Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1322/01

PHYSICS – PH2
Waves and Particles

A.M. WEDNESDAY, 5 June 2013

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	8	
2.	9	
3.	13	
4.	10	
5.	12	
6.	10	
7.	10	
8.	8	
Total	80	

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ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

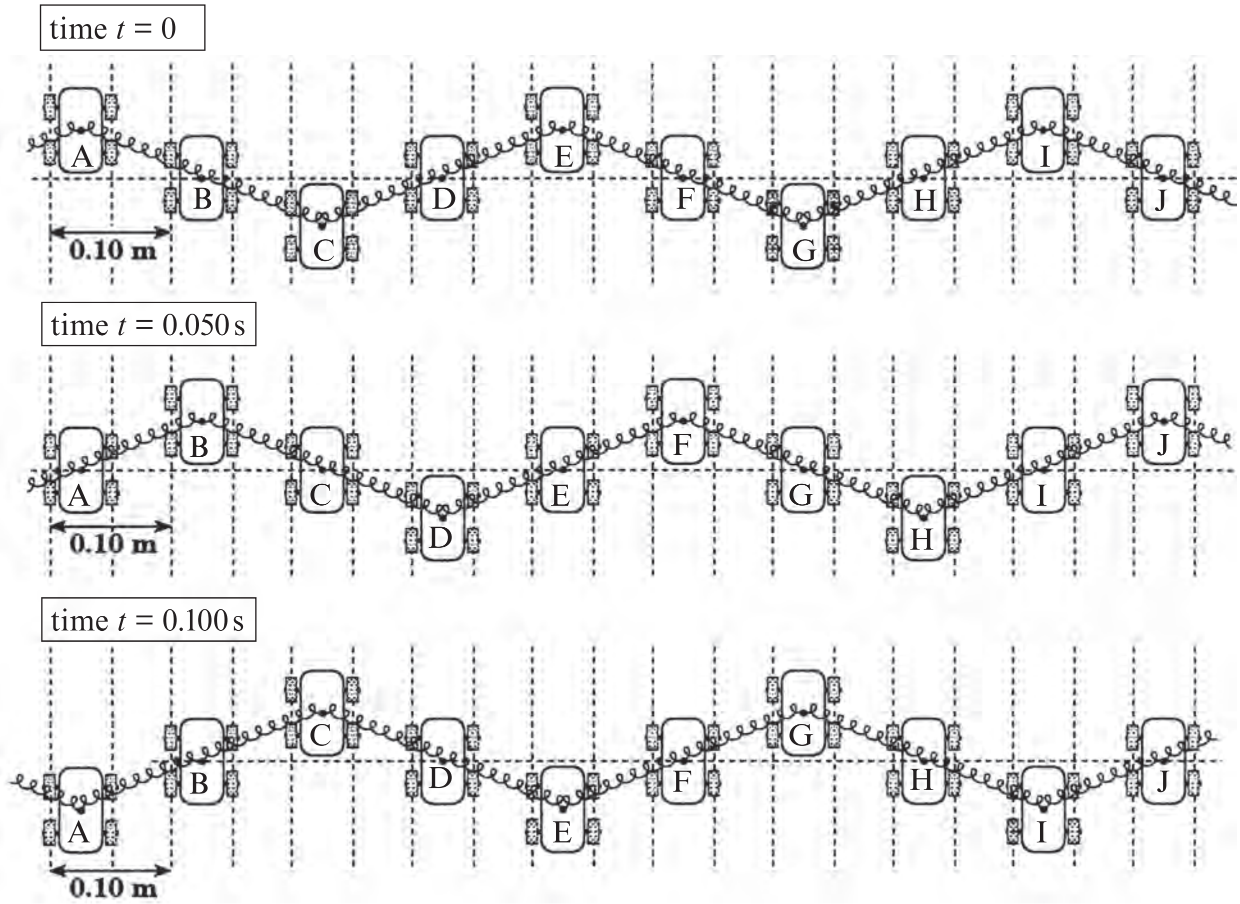
You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer is incorrect.

JD*(S13-1322-01)

Examiner only

1. Shown below are three 'snapshots' (three diagrams at different times) of a transverse wave travelling from left to right along a line of toy cars joined by springs.



