	Additional guidance	Mark
(a)	<i>Staphylococcus</i> spp.		(1)

Question Number	Correct Answer	Additional guidance	Mark
(b)	An explanation that makes reference to the following: - the number of living bacteria does not increase (1) - because cell division is prevented (1)	Accept more sophisticated answers that give details of how cell division is prevented	(2)

Question Number	Indicative content	
*(c)	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. Candidates are expected to reach a decision/conclusion on whether the development of bacterial resistance is so serious and rapid that antibiotics will become ineffective in the treatment of the majority of bacterial infections. • Prior use of antibiotics increases the percentage of resistant bacteria, supported by quantitative data • Prior use of the named antibiotic has the greatest effect, supported by quantitative data • Increasing use of antibiotics increases selection pressures so more resistant strains • Shows understanding that resistance mechanisms are inherited by sexual means and lateral gene transfer, e.g. via plasmids and this means they can spread rapidly and in some cases across species • Bacteria have high reproduction rates and mutations more likely within a short time • Understands current methods used to limit increase in resistant strains such as strict controls on antibiotic prescribing, problems of ensuring patients complete course of treatment when symptoms disappear, limit use of antibiotics in animal husbandry etc. • Comments on difficulties of developing new drugs • Methods of preventing spread of resistant strains especially hospital infection • Movement of humans means that transfer of resistant strains will spread to	
Level	Mark	Descriptor
	0	No rewardable material
Level 1	1-3	Provides little or no reference to a range of scientific ideas, processes, techniques and procedures. Scientific argument may be attempted, but fails to link biological concepts and/or ideas in order to support decision/conclusion. Limited attempt to address the question.
Level 2	4-6	Scientific reasoning occasionally supported through the linkage of a range of scientific ideas, processes, techniques and procedures. Scientific argument is partially developed. Attempts to synthesise and integrate relevant knowledge with linkages to biological concepts and/or ideas, leading to a notional scientific argument or decision/conclusion based on evidence.
Level 3	7-9	Scientific reasoning supported throughout by sustained linkage of a range of scientific ideas, processes, techniques or procedures. Scientific argument is well developed and logical. Demonstrating throughout the skills of synthesising and integrating relevant knowledge with consistent linkages to biological concepts and/or ideas, leading to nuanced and balanced scientific argument or decision/conclusion based on evidence.

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 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)

Q9.

Question Number	Answer	Mark
(a)(i)	C T helper cells ;	(1)

Question Number	Answer	Mark
(a)(ii)	D reverse transcriptase ;	(1)

Question Number	Answer	Additional guidance	Mark
(b)(i)	- reference to glycoprotein ; - credit detail of structure e.g. specific (3D) shape, L and H regions, Y-shape, 4 (peptide) chains, disulphide bridges between peptides, hinge region ; - reference to {antigen-binding site / variable region / Fab (region) / eq }; - idea of antibodies have a {similar / constant / Fc / eq } region; - produced by plasma cells / present on B cells ; - role of antibody described e.g. opsonisation, immobilisation, agglutination, lysis ;	1. Accept protein, chains of amino acids 2. Ignore active site Accept a Y-shaped drawing 3. Accept references to {binding to specific antigen / antigen-specific / antigen receptors} 5. Accept present on B effector cells	(2)

Question Number	Answer	Additional guidance	Mark
*(b)(ii)	(QWC – answer must be organised in a clear, logical sequence) 1. reference to artificial (active) immunity ; 2. reference to {vaccine / vaccination} ; 3. containing {synthetic molecule / (synthetic) antigen / (synthetic) glycoprotein} ; 4. ref to stimulation of the {specific / humoral} immune response (to the synthetic antigen) ; 5. credit detail of process of producing effector B cells e.g. clonal expansion of B cells, involvement of cytokines, T helper cells activate B cells ; 6. reference to (production of B) memory cells ; 7. idea that (2G12) antibodies are produced {faster / in greater concentration} on {reinfection / eq} ;	Mps are awarded if the statements are clearly expressed 5. Ignore references to production of activated T killer cells 6. Ignore references to production of T memory cells 7. Accept ref to secondary immune response	(5)

Question Number	Answer	Additional guidance	Mark
(c)	1. idea that HIV infection does not always produce symptoms ; 2. reference to {provirus / latency} ; 3. reference to test needed to detect (symptomless) HIV ; 4. idea that only people who suspect they may have contracted HIV would have a test ; 5. idea that {some people would not want to be tested / impossible to test everyone} ; 6. idea that symptoms are common to other diseases ; 7. {new cases arising/ patients dying} all the time / eq ; 8. idea of new strains of virus arising ;	2. Accept virus is dormant	(2)

Q10.

Question Number	Answer	Mark
	The only correct answer is C A is not correct because <i>Salmonella</i> are gram negative bacteria so will have a thin peptidoglycan cell wall B is not correct because <i>Salmonella</i> are gram negative bacteria so will have a thin peptidoglycan cell wall and they produces endotoxins D is not correct because <i>Salmonella</i> produces endotoxins	(1)