Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2022

Marking Scheme

Agricultural Science

Higher Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

How to use the marking scheme

- Examiners must conform to this scheme, however the descriptions, methods and definitions given in the marking scheme are not exhaustive and alternative valid answers are acceptable.
    - This does not preclude synonyms or terms or phrases which convey the same meaning as the answer in the marking scheme. Although synonyms are generally acceptable, there may be instances where the scheme demands an exact scientific term or unequivocal response and will not accept alternatives.
- The marking scheme is a concise and summarised guide to awarding marks and is constructed in order to minimise its word content.
    - In many cases only key phrases are given in the marking scheme. These points contain the information and ideas that must appear in a candidate's answer in order to merit the assigned marks.
- If an examiner determines that a candidate has presented a valid answer, and where there is no provision in the scheme for accepting that answer, then the examiner must first consult with his/ her advising examiner before awarding marks.
- The detail required in any answer is determined by the context, the phrasing of the question, and by the number of marks assigned to the answer in the examination paper. This may vary from year to year.
- Where only one answer is required alternative answers are separated by '**or**'.
- Use of an **asterisk***
    - This happens when the only acceptable answer is a specific word or term. Each such instance is indicated in the scheme by an asterisk*.
- Use of a **solidus** (**/**)
    - Words, expressions or statements separated by a solidus (**/**) are alternatives that are equally acceptable for a particular point.
    - Where multiple answers are required each word, term or phrase for which marks are allocated is separated by a solidus (**/**) from the next word, term or phrase.
- Use of **brackets ( )**
    - A word or term that appears in brackets **( )** in the scheme is not a requirement of the answer, but is used to contextualise the answer or may be an alternative valid answer.
- **Note** however, that words, expressions or phrases must be correctly used in context and not contradicted and where there is evidence of incorrect use or contradiction, the marks may not be awarded.
- The mark awarded for an answer appears in **bold** in the mark's column, e.g. **2**.
- Where there are several parts in the answer to a question, the mark awarded for each part appears as e.g. **3(2)**. This means there are 3 parts to the answer, each part is allocated 2 marks.
- Award unit marks separately e.g. if an answer merits three 2-mark units, write 3 separate '2's, under each other, in the space at the right-hand side of the question in the answer book (**2, 2, 2**).
- The answers to subsections of a question may not necessarily be tied to a specific mark e.g. there may be four parts to a question - (i), (ii), (iii), (iv) and a total of 10 marks allocated to the question. The

marking scheme might be as follows: 4 + 2 + 2 +2. This means that the first correct answer encountered is awarded 4 marks and each subsequent correct answer is awarded 2 marks.

- Italics are used where the examiner's attention is being drawn to an instruction relating to the answer or to some qualification of the answer.
- In general, names and symbols / formulae of elements / compounds are equally acceptable. However, in some cases where a name is specifically asked for, the symbol / formula may be accepted as an alternative. This will be clarified within the scheme.
- Examiners should write the total mark for each question at the beginning of the question, beside the question number, and circled.
- The cumulative total should be written in the bottom right-hand corner of each page on which a question total appears.
- All blank pages should be marked to indicate they have been inspected.

Cancelled answers

- The following is an extract from S.63O *Instructions to Examiners, 2022* (section 5.4, p.19), "*Where a candidate answers a question or part of a question once only and then cancels the answer, you should ignore the cancelling and treat the answer as if the candidate had not cancelled it.*"
- If the only answer offered is cancelled ignore the cancelling and mark as usual.
- If an answer is cancelled and a second version of the answer is given, you should accept the cancellation and award marks, where merited, for the un-cancelled version only.
- If two un-cancelled versions of an answer are given to the same question or part of a question, mark both and accept the answer that yields the greater number of marks. You may not, however, combine points from both versions to arrive at a manufactured total.

Surplus answers

- A surplus wrong answer cancels the marks awarded for a correct answer.
    - e.g. Question: Identify the cattle and sheep breeds.
      Marking scheme: A = Suffolk / B = Shorthorn / C = Belgian blue / D =Texel - **4(1)**
      Candidates Answer = A = Texel, Suffolk / B = Shorthorn / C = Belgian blue / D =Texel The surplus answer (Texel) is incorrect,
      Therefore, the candidate scores 4 - 1 = 3 marks.

Annotations used in the marking

The scripts were marked on-line by examiners. The following table illustrates the various **annotations** (symbols) applied by the examiners when marking the scripts. The meaning and use of each of the annotations applied are explained in the table below. These annotations will be seen on a script if viewed as part of the appeal process.

In some sections of the 'Individual Investigative Study' (IIS), where the mark award was greater than 12 marks for a single item(s), two annotations will be used to show the total marks awarded for the item(s). Annotations applied by an examiner will be viewed in red. Scripts that were also marked by an advising examiner will show annotations in a green colour.

Annotation	Meaning
✓	This symbol indicates a correct response / answer. Use when all marks awarded to any additional correct answers.
✗	This symbol indicates an incorrect response / answer.
[	This symbol indicates a surplus incorrect answer. A surplus incorrect answer has cancelled a correct answer.
	This symbol is placed on all blank pages or part of page to indicate it has been seen by the examiner.
	This symbol can be used by an examiner to indicate a part of a question answer of significance.
	This symbol is used to indicate where a candidate answer was awarded zero marks.
✓ 1	This symbol can be used by an examiner to indicate **One** mark awarded
✓ 2	This symbol can be used by an examiner to indicate **Two** marks awarded
✓ 3	This symbol can be used by an examiner to indicate **Three** marks awarded
✓ 4	This symbol can be used by an examiner to indicate **Four** marks awarded
✓ 5	This symbol can be used by an examiner to indicate **Five** marks awarded
✓ 6	This symbol can be used by an examiner to indicate **Six** marks awarded
✓ 7	This symbol can be used by an examiner to indicate **Seven** marks awarded
✓ 8	This symbol can be used by an examiner to indicate **Eight** marks awarded
✓ 9	This symbol can be used by an examiner to indicate **Nine** marks awarded
✓ 10	This symbol can be used by an examiner to indicate **Ten** marks awarded
✓ 11	This symbol can be used by an examiner to indicate **Eleven** marks awarded
✓ 12	This symbol can be used by an examiner to indicate **Twelve** marks awarded

Marking the Individual investigative Study (IIS)

Read the entire Individual Investigative Study (IIS) without allocating any marks. Mark the IIS using the marking criteria and total the marks. Each section of the IIS is awarded a single mark, which varies between sections (e.g. Introduction and back ground research is awarded 20 marks). To assist in the awarding of marks 'indicative content' has been stated for each section; e.g. in considering the allocation of marks for the introduction and background research section, this can be considered under;

- Introduction (context for the IIS) and
- Background Research (research, sources and knowledge).

To finalise the marks, review the criteria descriptors against the marked work.

Higher Level Agricultural Science Marking Criteria for Individual Investigative Study

Before commencing marking read the entire Individual Investigative Study to familiarise yourself with the content presented for marking.

Note: Be careful not to penalise skilful brevity, nor to reward unwarranted length.

These descriptors should be interpreted in the context of the challenges and demands of the investigation the candidate has chosen.

