1. (a) "Depolarisation" / reduced P.D. / –70 to –40 mV;
to threshold;
by local currents;
increased permeability of membrane to sodium ions / sodium gates open;
sodium ions enter;
by diffusion;
positive pd inside / eq via figures;
then potassium gates open / permeability to potassium ions increases;
potassium ions leave;
by diffusion (ONCE only);
resting potential re-established;)
) **N.B.** could
by ion pump / by active transport of ions / by Na-pump;) start here max 7

(b) Increased permeability of (presynaptic) membrane to calcium ions;
Ca^{2+} enter;
vesicles fuse with membrane;
exocytosis of / release of acetylcholine / neurotransmitter /
other named e.g.;
diffuses across synaptic cleft;
binds to receptors on postsynaptic membrane / side;
increased Na + permeability / opens sodium channels / depolarises
membrane / reference e.p.s.p.;
acetylcholine broken down by acetylcholinesterase; max 6

(c) **Rapid**:
Only involves three neurones / receptor, relay and effector neurone;
myelination / saltatory conduction;
and two / a few synapses;
chemical / synaptic transmission is slow OR electrical /
nervous transmission is fast;

Automatic;
does not necessarily involve passage to brain / only spinal cord;
same pathway used each time;
higher brain centres not involved / no thinking; max 4

[17]

2. (a) (i) Several rod cells to each neuron / bipolar cell/each synapse/convergence principle of additive effect of light striking several rod cells/(spatial) summation; 2

(ii) Each cone connects to a single neurone/no convergence;
brain receiving information from each cone cell individually; 2

(b) (i) –60 millivolts; 1

(ii) Increase in membrane permeability/gates open/channels open;
to sodium ions;
sodium ions enter;
by diffusion/down gradient;
(sodium) pump inhibited/eq; max 3

(iii) 0.6 milliseconds; 1

(iv) Calcium ion/Ca^{2+} entry;
vesicles fuse with preSM (and rupture);
exocytosis of/release (neuro)transmitter substance / named e.g.;
diffuse across gap;
attach to receptors on post SM; (not "fuse with....")
increase permeability to sodium (ions) open Na channels/ref. e.p.s.p.; max 3

(c) Insecticide binds to enzyme;
ACh / neurotransmitter not hydrolysed/not broken down;
remains attached to receptor;
Na channels remain open;
continued stimulus to muscles;
tetanus/fatigue/continuous contraction/spasms/no relaxation;
insect unable to move/fly/breathe;
(**I** refs. energy/ATP) max 3

(d) Diagram showing sarcomere shorter/Z lines closer together; 1

(e) (i) Ca^{2+}: moves/detaches/changes shape of switch protein/blocking molecule/tropomyosin/troponin;
expose binding sites/allows cross-bridge formation/eq; max 2
activates myosin ATP-ase/enables myosin head to split ATP;

(ii) Mitochondria: production of ATP;
to attach/release/cock myosin head/
move myosin head/removal of Ca^{2+} ions; 2

[20]

3. (Sodium/Na^+ - potassium/K^+ throughout)

(a) (i) ATP converted/used/energy from ATP; 1

(ii) More potassium pores than sodium pores/more permeable to K^+/
less permeable to Na^+;
more potassium / + ve ions (leaks) out;
R.ref to active transport
R. refs to channel opening/closing
therefore more positive on outside/ORA; max. 2

(b) Sodium ions pumped out (to create diffusion gradient);
sodium gates open/via Na^+ gate to allow sodium ions (to flood) in; 2
I refs to K^+

[5]

4. (a) ACh combines with **receptor** (on neurone C / on postsynaptic membrane);
causes influx of Na^+ ions;
down gradient / diffuse;
less negative/more positive inside/ „depolarisation" occurs;
reference to **above threshold** (to generate action potential); max 3

(b) (Cl^- entry to neurone C) makes potential more negative inside/hyperpolarises;
requires more stimulation (from A) / ACh / Na^+/ more impulses; 2

(c) Reference to modulation of activity of neurone C / impulse transmission not inevitable / eq; 1

[6]

5. (a) (i) **A** *Three marks for three of:*

Negatively charged proteins / large anions inside axon;
Membrane more permeable to potassium ions than to sodium ions;
Potassium ions <u>diffuse</u>* out faster than sodium ions diffuse in;
Sodium / potassium pump;
Sodium ions <u>pumped</u>* out faster than potassium ions pumped in / 3 for 2; 3 max
** mechanism is necessary for mark*

B Sodium ion gates open / membrane more permeable to sodium ions / sodium ions rush in; 1

(ii) *Two marks for two of:*

Membrane impermeable to sodium ions / sodium ion channels closed;
Sodium ions cannot enter axon;
Membrane becomes more negative than resting potential; 2 max

(b) (i) *Two marks for two of:*

Unique shape of receptor protein / <u>binding</u> site; *reject „active site"*
Due to (tertiary) structure of protein molecule;
Concept of complementary shape / ref. to neurotransmitter „fitting"; 2 max

