Coimisiún na Scrúduithe Stáit
State Examinations Commission

Junior Cycle Examination 2019

Science

Chief Examiner's Report

Contents

1. Introduction

This Chief Examiner's report provides a review of the performance of candidates in the 2019 Junior Cycle Science examination and provides an analysis of candidate achievement. This report should be read in conjunction with the examination paper, the marking scheme and the specification for this subject. The 2019 examination was the first occasion on which the 2015 Junior Cycle Science specification was examined. The examination paper and marking scheme are available on the website of the State Examinations Commission (www.examinations.ie) and the specification is available on the curriculum website of the National Council for Curriculum and Assessment (www.curriculumonline.ie).

The study of science allows students to enhance their scientific literacy, their ability to explain phenomena scientifically, and their understanding of the nature of scientific inquiry. Science in Junior Cycle aims to develop students' evidence-based understanding of the natural world and their ability to gather and evaluate evidence. Science promotes the development of analytical thinking skills such as problem-solving, reasoning, and decision-making.

2. What does the examination test?

Junior Cycle Science is offered at Common Level. The Assessment Task in Science is marked out of 40 marks. The examination paper is marked out of 360 marks. The time allocated for the examination is two hours.

The Assessment Task is a written task completed by students during class time, which is sent to the State Examinations Commission for marking. It offers students the opportunity to reflect on what they learned when completing their *Science in Society Investigation* (their second Classroom-Based Assessment).

In preparation for the Assessment Task, students first engaged with written stimulus material produced by the National Council for Curriculum and Assessment. The Assessment Task tested students' ability to analyse the information they gathered during their *Science in Society Investigation*, evaluate the reliability of their sources, and reflect on the communication methods they encountered and used.

The final examination paper asked candidates to engage with, demonstrate comprehension of, and provide written responses to stimulus material and associated questions. A sample of the specification's learning outcomes was assessed, including some of the learning outcomes from each of the five strands – *The Nature of Science*, *Earth and Space*, *Chemical World*, *Physical World*, and *Biological World*. Questions asked candidates to evaluate evidence and demonstrate their scientific knowledge, understanding, reasoning and problem-solving abilities.

The examination paper consisted of two sections. Section A comprised of ten questions worth 15 marks each, giving a section total of 150 marks. Section B comprised of six longer questions, worth 30 or 45 marks each, giving a section total of 210 marks. Other than question length, there was no formal distinction between the two sections – both sections required candidates to demonstrate a range of the cognitive skills encapsulated in the learning outcomes in the specification.

3. How well did the 2019 candidates achieve the objectives of the course, and how did they show us this?

The aims of Science in Junior Cycle are outlined on page five of the specification.

The specification's first stated aim is to develop students' evidence-based understanding of the natural world and their ability to gather and evaluate evidence. Linked to this aim, the specification encourages students to develop scientific literacy and apply this to the analysis of science issues relevant to society, the environment and sustainability; to find, use, manage, synthesise, and evaluate data; to communicate scientific understanding and findings; to justify ideas on the basis of evidence. The extent to which the candidates achieved this aim was assessed throughout the Assessment Task and the examination paper.

The *Science in Society* Investigation, upon which the Assessment Task was based, asked students to initiate research, to communicate their findings, and to evaluate the information gathered and communicated. The specification's aim of developing students' ability to gather and evaluate evidence was well achieved, as evidenced by the fact that the significant majority of candidates gave very good answers to questions 2(b), 3(a) and 3(b) on the Assessment Task. The aims of developing scientific literacy and of communicating scientific understanding and findings was also well achieved, as evidenced by the fact that most candidates performed very well on questions 4(a) and 4(b) on the Assessment Task, with 89% of candidates being awarded full marks in this section.

Candidates' ability to apply their scientific literacy was also well achieved, as evidenced most directly in parts (a) and (c) of question 14 on the final examination, which asked candidates to engage with a newspaper article on a scientific research topic. Other questions required candidates to engage with other types of scientific evidence, including graphical, diagrammatic and numerical data. In general, candidates performed better when engaging with evidence likely to be similar to that previously seen, such as the distance-time graph of question 7, than when engaging with evidence relating to less familiar contexts, such as the graph of temperatures on the surface of the Moon in question 16(e).

