

Microbiology, Immunity and Forensics practice questions

37 questions · 133 marks · mark scheme at the back

For Pearson Edexcel International AS Biology XBI11 and International A Level Biology YBI11. **A Level only** is IA2 content (Units 4 to 6), not needed for the International AS.

Name

Total / 133

Culturing and measuring microorganisms **Spec 6.1-6.4** **A Level only**

1 UNIT 4 STYLE [1 mark]
A Level only

Why are agar plates incubated upside down in a school laboratory?

- A. ☐ Condensation collects in the lid and cannot drip on to the agar
- B. ☐ It gives the bacteria more oxygen
- C. ☐ It stops the agar drying out
- D. ☐ It kills any contaminating fungi

2 UNIT 4 STYLE [4 marks]
A Level only

A student prepares a plate of bacteria using aseptic technique. Explain two precautions that should be taken, giving a reason for each.

3 UNIT 4 STYLE

[3 marks]

A Level only

A broth culture of yeast was diluted using a serial dilution, 1 cm³ into 9 cm³ each time. 0.1 cm³ of the tube diluted to 10⁻³ was spread on agar. After incubation 74 colonies grew. Calculate the number of colony-forming units per cm³ in the original culture. Give your answer in standard form.

Answer = ...

4 UNIT 4 STYLE

[4 marks]

A Level only

Compare and contrast dilution plating with turbidity measurement as methods of finding the growth of a bacterial population.

5 UNIT 4 STYLE

[1 mark]

A Level only

In which phase of the growth curve of bacteria in a closed culture is the rate of cell division equal to the rate of cell death?

- A. ☐ Lag phase
- B. ☐ Exponential phase
- C. ☐ Stationary phase
- D. ☐ Death phase

8

UNIT 6 STYLE

[3 marks]

A Level only

In core practical 13 a student measured the absorbance of yeast cultures every hour. Explain why a sample of sterile broth was used in the colorimeter, and why the culture was swirled before each sample was removed.

Bacteria, viruses and infection

Spec 6.5–6.7

A Level only

9

UNIT 4 STYLE

[1 mark]

A Level only

Which feature is present in HIV but not in lambda phage?

- A. ☐ An envelope containing viral glycoproteins
- B. ☐ A protein capsid
- C. ☐ Nucleic acid as genetic material
- D. ☐ Reproduction only inside a host cell

10

UNIT 4 STYLE

[4 marks]

A Level only

Compare and contrast the structure of a bacterium with the structure of a virus such as tobacco mosaic virus.

11

UNIT 4 STYLE

[4 marks]

A Level only

Explain what is meant by the terms lytic and latency in relation to viruses.

A Level only

Describe how HIV enters a helper T cell and is replicated.

A Level only

Explain how infection with *Mycobacterium tuberculosis* can lead to damage to the lungs.

A Level only

Describe how the skin, the stomach and the gut flora help to protect the body from infection.

A Level only

A nurse is infected with a pathogen after a needle-stick injury. By which route did the pathogen enter her body?

- A. ☐ Through the gas exchange system
- B. ☐ Through the digestive system
- C. ☐ Through a break in the skin
- D. ☐ Across the placenta

The immune response

Spec 6.8–6.12

A Level only

16

UNIT 4 STYLE

[4 marks]

A Level only

Explain how inflammation helps to destroy pathogens at a site of infection.

17

UNIT 4 STYLE

[4 marks]

A Level only

Describe how interferon and lysozyme each help to protect the body from infection.

18

UNIT 4 STYLE

[3 marks]

A Level only

Explain why an antibody that binds to the surface of one species of bacterium does not bind to a different species.

21 UNIT 4 STYLE

[4 marks]

A Level only

Compare and contrast natural passive immunity with artificial active immunity.

[illegible]

22 UNIT 4 STYLE

[1 mark]

A Level only

A baby is protected from infection by antibodies in colostrum. What type of immunity is this?

