# 6. Plant nutrition

## 6.1 Photosynthesis

## Paper 3 and 4

Marking Scheme

## Q1.

| | | | |
|---|---|---|---|
| (a)(i) | carbon dioxide + water ;<br>→ glucose + oxygen ; | **2** | |
| (a)(ii) | chlorophyll ; | **1** | |
| (b)(i) | 17(ºC) / 35(ºC) ; | **1** | |
| (b)(ii) | 21±0.5 (arbitrary units) ; | **1** | |
| (b)(iii) | (as temperature increases) the rate of photosynthesis increases, **and** then decreases ;<br>optimum / AW, temperature is, 24±1ºC<br>OR maximum / AW, rate of photosynthesis is 47 arbitrary units<br>OR no photosynthesis at, 0 ºC / (after) 43 ºC ; | **2** | |
| (c)(i) | energy store / AW ; | **1** | |
| (c)(ii) | cellulose / AVP ; | **1** | |
| (c)(iii) | nitrate ; | **1** | |
| (d) | *any two from:*<br>respiration ;<br>feeding / nutrition ;<br>decomposition / decay ;<br>combustion / burning ;<br>(formation of named) fossil fuels ; | **2** | |

## Q2.

| | | | |
|---|---|---|---|
| (a) | chloroplast ; | **1** | |

## Q3.

| | | | |
|---|---|---|---|
| (a) | *any two from:*<br>large surface area ;<br>thin ;<br>AVP ; | **2** | e.g. *idea of* not overlapping to maximise light capture / leaves are spreading / AW |

## Q4.

| | | | |
|---|---|---|---|
| (b)(i) | 10 (cm) ; | **1** | |

| | | | |
|---|---|---|---|
| (b)(ii) | increase (rate) ; | **1** | |
| (b)(iii) | increase (rate) ; | **1** | |

## Q5.

| | | | |
|---|---|---|---|
| (b) | glucose ;<br>oxygen ; | **2** | either order |

## Q6.

| | | | |
|---|---|---|---|
| (c) | growth ;<br>carbon ;<br>hydrogen ;<br>magnesium ;<br>chlorophyll ;<br>photosynthesis ; | **6** | carbon and hydrogen in either order |

## Q7.

| | | | |
|---|---|---|---|
| (a)(i) | carbon dioxide + water → ; glucose + oxygen ; | **2** | |

| | | | |
|---|---|---|---|
| (a)(ii) | sun / light ; | **1** | |
| (a)(iii) | chloroplast ; | **1** | |
| (b)(i) | 20 ; | **1** | |
| (b)(ii) | *idea of* (0.10 au) lowest concentration (of carbon dioxide) that produces the, maximum / highest, number of bubbles ;<br>number of bubbles, does not increase / stays constant, after concentration (of carbon dioxide) 0.10 au ; | **2** | |
| (b)(iii) | *prediction:*<br>fewer / no, bubbles produced ;<br><br>*explanation:*<br>chemical reactions or photosynthesis, are slower / less photosynthesis / ref. to enzymes being less active ; | **2** | |
| (c) | methane / AVP ; | **1** | |

## Q8.

| | | | |
|---|---|---|---|
| (b)(i) | carbon dioxide + water ; → glucose + oxygen ; | **2** | |
| (b)(ii) | water / suitable temperature ; | **1** | |

## Q9.

| | | | |
|---|---|---|---|
| (b)(i) | carbon dioxide + water ; ⟶ glucose + oxygen ; | 2 | |
| (b)(ii) | *any two from:*<br>no photosynthesis in the dark / light required, for photosynthesis / to make glucose / AW ;<br>starch converted to glucose / AW ;<br>(starch / glucose,) used, for respiration **OR** as a source of energy / AW ; | 2 | |
| (b)(iii) | <table><tr><th>part of leaf</th><th>starch present</th><th>starch absent</th></tr><tr><td>green</td><td>✓</td><td></td></tr><tr><td>white</td><td></td><td>✓</td></tr></table> ; | 1 | |
| (b)(iv) | magnesium ; | 1 | |

