

# **MARKSCHEME**

**May 2004**

**PHYSICS**

**Higher Level**

**Paper 2**

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## 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.

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 markscheme then award the mark.
- ◆ Mark positively. Give credit for what they have achieved, and for what they have got correct, rather than penalising 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**.

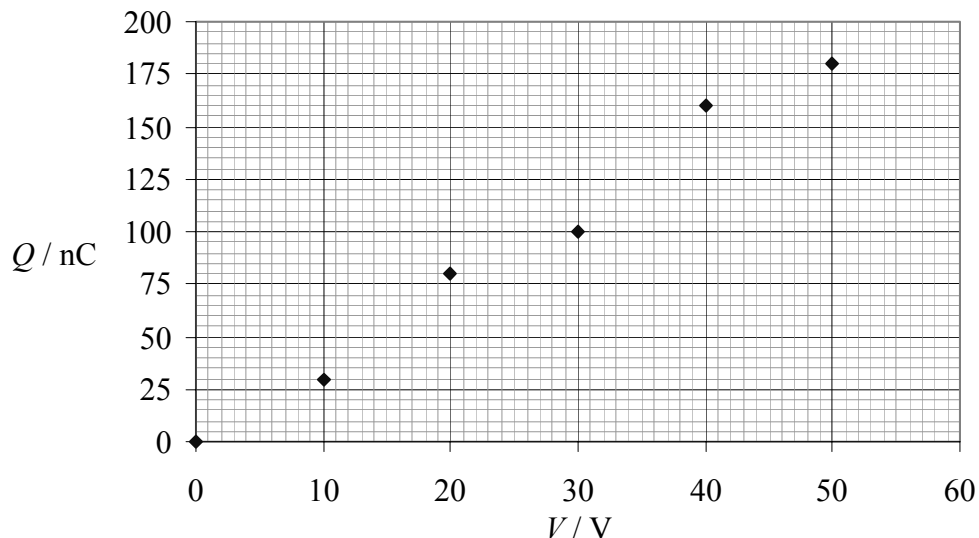
*e.g.* if the answer is 1.63:

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

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.

SECTION A

A1. (a)



half area of graph paper at least to be used;  
 axes labels including units;  
 scale;  
 data points; *((0, 0) need not be included)*

[4]

(b) absolute uncertainty in  $Q$  at 10.0 V =  $\pm 3$  nC;  
 absolute uncertainty in  $Q$  at 50.0 V =  $\pm 18$  nC;  
*Or read from graph or elsewhere in the question and do not deduct unit mark.*  
 correct placing on graph;

[3]

(c) from top of error bar at (50, 180) to bottom of error bar at (10, 30);  
 use of at least half the line or algebraic indication;  
 value = 4.3 *or*  $4.3 \times 10^{-9}$ ;  
*Watch for ecf.*

[3]

(d)  $CV^{-1}$ ;  
*Unit might be given in (c).*

[1]

(e) recognize that the gradient  $m = \frac{\epsilon_0 A}{d}$ ;

$$\text{therefore } \epsilon_0 = \frac{dm}{A};$$

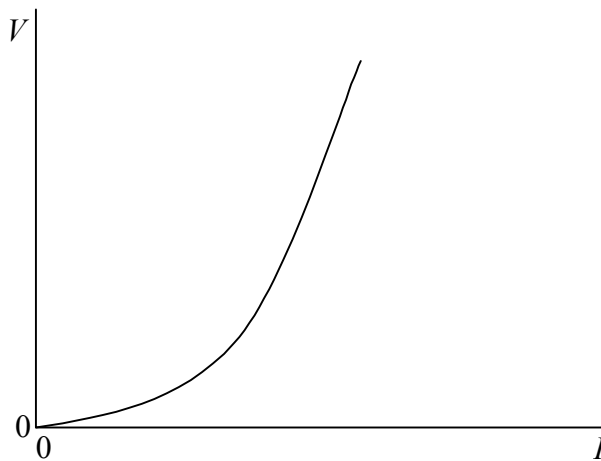
$$= \frac{0.51 \times 10^{-3} \times 4.3 \times 10^{-9}}{0.15};$$

$$= 1.5 \times 10^{-11} \text{ CV}^{-1} \text{ m}^{-1} \text{ (C}^2 \text{ N}^{-1} \text{ m}^{-2} \text{ – data book unit or F m}^{-1}\text{)};$$