(a) Calculate

(i) the wavelength, [1]

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(ii) the periodic time (assuming no car changes its direction of motion between one snapshot and the next), [1]

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(iii) the speed of the wave. [2]

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(b) Which cars are oscillating in phase with car B? .... [1]

Examiner only

(c) (i) Explain why the wave is described as transverse. [2]

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(ii) A *longitudinal* wave can be sent along a line of toy cars linked by springs if the cars are arranged differently. Make a sketch of the arrangement, showing **three** cars. [1]

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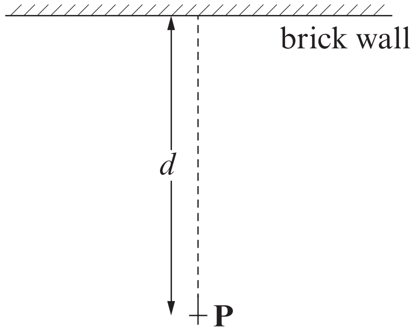
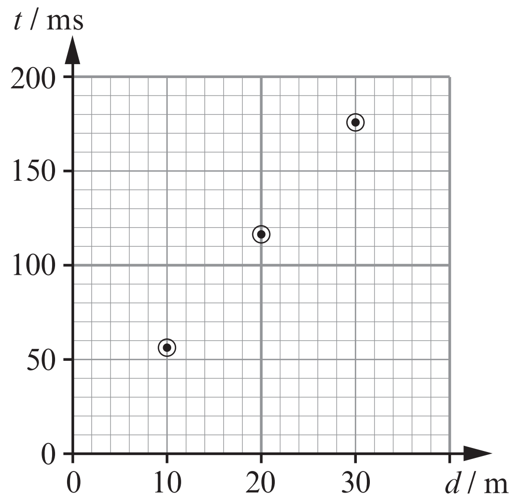
2. To determine the speed of sound, a student claps her hands at point **P**, which is a measured distance, *d*, from a brick wall. A microphone at **P** is connected to a timing device, arranged so as to record the time, *t*, between the original clap and its echo. The experiment is carried out for three distances *d*, and the results are plotted below.





(a) Calculate a value for the speed of sound, showing your working. [2]

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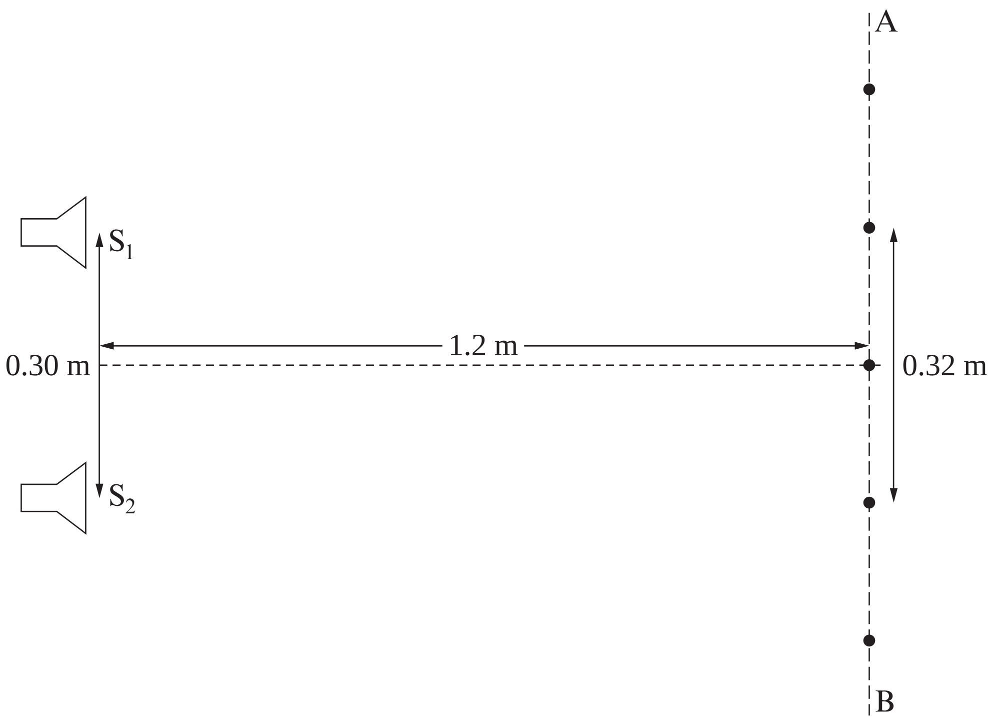
(b) In another experiment the student sets up two small loudspeakers, S_1 and S_2, connected to the same signal generator, set to 8 300 Hz. She moves a microphone along the line AB, and finds maxima of sound at the positions shown by dots, with minima in between.



