1. Quality of Communication

The answers to all sections of this question require the use of continuous prose. Quality of language should be considered in crediting points in the scheme. In order to gain credit, answers should be expressed logically and unambiguously, using scientific terminology where appropriate.

(a) Any **five** from:

Water potential in xylem reduced (by entry of ions);
Water potential gradient established between xylem and surrounding cells;
Plasma membranes of surrounding cells are partially permeable;
Water enters xylem by osmosis;
Volume of water in xylem increases;
Cannot move back due to gradient;
Pressure in xylem increases (and forces water upwards); max 5

(b) Any **four** from:

Evaporation from leaves / transpiration;
Water in xylem under ***tension****/negative pressure/pulled up;
Water molecules ***cohere****/stick together/form hydrogen bonds;
[*Ignore: references to adhesion*]
So water a single column;
Air bubble breaks column / prevents cohesion; max 4
[**Note: just mentioning the cohesion-tension theory is not enough*]

(c) 2 marks **per feature** for relating Fick's law to reducing water loss –max. 2 features

reduced number of stomata; reduced surface area;	thick waxy cuticle; increases diffusion distance;	leaves reduced to spines; reduced surface area ;
(epidermal) hairs; reduce diffusion gradient;	sunken stomata; reduce concentration difference;	curled leaves; reduced concentration gradient;

Statement of Fick's law:

$$\textit{Rate of diffusion} \propto \frac{\text{Surface area of exchange surface} \times \text{concentration difference across surface}}{\text{thickness of exchange surface}}$$;

Low surface area, low concentration difference and high thickness/equivalent reduce loss / candidate clearly relates features to equation to show how rate is reduced; max 6

[15]

2. (a) water enters root hair cells;
by osmosis;
because active uptake of mineral ions has created a WP gradient;
water moves through the cortex;
(by osmosis) down a WP gradient;
through cell vacuoles and cytoplasms / symplastic pathway;
through cell walls / apoplastic pathway; max 5

(b) WP in leaf cells decreases / becomes more negative;
therefore water moves out of xylem (into surrounding tissues) by osmosis;
this creates a pull/tension on the water in xylem;

(c) which is in a continuous column / water molecules cohere;
cohesion due to H bonding;
column doesn't break because of adhesion with xylem walls; max 4
(water is used in) the light-dependent reactions of photosynthesis;
electrons from water enable ATP production / H^+ are used to reduce NADP / produces O_2 ;
(water can be used in) hydrolysis reactions within the plant;
to create turgor;
as a solvent for transport;
as a medium for chemical reactions;
component of cells / cytoplasm; 6

[15]

3. (a) Suitable accepted evidence, 1 mark for evidence and 1 mark for explanation –
EITHER e.g.guttation
(only) upward pressure could force liquid water out of leaves;
OR
Sap exuding from a cut, rooted stem;
(only) upward force could make this happen; 2

(b) *(Note: max.* ***two*** *for any component)*

(i) Evaporation from leaves during daytime only/mainly;
tension/negative pressure (on water) in xylem creates inward pull (on walls of xylem vessel);
xylem vessels become narrower;
due to adhesion of water molecules (to walls of xylem vessels);

(ii) root pressure gives <u>outward</u> force/push on walls of xylem vessels;
tree would become wider/stay same diameter;
xylem vessels become wider/stay same diameter; max 3

[5]

4. (a) Increase in light (from 06.00) causes stomata to open;
water evaporates/lost by transpiration, from substomatal space/ mesophyll/air space/stomata;
(causing) water to move across leaf in apoplast / symplast / by osmosis;
(transpiration/evaporation) exerts force causing tension/
pulling force in <u>water</u> columns;
(hydrogen) bonding between molecules/
cohesion holds water (columns) together;
bonding/ adhesion between walls of xylem vessels and water molecules;
tension/pulling causes water columns to decrease diameter,
narrowing/stretching
xylem vessels (and hence tree trunk);
Decreases in light (from 20.00), water evaporation slows, tension falls
allowing water columns to collapse; max. 5

