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M04/432/S(3)M+

MARKSCHEME

May 2004

PHYSICS

Standard Level

Paper 3

11 pages

Subject Details: Physics SL Paper 3 Markscheme

General

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

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- Each marking point has a separate line and the end is signified by means of a semicolon (;).
- An alternative answer or wording is indicated in the markscheme by a "/"; either wording can be accepted.
- Words in (…) in the markscheme are not necessary to gain the mark.
- The order of points does not have to be as written (unless stated otherwise).
- If the answer has the same "meaning" or can be clearly interpreted as being the same as that in the mark scheme then award the mark.
- Mark positively. Give credit for what they have achieved, and for what they have got correct, rather than penalizing them for what they have not achieved or what they have got wrong.
- Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with **"ECF"**, error carried forward.
- Units should always be given where appropriate. Omission of units should only be penalized once. Ignore this, if marks for units are already specified in the markscheme.
- Deduct **1 mark in the paper** for gross sig dig error *i.e.* for an **error of 2 or more digits**.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

However, if a question specifically deals with uncertainties and significant digits, and marks for sig digs are already specified in the markscheme, then do **not** deduct again.

Option A — Mechanics Extension

A1. (a) satellite is accelerating / resultant force towards (centre of) Earth;
hence not in equilibrium; ***[2]***

(b) sum of forces (in any direction) is zero / *OWTTE*;
hence in equilibrium; ***[2]***

A2. (a) (i) $\text{speed} = \frac{\text{distance}}{\text{time}}$ ***or*** $\frac{72}{0.40}$;
$= 180\ \text{cm s}^{-1}$; ***[2]***
*Award **[1 max]** if time incorrect.*

(ii) $s = \frac{1}{2}gt^2$ ***or*** $80 = \frac{1}{2} \times g \times 0.4^2$;
$g = 10\ \text{m s}^{-2}$; ***[2]***
*Award answer with no working **[0]**.*
If it is clear that same mistake as in (i) has been made for the timing, then award full marks in (ii).

(b) horizontal distance moved = 90 cm; *(allow ecf from (a)(i))*
vertical distance moved = 125 cm; *(allow ecf from (a)(ii))*
correct plot from candidate's working; ***[3]***
Award full marks if the plot is correct but there is no working shown.

(c) *sketch:* overall reasonable shape (smooth curve "below" given path);
horizontal distance moved always decreasing when compared to given path;
angle to vertical always greater than given path; ***[3]***

A3. (a) (i) speed with which object must leave (surface of planet) to (completely) escape its gravitational field; ***[1]***

(ii) $v = 11.2 \times \sqrt{\frac{318}{10.8}}$ ***or*** full substitution;
$= 60.8\ \text{km s}^{-1}$; ***[2]***

(b) (i) $T^2 \propto R^3$ with symbols explained / in words; ***[1]***

(ii) for Ganymede, $\frac{7.15^2}{15^3} = 0.0151$
for Lysthea, $\frac{260^2}{164^3} = 0.0153$;
*Do not award the ratios if only 2 significant figure are given. This is **not** the significant figure mark.*
suitable comment based on candidate's calculations; ***[2 max]***

Option B — Quantum Physics and Nuclear Physics

B1. (a) (i) no change in photon energy;
no change in microammeter reading; ***[2]***
*Allow "bald" answer but award **[0]** if reasoning is fallacious.*

(ii) photons / photo-electrons have more energy;
so reading of microammeter increases; ***[2]***
*Allow "bald" answer but award **[0]** if reasoning is fallacious.*

(b) (i) photon energy = work function + **maximum** kinetic energy of electron; ***[1]***

(ii) photon energy $= \frac{(6.63\times10^{-34}\times3.0\times10^{8})}{(540\times10^{-9})}$;
electron kinetic energy $= 1.6\times10^{-19}\times1.9$;
$3.68\times10^{-19} = \Phi + 3.04\times10^{-19}$ ***[3]***
$\Phi = 6.4\times10^{-20}$ J ;

B2. (a) amplitude;
(amplitude) squared; ***[2]***
*Award **[1 max]** for displacement squared.*

(b) (i) $E = E_{\text{p}} + E_{\text{k}}$; ***[1]***

(ii) $p^2 = 2mE_{\text{k}}$; ***[1]***

(iii) $\lambda = \frac{h}{\sqrt{(2mE_{\text{k}})}}$;
$\lambda = \frac{h}{\sqrt{(2m\{E - E_{\text{p}}\})}}$; ***[2]***
*Allow any subject for each expression. Award **[2]** in (b) (iii) for correct expression in terms of E.*

B3. (a) conservation of momentum / conservation of mass/energy; ***[1]***

(b) lepton; ***[1]***

(c) $\lambda = \frac{\ln 2}{3} = 0.23$ minute^{-1};
and λ is the probability in 1 minute, so 0.23; *(explanation required for this mark)* ***[2]***

(d) $0.10 = e^{-0.23t}$;
t =10 minutes; ***[2]***
Working not required to achieve full marks.

