CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9700 BIOLOGY

9700/51 Paper 5 (Planning, Analysis and Evaluation), maximum raw mark 30

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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Mark scheme abbreviations:

;	separates marking points
/	alternatives answers for the same point
R	reject
A	accept (for answers correctly cued by the question, or extra guidance)
AW	alternative wording (where responses vary more than usual)
underline	actual word given must be used by candidate (grammatical variants accepted)
max	indicates the maximum number of marks that can be given
ora	or reverse argument
ecf	error carried forward
I	ignore
mp	marking point (with relevant number)

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Question	Expected answer	Extra guidance	Mark
1 (a) (i)	any 2 of: RNA probe / RNA / probe / it / they, is single stranded / has exposed, bases / nucleotides ; *idea of* complementary bases / base pairs, (between, RNA probe / RNA / probe / it, and DNA) ; *idea that* different RNA probes / AW, base pair with, different / specific sticky ends (of DNA) ;	**A** unpaired / available, bases / nucleotides **I** free bases **A** *idea of* (hydrogen) bonding / binding, between, complementary base pairs / named base pairs / bases / nucleotides / codons	[max 2]
(ii)	any 2 of: *idea that* genetic variation is due to, mutation / small differences in base sequence / small or single change in nucleotide (pairs) (of DNA) ; ref. to point mutations ; *idea that* small pore size of gel allows separation of variant fragments ;	**A** examples, e.g. substitution, deletion, insertion, addition **I** inversion **A** descriptions in terms of, altered, allele / protein / polypeptide (sequence) / amino acid (sequence) **I** gene / phenotype	[max 2]
(b)	any 5 of: ref. to making / using, agarose (gel) ; ref. to using, wells / channels / chamber / **AW**, to place samples ; sample / wells, placed at / connected to, negative electrode / cathode / negative end (of the gel) ; **ora**.	***A*** *from diagrams as appropriate* **A** agrose / agar / (poly)acrylamide **R** starch gel **I** support used, e.g. microscope slide **A** e.g. pits / slits / chambers / use of comb / holes / **AW** **A** in / on / near / **AW**	

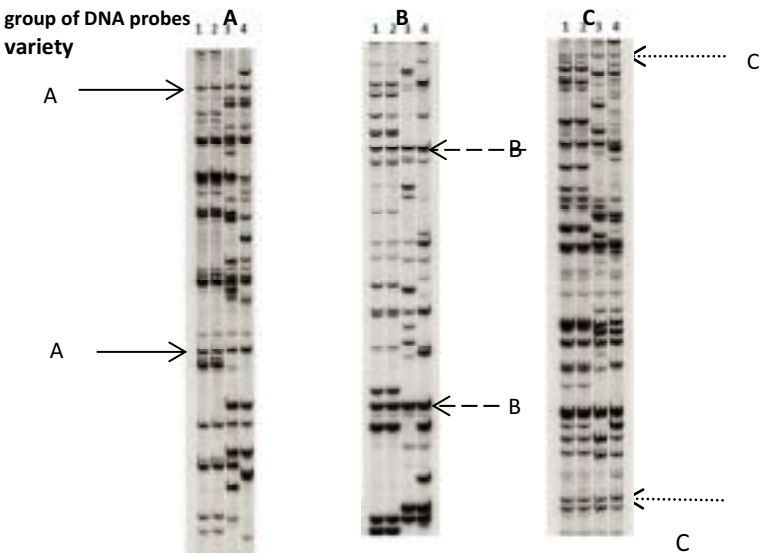
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Question	Expected answer	Extra guidance	Mark
	ref. to any detail of adding samples (to wells) ; e.g. adding (loading) dye or stain, to each sample / adding glycerine to sink DNA / use of micropipette or capillary tube / e.g. of care in loading such as preventing sideways movement / putting different DNA sample in different wells / using separate (micro)pipettes or tips or capillaries.	**A** Gilson / Finnpipette as a micropipette **I** any specified volumes	
	ref. to adding, buffer ;		
	ref. to applying potential difference / voltage difference ;	**A** ref. to current (between electrodes). **A** any description of connecting or applying a current or using a battery (to supply a current) or using a direct current **I** electricity or power unqualified / charge / electrons	
	ref. to a method of staining **and** observing the DNA ;	e.g using UV or fluorescent light **and** staining the DNA / using pre-stained gels. Stains need not be named, but must be correct if given, e.g. methylene blue / ethidium bromide / crystal violet / sybr green / acridine orange / fluorescien / **AW** **A** idea of DNA samples that are radioactive (at start) **and** autoradiograph (either directly from gel or indirectly from transfer) or take X-ray **I** radioactive or fluorescent RNA probes / Southern blotting	
	ref. to hazard **and** suitable safety precaution ;	e.g. electrical **and** not touching connectors with wet hands or wear gloves stains / named stains / buffer, toxic / irritant / harmful **and** wear gloves / goggles / mask UV light **and** goggles **A** allergy to stains / gel / buffer **and** wear, gloves / mask / goggles **I** low risk	[max 5]

