

Name of the Student: \_\_\_\_\_

Max. Marks : 26 Marks

Time : 26 Minutes

Mark Schemes

**Q1.**

(a)  $p_0 = 198.4$  (cm) ✓

*only acceptable answer*

1

(b) all  $x$  values correct and recorded to nearest mm ✓

$n$	$p/cm$	$x/cm$
0	198.4	174.6
2	157.0	133.2
4	125.4	101.6
6	101.3	77.5
9	75.4	51.6
13	53.8	30.0

*allow ecf for  $x = p - 23.8$  if  $p_0 \neq 198.4$* *penalise 2 sf  $x = 30$  for  $n = 13$* 

1

(c) six values of  $\ln(x/cm)$  recorded consistently i.e. all to (minimum) 2 dp; confirm that value of  $\ln(x)$  for  $n = 6$  corresponds to tabulated value of  $x_1$  ✓

vertical axis labelled  $\ln(x/cm)$  i.e. bracket required;suitable vertical scale (points should cover at least half the grid with a frequency of not less than 5 cm)  $_2$  ✓points plotted for  $n = 0, 2, 4, 6, 9$  and  $13$ ;check  $n = 6$  point is plotted within half a grid square of tabulated position;suitable continuous ruled line of negative gradient from  $n = 0$  to (at least)  $n = 13$   $_3$  ✓*expected data:*

$n$	$p/cm$	$x/cm$	$\ln(x/cm)$
0	198.4	174.6	5.162

for  $n = 0$ ,  $x = 0$ , ignore missing or incorrect  $\ln(x)$  and ignore missing/wrongly-plotted point

for  $_2$  ✓ vertical axis should be labelled  $\ln(x/\text{cm})$  (note that bracket is essential); expect vertical scale to start at 3 with major divisions of 0.2

for  $_3$  ✓ a suitable line must pass through all points if these have been correctly calculated;

for any errant plotted points the line must be the best line in the opinion of the marker;

line must not be thicker than half a grid square and width must not vary; points must not be thicker than half a grid square (reject any dots or blobs)

3

- (d) graph is linear and has negative gradient ✓

allow 'straight line' for 'linear'; statement must be confirmed by **Figure 4**

allow 'negative slope' or 'slopes downwards' for 'negative gradient'  
no ecf for non-linear graph

1

- (e) gradient triangle for **Figure 4**;

correct read offs ( $\pm 1$  mm) for all points or for both steps in triangle  $_1$  ✓

expected gradient result is  $-0.135$

for gradient between  $-0.139$  to  $-0.133$  (allow this intermediate answer shown as a fraction)

award two marks for minimum 3 sf  $x$  when  $n = 20$  in range 11.2 to 12.2 (cm)  $_{23}$  ✓✓

OR

one mark for  $x$  when  $n = 20$  in range 10.8 to 12.7 (cm)  $_{23}$  ✓

OR (if gradient out of range)

marker uses candidate's gradient (which must be negative) and (marker must read off) intercept on Figure 4 to calculate  $x$  when  $n = 20$

minimum 3 sf result in range  $\pm 4\%$   $_{23}$  ✓✓

OR

1 mark minimum 3 sf result in range  $\pm 8\%$   $_{23}$  ✓

(theoretical result for  $x$  when  $n = 20$  is 11.7(3) cm)

for  $_1$  ✓

allow 1 mark for sufficient evidence of working and a valid calculation of the gradient of a linear graph even if graph has a positive gradient

for  $_2$  ✓ and  $_3$  ✓

give no credit if graph drawn has a positive gradient

allow 1 mark for using a positive value for the (negative) gradient in the

calculation for  $x$  when  $n = 20$  (this leads to 2592 cm); result must be in range  $\pm 4\%$  <sub>23</sub> ✓

allow 'similar triangles' method;

$$\text{eg } \frac{5.16 - 3}{16} = \frac{5.16 - \ln x_{20}}{20} \quad 1 \quad \checkmark$$

$$\ln x_{20} = 2.46 \quad 2 \quad \checkmark; \quad x_{20} = 11.7(0) \text{ cm} \quad 3 \quad \checkmark$$

allow ecf  $x$  when  $n = 20$  based on Figure 4 if scales used enable value to be read directly using an extrapolated line; do not allow such working to extend beyond the grid into the margin <sub>1</sub> ✓; value in range 11.2 to 12.1 cm <sub>23</sub> ✓ = 1 MAX