(ii) Cause vesicles to move to presynaptic membrane / fuse with membrane; 1

(c) (i) *Two marks for two of:*

Impulses / action potentials from neurones A and B together / spatial summation;
Cause sufficient depolarisation / open sufficient sodium ion channels;
For threshold to be reached; 2 max

(ii) *Two marks for two of:*

Impulses from A and B independent / no summation;
Threshold not reached;
Insufficient sodium ion channels opened; 2 max

(iii) Inhibitory;
More IPSPs than EPSPs / reduces membrane potential / makes more negative (allow hyperpolarisation) / cancels effect of action potential from A; 2 max

[15]

6. (a) Sensory neurone correctly drawn and labelled;
Relay neurone correctly drawn and labelled;
Motor neurone correctly drawn and labelled; 3
(Synapses need not be labelled)
[Note: If relay neurone is positioned incorrectly, then can allow marks for"the other two if they are drawn correctly and synapse with th relay neurone]

(b) Transmitter substance/ neurotransmitter only produced in pre-synaptic neurone;
Receptor proteins for neurotransmitter only in post-synaptic membrane;
Enzymes in post-synaptic neurone hydrolyse neurotransmitter; max 2

[5]

7. (a) (i) Sodium ion channels open;
Allowing rapid influx of sodium ions; 2

(ii) Sodium ion channels close and potassium ion channels open;
Allowing efflux of potassium ions; 2

(b) Nervous stimulated secretion;
Begins quicker;
Does not last as long/ described using times from graph;
Is more intense/ peak is higher/ eq.;
[Allow: reverse arguments for hormone stimulated secretion] max 2

(c) (i) Proteins in cells of stomach lining;
Would be digested if pepsin was secreted in an active form /
pepsin is a protease; 2

(ii) Endopeptidases hydrolyse/ break/ digest (peptide)
bonds in middle of a protein molecule; 1

(iii) Exopeptidases hydrolyse/ break/ digest bonds at the ends of protein molecules; Endopeptidases create „more ends" larger area
(for exopeptidases to act on); 2

(c) High pH denatures enzyme/ alters charge on active site;
Breaks bonds;
Alters tertiary structure of enzyme molecule;
Changes shape of active site;
Active site can no longer bind with/ form ES complexes with/ is no longer complementary to substrate; max 4

[15]

8. (a) (Pressure) deforms/ opens (sodium) channels/ pores/ gates;
[Ignore: Deforms corpuscle]
Entry of sodium ions; *[Reject: Any other ion] [Accept: Error carried Forward of „wrong" ion]*
Causes depolarisation/ change in membrane potential/ generator potential;
Reference to threshold potential; max 2

(b) Sensory neurone correctly drawn and labelled;
Relay neurone correctly drawn and labelled;
Motor neurone correctly drawn and labelled; 3
(Synapses need not be labelled)
[Note: If relay neurone is positioned incorrectly, then can allow marks for the other two if they are drawn correctly and synapse with the relay neurone]
[Note: 1 mark if all 3 structures labelled correctly but drawn in white matter]

[5]

9. (a) (i) Circle drawn to include „+30" region of neurone;
Reference to depolarised membrane/ change in membrane opening potassium
channels
OR Idea that „this is voltage to start repolarisation"; 2

(ii) Arrow pointing to left hand margin of paper plus written idea that impulse has passed the -75mV point; = 1 mark
Arrow pointing to left hand margin of paper plus reference to hyperpolarisation/ description in terms of ion flow;; = 2 marks 2
[Accept: Description of repolarisation including „overshoot I
[Reject: Both marks if arrow incorrect]

(b) Oxygen used in respiration; *[Reject: Anaerobic reference]*
Valid reference to ATP/energy; *[Reject: Production of energy]*
(For) sodium-potassium pump/ active transport of ions/ uptake/ synthesis of transmitter/ vesicle movement;
(Higher rate of impulses means) more high / amount of sodium ion entry/ potassium ion loss / transmitter uptake / release / vesicle movement; 4

(c) (i) Accurate line of best fit;
Correct working shown, i.e. distance as a number using candidates line;
Time as a number
Correct answer in ms/m/s using candidates line; 3
[*Note: Allow 2 marks for correct answer in mm/ms or equivalent even if no best fit line or working shown*]

[11]

10. (a) (i) Any **three** from:
(Depolarisation of axon membrane causes) local currents to be set up;
Change permeability (of adjoining region) to Na^+/open Na^+ gates (in adjoining region);
sodium ions enter adjoining region;
adjoining region depolarises; max 3

(ii) Any **three** from:
Neurone B is myelinated/equivalent;
Correct reference to saltatory conduction/description;
Active transport of ions/ion pumps "only" used/less active transport of ions at nodes of Ranvier;
Less respiration needed / less ATP needed;
For repolarisation/restoration of ion balance; max 3
[*Allow: converse for neurone A*]