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Question	Expected answer	Extra guidance	Mark
(c)	any 2 of:	**I** size of wells	
	volume of, DNA / sample, (added to the wells) ;	**I** mass **I** amount **I** volume of genes	
	idea of time / distance, allowed for the samples to run (on the gel) / **AW** ;	**I** distance between anode and cathode / time unqualified	
	pH / (type of) buffer / electrolyte ;		
	volume of buffer / enough buffer to cover gel ;		
	voltage difference used for the electrophoresis ;	current / voltage / amount of voltage or current / charge applied / potential difference / intensity of current.	
	type of stain / time allowed for staining ;	**I** volume / amount, of stain	
	type / thickness / consistency / volume / density / concentration / composition / pore size / permeability, of gel ;	**I** amount	
	restriction enzymes used ;		
	temperature ;		[max 2]

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Question	Expected answer	Extra guidance	Mark
(d) (i)	an arrow to a row of DNA fragments at the same position for group A and group B and group C ; **I** extras *all must be correct*	e.g.  	[1]
(ii)	varieties 1 and 2 ; they have, an identical / the same / very similar, pattern (of DNA fragments) ;	**I** a lot of the same fragments / many fragments same **A** they have the same (DNA) fragments in common **A** they are stained in the same parts **A** the fragments reached the same distance	[2]
			[Total: 14]

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Question	Expected answer	Extra guidance	Mark
2 (a) (i)	for **one** mark, any 2 of: depth, seeds / grains, planted (is the same / 3 cm) ; distance between, seeds / grains (is the same / 25 cm) ; number of / #, seeds / grains ; distance between rows (is, the same / 75 cm) ; size / area / number, of plots ; time plot left before planting / **AW** ; variety / type / species, of legume ; *2 correct = 1 mark*	**A** fruits **A** planting depth / depth of seeds **I** time unqualified **A** 'only legume used as green manure' **I** sp of *Sorghum* **A** ref. to randomising the plots used for each type of manuring **I** parts of legume being ploughed in	[1]

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Question	Expected answer	Extra guidance	Mark
(ii)	any 2 of: rainfall / water / humidity / chance of rain ; temperature ; intensity / duration of (sun)light ; soil qualified ; ; ***2 max*** *– one from* ***P*** *and one from* ***Q*** wind (speed) ; pollution / named pollutant ; carbon dioxide ;	*Apply the 'lines rule' from page 2* **I** ref. to climate / weather unqualified **I** amount throughout **I** wavelength **I** exposure to light unqualified but **A** 'time of exposure to light as **AW** for duration **P** depth / fertility / organic content / minerals / humus / nutrients / ions / named minerals, e.g. nitrates / soil pH **Q** soil water / soil moisture / water potential / soil aeration / soil oxygen conten **R** microorganisms in soil **I** pesticide / herbicide as a pollutant **unless** linked to idea of drift	[max 2]
(iii)	*idea that* the plant ploughed in / the legume / green manure, (has time to,) decompose / release nutrients / fertilise the soil ;	**A** to allow nitrification / ammonification / description of decomposition, of green manure / **AW** **I** nitrogen fixing **I** general unqualified responses on 'let it adapt / equilibrate, etc.'	[1]
(iv)	4 / several / many / more than one, replicates of each, type of green manure / treatment / (type of) trial plot ;	**I** large number of seeds **I** use of random number generator **I** 'many experiments going on at same time'	[1]

