

6.3 Organisms - Responses to their environment (A-Level Only) - Skeletal Muscles – Mark schemes

Q1.

- (a)
1. Calcium ions diffuse into myofibrils from (sarcoplasmic) reticulum;
 2. (Calcium ions) cause movement of tropomyosin (on actin);
 3. (This movement causes) exposure of the binding sites on the actin;
 4. Myosin heads attach to binding sites on actin;
 5. Hydrolysis of ATP (on myosin heads) causes myosin heads to bend;
 6. (Bending) pulling actin molecules;
 7. Attachment of a new ATP molecule to each myosin head causes myosin heads to detach (from actin sites).

5 max

- (b)
1. Releases relatively small amount of energy / little energy lost as heat;
Key concept is that little danger of thermal death of cells
 2. Releases energy instantaneously;
Key concept is that energy is readily available
 3. Phosphorylates other compounds, making them more reactive;
 4. Can be rapidly re-synthesised;
 5. Is not lost from / does not leave cells.

2 max

[7]

Q2.

- (a) Increase in aerobic respiration

OR

Increase in / more mitochondria

OR

Increase in / more slow muscle fibres;

Ignore: reference to Krebs cycle as this in the stem of the question.

1 max

- (b)
1. (More aerobic respiration) produces more ATP;
 2. Anaerobic respiration delayed;
 3. Less or no lactate;
 1. *Accept: produces ATP faster.*
 2. *Accept: aerobic respiration can continue.*
 2. *Accept : no anaerobic respiration.*
 3. *Accept: lactic acid.*

3

- (c)
1. Correct answer in range 84 to 84.2 = 2 marks;
 2. For one mark accept incorrect answer but shows r (radius) = 0.63 (mm)
OR
 d (diameter) = 1.26 (mm);
2. Ignore: numbers after 0.63 and 1.26.

2

- (d)
1. A numerical comparison of range = **2 marks** i.e.
Young (fibres) range 14/15 – 47/48 (μm) **and** adult (fibres) 17/18 – 86/87/88 (μm)

OR

- Young (fibres) range 32/33/34 **and** adult (fibres) range 68/69/70/71;
2. Comparison of range without numbers = one mark i.e.
Adult (fibres) greater range / spread / variation (of diameters)

OR

- Young (fibres) smaller range / spread (of diameters);
3. Comparison of mode = one mark i.e.
Adult (fibres) peak/most common/frequent/mode at 50 (μm) and young (fibres) peak/most common/frequent/mode at 30 (μm);
1. *Accept: **one** mark for comparison of minimum values i.e.
14/15 compared to 17/18
Allow **one** mark for comparison of maximum values i.e.
47/48 compared to 86/87/88.*
 1. *Note: comparison of both maximum and minimum values = **2 marks**.*
 3. *Accept: adult (fibres) peaks at higher diameter or young (fibres) peak / most frequent at lower diameter.*
 3. *Reject: reference to mean / average.*

2 max

[8]

Q3.

- (a) 1. Splitting / breakdown / hydrolysis of ATP;
2. (Muscle) contraction requires energy / ATP;
*Accept 'uses energy'. Reject idea of 'movement' of muscles requiring energy.
Reject suggestion that 'energy is produced'.*
3. Use of ATP by myosin.
Accept a reference to any use of ATP by myosin. No credit for any further detail.

2 max

- (b) Fast because (lots of) ATPase allows rapid **hydrolysis** of ATP
OR
Slow because (lots of) ATPase allows rapid **synthesis** of ATP.
Accept either approach as some texts refer to ATPase as the enzyme at the end of the ETC in mitochondria.

1

- (c) 1. Need light to see colour / brown / yellow;
Requires reference to light.
2. Cannot see colour / brown / yellow with electrons / an electron microscope;
*Requires reference to electrons / electron microscope.
Accept 'see black and white with electrons / electron microscope'.*
3. No organelles are visible.
Accept appropriate named examples of organelles.

2 max

[5]

Q4.