Option C — Energy Extension

C1. (a) *pV* constant for isothermal / adiabatic always steeper;
hence AB; ***[2]***

(b) area between lines AB and AC shaded; ***[1]***

(c) area is 150 (±15) small squares; *(allow ecf from (b))*
work done $= 1.5 \times 1 \times 10^{-3} \times 1 \times 10^{5}$;
= 150 J; ***[3]***
For any reasonable approximate area outside the range 150 (±15) squares award ***[2 max]*** *for the calculation of energy from the area.*

(d) no thermal energy enters or leaves / $\Delta Q = 0$;
so work done seen as increase in internal energy;
hence temperature rises; ***[3]***
Award ***[0]*** *for a mere quote of the 1st law.*

C2. (a) (natural process of) production takes thousands/millions of years;
fossil fuels used much faster than being produced / *OWTTE*; ***[2]***

(b) *Any two sensible suggestions e.g.*
storage of radioactive waste;
increased cost;
risk of radioactive contamination *etc*.; ***[2 max]***
To achieve full marks the differences must be distinct.

C3. (a) solar panel: solar energy → thermal energy (heat);
solar cell: solar energy → electrical energy; ***[2]***

(b) (i) input power required =730 W (±5 W);
$\text{area} = \frac{730}{800} = 0.91\ \text{m}^2$; ***[2]***

(ii) power extracted =165 W (±20 W);
$\text{efficiency} = \frac{\text{(power out)}}{\text{power in}}$ ***or*** $\frac{165}{500}$; *(allow ecf)*
= 33 %; ***[3]***

Option D — Biomedical Physics

D1. (a) (i) mass ***or*** volume $\propto$ dimension^3 ***or*** height $= 175 \times \sqrt[3]{\left(\frac{85}{70}\right)}$;

height = 187 cm; ***[2]***

Allow "bald" correct answer.

(ii) surface area $\propto$ dimension^2 ***or*** ratio is $\left(\frac{187}{175}\right)^2$;

ratio is 1.1(4); ***[2]***

Allow "bald" correct answer.

(b) because ratio of masses > ratio of surface areas;
rate of heat loss per unit area must be greater for 85 kg man;
it is 1.07 times greater; *(allow for ecf)*
must have increased heat loss mechanism / *e.g.* sweating; ***[4]***

D2. (a) presbycusis / sensory hearing loss / hearing loss due to ageing ***[1]***

(b) hearing loss is 14 dB;

$14 = 10 \lg\left(\frac{I}{1.0 \times 10^{-12}}\right)$

$I = 2.5 \times 10^{-11}$ W m^{-2}; ***[2]***

(c) steep drop to about –65 dB at 4 kHz; *(clear indication of a hearing loss is essential)*
then levels out; ***[2]***

D3. (a) shows up **outline** of stomach/intestines ;
because barium meal absorbs the X-rays / other good comment; ***[2 max]***

(b) prevents reflections of ultrasound at skin surface;
because much reflection at skin/air boundary / other good comment; ***[2 max]***

(c) localizes the resonating atoms;
because resonance depends on magnitude of magnetic field;
any further detail in (a), (b) or (c); ***[3]***
The final mark is "floating" and can be awarded only once for further detail given in ***either*** *part (a)* ***or*** *part (b)* ***or*** *part (c).*

Option E — The History and Development of Physics

E1. (a) it is a pole star; ***[1]***

(b) from Earth, stars appear to move in circles;
with pole star on its axis / any other good physics; ***[2]***

(c) arc subtends 22.5° ($\pm 2^\circ$) at pole star;
length of day / time for one revolution $= \left(\frac{360}{22.5}\right) \times 1.5$;
= 24 hours; ***[3]***

E2. (a) (i) caloric fluid leaves the body; ***[1]***

(ii) flow of caloric;
due to its self-repellent nature; ***[2]***

(iii) different absorption abilities of caloric by different substances; ***[1]***

If (i), (ii) or (iii) refers to "calories", rather than caloric then award ***[3 max]*** *overall.*

(b) *Any three of the following.*
observed heat produced during the boring of cannons;
this seemed to be inexhaustible;
s.h.c. of shavings same as s.h.c. of barrel;
although caloric squeezed out of shavings; ***[3 max]***

E3. (a) electrons in orbit round nucleus;
these orbit at very high speed;
so "smear out", giving impression of being solid; ***[3]***

(b) (i) neutron is not charged; ***[1]***

(ii) "rays" emitted were highly penetrating;
"rays" caused protons to be ejected from hydrocarbons;
(Chadwick) proved "rays" to be neutral particles, mass same as proton; ***[3]***

Option F — Astrophysics

F1. (a) massive body of gas / gas/plasma;
giving off light / radiant energy / electromagnetic radiation *etc.*; ***[2]***
Allow alternative acceptable comments.

