

MARKSCHEME

November 2007

PHYSICS

Higher Level

Paper 2

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General Marking Instructions

Subject Details: **Physics HL Paper 2 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.
- ♦ 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.
- ♦ Words that are underlined are essential for the mark.
- ♦ The order of points does not have to be as written, unless stated otherwise.
- ♦ If the candidate’s answer has the same “meaning” or can be clearly interpreted as being the same 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 writing *OWTTE* (or words to that effect).
- ♦ 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 not achieved or what they have got wrong.
- ♦ Effective communication is more important than grammatical accuracy.
- ♦ 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.
- ♦ Only consider units in the final answer. Omission of units should only be penalized once in the paper.
- ♦ Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits**.

e.g. if the answer is 1.63:

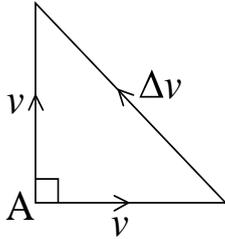
2	<i>reject</i>
1.6	<i>accept</i>
1.63	<i>accept</i>
1.631	<i>accept</i>
1.6314	<i>reject</i>

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.

SECTION A

- A1.** (a) equation corresponds to a straight line (and this is a curve); [1]
- (b) (i) unit is s/seconds; [1]
- (ii) 2.35; (*3 significant digit essential*) [1]
Responses may be given in table. Do not penalize wrong units.
- (c) (i) 31.5, 3.10; (*plotted to within $\pm 1\text{ mm}$*)
 22.5, 2.35; (*plotted to within $\pm 1\text{ mm}$*) (*allow e.c.f. from (b)(ii)*) [2]
- (ii) reasonable best-fit straight-line; [1]
- (d) (i) at 35 ms^{-1} , allow $\frac{D}{v}$ in range $3.30 \rightarrow 3.45$ (s);
 so D within range $116 \rightarrow 121$ m; [2]
Penalize once if $\frac{D}{v}$ is not in the range $3.30 \rightarrow 3.45$ (s) and then use ECF for the second marking point.
- (ii) intercept within range $0.55 \rightarrow 0.70$ (s); [1]
- (iii) use of “triangle” with hypotenuse at least $\left\{ \begin{array}{l} \text{Only allow use of data points if} \\ \text{half length of graph line;} \end{array} \right.$
 $\left. \begin{array}{l} \text{the points lie on the graph line.} \end{array} \right\}$
 gradient in range $0.074 \rightarrow 0.084$; [2]
Allow candidate’s values in (d)(ii) and (d)(iii).
- (e) $D = 0.62v + 0.079v^2$; [1]
Accept correct equation or correct statement about the values of a and b.
- (f) (i) fractional uncertainty in $\frac{D}{v}$ is $\frac{0.3}{74} + \frac{0.5}{27} = 0.023$;
 actual uncertainty = ± 0.06 ; (*answer must be 1 significant digit*) [2]
- (ii) uncertainty in v is unaffected;
 uncertainty in D *or* $\frac{D}{v}$ is reduced; [2]
Award [1 max] for a general comment that uncertainties will be reduced.

A2. (a)



arrow drawn (from A) of about correct length;
 arrow drawn (from A) at about correct angle;
 vector Δv labelled clearly and in correct direction;

[3]

Award [1 max] if vectors are added and [1 max] if Δv is opposite to correct direction.

(b) Δv is directed towards the centre of the circle;
 force necessary to cause change in velocity/ Δv ;

[2]

Response must clearly refer to diagram and be consistent with it.

A3. (a) straight-line from origin through to 6.0 V, 150 mA;

[1]

(b) (i) potential difference across R = e.m.f. of battery = 4.0 V ;

[1]

(ii) current in T at 4.0 V = 75 mA ;

[1]

(iii) use of equation $P = VI$;
 power (= 4.0 × 0.075) = 0.30 W ;

[2]

(c) (i) idea of same current in both and potential differences summing to 4.0 V ;
 current is 40 mA (horizontal line through 40 mA shown);
 Award [2] for a bald answer.

[2]

(ii) for 40 mA, potential difference is 2.4 V ;
 power dissipation (= 2.4 × 0.040) = 96 mW ;
 Award [2] for a bald answer.

