CHAPTER 13

From superconductors to maglev trains and superconductors

Answers to revision questions

1. (a) Bragg's X-ray diffraction experiment involves directing an X-ray towards a crystal which is mounted in such a way that it is able to freely rotate. The detector then picks up the scattered X-ray. For a detailed description, include the diagram shown in Chapter 13.

   (b) With the equation $n\lambda = 2d\sin\theta$, n is the order of diffraction, which is an integer; λ is the wavelength of the X-ray; d is the average distance between the atoms in the lattice; and θ is the angle between the X-ray and the surface of the lattice such that the interference pattern measured at the detector is a constructive interference. The significance of this equation is such that n, λ and θ can all be measured and are all known quantities, therefore the only unknown quantity, d, can be calculated. This gives a mathematical description of the internal structure of the lattice.

2. An increase in temperature will increase the resistance due to more collisions between the electrons and the lattice. A decrease in temperature will have the opposite effect. Adding impurities will increase the resistance of the metal as this impedes the movement of the electrons.

3. A superconductor can only drop its resistance to zero when it is cooled below its critical temperature.

4. (a) They all have high critical temperatures.

   (b) The higher critical temperatures mean that they are easier to cool down, such as with liquid nitrogen, and therefore they are easier and cheaper to use.

5. The theory to explain superconductivity is the BCS theory. For detail, see Chapter 13. The Cooper pair needs to be mentioned in the explanation.

6. (a) The Meissner effect.

   (b) See Chapter 13.

   (c) If one keeps pushing the magnet down, the magnetic field will penetrate through the superconductor and the superconductivity of the superconductor will break down.

7. (a) 'Maglev' stands for **mag**netic **lev**itation. Levitation refers to the hovering of the train over the ground when it is in operation.

   (b) The fact that the train is hovering over the ground while is being propelled forward means that there is less friction. Less friction means a faster velocity, less energy waste over the friction, less wear and tear, and less maintenance.

   (c) The drawback for maglev trains is that they have to be cooled by coolants, which is expensive and difficult to achieve.

8. This is an open-ended question – you will have your own opinion as to whether to support the proposal or not. However, you need to justify your opinion based on evidence. If you agree with the proposal, then your answer needs to be supported by the advantages of using superconductors for transmission wires; whereas if you are against

the proposal, you must list the disadvantages. Your arguments should be clearly listed and supported with examples, and you also need to provide a conclusion at the end.

9. 'Evaluate' means to describe something and give your opinion on it. As an example, you could describe the current uses of superconductors, whether for maglev trains, supercomputers or transmission wires – of which all are limited by the low temperatures at which the superconductors need to operate. Once superconductors can be made to run at room temperature, this problem will be solved and all applications made cheaper and more efficient.

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