(b) (i) C, least change in diameter of tree trunk; 1

(ii) Sunken stomata;
water evaporation into pit creates local humidity;
increased humidity reduces gradient for water evaporation;

close arrangement of stomata;
diffusion shells of individual stomata overlap;
interferes with water diffusion and slows evaporation;

restriction of stomata to lower side of leaf;
rate of air movement below leaf less/ heating effect of sun less;
gradient for water evaporation reduced/ water molecules have less kinetic energy;

thick cuticle/wax/suberin (on upper surface);
(wax/suberin)waterproof;
water unable to diffuse onto surface to evaporate,

presence of trichomes/ hairs;
surface traps water close to leaf surface;
increased humidity reduces gradient for water evaporation;

reduced leaves/spines/small surface area to volume;
less surface area for evaporation;
more distance across leaf for water to diffuse;

rolled leaves;
stomata enclosed in localised humidity;
increased humidity reduces gradient for water evaporation; max. 2×3 = 6

[12]

5. (a) *E. superba;*
Largest proportion of shallow roots; 2

(b) Roots go to greatest depths;
Able to get water when surface soil dried out;
or
Greatest root mass;
Able to store more water; 2

(c) Curled leaves;
Thick cuticle;
Sunken stomata;
Hairs; max 2

[6]

6. (a) arrow through cell walls; 1

(b) decreases as less lost by leaves/by transpiration;
high humidity due to decreased diffusion/water potential gradient; 2

(c) water potential decreases /becomes more negative in soil solution /outside root;
water unable to enter root (cells)/root(cells) lose water to soil; 2

(d) (i) A and D, total water loss/ percentage loss of mass comparatively small; 1

(ii) stomata sunken in pits creates local humidity/ decreases exposure to air currents;
presence of hairs creates local humidity next to leaf/ decreases exposure to air currents;
stomata mainly located on underside of leaf so less exposed to air currents/ heat from sun;
stomata close midrib so more sheltered from air currents;
stomata close together so diffusion shells overlap;
thick waxy cuticle makes more waterproof impermeable to water;
double palisade layer increases diffusion distance;
stomata on inside of rolled leaf creates local humidity/ decreases exposure to air currents; max 2

[8]

7. (a) (i) distance moved by bubble in specified time period;
diameter / radius of capillary (lumen); 2

(ii) surface area/ mass of leaves/ plant; 1

(b) rapid loss then decreases; 1

loss in mass as water loss is not replaced;
initially stomata are open / later the stomata close;
higher water potential of leaf cells compared with atmosphere / diffusion of water from leaf to atmosphere;
water potential of leaf reduced / diffusion gradient decreased; max 3

[7]

8. (a) inrolling of leaf;
reduces water potential gradient / air movement across stomata / traps <u>air</u> which becomes saturated / moist / humid / reduces surface area;

sunken stomata;
reduces water potential gradient / air movement across stomata / traps <u>air</u> which becomes saturated / moist / humid;

thick cuticle;
reduces <u>cuticular</u> transpiration / reduces evaporation /greater diffusion distance;

hairs;
traps air which becomes saturated / moist / humid; max 4

(b) (i) high salt content - reduces uptake - reference to water potential gradient / osmosis;

(i) high temperature - increases uptake as more water evaporates / transpired; 2

[6]

9. (a) (i) Xylem named and correctly shown on diagram; 1

(ii) Oxygen required for respiration;
ATP/energy necessary for active transport; 2

(b) Pathway shown as being through cytoplasm but not through vacuole;
Indicated as passing through cell wall via channels; 2

[5]

10. (a) **A** = xylem

B = endodermis 2

(b) (i) Cell walls 1

(ii) From high water potential to low water potential / higher water potential in soil / lower water potential in root;
By osmosis / diffusion of water. 2

[5]

11. (a) Vessels;
Have no end walls / hollow / no cytoplasm;
Allows unrestricted flow of water.
Lignification;
Provides support / strength / impermeability;
Pits allow lateral transport;
Tracheids with porous end walls. max 4

(b) (i) Root pressure
Involves active transport;Secretion / movement of salts into xylem;
Reference to role of endodermis;Water moves along water potential gradient.

