National 5 Physics

Waves and Radiation

Answer Book

DO NOT WRITE ON THESE SHEETS

Wave Parameters and Behaviours

Longitudinal and transverse waves

1. Sound wave – transfers sound energy, water wave – kinetic energy.

2 Wave A is a transverse wave and Wave B is a longitudinal wave.

3. (*a*) Stretch the spring and move sideways, back and fore at right angles to length of spring.
(*b*) Stretch the spring and move spring back and fore in direction of spring.

4. Water waves – transverse, Light – transverse, Sound – longitudinal,
Radio waves – transverse, X-rays – transverse.

Wave speed, frequency, wavelength and amplitude

5. (*a*) The distance from the mid line to a wave crest or wave trough.
(*b*) Wavelength.
(*c*) Hz
(*d*) s
(*e*) The distance travelled by a wave each second.

6. f = 1/T

7. 0·1 s

8. 4 s

9. 5 Hz

10. 100 Hz

11. (*a*) 5 Hz
(*b*) 3 Hz
(*c*) 1 Hz
(*d*) 5 Hz
(*e*) 0·5 Hz

12. (*a*) 1 Hz
(*b*) 2 Hz
(*c*) 5 Hz
(*d*) 4 Hz

13. (*a*) 0·1 m
(*b*) 0·5 m
(*c*) 10 cm or 0·1 m
(*d*) 2 m

14. (*a*) 256. (*b*) 15 360

15. 2 Hz

16. (*a*) 500
(*b*) 2500
(*c*) 50

Calculating wave speed using frequency and wavelength

17. $v = f \times \lambda$

18. (*a*) 20 m s^{-1}
(*b*) 5 m s^{-1}
(*c*) 2 m
(*d*) 5 m
(*e*) 68 Hz
(*f*) 0·2 Hz
(*g*) 1500 m
(*h*) 3×10^{6} Hz
(*i*) 3×10^{8} m s^{-1}

19. 0·02 m

20. 1360 Hz

21. 1 m s^{-1}

22. 6 m s^{-1}

23. (*a*) 3·2 m
(*b*) 3·1 m
(*c*) 2·8 m
(*d*) 247 m
(*e*) 1515 m

24 $4{\cdot}3 \times 10^{14}$ Hz

Calculating wave speed using distance and time

25. $d = v \times t$

26. (*a*) 8 m s^{-1}
(*b*) 20 m s^{-1}
(*c*) 5 s
(*d*) 400 s
(*e*) 2720 m
(*f*) 20 m

27. 20 s

28. 238 m s^{-1}

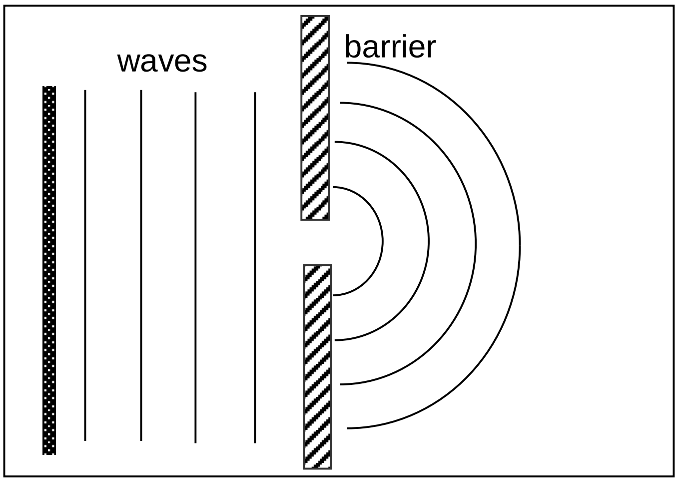
29. 0·3 seconds

30. 4 m s^{-1}

31. (*a*) 1·27 s
(*b*) 500 s

32. Diffraction

33.



34. (*a*) Diffraction

(*b*) Waves which have a **long** wavelength bend more than waves which have a **short** wavelength.

