Topic Test: OxfordAQA International AS level Physics

Oscillations and Waves

Name: ____________________

Class: ____________________

Date: ____________________

Time: **50 minutes**

Marks: **38 marks**

Comments:

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1 (a) State **two** differences between stationary waves and progressive waves.

first difference ____

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second difference ____

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(2)

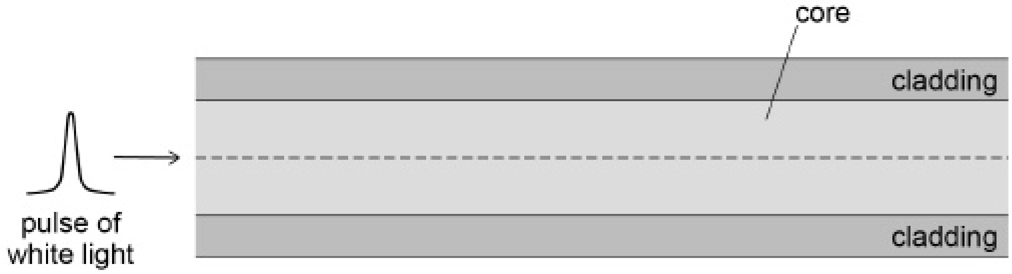
(b) A violin string has a length of 327 mm and produces a note of frequency 440 Hz.
Calculate the frequency of the note produced when the same string is shortened or "stopped" to a length of 219 mm and the tension remains constant.

frequency ______________________ Hz

(2)

(Total 4 marks)

2 The diagram shows a pulse of white light entering an optical fibre along the central axis of the core.



The pulse of white light broadens as it travels through this optical fibre.

State the name of this effect and explain its cause.

Name ____

Cause ____

____

____

____

(Total 2 marks)

3 A diffraction grating has 300 lines per mm. It is illuminated with monochromatic light of wavelength 540 nm.
Calculate the angle of the 2^{nd} order maximum, giving your answer to the appropriate number of significant figures.

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____

angle ____________________ degrees

(Total 4 marks)

4 Ultrasound waves are used to produce images of a fetus inside a womb.

(a) Explain what is meant by the frequency of a wave.

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(1)

(b) Ultrasound is a longitudinal wave. Describe the nature of a longitudinal wave.

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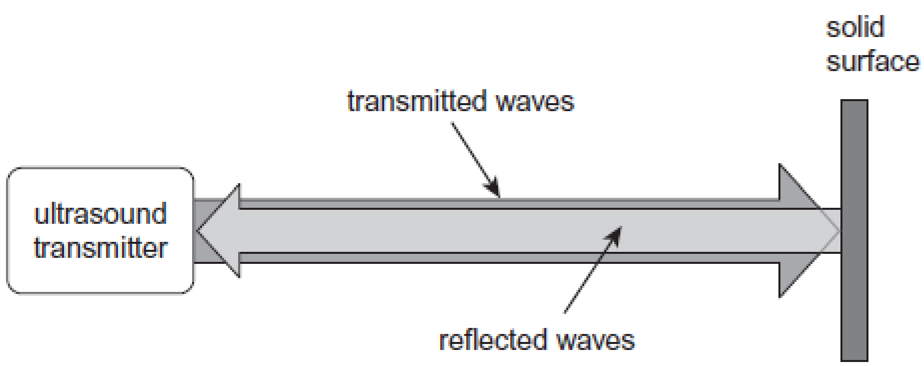
(2)

(c) In order to produce an image with sufficient detail, the wavelength of the ultrasound must be 0.50 mm. The speed of the ultrasound in body tissue is 1540 m s^{-1}. Calculate the frequency of the ultrasound at this wavelength.
Give your answer to an appropriate number of significant figures.

frequency ____________________ Hz

(2)

(d) A continuous ultrasound wave of constant frequency is reflected from a solid surface and returns in the direction it came from.



