

1. (a) Large surface area: volume ratio;  
meet requirements by diffusion (over body surface); 2
- (b) Maintains a concentration gradient;  
(allowing diffusion of oxygen) across width of gill; 2
- (c) Large surface area for diffusion / O<sub>2</sub> uptake / gaseous exchange;  
short diffusion path;  
highly vascularised / many blood capillaries for O<sub>2</sub> transport; max 2
- (d) Gas exchange surfaces are permeable (to small molecules);  
higher concentration of water molecules inside animal than out /  
ψ gradient;  
water will diffuse outwards / evaporation; max 2
- (e) (i) 6.53 / 6.25 / 6.5; (2.61 × 2.5)  
(ii) 0.28 / 0.275 / 0.3; (0.11 × 2.5)  
Both answers correct – 2 marks  
error in calculation but clearly shows answer  
obtained by multiplying figures – 1 mark 2
- (f) **EITHER**  
Reference to spiracles;  
limits exposure of respiratory surface / can close spiracles;  
**OR**  
sunken spiracles / hair round spiracles;  
trapping moist air;  
**OR**  
trachea cuticle lined;  
only lose water through tracheoles;  
**OR**  
trachea / tracheoles inside;  
limiting exposure of respiratory surface; max 4

- (g) (i) Partial pressure on oxygen in muscle falls more;  
high / more carbon dioxide produced;  
lowers PH;  
increase in temperature;  
percentage saturation of Hb falls / lowers affinity /  
increase dissociation;  
displaces curve to right / results in Bohr shift; max 4
- (ii) In absence of oxygen / low partial pressure of oxygen in tissues /  
oxygen still used in respiration;  
haemoglobin acts as an oxygen store;  
releases (large amount of) oxygen when low level in tissues; max 2

[20]

2. (a) Waxy cuticle;  
Prevents passage/evaporation of water;  
**OR**  
Hairs on surface (allow description);  
Moist air trapped/reduces water potential gradient;  
**OR**  
Sunken “openings”;  
Moist air trapped/reduces water potential gradient;  
**OR**  
Stomata/spiracles can close;  
Reduces evaporation; max 4
- (b) Carbon dioxide in tracheae;  
Therefore spiracles open;  
allowing water vapour to escape; 3

[7]

3. Picks up oxygen more readily (in lungs) / greater affinity / idea of  
more readily saturated;  
Where O<sub>2</sub> is low;  
*Ignore ‘rate of loading / unloading’.* 2

[2]

4. (a) Accurate description of ventilation by water flow;  
(Oxygen) removal by bloodstream;  
Description of / countercurrent flow of blood and water (at gills);  
*Accept labelled diagram, ignore ‘contraflow’, reject ‘multiplier’.* 2

- (b) 4.0 seconds / s; *accept 2 x 2s* 1  
 (Total) time when oxygen (concentration) was increasing /  
 oxygen diffusing in;  
 OR  
 (Total) time when carbon dioxide (concentration) was decreasing /  
 carbon dioxide diffusing out; 1 max [4]
5. (a) More work done / more energy / ATP required;  
 To overcome greater buoyancy;  
*Look for idea of buoyancy, not term.* 2
- (b) (i) Retains oxygen until the partial pressure is low / myoglobin  
 has high affinity for oxygen;  
 Partial pressure of oxygen late in dive low;  
 Gives up oxygen (readily) at low partial pressures; 2 max
- (ii) Remains under water for long time;  
 Unable to breathe while under water;  
 Greater amount of myoglobin can release / provide more oxygen;  
 More myoglobin, the darker the muscle; 3 max
- (c) (i) 0.267 hours or 16 minutes;; 2  
 Error, but  $30\ 00\ \text{cm}^3$  divided by 250 = 1 mark
- (ii) Heart rate slows;  
 Less blood flowing to / from muscles / liver / gut / blood flow to  
 body other than brain reduced by 90%;  
 Large volume of blood compared with body mass;  
 Greater concentration of haemoglobin;  
 Less blood required to supply heart / to heart muscle; 2 max  
*Reject imprecise answers relating to 'organs' / 'the body'.*
- (d) Less blood to muscles / heart muscle / skin; 1 [12]
6. (a) (i) Many, small/ branching tracheoles; 1  
 (ii) Blood not involved in transport of respiratory gases in insects; 1

- (b) Correct answer (ignoring working)  $600x = 2$  marks;;  
 Answer correct for candidate's R = 1 mark;  
 Candidate clearly derives answer by dividing measured diameter by actual  
 size = 1 mark; 2
- (c) Higher concentration of oxygen at S than in muscle; 1  
*[Not just concentration gradient: direction of gradient must be clear]* [5]
7. (a) (gills have) lamellae on filaments; 2  
 lots of both;
- (b) (i) all 3 go up; *[Accept converse]* 1  
 (ii) more oxygen can be supplied;  
 for more respiration; *[Accept answer relating to CO<sub>2</sub>]* 2 [5]
8. (a) It is a measure of the concentration of a gas (in a mixture of gases or a liquid); 1  
 (b) 37-38% *[Accept 36 – 39]*  
 (c) muscle contraction causes increased respiration;  
 increased CO<sub>2</sub> production lowering blood pH;  
 lactate released lowering blood pH;  
 increased heat released therefore increased temperature;  
 increased O<sub>2</sub> consumption lowering tissue PO<sub>2</sub>; max 4  
 (d) haemoglobin has a lower affinity for oxygen;  
 more O<sub>2</sub>;  
 for respiration; max 2