(a) C = M line / M disc / myosin filament

D = mitochondrion

E = myofibril

3

(b) Sarcomere

1

(c) Answer in range 1.14–1.18

1

(d) 1. As a store of glucose

Ignore provide energy

OR

To be hydrolysed to glucose;

2. For respiration / to provide ATP;

2

(e) 1. Low pH changes shape of calcium ion receptors

Do not accept tropomyosin does not move

2. Fewer calcium ions bind to tropomyosin;

Accept troponin

3. Fewer tropomyosin molecules move away;

4. Fewer binding sites on actin revealed;

5. Fewer cross-bridges can form

OR

Fewer myosin heads can bind

Must include idea of fewer at least once

3 max

[10]

Q5.

(a) 1. (Reaction with ATP) breaks/allows binding of myosin to actin/ actinomyosin bridge;

2. Provides energy to move myosin head;

1. Credit 'breaks' or 'allows' binding to actin (because cyclical)

2. Allow in context of 'power stroke' or 're-cocking' (because cyclical)

2. Ignore contraction on its own

2

(b) (i) Any value between 68.5 and 69.49 (%);;

If get difference of 0.9 but calculation of percentage incorrect, then award 1 mark;

2

(ii) (Mutant mice)

1. Unable to make phosphocreatine/ less phosphate available to make/recycle ATP;
2. So less energy/so less ATP available for contraction/fast muscle fibres;
1 and 2. Reject production/creation of energy once
2. Accept less energy for grip
2. Accept no energy/no ATP for contraction/fast muscle fibres

2

- (c) 1. (Heterozygous) have one dominant/normal allele (for creatine production);
2. (This) leads to production of enough/normal amount of creatine;
1. Accept has one allele/one copy of the gene for/that is making creatine

2

[8]

Q6.

(a)

Function	Name
Attaches to Z line at the end of the sarcomere	1. Actin;
Breaks down ATP	2. ATPase / myosin (head);
Covers binding site on actin in relaxed myofibril	3. Tropomyosin;

Accept water

Accept troponin

3

- (b) 1. Can't form myosin / thick filaments;
Neutral: prevents actin and myosin sliding filament action
2. Can't pull / can't move actin / slide actin past / (myosin) have to be joined / fixed to pull actin;
Accept: myosin can't pull on each other
3. Myosin moves / if attached doesn't move;
4. Can't move actin towards each other / middle of sarcomere / between myosin / can't shorten sarcomere / can't pull Z lines together.

Q7.

- (a) 1. Fields of view randomly chosen;
 2. Several fields of view;
 3. All same species (of animal / hamster);
Reject general statements related to sample size. All mark points relate directly to information provided in Resource A. Accept 'all (Mesocricetus) auratus'.
4. Same muscle / organ used / only diaphragm used;
 5. Used at least 8 (animals) in each (age) group.
- 4 max
- (b) (i) 15
*Correct answer = 2 marks.
 Allow 1 mark for showing
 $69 \div 4.6$
 OR
 answer of 10 / 10.1 (correct calculation using fast in error.)*
- 2
- (ii) 1. (Calculation) used mean (number of capillaries);
 2. Variation in number of capillaries per fibre.
*Note: maximum of 1 mark for this question.
 Ignore reference to an anomaly or calculation errors.*
- 1 max
- (c) (i) (Removing diaphragm means) animals / hamsters are killed.
- 1
- (ii) 1. (Suggests) significant (difference) between young and adult;
MP1, MP2, MP4 and MP5 can include use of figures but check figures are used correctly.
2. (Suggests) not significant (difference) between adult and old;
Statements related to 'results being significant / not significant' do not meet the marking points. It is the difference that is significant or not. However, only penalise this error once.
3. For slow **and** fast fibres;
This MP can be given in the context of either MP1 or MP2 but only allow once. As well as this context there must be a reference to 'both' types of fibre.
4. (Suggests) significant (difference) between young and old for fast (fibres)
 OR
 (Suggests) not significant (difference) between young and old for slow (fibres);
All aspects of either approach required to gain credit.
5. (Suggests) significant (difference) where means \pm SD do not

overlap

OR

(Suggests) not significant (difference) where means \pm SD overlap;

All aspects of either approach required to gain credit.

6. Stats test is required (to establish whether significant or not).

4 max

[12]

Q8.

- (a) (i) (Group) 5 / marathon runners.

Must only include this group and no other.

1

- (ii) 1. (5 / marathon runners) have highest percentage of slow fibres;

Maximum of 1 mark if the wrong fibres have been identified.

