

- 6 (a)** Fig. 6.1 shows some of the energy levels of gas atoms used in a lamp.

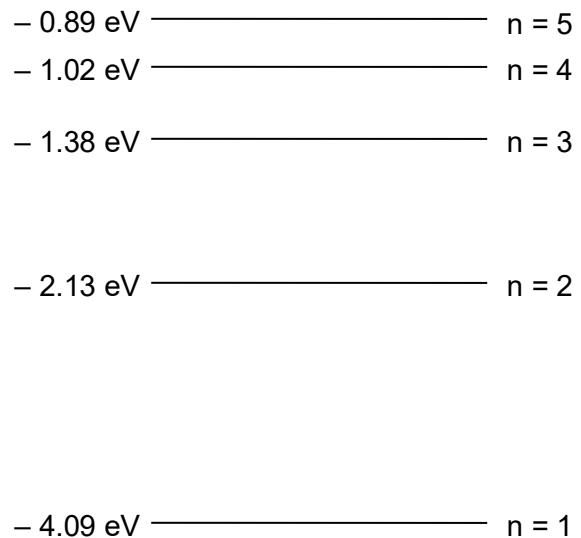


Fig. 6.1

The atoms, initially at ground state, are excited by collisions with fast moving electrons of energy 3.10 eV.

- (i) State the total number of possible emission transitions resulting from this excitation.

number of possible transitions = [1]

- (ii) Show that the shortest wavelength of the radiation that can be emitted when the atom de-excites is 405 nm.

[2]

- (b) The radiation emitted from the gas lamp in (a) is focused into a radiation beam for a photocell.

A photocell is a vacuum tube with a concave metal cathode called an emitter. The photocell works using the photoelectric effect. The concave emitter focuses the photoelectrons on a thin anode wire called a collector. The thin anode wire does not block light. When the collector is at a positive potential, photoelectrons are attracted to it. The structure of a typical photocell is shown in Fig. 6.2.

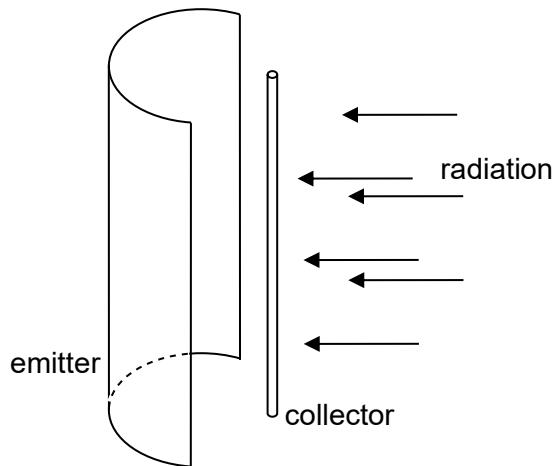


Fig. 6.2

The photocell can be used as a sensor in automated roller shutter systems as shown in Fig. 6.3. The photocell is housed in the receiver unit and acts as a sensor to detect if any object moves past the door while the shutter system is in use.

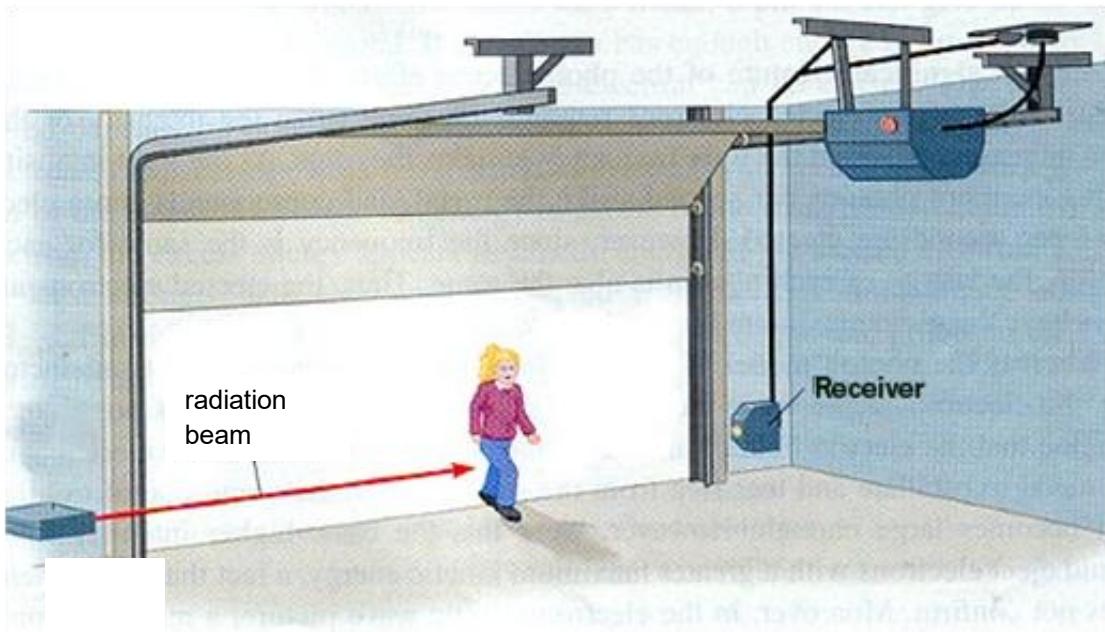


Fig. 6.3

A simplified circuit diagram of the system is shown in Fig 6.4.