Question 15 required candidates to engage with three separate types of evidence (a novel version of the Periodic Table of the elements, particle-diagrams for aluminium and chlorine, and physical data for three different elements) and, in each case, to use the evidence to justify scientific statements. The candidate achievement on each of these items was only moderate, indicating that the aim of using evidence to justify ideas had not been as well achieved as some other aims.

The specification's second aim is to consolidate and deepen students' skills of working scientifically. Linked to this aim, the specification encourages students to develop a scientific habit of mind and inquiry orientation through activities that foster investigation, imagination, curiosity and creativity in solving engaging, relevant problems, and to improve their reasoning and decision-making abilities.

Candidates' facility to work like a scientist was partially assessed in the Assessment Task. During the completion of the task, candidates were allowed access to their own research record and research report. The high levels of achievement shown in questions 1(c) and 2(a) on the Assessment Task are evidence that candidates were able to extract relevant information from their research record and/or report.

Evidence for how well other aspects of this aim were achieved is more varied. The ability to process numerical data is central to the work of a scientist. While calculation questions on the final examination were answered well in the cases of simple or familiar operations – averaging data in question 11(e), calculating the volume of a cuboid in question 2(a) – lower levels of candidate performance were observed in the cases of more complex and/or less familiar operations, such as in question 2(b) and question 13(b). Answers to question 2(b) also indicated that many candidates struggled to understand the use of compound scientific units.

Question 12(a) asked candidates to plot a graph of bivariate data. Candidates performed very well on this question, despite the data not fitting on the "standard" straight line through the origin. 74% of candidates were awarded full marks on this item.

From how candidates engaged with questions assessing scientific reasoning, another aspect of this aim, there is evidence of significantly incomplete achievement. This is seen in the poor reasoning skills displayed in the answering of, for example, question 16 parts (c) and (g), where candidates frequently showed confused reasoning regarding the rotations of the Moon within the Earth-Sun-Moon system.

One of the new characteristics of this specification is the development of the unifying *Nature of Science* strand. While some aspects of this strand are assessed directly in a classroom-based context, question 11 of the paper largely focussed on this part of the specification; almost all parts of question 11 assessed candidates' ability to work and think scientifically.

Central to question 11 was the assessment of candidates' understanding of the concept of a scientific hypothesis, assessed in parts (a) and (g); the evidence from the answering of these parts of the question is that while some candidates demonstrated a full understanding of this concept, many other candidates demonstrated moderate-to-poor levels of understanding. Other parts of question 11 – parts (c), (d) and (f) – assessed candidates' ability to engage with the design of a scientific experiment; the evidence from the answering of these parts of the question is that candidates have good understanding of experimental design and the use of standard laboratory equipment and techniques.

A further aspect of experimental methodology, the concept of a control experiment, was assessed in question 14(b). Candidates answered this question very poorly, with only 12% of candidates being awarded marks in this item. From this, it is clear that some aspects of the aim of learning to work scientifically were not fully achieved by very many candidates.

The specification's third and final aim is to make students more self-aware as learners and become competent and confident in their ability to use and apply science in their everyday lives. Linked the this aim, the specification encourages students to develop a sense of enjoyment in the learning of science, leading to a lifelong interest in science; to acquire a body of scientific knowledge; to develop an understanding of Earth and space and their place in the physical, biological, and chemical world; to help establish a foundation for more advanced learning.

Aspects of this aim and those linked objectives were tested both in the Assessment Task and throughout both sections of the final examination. In particular, candidates' self-awareness as learners is addressed in the Assessment Task, while both it and the examination paper test the extent to which the candidates have developed competence to use and apply science and acquired the stated forms of knowledge and understanding, and thereby established a foundation for more advanced learning. The aim was achieved to a reasonable degree, with evidence for high levels of scientific knowledge across many parts of the specification. However, lower levels of candidate performance were evident in questions that required deeper understanding, application or analysis of this knowledge.

