Physics Olympiad Competition 2011 Paper 1: Solutions

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Mark Scheme Sept/Oct 2010

Allow ecf where this gives sensible answers

Question 1

(a) Resistances of individual sections are R, $R/2$, $R/3$ ✓
Total resistance is (11/6) R ✓
(11/6) R = 33 kΩ ✓
R = 18 kΩ ✓

[4]

(b) Power = I^2R ✓
B has half the current therefore ¼ of the power, 0.45 mW ✓✓
C has one third of the current therefore 1/9 of the power, 0.2 mW ✓

or
calculate the current (0.234 mA) in A
current in B is ½ of this and I^2R gives 0.45 mW
current in C is 1/3 of 0.234 mA and I^2R gives 0.2 mW

[4]

[Q1: 8 marks]

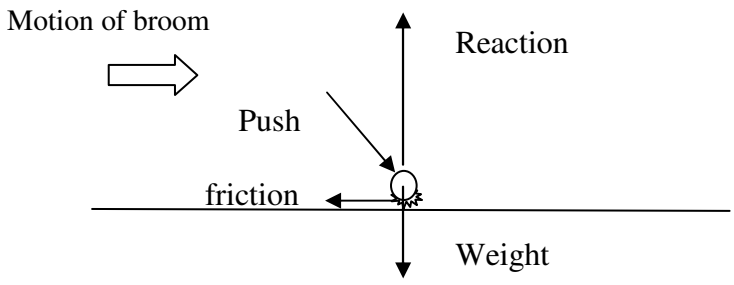
Question 2

Lifetime = range / speed of light ✓
= $10^{-15}/3 \times 10^{8}$ ✓
= 3×10^{-24} seconds ✓✓

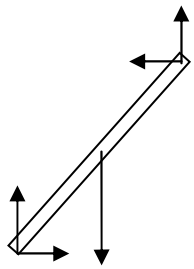
[Q2: 4 marks]

Question 3

(a) Arrows as shown. Names not required.

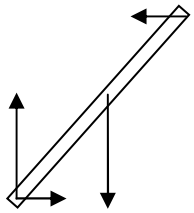


One mark per correct arrow [4]



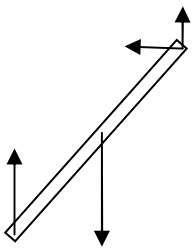
(b)

✓✓ [2]



(c)

✓ [1]



(d)

✓

One mark lost for each incorrect arrow (minimum is zero marks)

In (d) the **vertical** forces can be balanced (✓), but there is a **resultant horizontal** force (✓) and so the ladder is not in equilibrium (✓) and so will accelerate (to the left)
The length of the arrows is not crucial.

[4]

[Q3: 11 marks]

Question 4

(a) weight = pressure x area / $F = P \times A$ or equivalent ✓

(b) weight = $4 \times \pi \times (6.4 \times 10^6)^2 \times 101 \times 10^3$ ✓

$= 5.2 \times 10^{19}$ N ✓

(c) mass = weight / 9.81 ✓

$= 5.3 \times 10^{18}$ kg ✓

(d) no. of molecules = Avogadros number. x no. of moles

$= N_A \times$ mass /0.030 ✓

$= 1.1 \times 10^{44}$ molecules ✓

(e) Volume = mass / density ✓

$= 5.3 \times 10^{18} / 1.2$

$= 4.4 \times 10^{18}$ m^3 ✓

Height = volume / surface area of earth

$= 4.4 \times 10^{18} / 4 \times \pi \times (6.4 \times 10^{6})^2$ ✓

$= 8600$ m ✓

Or $P = \rho g h$

$1.01 \times 10^5 = 1.2 \times 9.81 \times h$ for [4] marks

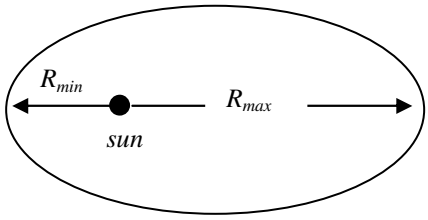
(f) The air is compressible (✓) and the air at the ground is compressed due to the weight of the air above it (✓). We have used the density of the air at ground level. [2]

(g) The value for the mass obtained is good because the weight of the air (and hence the mass) is independent of whether or not it is compressed (as long as the height is not so great that g reduces significantly and here 200 km << 6400 km) ✓

[Q4: 14 marks]

Question 5

(a)



✓

(b) $T^2 = k R^3$ ✓

$R = \dfrac{(R_{min} + R_{max})}{2}$ ✓

(c) $1^2 = k\ 1^3$

$k = 1$ year^2 AU^{-3} ✓

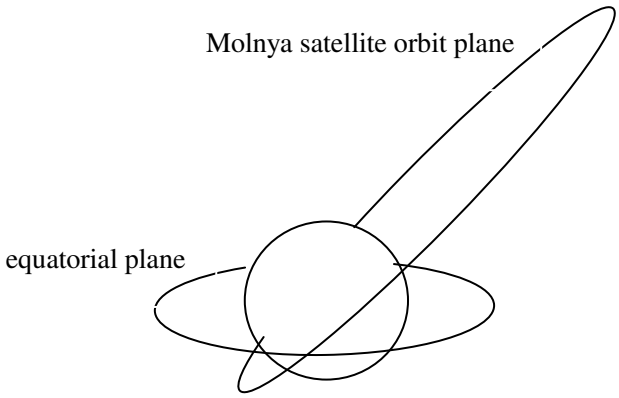
(d) $75.3^2 = 1 \times R^3$ giving $R = 17.8$ AU ✓

(e) $17.8 = ½ (0.585 + R_{max})$

$R_{max} = 35.1$ AU ✓

(f) The speed is slower at the distant point ✓
Total mechanical energy is constant ✓
Increase of gravitational pe accompanied by loss of ke. ✓

(g) The satellite is in a highly elliptical orbit ✓
(with the centre of the earth at one focus) not centred on the earth ✓
plane of the ellipse tilted at a large angle ✓
with respect to the plane of the equator.



(h) At the furthest point of the orbit, when the satellite is moving slowest / spends more time (✓), the region below the satellite is Russia or the USA

[Q5: 13 marks]

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