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N00/430/S(2)M

MARKSCHEME

November 2000

PHYSICS

Standard Level

Paper 2

16 pages

SECTION A

A1. (a) Yes. Points lie on a straight line. ***[1]***

(b) $k = \text{slope}\ (\textbf{\textit{[1]}}) = \dfrac{3.6\ \text{y}^2}{120\times10^{-32}\ \text{m}^3} = 3\times10^{-34}\ \text{y}^2\ \text{m}^{-3}$ ***[1]***

[2]

If one pair of values used to calculate K instead of slope then ***[1]***.

(c)

$$T^2 = kR^3$$

$$R^3 = \frac{T^2}{k}\ \ \textbf{\textit{[1]}}$$

$$= \frac{144\ \text{y}^2}{3\times10^{-34}\ \text{y}^2\ \text{m}^{-3}}\ \ \textbf{\textit{[1]}}$$

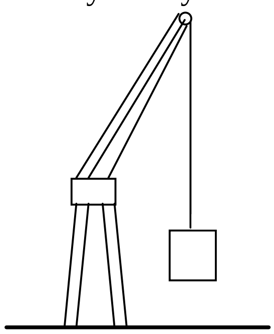
$$= 480\times10^{33}\ \text{m}^3$$

$$R = 7.8\times10^{11}\ \text{m}\ \ \textbf{\textit{[1]}}$$

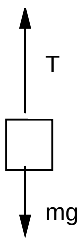
[3]

A2. (a)

Physical system

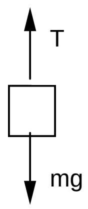


Free-body diagram



Accelerating upward

Free-body diagram



Moving upward
at constant speed

Figure 1 **Figure 2** **Figure 3**

Upward force T exerted by cable or "crane". Downward force mg exerted by "earth".

(Award marks as follows:
[1] *for unequal forces in Figure 2;*
[1] *for equal forces in Figure 3;*
[1] *for naming objects exerting the forces.)* ***[3]***

(b) Net $F = ma$

$$25000 - 20000 = 2000\,a\ \ \textbf{\textit{[1]}}$$

$$a = \frac{5000}{2000} = 2.5\ \text{m}\,\text{s}^{-2}\ \ \textbf{\textit{[1]}}$$

[2]

continued…

Question A2 (c) continued

(c) (i) $W = F \times d$

so $P = F \times v$ ***[1]***

$= 20\,000 \times 0.5 = 10\,000 \text{ J s}^{-1}$ ***[1]*** ***[2]***

(ii) $P = IV$

$I = \dfrac{P}{V}$ ***[1]***

$= \dfrac{10\,000}{400} = 25 \text{ A}$ ***[1]*** ***[2]***

(iii) Gone into (gravitational) potential energy (of the container). ***[1]***

A3. (a) Prediction and reasoning both wrong. ***[1]***
Reply: free (conduction) electrons throughout wire all start moving essentially together when the switch is closed. So bulbs light simultaneously. No need for any electron from the battery to have reached the bulbs. ***[1]*** *(Or answers to this effect.)* ***[2]***

(b) All equal brightness. ***[1]***

(c) A and C will get brighter, because the equivalent resistance of the circuit is less, so the current is greater. ***[1]***
B will get dimmer: the circuit current increases so the PD across A and C increases (***[1]***) so PD across B decreases (***[1]***). ***[3]***

(Note: It is incorrect reasoning to say that the current through B decreases since some of the current goes through D. Give ***[1]*** *for this 'local' reasoning, against* ***[2]*** *for the 'global' reasoning above.)*

(d) Several methods.
One way is to look at resistor arrangement as a potential divider.
PD across B/D is one fifth of 30V since the parallel resistance is $\frac{1}{5}$ of the whole.

So PD across B is $\frac{30}{5} = 6$ V. ***[1]***

Original PD was 10 V.