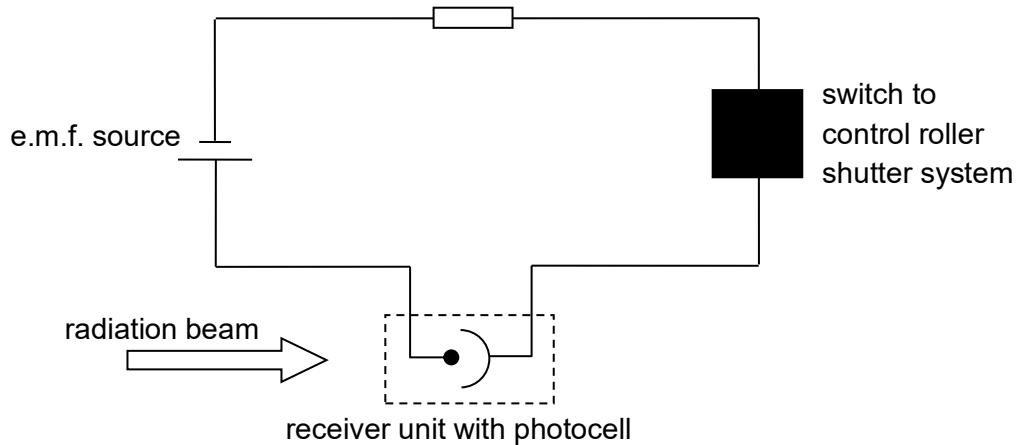


Fig. 6.4

When a current flows in the circuit, the switch to control the roller shutter system will be turned on and the roller shutter will function normally.

- (i) State what is meant by *photoelectric effect*.

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[1]

- (ii) With reference to Fig. 6.4, explain how the photocell is used to detect objects moving past the shutter door and how this acts as a safety feature.

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[2]

- (c) In choosing the type of metal to be used as the emitter in the photocell, the manufacturer has to consider several properties of the metal. One of the properties considered is the work function of the metal. Fig. 6.5 shows the work function of some metals.

Metal	Work function / eV
A	2.69
B	3.44
C	3.81

Fig. 6.5

Fig. 6.6 shows how the maximum kinetic energy $E_{k,max}$ of photoelectrons varies with the frequency f of the incident radiation. The graph for metal C is included in Fig. 6.6.

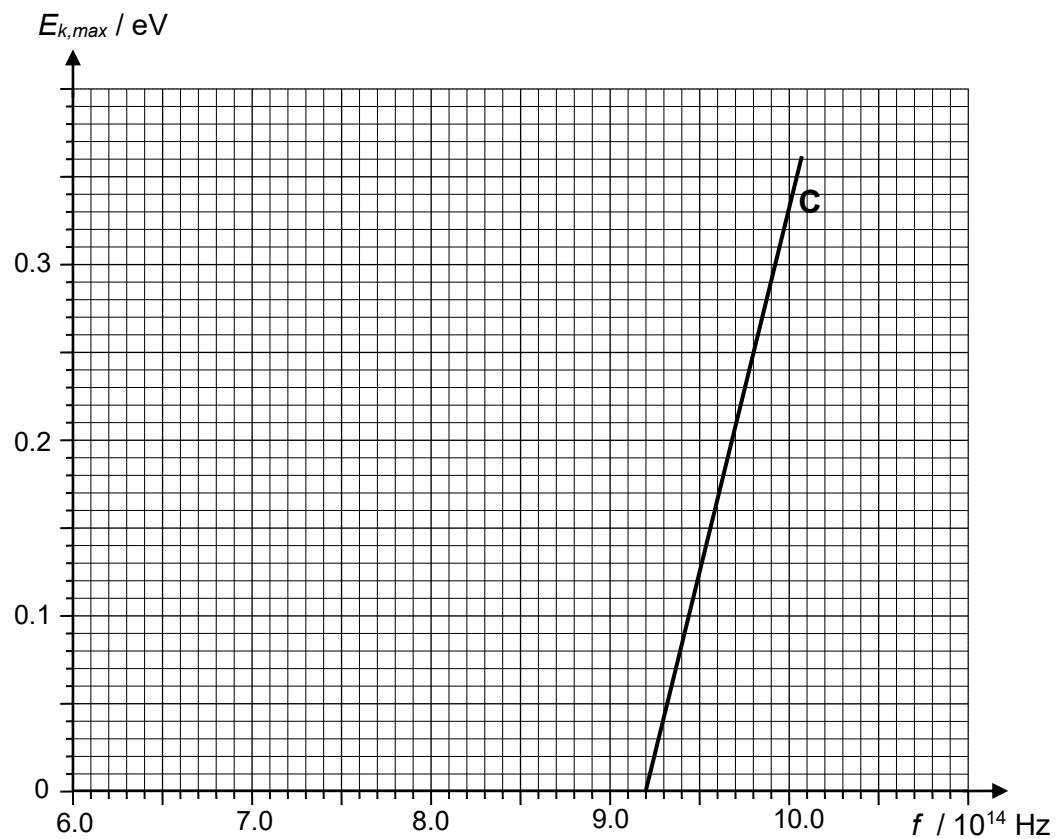


Fig. 6.6

- (i) Draw, on Fig. 6.6, the respective graphs for metals **A** and **B**. Label your graphs **A** and **B** respectively. [2]

- (ii) By considering your answer in (a)(ii), state and explain which metal should be used for the photocell.

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[2]

- (iii) While installing the roller shutter system, the electrician made a mistake and switched the polarity of the e.m.f. source, such that the emitter is now at a positive potential. After installation, the potential difference between the emitter and the collector is 2.0 V.

Explain, quantitatively, whether the photocell will still be able to function properly as a sensor to detect objects moving past the shutter door.

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[3]

End of Section A

Section B

Answer only ONE question from this section.