2008 HSC Notes from the Marking Centre
Physics

Published by Board of Studies NSW
GPO Box 5300
Sydney 2001
Australia

Tel: (02) 9367 8111
Fax: (02) 9367 8484
Internet: www.boardofstudies.nsw.edu.au

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2008 HSC NOTES FROM THE MARKING CENTRE PHYSICS

Introduction

This document has been produced for the teachers and candidates of the Stage 6 course in Physics. It contains comments on candidate responses to the 2008 Higher School Certificate examination, indicating the quality of the responses and highlighting their relative strengths and weaknesses.

This document should be read along with the relevant syllabus, the 2008 Higher School Certificate examination, the marking guidelines and other support documents which have been developed by the Board of Studies to assist in the teaching and learning of Physics.

General Comments

In 2008, approximately 9000 candidates attempted the Physics examination. The most popular options were From Quanta to Quarks (46%) and Medical Physics (29%).

Teachers and candidates should be aware that examiners may write questions that address the syllabus outcomes in a manner that requires candidates to respond by integrating their knowledge, understanding and skills developed through studying the course, including the prescribed focus areas. This reflects the fact that the knowledge, understanding and skills developed through the study of discrete sections should accumulate to a more comprehensive understanding than may be described in each section separately. It is important to understand that the preliminary course is assumed knowledge for the HSC course.

Teachers and candidates are reminded that mandatory skills content in Module 9.1 is examinable in both the core and option questions.

Candidates need to be reminded that the answer space provided and the marks allocated are guides to the maximum length of response required. Candidates should use examination time to analyse the question and plan responses carefully, working within that framework to produce clear and concise responses. Responses may include the use of dot points, diagrams and/or tables, and should avoid internal contradictions. This is particularly so in holistic questions which need to be logical and well structured. There was evidence that some candidates had a very poor knowledge of basic definitions specific to terminology associated with the course.

Better responses indicate that candidates had followed the instructions provided on the examination paper. In these responses, candidates:

- set out all working for numerical questions
- thought carefully about the units to be used and the quantities to be substituted into formulae

- did not repeat the question as part of the response
- looked at the structure of the whole question and noted that in some questions the parts follow from each other, ie responses in part (a) lead to the required response in part (b) etc
- used appropriate equipment, for example, pencils and a ruler to draw diagrams and graphs. (A clear plastic ruler helps candidates to plot points that are further from the axes and rule straight lines of best fit.)

In Section II the option question is divided into a number of parts. Candidates should clearly label each part of the question when writing in their answer booklets. In part (e) of the 2008 option questions the best responses presented ideas coherently and included the correct use of scientific principles and ideas. Many candidates wrote a lot of information that was not relevant to the question. Some responses showed evidence of rote learning of an anticipated answer based on a single source. These responses did not address the syllabus content and/or outcomes being assessed and hence did not score full marks. Candidates are required to attempt one question only in Section II, but some candidates responded to more than one option question. Candidates are strongly advised to answer the option they have studied in class.

Section I – Core

Part A – Multiple choice

Question	Correct Response
1	C
2	C
3	B
4	A
5	C
6	A
7	C
8	B

Question	Correct Response
9	B
10	A
11	D
12	B
13	A
14	D
15	B

Part B

Question 16

Better responses included accurate diagrams of investigations and a clear description of both production and reception of radio waves.

Question 17

(b) Weaker responses selected the correct equation although some were not able to pinpoint the relationship between E_p and R.

(c) Better responses focused on energy transformations rather than changes in CPE, GPE and KE. Better responses recognised that CPE was transformed to GPE directly. Weaker responses confused momentum with force.

Question 18

(b) Better responses related the origin of the effect in part to the production of a back emf and clearly described the formation of this back emf.

Question 19

(a) Weaker responses discussed change without referring to both the satellite and the gases.

Question 20

Better responses indicated an understanding of 'cooper pairs' than the interaction of electrons and holes within the band structures of metals and semi-conductors and some included diagrams to help support their answers. Weaker responses failed to recognise liquid mercury as a metal or 3K as a low temperature or that germanium could be a semi-conductor without being doped.

Question 21

The better responses were organised and succinct, demonstrated linkages between the work of the scientist(s) and the outside factors influencing their work, in a chronological manner and provided an opinion. In some weaker responses, candidates discussed external factors in a general way without linking it to the work of a named scientist or some confused personal scientific curiosity with external factors.

Question 23

(a) Weaker responses drew the path the electron would follow rather than the direction of the force.

(b) Better responses selected the appropriate equation and substitute the supplied data to gain an answer.

(c) In some weaker responses, candidates struggled with the simple algebra and often confused force and electric field.

Question 24

In the better responses, candidates showed evidence of planning and included two reconceptualisations of light and related them to the two named areas investigated by Einstein.

Better responses stated both the models of light before and after the reconceptualisations.

Weaker responses discussed the two areas investigated by Einstein (the photoelectric effect and special relativity) but could not clearly relate them to the reconceptualisations of light. They had

difficulties understanding the idea of a reconceptualisation. In the weaker responses, candidates often stated that light was constant rather than the speed of light being constant. Some weaker responses showed a lack of planning and the information did not always follow a coherent pattern.

Question 25

(a) Some weaker responses confused the AC graph with the DC or did not realise that both generators move with constant speed.

Question 27

(a) In the better responses, candidates correctly plotted the points and drew a correct trend line.

(b) Weaker responses did not realise that the resistance was the reciprocal of the gradient of the graph.

(c) The better responses indicated that the pure substance was chromium and correctly selected the graph of lower resistance.

(d) In the weaker responses, candidates did not provide a physical reason, many stated human error or meter malfunction.

Section II – Options

Question 28 — Geophysics

(a) (ii) Better responses outlined the type of information generated and then linked this to a change in our understanding of Earth.

(b) (i) Better responses used the scale and converted cm to km.

(ii) In better responses, candidates were able to relate P and S waves to both reflection and refraction at an interface.

(c) (i) In the better responses, candidates understood that the thermal image identified areas of intense heat and that the thermal image was a result of IR radiation taken from a satellite.

(d) Better responses conveyed a sound knowledge of the structure and function of both geophones and seismometers and compared these devices.

Question 29 — Medical Physics

(a) (i) The better responses related changing potential difference with changing shape of the piezoelectric crystals for production of ultrasound; and changing shape of the piezoelectric crystals caused by reflected ultrasound, producing alternating potential that was used to produce an image.

(ii) Better responses identified that the relative size of the difference in acoustic impedance of the tissues on either side of an internal boundary in explaining the amount of ultrasound reflection. Weaker responses did not give clear cause and effect statements for the reflection of ultrasound.

(b) (ii) Better diagrams clearly showed the differences in the arrangements of fibres in the bundles and included labels.

(c) (ii) Weaker responses had problems in describing how x-rays are produced. Some started after the electrons collide with the anode while others identified that x-rays go through the body and than exposing the x-ray film to a degree of x-ray attenuation. Some weaker responses gave a very general description without discussing much about the physics processes.

(iii) Weaker responses had problems distinguishing between radioisotopes and radiopharmaceuticals.

(d) Better response described the different scan technologies which use tomography and demonstrated understanding of the physics behind the scan technologies which use tomography. These responses included the impact of tomography on diagnosis.
Weaker responses confused the radioisotopes used in PET and SPECT. Better responses clearly linked the improvement in tomography to the impact on diagnosis. Weaker responses included generalisations.

Question 30 — Astrophysics

(a) (i) Weaker responses did not answer the question asked and contrasted only the difference in appearance of the two spectra. The best responses identified the necessity of discussing energy released/emitted by electrons (or atoms) rather than simply the gas, or the atmosphere of the star.

(ii) Better responses identified that (surface) temperature, spectral class/colour, density, chemical composition were characteristics of stars revealed by spectroscopy, and 'motion' involved translation, rotation, and (spectroscopic) binaries.
Weaker responses referred almost entirely to planets rather than stars and stated that or the product elements in the core can be identified by observation of the absorption spectrum of the star.

(b) (ii) Weaker responses assumed the logarithm to be base e rather than base-10.

(iii) Better responses not only identified the C.I. = B – V formula, but were able to describe the meanings of 'B' and 'V' in this formula.

(c) (i) Better responses showed an understanding of the role of gravity and the subsequent temperature increase in star formation.

(ii) Better responses named the different reactions occurring at X and Y, and provided correct descriptions of these reactions.

(d) In the better responses, candidates discussed the various ways binary stars are detected, and explained how observations could be used to infer the physical properties of binary stars.

Weaker responses described the classification of variable stars, but did not relate the observations to the variable stars' properties.

Question 31 — From Quanta to Quarks

(a) (i) Better responses identified how to produce an emission spectrum and how to observe the lines in the spectrum. Weaker responses did not describe how to produce an emission spectrum.