(ii) Cohesion tension
Solar energy source;
Evaporation of water;
Water potential gradient created across leaf / mesophyll cells;
Tension created in xylem / water column;
Cohesion (or description) of water molecules maintains column;
Due to H-bonding / polarity / charges of water molecules ;
Adhesive force between water and wall.
(*Max 5 marks for cohesion-tension*) max 8

(c) Feature and explanation required for mark, e.g.
(*3 features without a suitable explanation = 1 mark*)

Rolled leaves –
reduces water potential gradient air movement across stomata / traps air which becomes saturated / moist / humid / reduces surface area;

Sunken stomata –
reduces water potential gradient air movement across stomata / traps air which becomes saturated / moist / humid;

Thick cuticle –
Reduces cuticular transpiration / reduces ration greater diffusion distance;

Hairs -
traps air which becomes saturated / moist / humid;

Reduced leaves / spines –
less surface area / fewer stomata (for evaporation). max 3

[15]

QWC Award 1 or 0 according to criteria

12. (a) (i) High transpiration rate, lower water potential of leaves; 1

(ii) Transpiration involves <u>evaporation</u> of water;
Reduced water content lowers water potential / becomes more negative; 2

(iii) Opening and closing of stomata / degree of opening; 1

(b) (i) Initially high loss in mass, then decreases; 1

(ii) (Loss in mass as) water is not replaced;
Initially stomata are open / later stomata close;
Higher water potential of leaf / diffusion of water from leaf to atmosphere;
Water potential of leaf reduced / diffusion gradient decreased; 3 max

(iii) Reduce sampling error / improve reliability of results; 1

(c) <u>Thick</u> cuticle; hairs; sunken stomata; inrolled leaves; fewer stomata ;
Reduced leaf surface area; 2 max

(d) (i) Higher temperature provides more kinetic energy;
For evaporation / diffusion;
Air can hold more water vapour / increases water potential gradient; 2 max

(ii) Reduces transpiration as less water uptake;
Reference to water potential gradient (leaf and air / soil and root); 2 max

[15]

13. (a) A = phloem/sieve tube;
B = endodermis;
C = xylem; 3

(b) (i) A; 1

(ii) C; 1

(c) (i) higher /less negative to lower/more negative water potential;by osmosis; 2

(ii) apoplast; 1

[8]

14. (a) (i) Osmosis; 1

(ii) Apoplast(ic); 1

(b) Casparian strip / waterproof walls;
so water must go through cytoplasm / vacuole / symplast; 2

(c) In xylem;
evaporation / transpiration from leaves;
through stomata;
cohesion of water molecules;
leaf cells have more negative water potential, so water enters from xylem;
water drawn up as column/continuous stream;
adhesion of water to walls;
capillarity due to narrow lumen of xylem (vessels);
lignified walls keep xylem (vessels) open;
root pressure forces (some) water up; 6 max

(d) Description includes rise and fall, with max at midday;
rise related to increasing temperature;
fall related to stomatal closure;
explanation in terms of rate of evaporation;
explanation of factor affecting stomatal opening/closure, e.g. light;
(*Accept all converses; references to photosynthesis neutral*) 4 max

[14]

15. (a) increased humidity leads to decreased transpiration;
high humidity means more water in the air / increased saturation / increased water potential;
reduced diffusion gradient / water potential gradient;
slower rate of water loss / less evaporation; 3 max

(b) thick cuticle;
impermeable to water / waterproof;
sunken stomata;
reduces water diffusion gradient;
shape of leaf / rounded / small surface area;
small surface area : volume ratio; 4 max
(*explanation must be linked to feature*)

[7]

16. (a) (i) movement (of water) through cell walls/intercellular spaces; 1

(ii) Casparian bands; (*accept ref to suberin*)
which are impermeable/waterproof;
lower water potential in the cytoplasm of endodermis cell;
enters symplastic pathway / cytoplasm of cell;
by osmosis; 3 max

(b) (i) rate of flow increases to max at 1200 and then decreases;
increasing transpiration/evaporation from leaves;
transpiration creates tension / increases transpirational pull;
water molecules are cohesive/stick together;
produces a water column; 3 max

(ii) (increase transpiration) produce a higher tension / reduces the pressure in the xylem reducing the diameter;
adhesive forces between xylem and water; 1 max

(c) water moves in dead cells / xylem is non-living tissue;
the process is passive / no energy is needed; 2

[10]

17. (a) 1. water <u>evaporates/transpires</u> from leaves;
2. reduces water potential in cell /water potential/osmotic gradient across cells *(ignore reference to air space)*;
3. water is drawn out of xylem;
4. creates tension *(accept negative pressure, not reduced pressure)*;
5. cohesive forces between water molecules;
6. water pulled up as a column; 4 max

(b) (i) same surface area of leaf / number of leaves / age/thickness of cuticle; 1

