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CCEA A2

BIOLOGY EXAM PRACTICE

MARK SCHEME

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Unit A2 1:

Physiology, Co-ordination and Control, and Ecosystems

Chapter 1 – Homeostasis and the Kidney

1 **(a)** The removal of the toxic waste of metabolism; [1]

(b) *Basement membrane* – the effective filter during ultrafiltration;

only allowing substances/molecules below a certain size to enter the nephron/ Bowman's capsule; [2]

collecting duct – water is removed from the urinary filtrate (in the collecting duct) and enters surrounding capillaries by osmosis;

(the part of the nephron) where osmoregulation takes place/enough water is removed to ensure the blood solute potential remains normal; [2] **[5]**

2 Any **three** from:

- the capillaries are tightly coiled
- the efferent capillaries are thinner than the afferent capillaries
- the presence of pores in the capillary wall
- the blood is at high pressure (due to the renal artery being relatively close to the heart)

[3] **[3]**

Note: this answer emphasises the importance of reading the question carefully. If the question had only asked how the structure of the capillaries was adapted to facilitate ultrafiltration then bullet point four would not be credited.

3 **(a)** **(i)** Arrow from right to left into the cell; [1]

(ii) Presence of microvilli;

to increase the surface area for reabsorption/increase the number of receptors for active transport;

or

infolding of cell inner membrane/basal invaginations;

to increase the surface area for reabsorption/increase the number of receptors for active transport;

or

(many) mitochondria;

to provide the ATP/energy required for reabsorption/active transport; [2]

(iii) Facilitated diffusion is involved as glucose is too large to cross the membrane by (simple) diffusion;

(facilitated diffusion) occurs when there is a greater concentration of glucose in the PCT lumen/when the concentration gradient permits;

active transport occurs when transport (of glucose) is against the concentration gradient; [3]

Note: this is an example of a question requiring synoptic knowledge or understanding (i.e. knowledge or understanding from AS). Membrane structure and methods of transport across membranes are two parts of AS content frequently required in A2 papers – largely because they underpin so many aspects of biology.

(b) (i) 0.5 (arbitrary units) is the minimum concentration that will be in the blood/there is always some glucose in the blood; [1]

(ii) As blood glucose concentration increases more glucose is reabsorbed (into the blood);

all the glucose is reabsorbed/there is an exact correlation/or by example, e.g. when 1 au in blood then 1 au is reabsorbed; [2]

Note: this is a 'describe' question, so an explanation is not required. However, while the first mark is very straightforward the second is much more demanding and would only be awarded to those students who pick up the fact that all the glucose is reabsorbed within this range.

(iii) All the (glucose) carriers are involved/there are not enough carriers to absorb more glucose/rate limited by the number of carriers present; [1]

(c) Osmosis;

as glucose enters the cells/blood vessels (surrounding the lumen of the nephron) it lowers their solute/water potential (increasing the concentration gradient); [2] **[12]**

4 (a) (i) Loop of Henle; [1]

(ii) Medulla; [1]

(iii) Decreases the solute/water potential of the medulla;

for the absorption of water from the collecting ducts;

by the creation of a salt gradient in the medulla (as a consequence of the ions being removed from the ascending limb);

some water leaves the descending limb (by osmosis and enters surrounding capillaries); [4]

(b) ADH increases the permeability of the collecting ducts (and the distal convoluted tubule) to water;

leading to more reabsorption from the collecting ducts (back into the blood);

the concentration of ADH in the blood is linked to the solute/water potential of the blood to control the amount of water reabsorption/the more ADH in the blood the more water is reabsorbed (or converse); [3] **[9]**

5 **(a)** Homeostasis is the maintenance of a steady/constant state (within the body); [1]

(b) **(i)** Hypothalmus; [1]

(ii) Exercise/not drinking enough water/other appropriate response (e.g. high rate of sweating in very hot weather); [1]

Note: as with most 'suggest' questions there are a range of possible correct answers. The key thing is that you have to suggest something that could cause the blood's solute potential to decrease (i.e. the blood becomes more concentrated). The key thing is working out exactly what is required – many students will get confused by 'decreased water potential' and think that the blood becomes more dilute and answer 'drinking water'!

(iii) More ADH is released into the blood;

making the walls of the collecting ducts (and distal convoluted tubules) more permeable;

leading to the reabsorption of more water; [3]

(iv) Negative feedback; [1] **[7]**

Chapter 2 – Immunity

1 **(a)** **(i)** Time required to activate (appropriate) B-lymphocyte;

time to produce plasma cells; [2]

(ii) (Faster response as) memory cells (that produce the antibodies) are already present;

(more antibodies as) more plasma cells as both memory cells and reactivated B-lymphocytes are producing the plasma cells which produce antibodies; [2]

(b) Antibodies combine with complementary antigens (on the pathogens);

causing agglutination/clumping of pathogens; [2]

(c) Phagocytosis;

polymorphs/phagocytes engulf the pathogens;

enzymes (within the polymorph) hydrolyse the pathogens; [3] **[9]**

2 Cell-mediated;

plasma;

active; [3] **[3]**

3 **(a)** Chemicals/molecules capable of producing a specific immune response (or by example, e.g. specific and complementary antibodies); [1]

(b) **(i)** Killer T-cells destroy (foreign or infected) cells by enzyme action;

helper T-cells stimulate B-cells in the production of antibodies/promote phagocytosis; [2]

(ii) Cytokines communicate between different parts of the immune system/help regulate or control the different components of the immune system; [1]

(iii) Cytokines are released early in the immune response/they will be at a higher level than normal during an infection;

they will be produced in both antibody and cell-mediated immune responses/other appropriate response; [2]

(c) The infection is caused by a strain of flu different to those in the vaccination/flu virus with different antigens;

therefore the body has no memory cells (to this strain); [2]

(d) In an epidemic a higher proportion of the population than normal is affected in a particular region/country; [1] **[9]**

4 **(a)** **(i)** The number of infected individuals in the population will be so low there is little chance of being infected/little chance of an individual being in contact with someone infected (so therefore will not be ill from that disease); [1]

(ii) The vaccination contains antigens similar to antigens found on the relevant disease-causing pathogen;

this causes the production of memory cells;

these memory cells (or plasma cells they produce) lead to the production of large numbers of antibodies that will combat the disease-causing pathogens (before they become established in the body); [3]

(iii) The antibodies are produced by the body (rather than being added to the body); [1]

(b) **(i)** The vaccinations themselves can cause harm/other appropriate response; [1]

(ii) The antigens on the antigen-presenting cells combine with receptors on T-lymphocytes;

this activates/sensitises the T-lymphocyte to divide by mitosis (to form many T-lymphocytes);

these produce a range of T-cells/or by example (e.g. killer and helper T-cells); [3]

(iii) The immune response will be based on both infected body cells (cell-mediated) and 'free' viruses in the blood stream (antibody-mediated); [1] **[10]**

5 **(a)** **(i)**

Blood group of donor	**Blood group of recipient**			
	A	**B**	**AB**	**O**
A	–	–	–	–
B	X	✓	–	X;
AB	X	X	–	X;
O	✓	✓	–	✓;

(Mark by row) [3]

(ii) Blood group AB can receive blood from any (ABO) blood group without causing agglutination;

as AB does not have anti-A or anti-B antibodies (in the plasma); [2]

Note: at A2, many students lose marks by not answering in sufficient detail. A student who answers 'blood group AB can receive blood from any other group' probably understands the concept but this will not be credited (for the first marking point); in reality, any blood group (not just AB) can receive blood from any blood group (it's just that some combinations will cause problems!).

(iii) Agglutination involves the clumping together of blood cells;

which can block capillaries; [2]

(b) **(i)** (Having been pregnant with a Rhesus positive (Rh^+) foetus) as blood cells containing Rh^+ antigens can pass across the placenta from a rhesus positive (Rh^+) foetus;

causing the production of anti-D antibodies (by the mother); [2]

(ii) If the mother has another child who is Rh^+;

any foetal blood cells/Rh^+ antigens passing across the placenta will cause the rapid production of anti-D antibodies (as the B-lymphocytes were already sensitised);

the anti-D antibodies to pass across the placenta to the foetus causing agglutination; [3]**[12]**

6 **(a)** Any **two** from:

• using antibiotics unnecessarily, e.g. for mild infections that will clear up in a few days

• using antibiotics for viral infections (as they will not work)

• not completing the full course of antibiotics

• other appropriate response, e.g. using antibiotics as growth promoters in animals [2]

(b) **(i)** Percentage increase in 12 hours = $96 \div 4 \times 100 = 2400$;

percentage increase per hour = $(2400) \div 12 = 200\%$; [2]

(ii) Percentage of non-resistant bacteria very high/96% initially and falls dramatically to zero immediately after the antibiotic is added;

percentage of resistant bacteria very low/4% initially then rises dramatically to 100% after the antibiotic is added;

the non-resistant bacteria are all killed by the antibiotic leaving only resistant bacteria in the population; [3]

(c) Human/eukaryotic ribosomes are larger/80S than bacterial/70S ribosomes (and are unaffected by this antibiotic)/have a different structure; [1]

(d) High numbers/variety of bacteria are found in the soil;

bacteria naturally produce antibiotics to combat other species of soil bacteria/other appropriate response; [2] **[10]**

7 **(a)** **(i)** Keeping two metres apart from other individuals will reduce the chance of inhaling viruses spread by coughing and sneezing (by other people); [1]

(ii) Elderly/people with underlying health conditions have compromised/weaker immune systems (or by example, e.g. produce fewer T-cells when infected); [1]

(b) **(i)** *Presence of antigens* – if antigens present/a positive antigen test shows that the individual currently has Covid-19 (and could be infectious) (or converse);

presence of antibodies – if antibodies present/a positive antibody test shows that the individual has had Covid-19 (at some stage in the past) (or converse); [2]

(ii) *Antigen test* – individuals who test positive for Covid-19 can be treated for the condition/can be isolated to reduce infection/(health) workers who test negative can return to work/other appropriate response;

Antibody test – individuals who test positive for antibodies ***may*** be immune (so could return to work)/scientists will have data re possibility of herd immunity developing/greater detail re effect of infection, e.g. the percentage of those affected who become seriously ill/other appropriate response; [2]

Note: the presence of antibodies and antigens could be present at the same time – for example, if someone has been ill for a period of time they may have had time to build up antibodies. Additionally, the presence of antibodies will provide evidence of a previous infection, but not necessarily that an individual is immune to further infection and illness from Covid-19.

