Name of the Student:_____
Max. Marks : 21 Marks **Time :** 21 **Minutes**

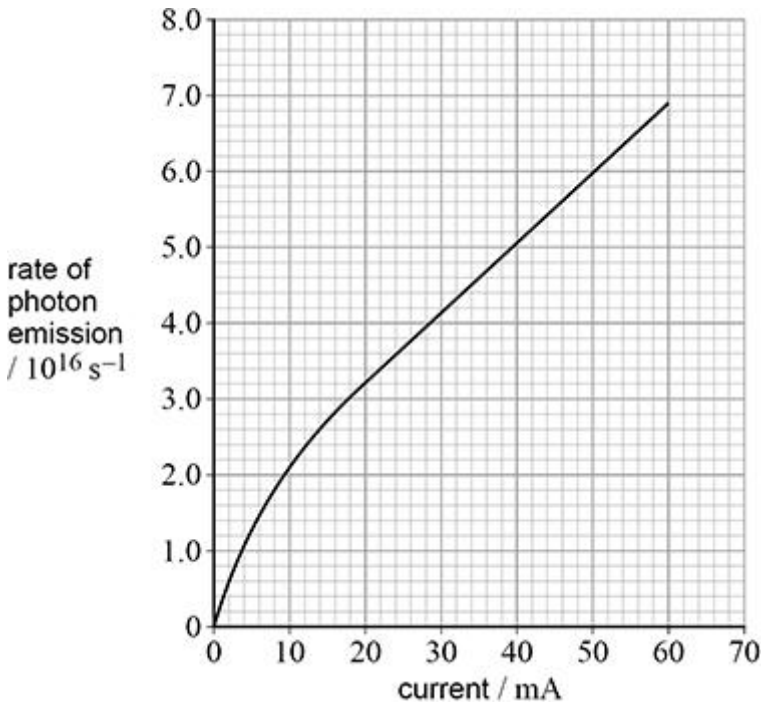
Q1.

(a) A light emitting diode (LED) emits blue light with a wavelength of 440 nm. The rate of photon emission is 3.0×10^{16} s^{-1}.

Show that the power output of the LED is approximately 0.014 W.

(2)

(b) A different LED emits red light with a wavelength of 660 nm.
The graph below shows how the rate of photon emission varies with current up to the maximum operating current of this LED.



A student claims that the red LED can have twice the power output of the blue LED.

Deduce whether the student's claim is correct.

(3)

(c) The student has paint that fluoresces when light of any wavelength is incident on it. She coats the blue LED and the red LED with the paint.

Compare the wavelengths of light emitted by the paint on each LED.

In your answer you should also explain the processes that cause the paint to fluoresce.

(6)

(Total 11 marks)