(ii) Better responses linked the spectral lines to the Bohr model.

(iii) Better responses candidates sketched in general terms a feature of the spectra that could not be explained by the Bohr model.

(c) (i) Better responses recognised all the particles necessary for mass defect calculations.

(ii) Better responses selected and substituted correctly in the appropriate equation and used the correct energy unit.

(d) (i) Better responses provided a clearly labelled diagram showing how the particle obtained the required energy.

(ii) Better responses recognised components of the model, and demonstrated an understanding of the features. Weaker responses did not answer the question asked and provided a learnt response from a known text.

(e) In the better responses, candidates chose two scientists and outlined the work of each and then described how the combined work led to a better understanding of atomic structure. They described how this led to new directions in scientific thinking in a logical and coherent response.
Better responses showed clear evidence of planning while weaker responses tended to overwrite and give more information than is needed to answer the question.

Question 32 — The Age of Silicon

In better responses, candidates demonstrated that they could relate improvements in digital technology to relevant analogue transducers, rather than merely listing many unrelated transducers, describing various histories in electronics, and/or simply comparing digital to analogue concepts without realising that most components can be configured to do both.

(a) (ii) In the better responses, candidates commented on the decreasing size and increased speed and capacity in digital technology and related this to the trend in the given graph, and extrapolated this to a meaningful interpretation in the future.

(b) Better responses demonstrated a clear understanding of the functions of an inverting summing operational amplifier and analysed the given circuit so as to determine any relevant part of the transfer function.

(c) Better responses included relevant information about the electrical structure and operation of LEDs rather than their mechanical construction and use.

(d) Responses that included intermediate states in truth tables for logic circuits avoided careless errors.

Physics

2008 HSC Examination Mapping Grid

Question	Marks	Content	Syllabus outcomes
Section I Part A			
1	1	9.2.1.3.3, 13.1d, 14.1f	H9, H13, H14
2	1	9.2.2.2.8	H9
3	1	9.2.2.3.1, 14.1f	H9, H14
4	1	9.2.2.3.1, 11.2a, 13.1f, 13.1g, 14.1	H11, H13, H14
5	1	9.2.4.3.5, 14.1f, 13.1d	H6, H13, H14
6	1	9.3.1.2.2, 14.1d	H9, H14
7	1	9.3.5.2.1, 9.3.5.3.1	H9
8	1	9.3.2.3.2, 9.3.2.2.4, 14.3c	H9, H14
9	1	9.3.2.3.3	H9
10	1	9.3.4.2.1, 9.3.4.2.2, 9.4.1.2.9, 9.4.3.2.8, 9.3.4.2.6	H9
11	1	9.4.1.2.5	H9
12	1	9.4.1.2.2	H10
13	1	9.4.2.3.4	H10
14	1	9.4.4.3.3	H9
15	1	9.4.3.2.2, 9.4.3.2.3, 9.4.3.2.7, 9.4.3.2.6	H9, H10
Section I Part B			
16	3	9.4.2.3.1, 13.1a, 13.1c	H10, H13
17 (a)	1	9.2.1.2.3, 14.1a	H6, H9, H14
17 (b)	1	9.2.1.2.3, 14.1f	H6, H9, H14
17 (c)	3	9.2.1.2.3, 9.2.2, 9.2.2.2.7	H6, H7
18 (a)	1	9.3.1.2.4, 9.3.1.2.5	H9
18 (b)	3	9.3.2.2.6	H9
19 (a)	3	9.2.2.2.7	H6, H9
19 (b)	3	9.2.2.3.4, 9.2.2.3.5, 12.4b, 14.1f,	H6, H9, H12, H14
19 (c)	2	9.2.2.3.5, 12.4b, 14.1f	H6, H9, H12, H14
20	4	9.4.4.2.3, 9.4.3.2.3, 9.4.4.2.5	H10
21	6	9.2.2.3.3, 9.3.3.3.2, 9.3.3.3.3, 9.3.3.2.5, 14.5 b	H1, H4, H14
22	3	9.3.4.3.4	H7, H9
23 (a)	1	9.4.1.2.3, 9.4.1.2.5	H9
23 (b)	2	9.4.1.2.5, 12.4b	H9, H12
23 (c)	2	9.4.1.3.3, 12.4b	H9, H12
23 (d)	2	9.4.1.2.8	H9
24	6	9.4.2, 9.2.4.2.5, 14.3b	H1, H2, H10, H14
25 (a)	2	9.3.3.2.3, 9.3.3.3.1, 13.1f, 14.3c	H9, H13, H14

Question	Marks	Content	Syllabus outcomes
25 (b)	3	9.3.3.2.3	H9
26 (a)	1	9.3.4.2.3	H9
26 (b)	2	9.3.4.2.3	H9
27 (a)	2	13.1f, 13.1g	H13
27 (b)	1	9.4.4.2.4, 13.1d	H13
27 (c)	2	9.4.4.2.4, 14.1c	H14
27 (d)	1	9.4.4, 14.1a, 12.4c	H12, H14
Section II Question 28 — Geophysics			
28 (a) (i)	3	9.5.1.2.2	H8
28 (a) (ii)	3	9.5.3, 9.5.4	H1, H8
28 (b) (i)	3	9.5.3.2.3, 9.5.3.3.2, 12, 14	H8, H12, H14
28 (b) (ii)	4	9.5.3.2.3	H8
28 (c) (i)	3	9.5.2.2.1, 14.1	H8, H14
28 (c) (ii)	3	9.5.2.2.1	H8
28 (d)	6	9.5.3.2.4, 9.5.3, 14.1a, 14.3b	H7, H8, H14
Section II Question 29 — Medical Physics			
29 (a) (i)	3	9.6.1.2.2	H7, H8, H10
29 (a) (ii)	3	9.6.1	H7, H8, H10
29 (b) (i)	2	9.6.2.2.7	H7, H8, H10
29 (b) (ii)	3	9.6.2.2.6, 9.6.2.2.5, 13.1e	H7, H8, H10, H13
29 (b) (iii)	1	9.6.2.2.7	H3
29 (c) (i)	3	9.6.3.3.1, 9.6.2.3.1, 9.6.4.3.4	H3, H4, H7, H8, H10
29 (c) (ii)	2	9.6.2.2.1	H7, H8, H9, H10
29 (c) (iii)	2	9.6.3.2.1, 9.6.3.2.2	H4, H7, H8, H10
29 (d)	6	9.6.2.2.3, 9.6.3.2.3, 9.6.3.2.4, 9.6.3.2.5,14.3b	H3, H4, H7, H8, H10, H14
Section II Question 30 — Astrophysics			
30 (a) (i)	3	9.7.3.2.1, 9.7.3.2.3	H7, H10
30 (a) (ii)	3	9.7.3.2.5	H7, H10
30 (b) (i)	2	9.7.4.3.1, 12.4b	H10, H12
30 (b) (ii)	2	9.7.4.2.2, 9.7.4.3.1, 12.4b	H10, H12
30 (b) (iii)	3	9.7.4.2.4	H9, H10
30 (c) (i)	2	9.7.6.2.1, 9.7.6.2.2	H7, H9, H10
30 (c) (ii)	2	9.7.6.3.2, 9.7.6.2.3	H7, H9, H10
30 (c) (iii)	2	9.7.6.2.6, 13.1e	H7, H9, H10, H13
30 (d)	6	9.7.6.2.2, 9.7.5, 14.3b	H7, H9, H10, H14

Section II **Question 31 — From Quanta to Quarks**			
31 (a) (i)	2	9.8.1.3.1, 11.2	H11
31 (a) (ii)	2	9.8.1.2.2, 14	H14
31 (a) (iii)	2	9.8.1.2.6, 9.8.1.3.4	H7, H10, H11, H12
31 (b) (i)	1	9.8.3.2.1, 12.3c	H12
31 (b) (ii)	2	9.8.3.2.4	H7
31 (c) (i)	3	9.8.3.3.2, 9.8.3.2.9, 12.4b, 14.2b	H7, H10, H12, H14
31 (c) (ii)	1	9.8.3.3.2, 14.1f	H7, H14
31 (d) (i)	2	9.8.4.2.4	H7, H9, H10, H11
31 (d) (ii)	4	9.8.4.2.5	H7, H9, H10
31 (e)	6	9.8.2.2.1, 9.8.1.2.5, 14.3b	H1, H5, H10, H14
Section II **Question 32 — The Age of Silicon**			
32 (a) (i)	3	9.9.7.2.1, 9.9.1, 14.1a	H14
32 (a) (ii)	2	9.9.7.2.2, 9.9.7.3.1, 12.4d	H7, H9, H12
32 (b) (i)	2	9.9.6.2.1	H7, H9
32 (b) (ii)	1	9.9.6.2.10	H7, H9
32 (b) (iii)	1	9.9.6.2.11	H7, H9
32 (b) (iv)	3	9.9.6.2.8, 12.4b, 13.1f	H7, H12, H13
32 (c) (i)	2	9.9.4.2.3	H7
32 (c) (ii)	2	9.9.4.3.3	H7
32 (d)	3	9.9.5.3.2	H7
32 (e)	6	9.9.7, 9.9.1.2.2, 14.3b	H7, H14

BOARD OF STUDIES
NEW SOUTH WALES

2008 HSC Physics
Marking Guidelines

The following marking guidelines were developed by the examination committee for the 2008 HSC examination in Physics, and were used at the marking centre in marking student responses. For each question the marking guidelines are contained in a table showing the criteria associated with each mark or mark range. For some questions, 'Sample Answers' or 'Answers may include' sections are included. These are developed by the examination committee for two purposes. The committee does this:

(1) as part of the development of the examination paper to ensure the questions will effectively assess students' knowledge and skills, and

(2) in order to provide some advice to the Supervisor of Marking about the nature and scope of the responses expected of students.

