Section A – Criterion 3

Question 1

a) IV = temperature of the pond weed

DV= rate of photosynthesis (1) concentration of oxygen (½)

b) Any of the following three and explanation (either specific or about validity):

- Species/type of pond weed
- Mass of pond weed
- Light intensity/distance of light source from the beaker
- Time in water bath
- Volume of distilled water – 200g
- Mass of sodium bicarbonate – 5g.

Variables need to be kept constant so they do not impact the results (½). If not fixed then these variables will invalidate the experiment (1). If not fixed then any one of these variables could mask the impact of the intended IV (temperature of the pondweed) (1) which would invalidate the experiment.

c) Beaker needs to spend 10minutes in the 10°C water bath so that the water temp drops to 10°C (1) This is the temperature that the test is being performed in so it is important to have it correct otherwise it will impact on the validity of the experiment – i.e., experiment should test what it is supposed to test(1)

d) At 30°C the amount of O2 release increases above all other temperature (1) which indicates the rate of photosynthesis increases.(1) – answer needs to relate to amount of O2 which indicates rate of photosynthesis.

e) Repeat the experiment several times to determine if the data is reliable i.e. that similar data is gained over many repeats.

Have more replicates (10) at each temperature within the experiment and gain an average. This would help to identify any outliers or potential human errors which can impact on the validity of the design.

Question 2

a) Student 3 is correct.

b) Student 1 – hypothesis has two independent variables so it would not be possible to determine which IV is impacting on the DV.

Student 2 – hypothesis is a question – should be a statement containing clear cause and effect relationship.

Student 4 – the IV is 'change in environment' which is not specific enough and therefore not testable.

Question 3

a) B (1)

b) A: Contents need enzyme and substrate to be present so that reaction can be measured (1)

C: temperature is not constant for different pH levels therefore there are two independent variables (1)

D: pH is not varied (is enough for 1 mark) and it is supposed to be the independent variable for the hypothesis (1).

Question 4

a) To prevent water loss by evaporation (½) form the surface of the tube (½) This would distort the actual amount of water loss from the leaves and affect the validity of the experiment (1) OR any water lost could then be attributes to transpiration through the leaf only (1).

b) Tube C Control (½) to show how much water is lost through the stem (1) which can be compared with Tubes A and B to determine how much water is lost through upper or lower leaf surfaces (½).

Tube D Control (½) to show total levels of water loss from the cutting under normal conditions (1) which can be compared back to tubes A and B to determine how much water is lost through upper and lower leaf surfaces (½).

Question 5

a) Strain C is the most resistant (½) because it is the one that has the greatest amount of bacteria present at the highest level of antibiotic (1 ½) or it takes the greatest amount of antibiotic to kill the bacteria strain.

b) 'Mice with melioidosis are cured of the disease after treatment with an appropriate dose of the antibiotic (chemical drug).'

c) Any three of the following ethical considerations:
    - reduce the number of animals used in experiments to the minimum considered necessary
    - refine or limit the pain and distress to which animals are exposed
    - replace the use of animals with non-animal alternatives when possible
    - take measures to ensure that the animals' environment and management are appropriate for the species and the individual animal and support the animals' wellbeing
    - ensure that steps are taken to safeguard animal wellbeing by avoiding and minimising harm, including pain and distress, to the animals.

d) If the mice are bred to be genetically similar, then other variables that may impact on the dependent variable (ability of antibiotic to cure melioidosis) can be controlled. (1) Other variables may include natural immunity to melioidosis, other health factors, reaction to antibiotic.(1) Controlling variables increases the validity of the experiment as the experiment is able to test what it was designed to test.(1)

Section B – Criterion 5

Question 6

a) (i) River buffalo 30°C cf. bacteria approx. 60°C

(ii) They both have a different level of pH where the activity of the enzyme is optional as river buffalo enzyme being efficient within pH 7-8 (½), while the bacterial enzyme is efficient at a lower pH range 5-6.6 (½). This is because the organisms live in different environments, the bacterium lives in hot springs that are likely to be acidic (½) and the water buffalo has a stable internal environment approximately pH 7 (½).

b) Correct graph: M (½)

Explanation: The initial response is very rapid (½) as there is plenty of substrate to collide effectively/bind with the active site of enzyme (½), but the rate of conversation plateaus as the amount of enzyme becomes a limiting factor when all the active sites are full and the enzyme is operating at maximum rate (½).

c) FX11 would have a similar shape to the active site of the enzyme and would compete with pyruvate (1). Pyruvate conversion into lactate would be slowed/prevented so energy would not be made available to the cell (1).

Question 7

a) Cellular respiration

b) ¼ mark each.

