1. (a) (i) Moves / detaches / changes position of / shape of / switch protein / blocking molecule / tropomyosin / troponin;
(Not just „switches on")
uncovering binding site (on actin) / allows cross bridges to form / eq;
activates myosin ATP–ase / enables myosin head to split ATP; max 2

(ii) Myosin <u>head</u> changes shape / position / „cocks" / works like a ratchet;
moving (actin and myosin) filaments between / past / along / over each other;
[Not just „sliding filaments"] 2

(b) ATP provides energy for release / attachment / movement of myosin (head) (from binding site) / removal of calcium ions; 1

[5]

2. (a) Produces ATP;
A correct equation **R** energy store 1

(b) (i) Anaerobic respiration / glycolysis inefficient / produces little ATP;
requires large amount of glucose to produce enough ATP;
glycogen acting as glucose store / glycogen converted to glucose;
R source of energy/ energy store max 2

(ii) Requires oxygen / glucose;
short diffusion pathway / rapid passage of oxygen;
Removal of heat/CO_2; max 2

[5]

3. ATP - energy source;
to enable formation of actomyosin cross bridges / detachment movement / of myosin head; 2

Ca^{2+} - activate myosin / cause myosin to hydrolyse ATP;
bind to / cause change in shape of troponin;
cause tropomyosin to detach from actin filament / expose binding site (in actin); max 2

[4]

4. (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]

5. (a) 1, 2 **A** and **D** (any order); 1

(b) Fast fibres make immediate/fast **contraction** possible before the circulation/blood supply adjusts/ most energy anaerobically generated;
fast fibres used in explosive/sprints locomotion;
slow fibres allow sustained **contraction**/anaerobic energy generation;
slow fibres used in maintaining posture/endurance events;
(answers which combine features of both,
without specifying which muscle
type provides which benefit: max 1) max. 2

[3]

6. (a) A-band: no change **AND** I-band: shorter;
H-zone: shorter / disappears; 2

(b) (i) A/A + H; 2

(ii) A and I;

(c) Binds / displace blocking molecules / troponin / tropomyosin / accessory filaments;
reveal binding sites on actin / allow actin-myosin combination;
activate ATP-ase;
ref. activate release of transmitter substance acetylcholine; max 2

[6]

7. *Quality of communication*

The answers to all sections of this question require the use of continuous prose. Quality of language should be considered in crediting points in the scheme. In order to gain credit, answers should be expressed logically and unambiguously, using scientific terminology where appropriate.

(a) *Four marks for four of:*

Calcium ions bind to troponin;
Remove blocking action of tropomyosin / exposes actin binding sites;
ATP allows myosin to join / bind to actin / form cross-bridge;
„Re-cocks" myosin cross bridge / allows detachment from actin;
Enables calcium ions to be pumped back in;
Phosphocreatine allows regeneration of ATP without respiration;
Phosphocreatine releases Pi to join ADP; 4 max

(b) *Six marks for six of:*

Endurance athletes exercise for long periods of time;
Respire / release energy aerobically;
Or too much lactate would accumulate;
Slow twitch fibres adapted to aerobic metabolism;
As have many mitochondria;
Site of Krebs' cycle;
And electron transport chain;
Much ATP formed;
Also are resistant to fatigue; 6 max

(c) *Five marks for five of:*

Receptors in hypothalamus detect increase in core temperature / temperature of blood;
Heat loss centre stimulated;
Skin arteries / arterioles dilate / vasodilation;
Shunt vessels / pre-capillary sphincters constrict;
More blood flows to surface (capillaries);
Heat loss by radiation;
Heat loss by evaporation of sweat;
Reduced metabolic rate;
Remove clothing / seek cooler area / cold drink; 5 max

[15]

8. (a) Myosin; *[Reject: any other protein]* 1

(d) A band - stays the same width/ nothing;
I band - becomes narrower/ shorter/ smaller; *[Accept: Contracts]* 2

