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INTERNATIONAL A-LEVEL
PHYSICS
PH04

Unit 4 Energy and Energy resources

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from oxfordaqaexams.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Marking guidance	Mark	Comments
01.1	Attempt to find area under graph ✓ Energy per small square = 0.2 (J) OR Total squares = 175 – 191 ✓ 35.0 – 38.2 (J) ✓	3	energy per big square = 5 J or total big squares = 7–7.5 allow one mark for candidate that try to use PΔV
01.2	Mass of gas = density × volume (with read off of volume from graph) $= 2 \times 10^{-4} \times 0.179$ ✓ (No. of moles = $\frac{2\times10^{-4}\times 0.179}{4\times10^{-3}}$ =) 8.95×10^{-3} (mol) ✓	2	
01.3	Use of PV = nRT ✓ Determines one temperature correctly as 269 K or 597 K Or uses the correct value of Δ(PV) = 24.2 ✓ Increase in temperature = 328 K ecf from 01.2 ✓	3	condone power of 10 error for 1st mark only

01.4	Internal energy increases giving particles more kinetic energy Pressure is due to change in momentum of gas atoms when they collide with the walls of the cylinder **Plus any two from** When volume decreases atoms collide more frequently with the walls Molecules have more momentum since temperature rises Change in momentum per second on given area is increased max 2	1 1 1 1 1 max 4	

Question	Marking guidance	Mark	Comments
02.1	Nuclei are both positively charged **or** Nuclei repel one another ✓ Idea that kinetic energy transfers to electrostatic PE as they approach ✓ Nuclei need to have high kinetic energy so that the nuclei 'touch' (or become close enough for SNF to act) ✓	1 1 1	 Accept statement that nuclei need enough kinetic energy to collide
02.2	Attempt to use $A^{1/3}$ ✓ $r_0 = 1.12 x 10^{-15}$ or radius of $^3H = 1.73 \times 10^{-15}$ ✓ Adds candidates two radii together ✓	1 1 1	Accept equivalent method via constant nuclear density Look for 1.73×10^{-15} m Correct distance between centres = 3.24×10^{-15} m
02.3	Use of KE = $\frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r}$ ✓ Correct substitution of charge data in the formula along with their 02.2 ✓ KE = 7.1×10^{-14} J ✓	1 1 1	If candidate used $r = 3.2 \times 10^{-15}$ then KE = 7.2×10^{-14} J

Question	Marking guidance	Mark	Comments
02.4	Attempt to calculate mass of (helium + mass of neutron) – (mass of deuterium + mass of tritium) ✓ Multiplies by 931.5 MeV ✓ Energy released = $2.7(4) \times 10^{-12}$ J ✓ **or** Attempt to calculate mass of (helium + mass of neutron) – (mass of deuterium + mass of tritium) ✓ Multiplies by 1.661×10^{-27} kg OR Multiplies by c^2 ✓ energy released = $2.7(4) \times 10^{-12}$ J ✓	1 1 1 1 1 1	correct change in mass = 0.018334 u
02.5	Superconducting coils used (to create magnetic fields) I^2R losses are 0 because R is 0	1 1	

Question	Marking guidance	Mark	Comments
03.1	Mass of the product nuclei is less than the mass of uranium ✓ There is an increase in mass defect ✓ Binding energy = Δmc^2 **or** binding energy is the energy equivalent of the mass defect. ✓	3	Accept that mass-energy is conserved for 1 mark
03.2	ANY 4 from: Calculates at least one correct total BE ✓	1	BE of U = 285.525 pJ, BE of Th = 281.589 pJ, BE of alpha = 4.528 pJ
	Energy released = (BE of Th) + (BE of He) – (BE of U) = 0.59(x 10^{-12})(J) ✓	1	
	Multiplies energy by 0.98 ✓	1	
	Use of ½ mv^2 ✓	1	
	Speed of alpha particle = $1.3(2) \times 10^7$ m s^{-1} ✓		Correct answer gets full marks

Question	Marking guidance	Mark	Comments
04.1	MAX 4 Uses $\alpha = \frac{\Delta\omega}{t}$ ✓ Uses $T = I\alpha$ ✓ Adds frictional torque (45) to candidate's T ✓ Uses $F = \frac{T}{r}$ ✓ Total force (= 129.36/1.6) = 81N or 80.9 N ✓	 1 1 1 1 1	 Expect to see α =2.9/11 or 0.264 Expect to see 84(.4) Expect to see 129 Correct answer gets full marks
04.2	Combined I = 320 + (35 × 1.3^2) = 379.2 kg m^2 ✓	1	Condoned 2 sf answer here
04.3	Attempt to apply conservation of angular momentum ✓ ω = 320 × 2.9/(379.2) = 2.448 (rad s^{-1}) ✓	1 1	 Answer given to at least 3 sf
04.4	Use of α= T/I ✓ Use of "suvat" ✓ θ in range 23–24 rad ✓ Rotations = their θ /2π ✓	1 1 1 1	= (−)45/379.2) =(−)0.12 eg $0.5^2 - 2.448^2 = -2$ × their α × θ expected answer in the range 3.6 to 3.8

Question	Marking guidance	Mark	Comments
05.1	Multiplies (incident power) by area ✓ Multiplies by efficiency ✓ Number of panels needed = $150 \times 10^3/250 = 601$ ✓	3	Expect to see $2.2 \times 630 = 1386$ J Expect to see $0.18 \times 1386 = 250$ W Allow reasonable variation due to rounding Allow convincing reverse calculation
05.2	Gets angle correct at 67^o ✓ Electrical power in winter with tracking = $310 \times 2.2 \times 0.18 = 122.8$ W OR Without tracking power = $122.8 \times \sin 67 = 113$ W ✓ Finds the difference between candidate's two values ✓	3	Expect extra power = 9.8 W Accept small variation due to rounding

Question	Key
06	D
07	D
08	A
09	C
10	C
11	C
12	A
13	C
14	C
15	A
16	B
17	D
18	A
19	D

Question	Key
20	B
21	B
22	B
23	C
24	B
25	A
26	A
27	D
28	B
29	C
30	A
31	D
32	A
33	B

Question	Key
34	A
35	B