Time Allowed: 40 minutes **Number of questions: 11** **Marks _____ /24**

- Write your answers in the spaces provided.
- Your answer should take up no more than the space provided.
- If you make a mistake cross it out and add the appropriate number or lines of writing to the spare paper attached.

1. Contrast the resistance of a room-temperature metal conductor such as copper with a metal such as niobium that is below its critical temperature. 1M

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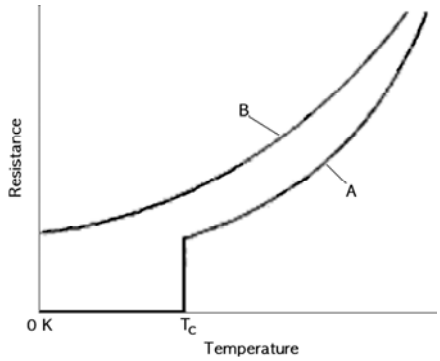
2. The following graph shows how resistance changes with temperature for two different materials, A and B.



Identify the superconducting material and justify your choice. 2M

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3. Outline one advantage of using superconducting material in an electric motor. 2 M

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4. The diagrams below are often used to describe a process that occurs during magnetic resonance imaging. Describe this process with reference to these images. 2M

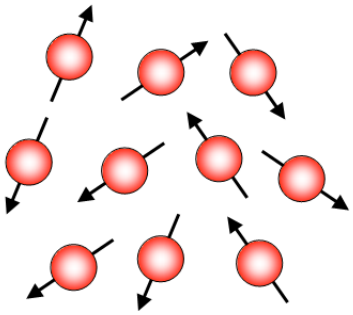

Fig. I

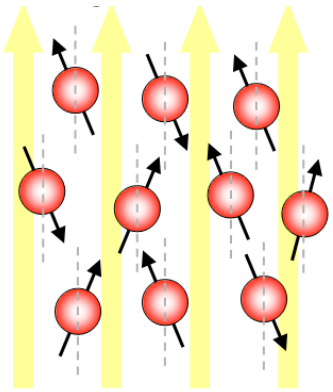

Fig. II

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5. Outline the role of electromagnetic waves in magnetic resonance imaging. 3M

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6. How does a magnetic resonance imaging machine produce the 2 T field required for its operation? 1M

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7. Explain how superconductors are used to make a maglev train levitate. 2M

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8. In the video about the National High Magnetic Field Laboratory that you watched, the following statement was made. "Cutting-edge magnet research will drive the magnetic technologies of the future".
Assess this statement with reference to two significant examples of such technologies. 4M

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9. BCS theory is unable to account fully for the phenomenon of superconductivity.
Identify one limitation of the BCS theory. 1M

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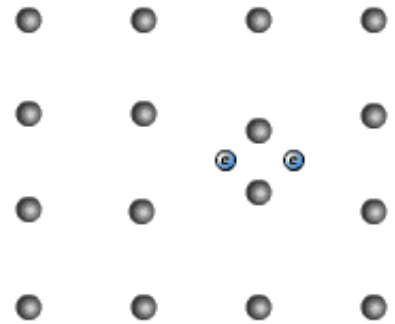
10. A key idea in the BCS theory is the ability of electrons to form pairs. Label the diagram and use it to help to explain the mechanism that allows electrons to move through a superconductor in pairs. 3M



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11. Assess the impact of one application of superconductivity on society. 3M

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End of Task

Q1. Criteria	Mark
States that copper (room temperature metal) has a higher resistance than the niobium below its critical temperature OR states that the room temperature metal has a resistance whereas the niobium has zero resistance.	1

Q2. Criteria	Mark
Names A as the superconductor and states that its zero resistance below Tc is a property unique to superconductors. (The best answer would state that there is an abrupt drop to zero resistance at Tc and that material B has a non-zero resistance at 0 K, distinguishing it from material A)	2
Names A as the superconductor and states that the resistance is zero without mentioning Tc.	1

Q3. Criteria	Mark
Clearly expressed idea links an identified advantage of a superconducting material in an electric motor to its use in the motor or states a reason for the advantage. [Advantages include increased efficiency – but not 100%!, reduced noise, reduced size for a given output, increased torque for a given size]. There must be NO INCORRECT information in the answer to achieve full marks.	2
Identifies an advantage.	1

Q4. Criteria	Mark
States that in figure I, there is no external magnetic field and the proton magnetic moments are randomly oriented and that when an external field is applied (figure II), the proton moments line up in both parallel and antiparallel directions (relative to the field) OR that the alignment is not exactly parallel to the field and this results in precession.	2
States that without an external field the proton magnetic moments are randomly oriented and that when an external field is applied, the proton moments line up in the applied field (but does not refer to the diagrams)	1