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Question	Expected answer	Extra guidance	Mark
(b) (i)	44 / 44.1 / 44.14 ; ; *working:* $(\frac{2964}{6715} \times 100 = 44\%)$	**A** answer up to 2 d.p. 44.1 or 44.14. (**not** 44.10 / 44.13) *max 1 for correct answer with incorrect decimal places* **A** ecf from incorrect subtraction for max 1 max 1 for following working 9679 – 6715 **or** divisor is the matching control value for chosen figures	[2]
(ii)	3:1 ; ; **or** × 3 ; ;	answer must be in whole numbers max 1 for following working 782 – 398 / 384 1:3 = one mark 1:3 with qualification (clearly identifying which is roots and which is shoots) = two marks **A** shoots have 3 × the effect of roots alone	[2]
(c) (i)	there is no significant difference between the (dry) mass of *Sorghum* grown, with green manure / with treatment, and *Sorghum,* without green manure / with no treatment / in the control ;	**A** ref. to 'roots' + 'shoots' + 'roots and shoots' / legume, as **AW** for green manure **R** 'no significant difference between different types of green manure' – needs to relate to control / no treatment **I** 'no significant difference between results of data compared' **I** 'no significant difference between control and other plots' **I** 'insignificant' for not significant but **A** non significant	[1]
(ii)	comparing the means (of two sets of data) / data is continuous / data is not discrete / normal distribution ;	*If more than one reason given, all must be correct.* **I** number of means	[1]

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Question	Expected answer	Extra guidance	Mark
(iii)	*statistically significant:* *idea that* the (observed) results are caused by, an outside factor / a factor other than chance / the green manure / the treatment ; *P < 0.05*: *idea that* 0.05 means that there is 5% / less than 5% chance of obtaining the (observed) results by chance ; ***or*** *idea of* 95% or more certain that the (observed) results are caused by an outside effect ;	**A** ref. to 'roots' + 'shoots' + 'roots and shoots' / legume (use), instead of 'green manure' **A** the results are not due to chance **I** difference is, more than / higher than, the critical value **I** reject the null hypothesis **I** random / systematic error **A** there is a 1 in 20 chance of the results being caused by chance / not caused by another factor **ora** **A** ref. to 'roots' + 'shoots' + 'roots and shoots' / legume as **AW** for green manure **I** random / systematic error	[2]

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Question	Expected answer	Extra guidance	Mark
(d)	any 3 of: mp1 *idea that* green manuring / it / AW, increases the (dry) mass of, shoots / roots / grain / whole plant / *Sorghum ;* mp2 (legume) shoots cause a greater / increase in (dry) mass than (legume) roots ; mp3 (legume) 'shoots and roots' cause greater / more, increase in (dry) mass than, shoots / roots, alone ; **ora** **or** (legume) 'shoots and roots' cause greatest / most, increase in (dry) mass ; mp4 (legume) 'shoots and roots' cause a significant, increase / difference / effect, in (dry mass of), Sorghum / the plant / each different part / AW (of Sorghum) ; mp5 (legume) shoots (only) caused a significant, increase / difference / effect, in, (dry mass of), grain / whole plant ; mp6 (legume) roots (alone) do not cause any significant increase / difference / effect, in (dry mass) ;	**A** yield / growth, for increase of (dry) mass mp1 a general point from Table 2.1 mp1 **A** 'roots' + 'shoots' + 'roots and shoots' / 'treatment' / it / legume, as **AW** for 'green manure' mp1 **A** ora – no, green manure / **AW**, shows the lowest (dry) mass of shoots / roots / grain / whole plant, (of *Sorghum)* mp2 and mp3 need a comparative statement / idea mp4, mp5 and mp6 need a ref. to significance **I** ref. to chance / insignificance	[max 3]
			[Total: 16]

