K14E Waves: Light and Sound: Depth and Practice

AQA AQA KS3 Physics · Calculator allowed · about 75 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Which type of wave is light? Choose from the options.

- [ ] A) Mechanical transverse
- [ ] B) Electromagnetic transverse
- [ ] C) Longitudinal pressure wave
- [ ] D) Matter wave

2 Complete the sentence: Sound needs a material medium to travel, so it cannot travel through _____.

(2)

3 A student sets up a ripple tank with regular waves approaching a gap in a barrier. Describe what happens to the waves after they pass through the gap and name the process.

(3)

4 Light shines from air into glass at an angle. Complete the sentences: a) When light enters the glass it bends _____ the normal. b) Inside glass the speed of light is _____ compared with air.

(3)

5 Name two parts of the ear involved in detecting sound and give one function for each.

(2)

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6 An experiment measures the frequency of a tuning fork by timing 120 vibrations. The stopwatch shows 60.0 s. a) Calculate the frequency of the tuning fork. b) State the unit of frequency.

(3)

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7 Explain why sound becomes quieter with distance from the source. Give one clear reason.

(2)

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8 A ray of light passes from glass (refractive index higher) into water (refractive index lower). The angle to the normal in glass is 35 degrees. Use Snell-like reasoning: predict whether the angle in the water will be bigger, smaller or the same and explain why.

(4)

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9 State what is measured by the amplitude of a sound wave.

(2)

10 A student measures the time for a pulse to travel along a spring: distance 1.5 m, time 0.30 s. a) Calculate the speed of the pulse. b) Give the unit.

(3)

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11 Describe an experiment to show that light travels in straight lines, including the main apparatus, the method and what you would observe.

(4)

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12 Which colours have longer wavelength: red or blue light? State the correct colour and one consequence in everyday life.

(2)

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13 An ultrasound pulse takes 36 microseconds (3.6×10^{-5} s) to travel through soft tissue and return from a structure 18 mm deep. Assuming the pulse travels to the structure and back in the given time, calculate the speed of sound in the tissue. Show working. (Distance given is one way.)

(3)

14 Extended response (6 marks). A teacher asks a class to investigate how the pitch of a sound produced by a stretched string depends on the tension in the string. Describe a fair method the students could use, including: a list of the main apparatus, which variables to keep the same, how to change and measure tension, how to measure pitch, and how to decide whether increasing tension increases pitch. Include one safety consideration. Note: this is a design and evaluation answer, so give clear steps and reasons.

(6)

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15 A student uses a concave mirror to form an image of a candle. State two differences between the image formed by a concave mirror when the candle is placed very close to the mirror compared with when the candle is far from the mirror.

(3)

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16 State which of the following can be reflected: radio waves, sound waves, water waves. Give yes or no for each.

(2)

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17 A red laser and a green laser are pointed at a white screen. Explain why the white screen shows different coloured spots for each laser.

(3)

18 A student notices that when they move away from a siren the pitch seems lower than when they move towards it. Name this effect and give a short explanation.

(2)

Mark scheme · K14E Waves: Light and Sound: Depth and Practice

Question 1

- **B1** B cao
- Answer: **B) Electromagnetic transverse**

Question 2

- **B1** vacuum cao
- **B1** explain that a vacuum has no particles to carry vibrations
- Answer: **vacuum**

Question 3

- **M1** state that waves spread out after passing through the gap
- **A1** use the word diffraction cao
- **B1** mention that spreading is greater when gap is similar in size to wavelength or when gap is narrow, oe
- Answer: **The waves spread out after passing through the gap; this is called diffraction. The spreading is larger when the gap size is similar to the wavelength or when the gap is narrow.**

Question 4

- **B1** towards the normal cao
- **B1** slower (than in air) cao
- **B1** mention that refraction causes the bending, oe
- Answer: **a) towards the normal; b) slower**

Question 5

- **B1** outer ear/pinna collects and directs sound into ear canal or ear canal carries vibrations to eardrum, accept either
- **B1** eardrum vibrates in response to sound / ossicles (small bones) amplify vibrations / cochlea converts vibrations to electrical signals, any one function
- Answer: **Pinna (outer ear) collects and directs sound into the ear canal; eardrum vibrates when sound waves hit it (ossicles then amplify vibrations).**

Question 6

- **M1** use frequency = number of vibrations / time or f = 120 / 60.0
- **A1** 2 Hz cao
- **B1** state unit hertz or Hz
- Answer: **2 Hz**

Question 7

- **M1** sound energy spreads out over a larger area as distance increases (intensity decreases)
- **A1** so the energy reaching your ear per second is less and the sound is quieter cao
- Answer: **Sound energy spreads out over a larger area as distance increases, so less energy reaches the ear per second and the sound is quieter.**

