OCR
Oxford Cambridge and RSA

AS Level Physics B

H157/02 Physics in depth

Question Set 5

1 A diffraction grating is marked '*xxx* lines mm^{-1} where the number *xxx* cannot be read. Tests show that it has a grating spacing of 1.50×10^{-6} m, measured to 3 significant figures.

(a) Calculate the number of lines per millimetre, *xxx*.

number of lines per millimetre = ... **[2]**

(b) Yellow light of wavelength 583 nm is incident at right angles to the grating. Calculate theangle θ_2 of the second-order diffraction maximum.

θ_2 = ... ° **[2]**

(c) Explain why this yellow light has no third-order maxima. **[2]**

[Question total: 6]

2 A source **S** emits monochromatic, coherent light which illuminates three equally-spaced slits **A**, **B**and **C** in an opaque barrier. An interference pattern is observed on a distant screen parallel to thebarrier (**Fig. 2**).

Point **1** is the central maximum in the interference pattern. Moving outwards from **1**, the intensity becomes a minimum, then a maximum again at **2**, then another minimum and then a maximum at **3**.

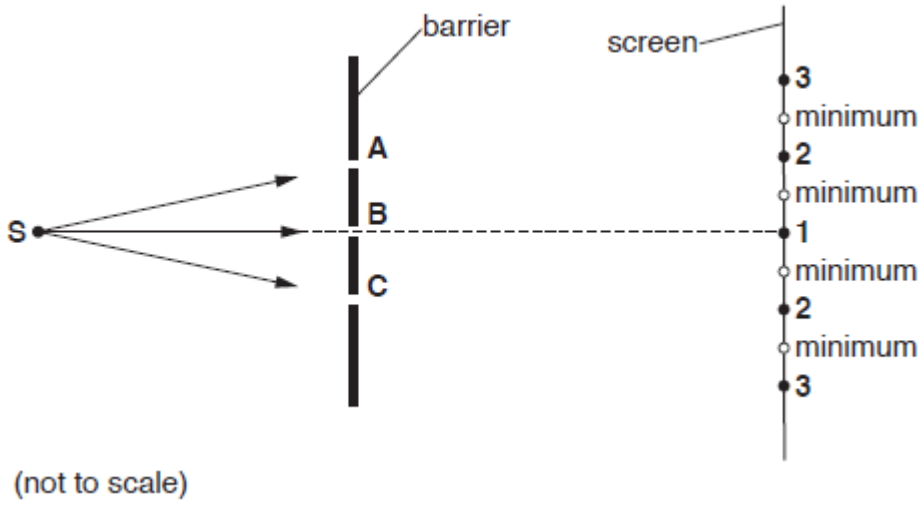
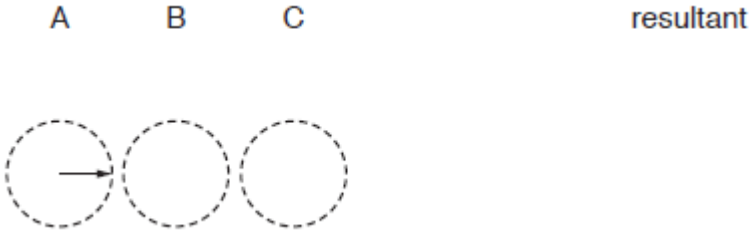


Fig. 2

You can assume that the amplitude of light from **S** reaching any point on the screen is the samewhether that light travels through slit **A**, through slit **B** or through slit **C**.

(a) The phasor for the light from slit **A** at point **1** is shown below.
Add to this diagram the phasors for the light at point **1** from slits **B** and **C** and their resultant.



[2]

(b) At the points marked ‘minimum’, the light has zero intensity. Draw a phasor diagram to show how this is achieved.

[1]

(c) The intensity of light at the maxima marked **3** is exactly the same as at the point marked **1**.At the places marked **2** the intensity of light is much less, even though it is larger than the positions just to the right or left of it. Draw a phasor diagram to show how this is achieved.

[2]

[Question total: 5]

3 A laser has an output power of 150 mW and emits light of wavelength 520 nm.

(a) Show that the laser emits about 4×10^{17} photons each second.

$c = 3.0 \times 10^{8}\ \text{m s}^{-1}$

$h = 6.6 \times 10^{-34}\ \text{J s}$ **[3]**

(b) Show that the momentum p of each photon emitted by the laser is about 10^{-27} kg m s^{-1}. **[1]**

(c) The light from the laser strikes a surface which absorbs all light falling on it.

Calculate the force F that the photons exert on this surface.