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Question	Expected answer	Extra guidance	Mark
1 (a) (i)	*idea that* the detergent disrupts (named) membranes / phospholipids (and proteins) ;	**A** make membrane permeable / destroys membrane **R** enzymes in detergent disrupt membrane **I** other feature of seeds included, e.g. testa / seed coat, etc. / cell walls / ref. to pH or alkaline	[1]
(ii)	*idea of* inhibiting / denaturing enzymes ;	**A** stops enzyme activity **I** denaturing DNA / melting DNA / extraction of DNA / strand separation of DNA **I** reference of constant temperature / cell membranes **I** kills microbes	[1]
(iii)	*idea of* removing / trapping / separating (cellular / **AW**) debris **or** separating the DNA from the debris / **AW** ;	**A** examples of cell debris / solids / cell walls **I** peas / particles / components / organelles / cell contents unqualified **R** impurities / precipitate / detergent / salt	[max 1]
(iv)	*idea of* breaking down some of the proteins or histones associated with DNA or chromosomes ;	**I** general ref. to function of proteases	[1]
(b)	any 5 of: ref. to making / using agarose gel ; ref. to using wells / channels / chambers / **AW** to place samples ;	***A** from diagrams as appropriate* **A** agar, (poly)acrylamide, agrose **R** starch gels **I** the support used e.g. microscope slides **A** e.g. pits / slits / chambers / holes / use of a comb	

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Question	Expected answer	Extra guidance	Mark
	ref. to wells / samples / **AW** being placed at or connected to the negative electrode / cathode / negative end (of gel) ; **ora**	**A** wells, in / on / near, the cathode	
	ref. to any detail of adding samples (to wells) ;	e.g. adding (loading) dye or stain to each sample / adding (glycerine) to sink DNA / use of micropipette / e.g. of care in loading such as preventing sideways movement / putting different DNA sample in different lanes / using separate (micro) pipettes or tips. **A** Gilson / Finnpipette as a micropipette **I** any specified volumes	
	ref. to adding buffer ;		
	ref. to applying potential difference / voltage difference ;	**A** ref. to passing a current (between electrodes). **A** any description of connecting or using a battery / power pack (to supply a current) or using direct current **I** electricity unqualified / charge / electrons	
	ref. to a method of staining **and** observing the DNA ;	e.g. staining the DNA **and** using uv or fluorescent light / using pre-stained gels. Stains need not be named, but must be correct if given, e.g. methylene blue / ethidium bromide / crystal violet / sybr green / acridine orange / fluorescein **A** idea of DNA samples that are already radioactive (at start) **and** then autoradiography (either directly from gel or indirectly from transfer) or take X-ray **I** Southern blotting / radioactive or fluorescent probes / VNTRs	
	ref. to hazard **and** suitable safety precaution ;	e.g. electrical **and** not touching connectors or wear gloves stains / named stains / buffer are toxic / irritant / harmful **and** wear gloves / goggles / mask UV light **and** wear goggles **A** allergy to stains / gel / buffer and wear gloves / goggles / mask **I** low risk	[max 5]

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Question	Expected answer	Extra guidance	Mark
(c) (i)	*idea of* (relative) distance moved by fragments / pieces of DNA / segments of DNA / lengths of DNA **or** number of fragments ;	**A** if it is clear they are measuring 'how far' the DNA fragments have moved. **A** position of fragment / **AW** **I** reference to bands / lines / stripes **A** identify length or size of fragments using known size standard markers ;	[max 1]
(ii)	Any 2 of : volume of DNA / sample (added to the wells) ; *idea of* time / distance allowed for the samples to run (on the gel) ; pH / (type of) buffer / electrolyte ; volume of buffer / electrolyte ; potential difference / voltage difference / current (used for the electrophoresis) ; (type of) stain / time allowed for staining ; type / thickness / consistency / volume / concentration / pore size of gel ; temperature ;	**I** size of wells **I** mass / amount / quantity / stated figure **I** time unqualified **I** distance anode and cathode **A** named buffer, e.g. EDTA / Tris **A** enough buffer to cover gel **A** number of batteries **I** volume / amount, of stain **I** amount	[max 2]