2. (Slow fibres) use aerobic respiration / aerobic respiration occurs in mitochondria;

Either approach requires identification of aerobic respiration.

3. (Slow fibres) best for endurance / long periods of exercise / to avoid fatigue.

2 max

- (b) 1. No (overall) change in number of fibres;

Reject any suggestion of an increase in number of fibres.

2. Increase in diameter of fibres;

'Size' without qualification is insufficient.

3. (Due to) training / exercise;

4. (Long-distance) cyclists have more / higher percentage of slow fibres (than fast);

A comparison is required to meet this MP.

5. Slow fibres of wider diameter than fast fibres;

6. (Long-distance) cyclists have more mitochondria;

7. (Long-distance) cyclists have more capillaries (in muscles).

Idea of 'more' (than non-athletes) is required to gain credit.

Accept converse (for non-athletes) in MP4, MP6 and MP7.

3 max

- (c) 1. Weightlifting favoured by / weightlifters have a high proportion of fast / low proportion of slow fibres

OR

Weightlifters have more fast / fewer slow fibres than non-athletes;

But (cannot tell because):

Reward for general statement or comparison with non-athletes.

For 'proportion', accept percentage (or idea of a ratio).

2. Do not know what 'weightlifters' (tested) were born with / had before started weightlifting / training

OR

Don't know if there has been a change (in proportion due to weightlifting

/ training);

3. No information about age / gender / number of weightlifters (in sample).

For this MP, accept another relevant factor that might affect 'weightlifter' e.g. weights lifted, sex, diet, ethnicity, country of birth.

Ignore general statements about 'other factors'.

2 max

[8]

Q9.

- (a) 1. (Phosphocreatine) provides phosphate / phosphorylates;

Accept P_i or P in circle

Reject phosphorus

2. To make ATP;

Accept:



Neutral – provides ATP

2

- (b) One suitable suggestion;

eg

1. Genetic differences;
2. Level of fitness / amount of regular exercise done / mass of muscle;
3. Sex;
4. Ethnicity
5. Metabolic rate;
6. Number of fast / slow muscle fibres
Neutral lifestyle / diet / illness

1 max

- (c) 1. Fast muscle fibres used for rapid / brief / powerful / strong contractions;

2. Phosphocreatine used up rapidly during contraction / to make ATP;

3. (As people get older) slower metabolic rate / slower ATP production / slower respiration;

4. ATP used to reform phosphocreatine;

4

[7]

Q10.

- (a) (i) 1. Moves out of the way when calcium ions bind;

1. Accept shape change with Ca^{2+}

1. Don't accept just "calcium"

2. Allowing myosin to bind (to actin) / crossbridge formation;
 1. *Accept presence of calcium ions leads to movement instead of binds*
Accept references to troponin

2

- (ii) 1. Head (of myosin) binds to actin and moves / pulls / slides actin past;
Q
2. (Myosin) detaches from actin and re-sets / moves further along (actin)
 1. *Accept myosin power stroke (to move actin)*
 1. *Accept push*
 1. *Accept crossbridges form instead of myosin head binds to actin*
 1. *Must refer to myosin head or crossbridges*
3. This uses ATP;

2 max

- (b) (i) 1. (Glycogen broken down) gives (lots of) glucose for glycolysis / anaerobic respiration;
 1. *Give if context of anaerobic respiration clear*
2. Glycolysis / anaerobic respiration not very efficient / only yields 2 ATP per glucose;
 2. *Accept anaerobic respiration is a quick source of ATP for exercise*
 2. *Accept very little ATP*

2

- (ii) 1. (Many capillaries) give high concentration / lots of oxygen / shorter diffusion pathway for oxygen / large surface area for oxygen exchange / diffusion / good glucose supply with little glycogen present;
2. Allows high rate of / more aerobic respiration **OR** prevents build-up of lactic acid / (muscle) fatigue;
 3. *Accept idea of aerobic respiration during endurance events / long periods of exercise*

2

[8]

Q11.