Assuming there is no significant loss in amplitude upon reflection, describe and explain the effect the waves have on the particles in the medium between the transmitter and the solid surface.

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(3)
(Total 8 marks)

5 (a) The work function of copper is 4.65 eV.

Explain the meaning of the term work function.

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(1)

(b) Determine the threshold frequency for copper.

threshold frequency = ____________________ Hz

(3)

(c) Electromagnetic radiation of frequency 850 THz is incident on a sheet of clean copper.

Explain whether photoelectrons will be emitted from the surface of the copper.

____

____

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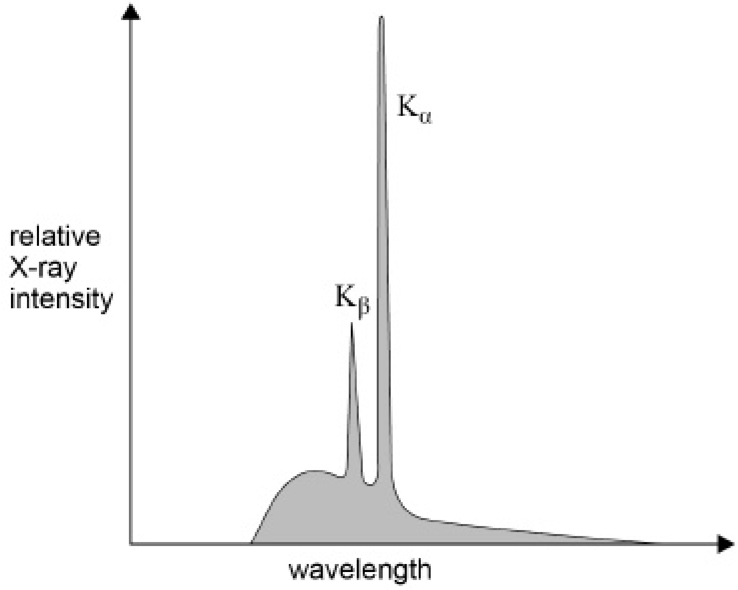
(2)

(Total 6 marks)

6 **Figure 1** shows the spectrum from an X-ray tube. The two peaks, labelled K_α and K_β, correspond to the production of characteristic X-rays.

Figure 1



(a) Explain how characteristic X-rays are produced in an X-ray tube.

____

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(3)

(b) The X-ray tube transfers 60 keV of kinetic energy to each accelerated electron.

Calculate the minimum wavelength emitted by the X-ray tube.

minimum wavelength = ____________________ m

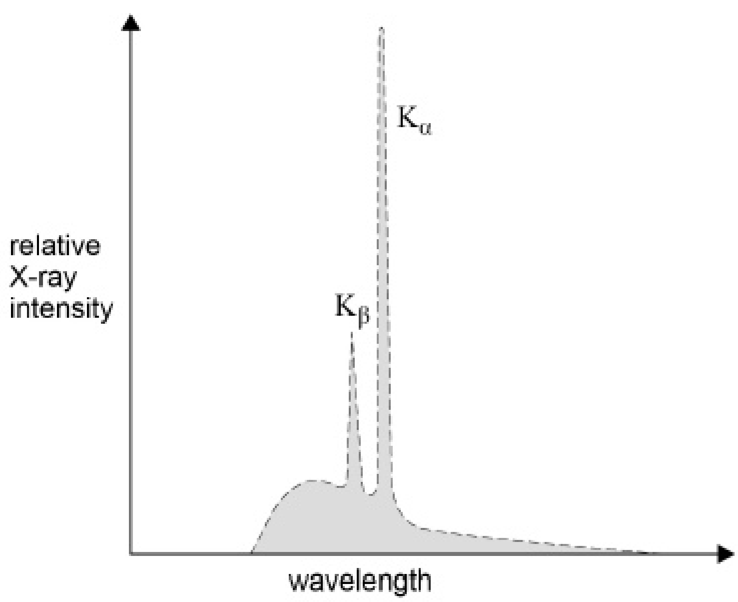
(3)

(c) The X-ray tube is now operated at a higher voltage, transferring 120 keV of kinetic energy to each electron.

