


Physics

Question	Maximum Mark	Mark Awarded
#1	7	
#2	8	
#3	10	
#4	11	
#5	11	
#6	13	
Total	60	

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 **Question Bank**
Part of WJEC

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#1

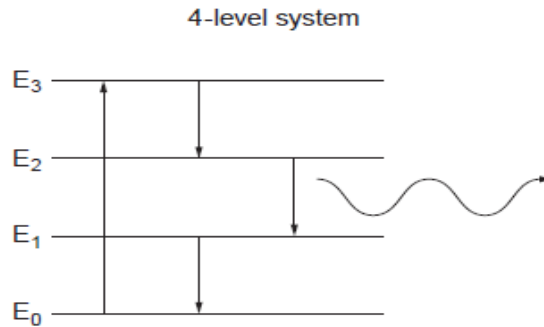
(a) Explain what is meant by stimulated emission of radiation. [2]

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(b) The energy levels of a 4-level laser system are shown.



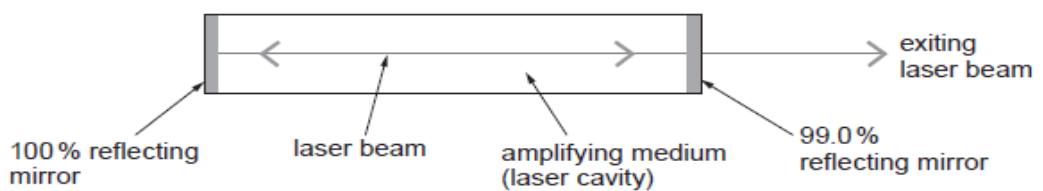
Give **two** reasons why energy level E_1 is always nearly empty. [2]

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(c) Victoria claims that when the laser system shown below is **in equilibrium**, the amplifying medium provides only a 0.5% increase in intensity of the beam each time it travels across the cavity. Her research partner, David, insists that the exponential increase in light intensity provided by the amplifying medium means that the beam intensity is increased by a factor of thousands for each pass even when the laser is in equilibrium. Discuss whether Victoria or David is correct. [3]



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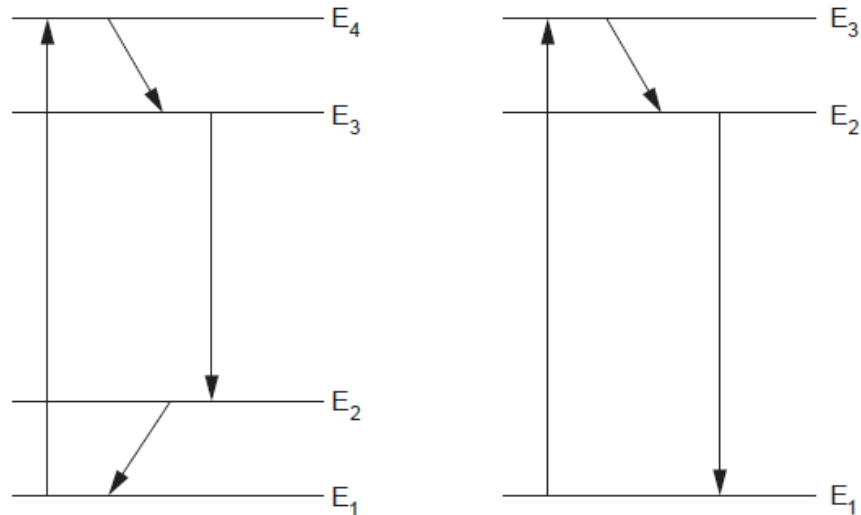
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Question taken from Eduqas examination paper 842103, November 2020

#2

- (a) Label the pumping and stimulated emission transitions in the four and three level laser systems shown below. [2]



- (b) Explain why a population inversion can be achieved far more easily in a four level system than in a three level system. [4]

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- (c) Give two reasons why the top level (E4 in the four level system and E3 in the three level system) must have a short lifetime. [2]

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Question taken from Eduqas examination paper 842103, June 2017

#3

3. (a) (i) Explain why a population inversion is not usually possible with a 2-level energy system pumped using light. [2]

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- (ii) State an advantage of semiconductor lasers and an example of their use. [2]

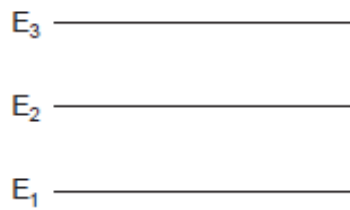
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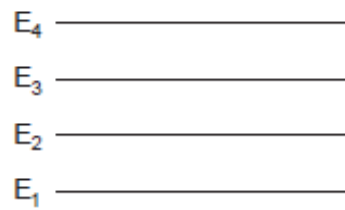
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- (b) Explain how 3-level and 4-level laser systems work and the advantages of a 4-level system. Refer to the diagrams in your answer. [6 QER]

3-level system



4-level system



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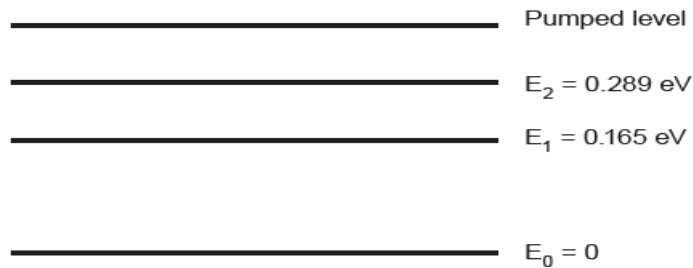
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#4

When sunlight shines on the atmosphere of Mars, carbon dioxide molecules at a height of 75 km behave like the amplifying medium in a laser. The energy levels involved are shown in the following diagram. A population inversion occurs between energy levels E_1 and E_2 .