- A. ☐ Natural active
B. ☐ Natural passive
C. ☐ Artificial active
D. ☐ Artificial passive

23 UNIT 4 STYLE

[5 marks]

A Level only

Explain how the way in which HIV evades the immune system supports the theory of an evolutionary race between pathogens and their hosts.

.....

Antibiotics and infection control Spec 6.13–6.15 A Level only

24 UNIT 4 STYLE

[1 mark]

A Level only

Which statement describes a bacteriostatic antibiotic?

- A. ☐ It kills bacteria by making holes in the cell-surface membrane
- B. ☐ It prevents bacteria multiplying without necessarily killing them
- C. ☐ It kills viruses in infected cells
- D. ☐ It destroys the immune cells that target bacteria

A Level only

Penicillin is a bactericidal antibiotic that prevents the formation of cross-links in the bacterial cell wall. Explain why penicillin kills bacteria but does not harm human cells, and why it does not kill viruses.

A Level only

A student investigated the effect of four antibiotics on a bacterium using discs on an agar plate. Disc E was a control. (a) Calculate the area of the zone of inhibition around antibiotic C. (2) (b) State which antibiotic was most effective and give a reason. (2) (c) Explain the purpose of disc E, and suggest what it contained. (2)

Diameter of zones of inhibition

Disc	Diameter of zone / mm
A	18
B	0
C	11
D	25
E (control)	0

A Level only

Describe how the risks are reduced when an investigation into the effect of antibiotics on bacteria is carried out in a school laboratory.

A Level only

MRSA is a common cause of hospital-acquired infection. Explain how an understanding of the causes of hospital-acquired infections has led to changes in hospital practice and in the prescription of antibiotics.

A Level only

A doctor refuses to prescribe antibiotics to a patient with a cold. Give three reasons that support the doctor's decision.

Decay, DNA techniques and forensics

Spec 6.16–6.20

A Level only

30

UNIT 4 STYLE

[4 marks]

A Level only

Explain the role of saprotrophic bacteria and fungi in the recycling of carbon.

31

UNIT 4 STYLE

[1 mark]

A Level only

Which step of the polymerase chain reaction takes place at about 72 °C?

- A . ☐ Denaturation of DNA
- B . ☐ Annealing of primers
- C . ☐ Extension of new strands by Taq polymerase
- D . ☐ Cutting of DNA by restriction enzymes

32

UNIT 4 STYLE

[4 marks]

A Level only

Describe the stages in one cycle of the polymerase chain reaction.

33

UNIT 4 STYLE

[2 marks]

A Level only

Calculate the number of copies of a DNA sequence after 25 cycles of PCR, starting with a single molecule. Give your answer in standard form to two significant figures.

Answer = ...

A Level only

A sample of DNA was cut with a restriction enzyme and the fragments were separated by gel electrophoresis alongside a DNA ladder. The table shows the distance moved by the ladder bands. A band from the sample moved 33 mm. (a) Explain why the DNA fragments move through the gel and why shorter fragments move further. (2) (b) Use the table to estimate the length of the fragment in the sample. (2)

DNA ladder	
Length of fragment / base pairs	Distance moved / mm
5000	12
3000	20
2000	27
1000	38
500	47

A Level only

Why do muscles become stiff (rigor mortis) after death?

- A. ☐ No ATP is available, so myosin heads stay attached to actin
- B. ☐ Calcium ions are no longer released, so actin and myosin are locked together
- C. ☐ Lactic acid denatures the muscle proteins
- D. ☐ Blood clotting prevents muscle fibres moving

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [1] A Level only

A A (1)

2. [4] A Level only

- sterilise the agar plates and loop before use (1) to kill all microorganisms / so that only the chosen organism grows (1)
- flame the loop until red hot and cool it before use (1) kills contaminants; a cool loop does not kill the culture (1)
- flame the neck of the bottle / work near a Bunsen flame (1) updraught carries airborne microorganisms away / kills microorganisms at the neck (1)
- open the Petri dish lid only slightly and briefly (1) to stop airborne microorganisms entering (1)
- tape the lid with short strips (1) so that oxygen can enter and anaerobic pathogens do not grow (1)
- incubate at 25 °C, not 37 °C (1) to reduce growth of human pathogens (1)
- disinfect the bench / wash hands (1) to reduce contamination of culture and infection of worker (1)
- Max 4