Section	Excellent	Very Good	Good	Fair	Weak
Introduction and background research Suggested range between 300 and 500 words	Directly address, contextualises and clarifies the brief theme. Identifies and interrogates convincingly, a broad range of relevant, authoritative and credible sources of evidence. Clear understanding and shows extensive knowledge of theme.	Directly address the brief theme. Identifies and questions a sufficient range of relevant, authoritative and credible sources of evidence. Logically based on a very good knowledge and understanding of the theme. Very few errors.	Brief theme is reasonably addressed in a limited context. Identifies and interrogates a limited range of evidence with an over reliance on unproven data. Basic knowledge and limited understanding of the theme. Minor errors.	Brief theme is vaguely addressed with no clear context. Evidence presented is simplistic or confused. Evidence is only vaguely relevant to the theme. Vague understanding of theme. Major errors.	Brief theme is vaguely or completely misunderstood Little or no evidence presented. Evidence is not relevant to the theme. Little or no knowledge of the theme. Significant major errors.
20 Marks	**18-20**	**14-17**	**10-13**	**6-9**	**0-5**
Award a single mark out of 20 for this section. In arriving at this mark consider the indicative content requirements below.					
Introduction - Context for the IIS - 10 marks	• Excellent - 9 - 10 marks • Very Good - 7 - 8 marks • Good - 5 - 6 marks • Fair - 3 - 4 marks • Weak - 0 - 2 marks		*Background Research -Research, sources and knowledge - 10 marks*	• Excellent - 9 - 10 marks • Very Good - 7 - 8 marks • Good - 5 - 6 marks • Fair - 3 - 4 marks • Weak - 0 - 2 marks	

Section	Excellent	Very Good	Good	Fair	Weak
The investigative process Suggested range between 500 and 800 words	Identifies and provides a comprehensive description of investigative process undertaken. Clear, specific and valid hypothesis generated and tested. Clear ideas, concepts and theories make focused links between complex aspects of the task and learning outcomes of the specification. An accurate detailed description of how data was gathered.	Identifies and provides a sufficient description of investigative process undertaken. Specific and valid hypothesis generated and tested. Ideas, concepts and theories make some links between aspects of the task and to learning outcomes of specification. Description of how data was gathered to a high standard, with a few inaccuracies.	Identifies and provides a limited description of investigative process undertaken. Hypothesis generated and tested is valid but may lack some specificity. Ideas, concepts and theories make basic between some aspects of the task and to learning outcomes of the specification. Description of how data was gathered to a good standard, with some minor omissions / errors.	Details of the investigative process presented are simplistic / confused and only vaguely relevant to the theme. Simplistic hypothesis generated and tested. Ideas, concepts and theories make very vague links between aspects of the task and learning outcomes of the specification. Vague description of how data was gathered with major omissions / errors.	Little or no details of investigative process presented which is not relevant to the theme. Very simplistic hypothesis generated. Little / no evidence of ideas, concepts and theories presented. No real link with learning outcomes of the specification. Very poor description of how data was gathered which is also incorrect and /or contradictory.
25 Marks	**23-25**	**18-22**	**13-17**	**8-12**	**0-7**
Award a single mark out of 25 for this section. In arriving at this mark consider the indicative content requirements below.					
Details of the actions undertaken in response to stated hypothesis - 12 marks	• Excellent - 11 - 12 marks • Very Good - 9 - 10 marks • Good - 6 - 8 marks • Fair - 4 - 5 marks • Weak - 0 - 3 marks		*Data collection undertaken - 13 marks*	• Excellent - 12 - 13 marks • Very Good - 10 -11 marks • Good - 7 - 9 marks • Fair - 4 -6 marks • Weak - 0 - 3 marks	

Section	Excellent	Very Good	Good	Fair	Weak
Results, analysis, and conclusions Suggested range between 600 and 1000 words	The data is relevant, comprehensively analysed, interpreted, evaluated and presented optimally. Draws insightful, independent informed conclusions based on a relevant, critical and perceptive analysis of the evidence to arrive at justification of own position (hypothesis).	Very good interrogation and presentation of the data. Analysis, interpretation and evaluation of data to a high standard. Draws very good independent conclusions based on a critical and perceptive analysis of the evidence and clearly justifies own position (hypothesis).	Good interrogation and presentation of the data, but may lack some structure. Draws some independent conclusions based on a basic analysis of the evidence to justify own position (hypothesis), but lacks depth and structure.	Limited interrogation and presentation of the data. Very basic conclusions stated to justify own position (hypothesis). Conclusions made are flawed with limited evidence in support and superficial analysis / with significant inaccuracies. Repetition of material is evident.	Poor / confused / illogical interrogation and presentation of the data. Little or no evidence presented / or not relevant. Analysis is poor. Little or no conclusions made with very little evidence in support. Irrelevant materials used with repetition of material evident.
35 Marks	**32-35**	**25-31**	**18-24**	**11-17**	**0-10**

Award a single mark out of 35 for this section. In arriving at this mark consider the indicative content requirements below.

Appropriate presentation of data - 10 marks	*Informed judgement and conclusions following analysis - 15 marks*	*Limitations of study considered and clear linkage of conclusions to research question – 10 Marks*
• Excellent - 9 - 10 marks • Very Good - 7 - 8 marks • Good - 5 - 6 marks • Fair - 3 - 4 marks • Weak -0-2 marks	• Excellent -14 - 15 marks • Very Good - 11 - 13 marks • Good - 8 - 10 marks • Fair - 5 - 7 marks • Weak - 0 - 4 marks	• Excellent -9 - 10 marks • Very Good - 7 - 8 marks • Good - 5 - 6 marks • Fair - 3 - 4 marks • Weak - 0 - 2 marks

Section	Excellent	Very Good	Good	Fair	Weak
Reflection on the study Suggested range between 150 and 200 words	Clear capacity to an in-depth, comprehensive and clear self-reflection on the completed study. Considers in depth the learning gained by and through engagement with the study. Considers in depth reliability, possible error(s) / changes / modifications while comprehensively relating back to the theme and hypothesis / action question.	Clear evidence of self–reflection on the completed work. Considers the learning gained by and through engagement with the study. Considers reliability, possible error(s) / changes / modifications while relating it back to the theme and hypothesis / action question to a high standard.	Some reflection on the completed work. Considers some of the learning gained by and through engagement with the study. Considers reliability, possible error(s) / changes / modifications with some linkage to the theme and hypothesis / action question.	Limited reflection on the completed work. Poor reference to the learning gained by and through engagement with the study. Poor consideration of reliability, possible error(s) and any possible changes / modification with limited linkage to the theme and hypothesis / action question.	Weak or no reflection on the completed work. Little or no reference to the learning gained by and through engagement with the study. No consideration of reliability, possible error(s) and any possible changes / modification very limited or absent. Weak linkage to the theme and hypothesis / action question.
10 Marks	**9-10**	**7-8**	**5-6**	**3-4**	**0-2**
Award a single mark out of 10 for this section. In arriving at this mark consider the indicative content requirement below.					
Knowledge and insights arrived at as a result of the study - 10 marks			• Excellent -9 - 10 marks • Very Good - 7 - 8 marks • Good - 5 - 6 marks • Fair - 3 - 4 marks • Weak - 0 - 2 marks		
References	Full references for all sources used during the study and / or referred to in the report.	References for the majority of sources used during the study and / or referred to in the report.	References for most sources used during the study and / or referred to in the report.	References missing for a significant number of sources used or referred to in the report.	Lack of proper or any referencing.in the study.
-	-	-	-	-	-
References should be checked within section(s) and linked to this section of study. *Any issues with the referencing should effect the mark awarded to the section in which the references are being cited in the study.*					