[2]

A4. (a) (alternate light and dark) concentric rings; (can be in the form of a diagram)
 with central bright spot;
 Accept diagrams with "spots" if these have a discernible circular pattern.

[2]

(b) de Broglie wavelength mentioned / use of $\lambda = \frac{h}{p}$;
 as v increases, momentum p increases;
 so λ decreases causing a change in the pattern;

[3]

SECTION B

B1. Part 1 Linear motion

(a) (i) $E_k = \frac{1}{2} \times 72 \times 23^2;$
 $= 1.9 \times 10^4 \text{ J};$ [2]

(ii) uses area between the t -axis and the line;
 correctly converts area \rightarrow distance (one $1\text{cm} \times 1\text{cm}$ square $\equiv 5.0\text{m}$);
 distance between 90 m and 105 m;
 improved accuracy, distance between 95 m and 100 m; [4]
Do not accept kinematic formulas. Distance can only be found from area.

(b) (i) $\Delta E_p = 72 \times 9.8 \times 41;$
 $= 2.9 \times 10^4 \text{ J};$ [2]
Accept $3.0 \times 10^4 \text{ J}$ for responses using $g = 10 \text{ m s}^{-2}$.

(ii) energy “loss” $= 1.0 \times 10^4 \text{ J};$
 average force $= \frac{(1.0 \times 10^4)}{98};$
 $= 100 \text{ N};$ [3]
N.B. *follow through working—answer is $\{(b)(i)-(a)(i)\} / (a)(ii)$.*

(iii) *e.g.* air resistance;
 friction between skis and slope;
 force to push snow away from skis; [2 max]
To award marks responses must specify where friction is acting.

(c) $1.8 = \frac{1}{2} \times 9.8 \times t^2;$
 time of flight $= 0.61\text{s};$
 horizontal distance travelled $(= 23 \times 0.61) = 14\text{m};$
 distance CD $(= 14 - 12) = 2.0\text{m};$ [4]
Accept a time of 0.60 s and $CD = 1.8\text{m}$ for responses using $g = 10 \text{ m s}^{-2}$.

(d) (i) D is further from the edge C; [1]

(ii) sensible reason *e.g.* velocity not normal to ground;
hence impact is less; (*any other sensible comment*) [2]

Part 2 Nuclear reactions

- (a) (i) nucleus emits;
an α -particle / a β -particle / *and/or* γ -ray photon / ionizing radiations; [2]
- (ii) cannot tell which nucleus will decay next;
cannot state at what time a nucleus will decay; [2]
Award [2] for constant probability of decay per unit time.
- (b) (i) ${}^{17}_8\text{O}$;
 ${}^1_1\text{p}$; [2]
- (ii) mass difference = $(-1.29 \times 10^{-3} u)$;
energy = $(1.29 \times 10^{-3} \times 931) = 1.20 \text{ MeV}$;
indicates in some way that mass defect is on left-hand side of equation /
mass defect is negative;
 α -particles must provide at least 1.20 MeV of energy; [4]

B2. Part 1 Momentum

- (a) the momentum of a system (of interacting particles) is constant;
if no external force acts on system / net force on system is zero / isolated system; [2]
A statement of "momentum before = momentum after" achieves first mark only.
- (b) (i) use of volume = $\pi r^2 \times v$;
 $= \pi \times (1.4 \times 10^{-3})^2 \times 18$;
 $= 1.1 \times 10^{-4} \text{ m}^3$ [2]
- (ii) mass ejected per second = $1.1 \times 10^{-4} \times 1000 = 0.11 \text{ kg}$;
change in momentum per second = 0.11×18 ;
by Newton's 2nd, this is force on (ejected) water ;
by Newton's 3rd, equal force acts upwards on rocket ;
so force is 2.0 N [4]
Do not accept references to momentum conservation.
- (iii) weight of rocket (and contents) is greater than the upward force; [1]
Do not accept rocket is heavy/heavier.