Evidence of high levels of knowledge – and lower levels of understanding, application and analysis – was seen in candidates' answers to questions related to each of the four contextual strands of the specification. In the *Biological World* strand, candidates gave high quality answers to, for example, questions 1(a), 1(b), 1(c) and 9(a), which directly assessed candidates' knowledge of fundamental biology. However, much lower levels of achievement were shown in, for example, answers to questions 14(g) and 14(h), which required candidates to describe and explain biological phenomena.

In the *Chemical World* strand, a high level of achievement was shown in, for example, answers to question 8(e), which asked candidates to correctly name a change of state. However, a much lower level of achievement was shown in answers to question 4(b), which required candidates to cite evidence for the conservation of mass during a chemical reaction – a test of candidates' abilities to understand, analyse and evaluate information. Question 15(f) asked candidates to apply their knowledge to determine the chemical formula for aluminium chloride; answers to this question were of a generally poor standard, which is disappointing given that a learning outcome explicitly states that students should be able to "use the Periodic Table to predict the ratio of atoms in compounds of two elements", and that a similar question appeared on the sample paper.

Similarly, in questions on the *Physical World* strand, candidates answered knowledge questions – such as questions 7(a) and 13(f) – very well, but performed less well on, for example, question 16(f), which asked candidates to apply their understanding of mass, weight and gravity in the context of different moons and planets.

In the *Earth and Space* strand candidates again performed well on questions relating to factual knowledge, such as questions 3(a), 10(a) and 10(b). As with questions in the other strands, students did not perform as well in questions requiring a level of understanding or application, such as question 16(a).

The concept of sustainability is one of four elements used to link learning outcomes across the specification's four contextual strands. The concept is, moreover, central to learning outcomes in both the *Physical World* and *Chemical World* strands, as well as within the *Framework for Junior Cycle* (Statement of Learning 10), and the discussion of the aims of the Science specification. In this context, questions 13(d) and 15(c) related directly to the topic of sustainability. While candidates performed relatively well on question 15(c), they performed less well on question 13(d) – *what do you understand by the term sustainability?* It is evident that while candidates were able to explain ways in which humans can contribute to sustainability, they were less able to explain sustainability as an abstract concept.

4. How can these observations help current and future students and their teachers?

Arising from an analysis of how well 2019 Junior Cycle Science candidates achieved the aims and objectives of the course through their performance in the Assessment Task and the examination paper, there are a number of recommendations applicable to current and future students and teachers.

The following recommendations are relevant when teachers and students plan for how they engage with the Junior Cycle Science specification.

- Students' performance in the two Classroom-Based Assessments is reported as part of the Junior Cycle Profile of Achievement. While students' performances in these assessments do not count directly towards students' grade descriptor in the state-certified examination (inclusive of the Assessment Task), it is important that teachers and students continue to fully engage with them, not only so as to achieve the aims and learning outcomes of the specification, but also to maximise candidate achievement in the final examination. Many of the skills which students develop while undertaking the Classroom-Based Assessments (and, indeed, while undertaking classroom activities in preparation for them) are assessed in the Assessment Task and the examination paper. It is therefore important that engaging with the Classroom-Based Assessments is not seen as disconnected from preparation for the terminal examination, but as part of a cohesive approach towards fulfilling the aims of the specification.
- While carrying out the *Science in Society Investigation*, students should produce a full research record as well as a final report. This research record will be helpful to students when completing the Assessment Task.
- It is recommended that while engaging with the course, students be helped to see links between different learning outcomes, both within a contextual stand, between two or more contextual strands, and indeed between a contextual learning outcome and the *Nature of Science* strand. The specification and its examination see the strands and learning outcomes as mutually supportive parts of one combined course of study, rather than as parts of three or four disparate subjects.
- A cursory analysis of the 2019 Junior Cycle Science examination paper and of the sample paper issued in advance of it shows that students' ability to engage with graphs is important and deserves emphasis. Such skills include: choosing what sort of graph (such as line chart, bar chart or pie chart) is most appropriate when presenting data; drawing such graphs, possibly including the choice of axes and scales; using graphs – student drawn or otherwise – to extract information, notice trends and patterns, and draw conclusions. It is important that students have experience of engaging with graphs that compare two or more sets of bivariate data. It is also important that students have experience of using graphs that present information from an unfamiliar context.

