2825/02 Health Physics

June 2003

Mark Scheme

The following annotations may be used when marking:

X	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
( )	=	words which are not essential to gain credit
___ (underlining)	=	key words which <u>must</u> be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument

1 (a)(i) the ability of the ear to <u>just</u> detect a sound / minimum intensity that can be detected (at a given frequency) / allow '<u>quietest</u> sound' **(B1)**
do not allow 'minimum frequency'

(ii) the variation of the (minimum) detectable intensity with frequency **(B1)**
or the ability of the ear to detect <u>changes in frequency</u>
and any 1 from **(B1)**
most sensitive at about 1 – 3 kHz
increasingly less sensitive at frequencies < 1 kHz and > 3 kHz
responds in the frequency range 20 – 10 kHz

(iii) resonance (due to the length of closed ear canal) /
length of ear canal $\lambda / 4$ **(B1)**

(b)(i) $IL = 10 \lg I/I_o$
$I_o = 10^{-12}$ W m^{-2} **(C1)**
$23 = 10 \lg I / 10^{-12}$ or $\lg(I / I_o) = 2.3$ **(C1)**
$I = 2.0 \times 10^{-10}$ Wm^{-2} (1.99×10^{-10}) **(A1)**

(ii)(no,) as the minimum intensity required to be detected at a frequency of 200Hz is about 10^{-9} Wm^{-2} / no because it is lower than the threshold (at that frequency) / ecf (b)(i) **(B1)**

2 (a) (i) $3 \times 2.8 \times 10^{-3}$ m = 8.4 mm or 8.3 mm if calculated with $\mu = 250\ m^{-1}$ **(A1)**

(ii) $I/I_o = e^{-\mu x}$ **(B1)**
$\ln 0.125 = -\mu \times 3 \times 2.8 \times 10^{-3}$ or $\ln 0.50$ (or–ln2) $= -\mu \times 2.8 \times 10^{-3}$ **(B1)**
$\mu = 248\ m^{-1}$ **(B1)**

(b) less photons (or X-rays) get through **(B1)**
some photons are absorbed / scattered / or ref. to photoelectric effect *do not allow other attenuation mechanisms* or 'reflection' **(B1)**

(c) (i) word equation q x V or $1.6 \times 10^{-19} \times 80 \times 10^{3}$ **(C1)**
$= 1.28 \times 10^{-14}$ J **(A1)**

(ii) $0.020 / 1.28 \times 10^{-14}$ ecf (i) **(C1)**
$= 1.56 \times 10^{12}$ **(A1)**

(iii) p = E / t
t = 0.020 / 200 **(C1)**
$t = 1.0 \times 10^{-4}$s *allow 1×10^{-4} s* **(A1)**

(iv) D = E / m **(C1)**
$D = 0.020 / 65 \times 10^{-3}$ **(C1)**
D = 0.31 **(A1)**
Gy or J kg^{-1} (allow Jg^{-1} if answer is 3.1×10^{-4}) **(B1)**

(d) any 5 from
direct: <u>ionisation</u> of (biologically important) <u>molecules</u> such as DNA **(B1)**
which damages DNA **(B1)**
leading to mutation / cancer / cell death /failure of cell to divide /cell damage **(B1)**

indirect: causes <u>ionisation</u> of water molecules (in cells) / produces free radicals / hydrogen peroxide formed / oxidising agent formed **(B1)**
which reacts with DNA **(B1)**

damages cell membrane / affects permeability of cell membrane **(B1)**

3 (a) table: any 3 correct, **(B1)** (ignore sig.fig.) 4th correct **(B1)**
0.25, 0.50, 1.00, 2.00
(b) 5 points plotted correctly **(B1)** +/- ½ a small square 6th correct **(B1)**
line of best fit **(B1)**

(c) measurements correctly taken from graph **(B1)**
gradient calculated as 1.04 +/- 0.05 *do not allow 1* **(A1)**

(d) y-intercept measured or calculated as 52.5 +/- 0.1 **(A1)**
unit D **(B1)**

(e) 1/b is the image distance / or 'b' is the power of the eye when viewing an object at infinity / or power of the eye when eye is relaxed / unaccommodated **(B1)**
it is a constant as the distance from the retina to the cornea is fixed / ref. to the <u>minimum</u> power of the eye is fixed / power cannot get any lower **(B1)**

