HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.3.2 Gas exchange

Mark scheme

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TOTAL MARKS	QUESTIONS
57	8

How to use this mark scheme

;	Separates marking points. Each semicolon marks the end of one creditable point, and each point is worth one mark.
;;	Two marks for this answer (used for calculations).
/	Alternative words or phrases that are credited for the same point.
OR	An alternative answer for the same mark.
( )	Words in brackets are not needed to gain the mark.
max	More marking points are listed than marks available. Award up to the number of marks shown.
Accept	An alternative answer that gains credit.
Reject	A wrong answer. It does not gain credit and cancels a correct point it contradicts.
Ignore	Neither credited nor penalised. Mark the rest of the answer.
ECF	Error carried forward: credit correct working that uses an earlier wrong answer.
AO	Assessment objective: AO1 knowledge and understanding; AO2 applying knowledge; AO3 analysing, interpreting and evaluating.

Where an answer is correct but not listed, credit it if it is biologically accurate and answers the question at the depth the marks require. Right + wrong = wrong: a contradiction cancels a correct point.

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Single-celled organisms and insects 3.3.2

Question	Marking guidance	Mark	Comments
01.1	Oxygen diffuses across its cell-surface membrane; the cell has a large surface area to volume ratio and a short diffusion distance;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
01.2	1. Large surface area to volume ratio (for its size); 2. Short diffusion distance/pathway to all parts of the cell OR no part of the cell is far from the surface; 3. (So) diffusion is fast enough to supply oxygen for respiration/to meet the demand of the cell;	**2 max** (2 × AO2)	1. **Accept** SA:V for surface area to volume ratio. Reject SA alone unless surface area is written in full 2. **Accept** oxygen reaches the centre of the cell quickly **Reject** active transport of oxygen

Question	Marking guidance	Mark	Comments
02.1	spiracle → trachea → tracheole → muscle cell;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
02.2	Correct answer of 175 (%) for 2 marks;; Accept for 1 mark, a difference of 0.84 OR 0.84 ÷ 0.48 **OR** 275 (%) (group B as a percentage of group A)	**2** (2 × AO2)	**Reject** 63.6 (%) for 2 marks (percentage decrease from B to A)

Question	Marking guidance	Mark	Comments
02.3	1. (Not supported:) in untreated beetles/group A the spiracles are open for only 8% of the time; 2. Keeping the spiracles open all the time only increases water loss by 0.84, so spiracles open for 8% of the time would lose much less (than half of 0.48) OR (so) most water is probably lost across the body surface; 3. Assumes water loss through the spiracles is proportional to the time they are open OR carbon dioxide may have other effects, eg on (rate of) respiration/breathing movements/activity; 4. Water loss across the body surface of untreated beetles was not measured directly OR removing the wax only shows that the wax reduces water loss; 5. No statistical test/measure of spread (eg standard deviation), so cannot tell whether differences are significant;	**3 max** (3 × AO3)	2. **Accept** a calculated estimate, eg about 8% of 0.84 ≈ 0.07 (the full model gives about 0.07, 15% of the total) **Max 2** unless point 1 or point 2 is given **Ignore** 'only 10 beetles' unqualified

Question	Marking guidance	Mark	Comments
02.4	1. Reduces water loss OR water (vapour) can only diffuse out (of the tracheae) when the spiracles are open; 2. (But) allows enough oxygen in/carbon dioxide out for its (low) rate of respiration at rest;	**2** (2 × AO2)	1. **Accept** prevents dehydration in the dry/desert air 1. **Reject** 'water' diffusing in 2. **Accept** gas exchange still happens when the spiracles open

Gas exchange in fish 3.3.2

Question	Marking guidance	Mark	Comments
03.1	60% of the length;	**1** (1 × AO2)	Water and blood both reach 55% saturation at 60% of the length, so there is no concentration gradient beyond this point.

Question	Marking guidance	Mark	Comments
03.2	Correct answer of 1.8 for 2 marks;; Accept for 1 mark, increases of 80 **and** 45 (%) **OR** 1.78/1.778 (not to 2 significant figures)	**2** (2 × AO2)	Plotted values: counter-current blood 10% → 90%; parallel blood 10% → 55% **Reject** 1.6 (ratio of final saturations) for 2 marks

Question	Marking guidance	Mark	Comments
03.3	1. (In counter-current flow) blood and water flow in opposite directions; 2. Blood always meets water with a higher oxygen saturation/concentration OR the water is 10% higher than the blood at every point; 3. (So) a diffusion/concentration gradient is maintained along the whole length of the lamella; 4. In parallel flow the water and blood reach equilibrium/the same saturation (at 55%/after 60% of the length), so there is no (net) diffusion beyond this point;	**3 max** (2 × AO1) (1 × AO2)	**Max 2** unless point 4 is given 3. **Accept** oxygen diffuses into the blood along the whole length of the lamella **Reject** 'blood and water flow in opposite directions' if applied to parallel flow **Ignore** references to surface area