3. [3] A Level only

- $74 \div 0.1 = 740$ (cfu per cm^3 of the diluted sample) (1)
- $\times 10^3$ (dilution factor) (1)
- 7.4×10^5 cfu per cm^3 (1) (allow 7.4×10^5 without working for 3)

4. [4] A Level only

- both can be used to estimate the number of bacteria / both can be used over time to follow growth (1)
- dilution plating counts only living cells (1) whereas turbidity counts living and dead cells (1)
- dilution plating needs incubation / takes a day or more, but turbidity gives an immediate reading (1)
- turbidity does not destroy the sample / can be repeated on the same culture, dilution plating uses up samples (1)
- turbidity needs a calibration curve to convert to cell numbers (1)
- Max 4

5. [1] A Level only

C C (1)

6. [7] A Level only

- (a) lag phase (1)
- cells are adjusting to the medium / synthesising enzymes, with no division yet (1)
- (b) change in $\log_{10} = 6.0 - 3.6 = 2.4$ (1)
- generations = $2.4 \div 0.301 = 8$ (allow 7.97) (1)
- $k = 8 \div 4 = 2.0$ generations per hour (1)
- (c) stationary phase / number of living cells constant (1)
- nutrients limiting / toxic waste accumulating (1) so the rate of cell division equals the rate of cell death (1)
- (c) max 2; Max 7 overall

7. [6] A Level only

- independent variable: set up water baths at several temperatures (at least five, over a suitable range such as 20 to 40 °C) (1)
- same volume of sterile broth and same starting yeast concentration / volume of inoculum in each flask (1)
- dependent variable: measure absorbance in a colorimeter / count cells / dilution plating at regular intervals (1)
- plot cell number or absorbance against time and compare gradients / calculate growth rate constant (1)
- repeat at least three times and calculate means (1)
- control other variables, for example pH, glucose concentration, aeration, same strain (1)
- use aseptic technique / sterile pipettes and equipment (1)
- use a harmless strain / risk assessment / lab coat and gloves (1)
- autoclave or disinfect cultures before disposal / use no more organisms than needed / dispose of cultures responsibly (1)
- Max 6

8. [3] A Level only

- sterile broth acts as a blank / sets zero absorbance (1)
- so that the absorbance recorded is only due to the yeast cells (1)
- swirling resuspends the cells (1) so that the sample is representative / cells settled at the bottom would give an inaccurate reading (1)
- Max 3

9. [1] A Level only

A A (1)

10. [4] A Level only

- both contain nucleic acid as genetic material (1)
- bacterium has DNA, but TMV has RNA (1)
- bacterium has cell wall / cell-surface membrane / cytoplasm, virus has none (1)
- bacterium has (70S) ribosomes, virus has none (1)
- virus has a protein capsid, bacterium does not (1)
- bacterium is much larger / virus is smaller (1)
- Max 4 (must include at least one similarity and one difference)

11. [4] A Level only

- lytic: the virus replicates / makes many new virus particles inside the host cell (1)
- the host cell bursts / lyses releasing the new particles (1)
- latency: viral nucleic acid is present in the host cell without producing new virus particles (1)
- for example, DNA integrated into the host chromosome as a prophage / provirus (1)
- and can later enter the lytic cycle (1)
- Max 4

12. [5] A Level only

- glycoprotein (gp120) on the viral envelope binds to CD4 receptor on the helper T cell (1)
- envelope fuses with the cell-surface membrane / capsid enters the cytoplasm (1)
- reverse transcriptase makes DNA from viral RNA (1)
- DNA is inserted into the host chromosome (1) as a provirus (1)
- host cell makes viral RNA and proteins / transcription and translation (1)
- new viruses assemble and bud off from the cell surface, taking part of the membrane as envelope (1)
- Max 5