Section	Excellent	Very Good	Good	Fair	Weak
Communication and innovation (This is not a distinct section of the report)	Excellent coherence, clarity, construction and organisation throughout the study. Adheres to the IIS structure. Communication of data and information is thorough, very well structured, relevant and accurate. The study exhibits an overall detailed knowledge involving critical thinking, deep insight, sharp focus, accomplished argument and is supported by a range of evidence and sources. Significant evidence of individual approach and innovation.	Very good coherence, clarity, construction and organisation throughout most of the study. Adheres to the IIS structure. Communication of data and information is well structured, organised and presented Study exhibits an overall good knowledge and evidence of critical thinking. Good evidence of individual approach and innovation.	The organisation and coherence of the study is of a basic level. Some of the points made may not be integrated well into the content and to the IIS structure. Communication of data and information presented is relevant which may have some errors / omissions. The study has reasonable knowledge and some critical thinking. Reasonable structure with some evidence of individual approach and innovation.	Organisation and coherence is limited and confused throughout the study. Study shows a limited understanding with limited valid and appropriate evidence which is not developed and connected and deviates from the IIS structure. Communication of data and information lacks clear focus and organisation, which has substantial errors / omissions. Limited knowledge and critical thinking. Poor structure with little evidence of an individual approach and innovation.	The study lacks organisation, coherence, context and clarity. Study shows very poor or no understanding with no evidence provided in support. IIS structure very poorly used or not used. Communication of data and Information contains only a few valid points, is of a very poor quality, with fragments of information of little or no relevance and is, littered with errors / omissions No evidence of an individual approach and innovation.
10 Marks	**9-10**	**7-8**	**5-6**	**3-4**	**0-2**
Award a single mark out of 10 for this section. In arriving at this mark consider the indicative content requirement below.					
The report has an overall coherence, quality and clarity with the inclusion of individual innovative thinking by the candidate - 10 marks			• Excellent - 9 - 10 marks • Very Good - 7 - 8 marks • Good - 5 - 6 marks • Fair - 3 - 4 marks • Weak - 0 - 2 marks		

Section A		Answer any 7 questions 10 marks for each question Total for section is 70 marks	Marks
Q1	**(a)(i)**	*Explain organic matter* Organic matter contains the remains of plants and animals (and microbes at various stages of decomposition, and the living component of soils)	**2**
	(ii)	*Briefly describe **one** advantage of organic matter in soil* Improves soil structure (microbes excrete compounds that act as a binding agent for soil particles) / improves drainage or aeration or root penetration or easier to till / increased water-holding capacity of the soil / enhances root growth which results in better plant health / allows more movement of (mobile) nutrients (such as nitrates to the root) or improves soil's capacity to store or supply nutrients (N, P, K, Ca, Mg) or improves cation exchange capacity / retains toxic elements or allows continuation of soil microbial activity or respiration to continue / allows soil to maintain a suitable pH (buffer) / acts as a carbon sink (sequestration) / soils with adequate levels of OM provide a good habitat for microbes or other living organism (which enhances soil biodiversity)	**2**
	(iii)	*Describe how % organic matter was determined in soil sample* Weigh empty crucible (& record mass) / weigh dried soil (& record mass)/ burn (on pipe clay triangle) on tripod over bunsen burner / (humus will glow red) until no more smoke or constant mass/ reweigh crucible / $\frac{\text{Soil mass lost after burning}}{\text{Soil mass before burning}} \times \frac{100^*}{1}$	**2(3)**
OR			
	(b)(i)	*Outline **one** advantage of spreading pig or cattle slurry on the land* Rich in nutrients (nitrogen to increase crop growth) / decreased need for chemical fertiliser / offset expensive chemical fertiliser costs / high in P & K for root development / (effective use on farms) can help balance soil fertility levels (especially on silage ground) where P & K nutrient requirement is high / pig slurry is better balanced than cattle slurry for grazed swards as the K content is lower (approx. values pig = 35% K and cattle = 68% K) / high organic matter	**4**
	(ii)	***Two** factors affecting the composition of slurry* Livestock type / animal diet / dilution of slurry with water / type of storage / stage of growth (production stage) / length of storage	**2(2)**
	(iii)	*Ideal timing and weather for spreading slurry for nutrient usage and to protect environment* In spring on an overcast and misty day*	**1**

	(iv)	*Justify your answer in (iii)* Reduces emissions or decreased volatilisation due to decreased conversion to ammonia gas / soil is damp to retain ammonia quicker / sward demand for N is high so N is used up by rapidly growing sward / more of the organic nitrogen will be mineralised (converted) to nitrate with rising temperatures throughout the growing season	**1**
Q2	**(a)**	*Identify any **four** breeds of animals* **A** = Landrace **B** = Blue Leicester **C** = Connemara (pony) **D** = Rhode Island red **E** = Limousine **F** = (Holstein) Friesian	**4(1)**
	(b)	*Describe the characteristics for breeding of a named female replacement animal* Details on next page	**2(3)**

Characteristic	*Description – Dairy heifer/ Beef heifer / Ewe / Gilt*
Good body conformation	Triangle shape (dairy) or block shape (beef) or smooth shoulders and straight backs (sheep) or long body with thick well-muscled hams (to allow for weight of boar at breeding) (pigs) / moderate frame size to reduce amount of feed required to maintain body condition and fertility (increase sustainability of farm) / good pelvic width to reduce incidence of dystocia (difficult calving – dairy or beef)) / long body or not too heavily muscled (pigs) / mature vulva (pigs)
Temperament	Docile (quiet temperament) for easy management / identified at birth (with tags) as lambing without difficulty or up suckling quickly
Good Health	No signs of discharge or thriving / longevity to improve sustainability of enterprise / not a twin to a male calf (freemartin) as her reproductive tract may not have developed / good mouth – not over or undershot / tail docked properly (not too long or short) reduce incidence of flystrike or frost damage to vulva (ewe) / not too much muscle – cause difficult farrowing (gilt)
Age and Weight	For increased fertility - 60% of mature weight at mating or 300 -350 kg (dairy) or 370 - 420kg (beef) at mating at 15 months of age to ensure she has reached puberty or will reach max body size when older (cows don't reach mature weight until they are 5 years old)(dairy) or liveweight of 45kg (sheep) or 130 – 150 kg at 240 days for breeding(pigs) / time of year heifer was born – need to be 2 years at the start of the calving season (early born heifers) (as heifers should calve at the start of the calving season to ensure compact calving herds) / ewe lamb is at least 10 – 12 months of age for first breeding or at least 7 – 8 months of age to ensure puberty has been reached (pigs)
Good Udder	Not pendulous to ensure less mastitis or less udder injury or greater longevity or young can suckle easily or easy of cluster attachment (dairy) / 4 well placed teats to ensure clusters attach or fit correctly / 4 (cows) or 2 (sheep) or 12 (pigs) well placed teats to allow for ease of suckling / free of pin (underdeveloped) nipples or free of inverted nipples (as they take up space and) do not allow milk to flow / presence of good milk vein (dairy)
Good feet	No sign of lameness or foot rot (sheep only) as can reduce milk yield or animal won't thrive / strong straight legs with large even sized claws to avoid lameness (pigs only) / walk straight
Milk production	Records of parents to determine her milking potential or daughters of high yielding cows (dairy) / daughters of low producing Friesian cows (or quarter bred Friesian) X good conformation beef bull to ensure good milk supply (not too much milk) for good growth rate of the calf (beef) / beef traits (conformation) and good growth potential from sire or Simmental breed can be used to maintain milk yield or good fertility to ensure a calf per cow per year / daughter of good mother or good mothering ability (good heritability) (sheep or pigs) / daughter of ewe with high milk yield (good heritability)

