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MARKSCHEME

May 2012

PHYSICS

Standard Level

Paper 3

18 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) by e-mail (or telephone) – if by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader by e-mail at any time if they have any problems/queries during the marking process.

Note:

The DHL courier service must be used to send assessment material to your team leader/senior moderator and to IB Assessment Centre. (However, this service is not available in every country.) The cost is met directly by the IB. It is vitally important that the correct DHL account number is used.

If you have any queries on **administration** please contact:

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1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use Scoris™ annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a question or part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a question or part question is worth no marks because the candidate has not attempted the part question, enter an "NR" in the mark panel on the right-hand side of the screen.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. Scoris™ will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp "seen" on any page, in the Options attempted by the candidate, that contains no other annotation.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the "CON" stamp.

Subject Details: Physics SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the Options **[2 % 20 marks]**.
Maximum total = **[40 marks]**

1. A markscheme often has more marking points than the total allows. This is intentional. Do **not** award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is shown by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are underlined are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect).

8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded when marking. Indicate this by adding **ECF** (error carried forward) on the script.

10. Do not penalize candidates for errors in units or significant figures, unless it is specifically referred to in the markscheme.

Option A — Sight and wave phenomena

A1. (a) cones; *[1]*

(b) (i) *Receptor A:* blue
Receptor B: green
Receptor C: red *[1]*
*Award **[1]** for all 3 correct.*

(ii) colour blindness is the inability for receptors to distinguish between light of different wavelengths;
red and green (cones) both absorb similar wavelengths;
red and blue (cones) absorb very different wavelengths / wavelengths hardly overlap / *OWTTE*; ***[2 max]***

(iii) green and red / B and C; *[1]*

A2. (a) at certain fixed frequencies;
incident wave and reflected wave;
superpose (or interfere); *[3]*

(b) (i) antinode clearly labelled in centre; *[1]*

(ii) wavelength = 1.7 m;
speed = 1.2×10^{2} m s^{-1}; *[2]*

(iii)

[1]

(iv) 1.2×10^{2} m s^{-1}; *[1]*

A3. (a) (apparent) shift in frequency of wave;
when relative motion between source of waves and observer;
approach gives increase in frequency / recession decrease in frequency; ***[3]***
Allow answer in terms of red or blue shifts.

(b) (i) galaxy moving away from Earth; ***[1]***

(ii) rearranges data book equation thus $v \approx \frac{\Delta f}{f} c$;

$v = \frac{3.0 \times 10^{11} \times 3 \times 10^{8}}{4.672 \times 10^{14}}$;

$v = 1.93 \times 10^{5}\ \text{m s}^{-1}$; ***[3]***

Option B — Quantum physics and nuclear physics

B1. (a) the probability of decay per unit time / constant of proportionality in the equation relating activity to number of nuclei; ***[1]***

(b) (i) power $P = A_0 \times E \Rightarrow A_0 = \frac{P}{E}$;

$A_0 = \left(\frac{6.0}{8.8\times10^{-13}} =\right) 6.8\times10^{12}$ Bq; ***[2]***

(ii) realization that power is proportional to activity / $P = P_0 e^{-\lambda t}$;

$4.0 = 6.0e^{-8.1\times10^{-3}t}$;

taking logs to get $\ln\frac{4}{6} = -8.1\times10^{-3}t$;

$t = \left(\frac{\ln\frac{4}{6}}{-8.1\times10^{-3}} =\right) 50$ yr; ***[4]***

First marking point may be implicit in second.
Award ***[2 max]*** *for using half-life (86 years) and linear fit to give 57 years.*
Award ***[4]*** *for correct answer by other methods.*

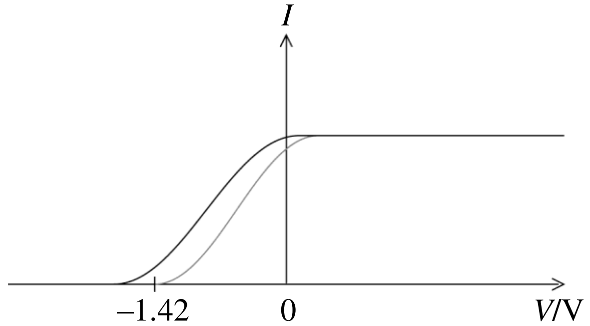
B2. (a) the light causes emission of (photo)electrons;
which move (from M) to C; ***[2]***

(b) (i) the (minimum) energy required to eject an electron from the metal; ***[1]***

(ii) 1.42 eV; ***[1]***
Allow answer in Joules.

