



# **A-Level Physics**

## **X-Ray Imaging**

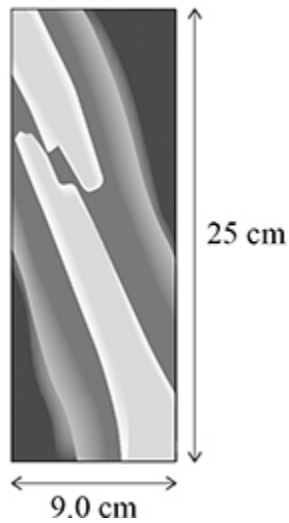
### **Question Paper**

**Time available: 69 minutes**  
**Marks available: 55 marks**

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The figure below shows an X-ray of a broken bone.



mean diameter of bone = 0.040 m

intensity of incident X-rays =  $0.013 \text{ W m}^{-2}$

exposure time of X-ray = 0.80 s

linear attenuation coefficient of bone =  $58.3 \text{ m}^{-1}$

(b) Calculate an estimate for the X-ray energy that is absorbed by the bone.

energy absorbed = \_\_\_\_\_ J

(5)

(c) State **two** reasons why the estimate of energy absorption in part (b) may be greater than the actual value.

1. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**(2)**  
**(Total 11 marks)**

2.

In an X-ray machine, X-rays are emitted from an emission spot on a tungsten target.

Figure 1

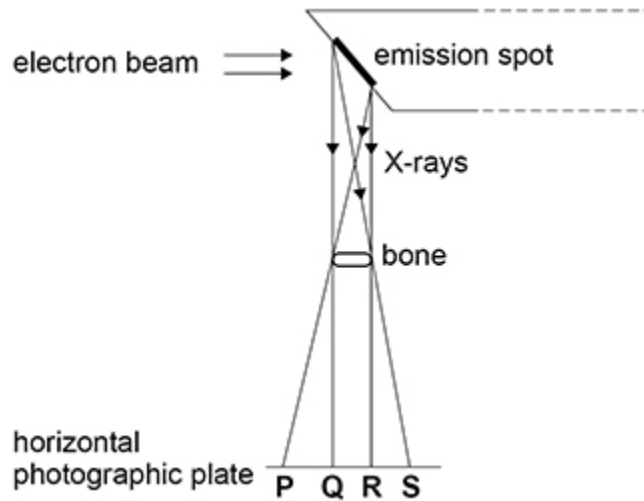


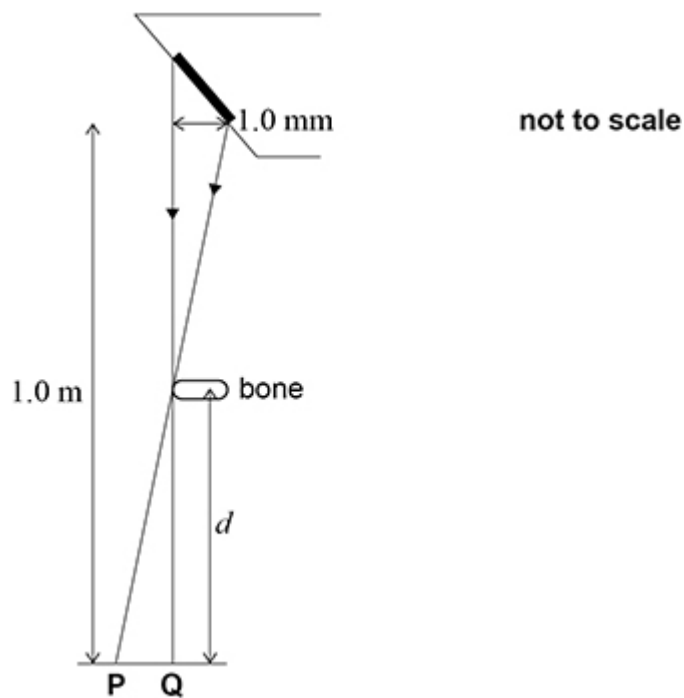
Figure 1 shows how a total shadow is produced in the region **QR** where no X-rays from any part of the emission spot can reach the photographic plate. Partial shadows are formed in regions **PQ** and **RS** where X-rays from only part of the emission spot can reach the plate.