Side A	Side B
i. Cytoplasm/cytosol ii. Not available iii. 2 ATP iv. Lactic acid	i. Mitochondria ii. Available iii. 30 – 38 ATP iv. Carbon dioxide and water

c) Glucose, a form of chemical energy, is the primary energy source used by a cell in the process of cellular respiration.(1) Glucose has high energy bonds which, when broken down during aerobic cellular respiration (Side B), provides energy for the build-up of ADP and P into approximately 36 ATP.(1) ATP is a molecule which provides energy in a useable form to the cell for processes such

as ion transport, nerve impulse propagation, muscle contraction, build up reactions such as protein synthesis and for growth and repair in cell division.(1)

Question 8

a) Chlorophyll absorbs light energy, water is split to form hydrogen ions and oxygen gas,(1) and oxygen will diffuse out of the membrane and create bubbles.(1)

b) Light dependent stage and light independent stage (1)

c) At low light intensities the amount of ATP synthesised is smaller as fewer chlorophyll molecules are excited in light dependent stage(1) There is therefore less ATP available for carbon fixation/glucose production in the light independent stage so relative rate of photosynthesis is slow (1)

Question 9

a) (i) ½ mark each

Enzyme	**Function**
Ligase	Joins together fragments of newly synthesized DNA to form a seamless strand.
Primase	Synthesizes short RNA sequences called primers
Helicase	Unwinds the double helix by breaking hydrogen bonds
Polymerase	Adds daughter nucleotides on the parent strands

(ii) Any ONE of the following:

Hydrogen bonds between bases are weak and easily broken which allows two strands to separate/unzip (1)

Double stranded so both sides act as a template for free DNA nucleotides to join which conserves both sides with every replication (1)

Complementary base pairing on template strands allows accurate replication of conserved strand (1)

b) (i) Nucleus (1)

(ii) 240 bases long (1)

(iii) Mature mRNA will move through the ribosome where each nucleotide is read one codon at a time.(1) tRNA will bring a specific amino acid to the ribosome where it will line up according to the corresponding codon on the mRNA molecule(1).

Question 10

a) Trp mRNA = UGG therefore DNA = ACC (1)
mRNA = AUG AAG CCG AGU CAU UGG (1)
Amino acids = met lys pro ser his trp(1)

b) If T is deleted then the following DNA sequence would be produced: TAC TCG GCT CAG (1) which would code for the same first amino acid (met) but all other amino acids after met would change to ser, arg and val respectively(1). This dramatically impacts on the final polypeptide chain as the shape of the final protein will be different (1)/ or functional protein will not be produced at all. If active site of the enzyme is affected then it will not be able to catalyse the reaction/substrate into product (1).

Question 11

a) RNA polymerase

b) The lac I gene codes for the repressor protein that binds to the operator (1). The repressor protein prevents transcription of the structural genes required to metabolise lactose (1) as it prevents RNA polymerase from starting transcription at the start of the gene. (1)

c) Lac Z codes for the enzyme which breaks down lactose (1). If the only nutrient source is lactose, then E.coli requires the enzyme to hydrolise lactose into glucose and galactose which it can then use for energy (1).

Section C – Criterion 6

Question 12

a) X = 30mV to 40mV – depolarisation Z = -60 to -70mV – resting potential (1)

b) Depolarisation: neuron at resting potential (-70mV) the ion channels are closed. (½)Environmental stimuli triggers Na+ gates to open (½). Inside cell has to get to -55mV for Na+ gates to open (all or nothing).(1) Once Na+ gates open Na+ rush into the neuron (½)Inside cell becomes more positively charged 30 to 40mV. Cell is depolarised. (½)

Repolarisation: K+ gated channels open to allow K ions out to restore balance in the cell (1) and membrane potential moves back towards resting potential.(1)

c) If a graded potential is not sufficient to bring the membrane up to the threshold value (-55 mV), (1) then an action potential cannot be initiated.(1) This kind of stimulus is referred to as a sub-threshold stimulus.

Question 13

a) C (1)

b)

A – acetylcholine does not need to be broken down to bind to receptors on the post synaptic cell. Acetylcholine can be broken down by enzymes as soon as it's released from the axon it's just that enough of it is released that at least some reaches the receptor. (1)

B – Action potential causes Ca++ to open NOT close (1)

D – Structure L is a vesicle which contains neurotransmitter not calcium (1)

Question 14

a) (i) Thermoreceptors are specialized parts of neurons, or nerve cell endings, that give *the body the ability to detect changes in temperature*. Cold receptors and heat receptors.(1)

(ii)Skin, hypothalamus, spinal cord, skeletal muscles (1)

(iii)The cells and their metabolic reactions that happen in them occur most efficiently at these temperatures (1).

b) (i) Effector 1: Capillaries near surface of skin vasodilate (1)

Effector 2: Sweat glands are activated (1)

(ii) When environment temperatures increase above 37°C thermoreceptors in the hypothalamus detect the change in body temperature (1) and send impulses to the spinal cord sympathetic neurons and these send impulses to the capillaries in the skin which cause them to vasodilate which

brings more blood to near the skin surface which allows heat to radiate out through the skin,(1) also sweat glands are activated to increase sweat on the skin surface which can evaporate which cools the body.(1). Both mechanisms help to maintain homeostasis of a constant body temperature of 37°C.