Question	Marking guidance	Mark	Comments
03.4	1. (Without water to support them) the filaments/lamellae stick together, so the surface area (for gas exchange) is (greatly) reduced; 2. (So) slower (rate of) diffusion of oxygen into the blood OR not enough oxygen for respiration;	**2** (2 × AO2)	1. **Accept** lamellae collapse/overlap, so less surface is exposed to the air 2. **Ignore** 'less gas exchange' unqualified; the answer must refer to rate (slower/reduced rate) **Ignore** gills dry out, unless linked to reduced surface area or slower diffusion

Leaves and xerophytic plants 3.3.2

Question	Marking guidance	Mark	Comments
04.1	1. Through (open) stomata; 2. Into/through air spaces (in the spongy mesophyll); 3. By diffusion down a concentration gradient (because mesophyll cells use carbon dioxide in photosynthesis);	**2 max** (2 × AO1)	**Reject** stroma or spiracles for stomata **Reject** osmosis or active transport **Ignore** 'for gas exchange' unqualified

Question	Marking guidance	Mark	Comments
04.2	Correct answer of 16 (µm) for 2 marks;; Accept for 1 mark, mean of 6.4 (divisions) **OR** a total/one reading correctly multiplied by 2.5	**2** (2 × AO2)	**Accept** 16.0 (µm)

Question	Marking guidance	Mark	Comments
04.3	1. The uncertainty is a large proportion of the bean readings (about 63% of the mean, compared with about 8% for oleander) OR the bean cuticle is less than one division thick; 2. Use a higher magnification/higher-power objective lens (so the cuticle covers more divisions);	**2** (2 × AO3)	1. **Accept** a calculated percentage uncertainty for the bean in the range 50–100% 2. **Accept** use a graticule with smaller divisions 2. **Credit** recalibrating the eyepiece graticule (with a stage micrometer), but it is not required **Ignore** 'repeat more times' for 2

Question	Marking guidance	Mark	Comments
04.4	1. Pits/hairs trap (moist) air/water vapour (outside the stomata) OR stomata on the lower surface are shaded/cooler/less exposed to wind, so less evaporation; 2. Reducing the water potential gradient (between the inside of the leaf and the air) OR less water vapour diffuses out (through the stomata); 3. Thick waxy cuticle increases the diffusion distance OR reduces evaporation (through the upper surface/epidermis); 4. Stomata can still open so carbon dioxide/oxygen can diffuse in/out (through the pits);	**3 max** (1 × AO1) (2 × AO2)	**Max 2** unless point 4 is given 1. **Reject** 'trap water' or 'trap moisture' unqualified 2. **Accept** diffusion/concentration gradient (of water vapour) for water potential gradient 2. **Reject** 'WP': water potential must be written in full (the symbol Ψ is accepted) **Ignore** 'prevents water loss' **Ignore** stomata close, unless linked to a feature of oleander

The human gas exchange system and ventilation 3.3.2

Question	Marking guidance	Mark	Comments
05.1	Correct answer **and** unit for 2 marks: 6.0 dm^3 min^{-1};; Accept for 1 mark, tidal volume of 0.5 (dm^3) **and** breathing rate of 12 (per minute) **OR** 6 with no unit or an incorrect unit	**2** (2 × AO2)	Plotted trace: peak 2.9 dm^3, trough 2.4 dm^3, one breath every 5 s **Accept** answers in the range 5.4–6.6 dm^3 min^{-1} from readings of the tidal volume within ± 0.05 dm^3 **Accept** equivalent answers in other units for 2 marks, eg 0.1 dm^3 s^{-1}, 6000 cm^3 min^{-1} **Accept** dm^3 per minute, L min^{-1}

Question	Marking guidance	Mark	Comments
05.2	0.9 dm^3;	**1** (1 × AO2)	

Question	Marking guidance	Mark	Comments
05.3	1. Internal intercostal muscles contract (and external intercostal muscles relax); 2. (Pulling the) ribcage down and in; 3. Diaphragm (muscle) relaxes **and** moves up/becomes dome-shaped; 4. Volume of the thoracic cavity decreases **and** pressure (in the thoracic cavity) increases; 5. Pressure (in the lungs) is higher than atmospheric pressure, so air moves out down a pressure gradient;	**4 max** (4 × AO1)	1. **Reject** external intercostal muscles contract 2. Muscle action must be linked to the movement it causes, eg ribs move down because internal intercostals contract 4. **Accept** thorax or lungs for thoracic cavity; reject chest 5. **Ignore** 'along' for 'down' **Credit** abdominal muscles contracting and pushing the diaphragm up, but this is not required

Question	Marking guidance	Mark	Comments
05.4	1. (Supports:) tidal volume increased 3 times, breathing rate increased 2.5 times, so tidal volume increased by a (slightly) greater factor; 2. (Against:) the increase in breathing rate was almost as large, so both contributed (almost equally) OR 'mainly' is not justified; 3. Data from only one person/one period of exercise OR no repeats;	**2 max** (2 × AO3)	1. **Accept** tidal volume increased by 200% and breathing rate by 150% **ECF** from resting values calculated or read in 05.1 **Ignore** 'correlation does not show causation'