Now $P = \frac{V^2}{R}$ *i.e.* P proportional to V^2. ***[1]***

So new power is $\left(\frac{6}{10}\right)^2 \times 3\text{ W} = 0.36 \times 3 = 1.08\text{ W}$ ***[1]*** (1W OK)

Another way would be to work out the resistance of a bulb (33.3 Ω) and then do a normal circuit calculation of equivalent resistances, currents, voltages and hence power. ***[3]***

SECTION B

B1. Part 1

(a) Forces equal (***[1]***), by Newton's third law (***[1]***). ***[2]***

(b) Move in the direction of the truck, *i.e.* to the left. ***[1]***
Total system momentum before collision was to the left and must remain so after the collision, by conservation of momentum. ***[1]*** ***[2]***

(c) Momentum before = momentum after (*award* ***[1]*** *for explicit or implied*).

$m \times 60 - 2m \times 60 = (m + 2m)V$ ***[1]***

$-m \times 60 = 3m\ V$

$V = \frac{-60}{3} = -20\ \text{km h}^{-1}$ (*i.e.* $20\ \text{km h}^{-1}$ to the left). ***[1]*** ***[3]***

(d) Car acceleration is greater (***[1]***), because force on car and truck is the same but car mass is smaller (***[1]***). ***[2]***

(e) Car driver.
Because car reverses direction, change of velocity is greater in the same time, *i.e.* acceleration is greater (***[1]***), hence force by seatbelt greater (for same mass person). ***[1]*** ***[2]***
OR: Acceleration of car driver is greater than of truck driver (inferred from (d)) ***[1]***
Hence force by seatbelt greater on car driver (for same mass person of course). ***[1]***

(f) Not violated, since some energy goes into deformation and heat… ***[1]***

continued…

Question B1 continued

Part 2

(a) When two or more waves are present the resultant disturbance at any point is the vector sum of the disturbances due to each wave – or the resultant waveform is the vector sum of the individual waveforms – or words to that effect, showing understanding of superposition. ***[2]***

(b) Point P: Both displacements maximum in same direction hence resultant is double ***[1]***
Point Q: Vector sum OK (may estimate magnitudes). ***[1]***
Point R: Displacements equal and opposite hence cancel to give zero. ***[1]*** ***[3]***

(c) (i) **A**: From graph, period is 1 ms so frequency is 1000 Hz. ***[1]***
B: From graph, period is 0.9 ms so frequency is 1100 Hz. ***[1]*** ***[2]***

(ii) Beat frequency: A maximum intensity every 10 ms so beat frequency is 100 Hz. ***[2]***

(d) (i) This beat frequency is too high to be perceived as loudness variations. ***[1]***

(ii) Frequency difference must be smaller ***[1]*** in order to decrease the beat frequency. ***[1]***

