**1.** (a) water uptake / AW**;** **R** *water used* 1

(b)
1 cut (healthy) shoot under water (to stop air entering xylem vessels)**;**
2 cut shoot at a slant (to increase surface area)**;**
3 check apparatus is full of water / is air bubble free / no air locks**;**
4 insert shoot into apparatus under water / AW**;**
5 remove potometer from water and ensure , airtight / watertight, joints around shoot**;**
6 dry leaves / AW**;** max 4
7 keep , condition(s) / named condition(s) , constant**;**
8 allow time for shoot to acclimatise / AW**;**
9 shut screw clip**;**
10 keep ruler fixed and record position of air bubble on scale**;** **R** *'move bubble to end' ideas*
11 start timing and, measure / calculate, distance moved per unit time / AW**;** max 3

**[8]**

**2.** (i) 103**;** **R** *decimals* 1

(ii) plant **A**

hairs around stoma**;**
trap, moisture / water vapour**;**
reduces the water potential gradient**;**
so transpiration rate is reduced**;** max 3

**[4]**

**3.** (a) (i) 5:1; 1

(ii) 7 [× smaller]/AW; 1

(b) 0.5; 1

(c) surface area relative to volume too small/AW;
diffusion too slow/AW; *idea of speed needed*
distance too great/some cells deep in body/not all cells in contact with environment/AW; **R** *large if unqualified*
insufficient/AW, oxygen/(named) nutrient, supplied/(named) waste removed;
idea of linking (named) areas; *look for 'from…' 'to…' with an implication of organs, not just 'all over body'*
(may be,) more (metabolically) active/AW/, homoiothermic;
**R** *just 'need more energy'* 3 max

**[6]**

**4.** (i) potometer; **R** '*transpirometer'* 1

(ii) transpiration is the loss of water, vapour/by evaporation;
(apparatus) measures water uptake;

to replace loss;
assumes all uptake is lost/AW; ora some may be used
explanation of how some uptake may be used e.g. used to regain turgor/used in photosynthesis;
uptake by detached shoot may not be same as whole plant/AW; 3 max

(iii) cut shoot under water/insert into apparatus under water/AW;
cut shoot at a slant;
no, airlocks/bubbles/AW in, plant/apparatus, **or** airtight/watertight, joints;
dry off leaves/AW; use a healthy/undamaged/AW, shoot; **A** *fresh*
allow time to acclimatise/AW;
keep (named) condition(s) constant; **R** *'control' conditions if unqualified*
measure per unit time;
AVP; e.g. reference to scale, qualified – note position/fix scale
**R** *'set at 0'*
qualified reference to reservoir

**R** *repeat readings – gives reliable results not valid readings* 4 max

**[8]**

**5.** (i) 1 temperature increased;
more KE/energy/AW;
more evaporation/faster diffusion; **R** *transpiration max 3*

2 light (intensity) increased; **A** *sunlight* but **R** *'sun'* but ecf
stomata opened (wider);
allowed more water vapour out/AW;
*must be linked to stomatal point above*
temp increase linked to light; *max 3*

3 humidity dropped/air less saturated/AW;
internal spaces c. 100% saturated/AW;
steeper water potential gradient/AW; **A** *diffusion gradient*
**R** *concentration gradient max 3*

4 wind (increased);
removed, saturated air/diffusion shells/AW;
steeper water potential gradient/AW;
**A** *diffusion* **R** *conc gradient max 3*

*Score the first two explanations given to a max of 4* 4 max

(ii) 1 **P** has, many/more, leaves;
(so total) area (of leaves) greater;
(so) more, area for transpiration/evaporation/stomata;

**or**

2 **P** has more stomata;
idea that stomata are (main) site/AW, of transpiration/evaporation;

**or**

3 **Q** has a stated xerophytic modification;
**R** *Q is a xerophyte, if unqualified*
**R** *Q has smaller/AW leaves*
explanation of modification; needs how it reduces transpiration
e.g. hairs – wind barrier/stops water vapour removal
sunken stomata – traps water vapour/AW
thick cuticle/wax/AW reduces loss/AW **R** *stops all loss*
curled leaves – trapping water vapour idea 2 max