13. [4] A Level only

- bacteria inhaled reach alveoli and are engulfed by macrophages (1)
- bacteria are not digested / survive inside macrophages (1) because they prevent lysosomes fusing with phagosome / have a waxy cell wall (1)
- immune system forms tubercles around the infected cells (1)
- if immunity is weakened, the tubercle breaks down and bacteria spread (1)
- lung tissue is destroyed / cavities form, reducing gas exchange (1)
- Max 4

14. [3] A Level only

- skin: keratinised layer forms a physical barrier / sebum makes surface acidic / skin flora compete with pathogens (1)
- stomach: hydrochloric acid at about pH 1 to 2 kills most pathogens in food and drink (1)
- gut flora: compete with pathogens for nutrients and space / produce substances that inhibit pathogens (1)

15. [1] A Level only

C C (1)

16. [4] A Level only

- mast cells / damaged cells release histamine (1)
- vasodilation increases blood flow to the area (1)
- capillary walls become more permeable, so more tissue fluid / plasma leaves (1)
- phagocytes / neutrophils / macrophages move out of the capillaries to the site (1)
- phagocytes engulf and digest pathogens (1)
- Max 4

17. [4] A Level only

- interferon is released by virus-infected cells (1)
- it binds to receptors on neighbouring cells (1)
- switching on genes for enzymes that break down viral mRNA / stop protein synthesis (1)
- lysozyme hydrolyses peptidoglycan in the bacterial cell wall (1)
- so the cell bursts by osmosis (1)
- Max 4

18. [3] A Level only

- antibody has a specific tertiary structure in the variable region (1)
- which is complementary in shape to the antigen on the first bacterium (1)
- the different species has different antigens that do not fit the antigen-binding site (1)

19. [6] A Level only

- macrophage / antigen-presenting cell presents antigen on its surface (1)
- T helper cell with complementary receptor binds to the antigen and is activated (1)
- T helper cell divides / clonal expansion and releases cytokines (1)
- cytokines activate B cells with complementary antibody receptors (1) which divide by mitosis and differentiate into plasma cells and B memory cells (1)
- plasma cells secrete antibody (1)
- cytokines activate T killer cells (1) which kill infected cells by releasing perforin / enzymes (1)
- T memory cells and B memory cells produced for future responses (1)
- Max 6

20. [5] A Level only

- (a) after the first dose the antibody concentration rises slowly / takes about 14 days to rise significantly (1)
- after the second dose the concentration rises much faster / is 95 units by day 35, 7 days later (1)
- the peak after the second dose is higher (150 compared with 30 units) (1)
- (b) memory cells are present after the first dose (1)
- they divide rapidly into plasma cells that secrete large amounts of antibody (1)
- Max 5

21. [4] A Level only

- both involve antibodies in the blood / both give protection against a pathogen (1)
- natural passive: antibodies come from the mother (across the placenta or breast milk) and artificial active: antibodies are made by the person after vaccination (1)
- passive does not form memory cells, active does (1)
- passive protection is immediate but short-lived, active takes time but lasts longer (1)
- Max 4

22. [1] A Level only

B B (1)

23. [5] A Level only

- HIV has a high mutation rate because reverse transcriptase makes errors / does not proofread (1)
- so surface antigens (gp120) change / antigenic variation (1)
- memory cells and antibodies for the earlier antigens do not recognise the new antigens (1)
- HIV infects helper T cells, destroying them, so the immune response fails / HIV hides in cells as a provirus (1)
- pathogens with advantageous mutations survive, reproduce and pass them on (natural selection), then hosts evolve further resistance (1)
- Max 5

24. [1] A Level only

B B (1)

25. [4] A Level only

- cross-links in the peptidoglycan wall cannot form, so the wall is weakened (1)
- water enters by osmosis / the cell bursts (1)
- human cells have no cell wall / peptidoglycan, so are not affected (1)
- viruses have no cell wall / are not cells / replicate inside host cells (1)
- Max 4