4 (a) (i) *near point*: is the closest point (to the eye) that an object may be placed and still be in focus / viewed clearly **(B1)**

(ii) *accommodation*: the ability of the eye to change its power / focal length ref. to changing the shape of the lens /ability of eye to focus on objects at different distances from the eye **(B1)**

(b) (i) $p_1 = 1/u_1 + 1/v$ *allow substitution of v as about 0.020 m*
$p_2 = 1/u_2 + 1/v$
$p_1 - p_2 = 1/u_1 - 1/u_2$ **(C1)**
change in power = 1/0.25 – 1/0.15 **(C1)**
= (-)2.67 D **(A1)**

(ii) concave / diverging *(do not allow ecf from (i))* **(B1)**

5 (a) correct position of T indicated by a line ending on the black area of the muscle **(B1)**
any correct position of X **(B1)**

(b) ligaments hold the bones together **(B1)**

(c) total weight supported by legs is 0.70 x 700 = 490 N **(C1)**
each leg weighs (700 – 490)/2 = 105 N **(A1)**

(d) centre of mass / centre of gravity is moved **(B1)**
over the other foot / leg **(B1)**

(e) (i) moment = force x (perpendicular) distance to fulcrum **(C1)**
moment = 4.0 x 9.8 x 0.20cos45^o **(C1)**
moment = 5.54Nm **(A1)**
7.84 Nm (omit cos 45) gets 2/3 5.6 or 5.7 Nm (g = 10 ms^{-2}) gets 2/3

(ii) clockwise moment (at equilibrium) = anticlockwise moments or
F x 0.020sin45^o = 5.54 **(C1)**
F = 392 N *F = 277 N (omit sin 45) gets ½* **(A1)**

(iii) MA = load / effort **(C1)**
MA = 4.0 x 9.8 / 392 ecf from (ii) **(C1)**
MA = 0.10 *ignore units if given 0.1 scores 1/3 unless with working* **(A1)**

6 *Any 7 e.g.*

nuclei /atoms, (with unequal nos. of neutrons and protons) spin	**(B1)**
act like tiny magnets	**(B1)**
align in an external magnetic field	**(B1)**
they precess / wobble	**(B1)**
RF radiation pulse is applied	**(B1)**
resonance occurs / nuclei flip	**(B1)**
RF emitted by nuclei and detected	**(B1)**
the time taken for the nuclei to return to their equilibrium state (is measured) / time taken to return to equilibrium state is called the relaxation time	**(B1)**
hydrogen atom is (most commonly) used	**(B1)**
different tissues have different hydrogen content and so can be differentiated	**(B1)**

any 2 e.g.

it is <u>non-ionising</u>	**(B1)**
differentiates well between tissues (of similar density)	**(B1)**
higher resolution	**(B1)**

allow response if corresponding disadvantages given

7	(a)		Quieter Less pollution/more environmentally friendly	Or other valid point, eg petrol supplies finite, safety(batteries less of fire hazard), can utilise renewable energy	2
	(b)		*P* = *VI* 750 Wh = 750/12 = 62.5 Ah	0/3 for wrong ans no working 0.75/12=0.0625 (2/3) 3/3 for correct ans.	1 1 1
	(c)	(i)	No. of batteries = 960/16 = 60 No of kWh = 0.75 x 60 = 45 kWh = 45 x 1000 x 3600 =162 MJ	-1 for each error 1.62×10^8 MJ (2/3)	1 1 1
		(ii)	Work done = Fd D = $162 \times 10^6/300$ = 540 km	Allow 1sf if working shown	1 1 1
	(d)	(i)	Mass of petrol = 162/50 kg = 3.24 kg Volume = m/ρ(stated or implied) =3.24/700 = 4.6×10^{-3} m^3	Ecf Or equivalent	1 1 1 1
		(ii)	Energy lost/not 100% efficient As heat etc.	General comment + detail	1 1
	(e)		Compare :- • mass, • size, • likely performance of petrol vs batteries, • sensible statement about range Concluding comment	Any 3 from 4	3