(e) Correct working of $\frac{48 \times 100}{1.6}$ / or equivalent;
= 30,000 ×; 2
(*Note: Allow 2 marks for correct answer even if no working shown but max 1 mark if units of measurement given*)

[5]

9. (a) (i) H band not visible/reduced / little/no thick filament/myosin only region / ends of thin filaments/actin close together;
I band not visible/reduced / little/no thin filament/actin only region;
A band occupies nearly all sarcomere / thick filament/myosin close to Z line;
Large zone of thick-thin overlap; max 2

(ii) *Calcium ions:*
Bind to troponin;
Remove blocking action of tropomyosin / expose myosin binding sites;

ATP:
Allows myosin to detach from actin / to break cross bridge;
[allow attach and detach]
Releases energy to recock/swivel/activate myosin head / drive power stroke; max 3

(b) (i) Depolarisation of axon membrane/influx of Na^+ <u>establishes local currents;</u>
Change permeability to Na^+ /open Na^+ gates of <u>adjoining region;</u>
<u>Adjoining region</u> depolarises / influx of Na^+ ;
This process repeated along axon / self propagation;
Correct reference to/description of saltatory conduction; max 3

(ii) Depolarisation of (presynaptic) membrane;
Ca^{2+} channels open / increased permeability to Ca^{2+} ;
Influx of Ca^{2+} ;
Vesicles move towards presynaptic membrane;
Vesicles fuse with presynaptic membrane; max 3

[If ions mentioned once assume candidate is referring to ions throughout; if no mention of ions penalise once only]

(c) (i) 1. Correct axes labelled, correct orientation, linear scale;
2. Key points (100%, 90% and 50%) plotted correctly;
3. Plots joined by straight lines;
[allow reasonable hand-drawn straight lines] 3

(ii) <u>Fast fibres used</u> (in explosive exercise); 1

[allow reverse for slow fibres]

[15]

10. (a) 1. e.m. gives high resolution;
2. due to short wavelength of electrons;
3. antibodies attach specifically to target proteins;
4. gold particles are electron dense;
5. electrons must pass through a vacuum;
6. material must be dead / fixed for e.m.;
7. cross-bridge cycling requires living cells / metabolism / named aspect-e.g. ATP synthesis; 5 max

(b) 1. Ca^{2+} removes blocking molecules / uncovers binding site on actin;
2. correct references to Ca^{2+} binding to troponin / moving tropomyosin;
3. allows myosin heads to attach to actin filaments;
4. allows sliding of the actin and myosin filaments;
5. binding of ATP causes myosin (head) to detach (from actin);
6. (hydrolysis of) ATP releases energy;
7. which changes the configuration / cocking of the myosin head; 5 max

[10]

11. (a) (i) A band; 1

(ii) H zone and I band; 1

(b) filaments in I / thin filaments / actin filaments slide in between myosin / thick filament; thin filaments enter H zone / meet in middle of A band / pull Z lines closer; 2

(c) correct answer: 22.5 mm ;; = 2 marks

OR relaxed sarcomere length = $\frac{48}{16}$ / = 3 μm ; = 1 mark 2 max

(d) (i) In table:

low	high
low	high
high	low

(1 mark per row;;;) 3

(ii) 1. overall rate of contraction limited by rate of ATP-splitting;
2. ATPase splits ATP / hydrolyses ATP / converts ATP to ADP (+ phosphate);
3. ATP-splitting provides energy for *any TWO from* myosin-actin interaction;myosin head movement / actin to move relative to myosin; to „cock" myosin head; 4 max

(iii) lactate = product of anaerobic respiration;

type 1 has higher activity of glycolytic enzymes / has lower activity of Krebs cycle enzymes / has fewer mitochondria; 2

[15]

12. (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]

13. (a) (i) P - actin;
Q - actin + myosin;
R - myosin; 3

(ii) Diagram with narrower band P and narrower or no band R 1

(b) ATP produced by respiration;
Hydrolysis/breakdown of ATP releases energy;
Cross-bridges or „links" between actin and myosin/ in actomyosin;
straighten/move myosin along actin;
Actin moves towards centre of sarcomere/ ends of sarcomere pulled in;
Action of tropomyosin at binding sites / ref. to action of
calcium ions. max 4