(iii) (1.42+0.48) = 1.90 eV; ***[1]***
Allow answer in Joules.

(iv) line starting to the left of where red curve starts;
and saturates at the same value as red; ***[2]***



B3. (a) $E_K = qV = \left(1.6\times10^{-19}\times750=\right)1.2\times10^{-16}$ J;

$p = \left(\sqrt{2mE_K} = \sqrt{2\times9.1\times10^{-31}\times1.2\times10^{-16}} =\right)1.48\times10^{-23}$ N s;

$\lambda = \left(\frac{h}{p} = \frac{6.63\times10^{-34}}{1.5\times10^{-23}} =\right)4.5\times10^{-11}$ m; ***[3]***

*Award **[3]** for correct answer by other methods.*

(b) (i) crystals have regular spacing between the atoms / spacing is of the same order as the de Broglie wavelength; ***[1]***

(ii) pattern is similar to an optical diffraction pattern / pattern shows rings of constructive and destructive interference;
which suggests electrons (behave as waves) show diffraction/interference effects; ***[2]***

Option C — Digital technology

C1. (a) (i) stronger; ***[1]***

(ii) there are other radio waves outside this frequency;
avoids interference with other radio signals; ***[2]***

(iii) two way conversations need two frequencies; ***[1]***

(b) *Any two reasonable points e.g.:*
visual pollution of antennae masts;
potential health risk due to absorption of radiation;
people using them whilst driving;
not recycled go to land fill;
toxic metals go into water table;
use of coltan fuels conflict in Africa; ***[2 max]***

C2. (a)

input impedance	infinite
output impedance	zero
(open loop) gain	infinite

[2]

Award ***[2]*** *for all correct and* ***[1 max]*** *for two correct.*

(b) $V_+ = V_- = V_{\text{IN}}$;

$I = \dfrac{V_{\text{OUT}}}{(R + R_{\text{F}})}$ $\quad$ $I = \dfrac{V_{\text{IN}}}{R}$;

equate giving $\dfrac{V_{\text{OUT}}}{V_{\text{IN}}} = \dfrac{R_{\text{F}} + R}{R}$; ***[3]***

(c) –2.5 (gain);
–7.5 V; ***[2]***
Award ***[1 max]*** *if negative sign is missing.*

C3. (a) (i) mention of destructive interference;

path difference $=\frac{\lambda}{2}$;

depth $=\frac{\lambda}{4}$; ***[3]***

(ii) recorded area = $\pi(58^2 - 25^2)$ irrespective of units;

length = $\frac{\text{area}}{\text{thickness}}$;

5.4 km or 5.4×10^6 mm *etc.*; ***[3]***

(b) difficult to recycle CDs or other equivalent sentiment; ***[1]***

Option D — Relativity and particle physics

D1. (a) only T measures the proper time interval;
for T the pendulum is (a single clock) at rest/same point in space; ***[2]***
Do NOT simply allow that the pendulum is in the same frame as T.

(b) $\gamma = \left(\frac{1}{\sqrt{1-0.95^2}} = \right) 3.20;$

$T = \left(\gamma T_0 = 3.20 \times 0.85 = \right) 2.72\,\text{s};$ ***[2]***

(c) (i) the arrivals at T of the light from the two strikes occurs at the same point in space for T and are simultaneous for T;
so the arrivals of the light are simultaneous for all other observers as well; ***[2]***

or

T measures a zero proper time interval for the arrivals of the light;
so G measures a time interval equal to $\gamma \times 0 = 0$ also;

(ii) according to G, T is moving away from the light from the left strike and yet receives the light at the same time as the light from the right strike;
since <u>the speed of light is the same</u> for light from both strikes;
the left strike occurred first ***[2]***
No marks for just stating left strike is first. Given.

(d) for T, 160m is the (contracted) distance between the marks on the ground;
so for G the proper length is $\gamma \times 160$ = 510m; ***[2]***

D2. (a) exchange particles are virtual particles/bosons;
that mediate/carry/transmit the weak/strong/em force between interacting particles / *OWTTE*; ***[2]***
Award first marking point for named bosons also, e.g. photons, W, Z, gluons.