(b) *constellation*:
pattern of stars as seen from Earth;
not close to one another in space;

galaxy:
large group of stars;

other detail *e.g.* $\approx 10^{10}$ stars, diameter $\approx 10^{5}$ ly *etc.*; ***[4]***
*Award other detail **[1]** for constellation or galaxy.*

F2. (a) if less than ρ_0, Universe will expand for evermore;
if greater than ρ_0, Universe will expand;
and then contract; ***[3]***

(b) (i) substitution to give $\rho_0 = 1.3 \times 10^{-26}\ \text{kg m}^{-3}$; ***[1]***

(ii) number density $= \dfrac{(1.3 \times 10^{-26})}{(1.66 \times 10^{-27})}$, about 7 or 8 m^{-3}; ***[1]***
***Note**: unit is m^{-3}.*

F3. (a) (i) light output varies periodically;
rapid brightening, gradual dimming; ***[2]***

(ii) caused by expansion / contraction of surface;
brighter as it expands; ***[2]***

(b) (i) apparent magnitude: how **bright** a star is, as measured on Earth;
absolute magnitude: apparent magnitude if star were to be 10 pc from Earth; ***[2]***

(ii) M = –6.2 (± 0.1);
(5.2 + 6.2) = 5 lg$d$ – 5;
d = 1900 pc; ***[3]***
*Award **[2 max]** if lg(d – 5) is used and results in d = 195 pc*
***or** if (5.2 – 6.2) is used and results in d = 6.3 pc*
***or** if ln and not lg is used and results in d = 26.6 pc.*

Option G — Relativity

G1. (a) frame moving with constant velocity / frame in which Newton's first law is valid; ***[1]***

(b) $T_0 = \frac{2D}{c}$; ***[1]***

(c) (i) light reflected off mirror when midway between F and R; ***[1]***

(ii) FR $= vT$; ***[1]***

(iii) $(\frac{1}{2}L)^2 = D^2 + (\frac{1}{2}vT)^2$;
$L = 2\sqrt{\{D^2 + (\frac{1}{2}vT)^2\}}$; ***[2]***

(iv) $T = \frac{2\sqrt{\{D^2 + (\frac{1}{2}vT)^2\}}}{c}$;
$c^2T^2 = 4\{D^2 + (\frac{1}{2}vT)^2\}$;
use of $4D^2 = c^2T_0^{\ 2}$;
hence $T = \frac{T_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$; ***[4]***

G2. distance $= vT$ and $T = \frac{T_{\frac{1}{2}}}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$;
$T = 8.63 \times 10^{-6}$ s;
distance $= 2.8 \times 10^8 \times 8.63 \times 10^{-6} = 2.4 \times 10^3$ m; ***[3]***

G3. (a) mass of object in observer's frame of reference;
or
mass when not moving;
relative to observer; ***[2 max]***

(b) for large V, calculated value of v would be greater than c;
this is not possible;
mass increases, so mass is not m_0 / other comment; ***[3]***

(c) $c^2\Delta m = eV$ ***or*** $\Delta m = \frac{(1.6 \times 10^{-19} \times 5.0 \times 10^6)}{(3.0 \times 10^8)^2}$;
$\Delta m = 8.9 \times 10^{-30}$ kg; ***[2]***

Option H — Optics

H1. (a) distribution of colours;
separated according to wavelength / frequency; ***[2]***

(b) dispersion at both faces of prism;
refraction at both faces correct (by eye) – rays cross normal, $i > r$, $i < r$;
greater deviation for the blue than for the red; ***[3]***

H2. (a) diagram showing ray emerging along flat face; ***[1]***

(b) $\tan\theta = \frac{138}{120}, \theta = 49.0^\circ$;
critical angle $= 41.0^\circ$;
$n = \frac{1}{\sin C} = 1.52$; *(allow ecf if sensible)* ***[3]***
*Award **[1 max]** if the critical angle is $= 49.0^\circ$ (answer $n = \frac{1}{sinC} = 1.33$).*

(c) n is greater at higher frequency;
so C is smaller;
hence AB is larger; ***[3]***
*Award **[2]** if logic totally reversed.*

H3. (a) rays continued to eye lens, emerging parallel and in correct direction;
broken (dashed) parallel lines to left of eyepiece to imply image formation at infinity; ***[2]***

(b) (i) $\frac{\text{angle subtended by image } \textbf{at eye}}{\text{angle subtended by object } \textbf{at eye}}$; ***[1]***
Allow α/β if α and β are shown correctly on the diagram.

(ii) correct identification of angles;
realizes $\tan\alpha \to \alpha$ for small angles;
$\alpha_O = \frac{h}{f_O}, \alpha_E = \frac{h}{f_E}$;
magnification $= \frac{f_O}{f_E}$; ***[4]***
*Award **[1 max]** for correct quote of final answer only.*

(c) *e.g.* bigger diameter, collects more light / less diffraction / greater resolution; ***[1]***