(iii) Any **two** from:

- the effect of the vaccination lasts for a long time/for life
- there are no serious side effects/does not cause (unanticipated) harm to the patient
- large quantities of the vaccination can be produced relatively cheaply
- other appropriate response [2]

(c) Communicate between different cells/parts of the immune system;

immune system is working at maximum extent (as Covid-19 is a very serious condition)/other appropriate response; [2]

(d) (i) No immune memory in individuals (e.g. no immunity in population/no memory cells produced)/no vaccination (or appropriate drugs) already tested/produced/other appropriate response; [1]

(ii) Any **two** from:

- viruses are less stable (than bacteria) and are more prone to mutate
- particularly viruses with RNA as their nucleic acid
- antibiotics do not work against viruses
- other appropriate response [2] **[13]**

Chapter 3 – Coordination and Control in Plants

1 Phytochrome;

long-day plant;

cytokinin;

internode/by description; [4] **[4]**

2 **(a)** Leaf; [1]

(b) **(i)** Flowering is initiated by decreasing length of continuous light period/increasing length of continuous dark period; [1]

Note: it is worth reminding students that lack of accuracy in answers will cost marks. Some students could answer 'decreasing brightness or increasing darkness' but this wouldn't gain credit. It is the length of the continuous light or dark period that is important (not how bright or dark it is in the relevant period in this question).

(ii) The length of continuous darkness is long enough;

for the concentration of P_{730} to reach a sufficiently low level (so that its inhibitory effect is removed); [2]

(c) **(i)** There is enough daylight to allow P_{660} to be converted to P_{730} to reach a critically high level to initiate flowering/dark periods are not long enough to prevent enough P_{660} being converted to P_{730} to reach a critically high enough level to initiate flowering; [1]

(ii) In light regime 1, the light period is long enough to convert enough P_{660} to P_{730} to initiate flowering/the continuous period of darkness is not long enough to prevent the P_{730} reaching the high/critical level required to initiate flowering;

in light regime 4, the period of far-red light rapidly converts P_{730} to P_{660};

preventing the P_{730} reaching a high enough/critical level to initiate flowering; [3]

(d) In the period before November, subject the dark period to (short period(s)) of light;

this will convert P_{660} to P_{730} rapidly,

preventing the P_{730} reaching the required/critical low level to initiate flowering; [3] **[11]**

3 **(a)** **(i)** 40 μm → 140 μm;

100 ÷ 40 × 100 = 250%; [2]

Note: in reality, to it is possible to work out a percentage increase here without calculating values in μm. The length/height of X is 8 mm before auxin is added and 28 mm after auxin to give a calculation of 20 ÷ 8 × 100 which = 250%.

(ii) The nuclei become elongated in the cells after auxin is added; [1]

(iii) Cells that have recently undergone division will not have started to grow (otherwise impossible to consistently compare growth); [1]

(iv) (A decrease in water potential) will cause water to enter the cell by osmosis which is necessary to cause the cell to become turgid; [1]

(b) **(i)** Letter Y added where the cell length begins to increase; [1]

(ii) As distance from tip increases, auxin rises to a peak and then falls to a lower level than at the tip;

as distance from tip increases, cell length initially is constant, then increases and then levels off;

increasing concentration of auxin causes the increase in cell length;

by making the cell wall more flexible and growth by elongation; [4]

(c) Both act at a site away from where they are produced/other appropriate response;

[1] **[11]**

Chapter 4 – Neurones and Synapses

1 **(a)** Dendrites;

synaptic bulb/knob;

nodes of Ranvier; [3]

(b) **(i)** Period following an action potential when a further stimulus will not produce another action potential/when repolarisation is taking place; [1]

(ii) Ensures action potentials are propagated in one direction only/ensues each action potential is a discrete entity/limits the number of action potentials (per unit time) in one neurone; [1] **[5]**

2 **(a)** **(i)** Y, W, X; [1]

(ii) Z is a cross-section through the node of Ranvier (the others are through the myelin shealth); [1]

(iii) All will be at the same temperature (i.e. body temperature as each of the neurones are in the same nerve); [1]

(b) Initially/between 0 – 1 ms/before the action potential the (inside of) the membrane is –70mV (relative to the outside);

this represents the resting potential/initially the membrane is impermeable to ions;

(after 1ms the inside of) the axon becomes less negative (relative to the outside)/ the membrane starts to become depolarised;

as positive ions diffuse into the membrane;

(the inside of) the membrane reaches a peak of 40 mV (relative to the outside); [5] **[8]**

3 **(a)** **(i)** A neurone cell body correctly identified; [1]

(ii) Arrow correctly added (i.e. somewhere on arc in the direction of receptor to muscle); [1]

(iii) Reflex will be faster;

as fewer synapses (speed of synaptic transmission is slower than neurone conduction); [2]

(iv) To make the brain aware of the reflex taking place/to allow the brain to prevent the reflex taking place (in some circumstances); [1]

(b) **(i)** Y – mitochondria;

Z –neurotransmitter receptors (on the post-synaptic neurone); [2]

(ii) Calcium ions diffuse into the synaptic bulb;

vesicles (containing transmitter) move to the (pre-synaptic) membrane and the neurotransmitter is released by exocytosis;

the neurotransmitter diffuses across the synaptic cleft and binds to receptors on the post-synaptic neurone;

this causes ion channels to open and positive/sodium ions diffuse in;

leading to rapid depolarisation/generation of a EPSP; [5]

(c) 20 [shortest distance];

$20 \times 10^{-9} \div 0.5$;

4×10^{-8} s;

Or

20 [shortest distance];

$20 \div 0.5 \times 10^{9}$;

4×10^{-8} s; [3] **[15]**

Note: in questions involving standard form, students are likely to show conversions in a range of standard form/non-standard form values. For calculations in general, full marks will be awarded to anyone who ends up with the correct answer.

4 **(a)** **(i)** Label M anywhere on membrane of dendron; [1]

(ii) Cell body; [1]

(iii) The inhibitory neurone/H1 releases neurotransmitter;

leading to hyperpolarisation/develops a IPSP in the dendron membrane;

preventing a EPSP being formed/preventing the membrane becoming depolarised; [3]

Note: other possible answers which could be credited involve an understanding of the process of summation (which is not explicitly required by the specification). In one form of summation, a number of excitatory neurones linked with the motor neurone would need to have impulses all contributing to creating a large enough EPSP to produce an action potential. Alternatively, in another type of summation the same neurone would need to produce a number of nerve impulses over time, with each contributing to the development of a high enough EPSP required to produce a nerve impulse in the post-synaptic neurone.

(iv) GABA/other appropriate example; [1]

(b) They are faster/no requirement for the synthesis of neurotransmitter/receptor sites/ other appropriate response; [1] **[7]**

Chapter 5 – The Eye and Muscle

1 **(a)** **(i)** Cornea and lens; [1]

(ii) The ciliary muscle/body relaxes (causing it to spring outwards);
pulling the suspensory ligaments taut;
causing the lens to become thinner (so that it has reduced refractive power); [3]

(b) By focusing on an object with both eyes,
the (slightly) different image produced by each eye allows depth/distance to be estimated; [2] **[6]**

2 **(a)** Visual acuity – precise vision of high resolution;

retinal convergence – the arrangement of rods (in the retina) that allows the sub-threshold generator potential in each rod to combine to reach the threshold required to produce an action potential in the bipolar neurone;

dark adaptation – (the time involved for) the re-synthesis of rhodopsin after exposure to (bright) light; [3]

(b) **(i)** Three different types of cones;
each sensitive to a different colour/cones for blue, green and red;
colours can be determined by the degree of stimulation of each type of cone; [3]

(ii) One of the types of cones is missing/faulty; [1] **[7]**

Note: if the individual is 'unable to distinguish between a small range of colours' only one of the types of cone is likely to be faulty or missing.

3 **(a)** **(i)** Bipolar neurones; [1]

(ii) A vertical arrow pointing upwards; [1]

(iii) Vitreous humour; [1]

(b) Cones provide high visual acuity and rods provide high sensitivity;
each cone is connected to a bipolar neurone;
so that each cone can produce a separate image;
rods show retinal convergence;
so that the sub-threshold generator potential in each rod combines to reach the threshold required to produce an action potential in the bipolar neurone; [5] **[8]**

4 (a) (i) Blind spot; [1]

(ii) No cones/smaller numbers of cones at periphery (of retina);
peak in centre/fovea and no cones in the blind spot; [2]

(iii) Few/no cones at the periphery/cones unable to work in low light levels;
cones necessary for colour vision/rods unable to provide colour vision;
in low light levels, due to retinal convergence, rods are able to distinguish shapes/outlines; [3]

(b) Any **two** from:

- (relatively) more rods/fewer cones;
- larger pupil/eye
- greater degree of retinal convergence
- cells with reflective properties at the back of the eye
- other appropriate response [2] **[8]**

Note: in this question part any reasonable structural suggestion that could increase the amount of light entering the eye or increase the eye's sensitivity to light is likely to be credited.

5 (a) A muscle fibre is a discrete unit within the muscle/a (discrete) unit surrounded by a sarcolemma/containing mitochondria and other structures, e.g. T-tubules;
myofibril is the contractile unit within the muscle fibre containing (mainly) myosin and actin; [2]

(b) (i) Actin filament correctly identified (as one of the thin horizontal lines); [1]

(ii) Any **two** from:

- sarcomere increases in length/distance between Z-lines increases
- H-zone gets larger/region of overlap between the myosin and actin filaments decreases
- I-band becomes longer [2]

Note: this question emphasises the importance of reading the question carefully. Most questions of this type in examination papers ask for differences as the sarcomere contracts, rather than relaxes as asked here. The answers are no more difficult to work out as long as you think through what happens.