Genetics	**Dairy Heifer**	Daughters of top cows in herd and sired by bulls with strong maternal traits (genomically selected) / genotyped where parentage is verified and reduce risk of future inbreeding / high EBI – improved profitability or lower GHG emissions / genomically selected – the DNA of the heifer has been analysed and milk performance predicted
	Beef Heifer	Genotyped where parentage is verified and reduce risk of future inbreeding / good beef merit (high EBI) to profitability and reduce GHG emissions / cross bred for hybrid vigour (best characteristics of both breeds) or pure bred heifer bred from a maternal bull (genotype) / daughters of top performing cows in herd (produce good quality calf with high weight gain from birth to weaning, fertile cows & have a tight calving interval, docile and easy calving)
	Ewe	Not a daughter of a ewe prone to prolapse / high genetic merit – perform well / was a twin or triplet for increased fertility / bred from 5 star ram
	Gilt	Cross bred gilt to allow for hybrid vigour (criss-cross breeding) / daughter of good producing sow

Q3	**(a)**	*Describe how to investigate the effect of soil temperature on the germination of the crop* At least 2 trays of 100 (or specific no) of seeds / same amount of water to all or same soil type/ put one tray in fridge and one at room temp or outside or propagator or heated propagator (method of varying temperature) / allow 2 weeks (or specified time) for germination / count no. of seeds germinated or calculate percentage germination or compare number of seeds germinated in each tray	**2(3)**
	(b)	*State with reason if results were qualitative or quantitative* Quantitative* – number of seeds (that have germinated)	**2**
	(c)	*Suggest how the results of the investigation inform decisions on sowing crops on the farm* Seeds will not germinate at colder temperatures or warmer soils allow for germination as heat promotes growth / delay sowing until soil temperatures increase (above 6^{o}C for barley or 10 – 12^{o}C for grass) / important to measure the soil temperature prior to sowing to ensure correct temperature of the crop for germinating	**2**
Q4	**(a)**	*Explain pathogenic* Disease causing (organism)	**2**
	(b)	*List **two** notifiable diseases* TB / brucellosis / foot & mouth / scrapie / Newcastle disease / bovine viral diarrhoea (BVD) / BSE / equine viral arteritis / contagious equine metritis / Aujeszky's disease / African swine fever / swine influenza / transmissible gastro-enteritis (Porcine respiratory corona virus) / sheep scab / warble fly / rabies / or other valid example	**2(3)**
	(c)	*Describe how poultry farms could protect their flocks from Avian Influenza* Lock up or fence or surround with netting flocks (to prevent birds mixing with wild birds or prevent area becoming contaminated with bird droppings or feathers) /vaccination/ restrict vehicles or visitors or wear protective clothing (to prevent any disease being carried on or off farm) or restriction signage / disinfect boots or vehicles or equipment on farms (to prevent any disease being carried onto or off farm) / don't allow birds to drink from outside water sources (in case of any contamination from wild birds) or feeding troughs and drinks located inside (so not to attract wild birds which may infect domestic flock) / use bird scares or flutter tape or scarecrows to scare wild birds from area / report any sick or dead wild birds found on your holding to department (regional veterinary office) who will remove bird for testing and remove domestic flock from the area / all poultry houses should be bird	**2(1)**

		and rodent proof (to prevent wild birds entering and spreading disease) / regular cleaning and disinfection(on all walkways, paths and at end of production cycle) to kill any diseases present or prevent disease entering the house / no other animals (e.g. pets) permitted into poultry house (to prevent disease entering the house) / equipment should not be shared between farms (as this may lead to spread of disease) / feed and bedding must not be stored where wild birds can access and contaminate with droppings (which could be source of disease) / only buy birds from a reputable source or isolate any newly introduced birds (for 2 weeks) or all-in all-out or closed flock / keep ducks and geese away from other birds as they may not show signs of disease but maybe carriers	
Q5	**(a)**	*List **two** factors that affect FCR in animals* Temperature (environment) of house or living environment / genetics or breed / sex / health or welfare status / feeding practice or forage or feed quality / days in milk (production) / age of animal or growth stage of animal / walking distances (e.g. from field to parlour) / body weight or BCS / stocking density	**2(3)**
	(b)(i)	*State which year the pigs were more efficient at converting feed to liveweight* 2020*	**2**
	(ii)	*Describe **two** reasons for the increased performance of the pigs from 2000 to 2020* Improved breeding (genetics) – increased growth rate of pigs / better feed quality or feed formulation – improved understanding of FCR (or FCE) and ration formulation allows for increased FCR (or feed losses) / better management of stock by training of all staff in technical skills and management training will ensure lower FCR of pigs / better housing – appropriate, stable temperature (critical temperature) or ventilation (good air movement) or hygiene to achieve optimal FCR / better animal health - good gut health to ensure well developed gut at weaning which ensures optimal feed conversion or good biosecurity or health management plan measures to prevent disease entry to farm (ensure healthy animals and optimise FCR) / lower stocking density lowers FCR (pigs finish faster with lower inputs)	**2(1)**

Q6	**(a)**	*Outline **three** reasons why hedgerow conservation is promoted in environmental schemes* Shelter for animals or crops (reduce wind speed) / prevent erosion – decreased sediment reaching watercourse or decrease pollution / improve soil health or vegetation growth / habitat for wildlife / increased biodiversity / physical barrier / improve air quality by capturing pollution particles or act as barriers to windborne pests / food source for many species / wildlife corridors to allow wildlife to travel / sequester carbon (reduces amount of carbon in the atmosphere) / reduce flooding	**3(2)**
	(b)	*Explain the purpose of conservation grazing* Increased use of traditional breeds / management of vulnerable habitats / restoring and maintaining grassland or heathland ecosystems / promote sustainable farming practices / (promotes) increased biodiversity (of flora and fauna) or prevention of monoculture (dominance of one species)	**2**
	(c)	*Outline **one** reason why it is important to preserve rare breeds of animals on farms* Adapted to local conditions / good genetics for the future (genetic diversity) / suited to lower input farming systems / increased meat flavour or meat quality / suitable for niche market (cheese or meat) adding value to product / more tolerant to disease compared to commercial breeds / protect cultural heritage or prevent extinction	**2**
Q7	**(a)**	*Calculate the % weaning efficiency for Sadie's suckler dam and calf 3* 333÷698 x 100÷1 = 47.7% (48%) (If a candidate just gives 47.7% or 48% then award 4m)	**2** **2**
	(b)	*Calculate the average daily gain (ADG) of calf 3* 333 – 50 = 283 days 283÷200 = 1.4 kg ADG (If a candidate just gives 1.4kg then award 4m)	**2** **2**
	(c)	*Outline **one** implication of calf 2 having a weaning efficiency of 39%* (39% is less than target efficiency of 42%) - less efficient at producing or cull cow or change bull or poor performance needs to be fully investigated or takes longer to finish or higher cost to finish	**2**