The examination committee develops the marking guidelines concurrently with the examination paper. The 'Sample Answers' or similar advice are not intended to be exemplary or even complete answers or responses. As they are part of the examination committee's 'working document', they may contain typographical errors, omissions, or only some of the possible correct answers.

The information in the marking guidelines is further supplemented as required by the Supervisor of Marking and the senior markers at the marking centre.

A range of different organisations produce booklets of sample answers for HSC examinations, and other notes for students and teachers. The Board of Studies does not attest to the correctness or suitability of the answers, sample responses or explanations provided. Nevertheless, many students and teachers have found such publications to be useful in their preparation for the HSC examinations.

A copy of the Mapping Grid, which maps each question in the examination to course outcomes and content as detailed in the syllabus, is also included.

Section I, Part B

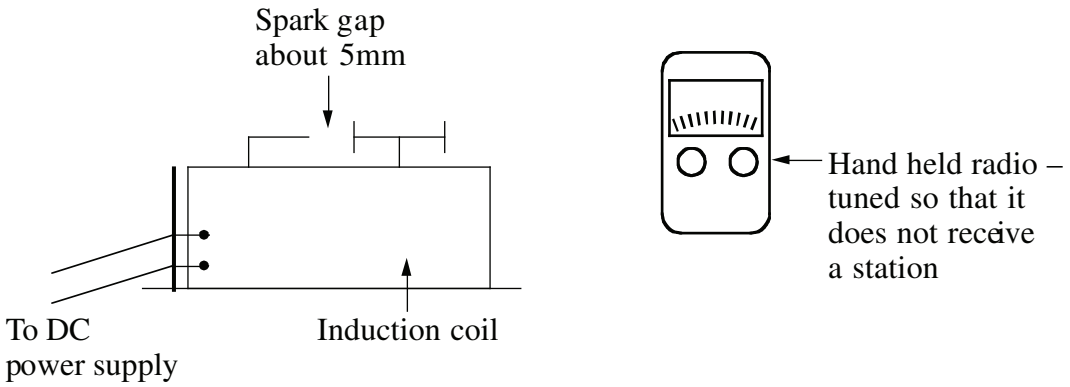
Question 16

Outcomes assessed: H10, H13

MARKING GUIDELINES

Criteria	Marks
• Draws a diagram of valid experimental set up • Describes detection and production of radio waves	3
• Draws a diagram of valid experimental set up and states method for detecting or producing radio waves OR • Describes a method for detecting or producing radio waves	2
• Draws a diagram of valid experimental set up OR • States method for detecting or producing radio waves	1

Sample answer:



Question 16 (continued)

Once the induction coil was set up, we turned on the radio and tuned it so it did not receive a station. We then moved around the room, estimating where to stand so the radio could receive the static noise from the spark. We also changed the tuner on the radio to scan across the range of wavelengths and frequencies.

We were able to demonstrate the production and reception of radio waves because when the power to the induction coil was switched on and a spark appeared across the gap, the radio crackled and made static noises. We inferred that the radio waves were produced by the induction coil and received by the radio.

Question 17 (a)

Outcomes assessed: H6, H9, H14

MARKING GUIDELINES

Criteria	Marks
• States the correct value	1

Sample answer:

(E_P =) -0.7 x 10^8 Joules

Question 17 (b)

Outcomes assessed: H6, H9, H14

MARKING GUIDELINES

Criteria	Marks
• States the correct equation for E_P • Shows that the relationship between E_P and r is non-linear	1

Sample answer:

The formula for gravitational potential energy is $E_P = -Gm_1m_2/r$ so that E_P is proportional to 1/r and not proportional to r as it needs to be to give a straight-line graph.

Question 17 (c)

Outcomes assessed: H6, H7

MARKING GUIDELINES

Criteria	Marks
• Identifies the energy changes correctly • Makes the relationships between the energy changes evident	3
• Describes energy changes OR • Describes one in detail	2
• Identifies ONE energy change OR • Makes a correct relevant statement	1

Sample answer:

During launch, the chemical energy stored in the fuel is converted into kinetic energy (KE) of the rocket and the exhaust gases and into gravitational energy (GPE). However total energy (KE + GPE + chemical energy of unburnt fuel) is equal to the total amount of chemical energy that was stored in the fuel before launch.

Question 18 (a)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• States the correct direction in which side PQ will move	1

Sample answer:

The side PQ will initially move downwards.

Question 18 (b)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of back emf, showing the sequence of events	3
• Outlines the origin of back emf	2
• States a feature of back emf	1

Sample answer:

The reduction is potential difference is known as "back emf". It occurs because the amount of magnetic flux that is threading the coil constantly changes as the coil is rotating. The voltage induced in the coil, as it rotates in the external magnetic field, is in the opposite direction to the voltage input by the power supply. This results in the potential difference being less.

Question 19 (a)

Outcomes assessed: H6, H9

MARKING GUIDELINES

Criteria	Marks
• Identifies the changes in momentum of the satellite and of the exhaust gases AND EITHER • Indicates that these momentum changes are equal and opposite (cancel each other) OR • Indicates that the total momentum of the satellite/gases system is conserved	3
Any TWO of the following: • Identifies the changes in momentum of the satellite OR the exhaust gases • Identifies change in direction • States that total momentum is conserved	2
• Identifies one change in momentum OR • States that total momentum is conserved	1

Sample answer:

Upon firing, the forward momentum of the satellite increases by an amount equal to the momentum in the opposite direction (relative to the satellite) of the exhaust gases. However the total momentum of the (closed) system containing the satellite and exhaust gases remains constant.

Question 19 (b)

Outcomes assessed: H6, H9, H12, H14

MARKING GUIDELINES

Criteria	Marks
• Substitutes correctly to determine the new speed	3
• Equates TWO appropriate equations AND EITHER • Makes an error in rearranging the equations OR • Makes an error in substitution	2
• Chooses one correct formula only and attempts to find the speed.	1

Sample answer:

$V = 3.8 \times 10^3 \text{ m/s}$

Question 19 (c)

Outcomes assessed: H6, H9, H12, H14

MARKING GUIDELINES

Criteria	Marks
• Substitutes correctly to calculate ratio	2
• Uses formula correctly but makes an error in substitution	1

Sample answer:

T^2 is proportional to R^3

$\left(T_1/T_2\right)^2 = \left(R_1/R_2\right)^3$ substitute $R_2 = 4 \times R_1$

$T_2 = 8x\ T_1$

Question 20

Outcomes assessed: H10

MARKING GUIDELINES

Criteria	Marks
• Shows how things are different by: – Correctly identifying Ge as a semiconductor, Hg at RT as a metal, and Hg at 3K as a superconductor – Valid comparison of the relative conductivity of the three substances – Demonstrating an understanding that metallic conduction occurs through the flow of free electrons – Demonstrating an understanding that conduction in semiconductors occurs through the flow of electrons and holes – Demonstrating an understanding that conduction in superconductors occurs through the lossless (resistance free) flow of Cooper pairs	3–4
• 1–2 of the points above	1–2

Sample answer:

- Ge is a semiconductor, Hg is a metal at RT, and Hg is a superconductor at 3K.
- Metallic conduction occurs through the flow of free electrons.
- Conduction in semiconductors occurs through the flow of electrons and holes.
- Conduction in superconductors occurs through the lossless (resistance free) flow of Cooper pairs.