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Question	Expected answer	Extra guidance	Mark
(d) (i)	*more restriction sites for Eco* RI *than for Hin* dIII any 1 of: *idea of* the total number of fragments / **AW**, from *Eco* RI is greater ; *idea of* more shorter (length) fragments for *Eco* RI ;	**A** bands / lines / stripes / sections, **AW** **A** numbers for *Eco* RI and for *Hin* dIII, but *Eco* RI must have more	[max 1]
	some Eco R1 *sites within fragments produced by Hin* dlll any 1 of: *idea of* (some) fragment(s) for *Hin* dIII / *Eco* R1 not present in mixed cut ; *idea of* mixed cut has many more (shorter) fragments ;	**I** some fragments disappear unqualified **A** more total number of fragments / bands in the mixed cut not present in the separate cuts **A** *idea of* any new or different fragments	[max 1]
(ii)	any 1 of: *idea of* cannot tell if the extra / new (short) fragments are due to *Hin* dIII sites within *Eco* RI fragments ; ora *idea of* difficulty in distinguishing the bands (as they are faint or close together) ;	**A** cannot tell where extra bands in mixed cut have come from / cannot assume that all the new fragments are from *Eco* RI cutting *Hin* dlll site **ora** **I** any ref. to insufficient data / repeats / replicates	[max 1]
(e) (i)	(3′) CCGAATGACCCAGATT (5′) ;		[1]

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Question	Expected answer	Extra guidance	Mark
(ii)	any 3 of: identify that start is where shortest / lightest fragment is located ; *idea that* the sequence (of nucleotides / bases) are identified by colour or from the key / **AW** ; *idea that* (strand synthesised) by (complementary) base pairing ; *idea that* the template (sequence) is antiparallel (to the fragment) ;	*need to make a link to the idea of a starting point at the 3′ end of the original / template DNA which is where the shortest fragments are located.* **A** read the sequence of the fragment from the right to left / from the anode end / opposite direction to electrophoresis. **I** if just restate the key **A** named base pairs **A** 5′ end of the fragment DNA is the 3′ end of the template (and so sequence is read in reverse) **I** the fragment is complementary to the template	[max 3]
			[Total: 19]

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Question	Expected answer	Extra guidance	Mark
2 (a) (i)	nitrogen supplied / present (in the medium) ; variety of *Sorghum* ;	**A** concentration / amount / quantity of nitrogen / high and low nitrogen / with and without nitrogen (in the medium) **I** mass / volume / nitrogen unqualified **I** high and low nitrogen plants **R** plant / species **A** cultivar / type	[2]
(ii)	eight / several / many / large number replicates of each variety ;	**I** more than one of each variety / enough if number quote must be 8 or 16 replicates of each variety	[1]
(b) (i)	83 % ; ; *working:* 19.8 – 3.3 (= 16.5) **or** $\frac{16.5}{19.8} \times 100$ **or** wrong data (x) $\frac{(16.4 - 2.0)}{16.4} \times 100$	**A ecf** for answer from incorrect arithmetic to max 1 **A ecf** for wrong data with correct working and answer to max 1	[2]

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Question	Expected answer	Extra guidance	Mark
(ii)	standard error is an estimate of the reliability of the mean (of a population) **or** shows the reliability of the mean ; a small standard error indicates the mean value is close to the actual (population) mean **or** small standard error indicates that mean is more reliable ;	*must ref. to S_M and not s, so must ref. to the reliability of the mean, not the data* **A** shows the closeness of the calculated mean (of a sample) to the actual mean (of a population) **A** the accuracy of the calculated mean value (in relation to the actual mean) **A** the spread of the sample means from the actual mean **A** examples from Table 2.1 e.g.: PEP carboxylase / Rubisco smaller S_M so sample mean is closer to actual mean NADP malate dehydrogenase very large S_M so sample mean not very close to actual mean	[2]
(c) (i)	**X** and **Z** ; ranges overlap / S_M values overlap (between **X** and **Z**) ;	 **I** error bars overlap	[2]
(ii)	*idea of* 8 replicates / samples for each strain and subtracting 1 from each ;	**A** as a formula (8 – 1) + (8 – 1) / 16 – 2 **R** (n – 1) +(n – 1) unless the value of n is given	[1]