Examiner only

(i) (I) Use the equation for Young's double slit experiment to calculate a value for the wavelength, λ. [2]

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(II) Hence calculate a value for the speed of sound from this experiment. [1]

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(ii) (I) **Label** with a letter 'M' the particular maximum (one of the dots on the diagram opposite) for which the path difference, $S_2M - S_1M = 2\lambda$. [1]

(II) Explain why the condition, $S_2M - S_1M = 2\lambda$, gives a maximum at M. [1]

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(iii) When the signal generator is set to 300 Hz the student does not find a succession of maxima and minima as the microphone is moved along the line AB. Explain why this is to be expected. [2]

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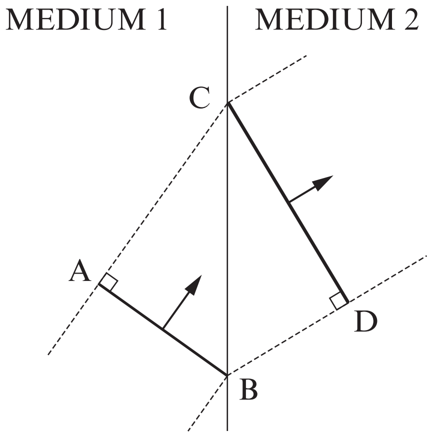
3. *(a)* Explain, in terms of waves, why *refraction* occurs. **Refer to the diagram below in your answer.** [Mathematics is not needed.] [3]



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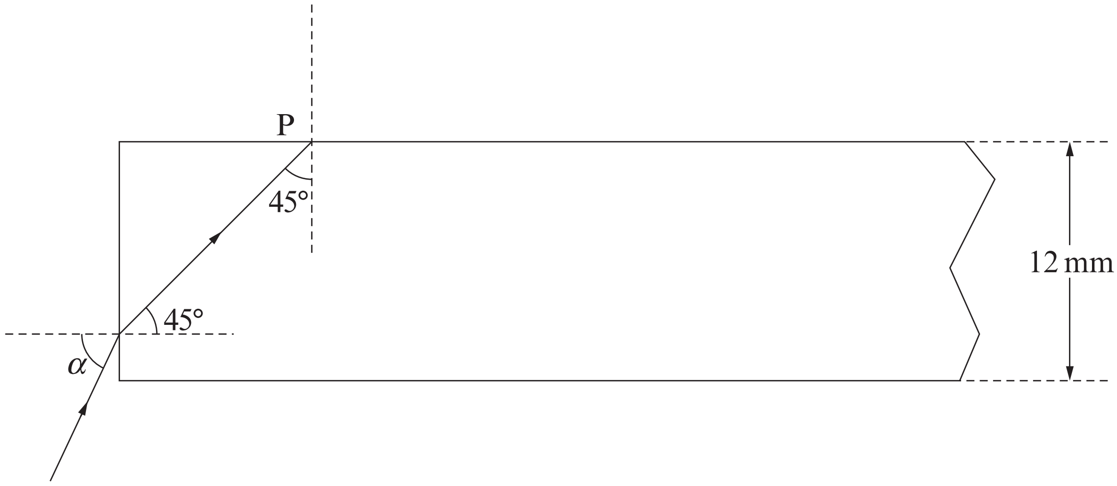
Examiner only

(b) A laser beam is directed on to the end-face of a rod of clear plastic of refractive index 1.33, surrounded by air (refractive index 1.00).



(i) Calculate the angle α. [2]

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(ii) At P, 90% of the light power is refracted out into the air, and 10% is reflected.

(I) **Draw** carefully on the diagram above the paths of the light refracted and reflected at P. The reflected ray need extend no further than the bottom of the rod. [2]

(II) Estimate how far the reflected light travels along the rod **from P** before the power drops to a millionth of the power of the beam incident on P. [Consider successive reflections.] [3]

