BRITISH PHYSICS OLYMPIAD

http://www.BPhO.org.uk

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Dear Teacher,

Please ignore any reference to AS students in the blue Physics Challenge mark scheme and covering information. This is a printing error. The Physics Challenge should be set for GCSE-level students.

I apologise for any inconvenience.

Erratum

2009 PHYSICS CHALLENGE PAPER

ONE HOUR PHYSICS COMPETITION PAPER

FRIDAY 6 th MARCH 2009

We hope teachers will set and mark the enclosed paper for their AS students, or equivalent students in Scotland. The solutions and marking scheme are contained herein. It is intended that the paper should be taken on Friday 6 th March. However if this is not possible, any date during the period 2 nd –9 th March will be acceptable. Scripts of the Gold Medallists and requests for certificates must be posted in sufficient time to arrive by first class post on Monday 23 rd March at the Olympiad Office at the University of Oxford. Any scripts arriving after this date cannot be considered for an award.

After the scripts have been marked please send those scripts with marks of 38 and above to the Oxford office, the scripts of the Gold Medal Certificate students, in order to be considered for the award of a book prize, together with the entry form, which is on the following page, and request form for certificates to:

Lorna Stevenson
BPhO Office
Physics Challenge Competition
Department of Physics
Clarendon Laboratory
Parks Road,
University of Oxford
Oxford OX1 3PU

We will invite the five outstanding Gold Medallists, together with their teachers, to the Physics Challenge Presentation Ceremony at The Royal Society in London on Thursday 30 April 2009. Prizes and certificates will be despatched to all remaining medallists, who are not amongst those invited to the Presentation, in May. Teachers are requested to complete the certificates according to the medal scheme specified on the last page, and present them to their students.

2009 PHYSICS CHALLENGE COMPETITION

ENTRY FORM

Name of teacher ______________________________

School ______________________________

Address ______________________________

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Tel. No. ______________________________

Email ______________________________

TOTAL NUMBER OF ENTRIES __________

GOLD MEDALLISTS: Full names and marks of Gold Medallists with marks in the range 38 - 50 for consideration of the award of a book prize.

NAME	TOTAL MARK

NAME	TOTAL MARK

Please complete and return the request form for certificates.

TEACHERS' COMMENTS

We welcome comments concerning questions in this AS Physics Competition paper and suggestions for possible future challenging questions.
Comments:

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2009 PHYSICS CHALLENGE CERTIFICATES

All Participating students will receive a certificate. They will be awarded Gold, Silver, Bronze and Participation Medal Certificates, based on their marks, according to the scheme below:

Medal Certificate	Gold	Silver	Bronze	Participation
Mark Range	50 – 38	37–31	30 - 20	19 – 0
No. of certs. Requested				

Total Number of Entries	

NAME OF TEACHER ______________________________

NAME OF SCHOOL ______________________________

ADDRESS OF SCHOOL ______________________________

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Please return to:

Lorna Stevenson
BPhO Office
Physics Challenge Competition
Department of Physics
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Parks Road, Oxford OX1 3PU

Physics Challenge 2009 - Marksheme

Please award marks as indicated below.

Equivalent valid reasoning should gain equal credit to the solutions presented here.

Error carried forward marks may be awarded where an incorrect answer is used as part of the data needed for a subsequent question, providing that the resulting answer is not plainly ridiculous.

If incorrect units are used more than once then **one** mark should be deducted from the total.

If an inappropriate number of significant figures are given more than once in final answers then **one** mark should be deducted from the total.

Section 1 – Multiple Choice Questions

1	2	3	4	5	6	7	8	9	10
E	D	B	A	E	A	A	B	C	B

Section 2 – Short Answer Questions

Marks for these two questions should be awarded for a clear explanation of the underlying Physical principals using correct scientific terminology. Answers that are incomplete, contain errors in Physics or use terminology incorrectly cannot be awarded full credit.

Award 0 marks:	No valid attempt made to answer question
Award 1 mark:	Valid point presented but other-wise incorrect or incomplete answer
Award 2 marks:	Partially correct answer but major error or omission in reasoning
Award 3 marks:	Mostly correct answer, only minor errors or omissions in reasoning
Award 4 marks:	Completely correct answer, no errors of reasoning or use of terminology

Question 11. [4 max]

- Charged rod attracts **electrons** in uncharged object
- Uncharged object has unevenly distributed charge / forms a dipole / has negative side closer to rod than positive side
- Negatively charged side of objects attracted to rod more strongly than the positive side is repelled from rod
- Therefore there is a net force of attraction

Question 12. [4 max]

- Activity depends on the number of radioactive nuclei
- As sample decays, number of radioactive nuclei decreases
- Therefore activity reduces

Section 3 – Longer Questions

Question 13.