Question 15

a) In the nervous system, electrical impulses carry messages to different organs of the body(½) The endocrine system uses hormones, chemical signals, to carry commands to the destined organs and cells (½). Nerve or electrical impulses transmit through neurons (½). Hormones travel through a bloodstream (½).

b) A target cell responds to a hormone because it has **receptors** that identify the hormone.(1)

c) Hormones (1)

Glucose regulation: insulin or glucagon released from pancreas cells (beta and alpha respectively) – target organ - insulin all cells/liver – glucagon liver (3)

Glucose regulation: increase in blood glucose level in blood stimulates more insulin from pancreas which allow cells to take up more glucose(1) and for liver to convert excess into glycogen (1). Low glucose levels stimulates release of glucagon (1)(less insulin) which causes stored glucagon in the liver to be converted back into glucose.(1)

Question 16

a) (i) Guard cells (1)

(ii) Initially the plant opens their guard cells so stomata are maximum width between 1 and 5 hours.(1) The hot brightly lit room would increase the rate of transpiration and therefore water loss in the plant.(1) To conserve water and maintain water balance (homeostasis) the plant closes its stomates at 9-10 hours.(1)

b) **Alcohol is A** (½) Alcohol causes a decrease in the amount of ADH released. A decrease in ADH will lead to less reabsorption of water, therefore more urine being produced (1). Therefore patient A, with urinary volumes of between 2.8 and 3.5L per day is more likely to be under the effects of alcohol (½).

Ecstasy is C (½) Ecstasy causes an increase in the amount of ADH released. An increase in ADH will lead to more absorption of water and less urine being produced (1). Therefore, patient C, with urinary volumes of between 0.2 and 0.4L per day is likely to be under the effects of Ecstasy (½).

Section D – Criterion 7

Question 17

a)

Structural: skin, mucous, cilia (skin physical barrier prevents pathogens from entering, mucous traps pathogens/particles, cilia brings particles back up trachea and out).

Biological: gut flora, skin flora (outcompetes bad bacteria).

b)

1. Phagocytic cell engulfs pathogen by moving its cell membrane (pseudopods) around it.
2. Phagosome created where pathogen is surrounded by membrane.
3. Lysosome fuses with phagosome and releases enzymes to digest pathogen.

Question 18

a) (i) Vector
(ii) Primary host: human, Secondary host: mosquito
(iii) Vaccine to break life cycle of the protist, mosquito nets to prevent being bitten, insecticide to kill mosquito.

b) Vaccine usually contains a part of the antigen associated with the pathogen (½). Naïve B-cell in the lymph node will recognise specific antigen and will divide into plasma B-cells and memory B-cells (1). Division of B-cells also enhanced by helper T cell activation and release of cytokines(½). Memory B-cells will be stored in the lymph nodes ready for a secondary exposure to the same antigen (1).

c) T-cell response destroys infected cells and so would destroy the infected liver cells. (½) Naïve helper T-cell, once antigen recognition has occurred and cytokines are released, will stimulate production of cytotoxic T-cells.(1) Cytotoxic T-cells can identify infected liver cell and destroy the cell and malaria protist by releasing cytotoxins (1). This would be more effective as antibodies cannot flag a pathogen inside a cell (½).

Question 19

a) Inflammatory response

b) Innate or non-specific immunity

c) (i) Circle the mast cell

(ii) Mast cells release histamine which causes vasodilation of blood vessels which brings more blood to the affected area.(1) This allows the passage of more white blood cells. The capillary walls also become more permeable/leaky which allows phagocytic cells to squeeze through and reach site of infection to phagocytose pathogen(1). This promotes healing as phagocytes destroy pathogen, excess heat from blood increase metabolic rate of cells and excess swelling causes pain and prevent movement of area (1).

Question 20

a) Primary response initiated on day 1(½). Clear lag phase where recognition of antigen is occurring by naïve B and T-helper cells. (½) Eventually plasma cells begin to release antibodies and reach a peak which is initially only a small number of antibodies (½). Memory B-cells are made and stored. (½)

b) The person has been exposed to the same flu antigen either naturally or through another vaccine (1) This has stimulated the secondary response (½) whereby memory B cells for the influenza A antigen are activated to proliferate into plasma B cells much faster (½). These plasma cells can produce large numbers of high affinity antibodies, quickly doubling the maximum number of antibodies produced during the primary response in only a few days (1)

c) This particular vaccine (above example) will only have an effect on the particular antigen (½) found on current Influenza A virus (½), it will not provide lifelong immunity to a new strain (½). This is because a new strain will invoke another primary response (½), there will be no memory cells for the new strain (1/2) as the person would not have been exposed to the new strain (½).

d) Herd immunity (½) occurs when the majority of the population are vaccinated which prevents spread and also protects those that can't be vaccinated. (½)

(i) Fever is a physiological response in relation to mass cytokine production in response to a pathogen (½). Cytokines cause hypothalamus to reset body temp/set point to higher than normal (1). Increase in temp aims to kill pathogen (½).

