1 This question is about the light from low energy compact fluorescent lamps which are replacing filament lamps in the home.

(a) The light from a compact fluorescent lamp is analysed by passing it through a diffraction grating. Fig. 6.1 shows the angular positions of the three major lines in the first order spectrum and the bright central beam.

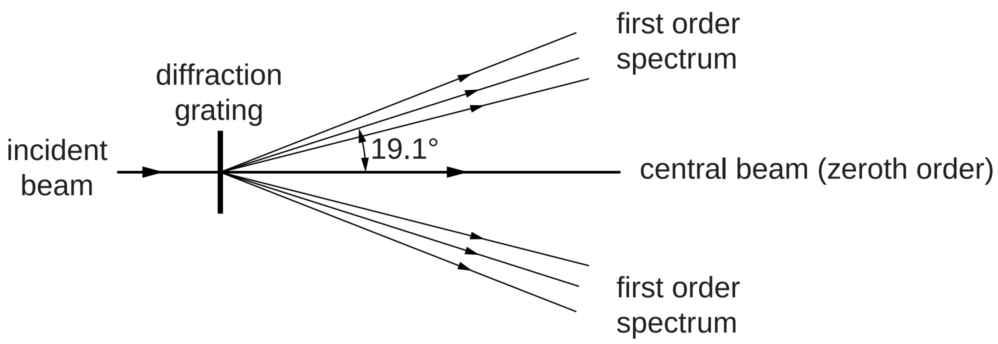

Fig. 6.1

(i) On Fig. 6.1 label one set of the lines in the first order spectrum **R**, **G** and **V** to indicate which is red, green and violet. **[1]**

(ii) Explain why the bright central beam appears white.

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.... **[1]**

(iii) The line separation d on the grating is 1.67×10^{-6} m.

Calculate the wavelength λ of the light producing the first order line at an angle of 19.1° to the central bright beam.

λ = ... m **[3]**

(b) The wavelength of the violet light is 436 nm. Calculate the energy of a photon of this wavelength.

energy = ... J **[3]**

(c) The energy level diagram of Fig. 6.2 is for the atoms emitting light in the lamp. The three electron transitions between the four levels **A**, **B**, **C** and **D** shown produce the photons of red, green and violet light. The energy *E* of an electron bound to an atom is negative. The ionisation level, not shown on the diagram, defines the zero of the vertical energy scale.

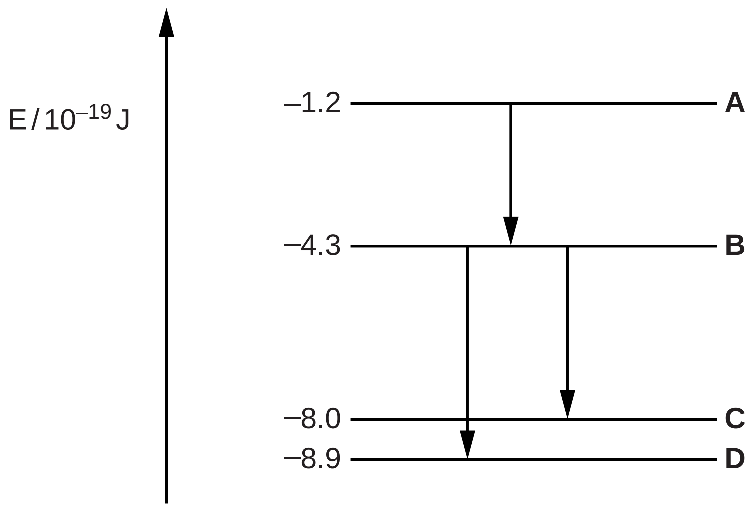

Fig. 6.2

Label the arrows on Fig. 6.2 **R**, **G** and **V** to indicate which results in the red, green and violet photons. **[2]**

[Total: 10]

2 **(a)** Explain what is meant by a *progressive wave*.

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.... **[2]**

(b) Describe how a *transverse* wave differs from a *longitudinal* wave.

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.... **[2]**

(c) **(i)** Explain what is meant by *diffraction* of a wave.

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.... **[1]**

(ii) Describe how you would demonstrate that a sound wave of wavelength 0.10 m emitted from a loudspeaker can be diffracted.

In your answer you should make clear how your observations show that diffraction is occurring.

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.... **[4]**

(d) Fig. 4.1 shows two loudspeakers connected to a signal generator, set to a frequency of 1.2 kHz. A person walks in the direction **P** to **Q** at a distance of 3.0 m from the loudspeakers.