[4]

- A2.** (a) mass  $\times$  velocity; [1]
- (b) (i) momentum before =  $800 \times 5 = 4\,000 \text{ N s}$ ;  
 momentum after =  $2\,000v$ ;  
 conservation of momentum gives  $v = 2.0 \text{ m s}^{-1}$ ; [3]
- (ii) KE before =  $400 \times 25 = 10\,000 \text{ J}$  KE after =  $1\,000 \times 4 = 4\,000 \text{ J}$ ;  
 loss in KE =  $6\,000 \text{ J}$ ; [2]
- (c) transformed/changed into;  
 heat (internal energy) (and sound); [2]  
*Do not accept "deformation of trucks".*

**A3.** (a)



- Any reasonable curve in the right direction.* [1]
- (b) (i) from the value of  $V/I$  at any point on the curve;  
*Do not accept just "from  $V/I$ ".* [1]
- (ii) non-ohmic because the resistance ( $V/I$  at each point) is not constant / *OWTTE*; [1]
- (c) (i)  $50 \Omega$ ; [1]
- (ii) recognize that the voltage must divide in the ratio 3 : 1;  
 to give  $R = 150 \Omega$ ; [2]  
*Or answer could be solved via the current.*

A4. (a) (i) out of the paper  ; [1]

(ii) to the left  ; [1]

*For (i) and (ii) award [1 max] if labels are missing.*

(b) (i)  $E = Blv = 0.2 \times 0.3 \times 5.5 = 0.33 \text{ V}$ ; [1]

(ii)  $F = BIL = 0.2 \times 0.8 \times 0.30 = 0.048 \text{ N}$ ; [1]

(c)  $P = Fv = 0.048 \times 5.5 = 0.26 \text{ W}$ ;  
 $= EI = 0.33 \times 0.80 = 0.26 \text{ W}$ ; [2]

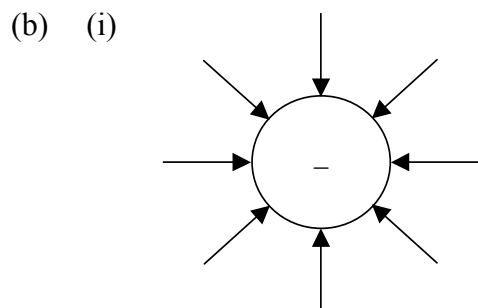
**SECTION B**

**B1. Part 1**      Circular motion

- (a) *Look for an answer on the following lines:*  
 the direction of the car is changing;  
 hence the velocity of the car is changing ;  
**or**  
 since the direction of the car is changing;  
 a force must be acting on it, hence it is accelerating; **[2 max]**
- (b) (i) arrow pointing vertically downwards; **[1]**
- (ii) weight;  
*Do not penalize the candidate if they state "gravity".*  
 normal reaction;  
*Do not penalize the candidate if they state "push of the track on the marble".* **[2]**
- (iii) loss in PE =  $0.05 \times 10 \times (0.8 - 0.35)$ ;  
 = gain in KE =  $\frac{1}{2} mv^2$ ;  
 to give  $v = 3.0 \text{ m s}^{-1}$ ;  
**or**  
 use of  $v = \sqrt{2gh}$  to give  $v = 4.0 \text{ m s}^{-1}$  at point B;  
 and then use of  $v^2 - u^2 = 2gh$  with  $v = 4.0 \text{ m s}^{-1}$  and  $h = 0.35 \text{ m}$  ;  
 to get  $u = 3.0 \text{ m s}^{-1}$ ;  
*Do not penalize the candidate if  $g = 9.8 \text{ m s}^{-2}$  is used.* **[3 max]**
- (iv) recognize that resultant force =  $\frac{mv^2}{r}$ ;  
 =  $\frac{(0.05 \times 9.0)}{0.175} = 2.6 \text{ N}$ ;  
 $N = \frac{mv^2}{r} - mg$ ;  
 =  $2.6 - 0.5 = 2.1 \text{ N}$ ; **[4]**