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(d)	**W and** comparing low nitrogen to high nitrogen shows there is an increase in activity of PEP carboxylase **and** the other varieties show a fall **or** comparing low nitrogen to high nitrogen shows there is a fall in activity of NADP –malate dehydrogenase **and** the other varieties show an increase ;	**A ora** for either enzyme **I** does not follow the trend unless qualified **A** between high to low nitrogen PEP carboxylase / NADP show a different or opposite effect to the others	[max. 1]
			[Total: 11]

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mp	marking point (with relevant number)

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1 (a) (i)	any 2 of: RNA probe / RNA / probe / it / they, is single stranded / has exposed, bases / nucleotides ; *idea of* complementary bases / base pairs, (between, RNA probe / RNA / probe / it, and DNA) ; *idea that* different RNA probes / AW, base pair with, different / specific sticky ends (of DNA) ;	**A** unpaired / available, bases / nucleotides **I** free bases **A** *idea of* (hydrogen) bonding / binding, between, complementary base pairs / named base pairs / bases / nucleotides / codons	[max 2]
(ii)	any 2 of: *idea that* genetic variation is due to, mutation / small differences in base sequence / small or single change in nucleotide (pairs) (of DNA) ; ref. to point mutations ; *idea that* small pore size of gel allows separation of variant fragments ;	**A** examples, e.g. substitution, deletion, insertion, addition **I** inversion **A** descriptions in terms of, altered, allele / protein / polypeptide (sequence) / amino acid (sequence) **I** gene / phenotype	[max 2]
(b)	any 5 of: ref. to making / using, agarose (gel) ; ref. to using, wells / channels / chamber / **AW**, to place samples ; sample / wells, placed at / connected to, negative electrode / cathode / negative end (of the gel) ; **ora**.	***A*** *from diagrams as appropriate* **A** agrose / agar / (poly)acrylamide **R** starch gel **I** support used, e.g. microscope slide **A** e.g. pits / slits / chambers / use of comb / holes / **AW** **A** in / on / near / **AW**	

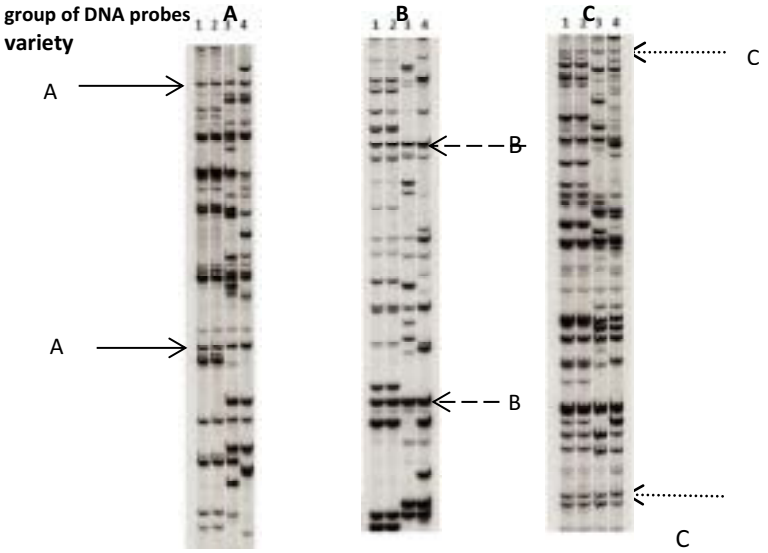
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	ref. to any detail of adding samples (to wells) ; e.g. adding (loading) dye or stain, to each sample / adding glycerine to sink DNA / use of micropipette or capillary tube / e.g. of care in loading such as preventing sideways movement / putting different DNA sample in different wells / using separate (micro)pipettes or tips or capillaries.	**A** Gilson / Finnpipette as a micropipette **I** any specified volumes	
	ref. to adding, buffer ;		
	ref. to applying potential difference / voltage difference ;	**A** ref. to current (between electrodes). **A** any description of connecting or applying a current or using a battery (to supply a current) or using a direct current **I** electricity or power unqualified / charge / electrons	
	ref. to a method of staining **and** observing the DNA ;	e.g using UV or fluorescent light **and** staining the DNA / using pre-stained gels. Stains need not be named, but must be correct if given, e.g. methylene blue / ethidium bromide / crystal violet / sybr green / acridine orange / fluorescien / **AW** **A** idea of DNA samples that are radioactive (at start) **and** autoradiograph (either directly from gel or indirectly from transfer) or take X-ray **I** radioactive or fluorescent RNA probes / Southern blotting	
	ref. to hazard **and** suitable safety precaution ;	e.g. electrical **and** not touching connectors with wet hands or wear gloves stains / named stains / buffer, toxic / irritant / harmful **and** wear gloves / goggles / mask UV light **and** goggles **A** allergy to stains / gel / buffer **and** wear, gloves / mask / goggles **I** low risk	[max 5]