(b) (i) Dilates;
More blood (to muscles)/more oxygen/more respiration;
OR Dilates;
Noradrenaline is neurotransmitter/smooth muscle relaxes; 2

(ii) Any **four** from:

Impulses **to SA node**;
Along (branch of) vagus nerve;
Acetylcholine;
Decreases activity of **SA node/equivalent**;
Decreases rate of contraction/decreases heart rate/heartbeat; max 4

(c) (i) P – impulses from same neurones close together in time/ temporal summation;
P & Q – impulses from different neurones at the same time/ spatial summation; 2

(ii) Inhibitory; 1

[15]

11. (a) Noradrenaline / norepinephrine; 1

(b) (i) 1 (Resting heart rate) controlled by both (divisions);
2 Heart rate changes when parasympathetic/sympathetic (nerve) cut;
3 Parasympathetic nerve is most active / larger change in heart rate when parasympathetic nerve is cut;
4 Parasympathetic reduces heart rate / sympathetic increases heart rate; max 3

(ii) Rate increased by, activity of sympathetic / decreased activity of parasympathetic / change in activity of both; 1

[5]

12. (a) 1 Stimulus to threshold / critical firing level;
2 Sodium channels/gates open;
3 Sodium ions enter;
4 Down electrical/chemical gradient;
5 Positive feedback;
6 Depolarisation;
7 Inside becomes positive / membrane potential reverses;
8 Potassium channels/gates open;
9 Potassium ions leave;
10 Down electrical/chemical gradient
[*Note: only credit if not awarded earlier in point 4*]
11 Repolarisation;
12 Sodium channels/gates close;
13 Undershoot / hyperpolarisation;
14 Sodium-potassium pump restores resting potential; max 6

(b) 1 Presynaptic membrane depolarises;

2 Calcium channels/gates open;
3 Calcium ions enter;
4 Vesicles move to/fuse with presynaptic membrane;
5 Release of transmitter / exocytosis;
6 Diffusion across gap/cleft;
7 Binds to receptors in postsynaptic membrane;
[*Reject: references to active site*]
8 Sodium channels open / sodium ions enter; max 4

(c) 1 Polypeptide (chain) folds;
2 Named bond; [*Reject: peptide bond*]
3 Between R groups;
4 Receptors/binding sites are proteins;
5 Reference to neurotransmitter shape;
6 Acetylcholinesterase/breakdown enzyme, is protein;
7 Carrier/channel protein;
8 Protein has a shape;
9 Idea of complementary/fit/bind/attach to; [*Note: in correct context*] max 5
[*Ignore: ‚lock and key'*]

[15]

13. (a) Transports Na^+ and K^+ ;
By active transport / pump / against concentration gradient;
Restores ion balance after an action potential;
[*reject* K^+ out and Na^+ in] 2

(b) each protein has a specific tertiary structure/shape;
because the ions have different sizes/shape/charge;
[*reject* receptors binding] max 2

(c) fewer protein B molecules, which transport sodium ions;
more protein A molecules, which transport potassium ions; max 1

[5]

14. (i) Binds to receptor/proteins; and opens Na^+ channels;
Na^+ enter and make membrane potential less negative/depolarised 2

(ii) (Vesicles containing) neurotransmitter only in presynaptic membrane/ neurone;
receptor/proteins only in postsynaptic membrane/neurone;
so neurotransmitter diffuses down concentration gradient; max 2

(iii) GABA opens K^+ and Cl^- channels;
K^+ passes out and Cl^- passes in;
Membrane potential more negative/hyperpolarised;
Requires increased stimulation/must open more Na^+ channels/allow more Na^+ to enter;
To reach threshold; max 4

[8]

15. (a) B – It is the 2nd contraction / occurs (immediately) after A / occurs after atrium;
Larger / more force / more pressure; 2

(b) $\frac{60}{\text{time for 1 cycle}}$
= 37 to 38
allow 1 mark if correct working shown max 2

(c) (i) (Heart rate) reduced;
(Stroke volume) no effect; 2

(ii) Reduced because C.O. = H.R. x S.V. / connection argument based on reduced H.R; 1

(iii) Parasympathetic; 1

(d) (i) 1. Coordination via medulla (of brain) / cardiac centre;
2. (Increased) impulses along sympathetic (/ cardiac accelerator) nerve;
3. To S.A. node / pacemaker;
4. Release of noradrenalin;
5. More impulses sent from / increased rate of discharge of S.A. node / pacemaker;

Not "beats"; not "speeds up"

6. Increased heart rate / increased stroke volume; max 4

(ii) In exercise – More energy release / more respiration / actively respiring muscles / for <u>aerobic</u> respiration;
Higher cardiac output – Increases O_2 supply (to muscles);
Increases glucose supply (to muscles);
Increases CO_2 removal (from muscles) / lactate removal;
Increases heat removal (from muscles) / for cooling; 3

If no "increase" – max 2 marks

[15]

16. General Principles for marking the Essay:

Four skill areas will be marked: scientific content, breadth of knowledge, relevance and quality of language. The following descriptors will form a basis for marking.