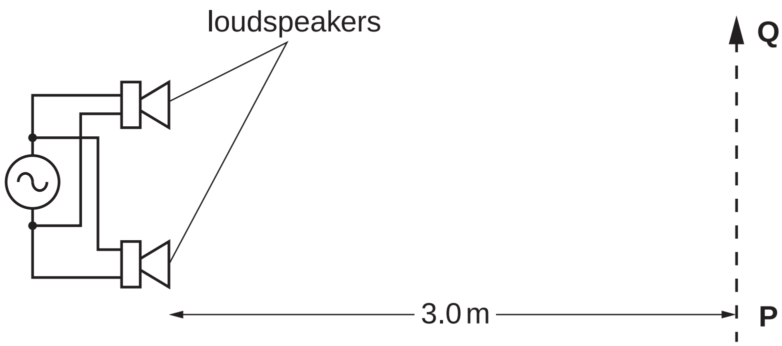

Fig. 4.1

(i) Calculate the wavelength λ of the sound waves emitted from the loudspeakers.

speed of sound in air = $340\,m\,s^{-1}$

λ = ... m **[2]**

(ii) Explain, either in terms of path difference or phase difference, why the intensity of the sound heard varies as the person moves along **PQ**.

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.... **[3]**

(iii) The distance x between adjacent positions of maximum sound is 0.50 m. Calculate the separation a between the loudspeakers. Assume that the equation used for the interference of light also applies to sound.

a = ... m **[2]**

(iv) The connections to one of the loudspeakers are reversed. Describe the similarities and differences in what the person hears.

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.... **[2]**

[Total: 18]

3 Fig. 5.1 shows a uniform string which is kept under tension between a clamp and a pulley. The frequency of the mechanical oscillator close to one end is varied so that a stationary wave is set up on the string.

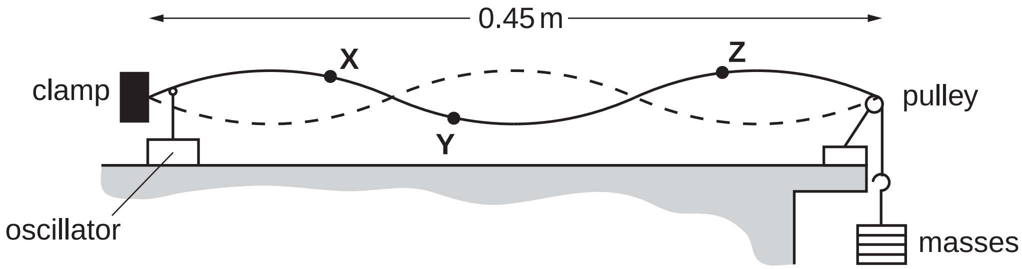

Fig. 5.1

(a) State two features of a stationary wave.

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.... **[2]**

(b) Explain how the stationary wave is formed on the string.

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.... **[2]**

(c) The distance between the clamp and the pulley is 0.45 m. **X**, **Y** and **Z** are three points on the string. **X** and **Y** are each 0.040 m from the nearest node and **Z** is 0.090 m from the pulley. State, giving a reason for your choice, which of the points **Y** or **Z** or both oscillate

(i) with the same amplitude as **X**

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.... **[2]**

(ii) with the same frequency as **X**

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.... **[2]**

(iii) in phase with **X**.

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.... **[2]**

[Total: 10]

4 **(a)** X-rays and radio waves are two examples of electromagnetic waves.

(i) Name **two** other examples of electromagnetic waves.

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.... **[1]**

(ii) State **one** similarity and **one** difference between X-rays and radio waves.

similarity ....

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difference ....

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.... **[2]**

(iii) Explain why X-rays are easily diffracted by layers of atoms, about 2×10^{-10} m apart, but radio waves are not.

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.... **[2]**

(b) On the Earth, we are all exposed to ultraviolet radiation coming from the Sun.
State **one** advantage and **one** disadvantage of UV-B radiation.

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.... **[2]**

(c) **(i)** Circle a typical value for the wavelength of an X-ray from the list below.

2×10^{-4} m $2 \times 1\ ^{-7}$ m $2 \times 1\ ^{-10}$ m $2 \times 1\ ^{-13}$ m **[1]**

(ii) Use your answer to **(i)** to determine how many X-ray photons must be collected to produce an energy of 1.0×10^{-6} J.

number of photons = ... **[4]**

(d) A plane polarised radio wave is transmitted from a vertical aerial to a nearby receiving aerial as shown in Fig. 6.1.

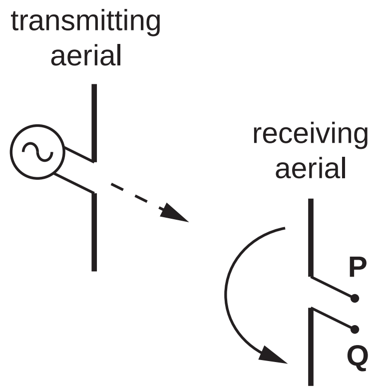

Fig. 6.1

A diode, resistor and ammeter are connected in series across the terminals **P** and **Q**.

(i) Draw the circuit between terminals **P** and **Q** on Fig. 6.1 in the space to the right of **PQ**. **[2]**

(ii) The entire receiving aerial is rotated slowly through 180° in the direction shown by the arrow. Explain clearly what will be observed on the ammeter and how the detected signal varies.

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.... **[3]**

[Total: 17]