- (a) (i) Blocks myosin binding (site) on actin;
Accept converse statements

Moves from binding site on actin due to Ca^{2+} ;
 Allowing myosin to bind (to actin) / crossbridge formation;

2 max

- (ii) Releases myosin from actin;
Accept coming / moving away from actin

Causes myosin head to move / cock;

Used in active transport of Ca^{2+} ;

2 max

- (b) Antagonistic muscles / opposing pairs of muscles;
Working across/at joints;
Both contract to keep joint/the body at certain angle / upright;
Isometric contraction;
Only a few fibres contract to avoid fatigue/slow muscle fibres used;

3 max

[7]

Q12.

- (a) (i) Decreases;

Accept any word that means a decrease e.g. shorter / narrower / smaller etc

1

- (ii) Nothing / stays the same length / does not change;

1

- (b) 1. Two marks for correct answer of 29545-30455;

Correct answer = 2 marks outright. Range allows for a 1mm error in measuring

2. One mark for incorrect answers in which candidate clearly divides measured width by actual width;

Ignore rounding up

2

- (c) (Idea ATP is needed for:)

1. Attachment / cross bridges between actin and myosin;

Accept the role of ADP in attachment

2. 'Power stroke' / movement of myosin heads / pulling of actin;

Not just 'filaments slide' as given in the question stem

3. Detachment of myosin heads;

4. Myosin heads move back / to original position / 'recovery stroke'

3 max

[7]

Q13.

- (a) (i) Contains more / large amount of succinic dehydrogenase;

Accept "the enzyme" since only one being discussed

(Slow fibres) have lots of mitochondria / (slow fibres) respire aerobically;

2

- (ii) Near edge / outside;

Short distance for diffusion of oxygen / Allows rapid diffusion / more diffusion of oxygen;

Ignore glucose

Accept carbon dioxide

Oxygen used by mitochondria / electron transfer system in mitochondria;

Accept effect of carbon dioxide on cell e.g. carbon dioxide changes pH / carbon dioxide affects enzymes

3

- (b) (i) Measure with graticule / eyepiece scale;

Calibrate against something of known size:

OR

Estimate / measure field diameter with a scale;

Estimate number of fibres to cover diameter;

Q Last point could be a calibrated slide / haemocytometer / red blood cell or reasonable alternative

Accept

Mount on ruler / haemocytometer / graph paper;

use this to measure size;

Note position of ruler must be specified and correct

2

- (ii) Equivalent measurements taken;

At random to avoid bias / avoid choice of particular fibres;

Large number to be representative / minimise effect of extremes / of anomalies;

As a stained slide is provided reject references to safety.

Ignore reliable

2 max

[9]

Q14.

- (a) (i) Crista / inner membrane;

1

- (ii) Matrix;

1

- (b) B;

1

- (c) (i) Reduce / prevent enzyme activity;

1

- (ii) Prevents osmosis / no (net) movement of water;

So organelle / named organelle does not burst / shrivel;

Q Allow reference to cell rather than organelle for first mark point only.

Regard damage as neutral

2

- (d) (Mitochondria) use aerobic respiration;

Mitochondria produce ATP / release energy required for muscles (to contract);

Q Do not accept reference to making / producing energy.

2

[8]

Q15.

- (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 = $\frac{48}{16} = 3 \mu\text{m}$; = 1 mark 2 max

- (d) (i) In table:

low	high
low	high
high	low

(1 mark per row;;;)

- (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]

Q16.

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

Q17.

- (a) (i) Myosin filaments drawn longitudinally in A-band region;
Actin filaments drawn longitudinally from Z-line to edge of H-zone;
[Max. 1 mark if Actin and Myosin are not correctly labelled]

2

- (ii) Electron microscope has greater resolution / able to tell two close objects apart better / electrons have shorter wavelength / higher frequency;

1

- (b) Correct answer = 20;

Allow 1 mark for: $\frac{16 \times 1000}{8000}$;

OR

$40 \div \frac{16}{8000}$

2

[5]

Q18.