## Q10.

| | | | |
|---|---|---|---|
| (a) | oxygen ;<br>glucose ; | 2 | |
| (b)(i) | increases / increases and levels off / AW ; | 1 | |
| (b)(ii) | light intensity ; | 1 | **A** water availability / pH |

| | | | |
|---|---|---|---|
| (c) | <table><tr><th>process</th><th>area **A**</th><th>area **B**</th></tr><tr><td>photosynthesis</td><td></td><td>✓</td></tr><tr><td>respiration</td><td>✓</td><td>✓</td></tr></table> ;; | 2 | one mark per row |
| (d) | *any two from:*<br>cuticle ;<br>epidermis ;<br>palisade (mesophyll) ; | 2 | |
| (e)(i) | xylem ; | 1 | |
| (e)(ii) | magnesium ; | 1 | |
| (e)(iii) | nitrate ; | 1 | |

## Q11.

| | | |
|---|---|---|
| (b) | <table><tr><th>name</th><th>into leaf</th><th>out of leaf</th></tr><tr><td>carbon dioxide</td><td>✔</td><td>;</td></tr><tr><td>oxygen</td><td></td><td>✔ ;</td></tr><tr><td>water vapour</td><td></td><td>✔ ;</td></tr></table> | 3 |

## Q12.

| | | |
|---|---|---|
| (a) | *any three from:*<br>number of leaves increases for both ;<br>group 1 grew more leaves ;<br>number of leaves increases more rapidly in group 1 ;<br>data quote with day and number of leaves ; | **3** |

| | | |
|---|---|---|
| (b) | **A** ;<br>**C** ;<br>**D** ; | **3** |
| (c) | (the) Sun ; | **1** |

## Q13.

| | | | |
|---|---|---|---|
| (c) | chlorophyll (production) ;<br>(named), amino acids / proteins ; | **2** | |

## Q14.

| | | | |
|---|---|---|---|
| (b)(i) | carbon dioxide + water ; ⟶ glucose + oxygen ; | **2** | |
| (b)(ii) | magnesium ; | **1** | |
| (b)(iii) | palisade (mesophyll) / spongy (mesophyll) / mesophyll / guard ; | **1** | |
| (c)(i) | nearer the light / increasing light (intensity), increases (the rate of) photosynthesis ;<br>*idea that* the relationship is not linear ;<br>rate of photosynthesis peaks at 10 cm / AW ; | **2** | |
| (c)(ii) | temperature ;<br>carbon dioxide (concentration) ;<br>number of chloroplasts ;<br>surface area / number / size, of leaves / plant ;<br>AVP ; e.g. species of plant | **2** | |
| (d) | (for) respiration ;<br>for / release, energy ;<br>converted to starch (for storage) / stored as starch ;<br>made into, cellulose / cell wall ; | **1** | |

## Q15.

| | | | |
|---|---|---|---|
| (b) | nitrate ;<br>for making amino acids / proteins ;<br>OR<br>magnesium ;<br>for making chlorophyll ; | **2** | |

## Q16.

| | | | |
|---|---|---|---|
| (a) | light is needed for (photosynthesis) / AW ;<br>carbon dioxide, is needed / increases rate (of photosynthesis) / AW<br>**or**<br>*idea of* no / low, carbon dioxide results in, low rate of photosynthesis / few bubbles ; | **2** | |
| (b) | *test 2:*<br>(the results) stay the same / no (oxygen) bubbles (are, released / produced) ;<br>no photosynthesis ;<br>(because) no light ;<br><br>*test 3:*<br>(the number of oxygen) bubbles increase ;<br>(because) more photosynthesis / increases rate of reaction ;<br>enzymes more active / correct ref. to increased energy ; | **4** | max 2 for each test<br><br>**A** no carbon dioxide<br><br>**A** less bubbles in the context of temperature being too high for aquatic plants so enzymes not working<br>**A** decreased solubility of carbon dioxide |

## Q17.

| | | | |
|---|---|---|---|
| (a)(i) | 02:00 **and** 05:00 ; | **1** | |
| (a)(ii) | 11 (arbitrary units) ; | **1** | **A** 10.8 to 11.1 |
| (a)(iii) | sunrise / light is present ;<br><br>carbon dioxide, absorbed / used ;<br><br>(for) photosynthesis ;<br><br>photosynthesis is using carbon dioxide faster than respiration can provide it ; | **3** | <br><br><br><br>**A** photosynthesis is faster than respiration |
| (b) | rain ;<br><br>wind ;<br><br>humidity ;<br><br>temperature ;<br><br>shade / clouds / time of year ; | **2** | |

