Question		Expected Answers	Marks	Additional Guidance
1	**(a)**	(6) CO_2 + (6) H_2O **;** $C_6H_{12}O_6$ + (6) O_2 **;** balancing **;**	[3]	**ignore** word equations
	(b)	acts as heat filter / absorbs heat from lamp / reduces heat effect of the lamp / AW **;** maintain constant temperature / make sure temperature is not another variable **;**	max [1]	**A** 'improves validity'
	(c)	*colour prediction:* purple *explanation* **1** CO_2 is an acidic gas / forms carbonic acid **;** **2** CO_2 been used up / taken in / absorbed (by the algae) **;** **3** by photosynthesis **;** **4** which causes pH increase / more alkaline / less acidic **;** **5** more photosynthesis than respiration **;**	max [3]	*no mark for prediction alone*

Question		Expected Answers	Marks	Additional Guidance
	(d)	**1** as distance increases / light intensity decreases, time taken for colour change increase / photosynthetic rate decreases **; ora** **2** rate of change slows, at low light intensity / furthest from lamp **;** **3** no change in rate, at high light intensity / close to lamp **;** **4** credit appropriate use of comparative figures with units stated at least once **;** **5** as distance (from lamp) increases, light intensity decreases **; ora** **6** light (intensity) is limiting (factor for photosynthesis) **;** **7** at high light (intensity), another factor could be limiting photosynthesis **;** **8** light provides energy (for photosynthesis) **;** **9** light is absorbed / trapped by, chlorophyll / chloroplast **;**	max [5]	
			[Total:12]	

2 **(a)**	**1** **2** **3** **4**	carbon dioxide uptake of **J** is higher (at all temperatures except at 10 °C) **;** peak / optimum / maximum / best, uptake of **J** is at a higher temperature **ora ;** data recorded in **J** between 35 – 40 °C / AW (but not for **H**) **;** correct use of comparative data between **J** and **H** with correct units **;**	[max 3]	**A** peak uptake for **J** is higher than **H** correct units must be stated at least once
(b) (i)	**1** **2** **3** **4** **5** **6**	temperature is a limiting factor **;** increases, (kinetic / heat) energy / the movement of molecules / diffusion **;** more collisions between substrate and enzymes **;** to speed up chemical reactions **;** stomata open wider **;** therefore increased carbon dioxide entering the leaf / AW **;**	[max 2]	
(ii)	**1** **2** **3** **4**	enzymes are denatured **;** enzymes are no longer active / AW **;** stomata close **;** therefore reduced carbon dioxide entering the leaf / AW **;**	[max 2]	
(c)	**1** **2** **3** **4** **5** **6** **7** **8** **9** **10** **11** **12**	plant growth is likely to increase **;** higher rate of photosynthesis **;** means more glucose / starch, is produced **;** glucose is used for respiration to provide energy (for growth) **;** more cellulose for cell walls **;** more protein for, enzymes / cell membranes **;** other limiting factors / CO_2 no longer limiting **;** carbon dioxide is a greenhouse gas / reference to (enhanced) greenhouse effect **;** increase in global temperatures increases rate of photosynthesis **;** reference to effect of temperature on enzymes **;** any relevant consequence of global warming **;** AVP **;** e.g. relevant use of data	[max 5]	‘more’ need only stated once **A** ‘global warming’

3 **(a)**			**[max 4]**	

	part of cycle	carbon compound found in each part
P	atmosphere / air	carbon dioxide / CO_2 ; **R** carbon monoxide
Q	(named) plant(s) / flora / producers	glucose / $C_6H_{12}O_6$ / starch / cellulose / any organic compound found in plants ; **R** glycogen
R	(named) animal(s) / fauna / consumers	glucose / maltose / glycogen / fats / fatty acid / glycerol / amino acid / protein / nucleic acid ; **R** starch
S	(named) decomposer(s) / saprophytes	glucose / glycogen / fats / fatty acid / glycerol / amino acid / protein / nucleic acid ;
T	fossil fuels, e.g. natural gas	Methane

(b)	**1**	CO_2 enters leaf ;		
	2	CO_2 diffuses to (cells) ;		
	3	carbon dioxide and water / $CO_2 + H_2O$;		
	4	chlorophyll / chloroplasts, traps light energy ;		
	5	light energy is used to make glucose / carbohydrates ;		
	6	oxygen is present ;		
	7	$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$;	**[ma 5]**	

3 (c)	1 2 3	***factor:–*** light intensity **or** duration / carbon dioxide concentration / temperature **;** ***effect of factor:–*** less photosynthesis, due to low light / low CO_2 / non optimum temperature **;** ***explanation:–*** light provides energy / CO_2 substrate for photosynthesis / temperature effects enzyme activity **;** ref to limiting (factor) **;**	**[max 3]**	
(d)		***carbon dioxide (enrichment)*** **–** burning / CO_2 gas cylinder **;** ***light (intensity)*** **–** supplemental / artificial lighting / shading **;** ***temperature*** **–** heating / cooling / ventilation / spray water **;** ***water*** **–** irrigation / watering / hydroponics described **;** ***pests / disease*** **–** (named) pesticides / biological control of pests **;** ***minerals (named)*** **–** hydroponics / added to water supply / soil **;** ***humidity*** **–** limiting ventilation / watering / humidifier or de-humidifier **;** ***pollination*** **–**adding insect (named) pollinators **;**	**[max 3]**	Mark is for the mechanisms of control in each case
			[Total: 15]	

4 (a) (i)	<table><tr><th></th><th>light intensity / a.u.</th><th>limiting factor</th></tr><tr><td>**A**</td><td>20</td><td>light intensity;</td></tr><tr><td>**B**</td><td>20</td><td>temperatur</td></tr><tr><td>**C**</td><td>20</td><td>carbon dioxide concentration;</td></tr><tr><td>**D**</td><td>5</td><td>light intensity</td></tr></table>	**3**	**A** % carbon dioxide

(ii)	factor in / aspect of, the environment; short supply; restricts / prevents, a (named) process;	**max 2**	**A** external / outside, factor **A** restriction in context of a named process e.g. photosynthesis
(b) (i)	allows oxygen to enter the compost; (decomposition by) bacteria / fungi / microorganisms; use aerobic respiration; allow liquid to drain out / avoid waterlogging;	**max 2**	**A** gas / air **I** carbon dioxide
(ii)	urea (from animal waste); (decomposers) break down proteins to amino acids; proteins / amino acids converted to ammonia; by deamination (to produce ammonia);	**max 2**	

4	**(c) (i)**	control; for a comparison / how much more carbon dioxide is available; improve validity of the investigation;	**max 2**	
	(ii)	with compost, CO_2 (concentration) reaches a peak; at 24–26 days / 600 – 610 ppm; without compost, CO_2 (concentration) remains constant; at about 200 ppm;	**max 3**	units must be given at least once **A** increases and decreases **A** very slight fluctuations
	(d)	carbon dioxide enrichment; increase in, growth rate / yield / production, of the vegetables; most effective for lettuce; reference to comparative figures that show an increase in production of at least one named crop; composting increases carbon dioxide concentration; therefore carbon dioxide not (as) limiting; (carbon dioxide required) for photosynthesis**;**	**max 4**	**A** any crop is about 3 times more in composting unit
			[Total: 18]	