Scientific Content (maximum 16 marks)

Category	Mark	Descriptor
	16	
Good	14	Most of the material of a high standard reflecting a comprehensive understanding of the principles involved and a knowledge of factual detail fully in keeping with a programme of A-level study. Some material, however, may be a little superficial. Material is accurate and free from fundamental errors but there may be minor errors which detract from the overall accuracy.
	12	
	10	
Average	8	A significant amount of the content is of an appropriate depth, reflecting the depth of treatment expected from a programme of A-level study. Generally accurate with few, if any fundamental errors. Shows a sound understanding of most of the principles involved.
	6	
	4	
Poor	2	Material presented is largely superficial and fails to reflect the depth of treatment expected from a programme of A-level study. If greater depth of knowledge is demonstrated, then there are many fundamental errors.
	0	

Breadth of Knowledge (maximum 3 marks)

Mark	Descriptor
3	A balanced account making reference to most if not all areas that might realistically be covered on an A-level course of study.
2	A number of aspects covered but a lack of balance. Some topics essential to an understanding at this level not covered.
1	Unbalanced account with all or almost all material based on a single aspect
0	Material entirely irrelevant.

Relevance (maximum 3 marks)

Mark	Descriptor
3	All material presented is clearly relevant to the title. Allowance should be made for judicious use of introductory material
2	Material generally selected in support of title but some of the main content of the essay is of only marginal relevance.
1	Some attempt made to relate material to the title but considerable amounts largely irrelevant.
0	Material entirely irrelevant or too limited in quantity to judge.

Quality of language (maximum 3 marks)

Mark	Descriptor
3	Material is logically presented in clear, scientific English. Technical terminology has been used effectively and accurately throughout.
2	Account is logical and generally presented in clear, scientific English. Technical terminology has been used effectively and is usually accurate.
1	The essay is generally poorly constructed and often fails to use an appropriate scientific style and terminology to express ideas.
0	Material entirely irrelevant or too limited in quantity to judge.

[25]

Additional notes

Care must be taken in using these notes. It is important to appreciate that the only criteria to be used in awarding marks to a particular essay are those corresponding to the appropriate descriptors. Candidates may gain credit for any information providing that it is biologically accurate, relevant and of a depth in keeping with an A-level course of study. Material used in the essay does not have to be taken from the specification, although it is likely that it will.

These notes must therefore be seen merely as guidelines providing an indication of areas of the specification from which suitable factual material might be drawn.

In determining the mark awarded for breadth, content should ideally be drawn from each of the areas specified if maximum credit is to be awarded. Where the content is drawn from two areas, two marks should be awarded and where it is taken only from a single area, one mark should be awarded. However, this should only serve as a guide. This list is not exhaustive and examiners should be prepared to offer credit for the incorporation of relevant material from other areas of study.

17. (a) closed open closed;
closed closed open; 2

(b) active transport / pump of Na^+ out of axon;
diffusion of K^+ out of axon / little diffusion of Na^+ into the axon; 2

(c) can not pass through phospholipid bilayer;
because water soluble / not lipid soluble / charged / hydrophilic / hydrated; 2

[6]

18. General principles for marking the Essay:

Four skill areas will be marked: scientific content, breadth of knowledge, relevance and quality of language. The following descriptors will form a basis for marking.

Scientific content (maximum 16 marks)

Category	Mark	Descriptor
	16	
Good	14	Most of the material of a high standard reflecting a comprehensive understanding of the principles involved and a knowledge of factual detail fully in keeping with a programme of A-level study. Some material, however, may be a little superficial. Material is accurate and free from fundamental errors but there may be minor errors which detract from the overall accuracy.
	12	
	10	
Average	8	A significant amount of the content is of an appropriate depth, reflecting the depth of treatment expected from a programme of A-level study. Generally accurate with few, if any fundamental errors. Shows a sound understanding of most of the principles involved.
	6	
	4	
Poor	2	Material presented is largely superficial and fails to reflect the depth of treatment expected from a programme of A-level study. If greater depth of knowledge is demonstrated, then there are many fundamental errors.
	0	

Breadth of Knowledge (maximum 3 marks)

Mark	Descriptor
3	A balanced account making reference to most if not all areas that might realistically be covered on an A-level course of study.
2	A number of aspects covered but a lack of balance. Some topics essential to an understanding at this level not covered.
1	Unbalanced account with all or almost all material based on a single aspect
0	Material entirely irrelevant.

Relevance (maximum 3 marks)

Mark	Descriptor
3	All material presented is clearly relevant to the title. Allowance should be made for judicious use of introductory material
2	Material generally selected in support of title but some of the main content of the essay is of only marginal relevance.
1	Some attempt made to relate material to the title but considerable amounts largely irrelevant.
0	Material entirely irrelevant or too limited in quantity to judge.