Question 21

Outcomes assessed: H1, H4, H14

MARKING GUIDELINES

Criteria	Marks
• Expresses an opinion about the statement • Demonstrates a thorough knowledge of the work of scientist(s) in the chosen area • Justifies their opinion by describing how the work of the scientist(s) is influenced by external factors eg social, political, economic, military • Demonstrates coherence and logical progression and includes the correct use of scientific principles and ideas	6
• Demonstrates a sound knowledge of the work of scientist(s) in the chosen area • Demonstrates a knowledge of external factors • A justification is attempted linking the two above	4–5
• Demonstrates some knowledge of the work of scientist(s) in the chosen area OR/AND • Demonstrates some knowledge of external factors and vague linking with work of scientists	2–3
• Names a scientist from the chosen area OR • States one external factor	1

Answers could include:

I would agree with this statement and would refer to von Braun in particular as his contribution in the development of the V–2 rocket was greatly influenced by the progress and 'needs' of Germany in the second World War. With the war's end, development took a different path as the victors then pushed development towards satellites and astronauts that became the next political race.

OR

I would agree with this statement. The distribution of electricity was influenced by forces in society and in government. With the need for electrical energy to supply both population and industrial increases, scientists such as Edison and Westinghouse were pushed by offers of financial gain to direct their attentions to lower cost, more efficient methods of producing and transporting electricity energy. Hence the competition between Edison DC supply and Westinghouse AC supply.

Question 22

Outcomes assessed: H7, H9

MARKING GUIDELINES

Criteria	Marks
• Relates large scale electrical distribution over long distances to power losses, as indicated in $P_{loss} = I^2R$ and/or relates stepping up the voltage to a reduction in power losses/greater efficiency because of a smaller current required • States that transformers can be used to step-up the voltage	3
• Indicates that power losses occur when electricity is distributed over long distances • States that transformers can be used to step up the voltage	2
• Makes one relevant statement regarding power losses associated with electricity distribution over long distances	1

Sample answer:

Large-scale distribution of electrical power is difficult over long distances, due to the large power losses, which occur in the transmission lines. This loss can be calculated from $P_{loss} = I^2R$. Transformers can be used to step up the voltage before transmission, so for example, if the transmission voltage is doubled, the current is halved and the power loss is reduced by a factor of four. This means that using transformers enables electrical energy to be supplied over large distances without wasting too much energy.

Question 23 (a)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Draws arrow, pointing downward	1

Question 23 (b)

Outcomes assessed: H9, H12

MARKING GUIDELINES

Criteria	Marks
• Substitutes correctly to calculate magnetic force	2
• Performs calculation but makes an error in substitution	1

Sample answer:

3.2×10^{-16} N

Question 23 (c)

Outcomes assessed: H9, H12

MARKING GUIDELINES

Criteria	Marks
• Equates electrostatic force and magnetic force and substitutes correctly	2
• Equates electrostatic force and magnetic force but makes an error in substitution	1

Sample answer:

20V

Question 23 (d)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Indicates similar method used by Thomson and gives a description of how Thomson determined the q/m ratio	2
• Identifies a feature of Thomson's experiment	1

Sample answer:

Thomson adjusted the electric field strength and magnetic field strength to make the electrons pass straight through. This allowed him to calculate the velocity of the electrons (cathode rays). He then passed the electrons through the magnetic field alone, and from the radius of their path, calculated the q/m ratio (q/m = v/Br)

Question 24

Outcomes assessed: H1, H2, H10, H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a thorough knowledge of aspects of Einstein's theory of special relativity • Demonstrates a thorough knowledge of the photoelectric effect • Relates both to reconceptualisation of light • Demonstrates a coherent and logical progression	5–6
• Demonstrates some knowledge of Einstein's theory of special relativity • Describes both reconceptualisation of light • Describes the photoelectric effect	3–4
• Outlines the photoelectric effect OR • States Einstein's theory of special relativity OR describes a reconceptualisation of light	1–2

Sample answer:

The photoelectric effect refers to the release of an electron from the surface of a metal exposed to electromagnetic radiation. Classical physics was unable to explain the photoelectric effect, in particular, the threshold frequency, which is the frequency of light at which electrons are emitted from the surface of a metal. It predicted that energy from light would be absorbed over time until an electron had sufficient energy to leave the surface of the metal. Einstein used Planck's theory and the concept that photons carried energy to explain the photoelectric effect. Einstein assumed that light existed as photons, each with an energy equal to $E = hf$ and that the number of photons determined the light intensity. Photons with the highest energy correspond to the highest frequency, and an electron would not be emitted from a metal surface unless the photons possessed energy equal to or greater than the energy needed to overcome the energy holding the electron on the metal surface. The energy required to release the electron from the surface was called the work function, W. Einstein was able to combine the photon energy with the work function and the KE of the emitted electrons in the equation $E = hf = W + E_K$.

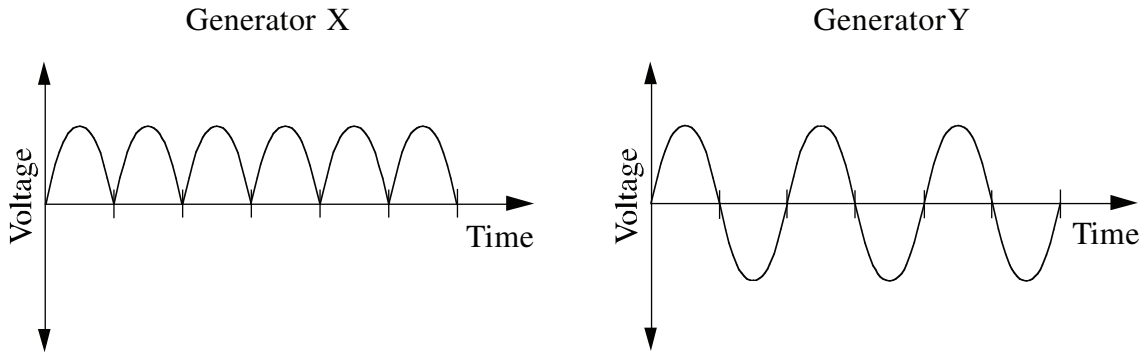
Question 25 (a)

Outcomes assessed: H9, H13, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly indicates on graph plots for Generator X and Y	2
• Correctly indicates on graph a plot for either Generator X or Y OR • Plots reversed	1

Sample answer:



Question 25 (b)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies generator X as a DC generator and generator Y as an AC generator • Links the use of the split-ring commutator in generator X to the current flowing in one direction only • Links the use of the slip-rings in generator Y to the current flowing in both directions	3
• Correctly identifies generator X as a DC generator and generator Y as an AC generator AND EITHER • Correctly describes the use of the split-ring commutator in generator X as allowing the current to flow in one direction only OR • Correctly describes the use of the slip-rings in generator Y as allowing the current to flow in both directions	2
• Correctly identifies generator X as a DC generator and generator Y as an AC generator OR • Correctly outlines the use of the split-ring commutator in generator X as allowing the current to flow in one direction only OR • Correctly outlines the use of the slip-rings in generator Y as allowing the current to flow in both directions	1

Sample answer:

Generator X is a DC generator. The voltage is transferred to the external circuit via the brushes that make contact with the split-ring commutator. When the voltage of the coil changes direction, the brushes swap over the side of the coil they are connected to, which causes the voltage supplied to the external circuit to be in one direction only. Generator Y is an AC generator, in which the coil is connected to the outside circuit by slip-rings, which rotate with the coil. This means that the voltage varies sinusoidally with time, which results in an alternating current.

Question 26 (a)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Identifies the correct photograph and provides a reason	1

Sample answer:

A spark would be seen in photograph A because the primary coil and iron core are completely inside the secondary coil.

Question 26 (b)

Outcomes assessed: H9

MARKING GUIDELINES

Criteria	Marks
• Shows how the effective turns ratio or magnetic coupling changes as the secondary coil is moved • Shows how the effective turns ratio changes voltages	2
• Shows how the effective turns ratio or magnetic coupling changes as the secondary coil is moved OR • Shows how the effective turns ratio changes voltages	1

Sample answer:

Different voltages are produced when the secondary coil is moved to different positions, because of the amount of flux that threads the secondary coil. Transformers are designed so that almost all the magnetic flux produced in the primary coil threads the secondary coil, so that when an alternating current flows through the primary coil, a secondary magnetic flux passes through the secondary coil, thus producing an AC voltage at the terminals of the secondary coil. When the relative positions of the primary and secondary coils change, different amounts of flux thread the secondary coil and so a different voltage is produced.

Question 27 (a)

Outcomes assessed: H13

MARKING GUIDELINES

Criteria	Marks
• Plots majority of data points correctly and the trend line reflects the plotted data	2
• Plots majority of the data points correctly OR • The trend line reflects the data as plotted	1

Question 27 (b)

Outcomes assessed: H13

MARKING GUIDELINES

Criteria	Marks
• Identifies the correct formula and substitutes correctly	1

Sample answer:

R = V/I = 7.5 V / 0.99 A = 7.6 ohms

Question 27 (c)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies that the resistance of Wire X is less than that of Wire Y • Supports choice with reference to the graph	2
• Either of the above	1

Sample answer:

The resistance of wire X is R = 6.0 V / 2.28 A = 2.63 ohms.
The resistance of a pure metal is less than an alloy because of reduced electron scattering.
Therefore, Wire X is the pure Chromium wire and Wire Y is the Nichrome wire.

