Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$E_K = 61.5 \log_{10}(5/140) \approx \mathbf{-89}$ mV

at rest the membrane is most permeable to K^+, so the potential sits near E_K

2.2

A: Na^+ channels open, Na^+ flows in

B: Na^+ channels inactivate, K^+ channels open and K^+ flows out

C: K^+ channels are slow to close, so more K^+ leaves (undershoot)

2.3

$61.5 \log_{10}(145/15)$

$\approx \mathbf{+61}$ mV

2.4

absolute: Na^+ channels are inactivated, so no stimulus can start a spike

relative: some Na^+ channels have recovered but K^+ channels are still open, so a stronger stimulus is needed

3.1

(a) $61.5 \log_{10}(8/140) \approx \mathbf{-76}$ mV

(b) a steady less negative potential keeps Na^+ channels inactivated, so fewer are ready to open and spikes fail

(c) calcium gluconate protects the heart membrane at once; insulin with glucose moves K^+ into cells

(d) insulin speeds up the Na^+/K^+ pump, which moves K^+ into cells

3.2

(a) the nicotinic **ACh receptors** on the muscle

(b) each nerve impulse releases less ACh when used again and again; with fewer receptors, the signal then falls below the level needed to fire the muscle

(c) it slows the breakdown of ACh, so ACh stays longer and binds more of the remaining receptors

3.3

(a) the skeletal refractory period is much shorter than the twitch, so new spikes come before it relaxes; in heart muscle the refractory period lasts almost as long as the contraction (about 250 ms)

(b) $1000 \div 50 = \mathbf{20}$ ms

(c) each new spike comes before the muscle relaxes, so Ca^{2+} stays high and the force builds into a steady pull

(d) Ca^{2+} binds troponin, which moves tropomyosin so myosin heads can bind actin and pull

(e) with no ATP, myosin cannot let go of actin

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