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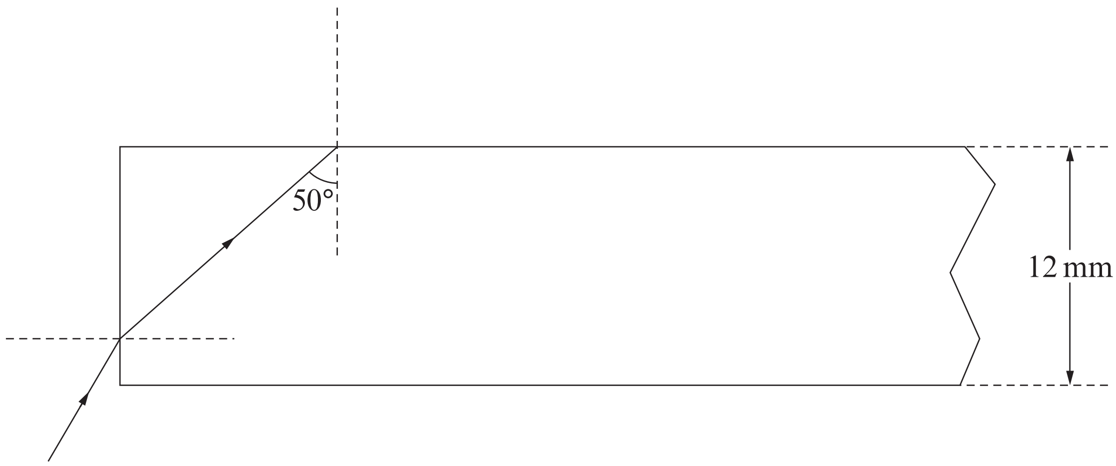
Examiner only

(c) The angle of the laser beam is changed as shown.



(i) By first calculating the critical angle, explain why the laser beam now travels along the rod with no loss of power at reflections. [2]

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(ii) Give the full name of the type of reflection occurring. [1]

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Examiner only

4. *(a)* Explain how a stationary wave can be regarded as being formed from progressive waves. [2]

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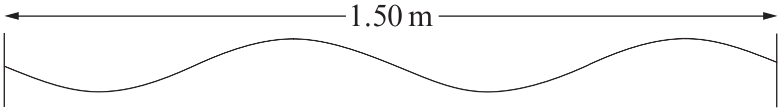
(b) A string, fixed at both ends, vibrates in a stationary wave pattern. The diagram shows the string at a time of maximum displacement.



(i) On the same diagram, **draw** the string

(I) a quarter of a cycle later [label the drawing '**I**'], [1]

(II) half of a cycle later [label the drawing '**II**']. [1]

(ii) The speed, *v*, of the progressive waves on the string is $96\,\mathrm{m\,s^{-1}}$. Calculate the frequency of the stationary wave. [2]

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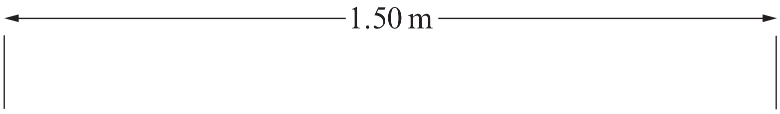
(c) (i) Sketch the string at its maximum displacement when it is vibrating in a stationary wave with a single antinode. [1]



(ii) Calculate the frequency of vibration. [2]

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(d) Write down an equation which gives the frequency of a stationary wave on this string when it is vibrating with a total of *n* antinodes. [1]

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Examiner only

5. *(a)* (i) The threshold frequency for electrons to be emitted in the photoelectric effect is $f_o = \frac{\phi}{h}$. Explain, in terms of energy, why this is so. [3]

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(ii) Explain why increasing the *intensity* of light will not increase the maximum kinetic energy, $E_{k\,max}$, of the emitted electrons. [2]

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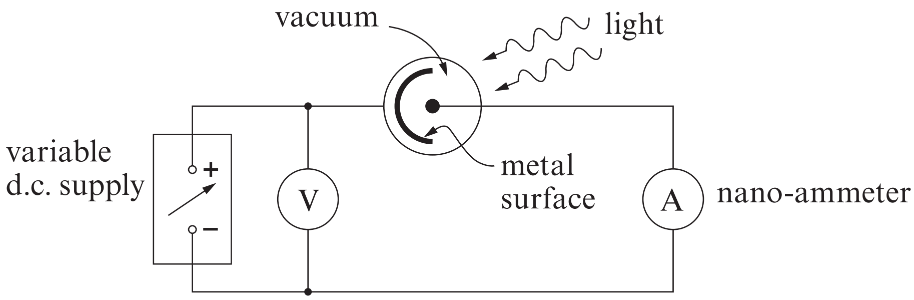
(b) Monochromatic light is shone on to a metal surface in a photocell connected as shown. Describe how you would find the maximum kinetic energy of the emitted electrons. [3]