26. [6] A Level only

- (a) radius = 5.5 mm (1)
- area = $\pi \times 5.5^2 = 95 \text{ mm}^2$ (allow 95.0 or 95.03) (1)
- (b) antibiotic D (1)
- the largest zone of inhibition / bacteria least able to grow (1)
- (c) shows that the paper disc / solvent has no effect on growth (1)
- sterile water / no antibiotic (1)

27. [4] A Level only

- use a non-pathogenic strain / harmless bacteria (1)
- use aseptic technique / flame loop and forceps / sterile equipment (1)
- tape the lids with short pieces and do not open the plates after incubation (1)
- incubate at 25 °C, not 37 °C (1)
- wash hands / disinfect the bench / wear a lab coat (1)
- autoclave or disinfect all plates and equipment before disposal (1)
- Max 4

28. [6] A Level only

- patients have weakened immune systems / are vulnerable, so infected patients are isolated / screened (1)
- bacteria are spread by hands of staff, so hand washing / alcohol gel between patients (1)
- equipment / surfaces contaminated, so sterilise instruments / cleaning (1)
- wounds / catheters give entry to pathogens, so aseptic technique / remove devices early (1)
- overuse of antibiotics selects for resistant bacteria (1)
- so antibiotics are prescribed only when necessary / not for viral infections (1)
- use narrow-spectrum antibiotics / test for sensitivity first / reserve antibiotics / take the course as prescribed (1)
- Max 6

29. [3] A Level only

- colds are caused by viruses (1) and antibiotics do not work on viruses (1)
- unnecessary use of antibiotics selects for resistant bacteria (1)
- antibiotics may kill gut / normal flora and allow pathogens such as *C. difficile* to grow (1)
- possible side effects / allergic reaction (1)
- Max 3

30. [4] A Level only

- they secrete (extracellular) enzymes onto dead organisms / waste (1)
- which digest / hydrolyse organic compounds to soluble products (1)
- the microorganisms absorb the products and use them in respiration (1)
- releasing carbon dioxide into the atmosphere (1)
- which is taken up by producers in photosynthesis (1)
- Max 4

31. [1] A Level only

C C (1)

32. [4] A Level only

- heat to about 95 °C to separate the two strands / break hydrogen bonds (1)
- cool to about 55 to 65 °C so that primers anneal / bind to the complementary sequences (1)
- heat to about 72 °C (1)
- Taq polymerase adds nucleotides to the primers to make complementary strands (1)
- Max 4

33. [2] A Level only

- $2^{25} = 33\,554\,432$ (1)
- 3.4×10^7 (1)

34. [4] A Level only

- (a) DNA is negatively charged (phosphate groups) so it moves towards the anode / positive electrode (1)
- smaller fragments move more easily through the gel mesh (1)
- (b) the band lies between the 2000 and 1000 base pair bands (1)
- estimate of 1300 to 1500 base pairs (1) (the band is a little over half way between the 2000 and 1000 bands; accept 1300 to 1500)

35. [4] A Level only

- (a) man 1 (1)
- the child has bands D and F, which the mother does not have, and man 1 has both while man 2 has neither (1)
- (b) other men might share the same bands by chance / the bands might match another man (1)
- only a small number of loci were used / more loci are needed to reduce the probability of a chance match (1)

36. [6] A Level only

- body temperature: measure core temperature and compare with 37 °C (1)
- body cools towards the surroundings, so a lower temperature suggests a longer time since death (1)
- rate affected by air temperature / clothing / body mass, which must be recorded (1)
- rigor mortis: ATP not made, so myosin heads cannot detach from actin and muscles stiffen (1)
- begins a few hours after death and passes off after 1 to 2 days, so the stage shows time since death (1)
- insects: blowflies lay eggs, hatch into larvae and pupate (1)
- the species and size / stage of the oldest larvae show the time since eggs were laid (1)
- growth depends on temperature, so allowance is made / degree days (1)
- the succession of species shows the stage of decomposition (1)
- using more than one method gives a more reliable estimate (1)
- Max 6

37. [1] A Level only

A A (1)