Q8	**(a)(i)**	*Explain **one**-way farmers can:* **(i)** *Reduce the use of pesticides in their farm* Crop rotation to prevent build-up of pests / resistant crop varieties so pests won't stay on crop / biological control (e.g. ladybird eats aphids) to prey on crop pests / increased plant diversity on farm to support predator numbers / indirect control (companion crop, scarecrow) or vermin proof storage / use of certified seed	**3**
	(ii)	*Outline **one**-way farmers can:* ***(ii)** Reduce use of antibiotics for farm animals* Targeted treatment of cows with high SCC or cull cow / isolate sick animals or good hygiene or 'all in all out' policy or closed herd or restrict visitors or vehicles to prevent infection / reduce stocking density which decreases animal contact / good ventilation in animal housing to lessen risk of airborne pathogens / good vaccination programme / breed for genetic merit or EBI health index	**3**
	(b)	*Briefly explain **two** benefits of converting to organic farming* Healthier soil or plants or animals or humans – lack of chemicals added / niche market commands higher price/ more environmentally friendly as less chemicals used or preservation of natural resources or decreases nitrate leaching into water sources / lower antibiotic use so less chance of entering the food chain / increased biodiversity as chemicals may kill more than targeted pest / high animal welfare standards - lower stocking density or must have loose straw bedding for animals to lie down / reduces soil erosion due to higher soil surface cover or higher SOM or reduction in intensive tillage practices / no chemical fertiliser required – very expensive or hard to get urea or CAN this year / increased grant incentives	**2(2)**

Q9	**(a)(i)**	*Draw a labelled diagram of a calf's stomach in its first week of life* Candidates diagram must clearly show all four chambers, the abomasum being the largest stomach in comparison to others, especially the rumen or oesophageal groove directing the milk straight to the abomasum Any three labels	**D = 3, 2, 0** **L = 3(1)**
	(ii)	*Describe how the calf's stomach differs from an adult ruminant stomach* (Smaller rumen) as the calf cannot digest cellulose / rumen is not fully developed / bigger abomasum (70% of digestive tract) (true stomach) digests the milk-based diet of the calf (most efficiently) / milk (food) goes straight to abomasum (via oesophageal groove and by passes the other 3 stomachs) / rennin (predominant enzyme) allows calf to digest proteins in milk	**2(2)**
OR			
	(b)(i)	*Outline two roles of micro-organisms in the ruminant stomach* Fibre (cellulose) degradation or breakdown cellulose/ protein or amino acid production / produce vitamin B or K / production of fatty acids / breakdown of nutrients / methane production / convert non-protein nitrogen (or named) to ammonia / microbes are a protein source at the end of their life cycles	**2(2)**
	(ii)	*Describe why is it critical to test the seaweed supplements* Majority of feed in Irish system is pasture based in beef or dairy or sheep production system / extended grazing improves sustainability of farming so it is important to have animals out on pasture for as long as possible / important to test supplement in environment where animals will spend majority of time rather than relying on data generated from higher input grain-based studies / to ensure no negative health aspects for animals / to ensure no negative impact on production	**3**
	(iii)	*Outline why this aspect of the trial would be important* To ensure the safety of food / no residues from the seaweed would pass on in the meat	**3**

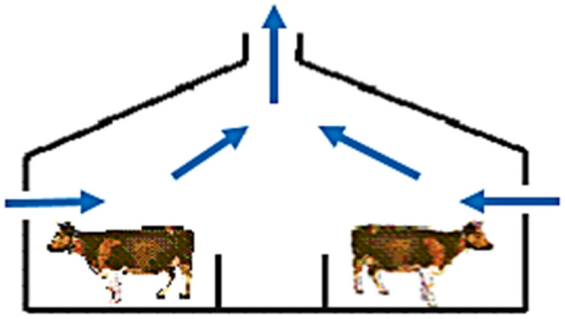
Q10	**(a)**	*Identify the type of lifecycle of chosen crop* ***Kale*** – biennial / ***Miscanthus*** – perennial / ***OSR*** – annual or other valid named catch or energy crop	**2**
	(b)	*Describe the method of planting chosen crop* **Kale:** sown into a cultivated(plough and harrow) seedbed / direct drilled or seed drill or one pass system or broadcast (require higher seed rate) or seeds should be sown into a fine (firm) seedbed/ maximum depth of 10mm (to ensure uniform germination) / seeding rate of 4-5kg/ha or 70 plants per m^2/ rolled well after sowing to ensure good soil:seed contact **Miscanthus**: Grassland site spray with total herbicide for controlling perennial weeds / ploughed from January 15th to control perennial weeds or allow frost activity to break down the soil further or help prevent 'ley' pests such as the larvae of two moths (the common rustic moth or the ghost moth) attacking the newly established plants / (later in the spring from March to April) the site should be rotovated or power harrowed (immediately prior to planting to improve establishment by aiding good root development, good soil root contact or improved soil aeration) / a planting rate of 16,000 rhizomes per ha or an emergence of 10-15,000 plants per ha / rhizomes need to be planted at a depth of 5-10 cm (in March or April) / sown using automatic planting machine **OSR:** preparing the seedbed min-till or cultivate (plough and harrow) or one-pass or strip-till cultivation or in shallow stubble ploughing to remove residual compaction / sown at a seed rate of between 3.0-4.0kg/ha (higher seed rates can be used to allow for winter losses or excellent emergence) / sown using a seed drill/ 25 cm spacing or depth of 20 mm / rolled to improve soil-seed contact	**2(2)**
	(c)	*Outline advantages of sowing chosen crop* **Kale** - high digestibility / long utilisation period or use of idle land / fodder crop / can use used to extend grazing season / out-winter animals (less housing or slurry storage requirement)/ high protein/ fast growing crop **Miscanthus** – renewable source of energy/ perennial crop / carbon neutral fuel / reduction in GHG (carbon sinks) / low input crop (fertilisers or herbicides or pesticides) / increased biodiversity **OSR** - Green manure crop (due to its developed root system to reaches the minerals located in the lower soil layers) /crop can be used for human consumption/ retains moisture well / saturates fields with oxygen / provides a take-all break / leaves high levels of residual nitrogen for subsequent crops / helps control annual or perennial grass weeds / spreads the harvest workload (normally be cut before winter wheat)	**2(2)**

Q11	**(a)(i)**	*Plant structure:* Root hairs *Process:* Active transport	**2** **2**
	(ii)	*Explain process – active transport (root hairs)* Active transport - movement of nutrient (ions) from a region of low concentration to high concentration (against a concentration gradient) / requiring energy *Answer in part (ii) **must** relate to part (i)	**2(2)**
	(iii)	*Explain symbiotic relationship* Two organisms living together with mutual benefit	**2**
OR			
	(b)(i)	*Explain tillering* Growth of side shoots / shoots arising from base of the stem	**2**
	(ii)	*Cause of symptoms* Phosphorus deficiency	**2**
	(iii)	*Role mycorrhizae fungi* (Hyphae (threads) increase surface area -) increased absorption of Phosphorus / increased soil:root contact / ability to solubilise P present in fixed form making it available to plants	**2(2)**
	(iv)	*Increase the presence of mycorrhizae fungi* Crop rotation / polycultures (multi species swards) / min till or decrease compaction / limiting fertiliser (especially Phosphorus) / use soil micro additive / addition of organic fertilisers	**2**