(c) **(i)** The muscle is unable to function as normal;

the sarcomere is unable to operate/contract/relax as a (single) unit/some actin filaments move more or less than others/other appropriate response; [2]

(ii) Skeletal and cardiac muscle both have sarcomeres/Z-lines/same muscle ultrastructure but smooth muscle does not; [1] **[8]**

Note: in this question part it would not be enough to state that skeletal and cardiac have the same structure, but smooth muscle is different – the presence or absence of the sarcomere structure with actin filaments is key. Reference to 'ultrastructure' implies molecular level so would be credited.

6 **(a)** **(i)** Arrow left to right; [1]

(ii) The change in orientation/rotation/movement of the myosin heads; [1]

(iii) Allows the myosin head to detach from the actin and return to its original position; [1]

(b) **(i)** If tendons stretched then muscle contraction would not lead to movement of bone/body part(s)/to ensure muscle contraction leads to movement of body part(s); [1]

(ii) Contains three polypeptides intertwined (to give strength)/other appropriate response; [1] **[5]**

Chapter 6 – Populations and Communities

1 **(a)** C;

D;

B;

A and B;

C and D; [5]

(b) The increase in (yeast) cell number is so large/is over several orders of magnitude;
semi-log graph paper caters for very large differences in number/appropriate scaling impossible on 'normal' graph paper; [2] **[7]**

Note: the first marking point in part (b) highlights the importance of accuracy in answers; the important part of the answer is that there is a very large range of numbers; not just that you are dealing with very large numbers (which is not the same thing).

2 **(a)**

Interaction	Nature of relationship
–	–
–	+/– ;
–	+/– ;
mutualism ;	–

[3]

(b) The species that survives will do less well than it otherwise would do if there is no competition at all; [1] **[4]**

3 **(a)** The periwinkles living in a particular area; [1]

(b) **(i)** 55 + 14 + 5 – (17 + 4);
53; [2]

(ii) Any **two** from:
- amount of algae (on or close to the rock)
- number of crevices available
- other appropriate response [2] **[5]**

4 **(a)** A parasite is an organism that lives in close association with another organism benefiting from it and causing it harm over an extended period of time; [1]

(b) A cellulose cell wall; [1]

(c) **(i)** Will have a larger number of host trees available/will allow greater rates of reproduction/spread (in a mixed wooded area)/distribution is not restricted if a particular tree species not present or dies out; [1]

(ii) Over half of the host trees were hazel;

laurel was next most common with small numbers of sycamore, beech and oak trees parasitised; [2]

Note: sometimes relatively 'easy' questions are not as straightforward as they appear – stating that hazel is the most common host tree does not really give enough detail, whereas stating that over 50% of the host trees were hazel gives a much clearer picture. The introduction in this book made the point that mark schemes are not finalised until candidate performance is reviewed. If very few candidates in an exam failed to note the 50%+ in this answer, the mark scheme would probably be adjusted slightly to give credit for answers that stated that 'there were many more hazel host trees than any other species – the 'many' qualification being important here.

(iii) Would need to excavate soil to be certain (to identify where toothwort and tree roots combined)/unable to be sure of the extent/position of each tree's roots/other appropriate response; [1]

(iv) Not clear how many trees of each species were in the wood/other appropriate response; [1] **[7]**

5 **(a)** **(i)** Any **two** from:

- it is not native/an invasive plant
- it is harmful to humans
- (as it colonises whole riverbanks) it will outcompete other (native) plants [2]

(ii) It outcompetes/restricts the growth of native plant species;

loss of food sources/habitats for animal species; [2]

(b) Any **four** from:

- seedlings from plant 1 extend a considerable distance downriver
- seedlings from plant 1 only extend a short distance upstream/are only found very close to river (on riverbanks)
- most seedlings from plant 2 are within a very short distance of parent plant/only a small number of seedlings extend more than e.g. 10 metres away from the parent plant
- most effective/main seed dispersal method in Giant Hogweed is dispersal by water (flowing river)
- dispersal by other methods is poor [4]

(c) (i) Any **three** from:

- unable to survive in the (riverside) environment
- too low a reproduction rate (to be effective)
- may outcompete native organisms
- fail to cause enough damage to the Giant Hogweed
- other appropriate response [3]

(ii) Any **two** from:

- more species-specific (compared to 'broad-spectrum' pesticides) so preventing the loss of beneficial species
- prevents the harmful (polluting) effect of pesticides on the environment
- prevents development of resistance in pests/less likely to have pest resurgence
- other appropriate response [2]**[13]**

Note: cost (unqualified) would not be credited as an answer under OAR as the research and set-up costs could be very significant before a living organism is used as a biological control agent. However, an answer that compared cost between biological control and pesticide use after the biological control organism had been introduced would be credited (i.e. from then on it probably would be less expensive than the cost of regular applications of pesticide).

6 (a) (i) Any **two** from:

- soil depth increases over time
- the total plant biomass increases over time
- the climax community (woodland) is the stable end stage [2]

Note: normally the communities in a succession become increasingly complex as the succession progresses; there is increased biodiversity and the later communities are more stable. However, while this may be true in this succession, there is no evidence for this based on the information provided. These answers would not gain credit as they do not involve 'using the information provided'.

(ii) Debris and nutrients flowing in the lake;
decomposition of dead plant material; [2]

(iii) Lake too deep/not enough soil in stage 1; [1]

(iv) Less light able to penetrate to lake bottom (due to presence of floating plants); [1]

(v) Trees transpire more water than plants in earlier stages/seres/less rain reaches the soil surface due to canopy coverage; [1]

(b) Climax community is the stable end stage of the succession;
which is in equilibrium with the environment; [2]

(c) **(i)** Increased surface plant growth due to the increased nutrients;
leads to less light able to reach lower parts of the lake;

or

reduced oxygen levels leads to fewer species of animals;

due to high rates of decomposition of the increased volume of dead plant material; [2]

(ii) Increased plant growth will lead to increased decomposition and increased 'soil' formation/other appropriate response; [1]**[12]**

7 **(a)** Indicative content:

- succession in a quarry is primary succession (as will start on bare/exposed rock)
- will be colonised by pioneer species such as lichens/moss
- as these do not have roots/do not require soil to be present
- (bare rock) will be too hostile a habitat for other (more complex) plant species
- as lichens/mosses die they will decompose to form material rich in nutrients/'soil'
- (over time) flowering plants/ferns will develop as soil becomes deep enough/rich enough to support these larger plants
- decomposition of more/larger plants creates the deeper/richer/more mature soil (allow once)
- shrubs and smaller trees start to appear
- animal biodiversity increases as range of habitats increase
- decomposition of more/larger plants creates the deeper/richer/more mature soil (allow once)
- larger trees appear and start to out-compete smaller shrubs/trees
- at this stage biodiversity may decrease as canopy closes/reduced light reaching the woodland floor
- eventually woodland/forest forms the (climatic) climax community
- the succession will take a very long time/very slow process/primary successions take longer than secondary successions
- succession is a predictable pattern as each stage/sere modifies the environment to create conditions suitable for the next stage
- (over time) the height and biomass of the vegetation increases/there is increased biodiversity/stability
- other appropriate response (e.g. the actual plant species that grow will be influenced by the rock type in the quarry)

Band	Response	Mark
3	Candidates use the most appropriate specialist terms to clearly describe and explain primary succession (in an abandoned quarry) using a minimum of **ten points** of indicative content. Spelling, punctuation and grammar are excellent and the form and style are of a high standard.	[9] – [12]
2	Candidates use appropriate specialist terms to clearly describe and explain primary succession (in an abandoned quarry) using a minimum of **six points** of indicative content. Spelling, punctuation and grammar are very good and the form and style are of a good standard.	[5] – [8]
1	Candidates partially describe and explain primary succession (in an abandoned quarry) using a minimum of **one point** of indicative content.	[1] – [4]
0	Response not worthy of credit.	[0]

[12]

Note: you will note that the seventh and the tenth bullet points are the same and qualified by an 'allow once' – this indicates that the answer 'decomposition of more/larger plants creates the deeper/richer/more mature soil' is credited at any stage of the succession, but not more than once. This marking point is separate to the marking point for the development of soil in the first place.

(b) Indicative content:

- large size
- (large trees) will gain more light/photosynthesise more than smaller species (in the woodland)

and/or

- high competitive ability
- will out-compete many other species for light (allow light here if not also awarded in answer above)/water/minerals

and/or

- live for many years/long life cycle
- requires many years for a tree to reach the canopy

and/or

- few offspring reach maturity
- as few opportunities for young seedlings to reach full size

and/or

- population size (relatively) constant
- number of trees that ecosystem could support remains relatively constant

and/or

- typically occur in stable habitats
- (as life cycles are very long) the trees are adapted to particular conditions (and highly specialised)

Band	Response	Mark
3	Candidates use the most appropriate specialist terms to clearly explain three features of K-selected species and suggest explanations of the features using a minimum of **five points** of indicative content. Spelling, punctuation and grammar are excellent and the form and style are of a high standard.	[5] – [6]
2	Candidates use appropriate specialist terms to clearly explain features of K-selected species and suggest explanations of the features using a minimum of **three points** of indicative content. Spelling, punctuation and grammar are very good and the form and style are of a good standard.	[3] – [4]
1	Candidates partially explain one or more feature(s) of K-selected species and suggest explanation(s) of the feature(s) using a minimum of **one point** of indicative content.	[1] – [2]
0	Response not worthy of credit.	[0]

[6]

Question 7 total **[18]**

Note: part (b) is an applied question as it is referring to K-selected species in a particular environment and some typical K-selection features such as a 'large amount of parental care' clearly don't apply in this situation as they apply to animals only.