3

(f) valid procedure 1

described <sub>1</sub> ✓

explained <sub>2</sub> ✓;

valid procedure 2

described <sub>3</sub> ✓

explained <sub>4</sub> ✓

explanation mark (<sub>2</sub> ✓) is only awarded when it is relevant to a correct procedure (<sub>1</sub> ✓); one procedure/explanation allowed per response

no credit for conflicting statements or wrong physics

any two from:

repeat experiment and average calculated ( $p$ ) <sub>1</sub> ✓

to reduce (impact of) random [human] error <sub>2</sub> ✓

and/or

repeat readings to detect anomalies <sub>1</sub> ✓

so these can be discarded (before averaging) <sub>2</sub> ✓

and/or

view air track at right angles [at eye level] <sub>1</sub> ✓

to reduce [eliminate] (impact of) parallax error <sub>2</sub> ✓

and/or

repeat experiment with track direction reversed and average calculated ( $p$ ) <sub>1</sub> ✓

to account for the effect of non-level bench <sub>2</sub> ✓

and/or

use video (camera) technology [or a motion sensor linked to a data logger or laser ranger] to view [record] the position of the glider as it reaches the top of the track <sub>1</sub> ✓

to reduce (impact of) random [human] error [to identify and eliminate anomalous results] <sub>2</sub> ✓

reject any suggestion that involves changing the glider, its initial position on the track or the air track itself including the position of the scale

4

[13]

## Q2.

- (a) Distance at which 1AU ✓ subtends an angle of 1/3600th degree ✓

or

Diagram with 1AU, 1pc and 1/3600th degree labelled ✓

*Allow 1 arc second for angle*

*1AU can be shown as Sun Earth distance*

*1pc can be either long side*

2

- (b) They are the same spectral class and therefore have similar temperatures. ✓

*No mark for the answer on its own.*

*First mark for identifying same T*

They have the same apparent magnitude, but K is significantly further away, therefore K has a greater power output (P)/ brighter absolute magnitude ✓

*Second mark for identifying greater P*

*Condone greater for brighter*

*Condone luminosity for absolute magnitude*

As  $P = \sigma AT^4$

to have a greater power output than R at the same temperature, K must have a greater area, and therefore be bigger. ✓

*Third mark for use of Stefan's Law to obtain the answer.*

3

- (c) Substitution into  $\lambda_{\max} T = 0.0029 \text{ mK}$  ✓

To give  $T = 2.9 \times 10^{-3} / 1.0 \times 10^{-6} = 2.9 \times 10^3 \text{ K}$  ✓

*Condone power of ten errors in first mark*

2

- (d) The spectral class is related to the temperature ✓

So the star is in spectral class M

*Allow ecf from (c) – see spec for table of spectral class and temperature*

And is therefore Rasalgethi ✓

*The second mark is for the correct class and therefore star identified*

2

- (e) Rasalgethi

1

- (f) Use of  $m - M = 5 \log (d/10)$

To give

$$3.1 - M = 5 \log(2.3) \quad \checkmark$$

$$3.1 - M = 1.8 \quad \checkmark$$

*First two marks are for the substitution of  $M$ ,  $m$  and unit of  $d$  and correct log.*

*Deduct one mark for each error; more than two errors give 0/3*

$M = 1.3$  ✓

*Third mark for the correct calculation: allow ecf for up to two errors*

3

**[13]**