Waves, sound and light: Electromagnetic radiation

Practice test and memo

Practice test
Mark allocation: 40 marks
Time allocation: 40 minutes
Refer to the formula sheet at the end of the test.

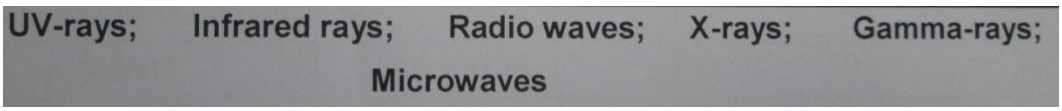
1. Four options are provided as possible answers to the following questions. Each question has only one correct answer. Write only the letter (A-D) next to the question number.

1.1 A photon that carries more energy will always have: **(2)**
   A. Large amplitude
   B. High frequency
   C. Long wavelength
   D. High speed

1.2 Electromagnetic waves are different from other types of waves in that they do not: **(2)**
   A. Have amplitude
   B. Need a medium
   C. Transfer energy
   D. Have speed

1.3 The relationship between energy and wavelength of electromagnetic radiation is: **(2)**
   A. Proportional
   B. Inversely proportional
   C. Opposite
   D. Unrelated

2. Some electromagnetic waves are listed below.



From the list above, write down the name of the wave:

2.1 With the highest frequency in the electromagnetic spectrum. **(1)**
2.2 Used to sterilise medical equipment. **(1)**
2.3 Used in gate and garage remote controls. **(1)**
2.4 Used to transfer energy to water molecules to warm food. **(1)**
2.5 That has the lowest energy. **(1)**

3. The following table shows a few electromagnetic waves and their corresponding wavelengths:

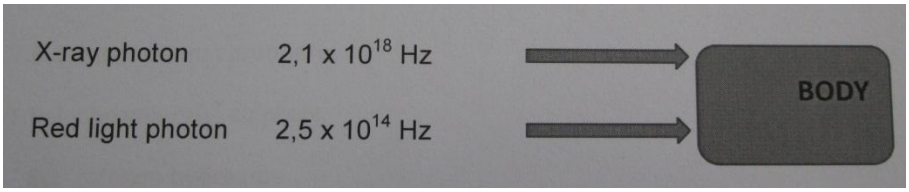
Radiation	Wavelength (m)
X-rays	$2{,}11 \times 10^{-10}$
Ultraviolet light	$3{,}00 \times 10^{-7}$
Visible light	$5{,}13 \times 10^{-6}$
Infrared	$4{,}05 \times 10^{-5}$
Medium-wave radio waves	$6{,}21 \times 10^{2}$

3.1 Explain how electromagnetic waves originate. **(1)**
3.2 Which of the radiation in the table has the highest penetrating ability? Provide a reason for your answer based on the information in the table. **(2)**

Electromagnetic waves from an unknown source are received and it is discovered that a photon of this radiation has an energy of 6.63×10^{-19} J.

3.3 Define a photon. **(2)**
3.4 Use a calculation to determine the kind of electromagnetic wave this is. **(4)**

4. An X-ray photon of frequency 2.1×10^{18} Hz and a photon of red light of frequency 2.5×10^{14} Hz fall on a body as shown below.



4.1 By means of calculation, show which of the photons will have the higher penetrating ability. **(6)**
4.2 Briefly explain how X-rays can take a photograph of the interior of the body. **(2)**
4.3 Briefly explain why X-rays are not always the preferred medical method. **(2)**

5. An infrared electromagnetic wave has a wavelength of 4×10^{-5} m.

5.1 Provide one use of infrared radiation. **(1)**
5.2 What is the period of the wave? **(3)**
5.3 What is the frequency of the wave? **(3)**
5.4 How much energy is associated with a photon of infrared radiation? **(3)**

TABLE/*TABEL* 1: PHYSICAL CONSTANTS/*FISIESE KONSTANTES*

NAME / *NAAM*	SYMBOL / *SIMBOOL*	VALUE / *WAARDE*
Acceleration due to gravity *Versnelling as gevolg van gravitasie*	g	9,8 $m{\cdot}s^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3,0 \times 10^{8}$ $m{\cdot}s^{-1}$
Planck's constant *Planck se konstante*	h	$6,63 \times 10^{-34}$ J.s
Charge on electron *Lading op elektron*	e^-	-1.6×10^{-19} C

TABLE/*TABEL* 2: FORMULAE / *FORMULES*

MOTION / *BEWEGING*

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$	$v_f^2 = v_i^2 + 2a\Delta x$	$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$

WEIGHT AND MECHANICAL ENERGY / *GEWIG EN MEGANIESE ENERGIE*

$F_g = mg$	$U = E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$E_m = (E_k + E_p)_i = (E_k + E_p)_f$

WAVES, LIGHT AND SOUND / *GOLWE, LIG EN KLANK*

$v = f\lambda$	$T = \frac{1}{f}$	$E = hf$ $\quad E = h\frac{c}{\lambda}$
$\Delta x = v\Delta t$	$n = \frac{c}{v}$	$c = f\lambda$

ELECTRICITY AND MAGNETISM / *ELEKTRISITEIT EN MAGNETISME*

$I = \frac{Q}{\Delta t}$	$V = \frac{W}{Q}$	$R = \frac{V}{I}$	$Q = \frac{Q_1 + Q_2}{2}$
$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	$R_s = R_1 + R_2 + \ldots$	$n = \frac{Q}{e}$	

Practice test memo

1.
1.1 B✓✓
1.2 B✓✓
1.3 B✓✓

2.
2.1 Gamma rays✓
2.2 UV rays✓ or gamma rays
2.3 Radio waves✓
2.4 Microwaves✓
2.5 Radio waves✓

3.
3.1 Accelerating charged particles✓
3.2 X-rays✓ They have the shortest wavelength✓
3.3 Particles associated with electromagnetic radiation that carry energy in discrete (isolated) packets✓✓
3.4 $\lambda = \frac{hc}{E}$✓
$= \frac{6.6\times10^{-34}\times3\times10^{8}}{6.63\times10^{-18}}$✓
$= 3\times10^{-7}\ m$✓
Ultraviolet light✓

4.
4.1 X-ray photon:
$E = hf$✓
$= 6.6\times10^{-34}\times\ 2.1\times10^{18}$✓
$= 1.37\ \times10^{-15}$ J✓
Red light photon:
$E = hf$
$= 6.6\times10^{-34}\times\ 2.5\times10^{14}$ ✓
$= 1.65\ \times10^{-19}$ J✓
Therefore X-ray photon has higher energy and higher penetrating ability✓

4.2 X-rays have high energy so they penetrate the body✓ They get absorbed by different tissues in different ways and create an image on the other side✓
4.3 Due to their high energy, they may penetrate cells✓ causing DNA damage and increasing risk of cancer✓

5.
5.1 Remote control for TV, infrared thermometers, infrared imaging✓
5.2 $t = \frac{\lambda}{c}$
$t = \frac{4\times10^{-5}}{3\times10^{8}}$
$t = 1.33\times10^{-13}\ s$
5.3 $f = \frac{1}{t}$
$f = \frac{1}{1.33\times10^{-13}}$
$f = 7.52\times10^{12}\ Hz$

5.4 $E = hf$
$= 6.6\times10^{-34}\times\ 7.52\times10^{12}$ ✓
$= 4.96\ \times10^{-21}$ J✓