$F =$ ..... N **[1]**

[Question total: 5]

4 A small rocket of mass 0.27 kg is mounted vertically on the ground. Exhaust gases emerge at high speed from the rocket, as shown in **Fig. 4**.

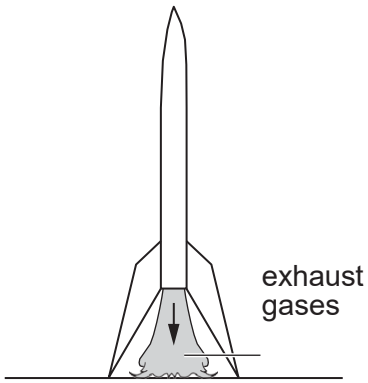


Fig. 4

At the start, the gases are ejected at a rate of 47 g s^{-1} with a speed of 110 m s^{-1} relative to the rocket and the ground.

(a) Show that the rocket exerts a downwards force of about 5 N on the exhaust gases. **[2]**

(b) Calculate the initial upward acceleration of the rocket.

$g = 9.8\ \text{m s}^{-2}$

acceleration = ... m s^{-2} **[2]**

(c) Explain why this acceleration is correct only at the instant when the rocket engine starts.

[2]

[Question total: 6]

5 A simple model of a gas atom consists of separate energy levels, as shown in **Fig. 5**.

In this model, there are three levels, **A**, **B** and **C**. The vertical separation between levels is proportional to the energy differences between the levels, showing that these energy differences are not uniform.

The electrons of the atom, shown as black dots, can have any of these three energies, but cannot have any other energy.

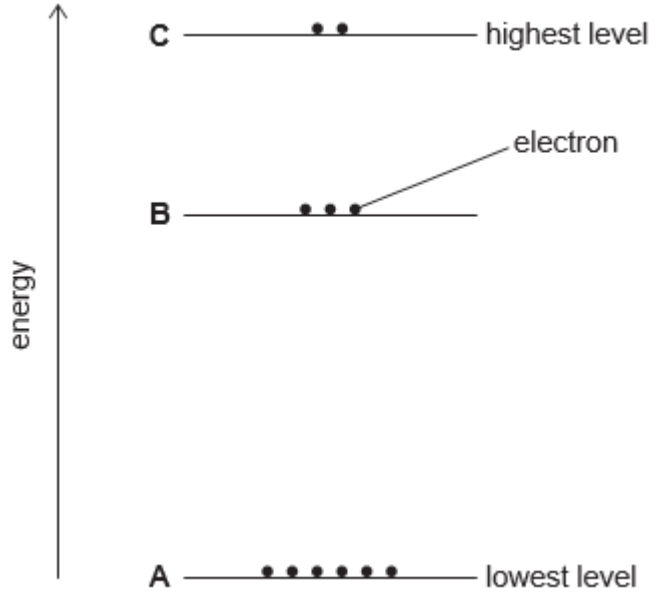


Fig. 5

(a) State why the spectrum of light emitted by excited atoms of this gas will contain exactly three different frequencies **[2]**

(b) In the spectrum of this gas, the longest wavelength of light emitted is 650 nm.

Calculate the energy released by a falling electron and state the two levels between which the electron has fallen.

speed of light, $c = 3.0 \times 10^{8}\,\text{m s}^{-1}$
the Planck constant, $h = 6.6 \times 10^{-34}\,\text{J s}$

energy = …….. J **[3]**

[Question total: 5]

6 This question is about the absorption of light by rod-shaped sensitive cells in the retina of the human eye. **Fig. 6** shows how efficiently these cells absorb light of different wavelengths across the range of visible light (400 – 700 nm).