**B1. Part 2** The charged sphere

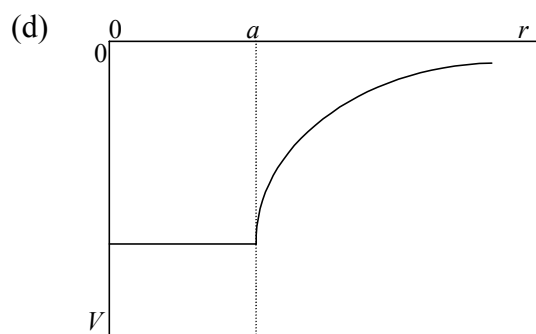
- (a) the work done per unit charge;  
 in bringing a small positive charge;  
 from infinity to that point; [3]  
*A completely accurate definition is necessary for [3 max].*



sufficient arrows to show decreasing radial field;  
 direction; [3]  
 no field in the centre;

- (ii) three concentric circles;  
 with increasing radii; [2]

- (c) since field strength is the gradient of potential;  
*E* must be decreasing; [2 max]  
**or**  
 some recognition that if the field were constant for example;  
 the lines would be equally spaced;  
*OWTTE*;  
*Allow [1 max] for bald statement "spacing between equipotentials is increasing" /*  
*OWTTE.*



constant  $V$  inside;  
 something that resembles a  $1/r$  dependency outside; [2]  
*V at surface must equal V inside.*

- (e) use  $V = k \frac{q}{r}$  to show  $V = -1800 \text{ V}$ ; [1]



(f) (i) along a field line; **[1]**

(ii) use  $V = k \frac{q}{r}$  to find  $V$  at 0.30 m = –270 V;

use  $\frac{1}{2} mv^2 = \Delta Ve$ ;

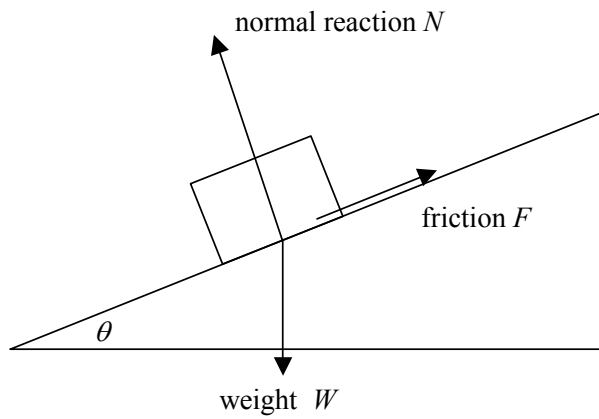
to give  $v = \sqrt{\frac{2 \times 1530 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}}$ ;

to give  $v = 2.3 \times 10^7 \text{ m s}^{-1}$ ;

**[4]**

**B2. Part 1**     Static equilibrium

(a)