Q12	**(a)(i)**	*Explain DMD%* The portion of the dry matter in a feed that is digested by animals (e.g. 80% DMD – 80% of the feed is digested by the animals)	**2**
	(ii)	*Using data in the table, briefly explain the effect of harvest date on the DMD%* As the harvest date is delayed after 20 May the DMD decreases (every 13 days) / DMD will drop 5% every 2 weeks or 0.38% per day or by 15% over 39 days *Answers must refer to data in table	**4**
	(iii)	*Referring data in the table, outline **two** benefits of good quality silage on beef animal productivity* The higher the DMD of the silage the higher LWG or milk yield / silage of 75% DMD has 0.83kg per day liveweight gain compared to DMD of 70% has 0.66kg per day liveweight gain / High DMD silage (75%) will increase intake (9.0kg/day) (and decreased concentrate requirement) / shorter finishing period or reach target weight quicker as animals have a higher liveweight gain of 0.83kg per day with 75% DMD silage *Answers must refer to data in table (qualitative or quantitative)	**2(2)**
OR			
	(b)(i)	*Suggest **one** reason why the nitrate level in the grass is high* Chemical fertiliser still present in the grass or nor enough time has elapsed from the chemical fertiliser spreading date or didn't wait 6 weeks (50 days) after fertiliser spreading to cut grass	**2**
	(ii)	*Suggest **one** reason why the sugar levels in the grass are low* Low leaf : stem ratio / cut early in the morning or on overcast day / poor weather or lack of sunshine in advance of cutting / grass not wilted prior to storage	**2**
	(iii)	*Outline why high sugar levels are important in the ensiling process* Sugar provides feed for *lactobacillus* bacteria to feed off / produce lactic acid / need for fermentation / needed to reduce to pH 3.8 – 4.2	**4**
	(iv)	*Briefly explain how Bill can increase the sugar content in silage* Add molasses or enzymes / cut in afternoon or evening on a sunny day (when sugars are highest in the grass) / wilt grass (>28% DM) quickly / wait 6 weeks after fertilizing until nitrate levels are lower to cut grass	**2**

Section B		Answer any 3 questions 50 marks for each question Total for section is 150 marks	Marks
Q13	**(a)(i)**	*Outline **two** advantages of grass measuring* Enabling farmers to determine grass supplies for good grassland management or achieve high pasture utilisation / improving grass quality / enhancing animal performance / matching grass supply with demand or maximising growth rates or manage seasonal variation / increasing stocking rate / composing a fertiliser plan / extended grazing season or increase proportion of grazed grass in the diet	**2(4)**
	(ii)	*Calculate the kg DM/ha with a sward height of 10 cm* 10 – 4 = 6cm 6 x 250 = 1500 kg DM / ha (If a candidate just gives 1500 kg DM / ha then award 6m)	**3** **3**
	(iii)	*Identify **two** of the following plants A, B or C* ***A*** = Italian ryegrass ***B*** = Chicory ***C*** = Cocksfoot	**2(1)**
	(iv)	*Identify the growth cycle stage of plants in part (iii)* Reproductive stage *Describe briefly what happens at this stage* Seed head develops or heading out or flowering / stem is strong enough to hold plant upright / wind pollination occurs in A or insect pollination occurs in B	**3** **3**
	(b)(i)	*Outline **three** advantages of reseeding grassland* Increased grass productivity or liveweight gain or milk yield / increased palatability/ increased digestibility/ increased stocking density / better nitrogen use efficiency or reduced nitrogen requirement / longer growing season or extended grazing / better silage quality / increased protein / less disease or weeds	**3(4)**
	(ii)	*Diagram of research trial to distinguish certified and uncertified seed* *Labelled diagram should contain the following:* Two sets of seeds of equal size (or mass) one labelled certified and one labelled uncertified in equal sized area or container Any other relevant point: both sets of seeds are all given same amount of water or nutrients or seedbed for both was prepared in the same way / observe both sets of plants until they reached inflorescence (maturity) / note height of plants every 2 weeks (or period of growth) or look at colour of plants (is the crop a good colour or are there patches of off-colour) or size and shape (is crop all tall and thick as each other) or look at crop as single plants (compare stem and roots of good and poor plants)	**2(2)**

<table>
<tr><td></td><td>(iii)</td><td>Characteristics observed to determine which was certified and which was uncertified
<table><tr><th>Certified Seed</th><th>Uncertified Seed</th></tr><tr><td>Min. 85% of the plants had germination / Reduced weeds / plants were all similar height / plants were all the same colour / plants all had same stem or root structure or leaf / true variety</td><td>Less than 85% germinated / increased number of weeds present / plants varied in height / plants varied in colour/ plants varied in stem or root or leaf / mix of other varieties</td></tr></table></td><td>2(4)</td></tr>
<tr><td></td><td>(iv)</td><td>Outline the effects of using certified seed on the environmental sustainability of the farm
Less weeds - less chemical herbicides required / higher yields or genetic improvement – less land required for produce or more nutrient absorption (less leaching) / lower seeding rate required – produce higher yields or less production required / disease or pest resistance – less chemical pesticide required / reduce biodiversity due to monoculture</td><td>2 + 2</td></tr>
<tr><td>Q14</td><td>(a)(i)</td><td>Outline using scientific reasons why colostrum is fed to calves
Laxative to clear out the digestive system / antibodies to provide immunity to diseases (present on farms) / warms up calf to increase body temperature after birth / provides energy for energy boost / high in protein for increased growth / high in fat for insulation or vitamins for body processes</td><td>2(5)</td></tr>
<tr><td></td><td>(ii)</td><td>Explain why colostrum should be fed to calves within 4 hours of birth
Colostrum quality decreases (3.7%) every hour after birth / a calf’s ability to absorb antibodies directly into its bloodstream decreases with time or maximum absorption of antibodies occurs in this time</td><td>2</td></tr>
<tr><td></td><td>(iii)</td><td>Outline one reason why dried colostrum is not as effective as colostrum from calf’ mother
Doesn’t contain antibodies to diseases present on the farm</td><td>3</td></tr>
<tr><td></td><td>(iv)</td><td>Briefly explain why good hygiene is essential in harvesting colostrum
Prevent bacteria multiplying (doubles every 20 mins) / antibody levels decrease / prevent bacteria entering udder or mastitis / prevent microbial infection in calf</td><td>3</td></tr>
<tr><td></td><td>(v)</td><td>Briefly describe advice you would give Alice when feeding new born calf
Quality of the colostrum is very poor – it wouldn’t have all the necessary antibodies or provide the calf with good immunity / get good quality colostrum from another freshly calved cow (on the farm) or feed calf good quality frozen colostrum from farm (allowed to defrost naturally or not in microwave) to ensure good immunity to diseases on the farm or feed dried colostrum to calf</td><td>4</td></tr>
</table>

	(b)(i)	*Complete the table for the composition of colostrum whole milk* ***A*** = 12 - 13% ***B*** = 6 - 7% ***C*** = 14 - 15% (answer allowed within range stated in A, B and C)	**2** **2** **2**
	(ii)	*Briefly explain advantages of feeding transition milk to replacement heifers* Increased energy to support metabolism – stronger calf / higher protein levels for increased growth rate or ADG or less concentrates required / increased immunoglobulins for better immunity or increased immunity – good animal health / better development of digestive tract / more nutrition (than powdered milk) / would be wasted otherwise/ no need to purchase powdered milk	**2(4)**
	(c)(i)	*Identify three aspects of the shed which makes it a suitable environment for calves* Space sheeting or high roof - good airflow (ventilation) / board or concrete walls ensuring pen is draft free / (clean) roof lights - plenty of natural light / large area with adequate lying space/ clean bedding or smooth surfaces for good hygiene or disease reduction / long feed barrier - adequate feeding space	**3(3)**
	(ii)	*Complete the diagram using arrows to show natural airflow expected through the shed*  Correct indication of arrows coming in at side / going out through roof	**4 + 1**
OR			
	(d)(i)	*Briefly describe the dosing plan Jim would carry out in Flocks 1 and 2* Flock 1 – medium level of eggs – benefit from being dosed Flock 2 – low level of eggs - no need to dose	**3** **3**
	(ii)	*Advice on dosing plan for flock 3* Parasites may have built up a resistance to dose - change dose (anthelmintic) type or move to clean pasture after dosing to prevent reinfection or put sheep on a multi-species sward (chicory is an anthelmintic)	**3**