(ii) (environmental conditions) affect rate of transpiration/evaporation; 1

(iii) presence of grease reduces water loss; 1

(c) (i) 1.2 / 1.3g; 1

(ii) more stomata on the lower surface;
(thicker) waxy cuticle on the upper surface; 2

[10]

18. (a) (i) unrestricted/free/quick/easy water flow/continuous column / maintains transpiration stream;

1

(ii) resists tension in water (column) / provides support/strength / maintains column of water/adhesion / prevents water loss 1

(allow waterproofing in correct context i.e. not absorbing);

(b) (i) as total area of stomata decreases the rate of water flow decreases / decrease is proportional; 1

(reject proportional, 'as one goes up the other goes up' and 'same shape')

(ii) increasing/higher temperature causes increasing/higher rate of evaporation/transpiration;
(*not water loss*) 1

(iii) lower plateau (start and finish at same point); 1
(allow *if curve sketched on original graph, reject 'curve is lower'*)

(c) conserves water / reduces water loss / reduces transpiration / reduces evaporation;
high humidity (in pit) / reduced water potential gradient / less water blown away / increased diffusion pathway;

2

[7]

19. (a) (i) apoplast; 1

(ii) (pathway from cells) along cell walls /
through spaces and out through stoma(ta);
by diffusion *(disqualify if osmosis mentioned)*;
down a WP/diffusion/concentration gradient; 3

(b) two suitable adaptations plus explanation, e.g.
sunken stomata, reduce air movement/diffusion gradient;

rolled leaves, reduce surface area (for evaporation) /
enclose still air around stomata;
waxy cuticle, reduce (cuticular) evaporation / impermeable to water;

(reject waterproof)
few stomata, to reduce SA for diffusion;
small leaves, reduce SA for diffusion; 2

[6]

20. (a) long cells / tubes with no end walls;
continuous water columns;
no cytoplasm / no organelles/named organelle;
to impede/obstruct flow / allows easier water flow;
thickening/lignin;
support / withstand tension / waterproof / keeps water in cells;
pits in walls;
allow lateral movement / get round blocked vessels; 4 max

(b) (i) increase in transpiration rate/evaporation due to increase in temperature ;
increased (kinetic) energy of water molecules;

OR

increase in light (intensity) increases transpiration rate/evaporation;
greater stomatal aperture / more stomata open;
increase in flow rate due to cohesion/attraction of water molecules; 2 max

(ii) adhesion/attraction of water molecules to walls of xylem;
results in tension as water pulled up stem;
pulling in walls; 2

[8]

21. (a) (i) Endodermis(reject pericycle / suberin); 1

(accept endodermis and / containing Casparian strip)

(ii) S; 1

(iii) R; 1

(b) (i) (waxy so) impermeable to water/waterproof/stops water passing through; 1

(ii) reference to hairs / position of stomata (sunken stomata / stomata in pits)
LINKED to reduced air movement / trap layer of air / trap water vapour (*reject water)* / maintains humidity;

reduces diffusion gradient / concentration gradient of water / water potential gradient;

OR

stoma can close;
reduces area for evaporation or transpiration; 2

[6]

22. (a) (i) absorption rate stays level (initially) then rises;
transpiration rate rises regularly / transpiration increases at a faster rate than absorption; 2

(principle that both increase 1 max awarded)

(ii) increased stomatal aperture/light/temperature(increases transpiration rate);
decreases water potential in root / increased uptake by osmosis; 2

(b) water evaporates/transpires;
reduces water potential / creates water potential gradient / increases osmotic gradient /
moves via apoplast pathway;
water drawn out of xylem;
creates tension/pulling effect / creates negative pressure (*in context);*
cohesive forces or H bonding between water molecules / water moves as a column; 4 max

(accept continuous stream)

[8]

23. (a) shallow roots enable rapid uptake of rainfall (in **X** and/or **Z**);
widespread/shallow roots allow collection of larger volume water/over a larger area/rapid uptake of water (in **Z**);
swollen stem for water storage (in **X**);
deep roots for accessing deep groundwater (in **Y**);
small/ no leaves so little transpiration; 3

(b) **Z**;
wide spread of roots for rapid water absorption; 2
(accept **X**; if linked to leaves channelling water to roots)
(ignore references to water storage abilities)
(accept other responses if justified)

[5]