*Award [1] for each correctly drawn and named force, up to [3 max].*

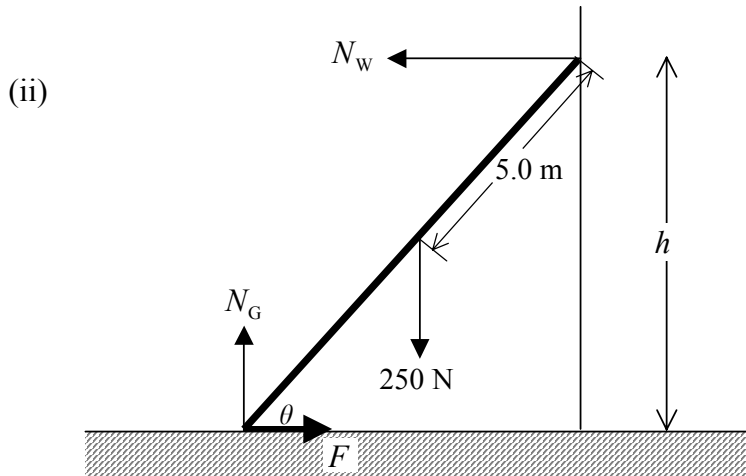
*Award [1 max] for three forces that are correct but not named.*

*Point of application need not be correct.*

*Award [2 max] if components of weight are shown.*

**[3]**

- (b) (i)  $F = 0.4N_G$ ; [1]



$$5 \times 250 \cos \theta = 10 \times N_w \sin \theta ;$$

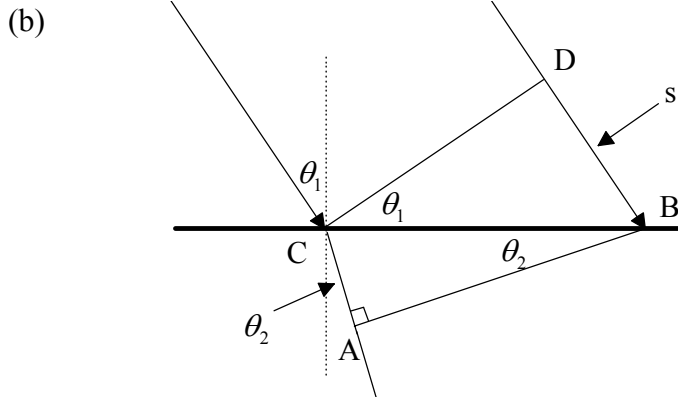
$$\text{to give } N_w = \frac{125 \cos \theta}{\sin \theta} = 125 \cot \theta ;$$
[2]

- (iii) resolve vertically  $N_G = 250$ ;  
 resolve horizontally  $N_w = 0.40N_G$ ;  
 therefore  $N_w = 0.40 \times 250 = 125 \cot \theta$ ;  
 therefore  $\theta = \cot^{-1}(0.80) = 51^\circ$ ;  
 $h = 10 \sin \theta$ ;  
 $= 7.8 \text{ m}$ ;
- [6]

- (iv) *Look for these main points:*  
 $N_w = 125 \cot \theta$  so if  $\theta$  is larger  $N_w$  is smaller;  
 since  $N_w = F$ ,  $F$  becomes smaller;  
 if friction decrease then ladder will slip;  
 to increase  $\theta$ ,  $h$  needs to be increased;
- [4]
- Answer could argue the point of view that if the ladder is slipping, then  $N_w$  is smaller etc. Correct answer with no justification or wrong physics would receive [0].*

**B2. Part 2** Refraction

(a) each point on a wavefront acts as a source of a secondary wave / *OWTTE*; [1]



(i) position of AB; [1]

(ii) line AC; [1]  
 $\angle CAB$  should look to be  $90^\circ$ .