	(iii)	*Outline **two** advantages of using faecal egg counts in parasite control* Help to determine the need to treat (dose) animals or prevents blanket treatment of animals with chemicals / reduce chemical use on farms / test efficacy of a treatment (resistance) / information on amount of contamination in pasture / reduces the risk of chemicals entering the food chain so only dosed if required / reduce cost of expensive worm drenches / identifies parasite present or use targeted dose (to prevent resistance)	**4 + 1**
Q15	**(a)(i)**	*Describe how a named animal is synchronised at breeding* **Ewes** Flush ewes on good quality pasture or tupping dose / place progesterone sponge in vagina of ewe / leave for 10 – 12 days / remove (in morning) and inject PMSG / inseminate (let rams out) 1-2 days later / ram ratio 1:10 or ram effect **Heifers or cow** **Prostaglandin (PG)** Allow heifers to mate to natural heats for 7 days / observe heats, then if not in heat give prostaglandin (PG) injection / repeat PG injection 11 days later if not in heat / observe heat and AI with AM:PM rule **Or** Give heifers first shot of PG 13 days before start of breeding season / another shot 11 days later / bull introduced 2 days prior to start of breeding season or AI 72-96 hours later **Progesterone (P4)** Progesterone (P4) based device (PRID or CEDAR) is placed in vagina of animal for 6 – 10 days / PG injection is given day prior to removal / gonadotrophin (GnRH) injection / AI (mating) 48 hours after removal of device **Sow** P4 is given to sows for 14 – 18 days prior to insemination / GnRH day prior to service (AI) / located beside to boar (releases phermones) to bring sow into heat / double service (to increase litter size)	**2(3)**
	(ii)	*Briefly describe one safety precaution a farmer would take during the breeding season* Beware of bull or ram or boar or cows with calves / be careful when handling the cow or sow for insemination / wear gloves when inseminating / use animal handling facilities	**3**
	(iii)	*Outline the advantages of using sexed semen* Choose the sex of the calf / increase in better dairy beef production (less Jersey x bull calves) / decrease GHG from beef (finish < 24 months) / increased EBI of herd / (accelerate) herd expansion or less unwanted bull calves / less calving difficulty (with heifer calves)	**2(4)**

	(b)(i)	*State the optimum pH of the rumen* pH = 6.2 – 7.0 *Give a reason for monitoring acidity levels in the rumen* Prevent acidosis (especially in high concentrate diets)	**3** **3**
	(ii)	*Outline **one** advantage of measuring tail movements triggered by labour contractions* Indicates when cow is calving and alerts farmer	**3**
	(iii)	*State the duration of oestrus* Duration of oestrus = 18 – 24 hrs *Advise the farmer of the best time for insemination* 12 hours after onset of oestrus (am:pm rule)	**3** **3**
	(iv)	*Outline **two** advantages of udder sensors* Identify cows with high cell count (mastitis) / allows for early detection of infection or to treat infected cows early to prevent it spreading to others / allows for detection of sub-clinical mastitis / provides evidence of cow with high cell count for farmer to administer dry cow antibiotics / measure milk solids or yield or fat or protein or to identify productivity of cow	**2(3)**
	(c)(i)	*List **three** harmful gases that can build up in animal housing* Ammonia or NH_3 / carbon dioxide or CO_2 / nitrous oxide or N_2O / methane or CH_4 / carbon monoxide or CO / hydrogen sulphide or H_2S	**3(3)**
	(ii)	*Outline **one** piece of technology that has been installed in animal housing that improves animal welfare* Rotating brushes – allow animals to scratch / fans to improve ventilation in house / automatic feeding systems to control feed dispensing or identify and alert farmer if animal is not eating and maybe sick / ability to feed wet feed to pigs – increase intake or improve digestibility / automatic scrappers to remove dung from the passages on a regular basis / temperature sensors in pig housing to ensure houses are kept at critical temperture for pigs to thrive / valid answer for other named valid technology	**3**
Q16	**(a)(i)**	*Identify **one** example of each of the following:* *IV* = Sward composition / rate of N application *DV* = milk production (milk yield or % fat or % protein) *Control* = post grazing height / same stocking rate or same number of cows per treatment / same level of concentrate feeding / milk yield, % fat and % protein was recorded for each cow	**3** **3** **3**
	(ii)	*Identify **one** way this investigation could be made more accurate* Increase number of cows per treatment / use (calibrated) scales to measure concentrates or automatic feeding system / milk record regularly or computerised yield recording for each cow for accurate measurement / grass measuring (plate meter) and use of computer package to analyse data (Pasture base) / same breed of cow used	**3**

	(iii)	*State with reason if this is a reliable investigation* Yes - as the investigation was carried out over a long period of time (a year) or study could be repeated or controlled variables were used	**3**
	(b)(i)	*Identify which treatment produced the highest amount of milk* Treatment 3	**3**
	(ii)	*From your knowledge of milk price, sate with reason which treatment would result in a higher milk price for the farmer* Treatment 2 Highest amount of fat and protein (A + B – C)	**3** **3**
	(iii)	*Outline **one** way a dairy farmer could reduce N requirement on their farm* Efficient use or spreading (spreader calibrated properly) or use of GPS when spreading or named technology to identify requirement / using low emission slurry spreading (LESS) or spread slurry or manure/ grass measuring (budgeting) (and if growth surplus to demand reduced chemical N) / correct soil fertility or pH (N use efficiency is great in soils with optimum fertility) / reseed poorly performing swards (better N use efficiency)	**3**
	(c)(i)	*Describe using a labelled diagram a named grazing system used to manage the swards in the trial in part (a)* *Named grazing system* – Paddock (rotational) / block / strip grazing / spokes of a wheel *(Zero grazing is not accepted)* For 6 marks: diagram must show fencing, water supply, indication of animal movement For 3 marks: diagram has one of the elements above missing Marks awarded for any 3 labelled parts	**2** **D - 6, 3, 0** **L - 3(1)**
	(ii)	*Describe with the aid of a labelled diagram how to isolate and grow bacteria from the root nodules of clover* Wash roots (remove soil) / any named aseptic technique / cut a (large pinkish) nodule off root / sterilise surface of root with Milton (mild bleach) / wash in alcohol / rinse in sterile water (cooled boiled water) / crush nodule using (sterile) pestle and mortar or sterile glass rod / sterilise the inoculating loop in bunsen flame (or aseptic technique)(until it glows red and allow to cool) / using the loop add some of the root nodule to surface of nutrient agar plate and streak / incubate (upside down) for week at 20-30^{o}C / white colonies of bacteria *Marks awarded from diagram also	**3(4)**