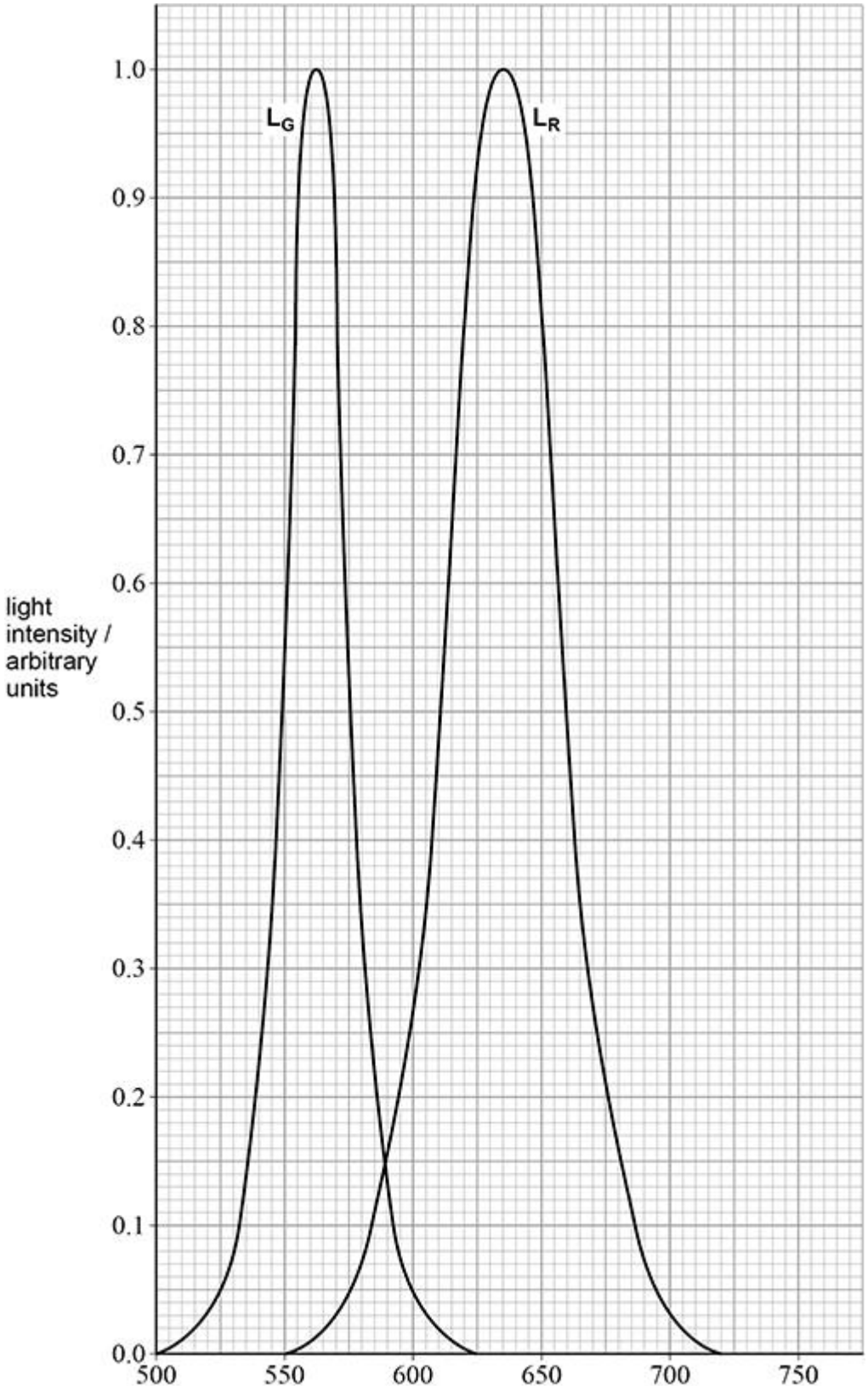
Q2.

A light-emitting diode (LED) emits light over a narrow range of wavelengths.
These wavelengths are distributed about a peak wavelength λ_p.

Two LEDs $\mathbf{L_G}$ and $\mathbf{L_R}$ are adjusted to give the same maximum light intensity.
$\mathbf{L_G}$ emits green light and $\mathbf{L_R}$ emits red light.

Figure 1 shows how the light output of the LEDs varies with the wavelength λ.

Figure 1



(a) Light from **L_R** is incident normally on a plane diffraction grating.
The fifth-order maximum for light of wavelength λ_p occurs at a diffraction angle of 76.3°.

Determine N, the number of lines per metre on the grating.

N = _____ m^{-1}

(3)

(b) Suggest **one** possible disadvantage of using the fifth-order maximum to determine N.

