9 **(a)** **(i)** State a *phenomenon* each that demonstrates the particulate nature and wave nature of light.

particulate nature: …….

wave nature: ……..…… [2]

(ii) Explain how the existence of discrete electron energy levels in atoms gives rise to a line emission spectrum.

…….....

……..

……..

…… [2]

(b) To produce electromagnetic radiation in a gas lamp, cool gas atoms in the lamp are excited by bombarding them with energetic electrons.

Fig. 9.1 shows some electron energy levels of an isolated gas atom of such a lamp.

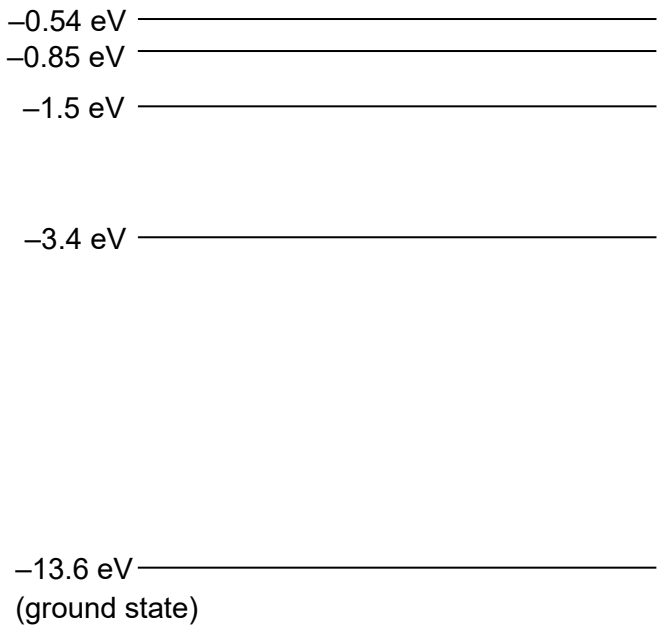

Fig. 9.1

The gas atoms are bombarded by electrons with energy of 12.8 eV, resulting in photons of different energies being emitted.

(i) On Fig. 9.1, draw clearly all the possible transitions which lead to the emission of photons.

[2]

(ii) Show that lowest wavelength of the photons emitted is 9.8×10^{-8} m.

[2]

(c) The electromagnetic radiation emitted from the gas lamp in **(b)** is now incident on metal Z used in a photoelectric experiment.

Fig. 9.2 shows the setup of the photoelectric experiment.

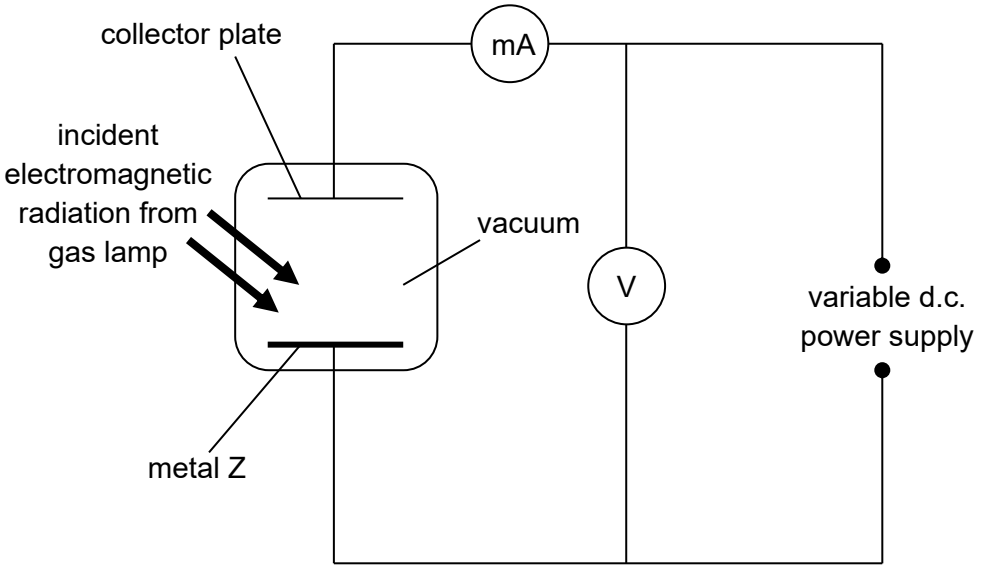

Fig. 9.2

The potential of the collector plate is varied gradually from positive to negative with respect to metal Z.