Sketch on **Figure 2** the new X-ray spectrum.

Figure 2 shows the spectrum from **Figure 1** to help you.

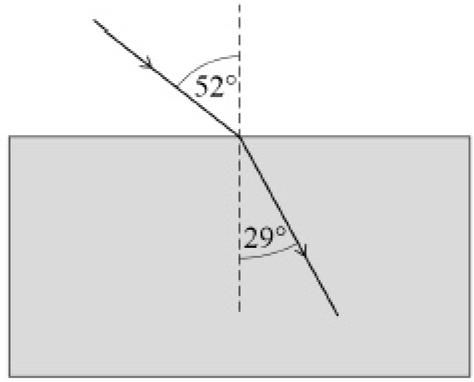
Figure 2



(2)

(Total 8 marks)

7 A ray of light passes from air into a transparent material.



What is the speed of light in the transparent material?

A 8.8×10^{6} m s^{-1} ○

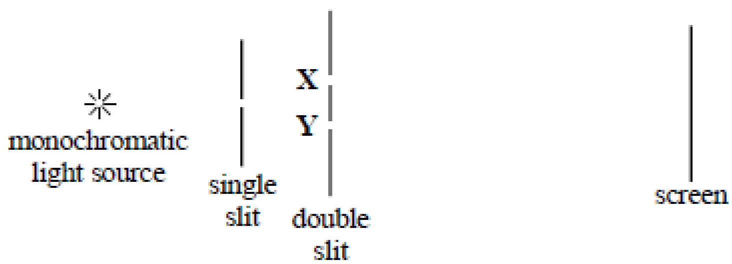
B 1.7×10^{8} m s^{-1} ○

C 1.8×10^{8} m s^{-1} ○

D 3.0×10^{8} m s^{-1} ○

(Total 1 mark)

8 The diagram represents the experimental arrangement used to produce interference fringes in Young's double slit experiment.



The spacing of the fringes on the screen will increase if

A the width of the single slit is increased

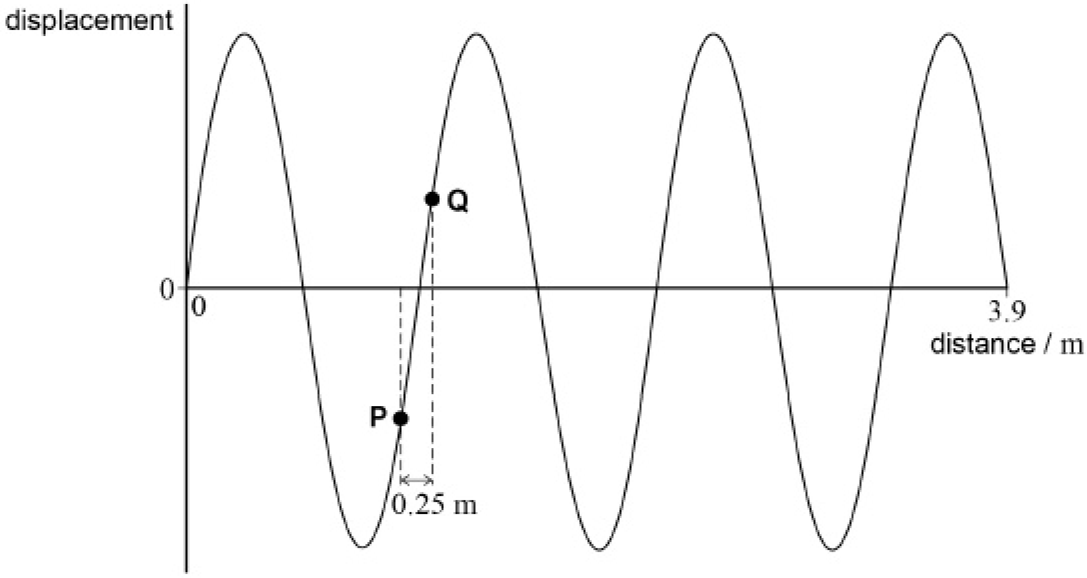
B the distance **XY** between the two slits is increased