*Apply ora throughout.*

**[6]**

**6.** (a) **C**;
**E**; 2

(b) large surface area (to volume) / many**;**
low water potential**; A** ref to low solute potential
**R** refs to water concentration
**A** refs to (high) solute concentration
thin <u>wall</u> / short diffusion path**;**
uncutinised / permeable / unlignified / AW**;**
rapid, growth / replacement**;** 2 max

(c) **1** osmosis in correct context**;**
*look for across membrane, or, into / out of, cell / root*

**2** moves down a water potential gradient / from high to low water potential**;**
**R** along / across **R** concentration / diffusion gradients

**3** most negative / lowest, in the xylem**;**

**4** (uptake of) ions / minerals / solutes, into xylem / root hair**;**
*in context of WP gradient*

**5** tension in xylem / transpiration pull / cohesion-tension**;**
*relate to pathway in root*

**6** (moves) via the cell walls**;**

**7** (moves) via, cytoplasm / vacuoles**;**

**8** passage via the plasmodesmata**;** *look for linking cytoplasm / through wall*

**9** Casparian strip / suberin / waxy / fatty / AW, blocks, cell wall route / apoplast**; A** waterproof

**10** water, crosses membrane / enters, cytoplasm / vacuole / symplast**;**

**11** AVP**;** e.g. pits in xylem / passage cells /aquaporins / protein channels / capillarity in cell wall (spaces) max 6

*credit points from diagram*

**QWC – legible text with accurate spelling, punctuation and grammar;** 1

(d) *1 for feature and 1 for role in each section **except lignin** but max 2 for features and max 2 for functions*
*apply AW throughout*

lignin / AW;
(allows) adhesion / waterproof / stops collapse (under tension);
**A** two functions

rings / spirals / thickening / AW**; A** thick wall / rigid sides
prevents collapse (under tension); **R** strong / support / stops bursting

no cytoplasm / lack of contents / hollow / (empty) lumen / AW**;**
**R** "dead" unqualified
less resistance to flow / ease of flow / AW / more space (linked to lack of contents)**;**

lack of end walls / continuous tube**; A** long tube idea
less resistance to flow / ease of flow**; A** continuous columns idea

pits / pores, inside walls**; A** holes **R** gaps
lateral movement / get round air bubbles / supplies(water) to cells or tissues / water in or out; **R** "just let things in and out" unqualified

develop as a continuous water-filled column / AW**;**
allows tension to pull water up / AW**;**

narrow lumen / AW**;**
*idea of* more capillary rise**;** 4

**[15]**

**7.** (i) to take account of variation / AW ;
reliable or representative / smaller SD or % uncertainty ;
**ignore** "accurate", "precise"
so result not skewed by, anomalies / extreme or unusual results ;
to ensure statistical significance ; 2 max

(ii) permanent record ;
avoid, heating effect / light, of microscope lamp ;
stomata size may change (under microscope) ;
photograph can be enlarged ;
measuring can be done at leisure ;
AVP ; e.g. system or method of measuring 2 max

**[4]**

**8.** **G;**
**I;** 2

**[2]**

**9.** (i) evap*ora*tion of water / water vapour lost (from plants)**;**
<u>diffusion</u>,
into atmosphere / out of leaf / down a water potential gradient /
via stomata**;**
**A** high to low water potential references

*stop if / when candidate says transpiration is 'upward movement of water in plant'* 2 max

(ii) linked to gas exchange / AW**; A** refs to **both** oxygen and carbon dioxide unqualified carbon dioxide for photosynthesis**;**
open stomata**;**
large area**;** *can apply to leaf area or pore area*
moist mesophyll to (relatively) dry air / water potential gradient / AW**;**
AVP**;** e.g. ref to some cuticular transpiration inevitable / AW
link open stomata to daytime when it is hottest / AW 3 max

(iii) hairs trap water vapour**; R** water unqualified / water particles **A** molecules
reduces water potential gradient / stops wind removing vapour /
more humid air around leaf**;** *ecf* for water
so less transpiration / AW**;**
AVP**;** e.g. ref reflective nature of hairs in context
ref to need of xerophytes to conserve water in dry habitat 2 max

**[7]**

**10.** **1** in the xylem <u>vessels</u>**; A** tracheids

**2** down a, water potential / Ψ, gradient**;**
**R** 'along' **A** refs to high to low water potential

**3** most negative, at the leaf / in the atmosphere**;**
*ora must refer to water potential*

**4** transpiration sets up a gradient / AW**;** *any valid gradient*

**5** (places) water (in xylem) under, tension / suction / negative pressure / pull / hydrostatic pressure gradient / AW**;**