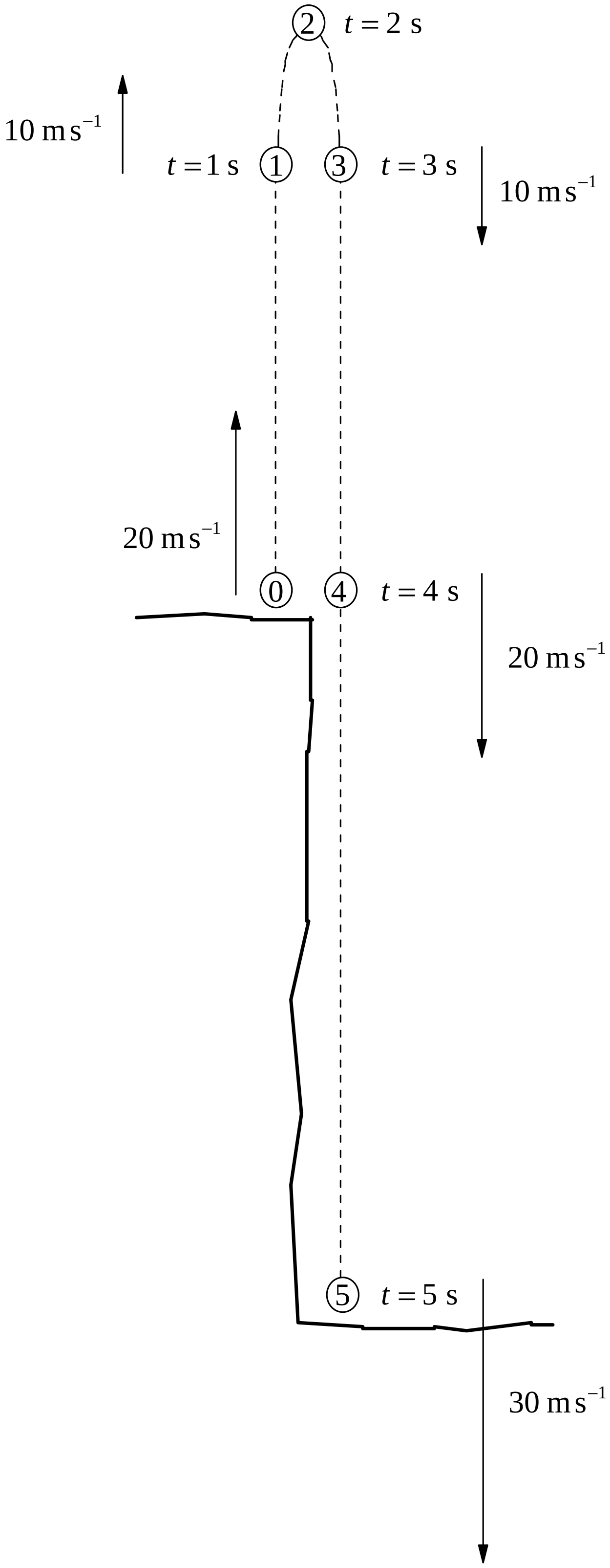
(e) Sound string and fork together and listen for beats. ***[1]***
Tune so that beats get slower, meaning string is getting closer to fork frequency. ***[1]*** ***[2]***

B2. Part 1

(a) (i) Downward. ***[1]***

(ii) Downward. ***[1]***

(ii) Downward. ***[1]***

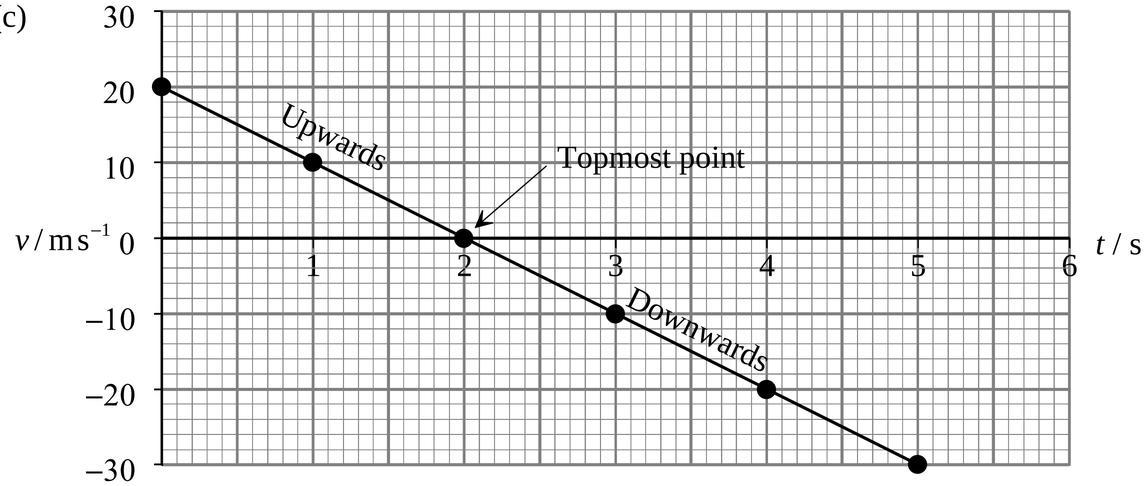


Question B2 Part 1 continued

(b) *Answer:* Given vector of 20 m s^{-1}: then 10 m s^{-1} upward, zero (no vector), 10 m s^{-1} downward, 20 m s^{-1} downward and 30 m s^{-1} downward. ***[3]***