Part 2 Temperature, specific heat and latent heat

- (a) property measured at two known temperatures (and at unknown temperature);
 (temperature calculated) assuming linear change of property with temperature; [2]
Award [1] for descriptions of constructing a thermometer.
- (b) thermometer absorbs (thermal) energy/heat from the body / has a thermal capacity;
 so changes temperature of body;
or
 time taken for (thermal) energy/heat to be conducted into thermometer;
 so may not be able to follow changing temperature; [2]
- (c) (i) quantity of (thermal) energy/heat required to raise temperature of unit mass;
 by one degree;
or

$$c = \frac{\Delta Q}{m\Delta\theta};$$
 with ΔQ , m and $\Delta\theta$ explained; [2]
- (ii) $m \times 330$;
 $+m \times 4.2 \times 8$;
 $= 0.45 \times 4.2 \times 16$;
 $m = 0.083 \text{ kg}$; [4]
Award [2 max] for an answer $m = 0.092 \text{ kg}$ – ignoring ice-water.
- (d) (i) change is adiabatic;
 change is sudden so no heat enters/leaves the gas / there is no time for heat
 exchange; [2]
- (ii) molecules rebound from piston;
 with increased speed;
 temperature depends on speed and so temperature rises; [3]
- (e) (i) substitution into equation for efficiency

$$0.15 = \frac{W}{(W + 680)};$$
 $W = 120 \text{ J}$; [2]
- (ii) gain G when thermal energy transferred to sink/cold reservoir;
loss L when thermal energy transferred from source/hot reservoir;
 the overall / total entropy of the universe increases;
 law implies $G + S_w > L$; [4]

B3. Part 1 Magnetic and electrical force fields

- (a) (i) use of $qV = \frac{1}{2}mv^2$;
 $1.6 \times 10^{-19} \times 420 = \frac{1}{2} \times 1.67 \times 10^{-27} \times v^2$
 $v = 2.8 \times 10^5 \text{ m s}^{-1}$; [2]
- (ii) arc of circle / continuous curve within region ABCD and deflected upwards
i.e. towards AB;
 straight-line as tangent to arc beyond BC; [2]
- (iii) $F = 1.5 \times 10^{-2} \times 1.6 \times 10^{-19} \times 2.8 \times 10^5$;
 $= 6.7 \times 10^{-16} \text{ N}$; (*allow* $6.8 \times 10^{-16} \text{ N}$) [2]
- (b) (i) arrow pointing down the page; [1]
- (ii) $6.7 \times 10^{-16} = 1.6 \times 10^{-19} \times E$;
 $E = 4.2 \times 10^3 \text{ V m}^{-1}$; (*allow* $4.3 \times 10^3 \text{ V m}^{-1}$) [2]
- (c) (i) induced e.m.f. / current acts in such a direction;
 to tend/produce effects to oppose the change causing it; [2]
- (ii) e.m.f. constitutes electrical energy;
 this energy is derived from working against the change causing the e.m.f.; [2]
Award [1 max] for references to forces against the direction of motion if a suitable example has been chosen.
- (d) (i) change in flux (linkage) $= 18 \times 10^{-6} \times 0.32 \times 0.95$;
 $(= 5.5 \times 10^{-6} \text{ Wb})$
 idea of induced e.m.f $= \frac{\Delta N\phi}{\Delta t}$;
 $= \frac{(5.5 \times 10^{-6})}{0.34}$
 $= 16 \mu\text{V}$; [3]
- (ii) side PQ cuts flux but side RS does not cut flux / not move;
 so, e.m.f. across QR/PS; [2]
- (iii) (as window opens) flux through window would not change;
hence no e.m.f. induced; [2]

Part 2 Gravitational force fields

- (a) gravitational force provides/is equal to the centripetal force;

$$\frac{GMm}{r^2} = \frac{mv^2}{r};$$

$$E_K = \frac{\frac{1}{2}GMm}{r} \quad [2]$$

Accept responses that use $E_K = -\frac{1}{2}E_p$ and state what E_p is.