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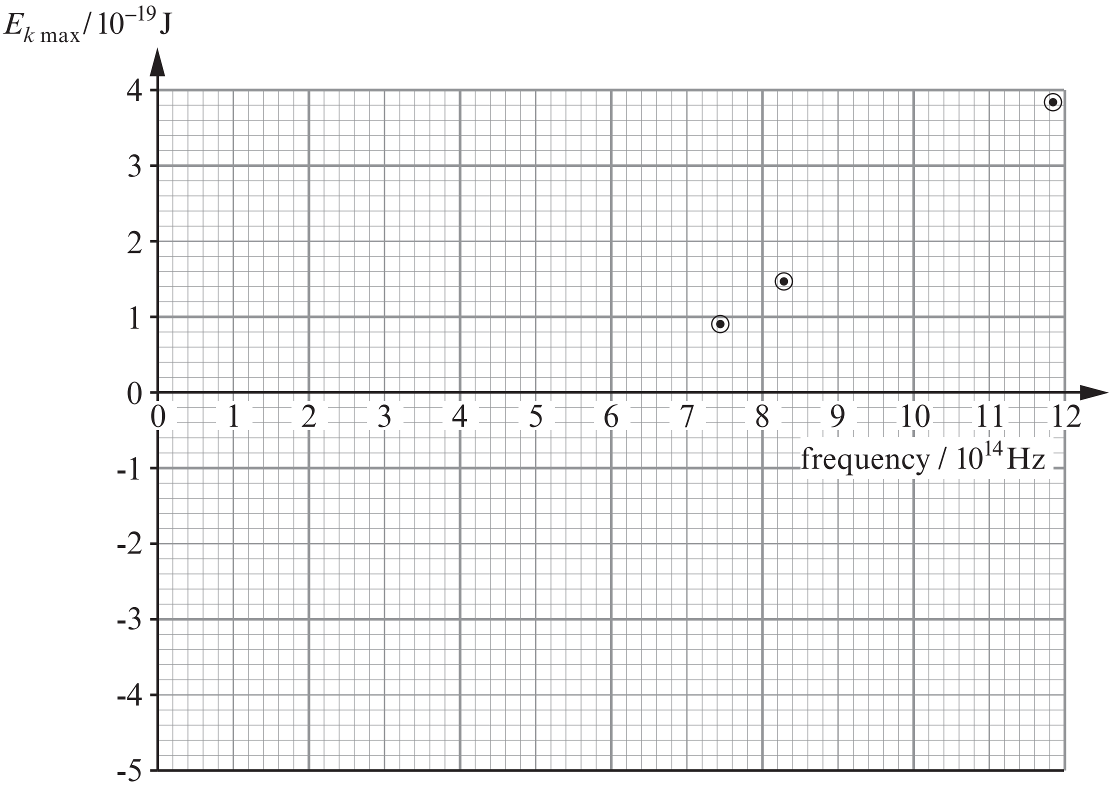
Examiner only

(c) The experiment is carried out, using three known frequencies of light in succession, giving the points plotted on the grid.



(i) Calculate the gradient of the graph and check whether or not it has the expected value, giving your working and conclusion clearly. [2]

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(ii) The metal with the exposed surface in the photocell is known to be one of the five metals whose work functions are listed.

metal	caesium	potassium	sodium	barium	calcium
ϕ / 10^{-19} J	3.12	3.68	3.78	4.03	4.59

Use the graph to determine which of these metals is in the photocell, giving your reasoning. [2]

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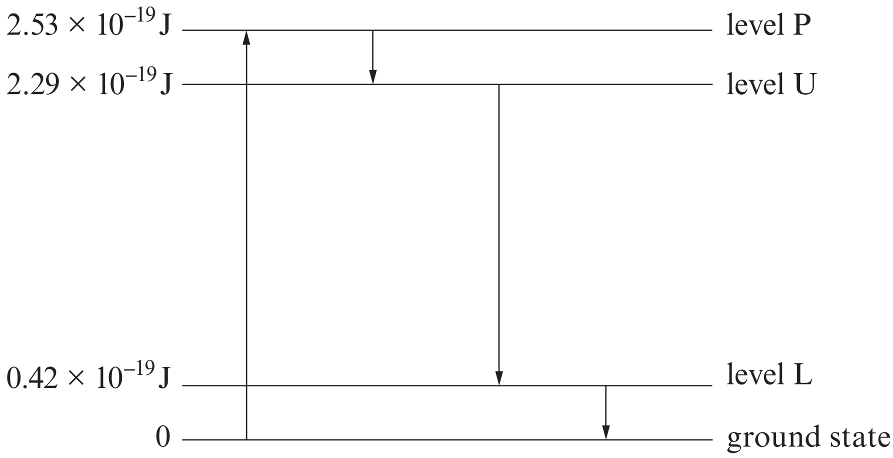
Examiner only

6. A simplified energy level diagram is given for the amplifying medium of a 4-level laser. The useful output of the laser is due to the 'lasing' transition between level U and level L. The laser is *pumped* using photons from an external source.