(a) (i) State what is meant by a population inversion. [1]

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(ii) Explain why a population inversion is needed for laser action. [2]

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(b) Calculate the output wavelength of this naturally occurring laser and determine the region of the electromagnetic spectrum in which it lies. [3]

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(c) The Llanesco crater is on the surface of Mars and has a cross-sectional area of 2290 km^2 . Carbon dioxide molecules in the Mars atmosphere collide with the surface and give rise to a surface pressure of 600 Pa . The mass of a carbon dioxide molecule is $7.3 \times 10^{-26} \text{ kg}$ and the perpendicular component of the speed of the molecules to the surface is 550 m s^{-1} **before** and **after** they collide with the surface. Calculate the number of carbon dioxide molecules that collide with the Llanesco crater in 1 s. [5]

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#5

5. (a) Explain how a 3 level laser operates, explaining also why a 2 level laser is not possible. [6 QER]

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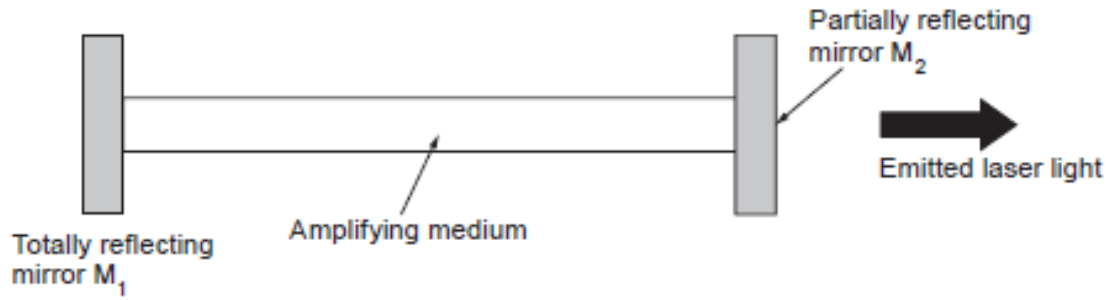
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(b) The simplified diagram shows the cavity of a laser.



(i) The wavelength of light from the laser is 633 nm. Calculate the energy of a photon of light emitted by the laser. [2]

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(ii) The power output of the laser is 1.0 mW. Mirror M₂ transmits 1 in 500 photons. Determine the number of photons per second incident on mirror M₂. [3]

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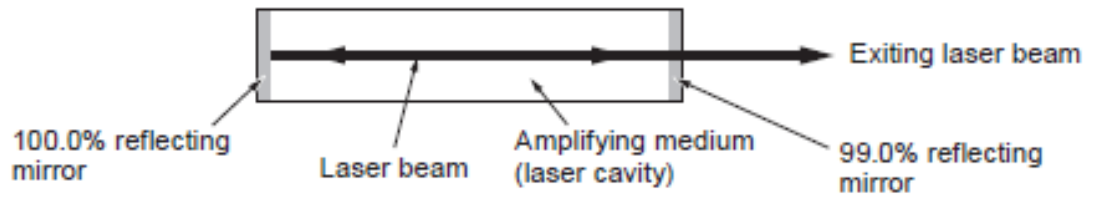
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Question taken from Eduqas examination paper 842002, June 2018

#6

4. A laser has two mirrors either side of the amplifying medium as shown.



(a) Explain the purpose of the 99.0% reflecting mirror and the 100.0% reflecting mirror. [2]

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(b) Explain the purpose of a population inversion in the laser cavity. [3]

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(c) (i) The light intensity inside a powerful laser is $2.0 \times 10^{15} \text{ W}$ and its wavelength is $1.05 \mu\text{m}$. Show that this corresponds to approximately 1×10^{34} photons per second. [2]

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- (ii) Show that the momentum of a $1.05\mu\text{m}$ photon is approximately $6 \times 10^{-28}\text{kg m s}^{-1}$. [1]

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- (iii) Show that the force exerted on a 100.0% reflecting mirror by a beam of power $2.0 \times 10^{15}\text{W}$ is approximately $1 \times 10^7\text{N}$. [2]

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- (iv) Calculate the strain produced in a laser structure if the power of the beam between the mirrors is $2.0 \times 10^{15}\text{W}$. You may assume that the structure of the laser cavity has a cross-sectional area of 43cm^2 and is made of a material with Young modulus $2.8 \times 10^{11}\text{Pa}$. [3]

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Question taken from Eduqas examination paper 842103, June 2018