Question 27 (d)

Outcomes assessed: H12, H14

MARKING GUIDELINES

Criteria	Marks
• Puts forward a physical reason	1

Sample answer:

The inconsistent point is (7.5, 2.5). This is below the trend line for Wire X, indicating that the resistance of the wire has increased. This is because the power dissipated by the sample at this applied voltage is sufficient to heat the sample, increasing its resistance though enhanced electron scattering by atomic vibrations.

Section II

Question 28 (a) (i)

Outcomes assessed: H8

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies X, Y and Z	3
• Correctly identifies TWO of the above	2
• Correctly identifies ONE of the above	1

Answers could include:

X = ores, deposits, water, oil, gas
Y = resistance, conduction
Z = earthquake study

Question 28 (a) (ii)

Outcomes assessed: H1, H8

MARKING GUIDELINES

Criteria	Marks
• Describes the type of information generated • States an understanding of the Earth • Links information with changing the understanding of Earth	3
• Describes the type of information generated and states an understanding of the Earth OR • Links information with changing the understanding of Earth	2
• Outlines type of information OR • Outlines the changing understanding of Earth	1

Answers could include:

Seismic: Information is in the form of travel time and speed providing detail on reflection and refraction of waves within the Earth. This can be used to construct models, verify models or test models of Earth. For example earth has different layers. Travel times and speeds have been used to estimate how may layers, depth of layers and what the layers are made of.

Question 28 (b) (i)

Outcomes assessed: H8, H12, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly converts units and reads from graph • Correctly substitutes for the speed of S wave • Correctly substitutes for the speed of P wave	3
• Any TWO of the above	2
• Any ONE of the above	1

Answers could include:

- v=d/t
- d is distance wave travels in km on horizontal axis
- t is time in second and the figure shows the pulse at different times along vertical axis
- speed of s wave =1.6/1 =1.6km/s
- speed of p wave =2.0/1 =2km/s

Question 28 (b) (ii)

Outcomes assessed: H8

MARKING GUIDELINES

Criteria	Marks
• Describes reflection and refraction at an interface • Relates each to S and P waves	4
• Describes reflection and refraction at an interface • States features of S and P waves	3
• Outlines reflection and refraction at an interface • States a feature of S and P waves	2
• Outlines reflection, refraction or a feature of S and P waves	1

Answers could include:

- Reflection occurs when the elasticity of the material/medium in which the wave travels changes eg from soil to rock. A portion of the wave can be transmitted and a portion is reflected.
- When the wave goes from one material/medium to another or as the properties of the medium changes gradually the wave refracts or bends.
- S waves are transverse waves and P waves are longitudinal waves.
- Apply reflection and refraction to P and S waves.

- **Question 28 (c) (i)**

Outcomes assessed: H8, H14

MARKING GUIDELINES

Criteria	Marks
• Relates the particular band of electromagnetic spectrum with the image and the imaging technique • Describes the role of different absorption, reflectance of surface/mediums in the images. • Describes the role of the satellite and features such as baseline data	3
• Any TWO of the above	2
• Any ONE of the above	1

Answers could include:

- The visible image used the visible part of the EM spectrum. Smoke plumes would absorb/reflect differently to sea and background vegetation and have a different shade.
- The thermal image uses the infrared part of the EM spectrum. The actual regions on fire are at higher temperatures and hence sharper in contrast to other regions in the image.
- The satellite stays positioned above the region or passes over collecting data. Sensors can collect data using a range of technologies and transmit back to Earth.

Question 28 (c) (ii)

Outcomes assessed: H8

MARKING GUIDELINES

Criteria	Marks
• Provides feature of the monitoring • Describes role of remote sensing in management and control • Describes benefits	3
• Any TWO of the above	2
• Any ONE of the above	1

Answers could include:

- Remote sensing provides:
  - Real time image
  - Continuous data or images
  - Large-scale data/information/images
- Remote sensing can be used for predicting events or obtaining information early enough to warn of disasters
- Remote sensing can hence save lives, money and resources – economic and social benefit

Question 28 (d)

Outcomes assessed: H7, H8, H14

MARKING GUIDELINES

Criteria	Marks
• Provides structure and function of devices • Provides information obtained using the techniques • Relates information to large-scale structure of Earth • Demonstrates a logical and coherent progression with correct use of scientific principles and ideas	6
• Provides structure and function of devices • Provides some information obtained using the techniques • Provides some features of the large-scale structure of Earth	4–5
• Outlines structure and function of devices • Provides limited information obtained using the techniques AND/OR large-scale structure of Earth	2–3
• Outlines structure or function of one device OR • Provides limited information obtained using a technique OR • Provides limited information about large-scale structure of Earth	1

Answers could include:

Devices	Structure	Function	Structure of the Earth
Geophones	Detects induced current. Are set out in lines.	Provides a picture of the sub-surface.	Provides depth of the sub-surfaces.
Seismometer	Detect vibrations/waves on a revolving drum.	Determine intensity in horizontal and vertical direction.	The *P* and *S* waves provide evidence for inner core, outer core.

Question 29 (a) (i)

Outcomes assessed: H7, H8, H10

MARKING GUIDELINES

Criteria	Marks
• Identifies piezoelectric effect as basis for ultrasound waves production and detection • Gives reason for both in terms of crystal shape and PD	3
• Identifies piezoelectric effect and describes production or detection OR • Describes both production and detection	2
• Identifies piezoelectric effect as basis for production and detection OR • Describes production or detection	1

Answers could include:

The production and detection of ultrasound waves are possible because of the properties of piezoelectric crystals such as PZT. When a potential difference is applied across these crystals they change shape. When that PD is from an alternating source (as in an AC supply), the regular changing of the shape of the crystal results in the production of ultrasound waves. When these crystals are subject to pressure, the reverse happens – pressure (from returning ultrasound waves) causes distortion of the crystal with a resultant change in the PD across the crystal. This changing PD provides a means of detecting ultrasound waves.

Question 29 (a) (ii)

Outcomes assessed: H7, H8, H10

MARKING GUIDELINES

Criteria	Marks
• Shows how reflection of ultrasound waves occurs within the body with reference to acoustic impedance and a qualitative consideration of amounts reflected	3
• Describes how reflection of ultrasound waves occurs within the body with reference to acoustic impedance	2
• Identifies that ultrasound waves are reflected from within the body	1

Answers could include:

As ultrasound waves move through the body they pass through different tissues. At each boundary ie interface between different tissue types, a proportion of the ultrasound waves is reflected while the balance is transmitted (with some energy being absorbed by tissues). The amount of reflection is determined by the difference between the acoustic impedances (Z) of the tissues – the larger the difference between the Z values for 2 different tissues the greater the amount of reflection. The transducer is able to detect the intensity and time of return for the reflected ultrasound waves, ultimately presenting this information as an US image.

Question 29 (b) (i)

Outcomes assessed: H7, H8, H10

MARKING GUIDELINES

Criteria	Marks
• Sketches in general terms TWO uses	2
• Sketches in general terms ONE use OR • Identifies TWO uses	1

Answers could include:

Endoscopy involves using visible light to investigate the body. One use is for actually viewing internal structures of the body to detect any abnormalities. Another use is for taking tissue samples from generally inaccessible areas for further investigation.

Question 29 (b) (ii)

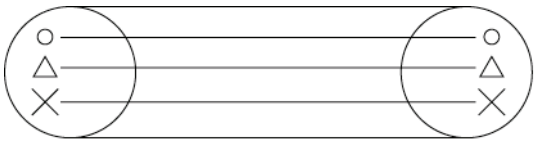
Outcomes assessed: H7, H8, H10, H13

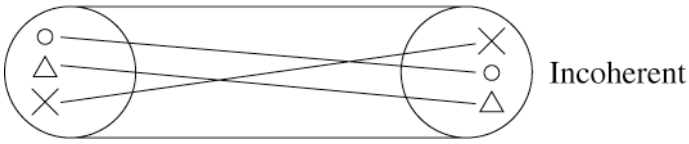
MARKING GUIDELINES

Criteria	Marks
• Shows differences between coherent and incoherent bundles and their roles and includes diagrams	3
• Shows differences between coherent and incoherent bundles and their roles excluding diagrams OR • Shows, with diagrams, some of the differences between coherent and incoherent bundles and their roles OR • Describes ONE type of bundle including diagram	2
• Outlines differences without diagram OR • Describes ONE without diagram OR • Presents basic diagram	1

Answers could include:

Coherent bundles of fibres maintain position of individual fibres between beginning and end; their role is to produces a faithful image of the object being studied. Incoherent bundles do not need to maintain individual fibre position as their role is to provide light to illuminate the object being viewed.





