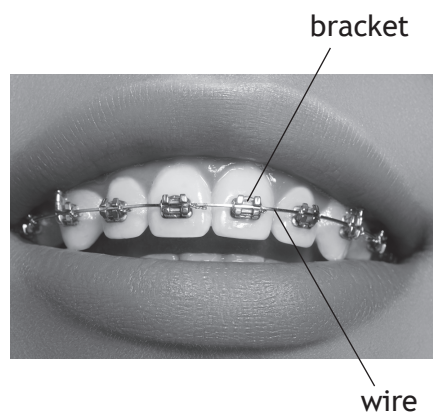


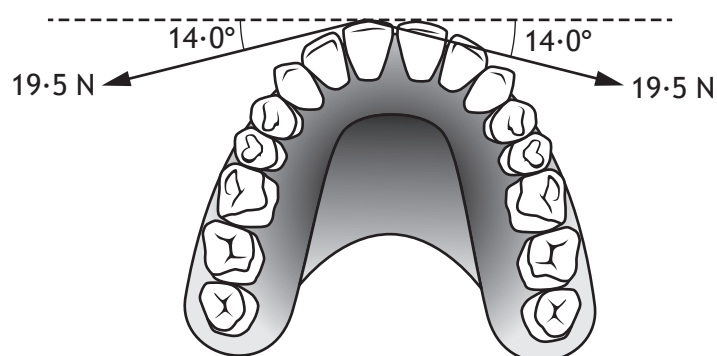
9. Dental braces are used to adjust the position of a patient's teeth.

Bonding cement is used to attach brackets to each tooth and then a stainless steel wire is attached to the brackets.



- (a) The tension in the wire exerts two forces to move one of the patient's front teeth backward.

Both forces are 19.5 N as shown.



- (i) Determine the magnitude of the resultant force applied to the tooth.

2

Space for working and answer

- (ii) Explain why the wire does not cause the tooth to move sideways.

1



9. (continued)

MARKS

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- (b) Light from an LED is used to harden the bonding cement applied to the patient's teeth.

- (i) The irradiance of the light from the LED on the cement on one tooth is $11\,800\text{ W m}^{-2}$.

The bonding cement on this tooth has an area of $1.24 \times 10^{-5}\text{ m}^2$.

The cement requires 2.10 J of energy to harden.

Determine the minimum time for which the light from the LED must be applied.

5

Space for working and answer



* X 8 5 7 7 6 0 1 2 5 *

9. (b) (continued)

- (ii) Concern has been raised about the effect the light from the LED may have upon dental assistants' eyes.

A medical researcher investigates how the irradiance I varies with distance d from the LED.

The following results are obtained.

d (m)	0.30	0.40	0.50	0.60
I (W m^{-2})	6.3	3.5	2.3	1.6

Use **all the data** to show that the LED acts as a point source over this range.

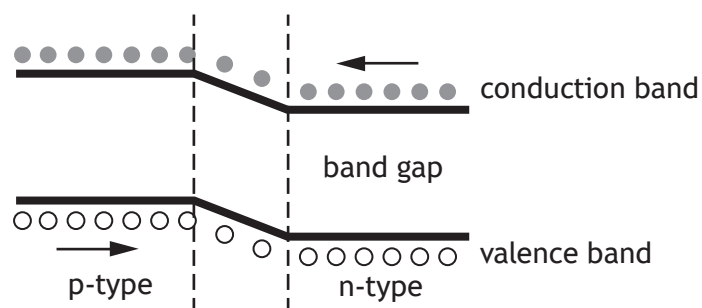
3



9. (b) (continued)

- (iii) The LED is made from doped semiconductor material to create a p-n junction.

The diagram represents the band structure of the LED.



- (A) State what is meant by a *doped semiconductor*.

1

- (B) A voltage is applied across the LED so that it is forward biased and emits light.

Using **band theory**, explain how the LED emits light.

3