(b) (i) anti-blue; ***[1]***

(ii) zero; ***[1]***

(c) strangeness in initial state is –1 and zero in the final;
hence it is not conserved; ***[2]***
Award ***[0]*** *for unsupported second marking point.*

(d) $\Delta t \approx \left(\frac{h}{4\pi\Delta E} =\right)\frac{6.63\times10^{-34}}{4\pi\times1.2\times10^{9}\times1.6\times10^{-19}}$;

$\Delta t \approx 3\times10^{-25}$ s; ***[2]***

(e)

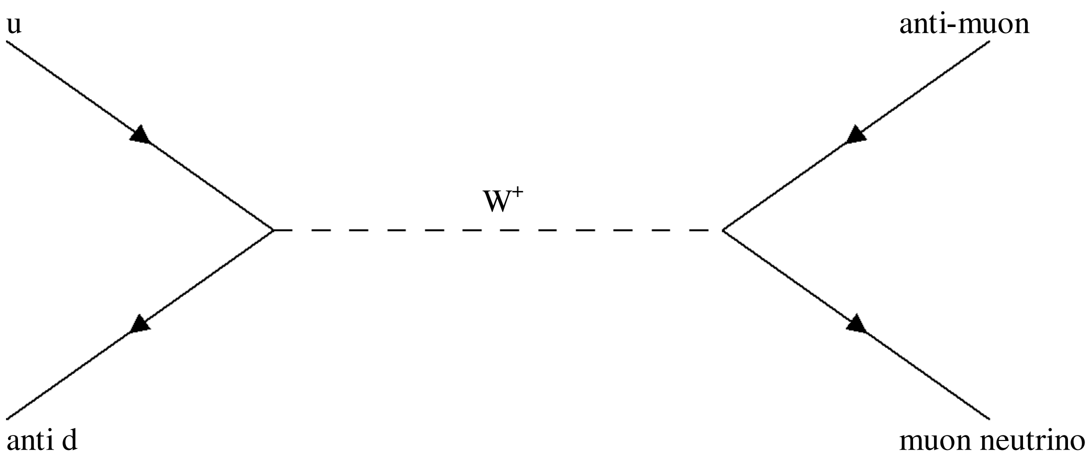


diagram as above;
correctly labelled W^{+}; ***[2]***
Allow time to run vertically. Allow particle symbols. Ignore missing or wrong arrow directions.

Option E — Astrophysics

E1. (a) O class; *[1]*

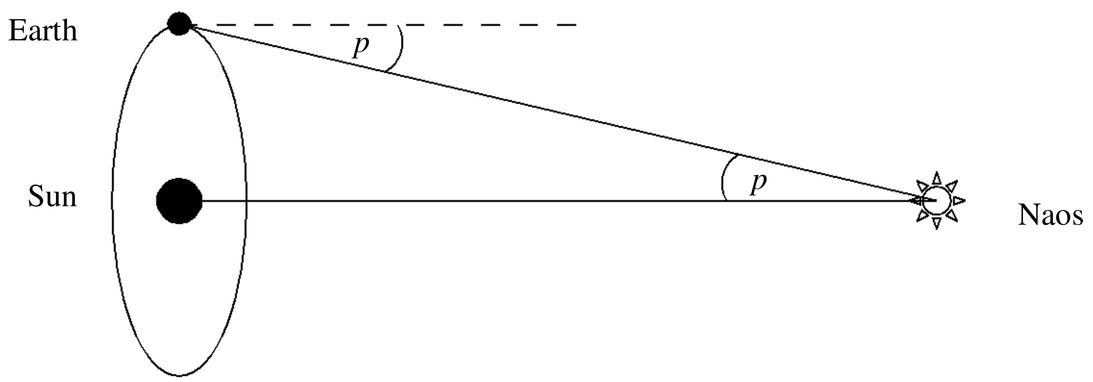
(b) apparent magnitude is a measure of the (apparent) brightness of a star (on a logarithmic scale); *[1]*

(c) (i) $d = \left(\frac{1}{p} = \frac{1}{3.36 \times 10^{-3}} = \right) 298\,\text{pc}$; *[1]*

(ii) $2.21 - M = 5 \times \lg\frac{298}{10}$;

$M = \left(2.21 - 5 \times \lg\frac{298}{10} = \right) -5.16$; *[2]*

(d) (i) either angle p as shown; *[1]*



(ii) the star's position is observed at two times, six months apart;
the shift in the star's position relative to the distant stars is (twice) the parallax angle; *[2]*
Accept correct answers which are clear from annotations on the diagram.