Question 8

- **M1** state that light goes from more optically dense to less optically dense medium (glass to water)
- **A1** light bends away from the normal when moving into a less dense medium cao
- **B1** therefore angle in water will be larger than 35 degrees, oe
- **B1** mention that speed of light increases when going into water from glass, leading to bending away from the normal, oe
- Answer: **The angle in the water will be larger than 35 degrees because light moves from a more optically dense medium (glass) into a less optically dense medium (water) and so bends away from the normal; the speed of light increases, causing the larger angle.**

Question 9

- **B1** loudness or volume is related to amplitude
- **B1** amplitude measures maximum displacement of particles from rest / size of pressure variation, oe
- Answer: **Amplitude measures the maximum displacement of particles (size of pressure variation) and is related to the loudness of the sound.**

Question 10

- **M1** use speed = distance / time with 1.5 / 0.30
- **A1** 5 m/s cao
- **B1** unit m/s stated
- Answer: **5 m/s**

Question 11

- **M1** apparatus: ray box or torch, card with small hole, screen or white paper, several cards with holes in a line
- **M1** method: align holes and shine light through holes so beam passes through all holes onto screen
- **A1** observation: a single bright spot or straight line on the screen shows the light beam travelled straight
- **B1** mention that if any card is moved out of line the spot disappears showing straight path dependence, oe
- Answer: **Use a ray box or torch and several cards with aligned small holes, shine the light through all holes onto a screen; you will see a single bright spot or straight line on the screen, and if any card is moved out of line the spot disappears, showing light travels in straight lines.**

Question 12

- **B1** red
- **B1** consequence e.g. red light is scattered less by the atmosphere so sunsets appear red, oe
- Answer: **Red light has a longer wavelength. One consequence is that red is scattered less in the atmosphere, which is why sunsets often look red.**

Question 13

- **M1** use total distance = 2 x 18 mm = 36 mm = 0.036 m and speed = distance / time
- **A1** 1000 m/s cao
- **B1** show unit m/s
- Answer: **1000 m/s**

Question 14

- **Level 3** (5-6): Detailed method: clear list of appropriate apparatus, specific controlled variables, correct way to change and measure tension, valid method to measure pitch and clear description of how data would show the effect; includes a safety point and justification.
- **Level 2** (3-4): Acceptable method: main apparatus and idea to change tension and measure pitch present, some controls stated, limited detail on measurement or analysis, safety mentioned.
- **Level 1** (1-2): Basic ideas: mentions that tension and pitch are related and gives one or two brief steps but lacks detail on measurement, controls or safety.
- **Indicative content:**
  - Apparatus: string fixed across a wooden bridge or meter rule, set of known masses and pulley to change tension, clamp, frequency meter or mobile phone app to measure pitch, ruler, mass hanger, stopwatch not required.
  - Variables to control: keep length of string constant, same string/material and thickness, same location and method of plucking, avoid changing temperature.
  - Change and measure tension: add known masses to a hanger over a pulley so tension approximates to the weight of the masses (tension = mass x g). Record mass used; convert to tension in newtons if required.
  - Measure pitch: use a frequency meter or phone app to record frequency for each tension, take several repeats and calculate mean frequency for each tension.
  - Decide increase: plot frequency (pitch) against tension or look for consistent increase in mean frequency as tension increases; state trend and whether it is clear and repeatable.
  - Safety: ensure masses are secured and fingers are clear when plucking to avoid getting hit by hanger; clamp apparatus to bench to avoid slipping.

Question 15

- **B1** when very close the image is virtual / upright
- **B1** when close the image is larger (magnified) compared with when far
- **B1** when far the image is real and inverted and may be smaller or at focus, oe
- Answer: **When the candle is very close the image is virtual, upright and larger (magnified); when the candle is far the image is real, inverted and smaller or near the focus.**

Question 16

- **B1** radio waves: yes (electromagnetic waves reflect from metal surfaces)
- **B1** sound waves: yes (echoes show reflection)
- Answer: **Radio waves: yes. Sound waves: yes. (Water waves are also reflected, but the question required two lines; common accepted answers include water waves: yes.)**

Question 17

- **M1** state that lasers emit light of a single colour (single wavelength) each
- **A1** explain that white screen reflects the light so the spot appears the colour of the laser
- **B1** mention that human eyes detect different wavelengths as different colours (red vs green) or that mixing would be needed for white, oe
- Answer: **Each laser emits light of a single wavelength; the white screen reflects that light so the spot appears the colour of the laser, and our eyes detect different wavelengths as different colours.**

Question 18

- **B1** Doppler effect or Doppler shift named
- **B1** explain that relative motion changes frequency heard: moving away reduces frequency so pitch lower, moving towards increases frequency so pitch higher
- Answer: **Doppler effect: because relative motion between source and observer changes the frequency reaching the ear; moving away reduces the frequency heard so the pitch is lower.**