- From the previous section of this report it is clear that while students, in many instances, perform well on questions that require them to recall information, they frequently perform less well on questions that require them to use higher-order skills, including understanding, application, analysis, evaluation and synthesis. It is crucial that students develop and regularly demonstrate these skills in a classroom environment.

- It is recommended that students practice and develop the skills needed to produce paragraph-length answers that demonstrate their scientific knowledge and understanding. Questions such as 9(b) and 14(h) on the 2019 examination required students to be able to express themselves using clear and meaningful paragraph-length answers.

- Full engagement with the overarching *Nature of Science* strand is important for high levels of achievement in the examination. It is recommended that while engaging with the contextual strands of the specification, students are regularly stimulated to develop the skills relevant to the *Nature of Science* strand, especially those itemised in the *Investigating in Science* element.

- Students should understand the relevance of numerical literacy to science. In particular, they should develop the skills of data analysis and data processing, including calculations and the use of scientific units.

The following recommendations are relevant when students present as candidates for Junior Cycle Science examinations.

- Candidates should answer all questions. There is no choice on the examination paper, so all questions must be attempted. Candidates should remember that a poor or partial answer may gain marks, whereas a blank response cannot be awarded marks.

- Candidates should make sure that their work is presented clearly and legibly, so that an examiner may properly assess their work. This advice is relevant to examinations that are marked on paper in the traditional way and it continues to be relevant to examinations – such as Junior Cycle Science – that are now scanned and marked on computer screen. Candidates should write in blue or black pen, using pencils for diagrams and graphs only.

- On occasion, candidates may run out of room in the answer space made available immediately underneath the question; if this happens, they should continue their work on the additional writing spaces made available to them at the ends of Sections A and B, and they should clearly label all answers written in these additional writing spaces.

- Candidates should show their calculation work clearly. Calculations should be fully completed; an answer should not be left as $^{8}/_{2}$, for instance – this calculation should be completed to give 4. Candidates should remember to give units where relevant with all numerical answers, irrespective of whether or not the question explicitly asks for units.

Appendix: statistics & trends

Participation trends

Year	Science candidature	Total Junior Certificate/Cycle candidature	Science as % of total
2015	54290	59522	91.2
2016	55471	60248	92.1
2017	57208	61654	92.8
2018	58208	62587	93.0
2019	59538	64330	92.6

Table 1 Participation in Junior Certificate/Cycle Science, 2015 to 2019

Year	Total Science candidate	Female Candidates	Male Candidates	Female as % of total	Male as % of total
2015	54290	26136	28154	48.1	51.9
2016	55471	27003	28468	48.7	51.3
2017	57208	27850	29358	48.7	51.3
2018	58208	28361	29847	48.7	51.3
2019	59538	28942	30596	48.6	51.4

Table 2 Gender composition of Science cohort, 2015 to 2019

Junior Cycle Science candidates represented 92.6% of the 2019 Junior Certificate/Cycle cohort, which is consistent with previous years. The gender composition of Junior Cycle Science is also consistent with that of previous years Junior Certificate Science examinations.

Overall performance of candidates

The grading scale for Junior Cycle examinations is different from that used for Junior Certificate examinations. Furthermore, while Junior Certificate Science was assessed at both Higher and Ordinary levels, Junior Cycle Science is assessed at Common level. Arising from these two changes, direct comparison with all aspects of the grade distributions from previous years is not possible.

The results of the 2019 examination, along with comparative data from 2017 and 2018, are presented in the tables below.