*(Award **[1]** for all directions right, **[1]** for relative vector lengths, **[1]** for magnitudes.)*

(c)



*(Award **[2]** for the graph and **[1]** for all correct labels.)* ***[3]***

(d) The stone's acceleration. ***[1]***

(e) $s = ut + \frac{1}{2}at^2$

$= 20 \times 5 + \frac{1}{2}(-10)\,25 = 100 - 125 = -25$ m. ***[3]***

*(Award **[1]** for approach and equation, **[1]** for correct substitutions and signs, **[1]** for calculation and implicit interpretation of minus sign.)*

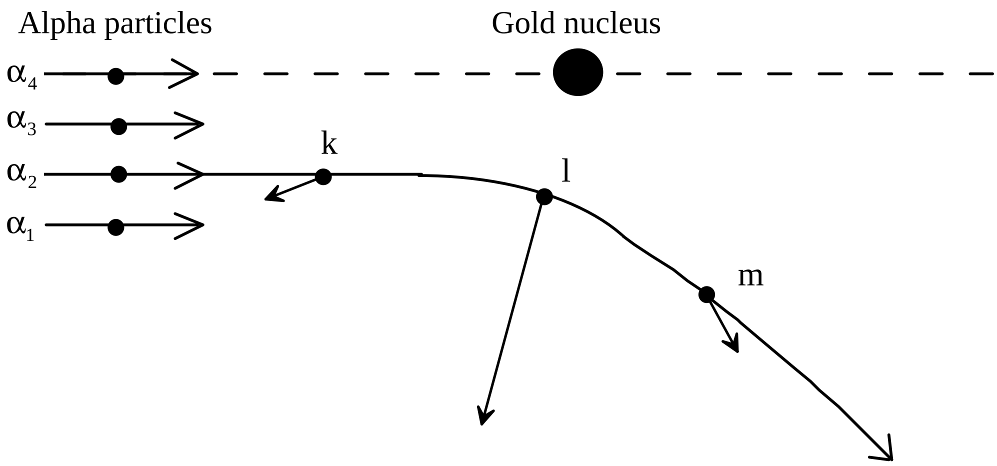
Question B2 continued

Part 2

(a) He concluded that the atom must consist of a very small positive nucleus carrying almost all the mass, surrounded by a much larger cloud of negative electrons, (***[1]***) since only if the alphas encountered a small massive charged object could they be turned back the way they came. ***[1]*** ***[2]***

*(If a candidate answers that the Thomson plum pudding model with positive charge throughout the volume of the atom would give very little deflection of any alphas as they passed through it, give **[1]**.)*

(b)



Force vectors: in right direction and of quarter the length at k and m than at l. ***[1]***
Forces are due to nucleus, electrostatic repulsion. ***[1]*** ***[2]***