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Question	Expected answer	Extra guidance	Mark
(c)	any 2 of:	**I** size of wells	
	volume of, DNA / sample, (added to the wells) ;	**I** mass **I** amount **I** volume of genes	
	idea of time / distance, allowed for the samples to run (on the gel) / **AW** ;	**I** distance between anode and cathode / time unqualified	
	pH / (type of) buffer / electrolyte ;		
	volume of buffer / enough buffer to cover gel ;		
	voltage difference used for the electrophoresis ;	current / voltage / amount of voltage or current / charge applied / potential difference / intensity of current.	
	type of stain / time allowed for staining ;	**I** volume / amount, of stain	
	type / thickness / consistency / volume / density / concentration / composition / pore size / permeability, of gel ;	**I** amount	
	restriction enzymes used ;		
	temperature ;		[max 2]

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Question	Expected answer	Extra guidance	Mark
(d) (i)	an arrow to a row of DNA fragments at the same position for group A and group B and group C ; **I** extras *all must be correct*	e.g.  	[1]
(ii)	varieties 1 and 2 ; they have, an identical / the same / very similar, pattern (of DNA fragments) ;	**I** a lot of the same fragments / many fragments same **A** they have the same (DNA) fragments in common **A** they are stained in the same parts **A** the fragments reached the same distance	[2]
			[Total: 14]

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Question	Expected answer	Extra guidance	Mark
2 (a) (i)	for **one** mark, any 2 of: depth, seeds / grains, planted (is the same / 3 cm) ; distance between, seeds / grains (is the same / 25 cm) ; number of / #, seeds / grains ; distance between rows (is, the same / 75 cm) ; size / area / number, of plots ; time plot left before planting / **AW** ; variety / type / species, of legume ; *2 correct = 1 mark*	**A** fruits **A** planting depth / depth of seeds **I** time unqualified **A** 'only legume used as green manure' **I** sp of *Sorghum* **A** ref. to randomising the plots used for each type of manuring **I** parts of legume being ploughed in	[1]

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Question	Expected answer	Extra guidance	Mark
(ii)	any 2 of: rainfall / water / humidity / chance of rain ; temperature ; intensity / duration of (sun)light ; soil qualified ; ; ***2 max*** *– one from* ***P*** *and one from* ***Q*** wind (speed) ; pollution / named pollutant ; carbon dioxide ;	*Apply the 'lines rule' from page 2* **I** ref. to climate / weather unqualified **I** amount throughout **I** wavelength **I** exposure to light unqualified but **A** 'time of exposure to light as **AW** for duration **P** depth / fertility / organic content / minerals / humus / nutrients / ions / named minerals, e.g. nitrates / soil pH **Q** soil water / soil moisture / water potential / soil aeration / soil oxygen conten **R** microorganisms in soil **I** pesticide / herbicide as a pollutant **unless** linked to idea of drift	[max 2]
(iii)	*idea that* the plant ploughed in / the legume / green manure, (has time to,) decompose / release nutrients / fertilise the soil ;	**A** to allow nitrification / ammonification / description of decomposition, of green manure / **AW** **I** nitrogen fixing **I** general unqualified responses on 'let it adapt / equilibrate, etc.'	[1]
(iv)	4 / several / many / more than one, replicates of each, type of green manure / treatment / (type of) trial plot ;	**I** large number of seeds **I** use of random number generator **I** 'many experiments going on at same time'	[1]