Chapter 7 – Ecological Energetics and Nutrient Cycling

1 **(a)** **(i)** 3; [1]

(ii) $(3.6 \times 10^3) \div (5.5 \times 10^4) = (6.5 \times 10^{-2}) \times 100$;
6.5%; [2]

(iii) A high percentage of energy is lost at each stage so there will be very little/not enough energy available if more than four stages; [1]

(b) NPP = GPP – R; [1]**[5]**

2 **(a)** Excretion; [1]

(b) $X = 0.8 - (0.4 + 0.14 + 0.2)$;
$= 0.06$; [2]

(c) Animal tissue is more easily digestible than plant tissue;
cellulose not digestible/other appropriate response; [2]

(d) Both are endotherms/have constant body temperatures higher than the external environment; [1] **[6]**

3 **(a)** Active transport; [1]

(b) 1; [1]

(c) 2 and 3; [1]

(d) Denitrifying bacteria; [1] **[4]**

4 **(a)** Primary succession; [1]

(b) **(i)** It is able to make nitrogen-rich compounds/amino acids;
even though there is very little soil/soil with little nitrate; [2]

(ii) Long-lived/large/other appropriate response; [1]

(iii) $60 \div 120 \times 100$;
50%; [2]

(iv) From 10 years on as tree biomass increases gorse biomass decreases/when tree biomass reaches a critical level gorse biomass starts to decrease;

gorse biomass starts to decrease at the time tree biomass is increasing at its fastest; [2]

Note: while the first marking point seems relatively straightforward, it is important to emphasise 'from 10 years on' (or 'when tree biomass reaches a critical point') as it is clearly not true to state that as tree biomass increases, gorse biomass decreases.

(v) The trees are reducing the amount of light available to the gorse/out-competing the gorse for water/nutrients; [1] **[9]**

5 (a) (i) Combustion of trees releases carbon dioxide to the atmosphere;

fewer trees to photosynthesise and remove carbon dioxide from the atmosphere; [2]

(ii) Reduction in habitats/rare plants or animals killed as trees are burned/land scorched; [1]

(iii) Process repeated on a regular basis; [1]

(b) Any **five** from:

- nitrate concentration in soil remains steady when covered by forest and rises dramatically when trees burned
- burning releases nitrogen-containing compounds from the trees
- decreases at a decreasing rate as land used for crops
- crops use nitrate to form amino acids/nitrogen-containing compounds
- (as crop use continues) soil nitrate level decreases below the level when initially forested
- when crops are removed, nitrate used is not replaced [5]

(c) (i) Denitrifying bacteria convert nitrates into nitrogen gas; [1]

(ii) Better drainage of land/avoid compaction of land; [1] **[11]**

6 **(a)** The decay/decomposition of a compound into a usable inorganic form; [1]

(b) Dead leaves/earthworm food has very high proportions of cellulose/contains very few nutrients; [1]

(c) **Any two pairs from:**

earthworms increase the surface area of leaves/decomposable material (in their egested material);

for other detritivores/decomposers to continue decomposition/mineralisation;

or

earthworms spread nitrogen-containing compounds through the soil;

for other detritivores/decomposers to continue decomposition/mineralisation;

or

burrows aerate the soil;

nitrifying bacteria are aerobic/require oxygen;

or

burrows drain the soil;

preventing the soil becoming waterlogged and deficient in oxygen;

or

other appropriate suggestion;

with other appropriate explanation; [4] **[6]**

Unit A2 2:

Biochemistry, Genetics and Evolutionary Trends

Chapter 8 – Respiration

1 The link reaction;

ATP and H_2O;

oxygen debt;

cytoplasm; [4] **[4]**

2 **(a)** **(i)** Mitochondrial matrix; [1]

(ii) Carbon dioxide; [1]

Note: although many candidates will be able to recall that carbon dioxide is evolved at these stages in the Krebs cycle, it is possible to deduce this as there are changes from a 6C acid to a 5C acid and from a 5C acid to a 4C acid at these points.

(iii) The phosphate needed to convert ADP to ATP is a by-product of cellular metabolism/there is a direct transfer of phosphate to ADP from another phosphorylated compound; [1]

(b) Pyruvate is decarboxylated/emits carbon dioxide to produce acetate/acetyl group;

(in this process) hydrogen is lost which reduces NAD/produces NADH;

the acetate/acetyl group combines with co-enzyme A; [3]

(c) **(i)** Reduced NAD/NADH is at the start of the electron transport chain/hydrogen from the reduced NAD/NADH passes along a series of carriers/along the electron transport chain;

hydrogens/electrons lose/release energy as they pass along the chain;

at three points sufficient energy is released/available to produce ATP; [3]

(ii) 18; [1] **[10]**

Note: again the diagram is helpful – it shows that 3 reduced NAD/NADH are produced in the Krebs cycle – as the question is asked, the reduced NAD/NADH produced in glycolysis and in the link reaction are not included. Also, remember that for each molecule of glucose there are two turns of the Krebs cycle.

3 **(a)** **(i)** Glycolysis; [1]

(ii) Cytoplasm; [1]

(iii) To regenerate NAD/frees up NAD to pick up H from glycolysis;
so that glycolysis can continue/so that glucose can be converted to pyruvate; [2]

(b) **(i)** Any **two** from:

- carbon dioxide is produced in plants (but not in anaerobic respiration in animals)
- plants produce ethanol rather than lactate
- the final product/ethanol in plants is not converted back to pyruvate [2]

(ii) Plants can survive for a period of time in anaerobic/waterlogged conditions; [1] **[7]**

4 **(a)** **(i)** Fructose bisphosphate; [1]

(ii) The fructose bisphosphate/X splits into two molecules of triose phosphate;
(as a consequence) 4 molecules of ATP are produced and 2 used; [2]

(b) **(i)** Some yeast cells are grouped in a clump (for a period of time) with the cells in the middle of the clump not receiving oxygen/other appropriate response; [1]

Note: this is clearly a very difficult question, but the shape of the graph should suggest that it is not just that the solution in the flask is starting to become oxygen deficient, otherwise the level of ethanol would continue to increase over this time.

(ii) $2.5 - 0.3 = 2.2$;
$2.2 \div 40 = 0.055/0.06$; [2]

(iii) The volume of ethanol produced rises steadily to 2.5 arbitrary units then levels off;

Note: quite a lot of information is expected for this first marking point – this is not surprising as the shape of the graph is very straightforward and an answer such as the amount of ethanol produced rises and then levels off is just not detailed enough.

as the yeast are respiring anaerobically (due to the oxygen having been used up);

the levelling off is due to the glucose being used up; [3] **[9]**

5 **(a)** The volume of carbon dioxide released divided by the volume of oxygen consumed; [1]

(b) **(i)**

RQ value	Respiratory substrate
	protein;
	fat/lipid;

[2]

(ii) Anaerobic respiration must be taking place/an RQ value above 1 shows anaerobic respiration is taking place;

carbohydrate is the only substrate that can be respired anaerobically; [2]

(c) **(i)** $0.970 - 0.755 = 0.215$;

$0.215 \div 0.970 \times 100 = 22.16/22.2\ \%$; [2]

(ii) At the start/in the first 2 hours, a mixture of food substrates/combination of carbohydrate and fat and/or protein are being respired;

from 2 hours on CHO is not being respired/there is a reduction in the CHO being used as a respiratory substrate;

as a consequence of not enough insulin being available and the cells are unable to absorb glucose;

lipid/fat increasingly becomes the respiratory substrate; [4] **[11]**

Chapter 9 – Photosynthesis

1 **(a)** **(i)** Light-dependent stage; [1]

(ii) NADPH/reduced NADP; [1]

(iii) Ribulose bisphosphate; [1]

Note: when asked to 'name' a substance, you should really give the name rather than the abbreviation (in this case RuBP).

(b) The light absorbed by the photosynthetic pigments at different wavelengths; [1] **[4]**

2 **(a)** **(i)** The electrons are used to replace those emitted from photosystem II;

the hydrogen ions combine with electrons to reduce NADP to NADPH; [2]

(ii) X added on the diagonal line between the electron acceptor of PSII and PSI; [1]

(iii) Can harvest a greater range of wavelengths of light/other appropriate response; [1]

(b) **(i)** NADPH is used to reduce glycerate phosphate/GP to form triose phosphate/TP;

with energy provided by ATP;

phosphate from ATP is used to convert ribulose phosphate/RuP to ribulose bisphosphate/RuBP; [3]

(ii) Stroma of the chloroplast; [1]

(c) Very high light intensities;

to avoid (heat) damage; [2] **[10]**

3 **(a)** Provides energy in the reduction/conversion of glycerate phosphate/GP to triose phosphate/TP;

provides a phosphate to convert ribulose phosphate/RuP to ribulose bisphosphate/RuBP; [2]

(b) **(i)** When CO_2 is no longer available it cannot be 'fixed' and combine with ribulose bisphosphate/RuBP (to form glycerate phosphate/GP);

therefore concentration of glycerate phosphate/GP falls as it is converted to triose phosphate/TP (but is not replaced);

concentration of ribulose bisphosphate/RuBP builds up as still being produced (from RuP) (but unable to combine with CO_2);

concentration of both ribulose bisphosphate/RuBP and glycerate phosphate/GP level off as all reactions of light-independent reaction stop (i.e. no further change in concentration of intermediates); [4]

(ii) High CO_2 concentrations, high temperature and high light levels;

if any environmental factor is limiting then increasing other factors will have no/little effect; [2]

(c) **(i)** High rates of respiration/many ATP molecules/many metabolic intermediates/are required; [1]

(ii) More glycerate phosphate/GP is produced with carboxylation/other appropriate response; [1]

Note: not just more glucose produced as this does not really show the understanding required.