Q17	**(a)(i)**	*Describe using a labelled diagram the activity of earthworms in a soil* Diagram: A number of layers, presence of organic matter, earthworms, creating channels or mixing layers (indication of activity) Layer of organic matter (leaf litter) on top or decomposed organic matter / layer of chalk or layer of compost or layer of sand or layer of gravel / earthworms /create channels / mixing layers / wormery or soil profile	**D - 6, 3, 0 (showing layers)** **Labels - 3(1)**
	(ii)	*Justify the benefits the activity of earthworms contribute to soil productivity* Creating channels for increased drainage / channels increase aeration / mixing layers leads to increased fertility or reduced compaction or increased nutrient availability / waste (castings) adds nutrients / castings form soil aggregates (by combining minerals and organic matter) or improve the soil structure / add organic matter	**2(4)**
	(iii)	*Estimate the total number of earthworms* Area of pasture = 98 x 178 = 17444m^2 / Average number of earthworms per quadrat = 28 + 45 + 23 + 19 = 115 ÷ 4 = 28.75 **or** Average number of earthworms per m^2 = 115 or 17444 ÷ 0.25 = 69,776 quadrats/ Total number of earthworms = 115 x 17444 = 2,006,060 earthworms or total 69,776 x 28.75 = 2,006,060 (If a candidate just gives 2,006,060 earthworms then award 6m)	**2** **2** **2**
	(iv)	*Suggest one reason for high concentration of earthworms in quadrat 2* Area was close to dung pad or higher organic matter / area under clover	**3**
	(b)(i)	*Outline **two** reasons why scientists select the plants with the highest yield for breeding* Continually produce offspring with higher yields / more food produced with same amount of resources / produce more of desired characteristics	**2(2)**
	(ii)	*Explain the terms genotype and hybrid vigour* ***Genotype*** genetic make-up of an organism ***Hybrid vigour*** - a cross-bred individual to shows qualities superior to those of both parents	**3** **3**
	(c)(i)	*State with reason which variety would suit the diet of his enterprise* Bazooka* Higher protein content	**4** **4**
	(ii)	*Describe how the hybridising process between two plants is carried out* Remove anther (from the male spikelet) for pollination (or male part of flower) / collect pollen from anther / transfer pollen to stigma / using a sterile swab(brush) / cover female plant to prevent cross pollination or remove stamens to prevent self-pollination / ensure both plants are in bloom at the same time	**2(3)**

OR			
	(d)(i)	*Briefly explain the principles of gene editing* Gene responsible for a specific trait is identified / using enzymes or named gene editing technique (e.g. CRISPR)/ introduce cuts into the DNA strands / allows removal of existing DNA / insertion of replacement DNA	**2(3)**
	(ii)	*Outline reasons why producing more disease, pest resistant and nutritious varieties are beneficial to feeding the increasing world population* Disease and pest resistant varieties would lead to increased yields / nutritious varieties would lead to healthier diets / with increased yields less demand on resources (land and water) / more pest and disease resistant varieties require less chemicals – less chance of getting into food chain / greater viability of crop leads to greater availability to populations /reduced risk of crop failure	**2(4)**
Q18	**(a)(i)**	*Briefly describe ow each of the following key components relate to food safety* ***Animal Welfare*** – less animal stress leading to better quality product / good animal housing leads to less injury or less antibiotics or less chance of antibiotics ending up in food chain / animals grazing on grass provide good animal welfare and good quality, safe or clean product ***Health & Safety*** - Food safety and food hygiene are important as they ensure that the food you handle and produce is safe for consumption / clean equipment (e.g. bulk tank, clusters, milk lines) or housing to avoid contamination of food / document or observe withdrawal periods ***Animal Health*** – better health of the animal results in requirement for less antibiotic use / benefit of less antibiotics ending up in food chain / animal health plan to minimise use of antibiotics or medications / routine testing to prevent transfer of disease (e.g. zoonotic) ***Traceability*** – farm to fork to allow recall of product / it is important that all animals are able to be traced back to original farm where animal health records are stored / to identify origin of food in case of recall	**4 + 4 + 3 +2**
	(ii)	*Briefly explain two ways a named livestock or tillage enterprise could reduce their energy and emissions on the farm* ***Animal enterprise*:** use renewable energy sources (install solar panels or install windmills or rainwater harvesting) / low emission slurry spreading (LESS) (to reduce amount of ammonia being lost to atmosphere) / extended grazing – animals are out on grass longer – less slurry storage required /inclusion of clover to reduce need for fertiliser / efficient farm layout to reduce machinery use / addition of additive (e.g. seaweed) into diet to reduce methane emissions or formulated feed for pigs to reduce ammonia / heat recovery system or temperature sensors for energy efficient housing or automatic lighting to reduce energy use **Or** ***Tillage enterprise:*** mintill reduces the number of passes on the land reducing energy (diesel) requirement / crop rotation or break crop reduces	**2(4)**

<table>
<tr><td></td><td></td><td>pests or diseases or weeds so less spraying requirement or less energy or lower emissions / energy crops provide alternative sources of energy that are more environmentally friendly and reduce emissions</td><td></td></tr>
<tr><td></td><td>(b)(i)</td><td>Explain pre-emergence weed control

Weed killer used before you see weeds to prevent them growing / prevents germinating weed seedlings from becoming established / protective barrier contains chemical the inhibit growth of plants</td><td>3</td></tr>
<tr><td></td><td>(ii)</td><td>Using the integrated management system for controlling weeds, provide advice on the future of weed control on farms
<table>
<tr><td>Integrated Management</td><td>Cultural control has to be the most important part of the IMS, and use of herbicides is less important</td></tr>
<tr><td>Use of herbicides</td><td>Increase use of pre-emergent herbicides and decrease the use of post-emergent herbicides</td></tr>
<tr><td>Increased seed rates</td><td>increase in plant numbers for increased competition with weeds so less chemical sprays required</td></tr>
<tr><td>Cover crops</td><td>increased competition for space or light or nutrients so less chemical sprays required or some cover crops– release chemicals that suppress weeds (allelopathic) (e.g. wheat, kale, cabbage)</td></tr>
<tr><td>Competitive crops</td><td>increase in plant numbers for increased competition with weeds so less chemical sprays required</td></tr>
<tr><td>Rogueing</td><td>hand pulling of weeds (prior to flowering) to reduce the chemical requirement</td></tr>
<tr><td>Crop rotation</td><td>breaks lifecycle of weeds or weeds don’t get a chance to establish in an area</td></tr>
<tr><td>Whole cropping</td><td>breaks lifecycle of weeds or weeds don’t get a chance to establish in an area</td></tr>
<tr><td>Crop destruction</td><td>crop is deliberately destroyed by burning due to high incidence of weeds or disease</td></tr>
<tr><td>On-farm hygiene</td><td>remove all weeds from farmyard to prevent seeds being spread on fields through FYM or slurry</td></tr>
<tr><td>Machinery hygiene</td><td>ensure that all machinery is free from plants or seeds when moving fields to prevent cross contamination</td></tr>
</table></td><td>3(4)</td></tr>
</table>

	(c)(i)	*Identify which enterprise relies heaviest on direct payments* Cattle rearing* *State a reason for your answer* 157% of income comes from direct payment/ heavily dependent on market price at the time of selling / low margins in system / high input – fertiliser or concentrates or stock / small scale / long periods of time with no income	**4** **3**
	(ii)	*Identify which enterprise relies the least on direct payments* Dairy* *State a reason for your answer* 28% of income dervied from direct payment / high price per litre of milk / large scale / regular income	**4** **3**