Figure 2 shows detail of the formation of edges of the partial shadow **PQ**.

The bottom of the emission spot is 1.0 m vertically above the plate.

The horizontal distance across the beam is 1.0 mm at the bottom of the emission spot.

Figure 2



- (a) To produce a sharp image of a bone, the partial shadow in region **PQ** must be no more than 0.10 mm wide.

Calculate the maximum distance  $d$  between a bone and the plate.

$$d = \text{_____} \text{ m}$$

**(2)**

- (b) Discuss whether an X-ray image of a chest or an X-ray image of a hand is likely to be sharper when exposed to the same X-ray source.

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**(2)**

**(Total 4 marks)**



- (c) The half-value thickness of lead for 500 keV X-rays is  $4.2 \times 10^{-3}$  m  
Calculate the mass attenuation coefficient of lead for 500 keV X-rays.  
State an appropriate unit for your answer.

density of lead =  $1.1 \times 10^4$  kg m<sup>-3</sup>

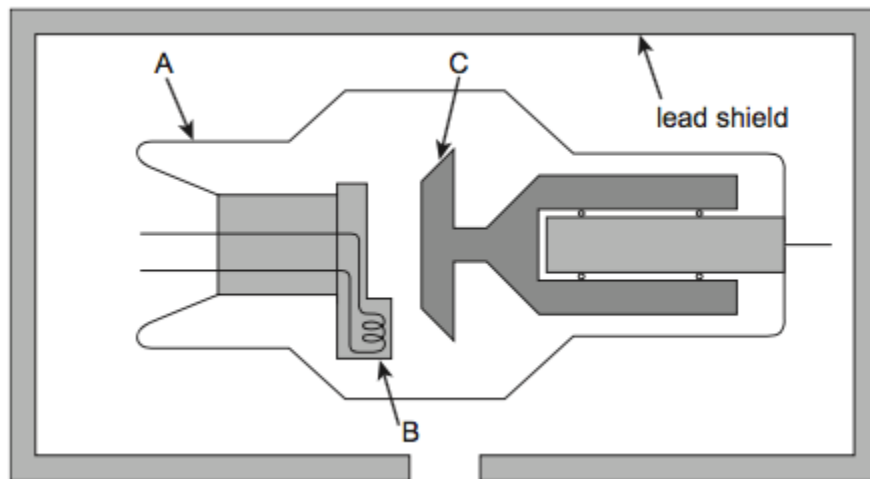
mass attenuation coefficient = \_\_\_\_\_ unit \_\_\_\_\_

(4)

(Total 8 marks)

4.

The diagram shows a simplified modern X-ray tube with a rotating anode.









(b) A film cassette, placed under a patient being X-rayed, is shown in **Figure 2**.

**Figure 2**



Explain how the intensifying screens in the film cassette achieve their purpose and state their benefit to the patient.

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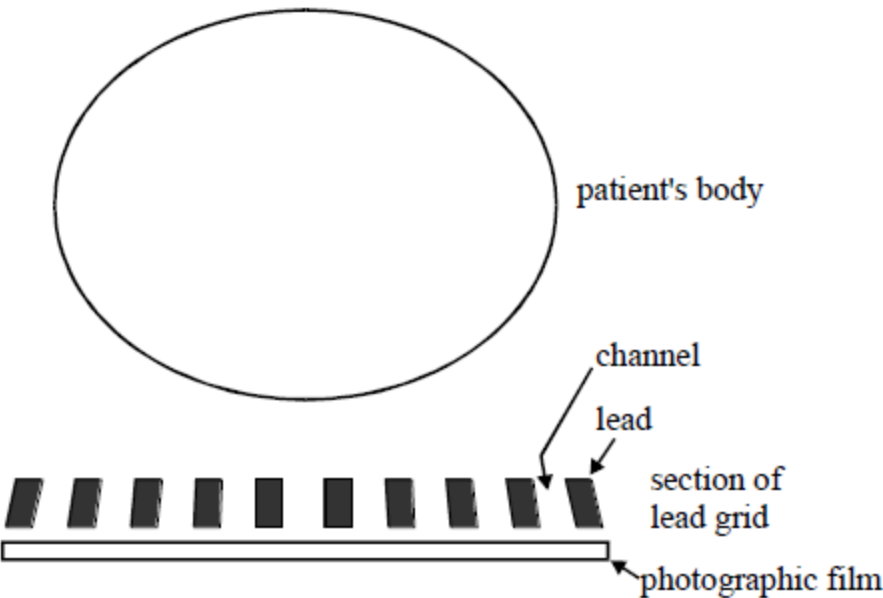
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**(3)**  
**(Total 6 marks)**