Quality of language (maximum 3 marks)

Mark	Descriptor
3	Material is logically presented in clear, scientific English. Technical terminology has been used effectively and accurately throughout.
2	Account is logical and generally presented in clear, scientific English. Technical terminology has been used effectively and is usually accurate.
1	The essay is generally poorly constructed and often fails to use an appropriate scientific style and terminology to express ideas.
0	Material entirely irrelevant or too limited in quantity to judge.

[25]

Additional notes on marking

Care must be taken in using these notes. It is important to appreciate that the only criteria to be used in awarding marks to a particular essay are those corresponding to the appropriate descriptors. Candidates may gain credit for any information providing that it is biologically accurate, relevant and of a depth in keeping with an A-level course of study. Material used in the essay does not have to be taken from the specification, although it is likely that it will be. These notes must therefore be seen merely as guidelines providing an indication of areas of the specification from which suitable factual material might be drawn.

In determining the mark awarded for breadth, content should ideally be drawn from each of the areas specified if maximum credit is to be awarded. Where the content is drawn from two areas, two marks should be awarded and where it is taken only from a single area, one mark should be awarded. However, this should only serve as a guide. This list is not exhaustive and examiners should be prepared to offer credit for the incorporation of relevant material from other areas of study.

19. (a) In table:

D
B
C

All 3 correct = 2 marks;;
2 correct = 1 mark;
0 or 1 correct = 0 marks

2

(b) (i) myelin insulates / prevents ion movement; saltation / described re leaping node to node; 2

(ii) cat has higher body temperature;
ignore references to homoiothermy"/warm-blooded
faster diffusion of ions / faster opening of ion pores/gates/channels; 2

(c) 1. increasing stimulus (potential) causes decrease in potential difference / rise in potential at P;
2. 1 or 2 is sub-threshold / 1 or 2 does not give action potential;
3. 3 or 4 is above threshold / 3 or 4 does give an action potential;
4. influx of Na^+ ions; *(not just Na/sodium)*
5. voltage-gated channels (in axon membrane) opens / opens Na^+ channels /membrane more permeable to Na^+ *(NOT just Na/sodium)*;
6. sufficient for stimulation of adjacent region of axon;
7. impulse propagated (from P to Q);
8. suitable ref. to ‚all-or-nothing" law; 5 max

(d) 1. X / Acetylcholine → pening of Na^+ channels / increases Na^+ permeability;
2. X / Acetylcholine → Na^+ ion entry into Z;
3. X / Na^+ entry - raises potential / reduces potential difference / makes potential less negative;
4. Y / Cl^- entry - lowers potential / increases potential difference / makes potential more negative;
5. X stimulates and Y inhibits (Z);
6. balance of impulses from X and Y determines whether Z fires action potential / determines whether potential rises above threshold; 4 max

[15]

20. (a) (i) Acetylcholine./ Ach 1

(ii) Diffusion. 1

(iii) measurements of cleft & scale, with working;
1/20 or 0.05 micrometre/ 50nm (or in mm, m, etc.)
(must include unit) (1 mark if no unit)
(*2 marks for correct answer without working*)
Accept 0.025-0.075µm, 25-75nm. 2

(b) Active transport of ions/ ionic pump; (reject active transport of Ach)
Synthesis of acetylcholine / neurotransmitter/ reform vacuole;
Reabsorption of acetylcholine, or acetyl + choline (from cleft);
Movement of vesicles (to membrane);
Synthesis of relevant enzyme, e.g. acetylcholinesterase.
(*Reject - general uses of energy,* ***or*** *use in muscle fibril*) max 2

(c) Reduction/ shortening of terminal light bands;
Central H zone disappears / reduced;
Overall shortening of S/fibril/ Sarcomere; 2

[8]

21. (a) Increased permeability to ions/ influx of sodium ions;
Excess +ve ions inside axon/ inside positively charged/ change to +30 mV; 2

(b) All action potentials same size. 1

(c) (i) 0.44s.(*Accept 0.4-0.47 s*) 1

(ii) Action potentials become less frequent, then cease/ stop after 0.2s;
Adaptation/ stimulus no longer generates impulse.
(Reject adaptation at synapse) 2

(iii) Avoids response to „background noise"/ „harmless" stimuli can be ignored/ prevents overloading of cns. 1

[7]

22. (i) Rod cells (responsible for sensitivity);
Several rods connected to each bipolar cell;
Additive effect of small amount of light striking several rod cells;
creating a large enough depolarisation to generate an action potential; max 3

(ii) Cone cells (responsible for acuity);
Each cone cell connected to an individual neurone;
idea of light striking each individual cone cell to generate a separate action potential / impulse;
very small area of retina stimulated, so very accurate vision; max 3

[6]

23. (a) Diffusion across cleft / to postsynaptic membrane;
Attachment to receptors;
Depolarisation/ influx of sodium ions/ change in permeability to ions;

Action potential produced / inside becomes more +ve. max 3

(b) Prevent continuing stimulation / prevent succession of action potentials / allow further transmission across synapse; 1