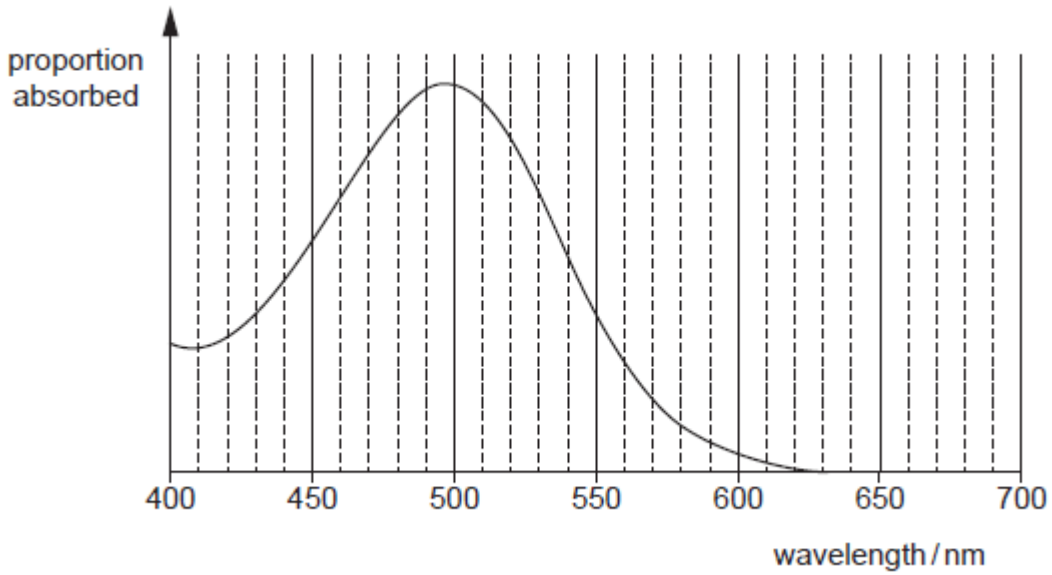


Fig. 6

(a) A typical rod cell can be activated (switched on) by a single photon.

Show that the energy required to activate a rod cell detecting light at the wavelength to which it is most sensitive is less than 5×10^{-19} J. **[3]**

(b) The responses from neighbouring rod cells are added to send a signal to the brain. A constant light is seen coming from the direction viewed if at least twelve neighbouring cells are activated during a time interval of 100 ms.

Calculate the smallest value of power of visible light absorbed by rod cells to give a constant light signal.

power = ... W **[2]**

[Question total: 5]

7 The comb shown in **Fig. 7.1** has 53 teeth in a distance of 5.0 cm. It is mounted parallel to a wall 3.6 m away.

Fig. 7.1

A laser emitting light of wavelength 630 nm is set up perpendicular to the comb and produces an interference pattern of red dots on the distance wall as shown in **Fig. 7.2**.

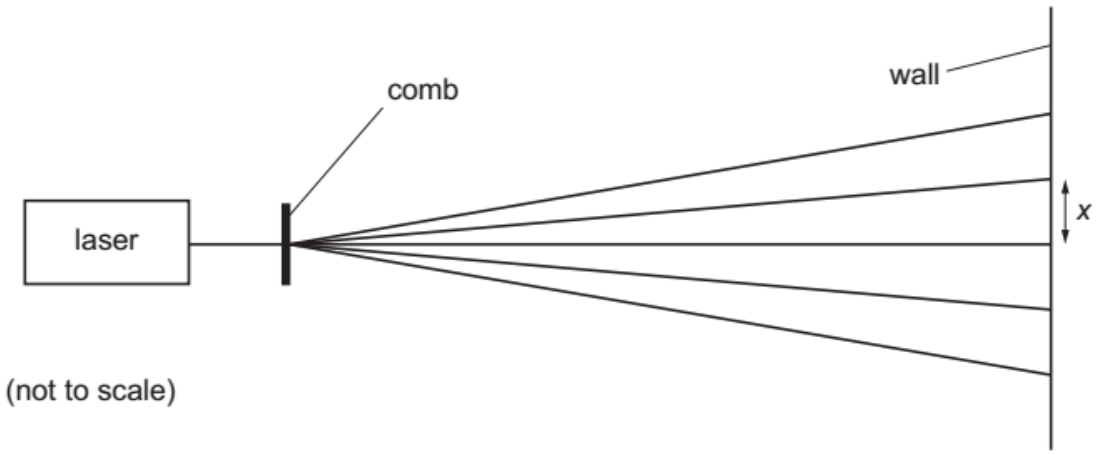


Fig. 7.2

Calculate the separation *x* of the dots on the wall. **[3]**

[Question total: 3]

8 **Fig. 8** shows a trolley of weight 8.2 N rolling down a ramp inclined at 35° to the horizontal. You can assume that there is very little friction between the trolley and the ramp.

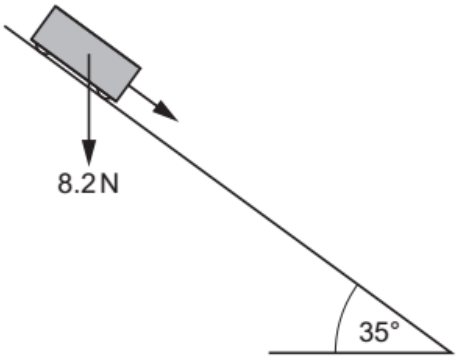


Fig. 8

(a) Calculate the acceleration *a* of the trolley along the ramp. **[3]**

a = ... m s^{-2}

(b) Calculate the kinetic energy gained by the trolley as it travels 68 cm along the ramp. **[1]**

[Question total: 4]

Total Marks for Question Set 5: 39