C a light source of lower frequency is used

D the distance between the single and double slits is decreased

(Total 1 mark)

9 The graph shows the variation with distance of the displacement of a progressive wave.



What is the phase difference between points P and Q?

A 0.22 rad ⬭

B 0.40 rad ⬭

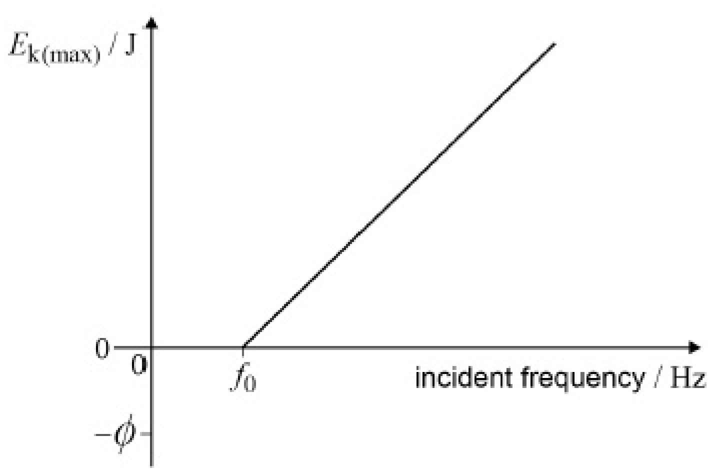
C 1.2 rad ⬭

D 1.4 rad ⬭

(Total 1 marks)

10 Photoelectrons may be emitted from a metal surface when electromagnetic radiation is incident on the metal surface.

The graph shows the variation of the maximum kinetic energy $E_{k(max)}$ of the emitted photoelectrons with the frequency of the incident radiation.



Which expression is equivalent to the Planck constant?

A $\frac{\text{gradient}}{f_0}$ ⬭

B $\frac{1}{\text{gradient}}$ ⬭

C $\frac{f_0}{\phi}$ ⬭

D $\frac{\phi}{f_0}$ ⬭

(Total 1 mark)

11 Which one of the following statements always applies to a damping force acting on a vibrating system?

A It is in the same direction as the acceleration.

B It is in the same direction as the displacement.

C It is in the opposite direction to the velocity.

D It is proportional to the displacement.

(Total 1 mark)

12 An electron has a kinetic energy E and a de Broglie wavelength λ. The kinetic energy is increased to $4E$. What is the new de Broglie wavelength?

A $\frac{\lambda}{4}$ ⬭

B $\frac{\lambda}{2}$ ⬭

C λ ⬭

D 4λ ⬭

(Total 1 mark)

Mark schemes

1 (a) **max 2 from**

in progressive waves, all points have the same amplitude (in turn),
in stationary waves, they do not

B1

in stationary waves, points between nodes are in phase, in progressive waves, all points within one wavelength are out of phase with each other

B1

in stationary waves, there is no energy transfer along the wave,
in progressive waves, there is

B1

stationary waves have nodes and antinodes but progressive waves do not

B1

where there are single relevant statements but no clear comparison between stationary and compressive waves, award 1 mark for two such statements

2

(b) $f \alpha 1/l$ or $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ *or fl* = const

C1

657/660 (Hz)

A1

2

[4]

2 **Name**: material dispersion ✓

Cause: different wavelengths (of white light) travel at different speeds (in the optical fibre)
OR have different refractive indices ✓