## Q18.

| | | | |
|---|---|---|---|
| (a)(i) | yellow / brown ; | **1** | |
| (a)(ii) | blue-black ; | **1** | |
| (a)(iii) | chlorophyll is required for, photosynthesis / production of starch or glucose ; | **1** | |
| (b) | light required, for photosynthesis / to make starch or glucose ;<br>no photosynthesis took place ; | **1** | |

## Q19.

| | | | |
|---|---|---|---|
| (a) | magnesium (ions) / AVP ; | 1 | |
| (b)(i) | *any four from:*<br>1 (algae) photosynthesise in light / no photosynthesis in the dark ;<br>2 carbon dioxide is, used / absorbed / taken / AW, in photosynthesis ;<br>3 (purple because $CO_2$ used in) photosynthesis results in, pH increase / becomes (more) alkaline / less acidic ;<br>4 (algae) respire in light and dark ;<br>5 carbon dioxide is, produced / released / AW, in respiration ;<br>6 in light there is a higher (rate of) photosynthesis than (the rate of) respiration ;<br>7 (yellow because $CO_2$ given off from) respiration results in, pH decrease / more acidic / less alkaline / becomes (nearer to) neutral ; | 4 | |
| (b)(ii) | *total of three from:*<br><br>*X:* light (intensity) ;<br><br>*Y max two from:*<br>temperature ;<br>carbon dioxide concentration ;<br>(amount of) chlorophyll / (number of) chloroplasts ;<br>water ; | 3 | |

## Q20.

| | | | |
|---|---|---|---|
| (d) | *any two from:*<br>needed to make amino acids ;<br>(amino acids) to make proteins ;<br>(proteins) for growth ; | 2 | |

## Q21.

| | | | |
|---|---|---|---|
| (a)(iv) | (to build) cell walls / provide support ; | 1 | |
| (a)(v) | translocation ;<br>phloem ;<br>nitrate(s) ; | 3 | |

## Q22.

| | | | |
|---|---|---|---|
| (a) | 40 (°C) ; | **1** | |
| (b) | *any six from:*<br><br>*before 40 °C*<br>1 increasing temperature increases the kinetic energy (of reactants / molecules) ;<br>2 increasing the, frequency / rate, of (effective) collisions ;<br>3 more enzyme-substrate complexes are formed ;<br>4 releasing more, oxygen / glucose / products ;<br>5 temperature is the limiting factor ;<br><br>*at 40 °C*<br>6 (optimum temperature) maximum number of, enzyme-substrate complexes / collisions;<br><br>*after 40 °C*<br>7 increasing temperature changes the shape of active site(s) (of enzyme(s)) ;<br>8 ref. to denaturation ;<br>9 substrate, no longer complementary (to active sites) / can no longer fit into active sites ;<br>10 fewer / no, enzyme-substrate complexes are formed ;<br>11 fewer / no, products are released ;<br>12 AVP ; | **6** | e.g. stomata close (as high rate of transpiration) so no $CO_2$ enters |
| (c) | *any two from:*<br>carbon dioxide is a limiting factor / so that carbon dioxide is **not** a limiting factor / AW ;<br>so that temperature is the only, variable / limiting factor ;<br>to ensure that the effects are caused (only) by temperature ; | **2** | |
| (d) | *any one from:*<br>(some is) used, for (aerobic) respiration / to react with glucose ;<br>some remains in air spaces ; | **1** | |

| | | | |
|---|---|---|---|
| (e) | *any two from:*<br>absorbs / traps / captures, light ;<br>transfers / converts, light energy into chemical energy ;<br>for the synthesis of, glucose / carbohydrates ; | **2** | |

## Q23.

| | | | |
|---|---|---|---|
| (d) | (leaves are) yellow / (leaves show) chlorosis ;<br>magnesium required for making chlorophyll ; | **2** | |

## Q24.

| | | | |
|---|---|---|---|
| (a) | *any six from:*<br><br>LIGHT<br>(B and C as light intensity increases) the rate (of photosynthesis) increases and remains constant / AW ;<br>rates (of photosynthesis) are the same at low(est) light intensities ;<br>light provides energy (for photosynthesis) ;<br>where the line rises / initially, light intensity is, limiting / the limiting factor ;<br>line(s) / rate, levels off where light intensity is **not** limiting ;<br>in **B** light intensity becomes limiting at higher light intensity than **C** / **ora** ;<br><br>CARBON DIOXIDE<br>*Idea that* line C levels off, at a lower rate (of photosynthesis) / lower light intensity ;<br>carbon dioxide (concentration) is, lower for **C** / 0.04% vs 0.4% ;<br>carbon dioxide is, reactant / substrate / raw material / needed, for photosynthesis ;<br>in **C** carbon dioxide is a limiting factor at a lower light intensity /<br>in **B** carbon dioxide is a limiting factor at a higher light intensity ;<br><br>TEMPERATURE<br>*idea that* temperature is limiting for **B** at high light intensities ; | **6** | **I** if C given as well (as no evidence for C) |