The variation of the current I with the potential difference V is shown in Fig. 9.3.

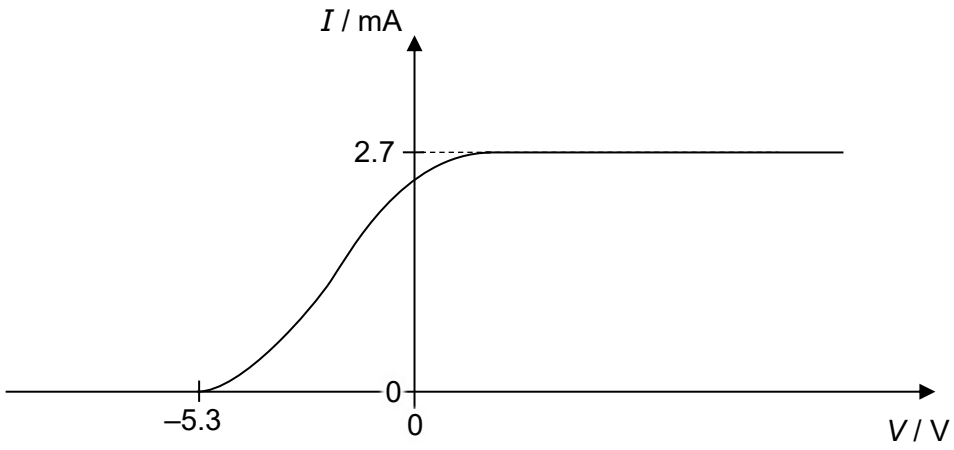

Fig. 9.3

(i) Explain why I decreases gradually as the potential of the collector plate is made more and more negative with respect to metal Z.

……..

……..

……..

…… [2]

(ii) Calculate the maximum rate of emission of photoelectrons.

rate of emission = …….…… s^{-1} [2]

(iii) Show that the work function energy of metal Z is 1.2×10^{-18} J.

work function energy = …….…… J [2]

(iv) Hence, calculate the threshold wavelength of metal Z, leaving your answer in nm.

threshold wavelength = …….…… nm [1]

(v) The gas lamp is now replaced with a new electromagnetic radiation source, and the experiment is repeated.

Graph R in Fig. 9.4 shows the results of the new experiment.

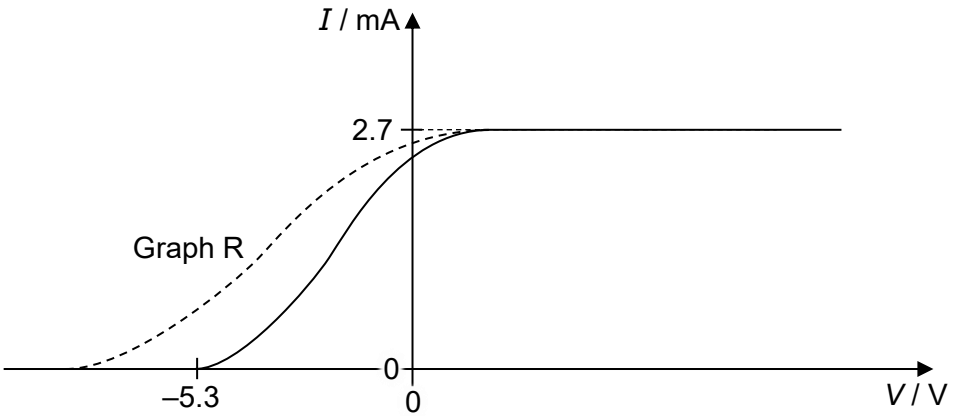

Fig. 9.4

State and explain one difference between this new electromagnetic radiation source and the gas lamp.

……..

……..

…… [2]

(vi) Photoelectric effect is applied in the manufacture of light meters.

Light meters are typically used by photographers to check the intensity of ambient visible light so that they can make adjustments before taking any photographs.

Explain briefly how photoelectric effect is used for such a purpose in a light meter.

……..

……..

…… [2]

(vii) Using your answer in **(iv)**, explain why metal Z is not suitable to be used in the manufacture of light meters.

……..

……..

…… [1]

End of paper

BLANK PAGE