Q5. (H8) Criteria	Mark
Identifies the electromagnetic radiation used as being radio waves AND outlines the absorption of energy by protons, the re-emission of radio waves and the detection of these outside the body. [A really good quality answer would mention the processing of detected radio waves by a computer to produce an image]	3
Outlines the absorption of electromagnetic waves by protons, the re-emission of electromagnetic waves (but does not identify the waves as being radio frequency)	2
Identifies one role of electromagnetic waves in the MRI process.	1

Q6. Criteria	Mark
States that the field is produced by an electromagnet made from superconductors.	1
States that either superconductors or an electromagnet is used	0.5

Q7. Criteria	Mark
A clear outline of the components found on the train and the tracks and an explanation of how they interact to levitate the train.	2
An outline of the components or an explanation of how levitation is achieved.	1

Q8. (H3) Criteria	Mark
A judgement of the statement AND Two future technologies outlined AND A clear statement relating the nature of the research to the technology outlined.	4
A judgement and two future technologies OR A judgement, one future technology and a statement about the nature of the research.	3
A judgement and one future technology	2
A judgement or one future technology outlined	1

NOTE : Current technologies such as MRI were not awarded marks unless student demonstrated how these technologies may change as a result of research.

Q9. Criteria	Mark
Identifies one significant limitation (e.g. cannot explain high temperature superconductivity)	1

Q10. Criteria	Mark
Essential features clearly labelled on diagram (must include the cooper pair of electrons and the positive ions of the lattice) AND states that electrostatic attraction of positive ions to the first electron distorts the lattice as shown in the diagram AND that this creates an increase in the positive charge density in that region which attracts a second electron forming a Cooper pair OR that these distortions create a phonon which is absorbed by a nearby electron as it is drawn into the region of positive charge density increasing its momentum and resulting in the formation of the Cooper pair. (Note: 0.5 marks were deducted if the diagram was missing one essential label)	3
Missing one part of the above explanation	2
Missing two parts	1

Q11. Criteria	Mark
Response contains a clear and reasonable "assess" statement of the impact AND identifies a relevant application (e.g. in MRIs) AND provides an outline of at least one significant impact on SOCIETY.	3
Identifies a relevant application (e.g. in MRIs) AND provides an outline of at least one significant impact on SOCIETY but response contains no clear assessment OR response contains a clear and reasonable "assess" statement and Identifies a relevant application but outlines impact(s) on the individual rather than society	2
Identifies a relevant application	1

Plagiarism: In the marking of this task, consideration was given to awarding up to about 6 students zero for the task because of plagiarism. In the end, this action was not taken, however students are reminded that copying work from ANY source and presenting it as your own answer is considered to be plagiarism. Even if the answers are altered versions of the original material, if the original material is still clearly recognisable the BOS will consider it to be plagiarised. You have done a workshop on this and you MUST take this into account. This includes learning answers off by heart in any task, including the HSC. Clearly parts of the science course, such as definitions, even if identical to what is in a textbook will not attract plagiarism concerns. When the answer involves analysing/synthesising information however, and it has been copied – zero marks may be awarded.

Research assessment task – Superconductivity and its applications

This research task will be based on the following dot points from the syllabus modules 9.4 (From Ideas to Implementation) and 9.6 (Medical Physics).

9.4 From Ideas to Implementation

Read the contextual outline in the syllabus document.

9.4.4. Investigations into the electrical properties of particular metals at different temperatures led to the identification of superconductivity and the exploration of possible applications

- describe the occurrence in superconductors below their critical temperature of a population of electron pairs unaffected by electrical resistance
- discuss the BCS theory
- gather and process information to describe how superconductors and the effects of magnetic fields have been applied to develop a maglev train
- process information to discuss possible applications of superconductivity and the effects of those applications on computers, generators and motors and transmission of electricity through power grids

9.6 Option — Medical Physics

Read the contextual outline for this module.

This module increases students' understanding of the history of physics and the implications of physics for society and the environment.

- describe the changes that occur in the orientation of the magnetic axis of nuclei before and after the application of a strong magnetic field
- gather and process secondary information to identify the function of the electromagnet, radio frequency oscillator, radio receiver and computer in the MRI equipment

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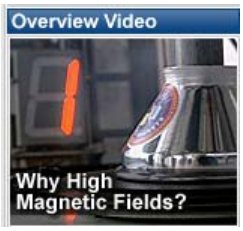
References

You need to look at the following explicit references, however this is not a complete and sufficient list, and you need to access other sources of material relevant to the task.

Superconductors – current research and future developments
http://www.magnet.fsu.edu/education/tutorials/gallery/scorganic.html

Superconductors and MRI
http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/
http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/fullarticle.html
[Including the PDF download]
Watch this video (Icon to right)



http://www.magnet.fsu.edu/mediacenter/publications/flux/vol2issue1/animals.html