(b) (i) $\Delta E_K = \frac{1}{2} \times 4.00 \times 10^{14} \times 850 \times \{(7.18 \times 10^6)^{-1} - (7.26 \times 10^6)^{-1}\};$
 $= 2.61 \times 10^8 \text{ J};$ [2]

(ii) $\Delta E_p = (-)4.00 \times 10^{14} \times 850 \times \{(7.18 \times 10^6)^{-1} - (7.26 \times 10^6)^{-1}\};$
 $= (-)5.22 \times 10^8 \text{ J};$ [2]

Award [2] for statement $\Delta E_p = (-)2 \times \Delta E_K = (-)5.22 \times 10^8 \text{ J}.$

(iii) change in total energy = $(-)2.61 \times 10^8 \text{ J};$ [1]

- (c) change in total energy is negative;
 total energy is less;
hence rockets fired to produce force in opposite direction to motion; [3]
Do not accept bald answer without correct explanation. Award [1] for statements such as K.E. increases and P.E. decreases or that total energy decreases which may evident from sign in (b)(iii).

B4. Part 1 Interference of waves

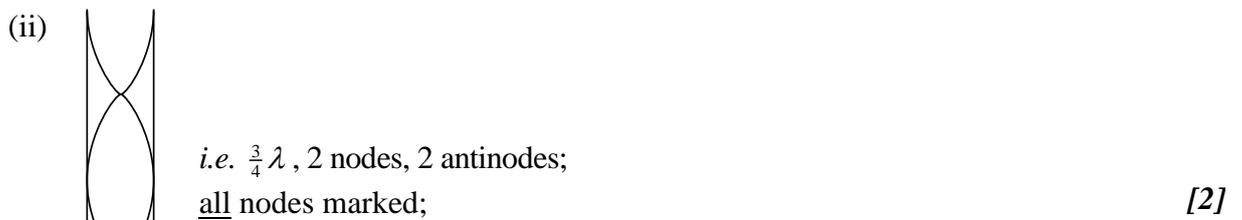
(a) (i) frequency $\left(= \{6.0 \times 10^{-3}\}^{-1} \right) = 170 \text{ Hz};$ [1]

(ii) at $t = 1.0 \text{ ms}$, displacement $(= 1.7 + 0.7) = 2.4 \text{ mm};$
 at $t = 8.0 \text{ ms}$, displacement $= 1.7 - 0.7;$
 $= 1.0 \text{ mm};$ [3]

(b) bright fringes are darker/less bright because resultant amplitude is less;
 dark fringes are brighter/less dark because summing amplitudes no longer gives zero; [2]

Award [1 max] for descriptions to both situations without explanations. To achieve full marks there must be clear reference to the resultant amplitude.

(c) (i) wave (travels down tube and) is reflected at (water surface);
 incident and reflected waves interfere/superpose; [2]



Accept pressure nodes if clearly identified.

(iii) substitution in $v = f\lambda$;
 $\frac{1}{2} \lambda = 56 \text{ cm};$
 $v = (2 \times 0.56 \times 310) = 350 \text{ m s}^{-1};$ [3]

(d) (i) observed change in frequency;
 when there is relative motion between source and observer; [2]

(ii) f waves emitted in a distance $(c - v)$;
 distance between wavefronts (*i.e.* apparent wavelength) $\lambda_o = \frac{(c - v)}{f};$
 apparent frequency $= \frac{c}{\lambda_o} = \frac{cf}{(c - v)};$ [3]

(iii) engine produces many frequencies;
 further relevant comment *e.g.* all frequencies are shifted so undetectable /
 siren frequency higher so Doppler shift more noticeable; [2]

Part 2 X-ray spectra

- (a) (i) corresponds to electron losing all its energy to give rise to one photon / max photon energy when photon receives all the energy of the electron; [1]
- (ii) electron in target atom moves from ground state to an excited state / atom is ionized;
photon with particular wavelength emitted on de-excitation;
each element has characteristic atomic energy levels; [3]
- (b) frequency = $\frac{(3.00 \times 10^8)}{(0.154 \times 10^{-9})} = 1.95 \times 10^{18} \text{ Hz}$;
 $1.95 \times 10^{18} = 2.5 \times 10^{15} (Z - 1.0)^2$;
 $Z = 29$; [3]
- (c) use of $\frac{hc}{\lambda} = eV$ **or** $hf = eV$;
 $6.63 \times 10^{-34} \times 1.95 \times 10^{18} = 1.6 \times 10^{-19} \times V$;
 $V = 8.1 \times 10^3 \text{ V}$; [3]
-