(a) Calculate the wavelength of

(i) the radiation emitted in the lasing transition, [3]

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(ii) the radiation needed for pumping. [1]

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(b) Pumping is needed to produce a population inversion.

(i) State what is meant by *a population inversion* **for this system**. [1]

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(ii) Explain carefully why a population inversion is needed for light amplification to take place. [3]

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(iii) In a *three* level laser system, level L would be the ground state. Explain why it is an advantage for level L to be *above* the ground state. [2]

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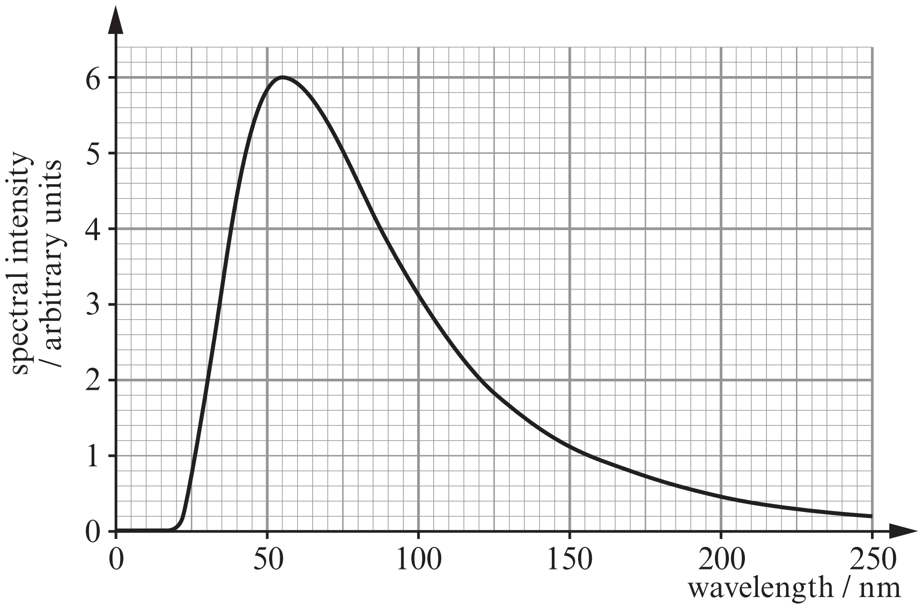
Examiner only

7. One of the hottest stars known is HD93129A in the Carina nebula. Its continuous spectrum is shown.



(a) (i) Name the region of the electromagnetic spectrum in which the wavelength of peak emission lies. [1]

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(ii) Show that the star's temperature is approximately 50 000 K. [2]

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(iii) The star is blue. Explain how this could be deduced from the spectrum. [1]

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Examiner only

(b) (i) The star is 7.10×10^{19} m away, and the intensity of its electromagnetic radiation reaching the Earth is $3.33 \times 10^{-8}\,\mathrm{W\,m^{-2}}$. Show that its luminosity is approximately $5 \times 10^{6} P_{sun}$, in which P_{sun} is the Sun's luminosity (3.84×10^{26} W). [3]

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(ii) Use Stefan's law to calculate the star's **diameter.** [3]

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TURN OVER FOR QUESTION 8

Examiner only

8. *(a)* Discuss why neutrinos and antineutrinos are difficult to detect. [2]

(b) In a special laboratory in Canada neutrinos from the Sun are detected by looking for electrons released in the interaction

$$\nu_e + {}^{2}_{1}\text{H} \rightarrow \text{p} + \text{p} + \text{e}^-$$

The ${}^{2}_{1}\text{H}$ is a deuterium nucleus.

(i) A proton (p) is a baryon. State what is meant by a baryon. [1]

(ii) Explain how *lepton number* and *charge* are conserved in this interaction. [2]

(iii) The quarks in ${}^{2}_{1}\text{H}$ and p occur in two 'flavours', u and d. Determine whether any quark *changes* its flavour in the interaction above. [2]

(iv) Explain why the interaction below is considered to be impossible. [1]

$$\nu_e + {}^{2}_{1}\text{H} \rightarrow \text{p} + \text{p} + \pi^-$$

END OF PAPER

