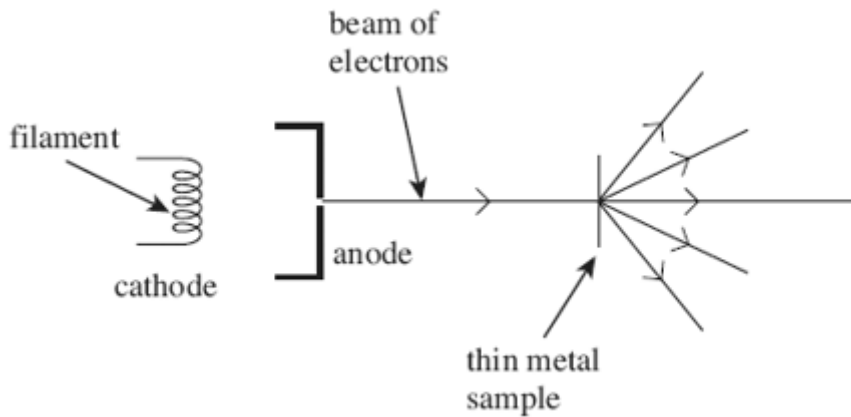


Q1. In the figure below, a beam of monoenergetic electrons is produced by thermionic emission from a wire filament in an evacuated tube. The beam is directed at a thin metal sample at normal incidence and it emerges from the sample in certain directions only, including its initial direction.



(a) (i) Name the physical process occurring at the thin metal sample in the figure above which shows the electrons behaving as waves.

.....

(1)

(ii) Explain why the electrons need to be monoenergetic in order for them to emerge in certain directions only.

.....

(2)

(b) A transmission electron microscope (TEM) operating at an anode potential of 25kV is used to observe an image of a thin sample.

(i) Calculate the momentum of the electrons emerging from the anode, stating an appropriate unit.

answer =

(4)

- (ii) Describe and explain how the resolution of the image would change if the anode potential were increased.

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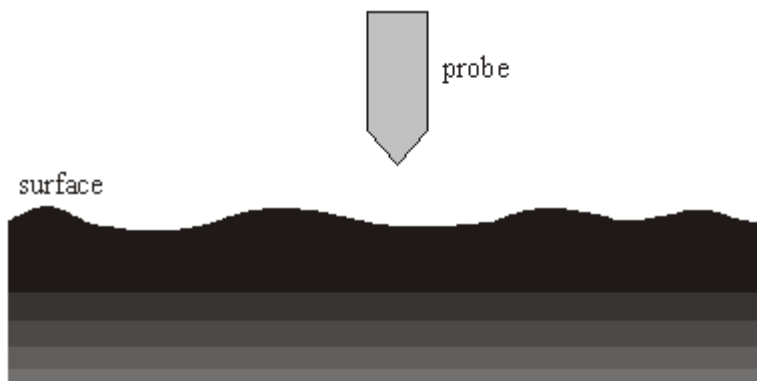
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(3)

(Total 10 marks)

Q2. In a scanning tunnelling microscope (STM), a metal probe with a sharp tip is scanned across a surface, as shown in the figure below.



- (a) Explain why electrons transfer between the tip of the probe and the surface when the gap between the tip and the surface is very narrow and a pd is applied across it.

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(3)

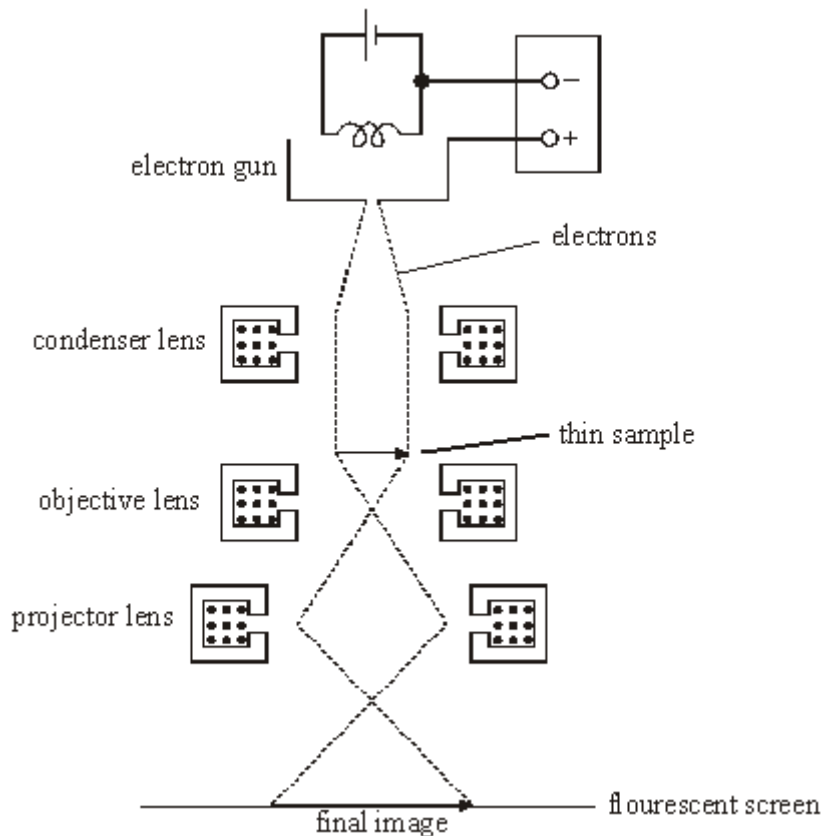
- (b) Describe how an STM is used to obtain an image of a surface.