(e) (i) $L = 5.67 \times 10^{-8} \times 4\pi \times (7.70 \times 10^{9})^2 \times (42\,400)^4$;
$L = 1.37 \times 10^{32}$ (W); *[2]*

Award ***[1 max]*** *for use of* πr^2 *giving* $\frac{1}{4}$ *of answer.*

(ii) $\lambda = \left(\frac{2.90 \times 10^{-3}}{42\,400} = \right) 6.84 \times 10^{-8}\,\text{m}$; *[1]*

(f) most of the energy emitted by Naos is in the ultraviolet/outside visible region;
and hence not detectable by the naked eye; *[2]*

E2. (a) universe is infinite in extent;
has no beginning/infinite age;
stars uniformly distributed in space / universe is homogeneous in space;
universe is static / universe is homogeneous in time; ***[2 max]***
*Award **[1 max]** for bald "homogeneous".*

(b) number of stars in a thin shell a distance d from Earth is proportional to d^2;
since apparent brightness of each star varies as $\frac{1}{d^2}$, the stars in each shell contribute a constant amount of brightness;
since the number of stars is infinite/since there is an infinite number of shells, the brightness should be infinite; ***[3]***

(c) the universe has a finite age/a definite beginning;
so light from very distant stars has not yet reached us; ***[2]***

or

the number of stars is finite;
the total energy emitted is finite;

or

Universe is expanding;
radiation is red-shifted to lower energy/becomes invisible;

Option F — Communications

F1. (a) (i) 456 kHz; *[1]*

(ii) 2 kHz ***or*** 2.0 kHz; *[1]*

(iii) 4 kHz; *[1]*

(b) (i) *X:* tuning circuit/tuner;
Y: <u>AF</u> amplifier; *[2]*

(ii) *X:* isolates the particular carrier frequency one wants to tune to;
Y: amplifies the electrical signal so loudspeaker can be driven; *[2]*

(c) FM has less distortion;
is less susceptible to interference from buildings;
carries more information;
has less interference between neighbouring stations;
has less radiated power;
for given transmitter power, has clear reception region;
AM has less attenuation;
low frequencies reflected back by ionosphere therefore can travel farther distances;
much smaller band width; *[3 max]*

F2. (a) (i) (in any time interval) there are (approximately 5.5) more samples;
giving much higher quality reproduction; *[2]*

(ii) higher sampling means more data stored/more memory needed; *[1]*

(b) (i) period = 0.2 ms;
lines or points at 0.2, 0.4; *[2]*
Award first marking point if it is implicit in the lines/points drawn.

(ii) 0101;
0100; *[2]*
Allow ECF from (i).

(c) (TDM is the) process in which available bandwidth is shared by different users;
signal is divided into samples/data blocks;
time for sample/data block (of a signal) is (very) short compared to the time in between samples;
different signals can be fed into the "dead time" in between samples of one signal;
at reception the different signals are read sequentially to separate into separate signals/channels; *[3 max]*

Option G — Electromagnetic waves

G1. (a) (i) ratio of angle subtended by image at eye to angle subtended by object at the <u>near point</u>; ***[1]***

(ii) $\theta_o = \frac{h_o}{25}$;

$\theta_i = \frac{h_o}{f}$;

$M = \frac{\theta_i}{\theta_o} = \frac{h_o}{f} \times \frac{25}{h_o} = \frac{25}{f}$; ***[3]***

*Award **[3]** for use of symbol (e.g. D) to represent distance to near point (25 cm).*

or

realizes object is at f;

obtains at least 1 correct angle as either $\frac{h}{25}$ or $\frac{h}{D}$, or $\frac{h}{f}$;

shows that $M = \frac{D}{f}$ or $\frac{25}{f}$;

(b) (i) $\left(\frac{1}{f} = \frac{1}{v} + \frac{1}{u}\right)$

$\frac{1}{15} = \frac{1}{v} + \frac{1}{8}$;

$v = (-)17.1\text{cm}$; ***[2]***

(ii) 2.14 or –2.14; ***[1]***

(iii) virtual; ***[1]***

G2. (a) (i) laser coherent (bulb incoherent);
laser is monochromatic; ***[2]***

(ii) requirement of metastable energy level;
pumping of optical medium;
population inversion;
mechanism of stimulated emission;
all excited atoms de-excite together; ***[4 max]***
Also look for these marks within a possible diagram.

(b) (i) equally spaced;
(red) spots/maxima/bright fringes;
and wide minima/dark fringes; ***[2 max]***

(ii) use of diffraction grating equation;
correct use of number of lines per mm or calculation of grating spacing;
one angle correctly calculated (angles are 22.3° and 49.3°);
27°; ***[4]***