(iii) line  $BD = s$ ; [1]

(c) Look for these points:

$\angle DCB = \theta_1$ ;

$\angle CBA = \theta_2$ ;

time taken to travel CA and DB is the same;

$CA = v_2 \Delta t$  and  $DB = v_1 \Delta t$

$$\sin \theta_1 = \frac{DB}{BC};$$

$$\sin \theta_2 = \frac{AC}{BC};$$

therefore  $\frac{\sin \theta_1}{\sin \theta_2} = \frac{DB}{AC} = \frac{v_1 \Delta t}{v_2 \Delta t} = \frac{v_1}{v_2}$ ; [6]

(d)  $f = \frac{c}{\lambda}$ ;

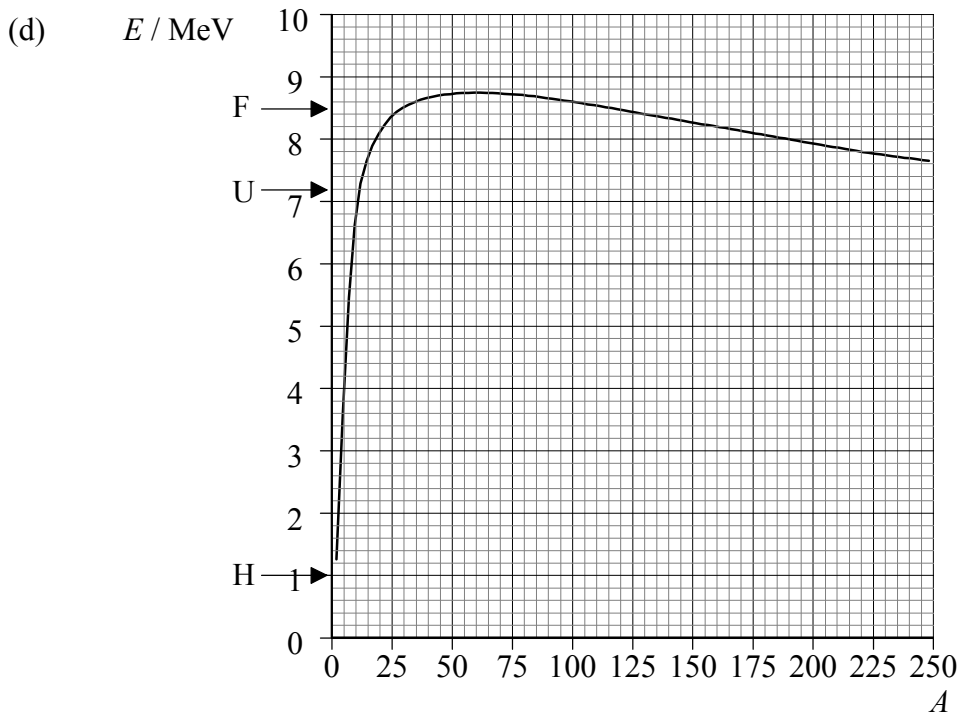
frequency in medium 1 = frequency in medium 2 =  $\frac{8.0}{4.0} = 2.0 \text{ Hz}$ ; [2]

(e)  $\frac{\sin 60}{\sin 35} = \frac{v_1}{v_2} = 1.5$ ;

therefore  $v_2 = \frac{8.0}{1.5} = 5.3 \text{ cm s}^{-1}$ ; [2]

**B3. Part 1** Nuclear binding energy

- (a) a proton or a neutron;  
*Both needed to receive [1].*  
hadron / baryon; [2]
- (b) proton  $\Rightarrow$  uud;  
neutron  $\Rightarrow$  udd; [2]
- (c) the difference between the mass of the nucleus and the sum of the masses of its individual nucleons / the energy required to separate a nucleus into its component nucleons / *OWTTE*; [1 max]