(iii) (Atmospheric) CO_2 levels are increasing;

therefore rubisco more likely to combine with CO_2 (rather than oxygen); [2] **[12]**

4 **(a)** Gross photosynthesis/quantity of carbohydrate produced in photosynthesis less that used up in respiration; [1]

(b) **(i)** Light; [1]

(ii) (Two) letter Y added at points where there is no net exchange of carbon dioxide; [1]

(iii) Between 0 – 6 hours and 18 – 24 hours;

at these times respiration > photosynthesis;

using up more carbohydrate than is produced; [3]

(c) **(i)** Thinner as reduced light will not penetrate as far through the leaf/the light will penetrate through fewer layers/so all layers will get light; [1]

(ii) Greater surface area/more chlorophyll/different range of photosynthetic pigments/thinner cuticles/other appropriate response; [1]

(d) **(i)** Shade leaves did not occur in light intensities higher than 55 arbitrary units; [1]

(ii) Any **six** from:

- with increasing light intensities both 'sun' and 'shade' leaves increase CO_2 uptake before levelling off
- in (very) low light intensities, 'shade' leaves give out less CO_2 (per unit mass and leaf area)
- in respiration (than 'sun' leaves)
- between light intensities of 10 and 20 AU, 'shade' leaves are taking in more CO_2 than 'sun' leaves as they are photosynthesising at a faster rate (per unit mass and leaf area) than 'sun' leaves
- CO_2 intake in 'shade' leaves levels off at relatively low light intensities/CO_2 intake never reaches high levels as these leaves are not adapted to photosynthesise at high light intensities
- whereas 'sun' leaves can increase CO_2 uptake even in relatively high light intensities as they are adapted to photosynthesise at high rates in high light levels
- at very high light intensities/above light intensities of 55 arbitrary units, CO_2 uptake/photosynthesis levels off (in 'sun' leaves) as some other factor becomes limiting [6] **[15]**

Note: to really understand this question it is important to appreciate that 'sun' leaves are those in the outer canopy, i.e. those that will be in full sunlight when conditions are good. As the graph shows, 'sun' leaves do experience the full range of light intensities (from complete darkness at night right through to full sunlight), whereas 'shade' leaves also experience complete darkness, but they never experience full sunlight as they are always in the shade of other leaves.

5 **(a)** Increase in temperature has no effect on (mean) leaf length;

as temperature increases, (mean) leaf width increases; [2]

(b) The increase in leaf width; [1]

(c) The difference in (mean) leaf length across the three geographical groupings is not significant at $p = 0.05$;

for (mean) leaf width, plants in Ireland and mainland Europe are significantly different (but neither are significantly different from Britain);

for (mean) leaf width/length (W/L) ratio, the plants in mainland Europe are significantly different from those in Ireland and Britain (but there is no significant difference between the means in Ireland and Britain); [3] **[6]**

Chapter 10 – DNA as the Genetic Code (Protein Synthesis)

1 Base triplet;

non-overlapping,

degenerate; [3] **[3]**

2 (a) (i) Transcription; [1]

(ii) 1 – cytosine;
2 – uracil; [2]

(iii) Extends the RNA molecule by bonding RNA nucleotides together by phosphodiester bonds; [1]

Note: it is important to be precise with wording in this answer as any suggestion that bonds are being formed between (parallel) strands will be penalised.

(b) (i) 539; [1]

(ii) 2800; [1]

(iii) Introns are removed/spliced out;

leaving exons to be re-joined; [2]

(iv) Sections of non-coding DNA can be removed;

makes translation easier (or explained);

or

sections can be reordered in a different sequence;

provides greater flexibility (in the genome); [2] **[10]**

3 (a) (i) Protein; [1]

(ii) Nucleolus (in the nucleus); [1]

Note: in this case it is the wording in the question you need to be careful with – while the functional ribosomes (the two sub-units link together) are formed as they lock on the mRNA at the start of protein synthesis, the sub-units themselves are constructed in the nucleolus.

(b) (i) Codon correctly circled; [1]

Note: this is another one to be careful with – the answer is not just any three adjacent bases on the mRNA - the position of the ribosome clearly identifies which groups of three adjacent bases are codons.

(ii) Aminoacyl/A; [1]

(iii) Transfer/t RNA; [1]

(iv) The ribosome moves along by one codon length/three bases;

the tRNA for PHE leaves the ribosome (so that the P-site becomes vacant);

so that the GLY-tRNA/CCC anticodon/GGG codon is now in the P-site/CGA (codon) occupies the A-site;

ARG tRNA enters the ribosome/A-site;

a peptide bond forms between the amino acids ARG and GLY/ARG joins the polypeptide chain via a peptide bond; [5]

(v) Fewer mRNA strands need transcribed/produced/other appropriate response, e.g. necessary enzymes, vesicles etc can be positioned together in one area (more efficient); [1] **[11]**

4 (a) Changes in gene expression/activity (that are mitotically heritable) but do not involve change to the DNA base sequence; [1]

(b) (i) Cytosine; [1]

(ii) Methyl/CH_3; [1]

(iii) Transcription; [1]

(c) Prevents transcription starting/part of a polypeptide being transcribed/other appropriate response; [1]

(d) Any **two** from:

- histone modification can increase or decrease expression, methylation can only decrease expression/or switch off genes
- histone modification can be temporary/methylation is long term/permanent
- other appropriate response [2]

(e) Allows greater flexibility/other appropriate response; [1] **[8]**

Chapter 11 – Gene Technology

1 **(a)** **(i)** This will ensure that complementary sticky ends are produced;

so that the gene will fit/join with the cut ends of the vector to form a continuous strand of DNA; [2]

(ii) Reverse transcriptase; [1]

(b) Treating disease or named example, e.g. killing cancer cells or treating bacterial infections; [1]

(c) Any **two** from:

- appropriate containment mechanisms, e.g. special air filters/negative-pressure atmospheric gradients
- use of strains that grow slowly/are poorly adapted to human physiology/that require specific nutrients to survive
- strains with 'suicide' genes
- appropriate staffing protocols, e.g. restricted access [2] **[6]**

2 **(a)** **(i)** Heating to 90 – 95 °C (to break the hydrogen bonds); [1]

(ii) Primers; [1]

(iii) They stop the two DNA strands rejoining/they bracket the section to be copied/DNA replication can only start within a double stranded region (the primer provides a point of origin that other nucleotides can attach to); [1]

(iv) The different stages take place at different temperatures; [1]

(v) 256; [1]

(b) **(i)** Two/three/small number of (DNA) bases that are repeated (many times) throughout a section of (non-coding) DNA; [1]

(ii) There is variation between individuals in the number of times the sequence of bases is repeated; [1]

Note: there is variation in the number of MRS repeats (rather than variations in base sequences) that forms the basis of DNA (genetic) fingerprinting.

(iii) Restriction endonucleases – cuts the MRSs to form different-sized fragments; gel electrophoresis – separates the DNA fragments on the basis of size; [2]

(iv) Paternity disputes/pedigree checking with pets/thoroughbreds, (e.g. racing horses)/identification of remains following disasters/other appropriate response; [1] **[10]**

3 **(a)** The wells are microscopic/many thousand/very large number of wells/other appropriate response; [1]

(b) Any **four** from:

- the DNA sequences in the wells are mutation free/well contains the mutation/wells contain normal and mutated sequences
- mRNA/cDNA from the individual is washed over the microarray
- the mRNA/cDNA binds/hybridises to complementary DNA sequences
- fluorescent/chemiluminescent tags are present on the mRNA/cDNA (to identify where hybridisation occurs)
- if the added mRNA/cDNA contains sequences with mutation(s) then will not bind with normal sequences (and therefore no tag at that point)/will bind with sequences complementary to the mutated sequences. [4]

Note: it is impossible to get full marks in this question unless the answer addresses the specific question asked – it is not just a question asking how microarrays work. Well(s) in the microarray could contain sequences complementary to the mutation(s) and then only DNA from individuals with the mutation would hybridise.

(c) **(i)** There is no difference in the expression levels between the cancer-free individual and the one with cancer/the two individuals for most of the genes/for 5 of the 8 genes;

the expression levels of gene 3 and 7 are lower in the individual with cancer with expression in gene 7 being very reduced/there is very little activity in gene 7;

in gene 5 the expression level is (slightly) higher in gene 5; [3]

Note: remember if you are asked to 'compare and contrast' you should have both similarities and differences.

(ii) The mRNA/cDNA from genes with high expression levels will bind/hybridise with more copies of the DNA in a particular well (or converse);

therefore there will be greater fluorescence/luminescence in that well (or converse); [2] **[10]**

Note: question 3 is a very difficult question and many students will struggle with the concepts involved. Remember, that all exam papers contain a balance of questions ranging from relatively straightforward questions through to a small number of question parts targeting the very top candidates – however, there should not be too many questions like this one!

4 **(a)** **(i)** The (epithelial) cells lining the respiratory passages are regularly replaced/the added gene is not incorporated into the host DNA;

the functional gene does not pass into the new/replacement cells (during cell division); [2]

(ii) Any **two** from:

- gene therapy does not affect other parts of the body, e.g. the pancreatic duct
- the aerosol may not reach all parts of the lungs
- the vectors (viruses/liposomes) may not penetrate the target cells
- if (adeno)viruses are used they may produce an immune response that destroys the vector/gene
- other appropriate response (e.g. (adeno)viruses may cause allergies) [2]

(b) **(i)** Viruses are adapted for gaining entry to cells/incorporating their DNA into host cells DNA; [1]

(ii) Genes that cause harm are deleted/other appropriate response; [1]

(iii) The nuclear membrane breaks down during mitosis (therefore it will not provide a barrier); [1]

(c) The eye/retina is easily accessible/self-contained; [1]

Note: while students would not be expected to recall answers for (b) and (c), understanding the issues with gene therapy and cystic fibrosis, e.g. the pancreas not being easily accessible, should give a clue.