[2]

3 $\sin\theta = n\lambda/d$ in this form/correct calculations of d/d = 1/300

C1

substitutes correctly – condone powers of 10

C1

18.9

C1

2 or 3 sf only

A1

[4]

4 (a) number of (complete) <u>waves</u> (passing a point) <u>in 1 second</u>
OR
number of waves / time (for the waves to pass a point)
OR
(complete number of) oscillations \ vibrations <u>per second</u>
OR
1 / T with T defined as time for 1 (complete) oscillation ✓

Allow: cycles

Allow: unit time

1

(b) <u>For two marks</u>:
oscillation of particles \ medium \ material etc, but not oscillation of wave is parallel to \ in same direction as
the direction wave (travels) ✓ ✓

<u>For one mark</u>:
particles \ material \ medium <u>move(s)</u> \ disturbance \ displacement
parallel to \ in same direction as
the direction wave travels
OR
(oscillations) parallel to direction of wave travel ✓

the one mark answer with:
mention of <u>compression</u>s and <u>rarefaction</u>s
OR
(longitudinal waves) cannot be polarised

gets **two** marks
✓

Allow
Vibration

Allow direction of energy transfer \ wave propagation

2

(c) ($f = 1540 / 0.50 \times 10^{-3}$)
= 3 100 000 (Hz) ✓ (3 080 000)
2sf ✓

2

(d) no more than two points from either list (max 3):
Description
- mention of nodes and antinodes
- particles not moving at a node
- maximum displacement at antinode
- particles either side of node in antiphase / between two nodes in phase
- variation of amplitude between nodes

Explanation
- a stationary wave (forms)
- two waves are of equal frequency or wavelength (and amplitude in the same medium)
- reflected and transmitted waves \ waves travelling in opposite directions, pass through each other
- superpose / interference occurs
- constructive interference at antinodes
- destructive interference at nodes

✓ ✓ ✓

Allow 'standing wave'

3

[8]

5 (a) minimum energy to remove an electron from the surface of a copper / metal ✓

1

(b) $4.65 \times 1.60 \times 10^{-19} = 7.44 \times 10^{-19}$ (J) ✓

Use of $f = \frac{\Phi}{h}\left(\frac{7.44 \times 10^{-19}}{6.63 \times 10^{-34}}\right)$ ✓

Allow 2nd mark only for failure to convert work function into joule.

1.12×10^{15} (Hz) ✓

3

(c) 850×10^{12} Hz

Power of ten must be seen; do not allow SI prefix.

OR

photon energy = 3.5 eV seen ✓

Must give a reason.

no photoelectrons emitted because f below threshold frequency

Comparison may be in joule.

Allow valid conclusion based on an incorrect conversion of THz or an ecf from their (b)

OR

no photoelectrons emitted because photon energy below Φ ✓

2

[6]

6 (a) Any three from ✓

Must be clear about which electrons are moving

Electrons (from beam) collide with metal target or anode ✓
Idea of excitation followed by de-excitation OWTTE ✓
…involving the inner / K shell✓
Photons emitted during de-excitation ✓
Photon energy = difference in energy levels ✓

max 3

(b) $60\ 000 \times 1.6 \times 10^{-19}$ **OR** 9.6×10^{-15} J seen ✓

Allow power of ten error

Use of $\lambda = \frac{hc}{E}$ $(= 6.63 \times 10^{-34} \times 3 \times 10^{8} \div 9.6 \times 10^{-15})$ ✓

Allow use of $E = hf$ *and* $c = f\lambda$

2.1×10^{-11} (m) ✓

Accept other values if appropriate unit given

3

(c) λ_{min} approximately halved (by eye) ✓

Ignore other features of the graph

K_{α} and K_{β} wavelengths unchanged ✓

2

[8]

7 C

[1]

8 C

[1]

9 D

[1]

10 D

[1]

11 C

[1]

12 B

[1]