Question 29 (b) (iii)

Outcomes assessed: H3

MARKING GUIDELINES

Criteria	Marks
• Sketches in general terms one advantage	1

Answers could include:

Endoscopy is minimally invasive as compared to the surgery that would be required to visualise the same area.

Question 29 (c) (i)

Outcomes assessed: H3, H4, H7, H8, H10

MARKING GUIDELINES

Criteria	Marks
• Shows how the advantages for BOTH techniques are different (with focus on bone imaging)	3
• Describes advantages of ONE technique for bone imaging OR • Outlines advantages of BOTH techniques for bone imaging OR • Describes advantages of BOTH without reference to bone imaging	2
• Outlines one technique for bone imaging	1

Answers could include:

Advantages of X-rays are that they are quick and cheap to produce while providing superior information regarding structure of bone, therefore ideal for the detection of eg fractures. Bone scans on the other hand provide invaluable information about function and are therefore able to detect abnormalities earlier hence improve treatment options and success rates.

Question 29 (c) (ii)

Outcomes assessed: H7, H8, H9, H10

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of X-ray production	2
• Outlines X-ray production	1

Answers could include:

X-rays are high energy EMR that are produced in 2 ways. In each case, electrons must be given very high velocities – (this can be achieved by subjecting them to very high Vs eg 100 000 V) and then having them strike a target (usually tungsten). One way X-rays are produced is through the rapid deceleration of the electrons as they strike the target. Another way is for the electrons to collide with K-shell electrons in the tungsten atoms and knock them out. As higher shell electrons drop down to fill the gap, EMR in the form of X-rays is produced.

Question 29 (c) (iii)

Outcomes assessed: H4, H7, H8, H10

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of at least TWO suitable properties	2
• Provides at least TWO suitable properties OR • Describes ONE suitable property	1

Answers could include:

Radiopharmaceuticals need to produce the appropriate type of radiation – in this case gamma radiation, as this is the type of radiation that is detected by the gamma cameras used for bone scans. They also need to target and accumulate in the organ being studied or the image will not be useful. Finally, they should have a half-life long enough to allow imaging, but not so long as to endanger the health of the patient.

Question 29 (d)

Outcomes assessed: H3, H4, H7, H8, H10, H14

MARKING GUIDELINES

Criteria	Marks
• Shows thorough understanding of the concept of tomography, how it is applied in at least TWO appropriate scans and its impact on our diagnostic abilities • Demonstrates logical and coherent progression and correct use of scientific principles and ideas	6
• Shows sound understanding of the concept of tomography, how it is applied in at least TWO appropriate scans; and its impact on our diagnostic abilities OR • Shows sound understanding of at least TWO appropriate scan technologies OR • Shows basic understanding of concept of tomography, how it is applied in at least TWO appropriate scans and its impact on our diagnostic abilities	4–5
• Shows basic understanding of tomography and basic understanding of ONE – TWO scan types OR • Shows basic understanding of at least TWO appropriate scan technologies	2–3
• Shows basic understanding of an appropriate scan technology OR • Shows basic understanding of tomography	1

Answers could include:

Tomography is a technique in which the body is "sliced" into thin sections and information from each section can be analysed to detect abnormalities. Each slice is further divided into voxels and some measurement is made regarding each voxel. This requires powerful computers to process, manage and present huge amounts of information. Since the voxels are so small, we can generally obtain good detail in the images. We can also rearrange the information to obtain views from a range of different angles. This provides improved diagnostic abilities.

The information being presented varies with the imaging technique. CT scans are based on the X-ray absorption of each voxel. X-rays are directed at the patient and the amount of X-radiation transmitted is used to calculated absorption. Many measurements from different angles allows for precise values of absorption to be determined. MRI scans are based on the radio signal emitted by each voxel after a NMR process. This essentially allows for the H content of each voxel to be determined and hence its water content, thereby providing a powerful diagnostic tool. PET scans are based on the gamma radiation emitted from each voxel when electrons in the body interact with positrons produced by certain radioisotopes. Although PET images are less clear than MRI or CT scans their value as assessors of function and therefore early detection, have improved our diagnostic abilities

Question 30 (a) (i)

Outcomes assessed: H7, H10

MARKING GUIDELINES

Criteria	Marks
• Shows how the production of emission and absorption spectra are different	3
• Outlines the production of emission and absorption spectra OR • Describes the production of ONE emission or absorption spectra	2
• Outlines either emission or absorption spectra	1

Answers could include:

Emission spectra appear as coloured lines on a dark background. They are produced when excited electrons return to their original energy levels. They emit energy in specific amounts that correspond with the frequencies of the coloured lines observed. These frequencies are characteristic for each element. Absorption spectra can be considered the "negative" of emission spectra. They appear as a continuous spectrum with dark lines at certain frequencies. These "missing" frequencies correspond with energy absorbed by electrons in the atoms in the gas that absorb these frequencies.

Question 30 (a) (ii)

Outcomes assessed: H7, H10

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of two relevant characteristics of stars and their motion	3
• Outlines ONE relevant characteristic of stars and their motion OR • Outlines TWO relevant characteristics	2
• Outlines ONE relevant characteristic or their motion	1

Answers could include:

Spectroscopy can provide information about the outer layers of stars. These can present absorption spectra that reveal the types and relative abundances of the elements present. Spectral analysis can also reveal surface temperature as this is the energy that excites electrons to move to higher energy states that produces spectra. Temperature can be deduced from the spectra observed. The frequencies of the EMR produced by a star can be altered to the observer by its motion – Doppler shift can reveal information about the motion of the star.

Question 30 (b) (i)

Outcomes assessed: H10, H12

MARKING GUIDELINES

Criteria	Marks
• Correctly substitutes into correct formula to calculate how much brighter Sirius A is	2
• States correct formula with an error in substitution	1

Answers could include:

17.5 times brighter

$I_{\text{Sirius A}}/I_{\text{Bellatrix}} = 100^{(1.64 - -1.47)/5}$

Question 30 (b) (ii)

Outcomes assessed: H10, H12

MARKING GUIDELINES

Criteria	Marks
• Correctly substitutes into correct formula to calculate the distance from Earth to Regulas A (including units)	2
• States correct formula with an error in substitution	1

Answers could include:

24.7 pc

$-0.52 = 1.35 - 5 \log(d/10)$

Question 30 (b) (iii)

Outcomes assessed: H9, H10

MARKING GUIDELINES

Criteria	Marks
• Describes determination of colour index • Provides reasons for cooler stars being more positive than hotter stars	3
• Outlines determination of colour index and provides reason for the colour index value for EITHER cooler OR hotter stars OR • Provides reasons for cooler stars being more positive than hotter stars	2
• States colour index = B –V OR • Provides reason for the colour index value of EITHER cooler OR hotter stars OR • Outlines colour and magnitudes	1

Answers could include:

Colour index is the difference between the photographic magnitude of a star (B - its magnitude as measured with a blue filter therefore the blue light it emits) and its visual magnitude (V - its magnitude as measured with a yellow-green light filter and therefore the yellow-green light it emits) ie CI = B-V. Cooler stars are towards the red end of the temperature spectrum, so are brighter through a V filter than a B filter. This means that they have a more negative V than B (since these are measurements of magnitude), giving a positive CI value.

Question 30 (c) (i)

Outcomes assessed: H7, H9, H10

MARKING GUIDELINES

Criteria	Marks
• Provides features and characteristics of both processes	2
• Provides features of ONE process OR • Outlines TWO processes	1

Answers could include:

There are two main physical processes that lead to the formation of a star. One is gravitational collapse (causing contraction and resulting from gravitational attraction between the particles of matter) and the other is outward pressure (causing expansion and resulting from the increase in temperature as KE is transformed into heat as the particles of matter slow down). When these two processes are balanced a new star is formed.

Question 30 (c) (ii)

Outcomes assessed: H7, H9, H10, H13

MARKING GUIDELINES

Criteria	Marks
• Shows how the type of reactions at BOTH positions are similar/different	2
• Outlines type of reactions at ONE position OR • Identifies type of reactions at BOTH positions	1

Answers could include:

At position X the star is helium burning, through the triple alpha reaction, which results in C and O being produced. Position Y is on the main sequence and therefore hydrogen burning; in this position the H burning is occurring through the CNO cycle predominantly and involves C as a catalyst.