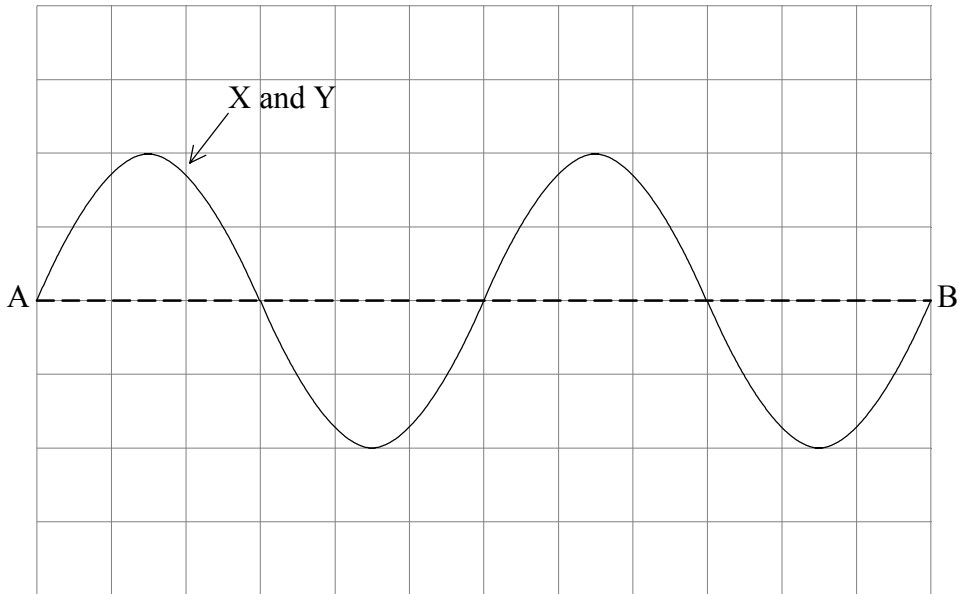


*Don't expect precision for any of these.*

- (i) F: between 8 and 9; [1]
- (ii) H: between 1 and 2; [1]
- (iii) U: between 7 and 8; [1]
- (e) general overall shape;  
max at F = 56, end point U; [2]
- (f) mass of nucleons =  $(2 \times 1.00728) + 1.00867 = 3.02323$  u;  
mass difference =  $0.0072$  u = 6.7 MeV;  
binding energy per nucleon =  $6.7/3 = 2.2$  MeV; [3]
- (g) (i) fusion; [1]
- (ii) from the position on the graph, the energy required to assemble two nuclei of  ${}^2_1\text{H}$  is greater than that to assemble one nucleus of  ${}^3_2\text{He}$  ;  
hence if two nuclei of  ${}^2_1\text{H}$  combine to form one nucleus of  ${}^3_2\text{He}$  energy must be released / *OWTTE*; [2]

**B3. Part 2** Wave interference

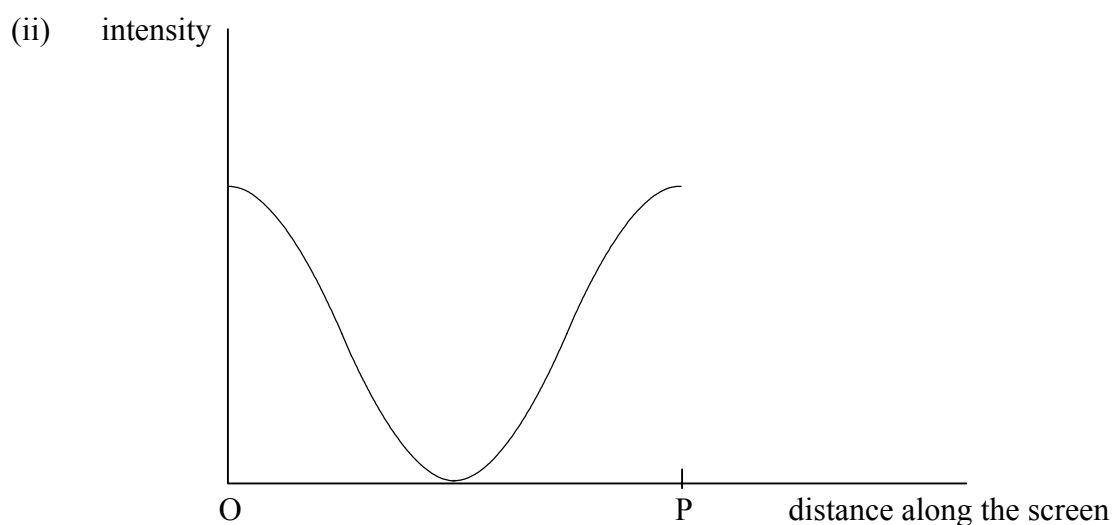
- (a) the net **displacement** of the medium/particles (through which waves travel); is equal to the sum of individual **displacements** (produced by each wave); **[2 max]**  
*Award a good understanding [2 max] and a reasonable one [1 max].*
- (b) *Wave X and wave Y should be identical.*



