(ii) Water potential is lowered inside the guard cells
(iii) Water moves in by osmosis and makes the guard cells turgid
(iv) Stomata open as guard cells swell

(2) Non-cyclic – produces reduced NADP, ATP and O_2
(a) Involves both photosystems I (P700) and II (P680)
(b) A photon of light strikes photosystem II – occurs almost exclusively on the granal lamellae
(c) A pair of electrons are excited from the central magnesium atom of the chlorophyll in the primary pigment reaction centre
(d) The electrons leave the chlorophyll from the primary reaction centre – captured by electron acceptors
(e) The electrons pass along a chain of electron carriers (such as ferredoxin) – NB: a lack of iron could lead to a lack of these carriers so less LDR would take place
(i) Electron carriers – molecules that transfer electrons
(f) A small amount of energy is released and is used to synthesise ATP (by pumping hydrogen ions into the thylakoid space to produce a proton gradient)
(g) Protons from photolysed water also take part in chemiosmosis – ATP is made
(h) A photon of light also strikes photosystem I
(i) A pair of electrons along with the pair of protons (produced at photosystem II by photolysis of water) join oxidised NADP to form reduced NADP – to be used in the light independent stage
(j) The electrons from the oxidised photosystem II replace the electrons lost from photosystem I
(k) The electrons from the oxidised photosystem II are replaced by a pair of electrons ultimately formed from the photolysis of water

i) Explain the role of water in the light-dependent stage

i) Photosystem II has an enzyme that can split water in the presence of light into protons, electrons and oxygen – photolysis
ii) $2H_2O \rightarrow 4H^+ + O_2 + 4e^-$
iii) Therefore, water is a source of…
(1) Oxygen – some is used for aerobic respiration but most diffuses out of the leaves through stomata and into the air
(2) Hydrogen ions
(a) Used in chemiosmosis (cyclic photophosphorylation) to produce ATP
(i) An accumulation of hydrogen ions will produce a proton gradient
(ii) Protons will move from the thylakoid space back out to the stroma via ATP synthases, through the thylakoid membrane, down a proton gradient
(iii) A proton motive force is produced
(iv) The proton motive force will generate ATP from ADP and Pi (phosphorylation) – chemiosmosis

(v) ATP can be used for light independent reaction or for guard cells to actively pump potassium ions into them so they can swell and the stomata can open

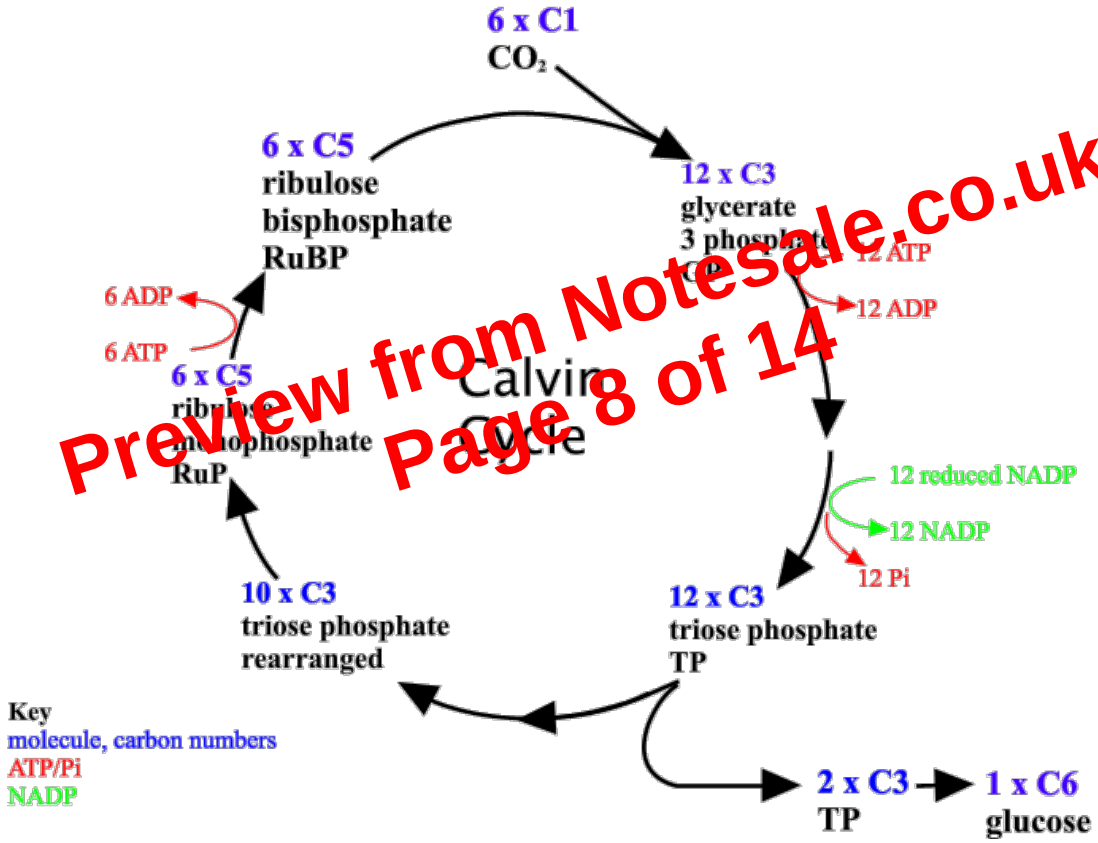
(b) Protons are accepted by the coenzyme NADP to form reduced NADPs – reduced NADPs are then used in the light independent stage to reduce CO_2 and produce organic molecules

(3) Electrons – replace those lost by oxidised chlorophyll at the centre of photosystem II

iv) Water also keeps palisade vacuoles of cells turgid, so pushes chloroplasts to the outer edges of the cells where they can move to readily trap light and create a short diffusion pathway for CO_2

*j) Outline how the products of the light-dependent stage are used in the light- independent stage (Calvin cycle) to produce triose phosphate (TP) (reference should be made to ribulose bisphosphate (RuBP), ribulose bisphosphate carboxylase (rubisco) and glycerate 3-phosphate (GP), but **no** other biochemical detail is required)*

k) Explain the role of carbon dioxide in the light-independent stage (Calvin cycle)



i) Light independent stage – where carbon dioxide is fixed and used to build complex, organic molecules which takes place in the stroma of chloroplasts

ii) Role of carbon dioxide

(1) Source of carbon and oxygen for the production of all large inorganic molecules

(2) Molecules are used as structures, act as energy stores or are sources for all carbon-based life forms on the planet

iii) CO_2 diffuses from the air through the stomata, the spongy mesophyll layer, the palisade cells, thin cellulose cell walls, cell surface membrane, cytoplasm, chloroplast envelope and then into the stroma