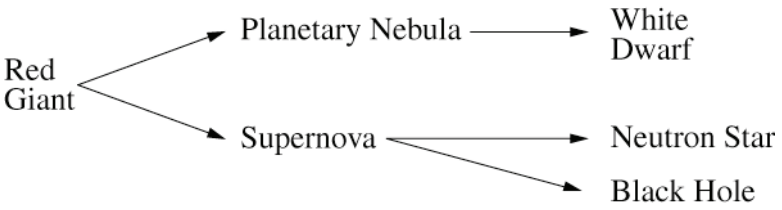
Question 30 (c) (iii)

Outcomes assessed: H7, H9, H10, H13

MARKING GUIDELINES

Criteria	Marks
• Provides a diagrammatic representation that shows a sequence by including possible outcomes with pathways followed	2
• Provides a diagrammatic representation that shows a sequence OR • Provides correct information NOT in flowchart	1

Answers could include:



Question 30 (d)

Outcomes assessed: H7, H9, H10, H14

MARKING GUIDELINES

Criteria	Marks
• Provides detailed description of both binary and variable stars • Shows how observations are used to infer physical properties • Relates the two • Demonstrates a coherent and logical progression and correct use of scientific principles and ideas	6
• Provides a discussion of both binary and variable stars and some properties that can be inferred OR • Provides a detailed discussion of binary AND variable stars relating observations to physical properties	4–5
• Provides a general discussion of binary and variable stars with one property that can be inferred OR • Provides a discussion of binary OR variable stars and some properties that can be inferred	2–3
• Outlines binary and/or variable stars and/or ONE piece of relevant information	1

Answers could include:

Direct measurement in astronomy is limited, and most knowledge we have about stars is inferred, based on relationships between physical quantities. Binaries and variable stars can provide us with information in this way. Binary stars are pairs of stars that are orbiting around each other, which may not always be obvious. Visual binaries are binaries in which both stars can be seen using a telescope. In these cases we can measure the period of their motion and the distance between them (by trigonometric parallax). Using this information the total mass of the system can be determined if x to centre of mass of one star is known then individual masses can be determined. Measurement of changes in brightness can indicate when one moves into the shadow of the other, as in eclipsing binaries.

Measurement of Doppler shift in spectroscopic binaries can reveal motion otherwise undetectable. Study of binary systems has also shown a relationship between luminosity and mass, so if luminosity is known (from brightness measurement), then mass can be determined. Variations such as Cepheid variable stars show distinct variation of luminosity with time. If period can be measured then luminosity determined, which can then be used to determine absolute magnitude. Since apparent magnitude can be measured, the distance modulus formula can be used to calculate its distance.

Question 31 (a) (i)

Outcomes assessed: H11

MARKING GUIDELINES

Criteria	Marks
• Sketches in general terms both the method of producing the emission of light AND the method of observing that the spectrum consists of lines	2
Outlines EITHER • The method of producing the emission of light OR • The method of observing that the spectrum consists of lines	1

Answers could include:

We applied a high voltage (may include the source of the high voltage) to a glass tube containing hydrogen at low pressure to produce a discharge ('spark').

We observed the light using a spectrometer (to break the light into its colours/wavelengths) and noted that we did not get a rainbow (continuous spectrum) but only had a number of coloured lines.

Question 31 (a) (ii)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Links an aspect of the Bohr model with the observed spectrum	2
• Makes a statement about the Bohr model AND/OR the spectrum but does not link the two	1

Answers could include:

The Bohr model states that electrons exist inside the atom in discrete orbits with different energy levels. The electrons only emit or absorb energy when they move from one level to another. The energy involved corresponds to the difference between levels, so the electrons can only emit specific amounts of energy in transitions, ie specific wavelengths. Hence only some wavelengths of radiation are observed as seen in investigation.

Question 31 (a) (iii)

Outcomes assessed: H7, H10, H11, H12

MARKING GUIDELINES

Criteria	Marks
• Sketches in general terms a feature of spectra that cannot be explained using the Bohr model	2
• Names a feature that cannot be explained using the Bohr model	1

Answers could include:

Different intensity of spectral lines. This means that there must be more electrons making one particular transition than there are electrons making other transitions. So, there are more emissions of one wavelength than there are emissions of other wavelengths, making one line brighter than others. This was not predicted by the Bohr model.

Question 31 (b) (i)

Outcomes assessed: H12

MARKING GUIDELINES

Criteria	Marks
• States the numbers correctly	1

Sample answer:

90 protons, 137 neutrons

Question 31 (b) (ii)

Outcomes assessed: H7

MARKING GUIDELINES

Criteria	Marks
• Writes the correct equation, including balanced and atomic mass in words or symbols	2
• Writes an equation for the transition with at most one mistake or omission	1

Sample answer:

Francium-223 → Astatine-219 + α
Or
$Fr^{223} \rightarrow At^{219} + \alpha$

Question 31 (c) (i)

Outcomes assessed: H7, H10, H12, H14

MARKING GUIDELINES

Criteria	Marks
• Shows an understanding of the meaning of the term 'mass defect' • Finds the total mass of the components • Shows the difference between this mass and the mass of Carbon-12	3
• Shows an understanding of the meaning of the term 'mass defect' • States that the sum of the components must differ by the stated amount from the atomic mass of Carbon-12 without any calculation	2
• Makes a correct statement about mass defect OR • Attempts to calculate the mass	1

Sample answer:

Mass defect is the difference between the sum of the masses of the particles that make up an atom and the mass of one atom.

Mass of 6 protons + mass of 6 neutrons + mass of 6 electrons = 2.0093×10^{-26} kg = 12.0969 amu = 12.097 amu
Mass of Carbon-12 atom = 12.000 amu (or u)
Hence mass defect = 12.097 – 12.000 = 0.097 amu (or u)

Question 31 (c) (ii)

Outcomes assessed: H7, H14

MARKING GUIDELINES

Criteria	Marks
• Correctly calculates giving appropriate units	1

Sample answer:

90.4 MeV

Question 31 (d) (i)

Outcomes assessed: H7, H9, H10, H11

MARKING GUIDELINES

Criteria	Marks
• Uses a diagram to show the main features of the basic workings of any particle accelerator	2
• Outlines the basic workings of any particle accelerator without a diagram of the same accelerator OR • Provides a basic diagram of an accelerator but no outline of its workings	1

Answers could include:

A linear accelerator works by sending a charged particle like a proton down a series of tubes with alternating voltages applied to them. As the proton approaches one tube it has negative voltage attracting it. As it is about to leave the tube, the voltage reverses, the tube it is leaving becomes positive and the next tube becomes negative.

Question 31 (d) (ii)

Outcomes assessed: H7, H9, H10

MARKING GUIDELINES

Criteria	Marks
• Provides some features of the model (the methods of classifying) and some components (the types of particles) giving examples of how the model is applied	3–4
• Describes some features of the model OR • Describes some components of the model	1–2

Answers could include:

Standard model henz families of particles

- Leptons – no strong interactions
- Quarks – that make up hedrons
- Particles that give rise to the interactions:

photons
- Gluons for strong interaction
- Em interactions
- W&Z particles for weak interaction
- Graviton for gravitational interaction

Question 31 (e)

Outcomes assessed: H1, H5, H10, H14

MARKING GUIDELINES

Criteria	Marks
• Names TWO physicists and outlines the work of each • Shows how the work of the two physicists fitted together • Relates their work to new direction for further investigation • Demonstrates logical and coherent progression with correct use of scientific principles and ideas	5–6
• Names TWO physicists and outlines the work of each AND describes how the work of the two physicists fitted together OR • Names TWO physicists and outlines the work of each AND outlines how this led to new understanding of observed phenomena	3–4
• Names ONE physicist and outlines how a new concept put forward by this person led to new understanding of observed phenomena OR • Names TWO physicists and their work but does not show how their work fitted together	1–2

Answers could include:

Rutherford's experiment scattering alpha particles off gold foil, led him to believe that the atom was made of a nucleus with a lot of empty space and electrons moving around the outside of the nucleus.

Bohr had developed a theoretical model of the atom, based on a number of assumptions that were not readily obvious. This model included orbits in which electrons could exist without emitting radiation. Electrons would only emit or absorb radiation as they moved from one orbit to another.

Rutherford's work gave support to Bohr's model while the two combined provided a new understanding by explaining the observed line spectra of hydrogen.

Question 32 (a) (i)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates an understanding that the linear IC element size determines the number of devices that can be manufactured on a given area of silicon • Relates an understanding that the processing and storage capability of a computer system is proportional to the number and speed of its component semiconductors • Demonstrates knowledge that these advances have increased computing performance many orders of magnitude over the interval 1970-2000	3
• Two of the above	2
• One of the above	1

Answers could include:

- The IC element size determines the minimum size of a transistor in an IC.
- As the linear size of the component transistors is reduced, the number of transistors that can be manufactured within a given area changes as one over the linear size squared.
- As the linear size of the transistors and other elements decreases, the speed of these components increases.
- The processing and storage capability of a computer is proportional to the number and speed of the transistors used to construct it.
- Because the linear size of IC element sizes has decreased by a factor of > 200 over 1970-2000, the processing capability of computers has increased by a factor of more than 10^7.