**6** cohesion**;**

**7** description of cohesion**;**

**8** ref to hydrogen bonding**;**

**9** (continuous) water columns / AW**;**

**10** mass flow**;**

**11** root pressure, in context / described**;**

**12** adhesion described / capillarity**;**

*treat refs to osmosis and descriptions of passage through root as neutral* 6 max

**QWC – legible text with accurate spelling, punctuation and grammar;** 1

**[7]**

**11.** (i) stem**;** 1

(ii) **B;** 1

**[2]**

**12.** (a) sucrose**;** 1

(b) (i) **P** = companion (cell)**;**
**Q** = sieve (tube) element / sieve tube cell**; R** sieve tube / sieve cell 2

(ii) *ecf - do not penalise sieve tube here*

**1** sieve elements / **Q**, end to end *or* sieve plates perforated / sieve pores , for ease of flow / AW**;**

**2** companion cells / **P**, metabolically active / have many mitochondria / produce ATP / release energy / AW**; R** make energy

**3** (active) loading into, companion cell / **P; A** into, sieve elements / **Q**

**4** ref to proton pump**;**

**5** ref to co-transporter**;**

**6** role of plasmodesmata (between **P** and **Q**)**; R** pores

**7** sieve element / **Q**, has few organelles / AW, for, ease of flow / more sucrose / AW**;**

**8** ref to, unloading mechanism / (hydrostatic) pressure gradient**;**

**9** ref to one role for sieve plate e.g. electro-osmosis or stops 'bulging'**;** 3 max

**[6]**

**13.** source when root converts, starch / insoluble carbohydrate, into sugars / AW**;**
sink when root **either** stores starch / (named) carbohydrate / assimilate
**or** uses carbohydrate for, respiration / growth / AW**;**
high hydrostatic pressure makes it a source **and** low hydrostatic pressure a sink**;**
when loading it is a source **and** when unloading a sink;
*treat refs to (potato) tubers as neutral* 2 max

**[2]**

**14.**

| | | |
|---|---|---|
| water potential**;** | **A** symbol | **R** other gradients |
| apoplast / apoplastic**;** | **A** apoplasm | **R** anoplast |
| endodermis / Casparian strip**;** | **A** starch sheath | **R** stele |

Casparian strip / suberin / AW**;** *only credit Casparian strip once*
symplast / symplastic**;** **A** vacuolar / symplasm / synplast

***A** endodermis in point 4 if point 3 is blank or neutral*

*if more than one response in a gap, take first on list for points 1, 3 and 4.*

*For apoplast and symplast look for single term i.e. **R** if put apoplast / symplast*

**[5]**

**15.** (i) long**;**
thin cell wall**;**
lack of **,** waterproof layer / cuticle**;**
large surface area**; NOT** if cilia / villi / microvilli / tails / etc
present in large numbers**;**
(membrane) proteins / carriers / channels / aquaporins**;**
many mitochondria**;**
AVP**;** (adaptation of part of the cell) 1 max

(ii) *if candidate gives a list or a choice, all must be correct*

active transport / diffusion / facilitated diffusion / described**;**
**A** pinocytosis
**NOT** passive transport / osmosis / bulk transport 1

(iii) lower <u>water potential</u> inside / ora**;**
movement **,** down water potential gradient / from high Ψ to low Ψ**;**
through **,** channel proteins / partially permeable membrane /
aquaporins / AW**;**
walls freely permeable**;**
osmosis**;** 2 max

**[4]**

**16.** 3 to 5 armed star of xylem with phloem more or less between**;**
**R** if star too close to the edge
xylem and phloem correctly labelled**;**

*ecf - if stem drawn, credit correct xylem and phloem labels* 2

**[2]**

**17.** lack of contents / no cytoplasm / hollow / lumen / continuous / AW**;**
**A** lack of end walls
less resistance to flow / more space linked to idea of lack of contents / AW**;**
*treat large as neutral*

thickening / rings / spirals / lignin (in the wall)**;** *treat cellulose as neutral*
prevents collapse / gives support / adhesion of water**;**
**R** strength / rigid, unqualified **R** ideas on resisting positive pressure

pits / AW**; A** pores / holes (in side walls)
allow lateral movement / AW**; R** 'let things in or out' unqualified 4 max