Question 21

(i) Artificially acquired passive immunity

(ii) Passive immunity means that antibodies have been injected into the park ranger and not the antigen. The park ranger will not develop memory cells for the venom and so will not be protected from future snake bites.

(iii) Venom is a neurotoxin which acts very quickly on a person to shut down organ function and cause death. There is no time to wait for a primary response which can take up to 14 days to produce enough antibodies hence why the anti-venom is necessary.

Section E – Criterion 8

Question 22

a) D,C,B,E,A

b) Yes correct (1), chromosomes break/pull apart at centromeres (1) and sister chromatids move to opposite ends of the cell (1)

Question 23

a)

F – chromosomes undergo DNA replication(1) where each DNA strand makes a replica of itself thereby doubling the amount of DNA in the cell.(1)

G – chromosomes have undergone reduction division during Meiosis I and II.(1) During Meiosis one homologous chromosomes separate creating two haploid cells. During Meiosis II the chromatids separate to produce 4 haploid cells so there is half the amount of genetic material in each cell.(1)

b) Amount of DNA would be restored (2 units) (½) as two gametes would fuse (½)

c) Crossing over occurs where homologous chromosomes swap genetic material between chromatids. (1) This then creates genetically different gametes. (1) Fusion of these gametes creates variation within the offspring which is important if the environment changes as variation enables long term survival of the species.(1)

Question 24

a)

(i) Recessive(½)

Carla is affected but her parents Anna and Michael are not (½). This is only possible if both parents carry the recessive allele (1) i.e. they are heterozygous with the dominant allele masking the expression of the recessive allele (½). Skips a generation only gains (½).

(ii) Cannot be X linked as for Carla to be affected i.e. to have two copies of the recessive allele X^aX^a (1), her father Michael would have to carry the recessive allele on his X chromosome (1). As daughters obtain an X chromosome from both their mother and father (1). The pedigree shows that Michael does not have the disease so it cannot be sex-linked (1). (Can also use Jane and George as evidence)

(iii) George: Aa

Arlene: aa

Sam: Aa

Sandra: AA or Aa

(iv) Both Ann and Michael are heterozygous for alkaptonuria. Aa X Aa results in a phenotypic ratio of 3:1 not affected to affected. So yes, they are more likely to have children who are not affected. (2)

1 mark for Punnett square

	A	a
A	AA	Aa
a	Aa	aa

Question 25

a) All offspring are HhGg – Hairy grey flies. Grey is dominant over black (1) as grey has masked the expression of the recessive allele in the F1.(1)

b) 50% hairy flies (highlighted orange) (2)

HhGg X hh

	h
HG	HhG
Hg	HHg
hG	hhG
hg	hhg

c) 2 marks for correct genotypes

	HG	Hg	hG	hg
HG	HHGG	HHGg	HhGG	HhGg
Hg	HHGg	HHgg	HhGg	Hhgg
hG	HhGG	HhGg	hhGG	hhGg
hg	HhGg	Hhgg	hhGg	hhgg

4 out of 16 would have the HhGg genotype (1)

Question 26

a) In 1999 the population of mosquitoes had variations within their gene pool (caused by random mutation) with a small minority mosquitoes carrying the KDR minus allele (1). Majority of the population carried the KDR plus allele. When the selective agent DDT was applied to the population the mosquitoes with the KDR plus gene died as they had no resistance.(1) The mosquitoes with the KDR minus gene survived to reproductive age and passed on the KDR minus allele to their offspring (1). This is Darwin's theory of Natural Selection where the 'fit' alleles (KDR minus) are being selected for by a particular agent in the environment (DDT).(1) As the KRD plus

mosquitoes are dying there is less competition in the environment so the mosquitoes with the KDR minus gene increase in number as seen on the graph.(1)

Question 27

Genetic drift (Bottleneck effect) whereby the random nature of hunting reduced the population of Northern Seals to nearly zero(1). The original gene pool would not be represented in this smaller population so they are susceptible to genetic drift and lack of variation in alleles(1). If a population of organisms lack genetic diversity, then, if environment changes, the population could be wiped out.(1) Increase in inbreeding could lead to more lethal genes expressing their phenotype which could affect success when reproducing (1).