Turning Points in Physics - 2

1.

Figure 2 shows a modern version of the apparatus used by Hertz to investigate the properties of electromagnetic waves. Electromagnetic waves are continuously emitted from a dipole transmitter. The electromagnetic waves are detected by a dipole receiver.
An oscilloscope is used to display the amplitude of the detected signal at the dipole receiver.

Figure 2

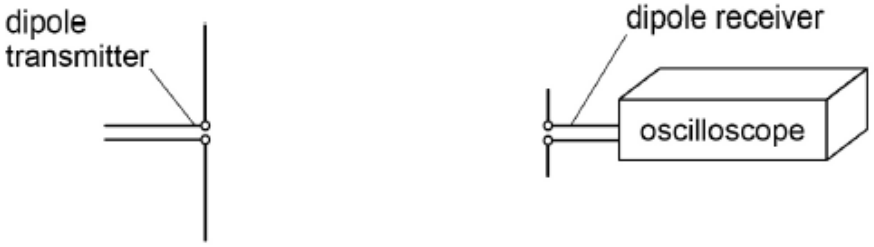
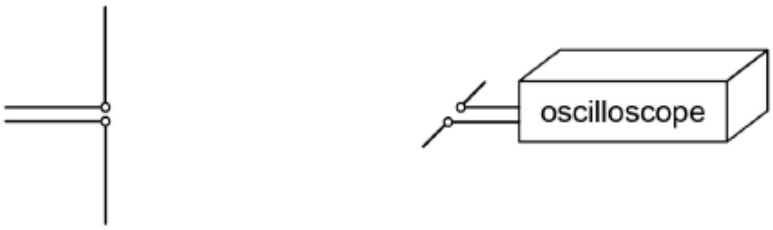


Figure 3 shows the same apparatus when the dipole receiver has been rotated through an angle of 90°

Figure 3

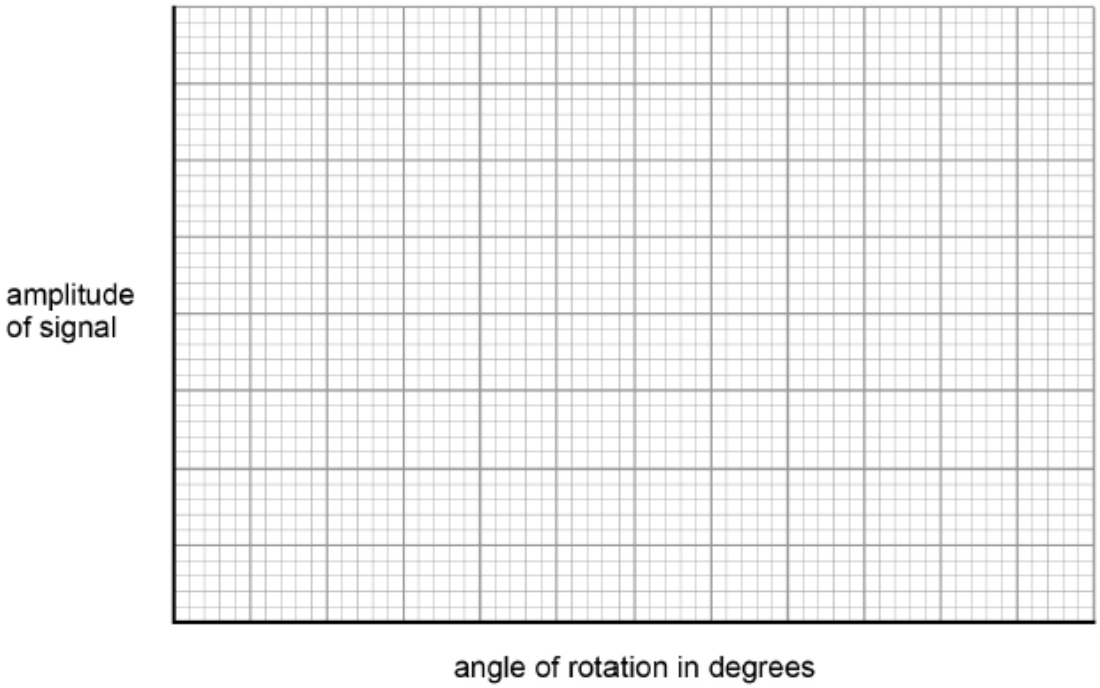


(a)

Sketch a graph on **Figure 4** to show how the amplitude detected by the dipole receiver varies with angle of rotation as the receiver is turned through 360°
Start your graph from the position shown in **Figure 2**.

[3 marks]

Figure 4



(b)

Maxwell derived the equation $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ for the speed c of electromagnetic waves, where μ_0 is the permeability of free space and ε_0 is the permittivity of free space.