[8]

14. multi-nucleate;
striations / sarcomeres / banding;
actin / myosin / contractile protein;
no microvilli / surface not folded;
more mitochondria;
contain myoglobin; max 3

[3]

15. (a) (i) myosin; 1

(ii) actin; 1

(b) myosin filaments;
form cross bridges to actin / bind to actin;
move actin filaments / actin filaments move;
ratchet mechanism described;
allow relevant reference to ATP as energy source;
allow reference to calcium switch / tropomyosin; max 4

[6]

16. (a) (i) actin; 1

(ii) myosin; 1

(b) (i) mitochodrion; 1

(ii) R and T decrease in length; 1

(iii) actin filaments are moved;
ratchet mechanism / description;
bridges formed between myosin and actin;
use of ATP in forming / breaking bridges;
reference to role of calcium / tropomyosin; 4

[8]

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

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

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

[9]

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.

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 materials 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 Written Communication (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 accurately throughout
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]

19. (a) Two differences with effects;;

myasthenic has fewer folds/ fewer receptors;
so less chance of depolarisation/fewer Na^+ channels open;

wider gap/cleft;
so takes longer for transmitter to diffuse across;
different ratio of receptors to esterase;
so transmitter more likely to be destroyed before binding to receptor;

acetylcholinesterase in shallower folds/more exposed;
so transmitter destroyed before binding (to receptor); 4 max

(b) tropomyosin on actin;
calcium ions needed to move it out of the way;
allows myosin to bind to actin/formation of cross bridges;
fewer calcium ions leads to fewer power strokes/
ratchet actions;
needed for activation of ATPase; 3 max

[7]

20. (a) **X** – ADP,
Y – phosphate/Pi/Ⓟ; 1

(b) (*candidates may start at any point but must refer to stages*)
Stage **A**, binding cause(d) myosin head to move and pull actin past:
Stage **B**, binding of ATP releases myosin head from actin;
leading to movement of myosin head in Stage **C**;
B/**C**/**D** linked to breakdown of ATP to ADP and phosphate;
Stage **D**, myosin head binds to actin;
binds to actin to left of first one;
also causes ADP and phosphate release; 4 max

(c) without ATP, myosin heads remain bound (to actin); 1

[6]

21. (a) **W** = myosin
X = actin; 1

(b) myofibril is contracting in **Figure 3** / relaxing in **Figure** 2;
movement of actin fibres between myosin fibres; 2

(c) interact with/move/touch tropomyosin; (*allow troponin as alternative*)
to reveal binding sites on actin; (*not active sites*)
allowing myosin (heads) to bind/touch actin / actinomyosin formed;
activate ATPase / energy released from ATP; 4

[7]

22. (a) calcium ions;
bind to/displace tropomysin; *(allow troponin)*
reveal binding site on actin;
myosin binds to exposed sites on actin/actomyosin formed/
cross bridges form between actin and myosin;
activates ATPase; 3 max

(b) distance single actin filament moves divided by distance moved
using 1 ATP;
15 ATP; 2

(c) respiration stops;
no ATP produced;
ATP required for separation of actin and myosin/cross bridges; 2 max

[7]

23. (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]

24. (a) (i) **W** = actin; 1

(ii) **X** = myosin; 1

(b) In Fig 2, only actin / thin filaments present;
In Fig 3, actin / thin filaments and myosin / thick filaments present;
Actin /thin filaments have moved into myosin / thick filaments; 2 max

(c) Hydrolysis/breakdown of ATP provides energy;
(Energy) for power stroke / breakage of actin-myosin cross bridges;
Calcium ions activate ATPase;
Calcium ions cause tropomyosin molecules to move / expose myosin-binding sites on actin; 4

Q *Do not allow reference to ATP making energy.*
As calcium ions is given in the question, allow references to 'calcium' (i.e. without ions in points 3 and 4.

[8]