(c) (i) Serotonin stays in cleft/ not reabsorbed / stays attached to receptors;
Continues to produce action potentials/ impulses /
continues to stimulate „mood enhancing centre". 2

(ii) Reduced supply of serotonin. 1

[7]

24. (a) Multiple connections of rod cells / single connection of cones;
Concentration of cones in fovea/cones in fovea where light/imaged focused; 2

(b) (i) Inflow of sodium ions;
So inside (more) positive (or outside more negative)/ change in membrane potential. 2

(ii) ATP/Energy required constantly/in dark;
To maintain sodium pump/ active transport of ions (from inner segment);
Synthesis of rhodopsin / recombining opsin & retinene;
Synthesis of transmitter. max 2

(iii) Entry of sodium ions to outer segment ceases / rod cell not depolarised / rod cell becomes repolarised or hyperpolarised;
so synaptic transmitter not released. 2

[8]

25. (a) **A-B** – sodium channels open;
sodium ions enter axon (causing increase in positive charge depolarisation);
C-D – sodium channels shut;
potassium channels open;
potassium ions leave axon
(causing decrease in positive charge/repolarisation); max 3

(b) Nerve impulse depolarises the presynaptic membrane;
calcium channels opened;
calcium ions enter the presynaptic membrane;
synaptic vesicles move towards/fuse with, the presynaptic membrane;
release of transmitter substance/ACh/noradrenaline into synaptic cleft;
diffusion of ACh/transmitter substance across cleft;
attachment to receptor sites/protein molecules on post synaptic membrane;
(ion gated) sodium channels opened;
sodium ion influx;
causing depolarisation of post synaptic membrane/sarcolemma; max 7

(c) Summation =
addition of a number of impulses converging on a single post synaptic neurone;
allows integration of stimuli from a variety of sources (spatial summation);
allows weak background stimuli to be filtered out before reaching the brain (temporal summation) max 2

[12]

26. (a) D - Cone/ and E-rod; 1

(b) optic nerve / brain / visual cortex 1

(c) reduces / stops reflection of light 1

(d) idea of retinal convergence <u>of impulses</u> / summation;
giving increased sensitivity at low light intensities 2

[5]

27. (a) protein (molecules);
transcending phospholipid bilayer / intrinsic / transmembrane 2

(b) (i) (blocking of sodium channels) blocks inward flow of sodium ions;
prevents depolarisation / action potential;
prevents passage of impulses along nerve cell;
no impulse - no contraction *both needed*

(ii) (blocking receptor) prevents acetyicholine binding onto receptor;
on postsynaptic membrane;
prevents depolarisation / action potential in postsynaptic nerve cell;
prevents passage of impulse by postsynaptic cell to muscle /
across synapse max 6

[8]

28. (a) Initially membrane impermeable to Na^+;
Sodium channels open;
allowing Na^+ into axon;
reverses potential difference across membrane/ charge on either side/depolarised;
membrane becomes more permeable to K^+ ions/K^+ leave the axon; max. 4

(b) (i) All action potentials are the same size;
threshold value for action potential to occur 2

(ii) frequency of action potentials 1

(c) several (sub-threshold) impulses add to produce an action potential 1

[8]

29. (a) (i) Several rod cells to each neurone/bipolar cell;
additive effect of light striking several rod cells;

(ii) Each cone is connected to a specific neurone;
light striking cone cells generating separate action potentials; max 3

(b) Objects viewed directly are focused on fovea;
mainly cones not rods in fovea/most rods lie outside fovea
dim objects will not stimulate cones; max 2

[5]

30. (a) (i) sodium gates open / membrane becomes more permeable to sodium;

sodium (ions) move in by diffusion / along gradient / since high concentration outside 2

(ii) sodium (ions) pumped out;

active transport / ATP involved/energy required;

sodium gates close / membrane becomes less permeable to sodium; max 2

(b) ATP production / respiration ceased;

ATP needed for sodium pumps / active transport /

to move ions against concentration gradient/energy required; 2

[6]

31. (a) calcium ions move into synaptic knobs / presynaptic membrane;

causing synaptic vesicles to move;

towards presynaptic membrane;

where they release acetylcholine into gap;

transmitter/acetylcholine <u>diffuses</u> across gap;

binds onto receptor / protein molecules;

on postsynaptic membrane;

causing depolarisation / opening of sodium gates / action potential in

postsynaptic cell membrane; max 6

(b) postsynaptic neurone has „high" threshold;
simultaneous arrival of impulses from two presynaptic neurones produces
sufficient transmitter substance;
to cause depolarisation / action potential in postsynaptic neurone /
reach threshold (once only);
this is spatial summation;
impulses in rapid succession from one presynaptic neurone produce
sufficient transmitter
substance;
to cause depolarisation / action potential in postsynaptic neurone /
reach threshold (once only);
this is temporal summation;
insufficient transmitter substance produced in A / B;
to cause depolarisation / action potential in postsynaptic neurone /
reach threshold (once only); max 6

[12]