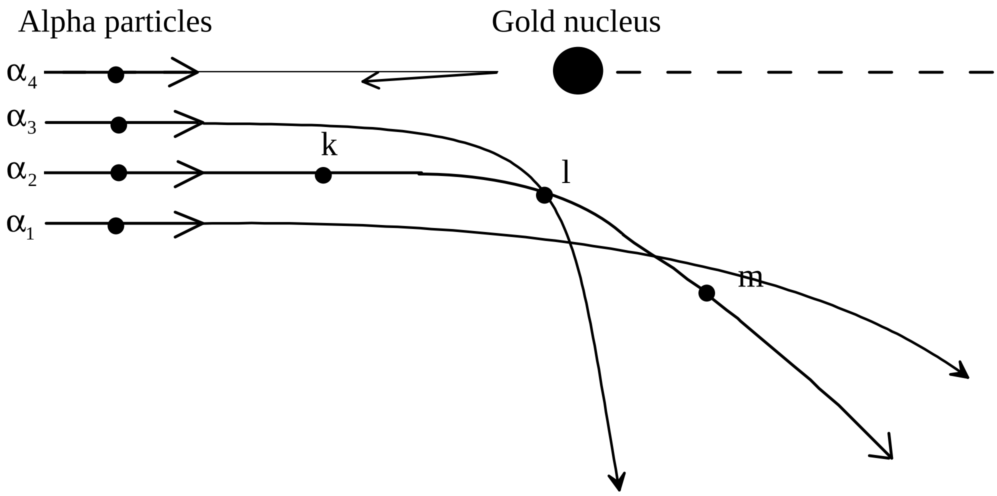
(If any non-existent forces are shown, e.g. along the path, subtract a mark.)

(c) Electric PE increases till l, then decreases, while KE decreases till l, then increases. ***[1]***
Total energy remains constant. ***[1]*** ***[2]***

continued…

Question B2 Part 2 continued

(d)



Alpha paths as shown in diagram above, supported by reasons below. *(Mark path and reason together.)*

- Generally, correct shapes of paths, *i.e.* curved more closer to nucleus and tending to straight path further away. ***[1]***
- α_1 is further from nucleus, hence smaller coulomb force, hence less deflection. ***[1]***
- α_3 is approaches nearer to nucleus, hence larger coulomb force, hence greater deflection. ***[1]***
- α_4 approaches head-on, repulsive force is against its motion and so it is repelled back the way it came. ***[1]*** ***[4]***

(e) $^{9}_{4}Be + ^{4}_{2}He = ^{1}_{0}n + ^{12}_{6}C$ ***[2]***

B3. Part 1

(a) ‘heat gained = heat lost’ or equivalent understanding, explicit or implicit. ***[1]***

$$m_i c_i \Delta T_i + m_i L_i + m_i\, c_w\, \Delta T_{i/w} = m_w\, c_w\, \Delta T_w \quad \textbf{\textit{[1]}}$$
$$2\times 2.1\times 10^3 \times 15 + 2\times 3.4\times 10^5 + 2\times 4.2\times 10^3\, T = 10\times 4.2\times 10^3 (30 - T) \quad \textbf{\textit{[1]}}$$
$$63 \quad + \quad 680 \quad + \quad 8.4T \quad = 42(30-T)$$
$$743 \quad = \quad 1260 - 42T - 8.4T$$
$$50.4T = 577$$
$$T = 10.3 \quad \approx \quad 10^\circ \quad \textbf{\textit{[1]}}$$

[4]

(b) Energy is conserved, but is used to break bonds between molecules in the solid – rather than increasing the KE of the molecules and hence the temperature. ***[2]***
Energy goes into increased intermolecular potential energy. ***[1]*** ***[3]***

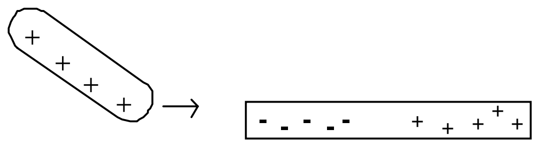
Part 2

(a) Electrons are transferred from the rubber to the fur, leaving the rubber with a net positive charge. ***[1]***

(b)

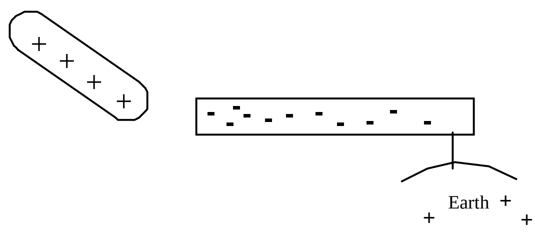
(i) The charged rubber rod is brought close to the metal rod. ***[1]***

Electrons are attracted toward the positive rod, leaving the other end with a net positive charge.