(a)

- 6.02 m/s^2 (allow 6.22 m/s^2 if candidate used $g = 9.8\ m/s^2$) [1]

(b)

- Straight line graph with a positive gradient starting from zero [1]
- Velocity axes correctly labelled from 0 to approximately 360 m/s (allow ecf) [1]

(c)

- Any graph showing acceleration increasing with time [1]
- Curve with increasing gradient [1]
- Axes labelled: $a \simeq 6m/s^2$ @ t = 0s and $a \simeq 9.5\ m/s^2$ @ t = 60s (allow ecf) [1]

(d)

- Air resistance (or any other acceptable answer) [1]

(e)

- General method $E_k = ½mv^2$, $v = s/t = 2\pi r^2/(24x3600)$, $r = 6400\cos(\theta)$ [1]
- Intermediate steps: $v_{ESA} = 463m/s$, $v_{CC} = 409m/s$, $E_{ESA} = 80x10^9J$, $E_{CC} = 63x10^9J$ [1]
- Conclusion giving 17/63 = 0.27 (or equivalent working) [1]

(10 max)

Question 14.

(a)

- 10 lux → $5k\Omega$, $I = 3v / 5k\Omega = 0.6mA$ [1]

(b)(i)

- 10 lux → $5k\Omega \Rightarrow R_{total} = 5k\Omega + 10k\Omega \Rightarrow I = 3 / 15k\Omega = 0.2mA$ [1]

(b)(ii)

- $V = I \times R$ where I = 0.2 mA [1]
- $V = 0.2\ mA \times 10k\Omega = 2v$ [1]

(c)

- Curve that shows voltage increasing as light level increasing:
  - with voltage scale labelled 0 – 3v [1]
  - clearly goes through point (10 lux, 2v) [1]
  - Approaches (but does not exceed) 3v for light level > 60 lux [1]

(d)(i)

- For LDR: $R_{LDR} = 1k\Omega$ and $V_{LDR} = 2v \Rightarrow I = 2mA$ [1]
- For $10k\Omega$ resistor: $V = 1v \Rightarrow I = 0.1mA$ [1]
- For unknown resistor: $I = 2mA - 0.1mA = 1.9mA$ and $V = 1v \Rightarrow R \simeq 530\Omega$ [1]

(d)(ii)

- The circuit is more sensitive in bright light, a change in the light level around 60 lux will produce a larger change in the reading on the voltmeter that when the $10k\Omega$ resistor was used on its own (owtte) [1]

(11 max)

Question 15.

(a)(i)

- $\Delta E = mc\Delta T \Rightarrow \Delta E = 20 \times 4200 \times 3 \Rightarrow E = 252kJ$ [1]

(a)(ii)

- Power per square metre = energy per second ÷ area of pool
- Power per square metre = $(252kJ / 60s) \div (\pi \times 2^2)$ [1]
- 334 W/m^2 [1]

(a)(iii)

- Thermal energy will be lost from pool and so measured temperature rise is too low and so measured energy and power values are too low (owtte) [1]

(b)(i)

- $P = 7v \times 0.2A = 1.4W$ and Area $= 0.15m \times 0.15m \Rightarrow$ Power/m^2 = 62 W/m^2 [1]

(b)(ii)

- Efficiency = 62 / 334 = 0.19 or 19% (Allow ecf) [1]

(c)

- $P = I \times 4\pi r^2 \Rightarrow P = 1400 \times 4\pi \times (150 \times 10^9)^2$ [1]
- $P = 4.0 \times 10^{26}$ W [1]

(d)(i)

- Power on solar panels = 200 / 0.4 = 500W
- Area = 500 / 1400 = 0.36m^2 [1]

(d)(ii)

- At Jupiter, $I = (4.0 \times 10^{26}) \div (4\pi \times (780 \times 10^9)^2) = 52\ W/m^2$ (Allow ecf) [1]
- Area = 500 / 52 = 9.6m^2 [1]

(11 max)