| | | | |
|---|---|---|---|
| (b) | $O_2$ ; | **1** | |
| (c) | *any four from:*<br>(glucose) used, in respiration / to provide energy / to release energy / as an energy store ;<br>(glucose) converted to / stored as, starch ;<br>(glucose) converted to sucrose ;<br>sucrose for, translocation / transport (in the phloem) / sent to sink(s) ;<br>(glucose / fructose / sucrose) in nectar ;<br>(nectar) to attract, insects / pollinators ;<br>(glucose / fructose / sucrose) in fruits (to attract animals) ;<br>(glucose) converted to cellulose ;<br>cellulose to build cell walls ;<br>lignin for cell walls ;<br>used to make, amino acids / fatty acids ;<br>AVP ; | **4** | e.g., used to make chlorophyll / (DNA/RNA) bases |

## Q25.

| | | | |
|---|---|---|---|
| (d)(i) | limiting factor ; | **1** | |

| | | | |
|---|---|---|---|
| (d)(ii) | (low / no) light intensity / (extreme air) temperature / (low / no) water (availability) / (incorrect) (wavelength of light / (short) day length ; | **1** | |

## Q26.

| | | | |
|---|---|---|---|
| (c)(i) | nitrate (ions) / sewage / fertilisers / AVP ; | **1** | |
| (c)(ii) | *15* °C – 8.9 ± 0.1 (mg per $dm^3$) **and** *25* °C – 7.3 ± 0.1 (mg per $dm^3$) ;<br><br>2.35 ± 0.05 (μm) **and** 1.95 ± 0.05 (μm) ;<br><br>(–)0.4 (in μm) ; | **3** | **ecf** from readings in MP1 for MP2 and MP3 |

## Q27.

| | | | |
|---|---|---|---|
| (a) | carbon dioxide is, raw material / substrate / reactant / AW ;<br>concentration of carbon dioxide is higher outside leaf than inside (so carbon dioxide diffuses into the leaf) ; | **2** | |
| (b) | subtract the concentration of carbon dioxide at the end from the concentration at the start / AW ;<br>divide by the time (taken) / per unit time ;<br>ref. to taking (rate of) respiration into account ; | **2** | |
| (c)(i) | light intensity ;<br>water (supply) ;<br>humidity ; | **1** | |
| (c)(ii) | increases and, reaches a plateau / remains constant / 'levels off' ;<br>increases (between 10 °C) to 30 °C / levels off at 30 °C ;<br>any comparative use of figures for rate with units at least once ; | **3** | |
| (c)(iii) | 36 ;; | **2** | |
| (c)(iv) | temperature is the limiting factor (over whole range) ;<br>increased temperature increases, kinetic energy / KE, (of molecules) ;<br>increases rate of diffusion of carbon dioxide (into leaf) ;<br>temperature, influences / affects, (activity of) enzymes ;<br>*idea of* more (effective) collisions between substrate molecules and enzymes (in plant) / more enzyme-substrate complexes formed ;<br>more carbon dioxide is, fixed / used in photosynthesis / converted into sugar / AW ;<br>carbon dioxide (concentration) is **not** limiting ; | **3** | |
| (c)(v) | ***B** shows that:*<br>rate of photosynthesis is, higher / continues to increase, if carbon dioxide is increased (at all temperatures / AW) ; | **1** | |
| (d) | *prediction:*<br>rate of photosynthesis, remains constant / decreases / slows ;<br><br>*any explanation one from:*<br>enzymes / active sites, are denatured (at high temperatures) ;<br>stomata close, so, little / no, carbon dioxide can enter leaves ;<br>plant is adapted to survive at high temperatures ; | **2** | |

## Q28.

| | | | |
|---|---|---|---|
| (c) | energy (store / sink) ;<br>example of use of starch in plant ;<br>as a reserve / source / store (of energy), when plant cannot photosynthesise / dormancy / winter / no leaves / dark / night ;<br>AVP ; e.g. insoluble | **2** | |