- correct phase for wave X;  
 correct phase for wave Y;  
 amplitudes the same for each wave;  
 amplitude for each wave is two divisions; **[4 max]**

- (c) (i) the phase difference between light leaving  $S_1$  and  $S_2$  is constant; **[1]**  
*Do not penalize the candidate if they state "has the same phase".*
- (ii) to produce **sufficient** diffraction;  
 for the beams to overlap;  
*OWTTE;* **[2 max]**

- (d) (i) path difference between  $S_1$  and  $S_2$  is an integral number of wavelengths; [1]  
 Accept "waves arrive at P in phase".



maximum at O and P;  
 general shape with minimum about half way between O and P; [2 max]

- (e) fringe spacing =  $2.5 \times 10^{-4}$  m;  
 $\lambda = \frac{(2.5 \times 10^{-4} \times 3.00 \times 10^{-3})}{1.50} = 5.0 \times 10^{-7}$  m; [2]

**B4. Part 1 Melting Ice**

(a) (165, 0); [1]

(b) *Look for these points:*  
 to change phase, the separation of the molecules must increase;  
*Some recognition that the ice is changing phase is needed.*  
 so all the energy input goes to increasing the PE of the molecules;  
*Accept something like "breaking the molecular bonds".*  
 KE of the molecules remains constant, hence temperature remains constant; [3]  
*If KE mentioned but not temperature then assume they know that temperature is a measure of KE.*

(c) (i) time for water to go from 0 to 15°C = 30 s;  
 energy required =  $ms\Delta\theta = 0.25 \times 15 \times 4200 = 15\,750$  J;  
 power =  $\frac{\text{energy}}{\text{time}} = 525$  W  $\approx 530$  W; [3]

(ii) ice takes 15 s to go from -15°C to 0;  
 energy supplied =  $15 \times 530$  J;  
 sp ht =  $\frac{(530 \times 15)}{(15 \times 0.25)} = 2100$  J kg<sup>-1</sup> K<sup>-1</sup>; [3]

(iii) time to melt ice = 150 s;  
 $L = \frac{(150 \times 530)}{0.25} = 320$  kJ kg<sup>-1</sup>; [2]

(d) the degree of disorder/order (of the molecules of the ice); [1]

(e) in any process, (reaction, event *etc.*) the overall entropy of the universe/a closed system increases; [1]

(f) entropy decreases;

*Award [1] each for any of these main points, up to [3 max].*  
 when water freezes it gives out energy (heat);  
 therefore speed (KE) of surrounding air molecules increases;  
 the air surrounding the ice is therefore in a more disordered state;  
 therefore disorder (entropy) of the universe increases; [4 max]