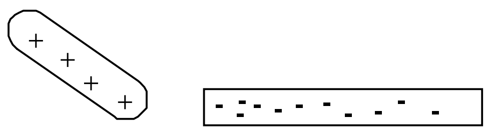
(ii) The metal rod is connected to earth. ***[1]***

Electrons flow in from earth, leaving earth with net positive charge.



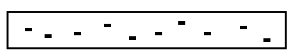
(iii) The earth connection is removed. ***[1]***

Charge distribution remains, with left end somewhat more negative.



(iv) The rubber rod is removed. ***[1]***

Excess negative charge spreads out.



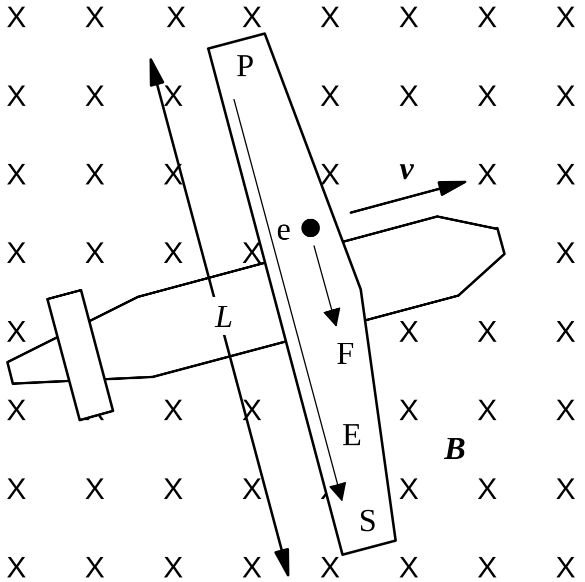
(c) Induction simply separates charge in the metal rod/earth system, so the metal rod becomes negative and earth becomes equally positive, so charge is conserved. Charge on rubber is unaffected. *(Award **[2]** for the essence of this.)* ***[2]***

continued...

Question B3 continued

Part 3

(a) (i) Toward wingtip S as shown. ***[1]***



(ii) $F = qv\boldsymbol{B} = ev\boldsymbol{B}$ ***[1]***

(b) (i) Electrons move toward S and build up there, leaving deficit of electrons at P. This charge separation sets up an electric field between the net positive and net negative wingtips. ***[1]***
Vector shown above from tip P to tip S. ***[1]*** ***[2]***

(ii) The charge separation causes an electric field which provides an opposing force to the magnetic force (***[1]***) and eventually equilibrium between the magnetic and electric forces on the electrons is reached and further motion stops (***[1]***).
(Alternatively could say the electrons that accumulate at one end repel any further electrons coming along, counteracting the magnetic force.)
If the forces were not equal, charge would move until they were. ***[2]***

(c) Equilibrium:
Magnetic force = electric force
$ev\boldsymbol{B} = eE$ ***[1]***
$E = v\boldsymbol{B}$ ***[1]***

(d) $E = v\boldsymbol{B} = 200 \times 8 \times 10^{-5}$ (***[1]***) $= 16 \times 10^{-3}\ \mathrm{V\,m^{-1}}$ or $16\ \mathrm{mV\,m^{-1}}$ ($\approx 20\,\mathrm{mVm^{-1}}$) ***[1]***

(e) Not between the wingtips, because the magnetic field and plane's motion are both horizontal. ***[1]***

(f) No. The magnetic force on the electrons is perpendicular to the plane's velocity, *i.e.* transverse to the plane not along it. ***[2]***