(d) **(i)** The mRNA is easier to access/in the cytoplasm/less risk of harming the chromosomes/DNA; [1]

(ii) By the bases on the RNA probe being complementary to those on the mRNA; [1]

(iii) The mRNA probe will have the uracil base (allowing fully complementary binding); [1]

(iv) As mRNA will be continually produced/as the gene itself is not affected (so will continue to produce mRNA); [1] **[12]**

5 **(a)** Working out the sequence of bases; in all the DNA/entire genome; [2]

(b) **(i)** The likelihood (or otherwise) of developing a genetic condition/illness/the likelihood (or otherwise) of certain genes affecting future health; [1]

(ii) *Advantage* – individuals can take action in advance to alleviate/delay the onset of a genetic condition/or condition in which there is a genetic pre-disposition/become emotionally prepared for the onset of a genetic disease;

Disadvantage – some individuals may not be able to cope emotionally with the information provided/may not have the (scientific) background to fully understand the information provided/other appropriate response; [2]

(iii) A single nucleotide/base variant that varies among individuals; [1]

(iv) It is the SNPs/variants that are linked to disease/genetic health/a majority of genetic-linked conditions;

much of the DNA is non-coding/does not affect health/rarely varies/other appropriate response; [2]

(c) **(i)** A drug that matches an individual's genome/genetic profile; [1]

(ii) Cost/individual genome data not available as yet/other appropriate response; [1] **[10]**

6 **(a)** Indicative content:

- PCR amplifies/increases number of (specific) sections of DNA
- which can be used for research/used to gain understanding (of genome)
- (DNA to be amplified initially) heated to (approx.) 95°C to break hydrogen bonds (allowing stands to separate)
- cooled to 40 – 60°C (approx.) to allow primers to anneal/bind
- primers brackets region to be amplified/necessary to allow replication to begin/prevents DNA strands from re-joining
- heated to 70°C to enable thermostable DNA polymerase to extend the primers/copy each of the strands (to double the amount of DNA)
- use of thermostable DNA polymerase allows process to occur at a faster rate
- the process is repeated many times
- microarray is a solid base of glass/silicon with thousands of microscopic spots or wells
- with each well having a different sequence of DNA
- (sample of) single stranded DNA/cDNA/mRNA can be added to the microarray and will hybridise/bind/anneal with complementary sections in the wells
- fluorescent/chemiluminescent tags show where hybridisation/binding/annealing has taken place
- strength of signal (in a particular well) can indicate level of expression of particular genes (in different individuals/between different organs)

- microarrays can be used to analyse differences in DNA/mRNA production among individuals/populations/identify mutations/other appropriate response
- knockin mice have gene(s)/section(s) of DNA added and knockout have gene(s)/section(s) of DNA removed
- provides information on the role particular gene(s)/section(s) of DNA play in an organism
- including the study of genetic disorders/drug therapies
- mice are suitable model organisms as are physiologically similar to humans/have short life cycles (therefore producing large sample sizes over a short period)/are easily kept in a laboratory/create fewer ethical issues than using larger mammals/primates/humans/other appropriate response

Band	Response	Marks
3	Candidates use the most appropriate specialist terms to clearly describe and explain the role of PCR, microarrays and knockin and knockout mice in our understanding of the human genome using a minimum of **ten points** of indicative content. Spelling, punctuation and grammar are excellent and the form and style are of a high standard.	[9] – [12]
2	Candidates use appropriate specialist terms to clearly describe and explain the role of PCR and/or microarrays and/or knockin and knockout mice in our understanding of the human genome using a minimum of **six points** of indicative content. Spelling, punctuation and grammar are very good, and the form and style are of a good standard.	[5] – [8]
1	Candidates partially describe and explain the role of PCR and/or microarrays and/or knockin and knockout mice in our understanding of the human genome using a minimum of **one point** of indicative content.	[1] – [4]
0	Response not worthy of credit.	[0]

[12]

(b) Indicative content:

- pharmacogenetics describes how drug effectiveness is linked to individual genome differences/genotype
- personalised medicine is using (designer) drugs/medicines tailored to an individual's genome
- benefits include increased effectiveness/efficacy
- and reduced side effects
- drawbacks include increased cost
- lack of knowledge of an individual patient's genome (i.e. currently most patients genomes are not available to the doctors treating them)
- reference to an example (e.g. codeine)

Band	Response	Marks
3	Candidates use the most appropriate specialist terms to clearly describe what is meant by pharmacogenetics and outline the potential benefits and drawbacks of personalised medicine using a minimum of **five points** of indicative content. Spelling, punctuation and grammar are excellent and the form and style are of a high standard.	[5] – [6]
2	Candidates use appropriate specialist terms to describe what is meant by pharmacogenetics and outline the potential benefits and drawbacks of personalised medicine using a minimum of **three points** of indicative content. Spelling, punctuation and grammar are very good and the form and style are of a good standard.	[3] – [4]
1	Candidates partially describe what is meant by pharmacogenetics and/or outline the potential benefits and drawbacks of personalised medicine using a minimum of **one point** of indicative content.	[1] – [2]
0	Response not worthy of credit.	[0]

[6]

Question 6 total **[18]**

1 (a) (i) Determined by (homologous pair of) sex chromosomes;

XX = female and XY = male; [2]

(ii) Certain characteristics/traits more likely to occur in males/a particular sex/there is not an equal chance of males and females being affected; [1]

(b) (i) $X^bX^o \times X^bY$;

	X^b	Y
X^b	X^bX^b	X^bY
X^o	X^bX^o	X^oY

;

X^bX^b		X^bX^o		X^bY		X^oY	
black female		tortoiseshell female		black male		ginger male	
1	:	1	:	1	:	1	;

[3]

Note: in terms of how the question is worded, it is important to identify offspring both in terms of coat colour and sex and only by doing this will you get a 1 : 1 : 1 : 1 ratio. If coat colour only is used and a 1 : 2 : 1 ratio is answered, a maximum of two marks will be awarded.

(ii) $X^bX^o \times X^oY$;

	X^o	Y
X^b	X^bX^o	X^bY
X^o	X^oX^o	X^oY

;

X^bX^o $\quad$ $\underbrace{X^oX^o \quad X^oY}_{\text{ginger}}$ $\quad$ X^bY

tortoiseshell 1 : ginger 2 : black 1 ;

[3]

Note: this is a trickier question in that you have to deduce the genotypes of the parents. The key thing is that if half (three) of the offspring are ginger and only one black then the father will most likely be X^oY. To have offspring of all three colours the mother must have both the black and the ginger alleles so she must be X^bX^o. With small numbers of offspring, an exact 1 : 2 : 1 ratio is unlikely to be achieved, but the clue was in the highest number of offspring being ginger. The question used the word 'probable' as it is possible that the male parent could be black – this would still give all the offspring phenotypes, but the ratio wouldn't fit as well.

(c) **(i)** The sex chromosome containing the black allele; [1]

(ii) Differential growth/different rates of cell division; [1]

(iii) Epigenetics; [1] **[12]**

2 **(a)** During the formation of gametes/meiosis, the segregation of the alleles of one gene is independent to the segregation of the alleles of any other gene; [1]

(b) **(i)** RRyy and Rryy; [1]

Note: R-yy indicates that it could be RRyy or Rryy, but it is better to write it out full as shown above.

(ii) 3 : 1; [1]

(iii)

RR Yy × Rr Yy ;

RY Ry   RY Ry rY ry ;

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy

;

RRYY   RRYy (x2)   RrYY   RrYy (x2)   RRyy   Rryy

round and yellow seeds 3 : round and green seeds 1 ;

[4]

Note: although a dihybrid cross, a 3 : 1 ratio is produced, but only in terms of seed colour and not seed shape. This should tell you that the two parents were heterozygous for seed colour. The seed shape genotype is trickier - you were told that they produced round seeds (same phenotypes) with one being heterozygous – this means that in terms of the R gene the parents must be RR and Rr (the two parents couldn't both be heterozygous, otherwise there would be wrinkled seeds in the offspring generation). As in (b) (ii) in the previous question, the final mark is for linking offspring phenotypes to genotypes rather than working out the ratio as you were given this.

(c) **(i)** 9 : 3 : 3 : 1; [1]

(ii)

Category	**Observed (O)**	**Expected (E)**	***(O – E)***	***(O – E)²***	***(O – E)²/E***
purple flowers and round seeds	327	324	3	9	0.03
purple flowers and wrinkled seeds	117	108	9	81	0.75
white flowers and round seeds	100	108	–8	64	0.59
white flowers and wrinkled seeds	32	36;	–4	16	0.44;

X^2 = 1.81; [3]

Note: 1 mark for working out the expected (*E*) values, 1 for completing the rest of the table and 1 for calculating the X^2 value.

(iii) 3;
0.9 > p > 0.5; [2]

(iv) The results of the cross are a good fit to a 9 : 3 : 3 : 1 ratio/there is no significant difference between the observed and the expected results; [1]

(d) Any **two** from:

- there are a large number of offspring produced in each cross
- there are a number of traits (e.g. seed shape, seed colour, flower colour) which are inherited in a typical Mendelian pattern/in a monohybrid/dihybrid pattern
- peas have short life cycles
- other appropriate response, e.g. peas are easy to grow [2] **[16]**

3 **(a)** **(i)** The condition is very rare/only one in 5000 people are affected; [1]

(ii) MM, Mm; [1]

(iii)

Mm × mm

M m   m

Mm × mm ;

1 : 1

50% chance / 1 in 2 chance ;

[2]

(iv) Age is only a factor in the cases caused by spontaneous mutation/only a factor in 25% of cases/where it is not inherited from a parent; [1]

(b) **(i)** mmX^HX^H, mmX^HX^h, mmX^HY; [1]

(ii)

$mm\ X^HY \times Mm\ X^HX^h$;

mX^H mY MX^H MX^h mX^H mX^h ;

	MX^H	MX^h	mX^H	mX^h
mX^H	MmX^HX^H	MmX^HX^h	mmX^HX^H	mmX^HX^h
mY	MmX^HY	MmX^hY	mmX^HY	mmX^hY

;

$\underbrace{MmX^HX^H \quad MmX^HY \quad MmX^HX^h}_{\text{Marfan Syndrome only}}$ $\underbrace{MmX^hY}_{\text{Marfan Syndrome and haemophilia}}$ $\underbrace{mmX^HX^H \quad mmX^HY \quad mmX^HX^h}_{\text{Neither condition}}$ $\underbrace{mmX^hY}_{\text{Haemophilia only}}$;

3 : 1 : 3 : 1 ;

[5] **[11]**

Note: many dihybrid questions in exam papers have 4 possible gametes in one parent and two in the other (as in the question above). In this situation, a Punnett square with 4 × 2 offspring cells is all that is needed – too many students use a 4 × 4 Punnett square which is unnecessary and the duplication involved uses up valuable time.

