9 **(a)** A beam of light of intensity 160 W m^{-2} is incident normally on a plane mirror, as shown in Fig. 9.1. The momentum of each photon in the beam is 9.5×10^{-28} N s.

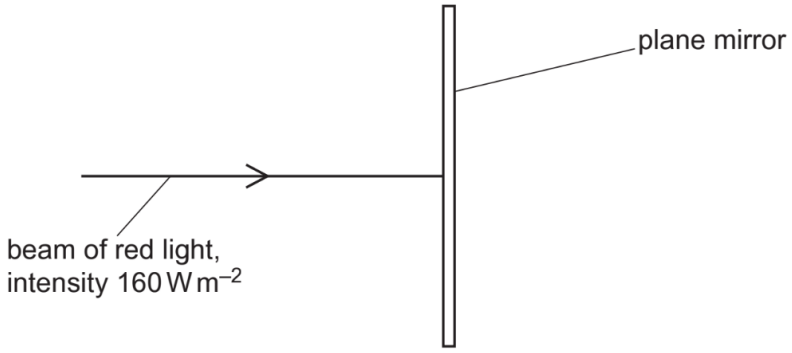

Fig. 9.1

All the light is reflected in the opposite direction to its original path by the mirror of cross-sectional area 2.5×10^{-2} cm^2. The number of photons incident on the mirror per unit time is 1.4×10^{15} s^{-1}.

(i) State what is meant by a photon.

.....
.

.....
[2]

(ii) Calculate the photon's de Broglie wavelength and determine its colour in the visible light spectrum.

wavelength = ... nm [1]

colour = ... [1]

(iii) Determine the pressure exerted by the light beam on the mirror.

pressure = ... Pa [2]

(b) Ultraviolet radiation of constant power is incident, in a vacuum, on a metal surface. Photoelectrons are observed to be emitted in the process.

The frequency of ultraviolet radiation is now increased.

State and explain the effect of this change on:

(i) the maximum kinetic energy of the photoelectrons

.....
.

.....
.

.....
[2]

(ii) the rate of emission of photoelectrons.

.....
.

.....
.

.....
[2]

(c) Fig. 9.2 shows a glass tube in which electrons are accelerated through a high p.d. to form a beam that is incident on a thin graphite crystal.

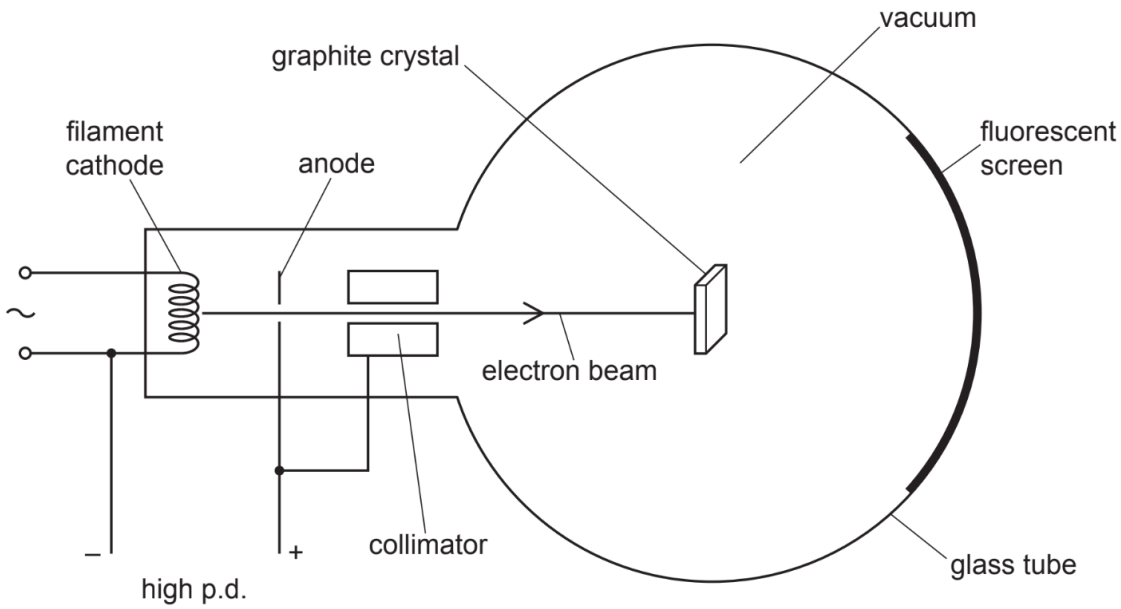

Fig. 9.2

After passing through the graphite crystal, the electrons reach the fluorescent screen. The screen glows where the electrons strike it.

Fig. 9.3 shows the fluorescent screen viewed end-on, from the right-hand side of Fig. 9.2.

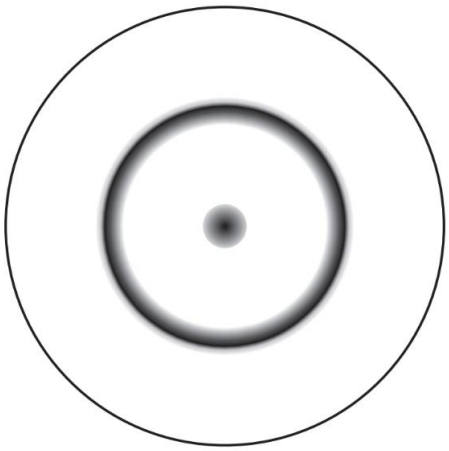

Fig. 9.3

(i) State the name of the phenomenon demonstrated by the pattern shown in Fig. 9.3.

..... [1]

(ii) Explain what can be concluded from the pattern in Fig. 9.3 about the nature of electrons.

.....
.

.....
.

.....
[2]

(d) A beam of white light passes through a cloud of cool gas. The spectrum of the transmitted light is viewed and contains several dark lines.

Explain why these dark lines occur.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(e) Some energy levels for the electron in an isolated hydrogen atom are illustrated in Fig. 9.4.

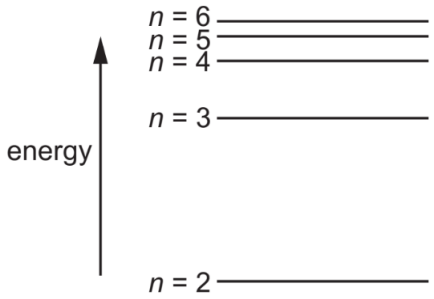

Fig. 9.4

Table 9.1 shows the wavelengths of photons that are emitted in the transitions to $n = 2$ from the other energy levels shown in Fig. 9.4.

wavelength / nm
412
435
488
658

Table 9.1

The energy associated with the energy level $n = 2$ is -3.40 eV.

Calculate the energy, in J, of energy level $n = 3$.

energy = ... J [3]

[End of Paper]