Year	Level	Total	A	B	C	D	E	F	NG
2017	Higher	45709	9.5	28.8	37.8	22.1	1.6	0.2	0.0
	Ordinary	11499	1.4	32.5	47.2	15.4	2.7	0.9	0.1
2018	Higher	46423	9.2	32.4	38.2	18.8	1.2	0.2	0.0
	Ordinary	11785	1.2	33.6	48	13.6	2.8	0.8	0.1

Table 3 Percentage of candidates awarded each grade in Science, 2017 and 2018

Year	Total	Distinction	Higher Merit	Merit	Achieved	Partially Achieved	Not Graded
2019	59538	2.0	25.3	49.0	17.2	5.9	0.5

Table 4 Percentage of candidates awarded each grade in Science, 2019

Year	Level	Total	A	B	C	D	E	F	NG
2017	Higher	23144	11.2	31.3	37.8	18.6	0.9	0.1	0.0
	Ordinary	4706	2.0	37.4	46.1	12.2	1.9	0.4	0.0
2018	Higher	23654	11.5	35.6	36.4	15.6	0.8	0.1	0.0
	Ordinary	4707	1.4	38.4	46.8	10.8	2.0	0.6	0.0

Table 5 Percentage of female candidates awarded each grade in Science, 2017 and 2018

Year	Total	Distinction	Higher Merit	Merit	Achieved	Partially Achieved	Not Graded
2019	28942	2.5	28.4	49.2	15.2	4.4	0.3

Table 6 Percentage of female candidates awarded each grade in Science, 2019

Year	Level	Total	A	B	C	D	E	F	NG
2017	Higher	22565	7.7	26.3	37.7	25.6	2.3	0.3	0
	Ordinary	11499	1.4	32.5	47.2	15.4	2.7	0.9	0.1
2018	Higher	22769	6.9	29	39.9	22.2	1.7	0.2	0.0
	Ordinary	6793	0.9	29.1	47.9	17.6	3.2	1.1	0.1

Table 7 Percentage of male candidates awarded each grade in Science, 2017 and 2018

Year	Total	Distinction	Higher Merit	Merit	Achieved	Partially Achieved	Not Graded
2019	30596	1.6	22.5	48.8	19.1	7.3	0.7

Table 8 Percentage of male candidates awarded each grade in Science, 2019

In 2019, female Science candidates outperformed male candidates. This was in line with previous years.

Performance on individual questions

The data in tables 9 and 10 are based on an analysis of all scripts.

Question	Average mark, out of question total (and as %)	% awarded full marks	% awarded zero marks	Rank order in average mark as %	Topic
1	13.9 / 15 (93%)	81%	0%	2	The cell
2	9.0 / 15 (60%)	17%	5%	10	Volume and density
3	14.3 / 15 (95%)	88%	0%	1	The water cycle
4	4.6 / 15 (31%)	3%	13%	16	Chemical change
5	13.1 / 15 (87%)	57%	1%	4	Inherited characteristics
6	7.4 / 15 (49%)	5%	11%	13	Acids and bases
7	9.9 / 15 (66%)	24%	4%	7	Distance-time graph
8	13.3 / 15 (89%)	63%	1%	3	Melting ice
9	11.0 / 15 (73%)	29%	0%	6	Human respiration
10	11.9 / 15 (79%)	29%	1%	5	Stars and planets
11	17.8 / 30 (59%)	1%	1%	11	Boiling point of water
12	19.3 / 30 (64%)	6%	2%	8	Resistance versus concentration
13	19.2 / 30 (64%)	7%	0%	9	Electrical energy
14	17.2 / 30 (57%)	2%	1%	12	Food, stress and micro-organisms
15	22.0 / 45 (49%)	2%	2%	14	Chemical elements
16	17.7 / 45 (39%)	0%	2%	15	The Moon

Table 9 Average mark for each question on the examination paper

There was a wide variation in the average mark achieved in questions, from 95% in question 3 to 31% in question 4. Marks in questions from Section A were, in general, higher than those from Section B.

Question	Average mark, out of question total (and as %)	% awarded full marks	% awarded zero marks	Rank order in average mark as %	Topic
1	9.4 / 10 (94%)	80%	0%	2	Investigation and research
2	9.4 / 10 (94%)	84%	1%	3	Knowledge and reliability
3	9.1 / 10 (91%)	81%	2%	4	Reliability and bias
4	9.5 / 10 (95%)	89%	1%	1	Communicating

Table 10 Average mark for each question on the Assessment Task

All questions on the Assessment Task were awarded, on average, between 90% and 95%.