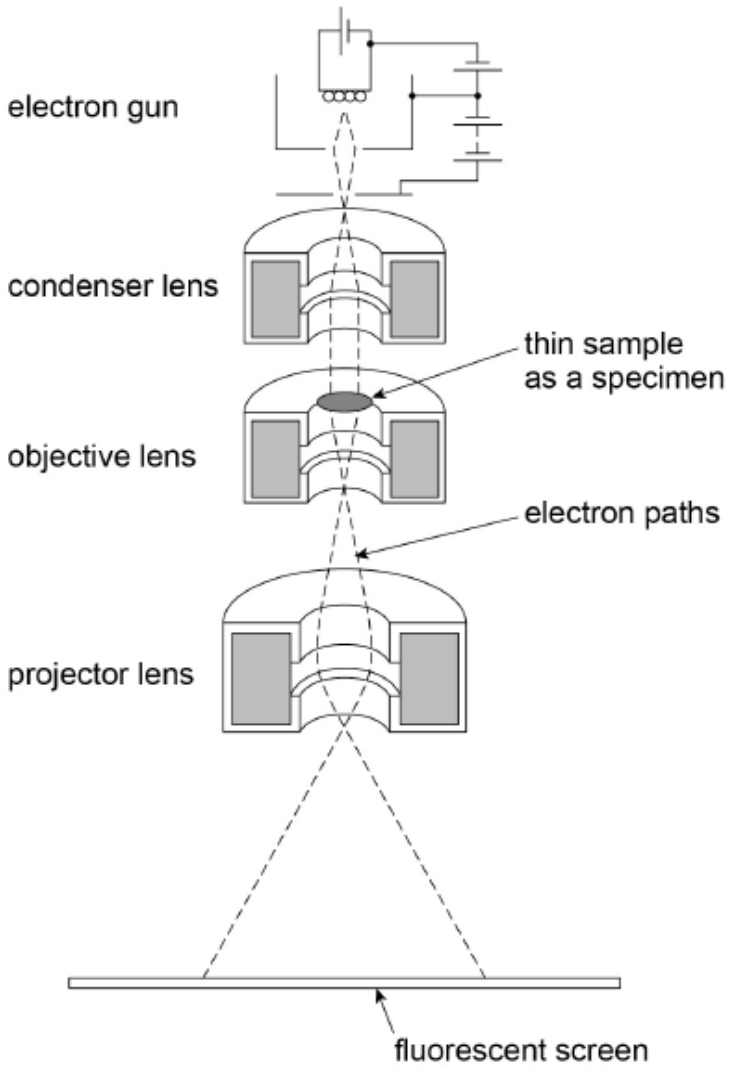
Explain, using a suitable calculation, why this equation led to the conclusion that light is an electromagnetic wave.

[2 marks]

2.

Figure 3 shows the main parts of a transmission electron microscope (TEM).

Figure 3



(a)

What is the process by which electrons are produced in an electron gun?
Tick (✓) the correct box.

[1 mark]

Beta particle emission ☐

Electron diffraction ☐

Photoelectric effect ☐

Thermionic emission ☐

(b)

The electrons in a particular TEM have a kinetic energy of 4.1×10^{-16} J.
Relativistic effects are negligible for this electron energy.

Suggest, with a calculation, whether the images of individual atoms can, in principle, be resolved in this TEM.

[3 marks]

(c)

A typical TEM can accelerate electrons to very high speeds and form high resolution images.

Explain:

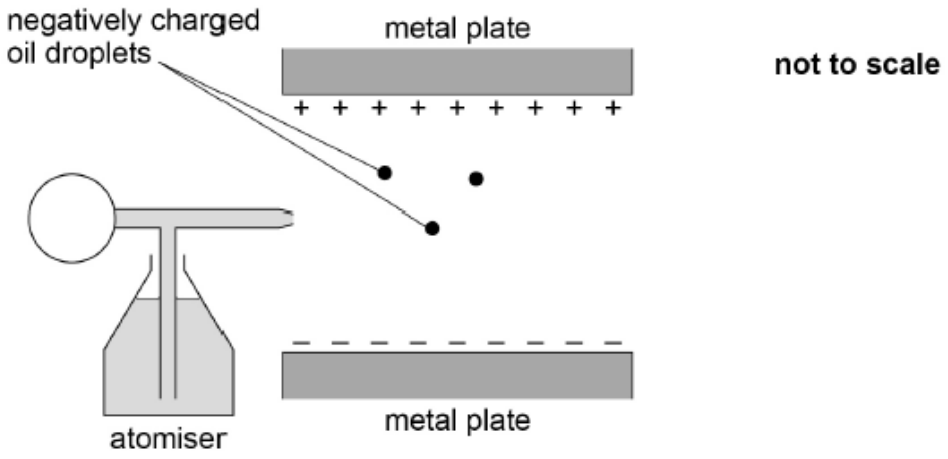
- the process of image formation, and
- the factors that affect the quality of, and the level of detail in, the image.

[6 marks]

3.

Figure 1 shows an experiment to measure the charge of the electron.

Figure 1



Negatively charged oil droplets are sprayed from the atomiser into the gap between the two horizontal metal plates. A potential difference is applied between the metal plates.

One of the droplets remains stationary.

(a)

Identify the forces acting on the stationary droplet.
In your answer you should state the relationship between the forces.

The upthrust on the droplet due to the air it displaces is negligible.

[2 marks]

(b)

The potential difference between the plates is changed to zero and the droplet falls at a terminal velocity of $1.0 \times 10^{-4}\ \text{m s}^{-1}$.

The density of the oil is $880\ \text{kg m}^{-3}$
The viscosity of air is $1.8 \times 10^{-5}\ \text{N s m}^{-2}$

Show that the radius of the droplet is about $1 \times 10^{-6}\ \text{m}$.

Assume that the droplet is spherical.

[3 marks]

(c)

The potential difference between the plates is restored to its initial value and the droplet becomes stationary.

The charge on the droplet is -4.8×10^{-19} C.

A student suggests that, if the droplet splits into two spheres of equal size, both spheres would remain stationary.

Deduce whether this suggestion is correct.

[3 marks]