6.

When using an X-ray source to produce an image of part of a patient a lead grid is sometimes placed between the patient and the photographic film, as shown in the diagram. The channels in the grid diverge from the X-ray source.

\* X-Ray source



(a) (i) Why is the grid made of lead? \_\_\_\_\_

\_\_\_\_\_

(ii) By drawing the paths of about 10 rays from the X-ray source to illustrate your answer, explain how the use of the grid improves the clarity of the X-ray image.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(5)

(b) Explain why it is important to use a *point source* of X-rays for imaging purposes.

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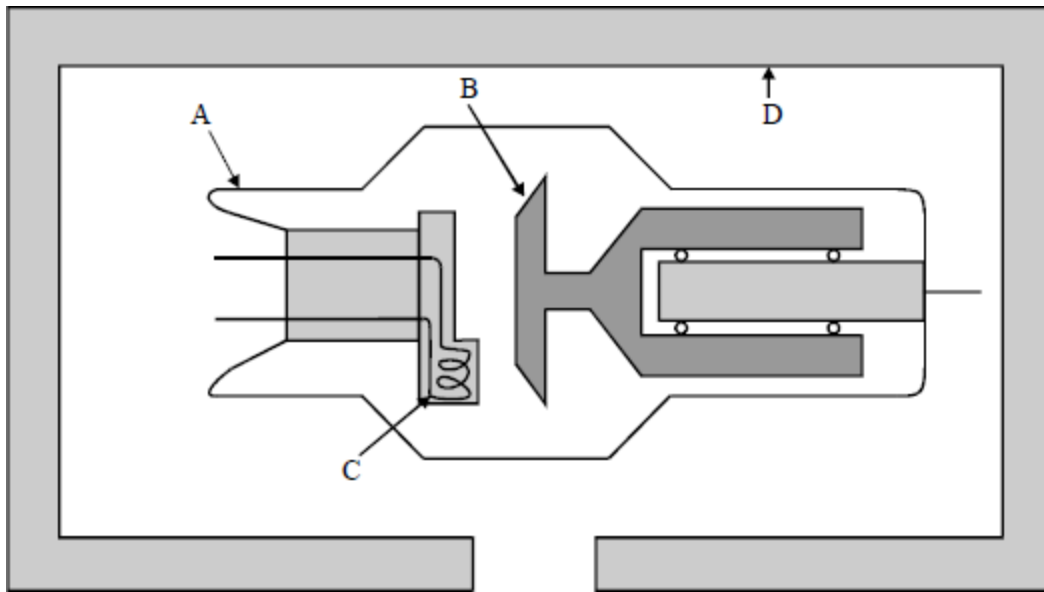
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(1)  
(Total 6 marks)

7. The simplified diagram shows a modern X-ray tube.



(a) For each of the labelled parts, state what it is and explain its purpose.

A name \_\_\_\_\_  
purpose \_\_\_\_\_  
\_\_\_\_\_

B name \_\_\_\_\_  
purpose \_\_\_\_\_  
\_\_\_\_\_

C name \_\_\_\_\_  
purpose \_\_\_\_\_  
\_\_\_\_\_

D name \_\_\_\_\_  
purpose \_\_\_\_\_  
\_\_\_\_\_

**(8)**

(b) On the diagram draw and label

- (i) the direction of the electron beam,
- (ii) the direction of the useful X-ray beam.

**(2)**

**(Total 10 marks)**