Extension Questions

35. (*a*) 0·00003 s
(*b*) 0·17 m

36. (*a*) 3×10^8 m s^{-1}
(*b*) 0·7 m
(*c*) Waves bend around the person to reach the car.

37. (*a*) Diffraction
(*b*) Sound can diffract around the corner of the building.
(*c*) Low frequency sound is able to diffract over the top of the barrier.
(*d*) The LW broadcasts can bend around obstacles whilst the high frequency FM cannot.

Light

Refraction of light

38. 90°

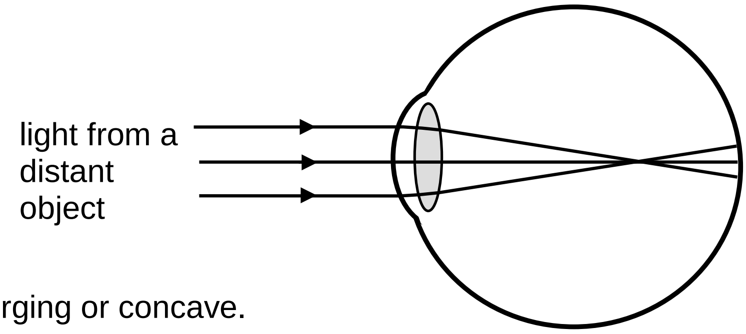
39. (*a*) Towards.
(*b*) Away from.
(*c*) Decreases.
(*d*) Increases.
(*e*) Less than.
(*f*) Greater than.

40. (*a*) P
(*b*) R

41. C, F, H, I, J

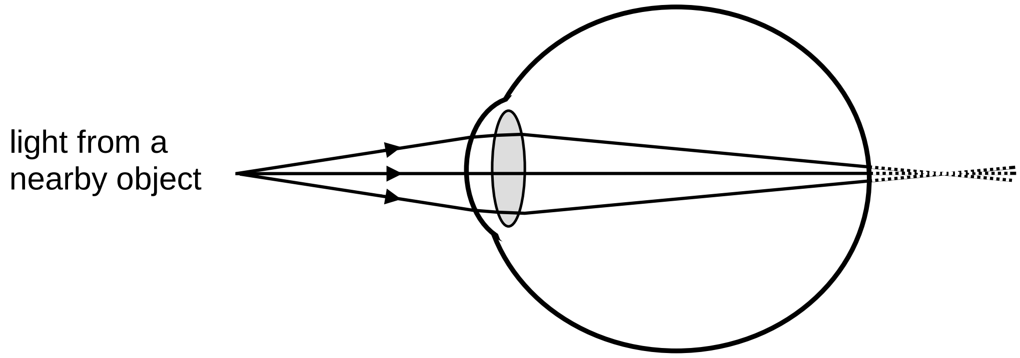
42. (*a*) angle of incidence = 40°, angle of refraction = 25°
(*b*) angle of incidence = 50°, angle of refraction = 31°
(*c*) angle of incidence = 25°, angle of refraction = 16°
(*d*) angle of incidence = 35°, angle of refraction = 23°

43. (*a*)



(*b*) Diverging or concave.

44. (*a*)

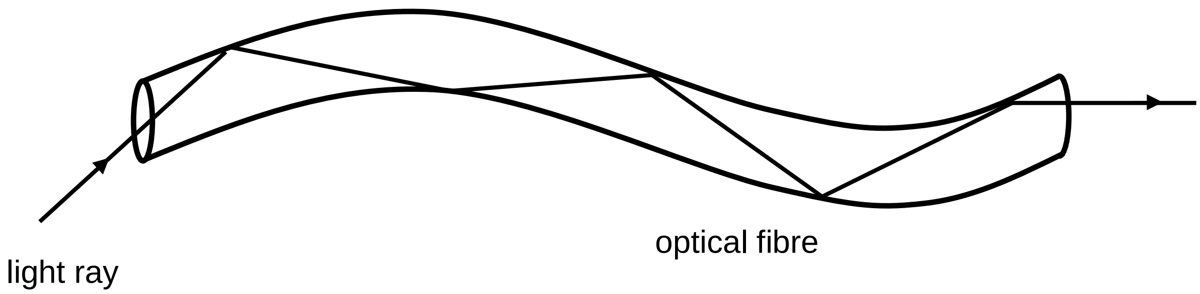


(*b*) Convex or converging.

