InkPhysics

ANSWER BOOK

Diffraction gratings

Waves · Year 12

AQA 3.3.2.2 · CIE 8.4 · OCR A 4.4.3

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 $d \sin\theta = n\lambda$, where d is the grating spacing (distance between adjacent slits), θ the angle of the maximum, n the order, and λ the wavelength. [2]

A2 $d = 1/(300 \times 10^3)$ lines per metre $= 3.33 \times 10^{-6}$ m. [2]

A3 A grating has many slits, so far more beams interfere. Constructive interference occurs only at precise angles where all beams are in phase, giving narrow, intense maxima; away from these angles the many beams cancel. [3]

SECTION B · Standard

B1 $d = 1/(500 \times 10^3) = 2.00 \times 10^{-6}$ m. $\sin\theta = n\lambda/d = (1 \times 600 \times 10^{-9})/2.00 \times 10^{-6}$, so $\theta = 17.5°$. [4]

B2 $\sin\theta = 2\lambda/d = (2 \times 600 \times 10^{-9})/2.00 \times 10^{-6}$, so $\theta = 36.9°$. [3]

B3 $d = 1/(600 \times 10^3) = 1.67 \times 10^{-6}$ m. $\lambda = d \sin\theta = 1.67 \times 10^{-6} \times \sin 21° = 597$ nm. [3]

B4 $d = \lambda/\sin\theta = (500 \times 10^{-9})/\sin 15° = 1.93 \times 10^{-6}$ m. Lines per mm = 1/d per metre ÷ 1000 = 518 lines per mm. [3]

SECTION C · Stretch

C1 Maximum order when $\sin\theta = 1$: $n_{max} = d/\lambda = (2.0 \times 10^{-6})/(600 \times 10^{-9}) = 3.33$, so the highest order is n = 3. At that order $\sin\theta = 3 \times 600 \times 10^{-9}/2.0 \times 10^{-6}$, giving $\theta = 64.2°$. [4]

C2 First order: $\sin\theta = \lambda/d$. For 400 nm, $\theta = 11.5°$; for 700 nm, $\theta = 20.5°$. Angular width = 9.0°, with red diffracted more than violet. [4]

C3 Measuring the wavelengths of light and analysing spectra (spectroscopy), for example identifying elements from their line spectra; also used in spectrometers and to separate light into its component wavelengths. [2]