_____

_____

_____

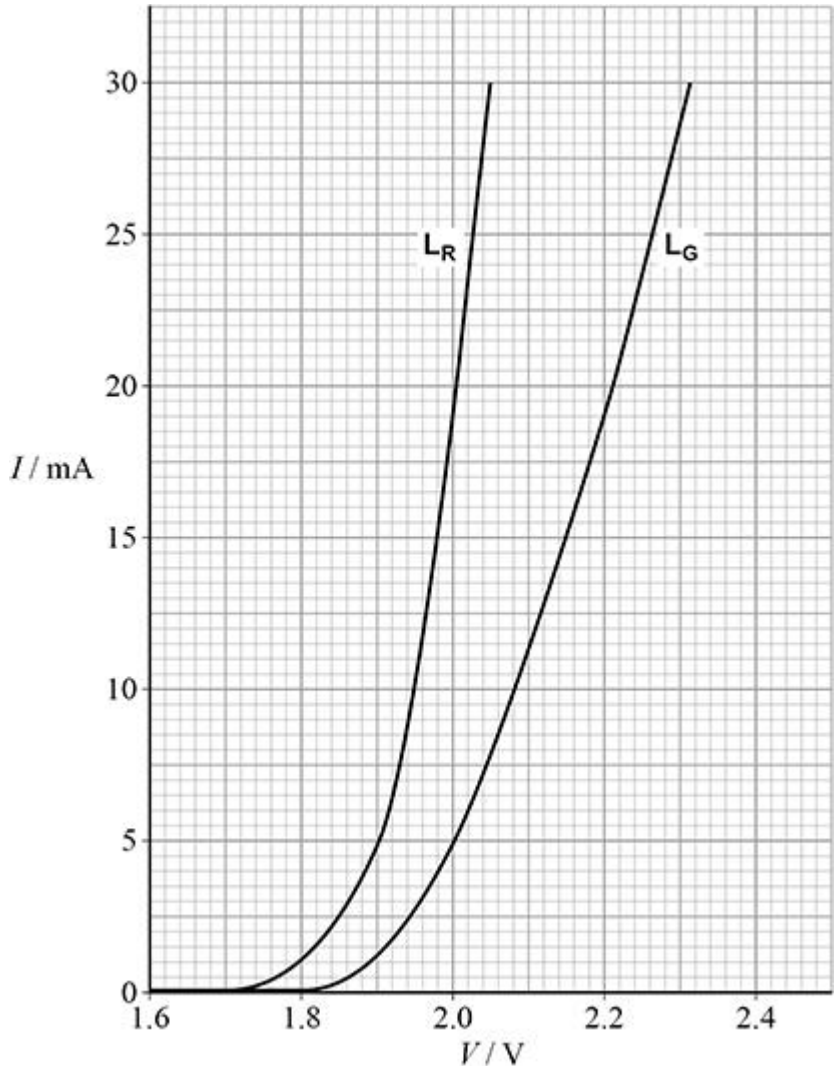
_____

_____

(1)

(c) **Figure 2** shows part of the current−voltage characteristics for $\mathbf{L_R}$ and $\mathbf{L_G}$.

Figure 2



When the linear part of the characteristic is extrapolated, the point at which it meets the horizontal axis gives the activation voltage V_A for the LED.
V_A for $\mathbf{L_G}$ is 2.00 V.

Determine, using **Figure 2**, V_A for $\mathbf{L_R}$.

V_A for $\mathbf{L_R}$ = _____ V

(2)

(d) It can be shown that:

$$V_A = \frac{hc}{e\lambda_p}$$

where h = the Planck constant.

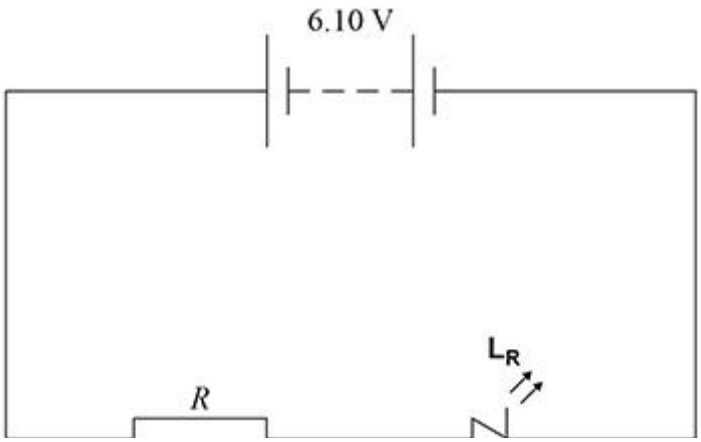
Deduce a value for the Planck constant based on the data given about the LEDs.

h = _____ J s

(2)

(e) **Figure 3** shows a circuit with $\mathbf{L_R}$ connected to a resistor of resistance R.

Figure 3



The power supply has emf 6.10 V and negligible internal resistance.
The current in $\mathbf{L_R}$ must not exceed 21.0 mA.

Deduce the minimum value of R.

minimum value of R = _____ Ω

(2)

(Total 10 marks)