45. Occurs when a ray of light tries to escape from a glass to air and the angle of incidence is greater than the critical angle. The ray is reflected back into the glass.

46. (*a*) Ray refracts out of block with some reflection.
(*b*) Ray refracts at 90° along block face with some reflection.
(*c*) Ray totally reflects back into block.

47.



48. (*a*) 28°
(*b*) 28°
(*c*) 28°
(*d*) 45°

49. (*a*) Total internal reflection.
(*b*) It will decrease as some of the light has been refracyed out of the windscreen.

50. (*a*) Convex or converging.
(*b*) Backwards.
(*c*) Long sight.

Electromagnetic Spectrum

The electromagnetic spectrum

51. (*a*) 3×10^8 m s^{-1}
(*b*) At the same time.
(*c*) (i) Radio and TV waves.
(ii) Gamma radiation
(iii) Gamma radiation.
(iv) Radio and TV waves

52.

	Wave frequency	***Wavelength***	***Type of wave***
(*a*)	3×10^{19} Hz	**1×10^{-11} m**	**Gamma radiation**
(*b*)	$4{\cdot}3 \times 10^{14}$ Hz	**$6{\cdot}97 \times 10^{-7}$ m**	**Red light**
(*c*)	3×10^{10} Hz	**0·01 m**	**Microwaves**
(*d*)	$7{\cdot}5 \times 10^{14}$ Hz	**4×10^{-7} m**	**Violet light**
(*e*)	**$1{\cdot}0 \times 10^{16}$ Hz**	3×10^{-8} m	**Ultraviolet**
(*f*)	**$1{\cdot}0 \times 10^{18}$ Hz**	3×10^{-10} m	**X-rays**
(*g*)	**$1{\cdot}0 \times 10^{8}$ Hz**	3 m	**Radio and TV**
(*h*)	**$1{\cdot}0 \times 10^{6}$ Hz**	300 m	**Long wave**
(*i*)	**$3{\cdot}0 \times 10^{13}$ Hz**	1×10^{-5} m	**Infrared**

53. 3×10^{-7} m

54. (*a*) 3×10^{8}
(*b*) 3·1 m
(*c*) 0·0003·s

55. 3×10^{12} Hz

56. (*a*) 500 s
(*b*) 1×10^{20} Hz

57. (*a*) 0·17 m
(*b*) $1{\cdot}7 \times 10^{-5}$ s

58. (*a*) 5
(*b*) 4
(*c*) 6
(*d*) 2
(*e*) 1
(*f*) 7
(*g*) 3

59. (*a*) Radio and TV waves.
(*b*) Infrared.
(*c*) Heating food in a microwave oven.
(*d*) Visible or Infrared.

60. (*a*) A hot object.
(*b*) An infrared camera or infrared sensitive film. It will also cause objects which absorb it to warm up.
(*c*) Thermographs, treating muscle injuries, remote controls, burglar alarm activators.

61. (*a*) Using materials which fluoresce (glow) under ultraviolet light.
(*b*) It can cause skin cancer.
(*c*) Can be used in the treatment of skin diseases or to security mark objects.

62. (*a*) Frequent exposure to X-rays would be harmful.
(*b*) X-rays are more likely to damage cells which are actively dividing, such as in a young child.
(*c*) It completely blocks more of the X-rays.

63. (*a*) The bone blocks the X-rays reaching the film.
(*b*) 3×10^{18} Hz
(*c*) X-rays could harm the foetus.
(*d*) Ultrasound.

64. Waves from the electromagnetic spectrum will transfer **energy** from one place to another. The amount of energy the waves carry depends upon the frequency or wavelength of the waves. The **higher** the frequency or **shorter** the wavelength, the more energy they carry. Waves with a **longer** wavelength and a **low** frequency carry less energy.