4 (a) **lethal allele –** an allele that when present (in a particular state, e.g. homozygous) will lead to death/an unviable individual;

multiple alleles – a situation when there are more than two alleles for a particular gene;

epistasis – a form of gene interaction where one gene influences/affects the expression of another gene; [3]

(b) (i) Coloured kernel; [1]

(ii) Aa Bb × aa bb ;

AB Ab aB ab   ab ;

	AB	Ab	aB	ab
ab	AaBb	Aabb	aaBb	aabb

;

coloured kernel (AaBb, Aabb, aaBb) : colourless kernel (aabb)

3 : 1 ;

[4] **[8]**

Chapter 13 – Population Genetics

1 **(a)** **(i)** $q^2 = (100 - 84 = 16) = 0.16$;

$q = 0.4$; [2]

(ii) q^2 (homozygous recessive individuals) = 0.16 = 16%;

(As $p + q = 1$), $p = 0.6$ so p^2 (homozygous dominant individuals) = 0.36 = 36%;

total homozygous individuals = (36 + 16) = 52%; [3]

(b) Any **two** from:

- population is large
- mating is random
- the individuals are diploid
- there is no differential selection
- there is no migration
- there are no mutations (relevant to the characteristic under consideration) [2] **[7]**

2 **(a)** **(i)** Base substitution; [1]

(ii) (The polypeptide produced) will (possibly) have a different amino acid (in place of X) as one base triplet has been altered/base triplet changed from ATA to ATG;

there may be no change (in amino acids/amino acid X) as in many base triplet codes the third base can change without effect/as it is the third base affected/code is degenerate; [2]

Note: the use of 'explain' in the question means that an explanation is required rather than just an answer along the lines of 'there may or may not be different amino acid in place of X'.

(iii) Base deletion; [1]

(iv) As all base triplets from the point of mutation on are affected/ 'frameshift' mutation;

so all amino acids from that point on are affected/possibility of producing a 'stop' codon (before the end of the polypeptide); [2]

(b) Any **two** from:

- chromosome mutations
- independent assortment
- crossing over
- the random nature of gametes fusing in cross-fertilisation [2] **[8]**

3 **(a)** **(i)** How well an organism is adapted for its environment; [1]

(ii) Stabilising selection is where the average individuals are best adapted and the extremes in the population (with respect to a particular trait) are selected against; in directional selection, individuals (close to or) at one of the extremes are selected for/are favoured; [2]

(b) The species only exists on that island; [1]

(c) **(i)** Shorter distance involved; [1]

(ii) **Any pair from:**

- morphology and/or anatomy;
- comparison between the external/internal features of species from Madagascar and similar species in Africa and India (will show greater similarities with the African species);

or

- cell structure;
- comparison between the cell structures of species from Madagascar and similar species in Africa and India (will show greater similarities with the African species);

or

- biochemistry;
- comparison between the genomes/DNA/RNA/protein structure of species from Madagascar and similar species in Africa and India (will show greater similarities with the African species);

or

- other appropriate example;
- with appropriate explanation; [2]

(d) **(i)** A species is a group of individuals of common ancestry/similar characteristics that are normally capable of interbreeding to produce fertile offspring; [1]

(ii) Any **four** from:

- some individuals are better adapted/fitter so are selected for/directional selection takes place as certain traits provide advantage
- these individuals more likely to survive and pass their beneficial alleles on to offspring
- beneficial alleles increase in frequency over time
- wide range of habitats (e.g. deserts, mountain and rain forests) create many ecological niches/opportunities for speciation
- as a consequence of geographical/reproductive isolation [4]

(iii) Barriers to reproduction (e.g. mechanical barriers to mating, offspring infertility)/ecological isolation/behavioural isolation/other appropriate response; [1] **[13]**

Note: in allopatric speciation, geographical isolation leads to reproductive isolation and as a consequence two or more isolated populations can diverge over time – this divergence will not take place unless the populations are reproductively isolated. In part (ii) reproductive isolation is used in this context. In part (iii), reproductive isolation is referred to in a different context – here it is the barriers that prevent interbreeding between species once speciation has taken place.

4 (a) Few resources available/difficulty in finding a mate/other appropriate response; [1]

(b) (i) Eyes are not beneficial in this habitat/too dark to see;

energy/nutrients/resources used in developing (and maintaining) eyes not required/can be diverted for other uses; [2]

(ii) Individuals without eyes/reduced eyesight are better adapted/fitter so are selected for/directional selection takes place as lack of eyes/reduced eyesight provides an advantage;

due to extra energy/nutrients/resources needed to develop/maintain eyes/vision providing no advantage;

individuals without eyes more likely to survive and pass their beneficial alleles on to offspring;

beneficial alleles increase in frequency over time/number of individuals without eyes increases over time; [4]

(c) Increase rate of speciation;

as individuals in different cave systems are reproductively isolated;

or

reduction in rate of speciation;

as populations are very small so fewer opportunities for mutations/so there will be reduced variation; [2] **[9]**

Note: as seen in part (c), as long as you can explain your answer, seemingly contradictory answers can be acceptable in some question parts. The key thing is that the answer must be logical (from the information provided), and it is underpinned by sound biological understanding.

5 **(a)** **(i)** $1.02 +/- 2.093 \times 0.12 = 0.25$;

upper limit $1.02 + 0.25 = 1.27$;

lower limit $1.02 - 0.25 = 0.77$; [3]

Note: in this type of question it is important not to get confused between number of sample sites (5 in this question) and the number of replicates within one sample (20 here, so the degrees of freedom in the t-table = 19).

(ii) Graph completed accurately; [1]

(iii) As soil moisture increases there is an overall decrease in mean bulb dry mass;

only significant between extremes/sites 1 and 2 significantly different from site 5; [2]

(b) **(i)** There is no significant difference between the mean bulb dry masses of wild garlic from samples points 1 and 5 when grown in Site B/very damp soils (in an experimental garden); [1]

(ii) $\dfrac{0.74 - 1.10}{\sqrt{(0.12)^2 + (0.12)^2}}$;

$t = 2.12$; [2]

(iii) $0.05 > p > 0.02$; [1]

(iv) The null hypothesis can be rejected/the mean bulb dry masses of plants from sample points 1 and 5 when grown in site B/very damp soils (in an experimental garden) are significantly different;

plants growing in different levels of moisture have developed genetic differences; [2]

(c) Some plants were better adapted for growing in very wet soils/were fitter so are selected for/selection takes place favouring those plants most able to grow in very wet soils;

example of directional selection;

these individuals more likely to survive and pass their beneficial alleles on to offspring;

plants with beneficial alleles in terms of adaptations to growing in very wet soils increase in frequency over time until (virtually) all plants growing in the very wet soil are adapted for this environment; [4] **[16]**

Chapter 14 – The Plant and Animal Kingdoms

1

	Mosses	Ferns	Flowering plants
cuticle present or absent:		present;	
support by:	support by turgor (only);		
dispersed by:			seeds;

[3] **[3]**

2 **(a)** **(i)** Fungi and plantae; [1]

(ii) Any **two** from:

- moss traps moisture
- moss provides support (for roots)
- decomposition of moss provides nutrients [2]

(iii) Advantage – less likely to be damaged by wind/leaflets can move independently in response to light/other appropriate response;

Disadvantage – reduced photosynthesis/other appropriate response; [2]

(b) Ferns have waxy cuticles and fine control over stomata;

to reduce water loss/transpiration; [2] **[7]**

3 **(a)** No vascular tissue present; [1]

(b) Any **four** from:

- there is sufficient light for moss growth between the slats and at the edge of the metal support
- moisture (and nutrients) will be more abundant/available in these positions
- due to moisture/nutrients accumulating in the crevices and reduced evaporation/transpiration of water at edge of metal support
- due to shading effect
- these areas are protected from trampling [4] **[5]**

4 **(a)** Succulent leaves; [1]

Note: there may or may not be spines present on the leaves of this plant (as is typical for cacti). However, if present, they are not visible in the photograph.

(b) **(i)** Not digestible/tough outer coat (to withstand digestion/damage as they pass through the gut)/small enough to pass through the birds gut; [1]

Note: it is important to answer this question in the context of the seeds – the bolding of 'seeds' is there to help you focus on this. Answer along the lines of the fruits being brightly coloured (to attract birds or being nutritious) will not be awarded.