Question 32 (a) (ii)

Outcomes assessed: H7, H9, H12

MARKING GUIDELINES

Criteria	Marks
• Correctly identifies that such an extrapolation predicts an IC element size of ~0.1 nm • Demonstrates knowledge that elements will be subject to quantum effects and this implies that alternative technology must be developed to replace current IC technology	2
• Any one of the above	1

Answers could include:

- An extrapolation predicts an IC element size of ~0.1 nm in 2040.
- Element this size will be subject to quantum effect.

The physical principles behind the operation of current ICs are not compatible with elements of this size. This implies that alternative technology must be developed to replace current IC technology.

Question 32 (b) (i)

Outcomes assessed: H7, H9

MARKING GUIDELINES

Criteria	Marks
• Provides features of the property by identifying an infinite/very high gain EITHER – Infinite input resistance/the amplifier does not load the source circuit OR – Zero output resistance/the amplifier output signal is not dependent on the load	2
• Identifies ONE of the above	1

Answers could include:

- Infinite input resistance/the amplifier does not load the source circuit.
- Zero output resistance/the amplifier output signal is not dependent on the load.
- Infinite/very high differential gain.

Question 32 (b) (ii)

Outcomes assessed: H7, H9

MARKING GUIDELINES

Criteria	Marks
• Demonstrates understanding that this resistor is involved in the feedback configuration of the amplifier	1

Sample answer:

This is a negative feedback resistor that supplies a signal (proportion to the output) to the inverting input of the amplifier.

Question 32 (b) (iii)

Outcomes assessed: H7, H9

MARKING GUIDELINES

Criteria	Marks
• Demonstrates understanding that this portion of the circuit sums the input signals	1

Sample answer:

This is a summing circuit that sums (with equal weighing) two input signals.

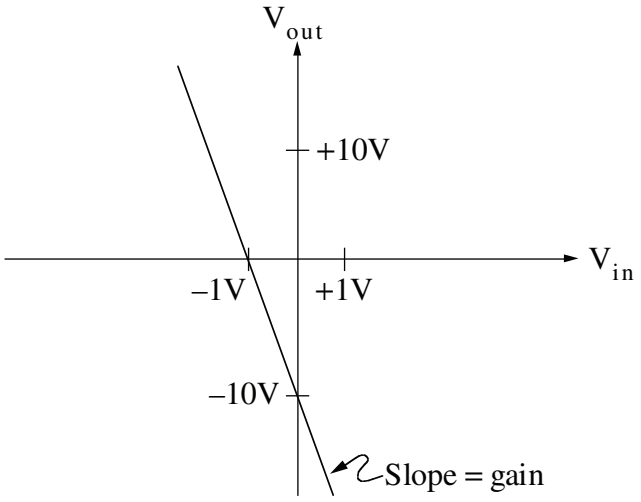
Question 32 (b) (iv)

Outcomes assessed: H7, H12, H13

MARKING GUIDELINES

Criteria	Marks
• Sketches a negative gradient line • Correctly identifies a single data point • Correctly identifies a second data point or the gradient	3
• TWO of the above	2
• ONE of the above	1

Sample answer:



$$= \frac{\Delta V_{out}}{\Delta V_{in}}$$

$$= -10$$

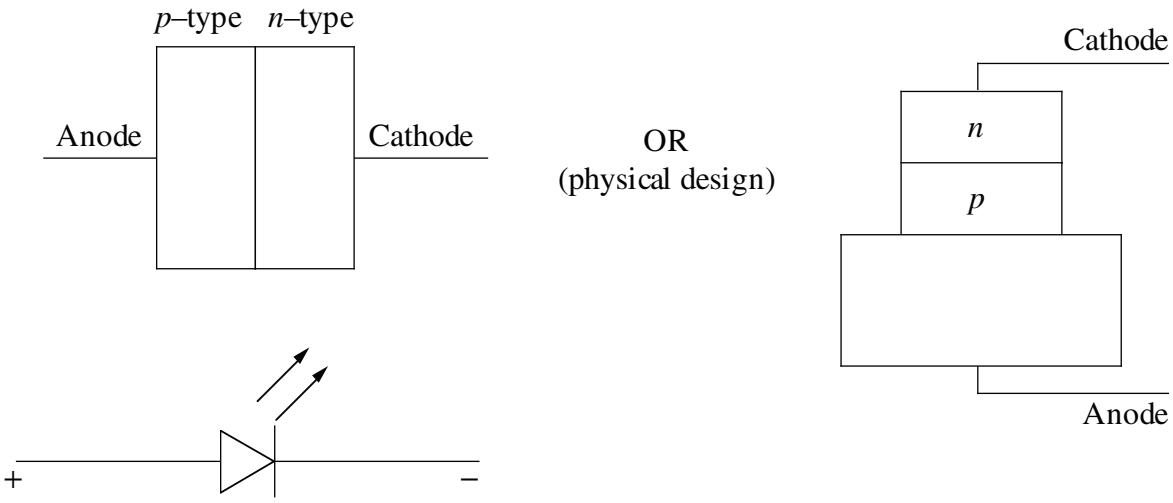
Question 32 (c) (i)

Outcomes assessed: H7

MARKING GUIDELINES

Criteria	Marks
• Demonstrates understanding that the LED is based on a p–n junction • Demonstrates understanding that the application of an appropriate energy to the device injects holes and electrons that recombine at the junction, emitting light	2
• Demonstrates knowledge that LEDs are based on p–n junctions OR • Demonstrates understanding that light is produced by the recombination of electrons and holes at the junction	1

Answers could include:



- *p–n* junction with metal contacts.
- When potential is applied to anode & cathode (+, –) holes are injected into the anode and electrons into the cathode. These meet and recombine at the junction emitting light that is characteristic of the energy gap at the semiconductor.

Question 32 (c) (ii)

Outcomes assessed: H7

MARKING GUIDELINES

Criteria	Marks
Shows why LEDs are preferable to incandescent bulbs by referring to: any TWO of: – LEDs are electrically more efficient at producing light – LEDs are mechanically more robust – The lifetime of LEDs is much longer than incandescent bulb	2
• Any ONE of the above	1

Answers could include:

- LEDs are in general much more efficient at converting electric power into light → longer battery life.
- The filament of an incandescent bulb is very fragile where as LEDs are mechanically robust → less likely to break during use.
- The lifetime of LEDs is much longer than typical incandescent bulbs → lifetime is longer.

Question 32 (d)

Outcomes assessed: H7

MARKING GUIDELINES

Criteria	Marks
• Constructs a truth table and correctly determines all 8 values for *D*	3
• Constructs a truth table, correctly showing the correct outputs for the majority of possible inputs • Correctly determines 5 or more of the output terms	2
• Demonstrates an understanding of how to construct a truth table for the logic circuit	1

Sample answer:

A	B	C	D
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

Question 32 (e)

Outcomes assessed: H7, H14

MARKING GUIDELINES

Criteria	Marks
• Demonstrates a thorough knowledge of modern circuits and shows that advances in digital technology have resulted in many orders of magnitude and that these have increased processing and storage capabilities • Shows that circuits interactivity with their environment must measure and/or output analogue signals as the environment is analogue in nature • Provides examples of modern circuits/devices where analogue transducers are critical to the function of the device • Demonstrates logical and coherent progression with correct use of scientific principles and ideas	5–6
• Describes some advances in digital technology and how these have increased processing/storage capabilities • Describes the environment • Provides an example	3–4
• Outlines an advance in digital technology that has increased processing/storage capabilities AND/OR • States that environment is analogue AND/OR • Provides a relevant example	1–2

Answers could include:

- Orders of magnitude increase in processing capacity.
- Many operations that were once performed using analogue circuits are now performed using digital computational techniques or in software.
- However, when the circuit must interact with its environment it must measure or output analogue signals because the environment is analogue in nature.

Examples:

- Digital camera stores and process image information digitally, however the level of light delivered through the lens to the image plane is an analogue quantity; without the analogue image sensor the digital processing capability of the camera is useless.
- Computer thermostat – temperature is an analogue quantity and an advanced modern building environment system is useless without measuring and outputting analogue signals.
- Digital TV – digital signal converted to an analogue transmission is received as analogue, converted to digital, decoded and displayed.
- LDR in camera is used by the processor to determine the exposure time.
- Image sensor in digital camera.
- Capacitive touch sensor in iPod.
- Speaker in MP3 player.