- (a) (i) actin (*Accept* tropomyosin);

1

- (ii) myosin head;

1

- (b) (i) Ca²⁺ binds to [part of] the actin / troponin;
this causes tropomyosin to be displaced;
uncovers [myosin] binding sites [on actin] / allows actin to bind;

max 2

- (ii) myosin heads bind to actin / cross bridge formation / actomyosin formed;
myosin heads / crossbridges swivel / ratchet mechanism;
causing actin to slide relative to myosin;
energy provided by hydrolysis of ATP;

max 3

- (c) (i) (number lightly stained fibres / total number of fibres) × 100;
(actual numbers are 10 / 18 × 100)

1

- (ii) sample not representative / large enough / individual muscle fibres different sizes / contain different number of myofibrils;

1

- (d) all some stain = 1
fast dark and slow lighter = 2

2

- (e) change in base sequence in DNA / addition / deletion / substitution of a base in DNA of the gene which codes for myosin;

change in amino acid sequence / primary structure;
causes a different tertiary structure;
which alters the binding properties of myosin;

4

[15]

Q19.

- (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⁺ establishes local currents;
Change permeability to Na⁺ / open Na⁺ gates of adjoining region;
Adjoining region depolarises / influx of Na⁺;

3

- (ii) Depolarisation of (presynaptic) membrane;
Ca²⁺ channels open / increased permeability to Ca²⁺ causing influx of Ca²⁺ ;
Vesicles move towards / fuse with presynaptic membrane;
[If ions mentioned once assume candidate is referring to ions throughout; if no mention of ions penalise once only]

3

- (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) Fast fibres used (in explosive exercise);
[allow reverse for slow fibres]

1

[15]

Q20.

- (a) Potassium channels open (and K⁺ ions diffuse out);
Accept references to sodium channels opening;

Sodium channels close (and stops Na⁺ ions diffusion in);
Leading to depolarisation;

Accept sodium pump (starts) to pump out sodium ions

2

(b) (Absolute) refractory (period);

1

(c) (i) Causes them to contract;

And relax;

Rapidly/twitch;

2 max

(ii) Cause continuous muscle contraction;

Accept a reasonable suggestion of harm – linked to muscle contraction

At high force;

Causing failure to breathe/heart stops pumping/
damage to bones or joints;

2 max

[7]

Q21.

(a) (i) maintaining a constant internal environment;

1

(ii) *one mark for example of factor kept constant; one mark for explaining its importance;*

e.g.

temperature / pH; optimum for enzymes / effect of pH /
temperature on enzyme activity;

OR

water potential / blood glucose;
effect of osmotic / blood glucose imbalance on cells;

2 max

(b) cannot interact with / move tropomyosin from binding sites on actin;
(reject active sites)

myosin(heads) do not bind / actinomyosin not formed;

does not activate ATPase / energy not released from ATP;

3

[6]

Q22.

(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]

Q23.

- (a) calcium ions;
bind to / displace tropomyosin; (*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

[7]

Q24.

- (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]

Q25.

- (a) Pancuronium has similar structure / shape to acetylcholine;

Reject same 're. Acetylcholine / re.receptor'

Complementary to / fits receptor;
Ignore 'active site'

2

- (b) (Pancuronium) not removed from receptor by ACh-esterase /
not broken down by ACh-esterase;
(Pancuronium) prevents ACh from binding / blocks receptor site;
ACh (normally) causes opening of Na⁺ channels / causes action
potential in muscle fibre;

Accept converse re. pancuronium

(Pancuronium) prevents influx of Ca²⁺ ions (to start contraction);
(Pancuronium) prevents unblocking of binding sites on actin;

3 max

[5]

Q26.

- (a) membrane relatively impermeable / less permeable to sodium ions / gated channels
are closed / fewer channels;
sodium ions pumped / actively transported out;
by sodium ion carrier / intrinsic proteins;
inside negative compared to outside / 3 sodium ions out for two potassium ions in;
*(if sodium mentioned but not in context of ions, negate 1
mark)*

4

- (b) (i) 1.6;

1

- (ii) $18 \div 1.6 = 11.25$;
multiply by 1000 to convert from ms to s / 11 250;

$$\frac{\text{distance}}{\text{time}} \text{ or } \times 1000$$
*(correct method = 1 mark, i.e. $\frac{\text{distance}}{\text{time}}$ or $\times 1000$)
(correct answer based on (b)(i) = 2 marks)*

2

- (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;

*(allow references to generating action potentials instead of
depolarisation, do not allow references to impulses in
muscles)*

2

- (ii) acetylcholinesterase is unable to breakdown acetylcholine;
acetylcholine still available to depolarise the membrane /

generate action potentials in the membrane;

2

[15]

Q27.