Lung disease and risk factors 3.3.2

Question	Marking guidance	Mark	Comments
06.1	Bronchioles;	**1** (1 × AO1)	**Accept** phonetic spellings, eg broncheoles **Reject** bronchi/bronchus/trachea

Question	Marking guidance	Mark	Comments
06.2	1. Fluid (between the epithelium and capillaries) increases the diffusion distance/pathway (between the air and the blood); 2. Fluid-filled alveoli are not ventilated/contain no air, so the surface area for gas exchange is reduced; 3. (So) slower (rate of) diffusion of oxygen into the blood; 4. (Oxygen) concentration gradient (between alveolar air and blood) is reduced because less fresh air reaches the alveoli;	**3 max** (3 × AO2)	2. **Reject** SA unless surface area is written in full 3. **Ignore** 'less oxygen uptake/less gas exchange': rate wording (slower/reduced rate) is required **Reject** 'alveoli have thicker walls' unless linked to fluid **Ignore** descriptions of healthy alveoli

Question	Marking guidance	Mark	Comments
07.1	Positive correlation OR as the concentration of $PM_{2.5}$ increases, asthma admissions increase;	**1** (1 × AO3)	**Reject** '$PM_{2.5}$ causes asthma' **Reject** 'proportional'

Question	Marking guidance	Mark	Comments
07.2	1. Correlation does not show a causal relationship; 2. Other pollutants from vehicles/traffic may also be higher in cities with more $PM_{2.5}$; 3. Other factors may differ between cities, eg rates of smoking/age of population/access to healthcare/climate; 4. Data are means for whole cities, not for individuals OR admissions do not show the cause of the asthma attack; 5. No statistical test (eg correlation coefficient) so cannot tell whether the correlation is significant;	**2 max** (2 × AO3)	Points 2 and 3 are separate marks **Ignore** 'only 14 cities' unqualified

Question	Marking guidance	Mark	Comments
07.3	Correct answer of 11.0 (%) OR 11.1 (%) for 2 marks;; Accept for 1 mark, means of 102.7 **and** 91.3 **OR** 11.04/11 (not to one decimal place)	**2** (2 × AO2)	11.1 (%) comes from rounding the means to one decimal place before calculating; it gains 2 marks **Accept** totals of 308 and 274 for 1 mark **Reject** a percentage increase

Question	Marking guidance	Mark	Comments
07.4	1. (For:) positive correlation between $PM_{2.5}$ and asthma admissions in Figure 4; 2. (For:) in city P, $PM_{2.5}$ fell after the law (by about 20%) and asthma admissions fell (by 11.0%); 3. (For:) in city Q/without the law, $PM_{2.5}$ and admissions changed little (admissions fell by only 3.8%), so Q acts as a control OR the fall in P was greater than in Q; 4. (For:) the fall in admissions happened at the same time as/after the fall in $PM_{2.5}$; 5. (Against:) admissions also fell in Q, so other factors (eg better treatment) may also reduce admissions; 6. (Against:) only one city with the law and one without OR the two cities may differ in other ways; 7. (Against:) other cities may have different main sources of $PM_{2.5}$, so banning older diesel vehicles may not reduce $PM_{2.5}$/admissions as much elsewhere; 8. (Against:) no statistical test, so cannot tell whether the difference between P and Q is significant OR only three years after the law;	**5 max** (5 × AO3)	**Max 4** if only points for, or only points against, are given 2. and 3. Accept correct manipulation of the figures from the table **Ignore** 'correlation does not mean causation' unless linked to these data

Extended response: comparing gas exchange systems 3.3.2

Question	Marking guidance	Mark	Comments
08	1. (Fish:) many (gill) filaments covered in many lamellae give a large surface area; 2. (Fish:) lamellae have thin cells/a thin epithelium OR capillaries close to the surface, giving a short diffusion distance (between water and blood); 3. (Fish:) blood and water flow in opposite directions (counter-current flow); 4. (Fish:) maintains a diffusion/concentration gradient along the whole length of the lamella OR water is continuously pumped over the gills (in one direction), maintaining the gradient; 5. (Fish:) oxygen diffuses into the blood, which carries it to respiring cells; 6. (Insect:) air enters through spiracles and passes along tracheae to tracheoles; 7. (Insect:) tracheoles are highly branched/numerous, giving a large surface area; 8. (Insect:) tracheoles have thin walls OR tracheoles end in/close to cells, giving a short diffusion distance; 9. (Insect:) oxygen diffuses directly into cells from the tracheoles, not via the blood; 10. (Both:) oxygen moves by diffusion down a concentration gradient, maintained because cells use oxygen in respiration OR (insect:) maintained by ventilation, eg abdominal pumping;	**6 max** (6 × AO1)	**Max 4** from fish points (1–5) or from insect points (6–9) alone To gain 6 marks, at least one direct comparison or contrast must be made, eg oxygen is carried by blood in fish but delivered directly to cells in insects 1. and 7. Reject SA unless surface area is written in full 2. **Reject** thin cell walls/thin membranes 4. and 10. Ventilation (water flow over the gills, abdominal pumping) is credited within these points; it is not required for full marks 8. **Accept** thin tracheole walls give rapid diffusion **Reject** active transport or facilitated diffusion of oxygen

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