**[4]**

**18.** (i) *source* – leaf / storage organ / named storage organ**; A** root qualified
*sink* – root / tuber / storage organ / (young) growing region / leaf qualified / flower / bud / fruit / seed**;**
**R** individual cells but **A** tissue <u>areas</u> such as mesophyll 2

(ii) *max 2 if no reference to diagram*

water will enter source**;**
by osmosis**;**
down / AW , a <u>water potential</u> gradient**;**
increase in (hydrostatic) pressure**;**
as source / sink cannot expand / AW**;**
force / AW, solution along (tube to sink)**;**
AVP**;** e.g. explanation of mass flow 4 max

**[6]**

**19.** (i) ATP involved / respiration involved / many mitochondria in companion cells / reduced by metabolic inhibitors / oxygen dependent / temperature dependent / loading against a concentration gradient / AVP**;**

*if evidence not given here look for it and credit it in part (ii)* 1

(ii) loading, into companion cell / from transfer cell / into sieve tube / into phloem – implied**;**
H ions / protons, pumped out of, companion cell / sieve tube / phloem**;**
diffuse back in with sucrose**;**
protein carrier / co-transporter**;**
possible active unloading by reverse mechanism**;**

AVP to cover alternative mechanisms**;;;**
e.g. electro-osmotic theory
$K^+$ pump
via companion cell
electrochemical gradient
sieve pores provide a capillary bed / AW 3 max

**[4]**

**20.** (i) cut shoot under water**;**
insert into apparatus under water / AW**;**
full of water / no extra bubbles / no airlocks**;** *applies to plant / apparatus*
cut shoot at a slant**;**
dry off leaves / AW**;**
ensure , air- / water- , tight joints / AW**;**
use a , healthy / AW , shoot **:**
allow time to acclimatise / AW**;**
keep , condition(s) / named condition(s) , constant**;**
measure per unit time / AW**;**
shut screw clip**;**
ref to scale**;** e.g. note where bubble is at start / keep ruler fixed
**R** '*move bubble to end' ideas* 4 max

(ii) water uptake / AW**;** **R** water used 1

**[5]**

**21.** (a) (i) 103**;** **R** decimals 1

(ii) ***R** refs to water or water particles*

**1** boundary layer / saturated air / water vapour / AW, around, leaf in still air / **A;**
**2** (which) fan / wind , removes / reduces**;**
*ecf wrong ref to water*
**3** ref steeper water potential gradient**;**
**R** concentration gradient
**4** (therefore) faster / greater / more / AW, evaporation / diffusion**;**
*must be linked to above* 3 max

(b) set up in same, (environmental) condition(s) / named condition**;**
calculate the rate per unit area of leaf / idea of getting same area of leaf in both**;**
detail of how this could be done**;** e.g. draw round all leaves on graph paper
replicates**;**
both picked at same time / same degree of turgidity / AW**;**
run for the same time / AW**;** 2 max

**[6]**

**22.** water moves down a water potential gradient / AW**;**
by osmosis**;**
(ref to roots being below –50 kPa means) water will enter (the root)**;** 2 max

**[2]**

**23.** *function must match adaptation, adaptation can stand alone*
*assume answer is about water vapour unless clearly wrong e.g. water droplets*

covered in hairs**;**
reflect heat *or* water vapour, trapped / not blown away**;**

thick, waxy layer / cuticle / AW**;**
reduces loss (via the epidermis) / reflects heat**;** **R** no loss
*if cuticle related to reflective nature, 'thick' not needed*

small / AW , leaves**;** **A** no leaves (e.g. cacti) / needles / spines / spikes **R** thorns
reduced surface area for loss / reduces number of stomata**;**
**R** *ref to spines etc related to preventing consumption by herbivores*

sunken stomata / AW**;** ***A*** *substomatal chamber hairs as an alternative here*
water vapour, trapped / not blown away**;**

rolling up of leaves / curled leaves**;**
less surface area / stomata on inside *or* water vapour, trapped / not blown away**;**

small air spaces in the mesophyll**;**
quickly become fully saturated / reduced area for loss**;**

stomata, shut in day / open at night / AW**;**
day hotter / night cooler**;**

AVP**;** e.g. reduced stomatal number plus reason
AVP**;** timed leaf fall
rosette of leaves close to ground 4 max