- (e) **3.4 times = 2 marks**  
 (incorrect answer in which candidate shows amount of oxygen removed at rest is 4.6 and amount removed during exercise is 15.8 = 1 mark) 2
- (f) Nearly all O<sub>2</sub> is transported by haemoglobin / v. little transported in plasma;  
**EITHER**  
 Haemoglobin is (nearly) fully saturated with O<sub>2</sub> at the alveoli both at rest and when exercising;  
 Therefore no (very little) further increase is possible;  
**OR**  
 Haemoglobin is only 95% saturated with oxygen at the alveoli;  
 Therefore enriching inspired /air with oxygen will raise this to 100%; 3
- (g) increased depth / rate / pulmonary ventilation;  
 increase stroke volume/heart rate/Q increases blood flow rate;  
 arterioles [*Accept* artery] supplying the muscles dilate / vasodilation / greater proportion of blood flow to the muscles; max 3
- [15]**
9. (a)  $\frac{10}{20} \times \text{measurment} / \frac{1}{2} \times \text{measurement} ;$   
 = 1.25 to 1.5;  
*allow 1 mark if correct working shown* max 2
- (b) Maintains concentration gradient (over whole length of gill) / diffusion can occur over whole gill;  
More oxygen enters blood (/ more CO<sub>2</sub> leaves);  
More (aerobic) respiration / more energy release in muscle / for swimming;  
*'more' needed ONCE only* 3
- [5]**
10. (a) increasing carbon dioxide concentration / partial pressure;  
*(decrease in oxygen negates)* 1
- (b) (oxygen is used in) respiration;  
 therefore diffuses (from tracheae) to tissues;  
 oxygen unable to enter organism; 2 max
- (c) spiracles not open all the time;  
 therefore there is less water loss  
 (by diffusion through spiracles); 2
- [5]**

11. (a) (i) high/higher CO<sub>2</sub> concentration / lack of oxygen; 1  
(ii) CO<sub>2</sub> asphyxiates / is toxic;  
lack of oxygen for (aerobic) respiration;  
lack of energy / ATP (for pumping movements);  
reduced muscle function / muscle fatigue 2 max
- (b) removal of (excess) CO<sub>2</sub> / oxygen to break down lactate / to repay oxygen  
debt/to enable aerobic respiration; 1

[4]

12. (a) dry conditions - stomata partially closed;  
due to less turgor in guard cells; OR  
watered conditions - stomata more open;  
due to greater turgor in guard cells; 2

*EITHER*

- (b) (i) temperature [*Allow heat*] - higher causes more water evaporation /  
diffusion [*not just transpiration*]  
OR  
light - causes stomatal opening  
OR  
soil texture - determines availability of water  
OR  
humidity - reduces evaporation / reduces gradient / wind causes more  
(water) evaporation; 1
- (ii) high CO<sub>2</sub> gives less variation AND watering gives less variation;  
OR insignificant difference in variability as small differences in SD;  
*reject 'no difference'* 1

[4]

13. (a) (i) oxygen concentration in air / water constant / surface area /  
thickness of skin constant; 1
- (ii) skin more important in winter and lungs in summer; 1
- (b) (i) (winter) – low temp – skin takes up more oxygen;  
(summer) – higher temp – lungs takes up more oxygen; 2
- (ii) skin is more important in winter and summer / all the time  
/ at all temperatures; 1

- (c) (i) (thin) – short diffusion pathway; 2  
(hairs) – greater surface area for exchange;
- (ii) provides more (oxygenated) water over surface / maintains the concentration gradient; 1

[8]

14. (a) 1 Large surface area provided by lamellae/filaments;  
*Q Candidates are required to refer to lamellae or filaments. Do not penalise for confusion between two*
- 2 Increases diffusion/makes diffusion efficient;
- 3 Thin epithelium/distance between water and blood;
- 4 Water and blood flow in opposite directions/countercurrent;
- 5 (Point 4) maintains concentration gradient (along gill)/equilibrium not reached;  
*5 Not enough to say gives steep concentration gradient*
- 6 As water always next to blood with lower concentration of oxygen;
- 7 Circulation replaces blood saturated with oxygen;
- 8 Ventilation replaces water (as oxygen removed); 6 max  
*6-8 Accept answers relating to carbon dioxide*
- (b) Mixing of air and water (at surface);  
Air has higher concentration of oxygen than water;  
Diffusion into water;  
Plants/seaweeds near surface/in light;  
Produce oxygen by photosynthesis; 2 max
- (c) Not much oxygen near sea bed;  
Toadfish haemoglobin (nearly) saturated/loads readily at /has higher affinity for oxygen at low partial pressure (of oxygen); 2
- (d) (i) The chimpanzee and the bonobo are more closely related (than to the gorilla);  
They have identical amino acids/one of the amino acids is different in the gorilla; 2

- (ii) (Chimpanzee) orang-utan;  
Amino acids different so bases different;  
Few hydrogen bonds;

3

**[15]**