(a) (i) A;

1

(ii) H + I;

1

(b) Correct answer: 7000;

Accept 6422 to 7608

Ignore working

OR

1 sarcomere = $\frac{48}{16}$ (μm) and use of 21 (000) μm / use of $\frac{21(000)}{3}$;

Allow 1 mark

OR

Allow for error re. interconversion of mm / μm : e.g. $\frac{21}{3}$ / $\frac{2100}{3}$

Allow 1 mark

2

(c) Rise in Ca^{2+} (in muscle cells) / Ca^{2+} enters (muscle cells) / Ca^{2+} from SR;

Leading to movement of blocking/inhibiting molecules/troponin/
tropomyosin;

Expose binding sites on actin/on thin filament;

Allow actin-myosin interaction / cross-bridge formation/allow myosin
to bind/allow filaments to slide past each other;

Activate ATP-ase (on myosin);

3 max

[7]

Q28.

(a) Correct answer: 1.25;

Ignore working

OR (if wrong answer)

$\frac{\text{measurement in } \mu\text{m}}{40000} / \frac{\text{measurement in mm}}{40} = 1 \text{ mark}$

125 but wrong order of magnitude = 1 mark

2

(ii) **C** has myosin / thick (and actin / thin) filaments;

OR

A has only actin / thin (/ no myosin / no thick) filaments;

1 max

(b) When contracted:

Thick & thin filaments/myosin & actin overlap more;

Interaction between myosin heads & actin / cross-links form;

Movement of myosin head;

Thin filaments / actin moved along thick filaments / myosin;

Movement of thin filaments / actin pulls Z-lines closer together;

Displacement of tropomyosin to allow interaction;

Role of Ca^{2+} ;

Role of ATP;

*Allow ref. to 'sliding filament mechanism' /
described if no other marks awarded*

4 max

(c) (i) 8 has DMD but 3 and 4 do not / 12 has DMD but 6 and 7 do not / neither parent has the condition but their child has;
Allow parents 3 and 4 give 8, parents 6 and 7 give 12

1

(ii) 4 **AND** 7;

1

(iii) Parental genotypes: 6 = $\text{X}^{\text{D}}\text{Y}$ AND 7 = $\text{X}^{\text{D}}\text{X}^{\text{d}}$

AND

Gametes correct for candidate's P genotypes – e.g.

X^{D} and **Y** + X^{D} and X^{d} ;

Offspring genotypes correctly derived from gametes e.g.

$\text{X}^{\text{D}}\text{X}^{\text{D}}$ + $\text{X}^{\text{D}}\text{X}^{\text{d}}$ + $\text{X}^{\text{D}}\text{Y}$ + $\text{X}^{\text{d}}\text{Y}$;

Male offspring with MD correctly identified: $\text{X}^{\text{d}}\text{Y}$;

Probability = 0.25 / correct for candidates offsprings genotypes;

Accept $\frac{1}{4}$ / 1 in 4 / 1:3 / 25%

NOT '3:1' / '1:4'

4

(d) (i) No gene fragment **G**;

1

(ii) Only one copy of gene fragment **F**;

Male has only one X-chromosome / is XY
(c.f. female has two / is XX);

2

(iii) 10 has only one copy of gene fragment **G**;

10 has only one normal X-chromosome / has one abnormal /
has only one normal allele / has one X^d / is $X^D X^d$ / is heterozygous;

11 has two normal X-chromosomes / has 2 normal alleles /
is $X^D X^D$ / has not got X^d / has 2 copies of (F and) G;

3

(e) (i) To prevent rejection / prevent antibody production vs. injected cells /
injected cells have (foreign) antigen (on surface);

1

(ii) Shows effect of cells / not just effect of injection / not just effect of
salt solution;

1

(iii) Only one person tested so far – need more to see if similar results /
need more to see if reliable;

Need to assess if new (dystrophin positive) muscle fibres are
functional / if muscle becomes functional;

Can't tell how widespread effect is in the muscle / sample taken
near injection site;

Need to test for harmful side effects;

Need to test if successful for other mutations of dystrophin gene;

Need to assess permanence / longevity of result/insufficient time
allowed in investigation;

(In this patient) only small response / %;

Further sensible suggestion;

4 max

[25]