(ii) They can resist desiccation/drying out;

due to the presence of a tough/waterproofed outer coat; [2]

(c) The (extra) xylem provides support for stems;

due to the presence of lignin;

the shortage of water may restrict plant's ability to have cells turgid/plant less reliable on turgor for support; [3] **[7]**

5 **(a)** **(i)** There is symmetry around a/any central axis/the body can be divided into two (similar) halves by any plane that goes through the central axis; [1]

(ii) Food can be obtained from all angles (e.g. *Hydra*'s tentacles cover 360°)/there is a 360° awareness of the environment/other appropriate response; [1]

(iii) Cnidaria; [1]

(b) **(i)** Exocytosis; [1]

(ii) Large numbers of ribosomes/Golgi bodies/large surface area/other appropriate response (e.g. protected against auto-digestion); [1]

(c) Hydrostatic; [1] **[6]**

6 **(a)** No evidence of a spinal column/bones; [1]

(b) It provides a hydrostatic skeleton/the ratio of surface area to metabolically active tissue is increased/provides room for the development of organs/the muscles involved in locomotion can operate independently from the gut muscles; [1]

(c) **(i)** Locomotion/can make predation more difficult (as can provide strong attachment to substratum); [1]

(ii) (As contain extensive capillary network) can increase the area available for gas exchange/other appropriate response (e.g. increases stability); [1] **[4]**

7 **(a)** **(i)** Arthropoda; [1]

(ii) Jointed limbs/metameric segments are organised into a distinct head, thorax and abdomen/other appropriate response, (e.g. have an exoskeleton); [1]

(iii) Different stages have different food sources/other appropriate response; [1]

(iv) *Advantage* - the insects/larvae evolve to become highly specialist feeders on that species (e.g. develop the mouthparts/enzymes best suited to feeding on that host species)/other appropriate response;

Disadvantage – if ragwort numbers fall the moth caterpillars will not have enough host plants/food available/other appropriate response; [2]

(b) **(i)** The pupa had already hatched by the time the survey had taken place/pupa is the overwintering stage; [1]

(ii) Very few larvae survive to adult stage;

larvae easier to find (e.g. only on ragwort plants/not very mobile/adults may have dispersed); [2] **[8]**

Unit A2 3:

Practical skills in Biology

1 (a)

Description	Apparatus/equipment
Apparatus used to provide the data required to calculate RQ values	**Respirometer;**
Strips containing a gradation of antibiotic concentration – these can be used to measure the minimum antibiotic concentration that can kill bacteria	**E-strips;**
A special slide used to count the number of unicellular organisms in a suspension	**Haemocytometer;**

[3]

(b) (i) Makes the readers aware of who/how many contributed to the work/gives an idea of how much research was done/how up to date the information is/other appropriate response; [1]

Note: answers allowable in the next question part (ii) would not be allowed in this question part, e.g. names the authors as these answers described what is in the bibliography rather than its function.

(ii) Any **four** from:

- name of author(s) contributing
- name of book/article
- publisher
- date
- page numbers (if relevant)

(four correct = 2; two/three correct = 1) [2] **[6]**

2 (a) Greater surface area/more of bacteria in contact with agar;

to obtain food/dilute the toxins produced; [2]

(b) (i) Provides fresh or more nutrients/reduces toxins; [1]

(ii) Any **five** from:

- flame a metal inoculating loop/use a sterile plastic disposable loop
- (if metal) allow to cool
- remove lid of culture bottle (with slope culture) and hold in hand/avoid setting on bench
- flame neck of culture bottle
- inoculate loop by gently scraping over the agar slope
- flame neck of culture bottle before replacing lid [this bullet point or bp4 allowed but not both]
- open Petri dish at angle/only open enough to transfer bacteria
- spread bacteria carefully/gently over the agar in the Petri dish/apply using a glass spreader
- other appropriate response, e.g. work beside a lit Bunsen to ensure 'up-draught' [5]

(c) (i) Using an inoculating loop, spread the microbes over a small section of agar;

sterilise loop/use a new disposable loop;

re-spread at right angles (from the end of first inoculation) and repeat; [3]

(ii) If contamination then the contaminating colony/colonies would appear different; in texture/colour/other appropriate response; [2]

Note: as two marks are available for this question you should be able to deduce that an answer stating that the introduced colonies would be different from the bacterial strain/species being streaked is just not enough.

(d) Viruses can only be active/multiply within cells; [1] **[14]**

Note: while you would probably not get penalised for it, you shouldn't really answer that viruses can only 'live' within cells, as viruses are not living organisms (that is why they are not included within the two classification systems you covered at AS).

3 **(a)** **(i)** A-band; [1]

(ii) Not light microscope – magnification too high/level of detail in image too great;
Not SEM – SEM gives a 3-D image (or converse); [2]

(iii) Intercalated discs/myofibrils branching; [1]

(iv) Spreads nerve impulse over the complete muscle fibre (or muscle)/ensures muscle contracts rhythmically; [1]

(b) **(i)** Myofibril accurately circled; [1]

(ii) Y – mitochondria; [1]

(iii) (Description) – they are closely associated with the myofibrils/no myofibril is far from a mitochondrion/Y;
to supply sufficient ATP/release enough energy for muscle contraction/ATP does not need to be transported a large distance; [2]

(iv) Myosin (fibres);
(contain heads which) attach to actin (fibres) and pull the actin fibres (thus contracting/shortening the myofibril); [2] **[11]**

Note: remember this question part is about the function of myosin, it is not just an account of how muscle contracts.

4 **(a)** Coverslip in correct position; [1]

(b) **(i)** Depth of sampling/degree of stirring/other appropriate response (e.g. sampling from same position (centre) of beaker); [1]

(ii) Not to overfill/avoid air bubbles/avoid suspension getting on top of coverslip; [1]

(c) **(i)** Too many to count in a type-A square or implied (e.g. too dense or too concentrated);
too few in the type-C squares to give reliable data/many type-C squares empty; [2]

Note: answers such as 'easier to count in a type-B square or too hard to see would not be credited as are too vague.

(ii) $12.5 \div (0.04 \times 0.1)/0.004$ **or** 12.5×250;
$3125\ mm^{-3}$; [2]

(iii) Mean number of yeast cells (from the 10 samples for each concentration) and standard error/standard deviation (error) of each mean; [1]

(iv) Yeast suspensions had not been left in the beakers for a long enough period;
yeast suspensions were still in the lag phase/hadn't reached the exponential phase/glucose concentration had not yet become limiting; [2] **[10]**

5 **(a)** KOH removed and replaced with an equal volume of water; [1]

(b) Volume changes would be too small to measure accurately with one maggot/10 gives greater differentiation/greater movements of the coloured bead reduces error due to lack of precision in the apparatus/scale/other appropriate response;

variation in individual organisms/each maggot may have a different metabolic rate/ if one maggot used may not have been representative/will allow an average to be calculated which will be more reliable; [2]

Note: the term 'distinct' was used in the question to steer you away from giving two answers that involved very similar understanding, i.e. the alternatives within each marking point.

(c) **(i)** 1.82 $mm^3\ min^{-1}$; [1]

(ii) 0.91 = CO_2 produced ÷ 182 or CO_2 produced = 0.91 × 182;
165.6/166 mm^3; [2] **[6]**

6 **(a)** **(i)** (Following the removal of the nuclei) the chloroplasts will be the organelles remaining with the greatest mass;

they will 'spin down' fastest/form a layer of sediment as other organelles/cell components remain in the supernatant; [2]

(ii) Mitochondria will also reduce DCPIP/greater control over number of chloroplasts in the samples; [1]

(b) **(i)** A control to show that DCPIP will not change colour over time (without being reduced by chloroplasts in bright light); [1]

(ii) No light;
so photolysis/light-dependent stage of photosynthesis will not take place to provide the H to reduce the DCPIP; [2]

(iii) Tube C would change colour and become green/DCPIP will become colourless;
as the light-dependent reaction/photolysis can take place producing the hydrogens to reduce DCPIP; [2] **[8]**

7 **(a)** Add buffer/solvent to leaves in a mortar/blender;

grind with pestle/blend;

filter through muslin (or equivalent)/decant liquid; [3]

(b) **(i)** Same volume of solvent or buffer/grind or blend for the same time/same mass (or number) of leaves/other appropriate response; [1]

(ii) There would be fewer types of pigment present/no chlorophyll in Y/the yellow leaves (or converse);

proportionally more of carotene/xanthophyll/reduced density of pigments overall; [2]

(iii) Leaves in brighter environments (e.g. outer leaves) retain chlorophyll as they photosynthesise for longer/other appropriate response; [1]

(c) **(i)** The pigments would be more bunched/less separation between different pigments; [1]

(ii) Use less absorbent chromatography paper/saturate vessel more effectively before adding the paper to the solvent; [1] **[9]**

8 (a) **(i)** Cathode correctly labelled (electrode on left, close to well); [1]

(ii) Buffer solution correctly labelled; [1]

(iii) Transporting DNA fragments; [1]

(b) **(i)** Bar 1 has shorter fragments (or converse);

there are more fragments in bar 1 (explaining the darker band) (or converse); [2]

(ii) All the bars present in lane A are also present in lane B;

there are additional bars in B/bars in B that are not present in A;

the same restriction enzyme was added to the DNA in both lanes and one or more additional restriction enzymes added to lane B DNA only; [3]

Note: the answer 'there was different DNA present' would not be credited as you were told in the stem of the question that the same DNA was added to each well.

(c) Any DNA in the lane would be close to the well/no DNA present in the lane;

the enzyme would be denatured/active site altered so that the DNA could not be broken into small fragments that could be transported down the lane; [2] **[10]**

9 **(a)** Middle lamella; [1]

Note: cell wall as an answer is incorrect – the resolution of the photograph is clear enough to distinguish between the middle lamella and the cell wall.

(b) Light microscope; [1]

(c) There are no distinct palisade and spongy mesophyll layers/the structure/arrangement of cells is consistent throughout the leaf/the cells are similar throughout the leaf; [1]

(d) The vacuole is in the centre of the cells;

and there are no chloroplasts in the vacuole; [2] **[5]**

10 **(a)** **(i)** The microscope was focused on the cell membrane/nuclei were in a different plane/nuclei require staining to be visible; [1]

(ii) (An automatic response to) the leaf losing water rapidly/suffering water stress; [1]

(b) Part of the mesophyll (containing chloroplasts) had not been removed; [1]

(c) **(i)** $\dfrac{13.0 - 8.7}{\sqrt{(1.21)^2 + (0.81)^2}}$;

2.95; [2]

(ii) $0.01 > p > 0.002$; [1]

(iii) The difference between the number of leaf hairs on the upper and lower leaf surfaces is (highly) significant;

there are more leaf hairs on the lower surface as there are more stomata/as it is through the lower surface most water is lost;

the leaf hairs reduce air flow (across the leaf surface) thus reducing the rate of water loss by evaporation/transpiration; [3] **[9]**