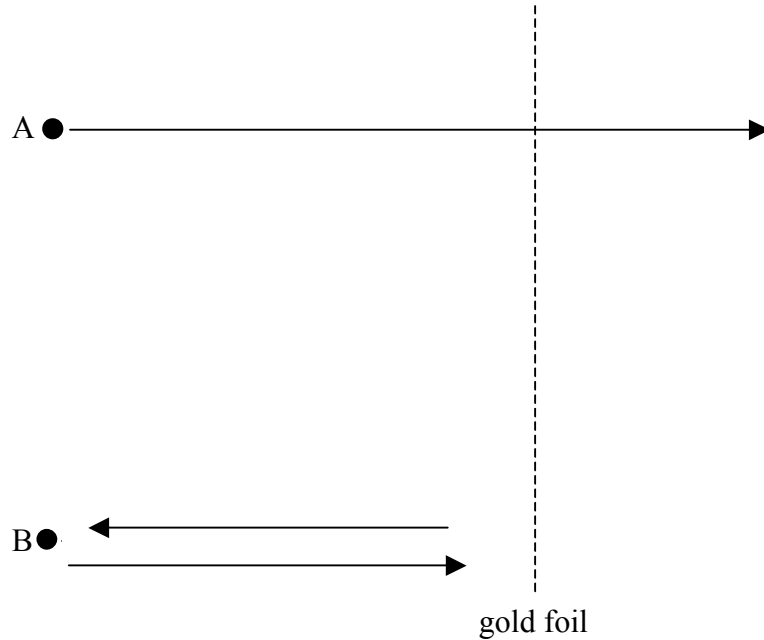


**B4. Part 2** The atom

(a) doubly ionized helium atom (helium nucleus);

[1]

(b)



(i) path A;

[1]

(ii) path B / any path that deflects back;

[1]

(iii) *Look for these main points:*

most of the  $\alpha$ 's pass straight through the foil with only small / zero deflection;  
hence most of atom is empty space;  
very few deflected back;

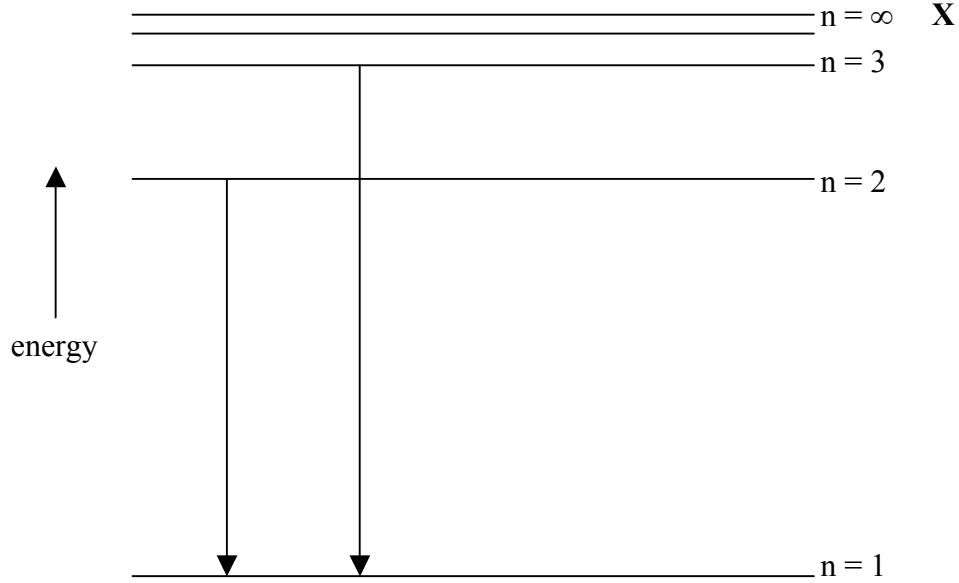
those that are deflected back must have had a "direct hit" with a massive object;  
whose mass is concentrated in a small volume of space;

[4 max]

*Answers could mention Coulomb repulsion between the  $\alpha$ -particle and the much more massive gold nucleus. Essentially [2] for good explanation of empty space and [2] for good explanation of the nucleus.*

(c) (i) X label at  $n = \infty$ ;

[1]



(ii) when an electron falls between two energy levels it will emit a photon;  
equal in energy to the difference in energy levels;  
since  $E = hf$  / frequency or wavelength depends on energy;  
if the energy levels are discrete, there will only be discrete wavelengths in the  
spectrum;

[4 max]

*Answer does not need to refer to diagram.*

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