65. (*a*) Uv A = 1×10^{15} Hz, uv B = $7{\cdot}5 \times 10^{14}$ Hz so uv A has the higher frequency
(*b*) Uv A as the higher frequency radiation carries more energy.

Extension Questions

66. (*a*) 0·33 m
(*b*) (i) Two from: infrared, visible light, ultraviolet, x-rays or gamma radiation.
(ii) TV and radio and long waves
(*c*) $1{\cdot}3 \times 10^{-5}$ s
(*d*) High frequency waves carry more energy.
(*e*) $3{\cdot}6 \times 10^{7}$ m

67. (*a*) Sound waves are longitudinal waves and cannot travel through a vacuum. Waves from the EM spectrum are transverse and can travel through a vacuum.
(*b*) Ultraviolet, X-rays and gamma radiation.
(*c*) They carry more energy.
(*d*) When electrons move in a conductor.
(*e*) Static.
(*f*) To ‘see’ when there is no light.
(*g*) The ozone layer in the atmosphere filters it out.
(*h*) It can be harmful.
(*i*) Sterilising medical instruments, destroying cancer cells.

Nuclear Radiation

Properties of Radiation

68. (*a*) Neutron.
(*b*) Proton
(*c*) Electron

69. They are equal in number.

70. When alpha or beta particles pass another atom, they tend to pull electrons off it leaving it with a positive charge.

71. There are three different types of nuclear radiation – alpha, beta and gamma. Alpha radiation is a **helium** nucleus and has a **positive** charge. It is a **strongly** ionising radiation so will damage cells if it gets into the body. Fortunately, it is blocked by a thin sheet of **paper** or a few centimetres of **air**. Beta radiation is a fast moving **electron** from the break up of a proton in an atom's **nucleus**. It has a **negative** charge and requires 3 millimetres of aluminium to block it. The last type is gamma radiation which is not a particle but a **wave** and part of the electromagnetic spectrum. Gamma requires 3 centimetres of **lead** to block its path. Beta and gamma are **weakly** ionising radiations and do not ionise as strongly as alpha radiation.

72. (*a*) Sheet of paper or 3 cm of air.
(*b*) Strongly ionises.
(*c*) Fast moving electron.
(*d*) Weakly ionises.
(*e*) Gamma.
(*f*) 3 cm of lead.

73. (*a*) When alpha or beta particles pass another atom, they tend to pull electrons off it leaving it with a positive charge.
(*b*) It is good at ionising the air.

74. Becquerel.

75. 2×10^6 Gy

76. $1{\cdot}8 \times 10^7$

77. 6×10^6

78. (*a*) Background radiation is present all time, either from natural sources or man-made sources.

(*b*)

Source	*Natural*	*Man-made*
Building materials		✓
Nuclear medicine		✓
Nuclear power stations		✓
Cosmic radiation	✓	
Granite rock	✓	
Radon gas		✓
Bananas	✓	
Water	✓	
Tobacco		✓
Smoke detectors		✓
Luminous watches		✓

Absorbed Dose and Equivalent Dose

79. (*a*) Absorbed dose = energy/mass
(*b*) Gray (Gy).

80. (*a*) 5×10^{-4} Gy
(*b*) 0·025 Gy
(*c*) $2{\cdot}5 \times 10^{-5}$ J
(*d*) $1{\cdot}5 \times 10^{-7}$ J
(*e*) 0·25 kg
(*f*) 1 kg

81. $1{\cdot}25 \times 10^{-3}$ Gy

82. 17 Gy

83. (*a*) Equivalent dose = absorbed dose × weighting factor.
(*b*) Sievert (Sv)

84. (*a*) Some form s of radiation are more harmful than others to living tissue.
(*b*) It strongly ionises so will cause greatest disruption and damage to living cells.

85. (*a*) 2×10^{-4} Sv
(*b*) 0·015 Sv
(*c*) 5×10^{-4} Sv
(*d*) 5×10^{-6} Sv
(*e*) 2×10^{-6} Sv
(*f*) 10×10^{-6} Sv

86. 20 μSv

87. 0·05 Sv

88. (*a*) 3·3 μJ
(*b*) 66 μj

89. 100 μSv

Applications of nuclear radiation

90. (*a*) Alpha will be blocked by the aluminium foil while gamma will pass straight through unaffected.
(*b*) It has become thicker.
(*c*) It would be reduced.