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(3)

(Total 6 marks)

Q3. In a transmission electron microscope, electrons from a heated filament are accelerated through a certain potential difference and then directed in a beam through a thin sample. The electrons scattered by the sample are focused by magnetic lenses onto a fluorescent screen where an image of the sample is formed, as shown in the figure below.



- (a) State and explain **one** reason why it is important that the electrons in the beam have the same speed.

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(2)

- (b) When the potential difference is increased, a more detailed image is seen. Explain why this change happens.

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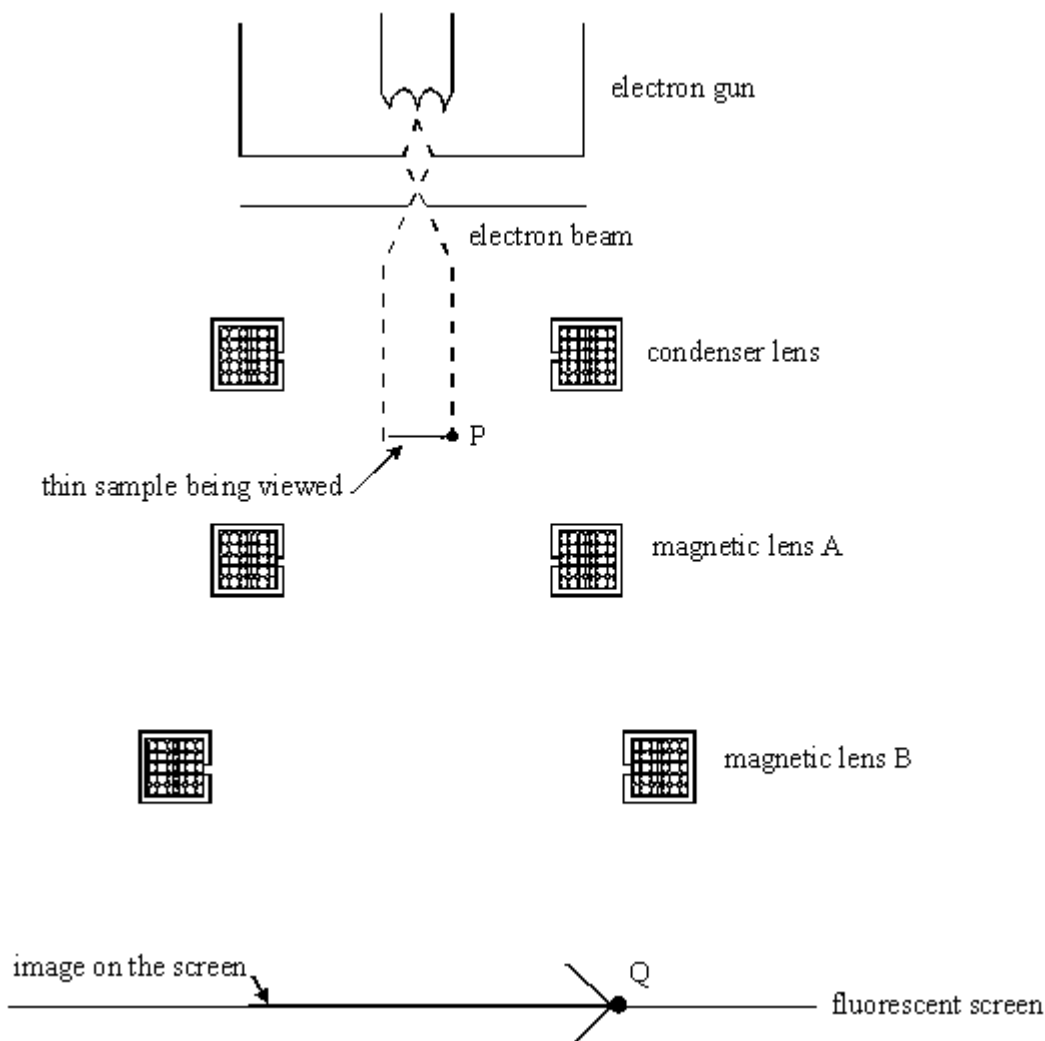
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(3)

(Total 5 marks)

Q4. The diagram below shows a Transmission Electron Microscope. Electrons from the electron gun pass through a thin sample and then through two magnetic lenses A and B on to a fluorescent screen. An enlarged image of the sample is formed on the screen.



- (a) (i) Sketch the path of an electron that reaches point Q on the screen after passing through the sample at point P and through the two magnetic lenses A and B.
- (ii) State the function of magnetic lens A and the function of magnetic lens B.
 magnetic lens A

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.....
magnetic lens B
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.....

(4)

(b) Explain why greater image detail is seen when the anode voltage is increased.

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(3)

(Total 7 marks)

Q5.(a) In the Scanning Tunnelling Microscope (STM), electrons cross a gap between a sharp metal tip and a conducting surface when the gap is small and a potential difference exists across it.

(i) Explain, in terms of wave particle duality, why an electron can cross this small gap.

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(ii) Explain, why it is necessary for a potential difference to exist across the gap?

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(4)

(b) Calculate the speed of an electron which has a de Broglie wavelength of 1 nm.

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(2)

(Total 6 marks)

Q6.(a) The anode voltage of a certain transmission electron microscope is 20 kV.

Calculate

(i) the speed of the accelerated electrons,

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(ii) the de Broglie wavelength of these electrons.

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(4)

- (b) State and explain how the image of an object observed using this transmission electron microscope in part (a) would change when the anode voltage was increased.

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(2)

(Total 6 marks)