Examiner only
*Arholwr yn unig*

**3. Read the passage in the resource folder carefully, before answering the questions which follow.**

Answer the following questions in your own words. Direct quotes from the original passage will not be awarded marks.

*(a)* Why is "pumping" necessary for laser operation (paragraph 4)? [1]

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*(b)* With the use of a simple ray diagram, show how the mirrors ensure that the laser beam is well directed (paragraphs 5-7 and Fig. 2). [2]

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*(c)* Explain the other purposes of the two mirrors in the laser cavity (paragraphs 5-8). [2]

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*(d)* Explain the difference between spontaneous and stimulated emission (paragraphs 9-12 and figures 3-5). [2]

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*(e)* Explain briefly why a population inversion is necessary for laser operation (paragraph 12). [2]

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*(f)* The fact that the F level in ruby is broad means that the pumping of this level is far more probable and successful than if it were a narrow level. Why is this so? (fig. 6 and paragraph 14). [1]

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*(g)* The broad F level in ruby has a short lifetime but the metastable state has a high lifetime. Explain briefly how this assists in obtaining a population inversion (fig. 6 and paragraph 14). [2]

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*(h)* (i) The amplifying medium that fills a laser cavity of length 15·0 cm has a constant gain coefficient of $0{\cdot}084\,m^{-1}$ and an initial intensity of $1{\cdot}00\,\mu Wm^{-2}$. Calculate the intensity of the laser beam after it has travelled a distance of twice its length (i.e. 30 cm) through the amplifying medium using equation 1. [1]

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(ii) The laser cavity has one mirror that reflects 100% of the light incident upon it and another that reflects 98% of the light. Calculate the intensity of the laser beam (inside the cavity) after it has completed a round trip of the laser cavity (i.e. travelling twice its length and reflecting off both mirrors). [2]

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(iii) The laser beam takes 1·60 ns to travel twice the length of the laser cavity. Assuming that the gain coefficient remains constant, calculate the intensity of the laser beam after 1·00 µs. [3]

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(iv) Explain briefly why the laser beam intensity cannot continue to increase at this rate. [2]

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**Turn over.**