32. (a) membrane more permeable to loss of potassium ions;
limits entry of sodium ions;
negatively charged proteins inside;
sodium pump; max 3

(b) (i) permeability increases for entry of sodium ions;
becomes positive inside / depolarisation; 2

(ii) potassium ions move out;
(sodium) pump / active transport removes sodium ions; 2

(c) (i) fewer sodium ions enter - (reducing the size);
diffusion is slower - (less steep rise); 2

(ii) sodium pump / active transport is inhibited; 1

[10]

33. (a) calcium ions enter synaptic knob;
vesicles fuse with presynaptic membrane;
neurotransmitter / acetylcholine released;
diffuses across (synaptic gap);
attaches to postsynaptic receptors;
stimulates depolarisation / action potential / end plate potential; 5

(b) (i) attach to postsynaptic receptors;
prevent attachment of acetylcholine / neurotransmitter; 2

(ii) cholinesterase breaks down acetylcholine;
drug prevents breakdown, more acetylcholine is available to bind; 2

[9]

34. (a) (i) Gate opens;
Allowing entry of sodium ions;
Brings about depolarisation/inside of neurone becomes positive with respect to outside 2

(ii) Sodium ions move out;
By active transport/pump; 2

(b) Blocks channel/makes channel too small;
Sodium ions can no longer enter;
Prevents impulses passing from receptors/to brain; 3

[7]

35. (a) A = rods AND B = cones; 1

(b) Fovea centralis / fovea / yellow spot; 1

(c) more receptor cells at 8 / fewer receptor cells at 12 **OR**
cones present in 8 / cones not present in 12;
cones capable of greater acuity (than rods);
because each cone has / is more likely (than rods) to have its own ganglion / bipolar cell / nervous supply; 2 max

[4]

36. (a) (acetylcholine) made in/stored in synaptic vesicles;
released into (synaptic) cleft;
diffuses/moves across (cleft);
binds to protein/receptor molecules on (postsynaptic) membrane/neurone;
causes depolarisation/action potential/new impulse (in postsynaptic neurone);
any 3 from 5 3

(b) to provide energy for the (re)synthesis of Ach OR associated active transport; 1

(c) receptor detects stimulus;
impulse to muscle
(*escape response effected by muscle to withdraw head into burrow*)
muscle (M) longitudinal OR when it contracts it pulls animal shorter;
no coordinator involved/only 3 neurones in reflex (arc);
reflex is „automatic" (or equivalent point);
any 3 from 5 3

(d) (impulses) may cross synapses in one direction only/
transmitter may only travel one way; 1

(e) (i) axon P myelinated;
OR axon diameter of P greater (than that of other axons); 1

(ii) (increased speed of escape response)
increases the animal's chances of survival; 1

[10]

37. (a) active transport/pumping of sodium (ions across membrane);
out of neurone/higher concentration outside;
differential permeability to K^+ and Na^+; 2 max

(b) (i) A – sodium;
B – potassium; Both for 1

(ii) sodium ions diffuse in;
causing depolarisation/described;
potassium ions then diffuse out, to start recovery; 2 max

(If first point wrong, K^+ in opposite direction mark can still be awarded)

(iii) no (new) action potential/nerve impulse be produced in this time; 1

(iv) 1 mark for principle of calculation, time ÷ stated duration
of refractory period/event;
360 – 3 70; (*accept 333-400*) (*correct answer = 2*) 2

[8]

38. (a) membrane relatively impermeable / less permeable to sodium ions / gated channels are closed / fewer channels;
sodium ions pumped / actively transported <u>out</u>;
by sodium ion carrier / intrinsic proteins;
higher concentration of sodium ions outside the neurone;
inside negative compared to outside / 3 sodium ions out for two potassium ions in; 4 max
(*if sodium mentioned but not in context of ions, negate 1 mark*)

(b) (i) 1.6; 1

(ii) $18 \div 1.6 = 11.25$;
multiply by 1000 to convert from ms to s / 11 250; 2
(*correct method = 1 mark, i.e.* $\frac{distance}{time}$ *or* (*1000*)
(*correct answer based on (b) (i) = 2 marks*)

(iii) time for transmission / diffusion across the neuromuscular junction / synapse;
time for muscle (fibrils) to contract; 1 max

(c) movement by diffusion;
binding to receptors on (post-synaptic) membrane;
causing sodium channels to open / sodium ions to move in to muscle (cell); 3

(d) (i) toxin binds to/competes for / blocks the acetylcholine receptors;
acetylcholine can not depolarise the membrane /
the toxin does not cause depolarisation; 2
(*allow references to generating action potentials instead of depolarisation, do not allow references to impulses in muscles*)

(ii) acetylcholinesterase is unable to breakdown acetylcholine;
acetylcholine still available to depolarise the membrane /
generate action potentials in the membrane; 2

[15]

39. (i) rhodopsin bleached/broken down by light;
time for resynthesis; 2

(ii) rhodopsin/pigment absorbs green light more readily than red / is more sensitive to green light;
(after resynthesis) less (intense) green light needed to break down rhodopsin (than red); 2