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Question	Expected answer	Extra guidance	Mark
(b) (i)	44 / 44.1 / 44.14 ; ; *working:* $(\frac{2964}{6715} \times 100 = 44\%)$	**A** answer up to 2 d.p. 44.1 or 44.14. (**not** 44.10 / 44.13) *max 1 for correct answer with incorrect decimal places* **A** ecf from incorrect subtraction for max 1 max 1 for following working 9679 – 6715 **or** divisor is the matching control value for chosen figures	[2]
(ii)	3:1 ; ; **or** × 3 ; ;	answer must be in whole numbers max 1 for following working 782 – 398 / 384 1:3 = one mark 1:3 with qualification (clearly identifying which is roots and which is shoots) = two marks **A** shoots have 3 × the effect of roots alone	[2]
(c) (i)	there is no significant difference between the (dry) mass of *Sorghum* grown, with green manure / with treatment, and *Sorghum,* without green manure / with no treatment / in the control ;	**A** ref. to 'roots' + 'shoots' + 'roots and shoots' / legume, as **AW** for green manure **R** 'no significant difference between different types of green manure' – needs to relate to control / no treatment **I** 'no significant difference between results of data compared' **I** 'no significant difference between control and other plots' **I** 'insignificant' for not significant but **A** non significant	[1]
(ii)	comparing the means (of two sets of data) / data is continuous / data is not discrete / normal distribution ;	*If more than one reason given, all must be correct.* **I** number of means	[1]

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Question	Expected answer	Extra guidance	Mark
(iii)	*statistically significant:* *idea that* the (observed) results are caused by, an outside factor / a factor other than chance / the green manure / the treatment ; *P < 0.05*: *idea that* 0.05 means that there is 5% / less than 5% chance of obtaining the (observed) results by chance ; ***or*** *idea of* 95% or more certain that the (observed) results are caused by an outside effect ;	**A** ref. to 'roots' + 'shoots' + 'roots and shoots' / legume (use), instead of 'green manure' **A** the results are not due to chance **I** difference is, more than / higher than, the critical value **I** reject the null hypothesis **I** random / systematic error **A** there is a 1 in 20 chance of the results being caused by chance / not caused by another factor **ora** **A** ref. to 'roots' + 'shoots' + 'roots and shoots' / legume as **AW** for green manure **I** random / systematic error	[2]

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Question	Expected answer	Extra guidance	Mark
(d)	any 3 of: mp1 *idea that* green manuring / it / AW, increases the (dry) mass of, shoots / roots / grain / whole plant / *Sorghum ;* mp2 (legume) shoots cause a greater / increase in (dry) mass than (legume) roots ; mp3 (legume) 'shoots and roots' cause greater / more, increase in (dry) mass than, shoots / roots, alone ; **ora** **or** (legume) 'shoots and roots' cause greatest / most, increase in (dry) mass ; mp4 (legume) 'shoots and roots' cause a significant, increase / difference / effect, in (dry mass of), Sorghum / the plant / each different part / AW (of Sorghum) ; mp5 (legume) shoots (only) caused a significant, increase / difference / effect, in, (dry mass of), grain / whole plant ; mp6 (legume) roots (alone) do not cause any significant increase / difference / effect, in (dry mass) ;	**A** yield / growth, for increase of (dry) mass mp1 a general point from Table 2.1 mp1 **A** 'roots' + 'shoots' + 'roots and shoots' / 'treatment' / it / legume, as **AW** for 'green manure' mp1 **A** ora – no, green manure / **AW**, shows the lowest (dry) mass of shoots / roots / grain / whole plant, (of *Sorghum)* mp2 and mp3 need a comparative statement / idea mp4, mp5 and mp6 need a ref. to significance **I** ref. to chance / insignificance	[max 3]
			[Total: 16]

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