91. (*a*) Gamma radiation can escape from the body, alpha radiation is very harmful within the body.
(*b*) The right kidney.
(*c*) Radioactivity decreases with time.
(*d*) (i) The left side of the thyroid has not absorbed the radioactive iodine (as well).
(ii) The radioactivity of the iodine may decrease to a low level before it is used.

92. (*a*) So that householders do not receive radiation in their water.
(*b*) About 40 metres.
(*c*) Only gamma will be able to travel through the rocks and soil to the surface.

Half-life

93. It is the time taken for the activity of the source to decrease to half its original value.

94. 8 minutes.

95. 500 Bq

96. 8 days.

97. (*a*) Radiation from natural or man-made sources that is always present.
(*b*) Deducted.
(*c*) Approximately 16 minutes

98. 16 g

99. 10 million

100. 625 kBq

101. Nuclear fission takes place when a **neutron** collides with a **large** unstable nucleus of **uranium**. This causes it to **split** into two **smaller** nuclei. At the same time it releases more **neutrons** and a quantity of **heat**.

102. Nuclear fusion takes place when two **small** nuclei collide and join together to create a **larger** nucleus. This also causes **heat** energy to be released. This is the same atomic reaction that provides the energy for the **Sun**.

103. (*a*) Turbine.
(*b*) It is used to produce steam.
(*c*) It converts the kinetic energy of the turbine into electricity.
(*d*) Nuclear energy into heat.

104. (*a*) Fission occurs when a large nucleus splits in two, releasing energy. Nuclear fusion occurs when two small nuclei combine together to form a larger nucleus, again releasing energy.
(*b*) Fission.

105. Neutrons are released by nuclear fission which go on to produce more fission which releases more neutrons and so on.

106. A A neutron strikes a large nucleus which becomes unstable.
B The nucleus splits into two smaller nuclei.
C Heat is released along with more neutrons.

107.
1. **TRUE** – Most radiation comes from cosmic rays from space and from radon gas escaping from underground rocks.
2. **FALSE** – Estimates vary, but there is sufficient nuclear fuel, in the form of uranium, to last for at least a hundred years. Newer types of nuclear reactors could make this last a lot longer.
3. **TRUE** – Radioactive waste from nuclear reactors remains radioactive for a long tome so needs to be stored underground till the radiation levels decrease enough.
4. **TRUE** - Nuclear fission is currently used though scientists are working on using nuclear fusion to produce energy.
5. **FALSE** - Nuclear reactors take many years to plan and build so can't be built quickly.
6. **FALSE** - Nuclear reactors do not produce any sulphur dioxide.
7. **FALSE** – Only a tiny fraction of the overall background radiation comes from nuclear power stations though there have been some major disasters such as Chernobyl power station in Russia which blew up as a result of workers switching off safety mechanism s.
8. **FALSE** – Industry can create demands for large quantities of energy but like fossil fuelled power stations, this can be supplied by nuclear power stations.
9. **FALSE** - Nuclear reactors do not produce any greenhouse gases.

10. **FALSE** – None of the nuclear power stations in the west are of the type that exploded in Chernobyl.

Extension Questions

108. (*a*) D
(*b*) B
(*c*) C
(*d*) A
(*e*) (i) 4000 Bq
(ii) 250 Bq

109. (*a*) Cosmic radiation, radon gas, rocks, medical radioactivity etc.
(*b*) Approximately 8·5 seconds
(*c*) Any spillages are kept enclosed.
(*d*) It is buried underground in sealed containers.

110. (*a*) It is the time taken for the activity of the source to decrease to half its original value.
(*b*) Approximately 9 minutes
(*c*) When alpha or beta particles pass another atom, they tend to pull electrons off it leaving it with a positive charge.
(*d*) 12 000 years.