**[4]**

**24.** (a) stem**;** 1

(b) phloem**; R** sieve tube, phloem vessel, single cell type 1

(c) **C;** 1

(d) *feature and role must match for 2 marks*
*mark for feature may be awarded even if role is incorrect*
*both marks may be given in right hand column.*

| *Feature* | *how it helps* |
|---|---|
| *either **D** or **E*** | |
| living**;** | allows active process / AW**;** stops escape of metabolites**;** |
| hydrogen pump / co-transporter**;** | (role in) loading / AW**;** |
| plasmodesmata / connections between sieve tube and companion cell**;** | allow exchange /AW**;** |
| ***D / companion cell*** | |
| (many) mitochondria | provide, energy / ATP**;** |
| much respiration / metabolically active**;** | |
| nucleus**;** | controls functioning of both cells**;** |
| ***E / sieve tube*** | |
| clear of most organelles / organelles at edge / little cytoplasm / AW**;** **R** empty (*if specific organelles given, need at least 2*) | less resistance / ease of transport / AW / more space for transport**;** |
| long / elongated / AW**;** | less resistance / ease of transport / AW**;** |
| sieve plate / (sieve) pores**;** | connects elements / lets materials through / AW**;** **A** reduces resistance |
| joined end to end**;** | continuous / long distance, transport**;** |
| bi-directional flow**;** | allows sugar to go to sink both up and downward / AW**;** 6 max |

**[9]**

**25.** *mark for transpiration / evaporation is not freestanding, in each case it must be related to the feature in each section*

(a) transpiration / evaporation / AW, occurs via stomata**;** **R** water loss
(generally) warm(er) in day**;**
more evaporation / transpiration will occur (in context)**;**
ref. to steeper water potential gradient**;**
shutting, stops / reduces, this loss**;**

*ora for open at night* 2 max

(b) small surface area**;**
less transpiration / evaporation / AW (in context)**;**
**R** water loss **R** no transpiration
fewer stomata / AW**;**
protection against grazing / AW**;** 2 max

(c) hairs trap, water vapour / moisture in air**;** **R** just moisture
prevent wind effect / AW**;**
reduces water potential gradient**;**
less, transpiration / evaporation / AW (in context)**;**
**R** water loss **R** no transpiration
correct ref. to condensation of water vapour**;** 2 max

**[6]**

**26.** (i) loss, of water vapour / by evaporation**;**
<u>diffusion</u> into, atmosphere / air / environment / out of plant**;**
via stomata *or* from, leaves / aerial parts**;**
*max 1 if response starts with 'transpiration is the upward movement of water'* 2 max

(ii) *Descriptions*
**1** increases then decreases / peaks / higher by day / lower by night**;**
**2** correct ref to figures to support e.g. highest at 1400 / lowest at midnight / ref to one rate with units**;**

*Comparisons*
**3** (rate of) transpiration greater, in day/ when hotter / 6 to 16 hours**;** ora
**4** (rate of) transpiration less, at night / when cooler / 16 to 6 hours**;** ora
**5** rates equal at 6 <u>and</u> 16 hours**;**
**6** both peak, at the same time / at 14 hours / accept midday**;** / AW**;**
**7** both lowest at, same time / midnight**;**
**8** transpiration rise is steeper**;** ora
**9** transpiration fall is steeper**;** ora
**10** any one figure quote for rate with units that supports comparison points above**;** 4 max

(iii) *award two marks if correct answer (58) is given – must be rounded up*
58 (%)**;;**
*max 1 if not whole number, award calculation mark for getting 14 hours*
*ecf If wrong time period read, but correct % calculated from it = 1 mark* 2

**[8]**

**27.** loss of water from mesophyll**;**
cell walls**;**
more drawn from, cytoplasm / cell / AW**;**
cohesion of water molecules**;**
hydrogen / H, bonds**;**
water under tension / ref to hydrostatic pressure gradient implied**;**
**A** water 'pulled' / 'drawn' **R** sucked
via, symplast / apoplast / vacuoles / description / AW**;**
(water from) xylem / xylem vessels**;**
ref to water potential gradient**;** 4 max

**[4]**