(iii) white has (high proportion of) wavelengths to which rhodopsin not sensitive; 1

[5]

40. (a) sodium gates or channels open / increase in permeability of axon membrane to sodium ion;
sodium ions enter axon; 2

(c) non-myelinated – next section of membrane depolarised / whole membrane;
myelinated – depolarisation / ion movement only at nodes;
impulse jumps from node to node /saltatory conduction; 3

[5]

41. (a) (i) in case normal coffee differs in some other way;
to control concentration of caffeine; 1 max

(ii) not telling them what the drink contained / purpose of experiment; 1

(b) (i) able to continue for longer; *(not just increases performance)*
(disqualify if also refers to fatty acids and glycerol) 1

(ii) breakdown of fats;
at increased rate / by mobilisation of fat stores; 2

(c) (i) idea that volumes of oxygen and carbon dioxide the same;
reference to equal moles, or quotient as 1 divided by 1/ or 6 by 6; 2

(ii) glycogen is a carbohydrate / broken down to glucose, linked to RQ;
with no caffeine, RQ nearer 1.0 / less carbon dioxide exhaled and more oxygen inhaled (or vice versa);
with caffeine higher proportion of fats/fatty acids respired;
increased time to exhaustion suggests slower use of glycogen: 3 max

[10]

42. (a) 1. automatic (adjustments to changes in environment)/ involuntary;
2. reducing/avoiding damage to tissues / prevents injury/named injury e.g. burning;
3. role in homeostasis/example;
4. posture/balance;
5. finding/obtaining food/mate/suitable conditions;
6. escape from predators; 3 max

(ignore „danger" or „harm" unless qualified)

(b) (i) 1. (impulse causes) calcium ions/Ca^{++} to enter axon;
2. vesicles move to/fuse with (presynaptic) membrane;
3. acetylcholine (released);
4. (acetylcholine) diffuses across synaptic cleft/synapse;
5. binds with receptors on (postsynaptic) membrane;

(reject active sites, disqualify point)

6. sodium ions/Na^{+} enter (postsynaptic) neurone;
7. depolarisation of (postsynaptic) membrane;
8. if above threshold nerve impulse/action potential produced; 6 max

(ii) neurone to neurone and neurone to muscle;
action potential in neurone and no action potential in muscle/ sarcolemma;
no summation in muscle;
muscle response always excitatory (never inhibitory);
some neuromuscular junctions have different neurotransmitters; 2 max

(penalise „nerve" once)

[11]

43. (a) no rods at blind spot or fovea;
greater distribution of rods at edge; 2

(b) more rods and no / fewer cones present;
rods at the fovea / rods not mainly at periphery;

rods have high sensitivity / show retinal convergence / converse for cones;

rhodopsin „bleached" at low light intensities / iodopsin „bleached";
at high light intensities; 3 max

[5]

44. (a) (i) A / dark band is mainly due to myosin filaments;
H zone only myosin filaments;
darker band has both types of filament;
light band has only actin filaments; 2 max

(ii) H zone narrows;
light band narrows;
outer darker regions of A / dark band widen; 2 max

(b) (i) breaks down ATP yielding energy;
used to form / break actomyosin bridges; 2

(ii) **A** and **B**
tropomyosin covers binding site on actin;
no cross bridges formed / ATPase activity on myosin head reduced; 2

B and **C**
calcium ions remove tropomyosin;
binding / calcium ions increase ATPase activity; 2

[10]

45. (a) action potential arrives / depolarisation occurs;
calcium ions enter synaptic knob;
vesicles fuse with membrane;
acetylcholine diffuses (across synaptic cleft);
binds to receptors; 4 max

(b) inside becomes more negatively charged / hyperpolarised; stimulation does not reach threshold level / action potential not produced;
depolarisation does not occur / reduces effect of sodium ions entering; 3

(c) (i) inhibits enzyme (which breaks down GABA);
more GABA available (to inhibit neurone);

OR

binds to (GABA) receptors;
inhibits neuronal activity / chloride ions enter (neurone); 2 max

(ii) receptors have different tertiary/3D structure/shape not complementary;
GABA cannot bind; inhibition of neuronal activity does not occur / chloride ions do not enter; 3

[12]

46. (a) (i) Motor; 1

(ii) Gland / glandular; 1

Q *Answers that name a specific gland may be awarded credit.*

(b) Hormones reach all cells (via blood);
Neurotransmitters secreted directly on to target cell;
Different hormones specific to different target cells; 3

[5]

47. (a) (i) Sodium ions move out of axon;
By diffusion/down concentration gradient;
Through sodium ion channels/sodium ion channels open; 2 max

(ii) Potassium ions enter / potassium ion channels open; 1

(b) Myelin insulates axon / ions can only pass through (plasma membrane of axon) at gaps in myelin sheath;
(Gaps in sheath are called) nodes of Ranvier; 2

Q *The second marking point should be awarded only where answers include the correct scientific term.*

[5]